VIRTUAL

Enterprise + Infrastructure Resilience Workshop

September 27-28, 2021

Organized by the Institute for Sustainability

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WELCOME ADDRESS

GREETINGS

We want to welcome you virtually for the **3rd Enterprise and Infrastructure Resilience Workshop** brought to you by the Institute for Sustainability (IfS), an AIChE Technological Community and sponsored by a generous grant from the United States National Science Foundation (#2131959).

Incorporating concepts from resilience engineering in the design of systems such as chemical plants, chemical supply chains, and energy networks would be very effective in minimizing undesired effects of unforeseen disturbances, yet requires expertise from various disciplines in science and engineering such as chemical engineers, sustainability engineers, mathematicians, and more. It is in this framework and deriving from the concepts of one of NSF's 10 Big Ideas in "Growing Convergence Research" that we designed this year's **Enterprise and Infrastructure Resilience Workshop**.

This workshop explores multifaceted resilience strategies for the modern enterprise with featured topical sessions:

- **Resilient Systems Modeling** that will incorporate various methods of systems modeling, including probabilistic modeling, empirical approaches, system dynamics-based approaches.
- **Energy and Fuels Sector Resilience Concepts**, which will focus on building resilience in this sector, analyzing past trends, and preparing for incoming changes.
- **Chemical/Chemical Related Infrastructure Resilient Processing** that will focus on strategies to develop resilience chemical plants, and considerations that must be taken when designing these systems
- **Broader Resilience Concepts**, which will focus on the relationship between these broader concepts, how to enhance them, and how to measure them, and will feature conceptual and modeling research as well as practical applications.
- **Environmental, Ecological and Disaster Resilience** that will focus on understanding environmental resilience and how ecological baselines continue to change.
- **Built Infrastructure** which will discuss methods for improving the physical and digital resilience of civil infrastructure systems.

This extraordinary conference is headlined by our featured Keynote lectures, represented by Invited presentations from various universities, academic and non-academic institutions, and characterized by selected talks. Much work has gone into making this conference a success. If it were not for the contributions of our Organizing Committee, who was instrumental in selecting our speakers and shaping the program, as well as the invaluable assistance from our sponsors, academic supporters, and media partners, this conference could not have happened. We want to thank you for attending the conference. We hope these next two days will be pleasant, educational, and inspiring.

Sincerely,
3rd Enterprise and Infrastructure Resilience Workshop Conference Chairs
Debalina Sengupta, TEES/Texas A&M University
Heriberto Cabezas, University of Miskolc/US EPA (Ret.).
Ignasi Palou-Rivera, RAPID

Thank you!

CONFERENCE ORGANIZERS

Conference Co-Chairs

Debalina Sengupta*, Associate Director; TEES Gas and Fuels Research Center Food, Energy, Water Nexus Coordinator, Texas A&M Energy Institute*

Dr. Sengupta's research focuses on sustainability in the context of process systems engineering. She has worked on process design, integration, intensification, optimization, life cycle assessment and other related concepts for Sustainable Supply Chain Design of Biofuels, Natural Gas, and Consumer Products, and decision-making in Sustainability using metrics and indicators. She has also been actively involved in the development of educational modules for sustainable manufacturing. Dr. Sengupta is currently appointed as the Associate Director of the TEES Gas and Fuels Research Center, Water, Energy and Food Nexus Coordinator at Texas A&M Energy Institute, and Lecturer at Texas A&M University, Artie McFerrin Department of Chemical Engineering. (Learn More Here)

Ignasi Palou-Rivera*, Chief Technology Officer; RAPID*

Ignasi Palou-Rivera is currently the Chief Technology Officer of the RAPID Manufacturing Institute. RAPID is a collaboration between the US Department of Energy Advanced Manufacturing Office and AIChE on Modular Chemical Process Intensification (MCPI). Ignasi holds an Engineer degree from the Universitat Politècnica de Catalunya in Barcelona and a Ph.D. in Chemical Engineering from the University of Wisconsin-Madison. Ignasi's professional career spans the areas of process development, modeling and optimization; techno-economic, life cycle, and sustainability analysis; and R&D management for a variety of organizations such as BP, LanzaTech and Argonne National Laboratory. Ignasi is a Senior Member of AIChE and the current Past Chair of the Sustainable Engineering Forum, an AIChE Community. (Learn More Here)

Heriberto Cabezas*, Professor, Research Institute of Applied Earth Sciences; University of Miskolc, Hungary*

Heriberto Cabezas is a Professor in the Research Institute of Applied Earth Sciences at the University of Miskolc in Hungary. He is a former Professor (2015-2020) at the Laudato Si Institute for Process Systems Engineering and Sustainability at the Pazmany Peter Catholic University in Budapest, Hungary. He retired (04/2019) as the Senior Science Advisor to the Land and Material Management Division in the U.S. EPA's Office of Research and Development (ORD). At the U.S. EPA he was responsible for the oversight of the scientific research teams under the guidance of the division director. He is a former Acting Director (2008-2010) of the Sustainable Technology Division consisting of approximately 50 scientists, engineers, and support staff, some thirty five at the doctoral level. Dr. Cabezas organized and led as Chief (2000-2008) the Sustainable Environments Branch, a multidisciplinary research group of some seventeen scientists and engineers. At the Peter Pazmany Catholic University he is responsible for conducting research on sustainability science and Graph Theory (P-Graph specifically) for network design including manufacturing processes, supply chains, and product and services distribution. Dr. Cabezas has served as Chair of the Environmental Division of the American Institute of Chemical Engineers (AIChE) for 2006. (Learn More Here)

Organizing Committee

Selen Cremaschi, *Associate Professor; Auburn University*

Selen Cremaschi is the B. Redd Associate Professor of Chemical Engineering at Auburn University. Her research interests are risk management, optimization, process synthesis, and planning under uncertainty. Her research group works at the intersection of operations research and chemical engineering, and develops systems analysis and decision support tools for complex systems, mainly focusing on healthcare and energy industry. (Learn More Here)

Bhavik Bakshi, *Richard M. Morrow Professor; Ohio State University*

Bhavik R. Bakshi is the Richard M. Morrow Professor of Chemical and Biomolecular Engineering at The Ohio State University. He received his B.Chem.Eng. degree from the Institute of Chemical Technology in Mumbai, India and his MSCEP and PhD degrees from the Massachusetts Institute of Technology. His research is in the area of Sustainable Engineering which is resulting in systematic methods for developing products and processes that make positive contributions to human well-being while being economically feasible and respecting nature's limits. He has recently authored a textbook on Sustainable Engineering and is on the editorial boards of several multidisciplinary journals. (Learn More Here)

Jose Maria Ponce Ortega, *Professor; Universidad Michoacana de San Nicolás de Hidalgo*

Dr. José María Ponce-Ortega got his Ph.D. and Master's degrees in Chemical Engineering from the Institute of Technology of Celaya in Mexico in 2009 and 2003. He stayed as a postdoctoral researcher at Texas A&M University from 2011 to visiting scholar at Carnegie Mellon University from 2006 to 2007. Dr. Ponce-Ortega is full professor at the Universidad Michoacana de San Nicolás de Hidalgo since 2012 until today, and he is member of the National Research System of Mexico (SNI II). (Learn More Here)

Fengqi You, *Roxanne E. and Michael J. Zak Professor; Cornell University*

Fengqi You is the Roxanne E. and Michael J. Zak Professor at Cornell University, and is affiliated with the Graduate Fields of Chemical Engineering, Electrical and Computer Engineering, Operations Research and Information Engineering, Systems Engineering, Mechanical Engineering, Civil and Environmental Engineering, and Applied Mathematics. Prof. You also serves as Chair of PhD Studies for Cornell Systems Engineering and Associate Director of Cornell Energy Systems Institute. His research focuses on novel computational models, optimization algorithms, statistical machine learning methods, and multi-scale systems analytics tools for energy systems, and sustainability. (Learn More Here)

Ignacio E. Grossmann, *R. R. Dean University Professor of Chemical Engineering; Carnegie Mellon*

Professor Ignacio E. Grossmann is the R. R. Dean University Professor of Chemical Engineering at Carnegie Mellon University. He obtained his B.S. degree at the Universidad Iberoamericana, Mexico City, in 1974, and his M.S. and Ph.D. at Imperial College in 1975 and 1977, respectively. He is currently director of the 'Center for Advanced Process Decision-making,' an industrial consortium that involves 20 petroleum, chemical, engineering and software companies. He is a member of the National Academy of Engineering and his major awards include the 1994 Computing in Chemical Engineering Award of AIChE, the 1997 William H. Walker Award of AIChE, 2009 Warren Lewis Award of AIChE, and 2011 Research Excellence in Sustainable Engineering Award. He was also named “One of the Hundred Chemical Engineers of the Modern Era” by AIChE in 2008. (Learn More Here)

Rajib Mukherjee, *Assistant Professor; The University of Texas Permian Basin*

Dr. Mukherjee graduated from the Process Systems Engineering Laboratory at Department of Chemical Engineering, Louisiana State University (2010). Before joining UTPB, he has conducted postdoctoral research at Tulane University, Center for Computational Science, United States Environmental Protection Agency (US EPA) as an ORISE postdoctoral fellow, University of Illinois Chicago (UIC)/Vishwamitra Research Institute and worked at the Department of Mechanical Engineering, Texas A&M University (TAMU) as visiting assistant professor. (Learn More Here)

Fadwa Eljack, *Associate Professor, Department of Chemical Engineering; Qatar University*

Fadwa Eljack is a faculty in the Department of Chemical Engineering at Qatar University. She obtained her bachelor (1999) and PhD (2007) degrees from Auburn University, USA. Her research focuses mainly in the area of Process System Engineering that includes optimization and management of gas processing facilities, flare reduction, product design, risk assessment and the inclusion of safety in design. Fadwa has served as the Director of the Gas Processing Center (GPC) at Qatar University (2008 – 2010). She has over 30 paper publications and is currently leading a number of research projects in collaboration with academic institutions and Qatari Industry, with over $3 million in funding. (Learn More Here)

Third Enterprise and Infrastructure Resilience Workshop

TECHNICAL PROGRAM

September 27th, 2021

10:00 AM	10:05 AM	Welcome Introductions
10:05 AM	10:35 AM	*Next-Generation Resilient Energy and Manufacturing Supply Chains* **Keynote Speaker:** Elefterios Iakovou (Harvey Hubbell Professor of Industrial Distribution; Director, Manufacturing and Logistics Innovation Initiatives, Texas A&M Engineering Experiment Station; Director of Supply Chain Management, SecureAmerica Institute; Assistant Director, Resilience and Sustainability of Integrated Energy and Manufacturing Supply Chains, Energy Institute, Texas A&M University)
10:35 AM	10:45 AM	Question and Answer Panel Moderated By: **Debalina Sengupta** (TAMU)
10:45 AM	11:05 AM	*Convergence Research Approach for Resilience - A Chemical Engineering Perspective* Debalina Sengupta (Associate Director, TEES Gas and Fuels Research Center, Water Energy Food Nexus Coordinator, Texas A&M Energy Institute, Graduate Faculty, Artie McFerrin Department of Chemical Engineering, Texas A&M University)
11:05 AM	11:15 AM	Break
11:15 AM	12:50 PM	Resilient Systems Modeling
11:15 AM	11:20 AM	Session Chair Introduction - Heriberto Cabezas (University of Miskolc)
11:20 AM	11:40 AM	*Resilient Design of Complex Networked Systems: Importance of Topological Features* **Invited Speaker:** Venkat Venkatasubramanian (Columbia University)
11:40 AM	12:00 PM	*Resilient Design and Operations of Process Systems* **Invited Speaker:** Fengqi You (Cornell University)
12:00 PM	12:20 PM	*Data Analytics for Resilient Systems: Variable Selection, Reliability Estimation and Optimization* **Invited Speaker:** Rajib Mukherjee (University of Texas Permian Basin)
12:20 PM	12:30 PM	*Resilience-Based Recovery Scheduling of Transportation Network Considering Connected and Autonomous Vehicles* **Qiling Zou** (Carnegie Mellon University)
12:30 PM	12:50 PM	Question and Answer Panel Moderated By: Heriberto Cabezas (University of Miskolc)
12:50 PM	1:00 PM	Break
1:00 PM	2:15 PM	Energy, and Fuels Sector Resilience Concepts
1:00 PM	1:05 PM	Session Chair Introduction - Fadwa Eljack (Qatar University)
1:05 PM	1:25 PM	*Midstream Infrastructure Resilience in the Digital Age* **Invited Speaker:** Helen Lou (Lamar University)
1:25 PM	1:45 PM	*Deploying Multi-Phase Flows, Machine Learning (ML) and Micro/Nano-Technologies (MNT) for Enhancing Reliability, Sustainability and Resilience for Mitigating the Food-Energy-Water (FEW) Nexus* **Invited Speaker:** Debjyoti Banerjee (Texas A&M University)
1:45 PM	1:55 PM	*Energy Transition and Decarbonization- Production of Biogas from Biowaste (Food waste) with Wood Chips Towards Low-Carbon Environment.* **Onyinyechukwu Njoku** (Rivers State University)
1:55 PM	2:15 PM	Question and Answer Panel Moderated By: Fadwa Eljack (Qatar University)

2:15 PM	2:25 PM	Break
2:25 PM	3:30 PM	Chemical/Chemical Related Infrastructure Resilient Processing
2:25 PM	2:30 PM	Session Chair Introduction - Ignasi Palou-Rivera (RAPID)
2:30 PM	2:50 PM	*Bottom-Up and Top-Down Design of Resilient Supply Chains* **Invited Speaker:** Gonzalo Guillen Gosalbez (ETH Zurich)
2:50 PM	3:10 PM	*Resilience of Processing Systems: Analysis and Synthesis* **Invited Speaker:** Ferenc Friedler (Széchenyi István University)
3:10 PM	3:20 PM	*Integrating Uncertainty Quantification in Reliability, Availability, and Maintainability (RAM) Analysis in the Conceptual Stage of Chemical Process Design* **Ahmad Al-Douri** (Texas A&M University)
3:20 PM	3:30 PM	*Aequor's Treatments Boost Biomass from Renewable Feedstocks (algae, plant material) By up to 40% in Half the Time, Increasing Margins of Biofuels and Coproduct Production.* **Cynthia Burzell** (Aequor Inc)
3:20 PM	3:30 PM	Question and Answer Panel Moderated By: Ignasi Palou-Rivera (RAPID)
3:30 PM	3:40 PM	Closing Statements

Third Enterprise and Infrastructure Resilience Workshop

September 28th, 2021

10:00 AM	10:10 AM	Introduction of Day 2 from the Conference Chairs
10:10 AM	10:40 AM	*Resilience Theory and Thinking Applied to Human-Natural-Engineered Systems* **Keynote Speaker:** Elena Irwin (Distinguished Professor of Food, Agricultural, and Environmental Sciences in Economics & Sustainability, Department of Agricultural, Environmental, and Development Economics; Faculty Director, Sustainability Institute, Ohio State University)
10:40 AM	10:50 AM	Question and Answer Panel Moderated By: Heriberto Cabezas (University of Miskolc)
10:50 AM	11:00 AM	Break
11:00 AM	12:35 PM	Broader Resilience Concepts
11:00 AM	11:05 AM	Session Chair Introduction - Rajib Mukherjee (The University of Texas Permian Basin)
11:05 AM	11:25 AM	*Strategics to Assess Resilience in the Water-Energy-Food Nexus at Different Scales* **Invited Speaker:** Jose Maria Ponce Ortega (Universidad Michoacana de San Nicolás de Hidalgo)
11:25 AM	11:45 AM	*Assessing Economic Resilience of Hydrocarbon Products* **Invited Speaker:** Dhabia Al-Mohanadi (TAMUQ)
11:45 AM	11:55 AM	*Resilience Requires All Disciplines: The Planetary Limits Academic Network (PLAN)* **Benjamin McCall** (University of Dayton)
11:55 AM	12:05 PM	*Deploying Deep Learning to Improve Reliability and Performance of Phase Change Materials (PCM) for Enhancing Reliability, Sustainability and Resilience while Mitigating the Food-Energy-Water (FEW) Nexus* **Aditya Chuttar** (Texas A&M University)
12:05 PM	12:35 PM	Question and Answer Panel Moderated By: Rajib Mukherjee (The University of Texas Permian Basin)
12:35 PM	12:45 PM	Break
12:45 PM	2:50 PM	Environmental, Ecological and Disaster Resilience
12:45 PM	12:50 PM	Session Chair Introduction - Debalina Sengupta (TAMU)
12:50 PM	1:10 PM	*Habitat Restoration and Resilience Along the Gulf Coast: The Nature Conservancy Perspective* **Invited Speaker:** Seth Blitch (The Nature Conservancy)
1:10 PM	1:30 PM	*Resilience and Sustainable Development Strategies in the Sunderbans* **Invited Speaker:** Anamitra Anurag Danda (Observer Research Foundation, Worldwide Wildlife Foundation)
1:30 PM	1:50 PM	*Water and Conflict - When do we choose to fight? And when to walk away?* **Invited Speaker:** Diogo Bolster (Notre Dame University)
1:50 PM	2:00 PM	*Shifting Baselines May Undermine Shoreline Management Efforts in the United States* **Riordan Correll-Brown** (University of Maryland)
2:00 PM	2:10 PM	*A Systematic Resilience Approach in the Assessment of the Water-Energy-Food Nexus Security Regions with Extreme Climate Conditions* **Jesus Manuel Nuñez Lopez** (Universidad Michoacana De San Nicolás De Hidalgo)
2:10 PM	2:20 PM	*Addressing Challenges of Industrial Biosolids Reuse in Qatar to Enhance Agriculture Industry* **Nivinya Hemachandra** (Texas A&M University at Qatar)
2:20 PM	2:50 PM	Question and Answer Panel Moderated By: Debalina Sengupta (TAMU)

2:50 PM	3:00 PM	Break
3:00 PM	4:25 PM	Built Infrastructure
3:00 PM	3:05 PM	Session Chair Introduction - **Jose Maria Ponce Ortega** (Universidad Michoacana de San Nicolás de Hidalgo)
3:05 PM	3:25 PM	*Electricity and Climate Change—Interconnected* **Invited Speaker:** **R. Neal Elliott** (American Council for Energy Efficient Economy)
3:25 PM	3:45 PM	*Sensing our Built Infrastructure systems - and Making Sense of it* **Invited Speaker:** **Vikram Pakrashi** (UCD Centre for Mechanics, Dynamical System and Risk Laboratory, University College Dublin, Ireland UCD Energy Institute, Ireland Science Foundation Ireland Centre for Energy, Climate and Marine (MaREI), Ireland)
3:45 PM	3:55 PM	*Transparency at Scale: Navigating Chemical Disclosure within the Built Environment* **Anthony Brower and Stacey Olson** (Gensler)
3:55 PM	4:25 PM	Question and Answer Panel Moderated By: **Jose Maria Ponce Ortega** (Universidad Michoacana de San Nicolás de Hidalgo)
4:25 PM	4:35 PM	Closing Statements

ABSTRACTS

ABSTRACTS IN ORDER OF SESSION

Keynote Presentations

Next-Generation Resilient Energy and Manufacturing Supply Chains

Elefterios Iakovou
Harvey Hubbell Professor of Industrial Distribution; Director, Manufacturing and Logistics Innovation Initiatives, Texas A&M Engineering Experiment Station; Director of Supply Chain Management, SecureAmerica Institute; Assistant Director, Resilience and Sustainability of Integrated Energy and Manufacturing Supply Chains, Energy Institute, Texas A&M University

Supply chains have recently experienced tremendous stresses due to disruptive weather, supplier disruptions, trade wars and other geopolitical events, and recent flus and pandemics. For example, due to the current Covid-19 pandemic, the world has witnessed dramatic surges in customer demand for some supply chains (groceries, household products, semiconductor chips, etc.), dramatic decreases in customer demand for other supply chains, and not only dramatic surges in the demand of healthcare related products and PPE but also demand that quickly shifts temporally and geographically. Such stresses have revealed the fragility of today's financialized supply chain, resulting in an increased interest in supply chain resilience and agility – the ability to quickly adjust to sudden disruptive changes that can negatively affect supply chain performance and business continuity.

These revelations have motivated the federal government and private firms to reassess the tradeoff of resiliency, agility, competitiveness, and security in their globalized supply chains. Approaches for strengthening the former two, include better use of data-driven supply chain control procedures; diversified sourcing (including reshoring, nearshoring and "ally-shoring"); product and supply chain redesign; building in redundancies (buffer inventories; buffer manufacturing and storage capacities; inventory transshipment; manufacturing and storage relocation). With data monetization, the increasing volume, variety, and velocity of data can be used to increase profitability and competitiveness, while supporting dynamic resilience and reducing risk. Indeed, real-time data can be used throughout all the six stages of the resilience lifecycle to predict, detect, respond to, recover from, learn from, and be used to better understand what intelligent and adaptive adversaries have learned from a disruption lifecycle.

However, building resiliency and agility into supply chains can be costly, reducing a firm's competitiveness and thus putting them at a disadvantage with businesses of adversarial nations that continue to embrace globalization while supporting key industries with extensive mercantilism consisting of aggressive industrial policies, subsidies and currency manipulation. Firm decisions to balance cost versus supply chain resilience and agility are stratified based on the product or service, the relevant risks, and the firm's appetite for risk. Risks beyond those specific to the firm (both chronic and novel risks) are typically left to the public sector and market forces for mitigation. We discuss ways and potential federal government policy interventions within the emerging global geopolitical contextual framework, to ensure that: (i) we engineer the supply chain and not just the balance sheet; (ii) the manufacturing and energy industry base has sufficient surge capacity during disruptions without significantly compromising firm-level global competitiveness and national security; (ii) the next generation of competitive, resilient and secure U.S.manufacturing and energy supply chains can be cultivated.

Resilience Theory and Thinking Applied to Human-Natural-Engineered Systems

Elena Irwin
Distinguished Professor of Food, Agricultural, and Environmental Sciences in Economics & Sustainability, Department of Agricultural, Environmental, and Development Economics;
Faculty Director, Sustainability Institute, Ohio State University

Resilience theory and concepts have evolved from several distinct disciplinary perspectives, including engineering resilience which emphasizes the ability of a system to absorb a shock and "bounce back" and ecological resilience which emphasizes the ability of a system to adapt and transform in the facing of changing conditions while maintaining the well-being of the system. This talk will lay a foundation for thinking about how to apply these concepts to human-natural-engineered systems so that we may better understand, quantify, and assess the ability of our communities and society to recover from shocks and adapt to changing conditions.

Resilient Systems Modeling

Resilient Design of Complex Networked Systems: Importance of Topological Features

Venkat Venkatasubramanian
Center for the Management of Systemic Risk, Department of Chemical Engineering, Columbia University

Complex dynamic networks play a crucial role in many sociotechnical applications such as global supply chains, electric power grids, transportation networks, the Internet, and so on. Typically, the design and architecture of such networks have emphasized their efficient performance and cost minimization more than their robustness and resilience to attacks and failures. However, as the recent failure of the Texas power grid and that of the global supply chain during the pandemic demonstrated, paying attention to robustness and resilience turns out to be important in the long run. Towards that goal, we have developed a conceptual framework that helps us model and analyze efficiency-robustness trade-offs in network design. In this talk, I will present an overview of this conceptual framework and discuss the trade-offs we need to make among efficiency, robustness, and cost for the long-term sustainability of such systems for model network topologies such as star, circle, hub, small-world, scale-free, and von Neumann networks.

Resilient Design and Operations of Process Systems

Fengqi You
Roxanne E. and Michael J. Zak Professor, Cornell University

This presentation introduces a general framework for resilience optimization that incorporates an improved quantitative measure of resilience and a comprehensive set of resilience enhancement strategies for process design and operations in response to disruption events. The proposed framework identifies a set of disruptive events for a given system, and then formulates a multiobjective two-stage adaptive robust mixed-integer fractional programming model to optimize the resilience and economic objectives simultaneously. The model accounts for network configuration, equipment capacities, and capital costs in the first stage, and the number of available processes and operating levels in each time period in the second stage. A tailored solution algorithm is developed to tackle the computational challenge of the resulting multi-level optimization problem. The applicability of the proposed framework is illustrated through applications on a chemical process network and a shale gas processing system.

Data Analytics for Resilient Systems: Variable Selection, Reliability Estimation and Optimization

Rajib Mukherjee
Department of Chemical Engineering, The University of Texas Permian Basin

Resilience of chemical processes or systems is generally evaluated with metrics. When a set of metrics is identified for a particular system of study, it is important to ensure that all of them are necessary and sufficient in defining system resilience. Generally, a large number of metrics are used to characterize a system considering them to be essential. However, they may not be relevant in defining the particular system of interest. It is essential to select the most important metrics from a large set so that reduced set can enhance the generalized performance of the resilience quantification. In this paper, the use of machine learning algorithms for sustainable process selection and relevant metrics identification will be presented.

Often time, the reliability of the system is compromised under uncertain process condition. Data driven modeling and simulation for important variable selection, optimization, reliability estimation, followed by reliability induced optimization will be discussed. Example of ecoindustrial park (EIP) in which a group of industries located in proximity share their products, byproducts, and waste in a symbiotic manner and of natural gas processing plant for sustainable operation will be used to define reliability, essential parameter selection and multi-objective optimization. Application of stochastic approach for characterization, assessment and optimization and its importance will be shown.

Resilience-Based Recovery Scheduling of Transportation Network Considering Connected and Autonomous Vehicles

Qiling Zou[1] and Suren Chen[2]
(1)Department of Civil and Environmental Engineering, Carnegie Mellon University, Pittsburgh, PA,
(2)Department of Civil and Environmental Engineering, Colorado State University, Fort Collins, CO

Enhancing the resilience of transportation networks (TNs) relies on effective post-hazard recovery strategies. However, little attention has been paid to the heterogeneous users' travel behavior in system functionality quantification and the extensive computational burden in metaheuristic solution procedures. A bi-level decision framework is proposed for the resilience-based recovery scheduling of the TN considering the presence of both connected and autonomous vehicles (CAVs) and human-driven vehicles (HDVs). The lower level quantifies the TN's functionality over time considering different travel behavior of CAV and HDV users. The upper level proposes a novel machine-learning-based optimization approach to solve large-scale network restoration problem. This framework can help better quantify the TN's functionality and support effective and efficient recovery scheduling of large-scale TN in different mixed traffic scenarios. A real-world traffic network in Southern California is provided to demonstrate the proposed framework.

ABSTRACTS

Energy, and Fuels Sector Resilience Concepts

Midstream Infrastructure Resilience in the Digital Age

Helen Lou, Thomas J. Kalb, Ravinder Singh
Center for Midstream Management and Science, Lamar University

The midstream industry is responsible for processing, transporting, and storing oil, natural gas, and associated commodities through an integrated system of gas processing plants, Natural Gas Liquids (NGL) fractionation facilities, pipelines, storage facilities, and terminals. The midstream industry's pipeline infrastructure in the US comprises thousands of companies and millions of miles of pipelines. The midstream industry is a crucial enabler of our economic and national security.

It is clear both physical resilience and cybersecurity are needed to ensure the resilience of the midstream infrastructure. This presentation will discuss viable approaches from different aspects. Advanced technologies for maintenance, corrosion management, and leak detection are the key elements to ensure pipeline integrity, the basic building block of physical resilience. The adoption of big data, AI, process simulation, and optimization technologies can help achieve reliable and economically viable operations under different circumstances. The industry needs to identify, protect against, and respond to cyber threats and remediate undesired consequences of these attacks in a timely matter. Workforce training and private-public partnership are critical in this mission.

Deploying Multi-Phase Flows, Machine Learning (ML) and Micro/Nano-Technologies (MNT) for Enhancing Reliability, Sustainability and Resilience for Mitigating the Food-Energy-Water (FEW) Nexus

Debjyoti Banerjee
Professor, J. Mike Walker '66 Department of Mechanical Engineering [MEEN], James J. Cain '51 Faculty Fellow I, College of Engineering [COE], TAMU Professor (Joint Courtesy Appointment), H. Vance Department of Petroleum Engineering [PETE], TAMU Texas A&M University [TAMU] Adjunct Faculty (Courtesy), Department of Medical Education, College of Medicine [COM] Fellow, Engineering Medicine Program [ENMED], TAMU Fellow, American Society of Mechanical Engineers [ASME]

At the Multi-Phase Flows and Heat Transfer Labs. (MPFHTL) we are leveraging bio/micro/nano-technologies for augmenting bio-sensing, cooling, energy storage and safety systems (involving both experimental and computational studies). Several projects in MPFHTL are focused on enhancing the reliability, sustainability and resilience of platforms deployed in the energy sector (ranging from applications in zero-water-usage/ air-cooled power plants, improving building thermal efficiency, microfluidic valves for precision agriculture/ smart-irrigation devices to thermal management of electronics, such as for reducing energy-water usage in data centers). Thus, these activities are geared towards mitigating the food-energy-water (FEW) nexus (some aspects of this work will be presented in the poster session also).

The stress on fresh water resources is increasing progressively due to expanding demand and evolving techno-economic/ socio-political issues (e.g., associated with climate change as well as evolving severity of intensity of weather events such as flooding and hurricanes). Power plants are the largest consumer of fresh water resources in the US. A significant proportion is lost to evaporation losses in the cooling towers with environmental issues arising from thermal-pollution due to hot water discharge to the surrounding eco-systems. To improve the sustainability and resilience of different industrial segments stressing the fresh water resources, thermal energy storage (TES) platforms were designed, fabricated and tested using phase change materials (PCM) to provide supplemental cooling. By deploying these platforms using Machine Learning (ML) the efficacy of dry cooling platforms can be improved (increased efficiency, enhanced reliability, zero water usage, lower cost of power production, etc.). While inorganic PCMs are preferred for these TES platforms due to their low cost, negligible environmental impact and low cost, they suffer from reliability issues (e.g., phase segregation, supercooling, incongruent melting etc. are major impediments for deploying PCM in TES. The issue of supercooling (phenomenon where the PCM solidifies at a significantly lower temperature than its thermodynamic freezing point) can be obviated using the 'cold finger technique' (CFT), where a fraction of PCM is maintained in solid state in contact with the liquid PCM. Supercooling is obviated using CFT – albeit at the expense of energy storage capacity. For CFT to be effective and successful, robust and real-time forecasting capability is necessary, especially to predict the time remaining to reach a particular target melt-fraction (in order to stop the discharge process of the TES while preventing the complete melting of the PCM). In this study, Artificial Neural Networks (ANN) are developed and deployed to predict the time remaining for a mass of PCM to reach a preselected melt fraction. The efficacy of this method is the high accuracy and in the simplicity of the approach since with a bare-bones apparatus of just three temperature sensors deployed strategically throughout the mass of the PCM (or even on the surface of the containment structure) and a simple computer program that performs real-time forecasting, the feasibility was proven that is cost-effective, reliable and sustainable (and can improve the resilience of air-cooled power plants). The algorithm can forecast within one hour (and as much as three hours in advance) before the system reaches the target melt-fraction (e.g., 90% or 95%) with a 5~10-minute prediction accuracy. The technique can be retrofitted on any existing cooling unit in any process industry or power plant (thus improving the resilience and operational reliability while helping reach the sustainability goals of zero net water usage in power plants). The application of this technique for thermal management of electronics is also explored in this study (e.g., for reduction of water usage in data centres while reducing manufacturing costs while improving system resiliency and reliability).

In another research project, the design, fabrication, assembly and testing of thermally actuated microvalve(s) is implemented for developing a precision irrigation system for "smart" agriculture applications. It is currently impossible to control irrigation at the level of a single plant. Even with drip irrigation, in which emitters could conceivably be placed on a plant-by-plant basis, there is no way to control the amount of water emitted according to the needs of individual plants. If such a capability were practically available on farms, the result would be a step change in precision agriculture, and the output of plants in a farm field could be optimized. Hence, at MPFHTL – we are designing, microfabricating (using soft lithography techniques) and testing microfluidic platforms that could be controlled, capillary by capillary, to deliver the needed amount of water to individual plants in a large field. The experimental results demonstrate the feasibility of deploying multiple platforms with individually controllable microfluidic ports from a pressurized tube of water (e.g., from utilities). This can also be deployed in NASA initiatives for precision-agriculture in deep space missions.

Energy Transition and Decarbonization- Production of Biogas from Biowaste (Food waste) with Wood Chips Towards Low-Carbon Environment.

Onyinyechukwu Njoku
Chemical and Petrochemical Engineering, Rivers State University, Port Harcourt, Nigeria

Depleting fossil fuel sources accompanied by continuously growing energy demands lead to increased interest in alternative energy sources. Besides, the uncontrolled generation of large amounts of food wastes has resulted in severe environmental issues. This is a major concern in global climate change. As the world drives toward sustainable development in all sectors, there is a need to adopt scientific methods to address the spiraling global environmental concerns associated with the continued generation of wastes especially in the light of limited availability of final disposal sites. Biogas is one of the excellent renewable sources of energy and it is produced from the Anaerobic Digestion (AD) of organic waste: hence, providing a great solution to both energy demand and waste management. AD involves a series of biological processes in which organic matter is broken down and transformed into biogas. Food wastes have a high biomethane production potential owing to their high organic matter contents. The most important parameters on the biomethane production, including feedstock characteristics (nutrient content, particle size, and inhibitory compounds) and process parameters (process configuration, temperature, Ph, retention rate, organic bounding, hydrogen concentration, moisture content, organic loading rate, and inoculums) are fully discussed. Due to problems related to efficient biogas production, an effective methane fermentation of food waste by mixing wood chips with feedstock to minimize the sludge generation during the process is proposed.

Chemical/Chemical Related Infrastructure Resilient Processing

Bottom-Up and Top-Down Design of Resilient Supply Chains

Gonzalo Guillen Gosalbez
ETH Zurich

Chemical supply chains are key to ensure the global production of goods and services underpinning many industrial sectors. However, extreme events, including weather-related events, have revealed vulnerabilities in global supply networks. Because these events will likely become more frequent and intense due to climate change, supply chains are at risk of disruption, which will have strong economic, societal, and environmental consequences. In this talk, I will first motivate the need to design more resilient supply chains, describing the modeling and optimization tools available to tackle this problem. I will focus on stochastic programming coupled with risk metrics to design resilient supply chains that can cope with extreme events (bottom-up). I will next introduce the planetary boundaries concept, which define a set of ecological thresholds that should never be exceeded to maintain the Earth's resilience. I will then explain how to design supply chains operating within the safe operating space defined by these limits, which will prevent the occurrence of extreme catastrophic events potentially shifting the planet's current state (top-down). I will demonstrate the applicability of these tools in a range of examples related to the design of petrochemical supply chains and supply chains for hydrogen and biomass production.

Resilience of Processing Systems: Analysis and Synthesis

Ferenc Friedler
Research Professor, Széchenyi István University, Győr, Hungary

Several aspects are considered in designing processing systems, these aspects are usually evaluated via assessment of expected events on the basis of cause-effect relations, e.g., the determination of the output of an operating unit by a simulation program under known values of its inputs and parameters. However, such evaluation is not appropriate for determining the resilience, since resilience is based on unexpected events in addition to the expected ones. Consequently, the cause part of the cause-effect relation is not known or not effective. Natural way of circumventing this issue is to enumerate all possible “effects” as the set of possible failures.

In the current work, the general formulation for determining the resilience of a system is embedded into the P-graph based mathematical modelling framework. The enumeration of all possible failures is performed by the P-graph based synthesis algorithm, i.e., resilience analysis is done by a synthesis tool. The proposed algorithm is general, there is no limitation on the structure of the processing system (e.g., on the number of loops, raw materials, and products) and on the types of operating units. Embedding this method into the synthesis algorithm of the P-graph framework, resilient processing systems can directly be synthesized. Since most of the critical infrastructures operate as processing systems, the proposed method can contribute to their analysis and design. Three case studies illustrate the method: a process with a single product, a processing system with multiple products, and a network of industrial plants.

Integrating Uncertainty Quantification in Reliability, Availability, and Maintainability (RAM) Analysis in the Conceptual Stage of Chemical Process Design.

Ahmad F. Al-Douri[1], Vasiliki Kazantzi[2], Nancy Currie-Gregg[3], and Mahmoud El-Halwagi[4]
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Traditional analysis of a proposed process design uses average input values in the performance assessment model, thereby generating single-point estimates. The resulting estimates ignore reliability, availability, and maintainability (RAM) considerations, or assume a fixed value based on prior experience. As a result, a probabilistic view of the impact of equipment unavailability on process profitability is not considered. Recent works have proposed a financial framework for incorporating safety and sustainability considerations in the analysis of proposed designs. Based on this research, we propose a framework to integrate RAM aspects during the conceptual design stage in a probabilistic manner using Monte Carlo simulation. Subsequently, full distribution profiles of key process performance indicators are generated, including system and section availability, annual net profit, and return on investment (ROI). Probabilistic characterization of equipment availability also facilitates the prediction of potential safety and sustainability issues, as more frequent process upsets may result in increased flaring and other potential negative consequences. A modified availability metric, using restoration instead of repair times, is used in this work to incorporate recovery, a key aspect of system resilience. A propane dehydrogenation (PDH) process system is used to demonstrate the application and benefits of the framework. The proposed approach allows designers and decision-makers to comprehensively assess the impacts of equipment RAM characteristics on process availability and economic performance

Aequor's Treatments Boost Biomass from Renewable Feedstocks (algae, plant material) By up to 40% in Half the Time, Increasing Margins of Biofuels and Coproduct Production.

Cynthia Burzell
Executive, Aequor Inc, San Diego, CA

Aequor's unique "green" treatment dropped into algae biomass cultivation systems and plant-based biomass fermenters was validated by DOE and private companies to boost the biomass of common strains of algae and yeast by up to 40% in half the time without the need for antimicrobials or equipment cleaners. This reduces the downtime and operational costs (labor, energy, cleaners, need for genetically modified algae and yeast strains, mechanical equipment upgrades, etc.) and extends the duration of production cycles. Aequor is currently a member of the DOE's DISCOVR Consortium demonstrating methods to improve algae biomass yields in open pond algae cultivation. Algae remains the feedstock that captures more CO2 than any other land-based alternative. Significantly in the yeast fermentation process, Aequor's treatment eliminates the need for antibiotics -- which are widely used and end up in residues sold as animal fee, contributing to the emergence of antimicrobial-resistant bacteria -- the Superbugs.Aequor's innovations are contributing to the profitability of the biofuels industries, which today total $120 billion and are projected to reach $750B in 2025. Today, blending bioethanol with gasoline at the pump is the fastest way to lower CO2 emissions in order to reach UN reduction targets. Bioethanol has been the fastest growing U.S. agricultural export for the past 5 years.

Boosting the profitability of biofuel also increases margins of the growing number of renewable co-products made from the algae biomass and plant residues: food (e.g. the meatless burger), feed, nutraceuticals, plastics, materials, chemicals, pharmaceuticals, etc. -- already a $200B industry.

Broader Resilience Concepts

Strategics to Assess Resilience in the Water-Energy-Food Nexus at Different Scales.

Jose Maria Ponce Ortega
Professor , Universidad Michoacana de San Nicolás de Hidalgo

This work presents a systematic approach to assessing resilience of the water-energy-food nexus in arid/semiarid regions that present low availability of resources. Several case studies at different scales have been analyzed and the results allow identifying attractive solutions. Dr. José María Ponce-Ortega is professor in the University of Michoacan in Mexico, he has published more than 250 papers and 3 books. The research interest of Dr. Ponce-Ortega is in the areas of optimization of chemical processes, sustainable design, energy, mass, water and property integration and supply chain optimization.

Assessing Economic Resilience of Hydrocarbon Products

Dhabia Al-Mohanadi
Assistant Professor, Texas A&M University at Qatar

Sustainability and growth cannot be obtained unless resilience in the face of instabilities is achieved. Qatar, a hydrocarbon exporter, currently dominates 30% of the world's liquefied natural gas (LNG) market, which accounts for the majority of the country's income. However, more LNG producers are entering the market, which can cause a decrease in demand for Qatar's main product. Moreover, global consensus on the need to reduce CO2 footprint and shift to renewable energy sources puts a strain on fossil fuel based economies to reduce emissions. Efficient use of natural resources and product diversification can reduce economic risk. This can be done through the implementation of Modern Portfolio Theory (MPT), which is typically used in financial investments. MPT utilizes historic pricing data of raw materials, products, and energy requirements to assess the plant's profit volatility over a certain time period. This volatility translates to the risk i.e. standard deviation for each plant. Using this method, we were able to predict the most stable products to be produced while maximizing return on investment.

Resilience Requires All Disciplines: The Planetary Limits Academic Network (PLAN)

Benjamin McCall
University of Dayton, Dayton, OH

Humanity's grand challenges – energy and resource depletion, climate change, ecosystem degradation, economic growth and stability, and equity – are not independent problems we can solve, but are aspects of an unprecedented *predicament*. Our current way of life exceeds planetary limits and cannot be sustained. Achieving true resilience will require engaging scholars in every academic discipline to develop an integrative understanding of planetary limits, and appropriate responses. This might involve envisioning and laying the groundwork for scenarios that lie between techno-utopian and apocalyptic.

The Planetary Limits Academic Network is a just-launched transdisciplinary community for scholars who appreciate the interlocking nature of humanity's grand challenges and recognize that modernity is incompatible with planetary limits.

If these principles resonate with you, please join us at planetarylimits.net!

1. Humans are a part of nature, not apart from nature.
2. Non-renewable materials cannot be harvested indefinitely on a finite planet.
3. The ability of Earth's ecosystems to assimilate pollution without consequences is finite.
4. Energy throughput is essential to all human activities, including the economy.
5. Technology is a tool for deploying, not creating energy.
6. Fossil fuel combustion is the primary cause of ongoing global climate change.
7. Exponential growth, whether of physical or economic form, must eventually cease.
8. Today's choices can simultaneously create problems for and deprive resources from future generations.
9. Human behavior is consciously and unconsciously shaped by mental models of culture that, while mutable, impose barriers to change.
10. Apparent success for a few generations during a massive draw-down of finite resources says little about chances for long-term success.

Deploying Deep Learning to Improve Reliability and Performance of Phase Change Materials (PCM) for Enhancing Reliability, Sustainability and Resilience while Mitigating the Food-Energy-Water (FEW) Nexus

Aditya Chuttar, Gangchen Ren, Ashok Thyagarajan, and Debjyoti Banerjee
Texas A&M University, College Station, TX

Existing dry cooling technologies in power plants are limited in their performance and cost effectiveness. Salt hydrate phase change materials (PCMs) can provide supplemental plant cooling in a TES platform. PCMs can absorb excess heat loads in electronics extending operation time, and performance. PCMs need supercooling for solidification. Compromises reliability and performance. "Cold Finger Technique (CFT)" obviates supercooling. Complete melting of PCM to be avoided. Artificial neural network (ANN) to predict time to melt.

Environmental, Ecological and Disaster Resilience

Habitat Restoration and Resilience along the Gulf Coast: The Nature Conservancy Perspective

Seth Blitch
Director of Coastal and Marine Conservation; The Nature Conservancy of Louisiana

For a variety of reasons coastal habitats of the Gulf of Mexico have been seriously diminished over the last century. Habitats like oyster reefs, salt marshes, seagrass beds, and mangrove stands are in need of restoration and recovery, both for their inherent ecological value and the increased resilience that restoration can afford to adjacent human communities and built infrastructure. The Nature Conservancy is active Gulf-wide in conserving and restoring these habitats and, where possible, marrying these "nature-based solutions" with opportunities to increase coastal resilience. This presentation will focus on the role of oyster restoration in estuarine systems and the decision support tools employed in the Conservancy's community engagement efforts along the Gulf coast

Resilience and Sustainable Development Strategies in the Sunderbans

Anamitra Anurag Danda
Observer Research Foundation, Worldwide Wildlife Foundation

This talk explored historic aspects of human resilience in the Ganga Delta regions in the Sunderbans. The author explained recent issues related to climate change, trends, and the path forward for policy towards sustainable development in the region.

Water and Conflict - When do we choose to fight? And when to walk away?

Diogo Bolster
Professor and Henry Massman Department Chair in Civil & Environmental Engineering & Earth Sciences, Associate Director of the Notre Dame Environmental Change Initiative; Notre Dame University

Often it is argued that increased water stress and lack of access to water will increase the likelihood of conflict, but many existing studies to date come to opposing conclusions in this regard when looking at actual data. We here present a hydrologically informed economic model that explains this, in particular highlighting when conflict might emerge and when it is likely not to. In essence, it is because for people to engage in conflict there should be a perceived opportunity cost, which may not always exist.

Shifting Baselines May Undermine Shoreline Management Efforts in the United States

Riordan Correll-Brown[1], Rachel Gittman[2], Emory Wellman[3], Devon Eulie[4], Steven Scyphers[5], Carter Smith[6], and Mariko Polk[7]
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Rising sea levels, extreme weather events, and unsustainable coastal zone development pose threats to coastal communities. Shoreline development and hardening in at-risk areas can damage nearshore ecosystems, exacerbating existing risks to coastal populations. A comprehensive understanding of changes in response to development, storm events, and sea-level rise is needed to effectively mitigate coastal hazards and promote resilient coastlines. Informed mitigation and adaptation decisions require accurate and current coastal data. Lacking such data, coastal communities risk accepting increasingly degraded coastal zones and making poor management decisions based on shifted baselines. To determine whether human modification of shorelines can be accurately quantified over time, we evaluated shoreline classification efforts in the United States. Using these data, we estimated the current extent of US shoreline modification. However, we found that quantifying shoreline modification over time nationally is currently infeasible due to shoreline resolution changes associated with advances in mapping methodologies and a lack of regularly updated shoreline maps. We coupled this analysis with a survey of coastal planners and managers involved with US state shoreline mapping programs, which revealed that 20 US coastal states have undertaken shoreline mapping projects. However, of the 36 projects identified, only 18 had planned updates. Thus, we recommend increasing the scale and funding for several ongoing shoreline mapping efforts focused standardizing mapping techniques and establishing accurate shoreline condition baselines. Without accurate baselines and consistent updates to data, shorelines cannot be managed in a way that effectively mitigates coastal hazards while promoting socio-ecological resilience in a changing climate.

A Systematic Resilience Approach in the Assessment of the Water-Energy-Food Nexus Security Regions with Extreme Climate Conditions

Jesus Manuel Nuñez Lopez[1], Brenda Cansino-Loeza[2], Xate Geraldine Sánchez-Zarco[2], and José María Ponce-Ortega[2]
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At present, satisfying the needs of water, energy and food represents one of the biggest problems worldwide due to its poor distribution and the social and environmental disturbances that affect its productivity, availability, and future security. To face these challenges, the concept of resilience was introduced, which has gained great relevance in the field of process engineering to be able to identify vulnerable areas and support decision-making for the use of alternatives so that functionality of the system is not affected. Our aim with this work is to introduce a systematic methodology to quantify resilience in economic terms, which allows us to identify the most vulnerable scenarios to different disturbances, such as random failures, personnel errors, or natural phenomena, to propose modifications

to the system that allow to cope its interruptions, in this way, a better operation and management of resources can be carried out. Moreover, it is possible to know the operation of the nexus, especially in regions whit extreme climatic conditions where is difficult to satisfy the water, energy, and food needs. The applicability of the proposed systematic methodology has shown that it is possible to identify the most susceptible scenarios, as well as the scenarios where the loss of functionality due to a disturbance is less. Therefore, it is possible to take corrective actions to maintain the security of water, energy, and food in future scenarios.

Addressing Challenges of Industrial Biosolids Reuse in Qatar to Enhance Agriculture Industry

Nivinya Hemachandra[1], Dhabia Al-Mohannadi[2], Debalina Sengupta[3], and Mahmoud El-Halwagi[4]
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Qatar is an extreme arid region with poor soil which makes agriculture activity impossible without heavy energy footprint to produce water and artificial fertilizers. At the same time, Qatar has abundance of natural gas that enables large petrochemical activity. Integration of industrial waste and by-products, such as biosolids, could help reduce emissions and enhance the agriculture sector's resilience by providing an alternative feedstock. Biosolids from industrial cities are currently disposed in landfills due to strict environmental regulations. This work addresses the regulatory limitations that are required to be put in place for the change in the application of the biosolids from land disposal to agricultural purposes. The agricultural focus remains within cash crops that grow in arid and semi-arid regions and the benefits of the usage of biosolids together with the problems associated with its usage are discussed. The paper includes a case study analysis of the composition of biosolids from Shell, Qatar in comparison to the guidelines and limitations from Environmental Protection Agency (EPA) and other countries. Variant treatment methods of bio sludge in general and specific treatment methods of heavy metals if they fail to comply with the regulatory limitations are discussed. The analysis is carried though an optimization model which takes the total cost of treatment, use and industrial crops growth and revenue from biosolids by-products.

Built Infrastructure

Electricity and Climate Change—Interconnected

R. Neal Elliott
American Council for Energy Efficient Economy

Electricity and climate changed are interlinked. Fossil-fuel-based electricity has been a major contributor to climate change, but now prospects of green electricity offer path for addressing climate change going forward by displacing fossil fuel. At the same time climate change is creating resilience challenges for our electric system with extreme weather and fires, creating economic and public health crises. To avoid exacerbating these challenges, we must carefully manage the transition to electricity to not create additional reliability problems and equity burdens on those most vulnerable in society. Balancing all these challenges will require rethinking how, when and where we use electricity

Sensing our Built Infrastructure systems - and Making Sense of it

Vikram Pakrashi
UCD Centre for Mechanics, Dynamical System and Risk Laboratory, University College Dublin, Ireland, UCD Energy Institute, Ireland Science Foundation Ireland Centre for Energy, Climate and Marine (MaREI), Ireland

Resilient offshore renewable energy solutions will lead to safer and more competitive energy for future. However, these solutions also come with challenges over their lifetime and several of them have not been addressed adequately. This talk will focus on two of the strongly emerging sectors in this regard: Offshore Wind Turbines and Tidal Wind Turbines. The talk will feature of particular challenges and needs to understand the soil-structure interaction, uncertainties and demands of such infrastructure over their lifetime and also investigate how data-driven monitoring can be beneficial and under what circumstances. The talk will investigate the possibility of repowering sites, maximizing the use of turbines and also minimizing operations and maintenance components. The work will also focus on some of the standardization needs and pathways in relation to the solutions developed.

Transparency at Scale: Navigating Chemical Disclosure within the Built Environment

Stacey Olsen
Gensler, Newport Beach, CA

This talk explores the various levels of complexities associated with disclosure of chemicals in the built infrastructure.

CODE OF CONDUCT

AIChE's volunteers are the core of the Institute and make all of its programs, conferences and educational efforts possible. These offerings provide excellent opportunities for AIChE members and meeting attendees to gain greater technical expertise, grow their networks, and enhance their careers. AIChE events provide engineers, scientists, and students a platform to present, discuss, publish and exhibit their discoveries and technical advances.

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