IBUILD Symposium 2025 Program

All presentations and posters will be in the Tennessee Rooms in the ORNL Conference Center.

Plenary Presentation Schedule all presentations will be held on 1/16/25

Date and Time	Presenter	Title
Morning (10:55-12:40)	Matthew "R.T." Williams	Energy Distribution and Pricing Strategies for Affordable Multifamily Housing: A Stackelberg Game Approach
Morning (10:55-12:40)	Linda Waters	Building Back Greener: Quantifying residential building decarbonization opportunities following floods
Morning (10:55-12:40)	Obi Nnorom	Extending Transformer Lifetime with Distributed Battery Control
Morning (10:55-12:40)	Jeremy Spitzenberger	Theoretical and Experimental Development of a Vapor-Compression Ejector Heat Pump Water Heater with Ultra-Low GWP Refrigerants
Morning (10:55-12:40)	Dylan Boylan	Scalable Quasi-Liquid Surfaces for Sustainable High-Performance Dehumidification
Early afternoon (1:40-3:45)	Gabriel Flechas	Dynamic Thermal Behavior of Mass Timber: Moisture Sensitivity and Energy Modeling Impact
Early afternoon (1:40-3:45)	Ramón Padín-Monroig	Thermodynamic Evaluation of Iron-Carbon Alloys in High Magnetic Fields for Thermomagnetic Processing
Early afternoon (1:40-3:45)	Lorenzo Castelli	Multi-season passive variable insulation for buildings using magnetic thermal diodes
Early afternoon (1:40-3:45)	Isabel Meléndez	Phase-Change Material Composites for Vat-Photopolymerization 3d Printing
Early afternoon (1:40-3:45)	Kathryn Jones	Sustainable Additively Manufactured Concrete for Building Infrastructure Based on a Life Cycle Framework
Early afternoon (1:40-3:45)	Helen Wexler	Sustainable Biocomposite Materials from Algae and Agricultural Residue
Late afternoon (3:55-5:40)	Ethan Hartley	Evolving Efficiency: Optimizing Building Management in a High-Renewable System with Variable Pricing
Late afternoon (3:55-5:40)	Bernadette Magalindan	Climate-resilient wood roofing for sheltering against rising global temperatures through synergetic radiative cooling and thermal energy storage

Late afternoon (3:55-5:40)	Madeline Morrell	Thermochemical Materials for Energy Storage and Dehumidification
Late afternoon (3:55-5:40)	Erin Blackley	Designing and Evaluating Thermal Energy Storage Devices to Enable Decarbonized Water Heating
Late afternoon (3:55-5:40)	Julia Lien Ho	A Systematic Design Methodology for 5th Generation District Energy Systems with a Focus on Rural Communities
Late afternoon (3:55-5:40)	Sameeraa Soltanian-Zadeh	Indoor Air Quality and Thermal Comfort in Student Dormitories: A Comparative Analysis of Pre- and Post-Retrofit Conditions and the Impact of Occupant Activities
Late afternoon (3:55-5:40)	Hannah Arnow	Annual Energy Production Estimation of Luminescent Solar Concentrators with Asymmetric Light Transmitting Interface
Poster	Denali Ibbotson	Degradation and Recovery of the Efficacy of Strontium Chloride Hexahydrate as a Nucleation Particle for Calcium Chloride Hexahydrate
Poster	Casey Troxler	Advanced Heat Exchangers for Air-to-Phase Change Material Thermal Storage

Plenary Presentations and Abstracts (alphabetical by last name)

Hannah Arnow

Title: Annual Energy Production Estimation of Luminescent Solar Concentrators with Asymmetric Light Transmitting Interface

Abstract: With the implementation of net-zero regulations across the US, the demand for aesthetic and high-performance Building Integrated Photovoltaics (BIPVs) has been steadily increasing. However, integrating solar panels on building sidewalls often results in lower performance when placed vertically as façades. To address this challenge, luminescent solar concentrators (LSCs) have been investigated as an enhancement to standard BIPVs, although they typically suffer from low optical efficiencies due to top surface losses.

This research investigates the use of an Asymmetric Light Transmitting (ALT) interface to enhance photon trapping and improve LSC performance. In this preliminary study, a trapezoidal alumina ALT nanostructured interface was integrated into a planar LSC consisting of four edge-mounted PV cells, a transparent PMMA matrix, and a bottom opaque specular mirror. The objective was to characterize and predict the annual energy output of an ALT interface LSC under direct solar irradiance for Albany, NY, and Phoenix, AZ, using a multi-scale modeling approach. The light transmission and propagation through the ALT interface were analyzed using COMSOL and incorporated into an in-house Monte Carlo ray-tracing code to simulate light behavior. A subsequent in-house energy estimation code took in the optical and spectral characteristics of the ALT LSC to predict the annual energy performance using an open-source PV modeling code called pvlib along with local solar irradiance data. Results show minimal energy production increase during the winter months in both locations for the ALT LSC. Current research is focusing on incorporating phosphor film into the matrix. Optimizing the nanostructure geometry for vertical ALT LSCs could further improve their overall performance.

Erin Blackley

Title: Designing and Evaluating Thermal Energy Storage Devices to Enable Decarbonized Water Heating

Abstract: Water heating comprises about 20% of an average household's energy consumption, and in the US, over half of all households still use gas water heaters. Of currently deployed electric water heaters, the majority use resistive elements rather than heat pump water heaters (HPWHs), which can be 60–70% more energy-efficient. Newer 120-volt HPWHs have the advantage of lower-cost installation and greater flexibility without requiring electrical panel upgrades, thus offering greater opportunities for HPWH deployment in low-income households. However, 120V HPWHs tend to have lower efficiencies and lower capacities than traditional 240V equivalents. Therefore, there is a need to develop a technology that would allow a 40-gal 120V HPWH to perform as a 50-gal HPWH by increasing the effective heat storage capacity of the tank. This can be achieved by introducing thermal energy storage via phase change materials (PCMs), which have a higher energy storage density than water. While PCMs have been studied in water heaters, a significant gap remains regarding effective design and implementation of PCM devices for HPWHs. Therefore, this study will outline the development of design constraints and preliminary PCM configurations that maximize PCM utilization and ensure effective HPWH operation. Current results show that adding PCMs in a variety of configurations both inside and outside of the water tank can provide enough storage capacity to effectively obtain a 50-gal capacity out of a 40-gal HPWH.

Dylan Boylan

Title: Scalable Quasi-Liquid Surfaces for Sustainable High-Performance Dehumidification

Abstract: Due to the growing concern about climate change around the globe, there are major challenges for our future water and energy sustainability. In the building sector, heating, ventilation, and air-conditioning (HVAC) account for anywhere from 40-60% of total energy consumption. Commonly humid air is cooled under the dew point to condense the present water vapor. In HVAC, dehumidification is achieved by various condensation technologies such as vapor compression cycles, thermoelectric cooling, and adsorption/absorption. In both vapor compression cycles and thermoelectric cooling, electrical energy is used to provide a cold surface for condensation, and in adsorption/absorption energy in the form of heat is used to release water that has been condensed. To reduce the energy consumed in cooling buildings, we propose a sustainable high-performance dehumidification that would occur before the air is cooled. Our proposed approach is centered on modifying the water/solid interface for effective condensation heat transfer with rapid nucleation to dehumidify the humid air. Traditional condensers are typically metals with high surface energy that results in filmwise condensation, which is not favorable for condensation. To achieve dropwise condensation, we propose the use of Quasi-Liquid Surfaces (QLS) that are slippery and durable for efficient dehumidification. QLS consists of flexible polymer brushes that are tethered on one end through chemical bonding and free on the other, which results in a liquid-like nature. Such surfaces repel a variety of fluids with minimal droplet adhesion, which can effectively remove condensates and maintain dropwise condensation for dehumidification.

Lorenzo Castelli

Title: Multi-season passive variable insulation for buildings using magnetic thermal diodes

Abstract: Passive variable insulation (PVI) could reduce the energy consumption for heating and cooling of buildings as compared to traditional static insulation, without requiring active control and sensing.

However, existing PVI systems are limited to single-season operation. Here, we demonstrate a PVI thermal circuit consisting of two anti-parallel oscillating thermomagnetic diodes that enables passive heating during a warm winter day and passive cooling during a cold summer night. Centimeter-scale prototype experiments show that the PVI has a narrow $4\ ^{o}C$ temperature regulation band, functions in all gravitational orientations, is durable over >104 oscillation cycles, and has a circuit-level passive thermal switch ratio of 3 in ambient conditions. Thermal modeling over the U.S. climate zones shows that PVI can reduce undesirable building envelope heat flows by up to 47% for base-case parameters, motivating further study of passive variable thermal insulation strategies for the building envelope.

Gabriel Flechas

Title: Dynamic Thermal Behavior of Mass Timber: Moisture Sensitivity and Energy Modeling Impact

Abstract: Mass timber buildings are gaining popularity as a sustainable structure and envelope solution for commercial and multi-family buildings. The mass timber elements of these buildings, such as cross-laminated timber (CLT), retain the timber's absorbent properties giving them unique thermal mass characteristics to store both sensible heat and moisture. The thermal properties of wood are a function of the amount of moisture in it, which makes the thermal properties of mass timber buildings dynamic if its moisture content can change through heat and moisture interactions with the building's interior air. Current examples of mass timber buildings incorporate mass timber in different ways. However, in most cases, almost all mass timber surfaces are exposed (such as the CLT ceilings and shear walls). Understanding the sensitivity of energy modeling to wood's moisture content is critical for accurately predicting the building performance of this emerging building class.

This presentation provides an overview of research into quantifying the sensitivity of building energy models to the moisture content of the timber. The models presented are validated and compared with experimental data. After this, the modified modeling cases explore how varied timber thermal properties affect heat flux through the envelope and, subsequently, whole building heating and cooling demand.

Ethan Hartley

Title: Evolving Efficiency: Optimizing Building Management in a High-Renewable System with Variable Pricing

Abstract: The efficacy and speed of decarbonization efforts will not only be dictated by what we build, but by how well we are able induce behavioral change in end-use consumers. Variable pricing tariffs seek to align the incentives of power suppliers and consumers by setting the price of electricity equal to the marginal cost at the time of consumption (typically on an hourly basis). This work explores the ability of such tariffs to not only shift the quantity but also the time at which energy is being consumed. Utilizing an open-source capacity expansion model, Switch, I develop optimal Real-Time Pricing (RTP) and Time-of-Use (TOU) tariffs and decarbonization trajectories for 26 regions spanning the 48 contiguous states. I further explore the zonal heterogeneity in costs observed in a least-cost high-renewable system and examine the varying incentives for consumers across the country. Characterization of the incentives consumers face, and how these may change across space and time in a high-renewable environment, is critical for efficient investment in capital and consumption strategies for buildings across the country.

Julia Lien Ho

Title: A Systematic Design Methodology for 5th Generation District Energy Systems with a Focus on Rural Communities

Abstract: There is a heavy focus on electrifying heating and cooling systems to meet global decarbonization goals, but it is unclear if individual electrified heating and cooling systems, such as air-to-air heat pumps, is an optimal heating and cooling solution for all applications. Rural areas are an understudied example of this question; rural housing stock tends to be older, larger, and more weather-exposed, which can strain air-to-air heat pump operation and efficiency.

5th generation district energy systems, which leverage heat pumps connected to an ambient temperature water loop, can provide a more efficient and reliable alternative to individual electrified heating and cooling systems. However, to the author's knowledge, no systematic design methodologies evaluating the cost and energy competitiveness of 5G systems against other low-carbon heating and cooling systems by simultaneously considering load patterns, characteristic load imbalances, and load densities have been developed. The lack of systematic design methodologies can increase the risk of choosing suboptimal low-carbon heating and cooling systems.

I will present my current research quantifying how thermal imbalances in geothermal 5G systems affect long-term performance and energy use by modeling a case study in Modelica, a dynamic modeling language. I will also explain how I plan to expand on this work to develop a more systematic, thermal source-agnostic design optimization framework for 5th generation systems that facilitates comparisons of 5G system feasibility against other electrified heating and cooling systems, and how that framework can be applied to rural areas by considering load densities.

Kathryn Jones

Title: Sustainable Additively Manufactured Concrete for Building Infrastructure Based on a Life Cycle Framework

Abstract: Concrete additive manufacturing, also known as 3D concrete printing (3DCP), is an emerging technology with the potential to reshape the construction industry by allowing structures to be built using less materials, time, and transportation than conventional manufacturing methods. However, there is a lack of knowledge concerning the environmental impacts of large-scale 3DCP structures compared to structures made using conventional alternatives. This study provides a life cycle perspective on the environmental feasibility, and paths towards improvement, of large-scale 3DCP structures. This is done firstly by conducting a series of cradle-to-grave life cycle assessments of both conventional and 3DCP ultra-tall wind turbine towers and foundations. From these results, an experimental regimen is conducted to investigate the use of recycled materials as a way to mitigate environmental impacts of 3DCP materials and structures.

Bernadette Magalindan

Title: Climate-resilient wood roofing for sheltering against rising global temperatures through synergetic radiative cooling and thermal energy storage

Abstract: Passive thermoregulation of buildings presents a sustainable means to alleviate the ever-growing and carbon-intensive demand for thermal comfort. Although emerging radiative cooling (RC) technologies effectively enable one-way heat rejection and achieve cooling, they alone cannot fully

satisfy all needs for thermal comfort – namely, the need for warmth in cold weather. In this work, we developed a dual-functional material, composed of microencapsulated phase change materials (mPCM) embedded in delignified wood pulp cellulose fibers (CFs), for energy-efficient thermal management of buildings through RC and thermal energy storage (TES). In warm weather, RC assists the re-crystallization of mPCM; in cold weather, TES serves as a valuable complement to RC by offering passive heating to offset excessive cooling. The dual-functional material exhibits 95% of solar reflection that ascribes the scattering by the CFs and mPCM, whereas the intrinsic emissivity of cellulose produces a strong RC effect. Meanwhile, TES through mPCM achieves a latent heat of 156 J/g with excellent shape stability. This material solves the typical shortcomings of RC and TES through their synergetic performance, demonstrated by outdoor testing and computational modeling. Whole-building simulations show this innovative approach can reduce thermoregulation-associated energy use by 7.2% in hot and dry climates (Phoenix, Arizona). Additionally, fabricating the material from abundant wood waste and cellulose promotes carbon sequestration and offers a promising avenue for the development of sustainable building materials for energy-efficient thermal regulation.

Isabel Meléndez

Title: Phase-Change Material Composites for Vat-Photopolymerization 3d Printing

Abstract: The present research integrates additive manufacturing techniques to develop phase-change material-based composites for thermal energy storage. Photocurable resin combined with microencapsulated phase-change material (MEPCM) enables uniform particle distribution across the composite, making it suitable for vat-photopolymerization techniques like stereolithography, digital light processing, and liquid crystal display. These techniques facilitate the manufacturing of intricate, heat-transfer-enhancing geometries that are unattainable with traditional methods like injection molding or casting. The method minimizes phase-change material leakage, supports rapid prototyping, and achieves high precision. However, the addition of MEPCM alters the resin's rheological properties, affecting print quality and increasing failure rates. This study characterizes composites with varying MEPCM mass fractions, focusing on thermal and rheological properties, including latent heats of fusion, melting and decomposition temperatures, thermal conductivity, viscosity, and thixotropy. To address viscosity issues, a heated 3D printing setup was developed. Elevated temperatures reduced viscosity, improving print resolution, decreasing failures, and shortening manufacturing time. This approach also allowed higher MEPCM concentrations in the composite, enhancing thermal energy storage capacity. The results identified the optimal MEPCM mass fraction for maximizing latent heat thermal energy storage while maintaining suitable rheological properties for vat-photopolymerization. This research demonstrates the potential of combining additive manufacturing with MEPCM-enhanced composites to produce high-performance thermal energy storage components.

Madeline Morrell

Title: Thermochemical Materials for Energy Storage and Dehumidification

Abstract: To meet the energy demand for buildings and decarbonize this sector, thermochemical energy storage materials and technologies that can achieve peak load shifting and shaving to complement intermittent renewables must be developed. The first part of this talk will discuss methodologies for characterizing effective mass transport, thermal transport, and mechanical stability, which are important parameters to consider when designing thermochemical material composites. Mass transport is analyzed

through developing an apparatus for measuring diffusion coefficients using a wet cup technique. Thermal transport is characterized by measuring the energy storage density and thermal conductivity with DSC and MTPS techniques. Ex-situ SEM images can identify material defects over multiple charging/discharging cycles, which is used to identify mechanically stable composites. These techniques enable the characterization of important composite properties, helping to identify which materials are best suited for short-term thermal energy storage and dehumidification applications within buildings.

The second part of this talk will feature a preliminary study where different system-level material regeneration methods are considered for sorption dehumidification applications. Sorption materials are incorporated into a vapor compression cycle where they provide dehumidification in high humidity environments. Different regeneration means, such as solar heating, water heating, and vacuum systems, are evaluated and compared using an energy and cost analysis. This preliminary study identifies approaches to reduce the time required for sorbent regeneration. Overall, these characterization methods and preliminary models provide insight into how thermochemical materials and component-level design can be properly selected to decarbonize sensible and latent thermal loads in buildings.

Obi Nnorom

Title: Extending Transformer Lifetime with Distributed Battery Control

Abstract: Residential electric vehicle charging causes large spikes in electricity demand that risk exceeding neighborhood transformer power limits. Residential battery energy storage systems can reduce these transformer limit violations, but they may not be cost-optimal when operated individually. While aggregating these batteries allows for cost-optimal operation, battery ownership challenges still remain. This paper proposes a model predictive controller using aggregated virtual batteries to reduce electricity costs, extend the lifetime of a transformer in a residential area, and control the batteries in real time. Furthermore, battery virtualization enables hybrid control that allows homeowners to simultaneously control a fraction of their battery while sharing the remaining fraction. A case study with simulated home loads, solar generation, and electric vehicle charging profiles demonstrates that joint optimization reduces consumer bills up to 36% compared to optimizing each battery individually. Both schemes reduce transformer aging by more than 99%. A hybrid optimization that provides owners with autonomy has similar transformer aging reduction but is slightly less cost-effective. These results suggest that controlling shared residential batteries are an effective way to delay transformer upgrades in the face of growing residential electric vehicle charging penetration.

Ramón Padín-Monroig

Title: Thermodynamic Evaluation of Iron-Carbon Alloys in High Magnetic Fields for Thermomagnetic Processing

Abstract: Industrial thermal processing of steel involves using open resistance furnaces that are regarded as a highly inefficient processing method. The development of Thermomagnetic Processing (TMP) allows simultaneous heating and the application of a high magnetic field, resulting in a highly efficient processing method. Early work shows an increase in phase stability in addition to anisotropic diffusion when a magnetic field is applied to the material during heat treatment. By altering phase equilibria and kinetics, the mechanical and microstructural properties of steels can be achieved in a manner previously not possible using traditional methods. This work uses in-field annealing to determine changes in phase

equilibria due to the magnetic field and their resultant microstructures. Computational simulations using CALPHAD will be used to build in-field phase diagrams to facilitate commercial adoption.

Sameeraa Soltanian-Zadeh

Title: Indoor Air Quality and Thermal Comfort in Student Dormitories: A Comparative Analysis of Pre- and Post-Retrofit Conditions and the Impact of Occupant Activities

Abstract: Indoor air quality (IAQ) and thermal conditions are crucial factors in maintaining healthy and comfortable living environments. Poor IAQ and inadequate thermal conditions can lead to respiratory issues and discomfort. While building retrofits primarily focus on reducing energy consumption, it is also important to consider the dynamic relationship between occupancy, activity patterns, and ventilation to maintain acceptable indoor air quality and thermal comfort. In dormitories and other similar residential environments, managing IAQ is challenging due to occupant behavior and diverse range of indoor activities. Unlike prior studies that focused predominantly on mechanical ventilation systems, this research emphasizes the role of occupant behavior in shaping IAQ and thermal comfort. Therefore, this research integrates occupancy data and environmental monitoring to examine how human behavior influences IAQ. The case study focuses on two dormitory buildings in Syracuse, NY, evaluating IAQ and ventilation before and after comprehensive energy retrofits using measured data on temperature, humidity, CO2, PM2.5 and occupant surveys. Results indicated: 1) Occupant interactions with windows significantly influenced ventilation rates in pre-retrofit buildings where no mechanical ventilation is provided. This effect was less pronounced in post-retrofit buildings, as mechanical ventilation systems with energy recovery units were installed. 2) CO_2 concentrations were lower and more stable, while PM2.5 showed faster decay rates in post-retrofit buildings. 3) Indoor temperatures were more stable post-retrofit, with a notable increase in comfort, especially during warm weather. These findings highlight the role of occupant behavior in enhancing retrofit effectiveness and indoor environment quality.

Jeremy Spitzenberger

Title: Theoretical and Experimental Development of a Vapor-Compression Ejector Heat Pump Water Heater with Ultra-Low GWP Refrigerants

Abstract: Ejector-assisted heat pump water heaters provide a more energy-efficient and environmentally friendly alternative to conventional water heating systems by utilizing waste heat and ambient thermal energy to enhance efficiency. While traditionally used in refrigeration, ejectors have recently shown great potential for heat pump applications. In this study, two theoretical models were developed based on conservation equations and isentropic relations to identify the optimal working fluid and ejector geometry, focusing on ultra-low GWP refrigerants. The models aimed to determine the fluid achieving the highest condensing temperatures and the best ejector heat pump COPs. R1233zd(E) was selected as the working fluid based on the theoretical results and was tested experimentally in an ejector heat pump setup. Experiments were conducted with primary fluid temperatures between 95–105 °C, secondary fluid cooling temperatures of 10–20 °C, and condenser cooling inlet temperatures starting at 15 °C and incrementally increased until ejector breakdown occurred. Four primary nozzles with varying area ratios and diverging angles were tested across a range of nozzle exit positions to evaluate the impact of operating conditions and ejector geometry on system performance. The findings will inform the design of an innovative vapor-compression ejector heat pump water heater.

Linda Waters

Title: Building Back Greener: Quantifying residential building decarbonization opportunities following floods

Abstract: Every year, tens of thousands of homes in the United States are rebuilt due to disaster damage. This rebuilding process presents an interesting and unexplored opportunity to transition homes to be more sustainable through energy-efficiency modifications. However, no systems-level analysis has been performed to quantify the potential energy savings and carbon abatement that could stem from green rebuilding following disaster damage.

In this work, we estimate the energy and environmental effects over time (namely projected residential energy demand and carbon abatement) from implementing energy efficiency requirements and incentives during residential building reconstruction after disasters. The approach builds a simulation modeling platform that includes all homes in the study area and their risk of damage. We focus on the risk from flooding. We then model how residential energy demands and carbon emissions change over time under various reconstruction policy scenarios, such as requiring the implementation of heat pumps. Embedded within the simulation is a parcel-level energy consumption model, ResStock, developed by the US DOE and NREL, that reports energy use and carbon emissions of a home given its climatic exposure and structural characteristics. We focus on Harris County, Texas, a region prone to intense flooding and high temperatures that are expected to worsen with climate change. Our findings help to inform and guide future disaster recovery policy, particularly those pertaining to potential energy efficiency incentives and requirements imposed on homes rebuilt after floods, in order to improve the country's long-term adaptation to climate change.

Helen Wexler

Title: Developing Algae-Based Biocomposites: A Sustainable Approach to Carbon Capture and Biodegradable Material Production

Abstract: Algae biocomposites present an economically viable co-product for low-cost, resource-efficient Carbon Dioxide Removal (CDR) process. Carbon-rich algal biomass can be transformed into a variety of sustainable biomaterials, including algae-based bricks, bioplastics, and particleboard. Algal growth naturally sequesters 1.6 to 2 grams of CO_2 per gram of biomass , utilizing solar energy to drive this process, making it a highly energy-efficient alternative to alternative carbon capture technologies. Additionally, incorporating agricultural waste fibers such as almond shells and banana fibers, into algal material aligns with sustainability principles by repurposing these waste materials, preventing them from ending up in landfills.

Unlike many existing bio-derived materials, which are non-biodegradable (e.g., PE, PET, PA) or exhibit limited recyclability, algae-based biocomposites offer a more sustainable alternative. With regulatory frameworks like California's SB 54 mandating the use of biodegradable materials, there is a pressing need for high-performance, fully biodegradable biocomposites with superior mechanical properties. This research aims to develop algae-based biocomposites for hard-shell product packaging, helping consumer goods companies to meet both market demands and regulatory requirements. Future applications could extend to furniture manufacturing and non-structural construction materials, such as insulation, broadening the scope of sustainable material solutions.

Matthew "R.T." Williams

Title: Energy Distribution and Pricing Strategies for Affordable Multifamily Housing: A Stackelberg Game Approach

Abstract: Balancing climate change efforts, affordable housing developments, and efficient energy management presents an ongoing challenge for regions like Utah. Electrification of multifamily housing introduces opportunities to address these intersecting issues, yet it also requires careful consideration of economic and environmental trade-offs.

This presentation introduces a non-cooperative Stackelberg game model designed to optimize energy distribution and pricing for affordable multifamily housing equipped with distributed energy resources (DERs). The model evaluates the impacts of flat-rate and real-time pricing structures on energy costs, emissions, and grid operations, providing a quantitative framework for understanding demand responses within this sector.

Salt Lake City, Utah, is used as a case study to demonstrate the application of the model in a carbon-intensive grid context. The findings offer insights into how energy systems can be optimized for affordability and sustainability, with implications for scaling to regions with diverse energy pricing structures and carbon profiles.

Posters

Denali Ibbotson, Patrick Shamberger

Title: Degradation and Recovery of the Efficacy of Strontium Chloride Hexahydrate as a Nucleation Particle for Calcium Chloride Hexahydrate

Abstract: Salt hydrates are a class of PCMs of interest due to their high energy densities, low cost, and the ability to tailor the TES temperature through the design of salt hydrate eutectics. However, salt hydrates can experience undercooling, a nucleation-limited phenomena that can lead to issues such as incongruent melting and phase segregation, therefore, nucleation particles (NPs) are often added to induce nucleation and suppress the formation of metastable phases. While compounds that are isostructural to the chosen PCM tend to have low interfacial energy with the target phase, resulting in decreased undercooling, these phases may be unstable under some conditions, potentially reacting to form other hydrates, or anhydrous solids, or even dissolving completely. In this study, we investigated the efficacy of strontium chloride hexahydrate ($SrCl_2 \cdot 6H_2O$) as a NP in calcium chloride hexahydrate ($CaCl_2 \cdot 6H_2O$) over a range of temperatures and concentrations. It was observed that $SrCl_2 \cdot 6H_2O$'s effectiveness as a NP depends on the time-temperature history of the system, suggesting that the $SrCl_2 \cdot 6H_2O$ phase is unstable under conditions of high concentration of $CaCl_2 \cdot 6H_2O$ or at Temperatures > $T_{melting}$, resulting in the formation of other hydrate phases. However, it was also observed that cooling below ~ -30°C recovers the efficacy of $SrCl_2 \cdot 6H_2O$, but only if the system is cooled for at least 5 minutes at ~ -30°C before holding at 0°C. Therefore, by allowing the system to solidify completely, we

can regenerate the phase responsible for nucleation of $CaCl_2 \cdot 6H_2O$, which indicates that the reactivity of $SrCl_2 \cdot 6H_2O$ affects its efficacy as a NP.

Casey Troxler

Title: Advanced Heat Exchangers for Air-to-Phase Change Material Thermal Storage

Abstract: There is growing demand for distributed energy storage technologies due to the growth of renewable power sources and increase in extreme weather events that disrupt the power grid. Buildings account for 74% of electricity consumption in the United States, largely for thermal applications such as space conditioning and hot water. Thermal energy storage (TES) has an inherent synergy with these applications, making it an ideal form of energy storage. TES often use phase change materials (PCMs) for latent energy storage; however, these materials often have low thermal conductivity, limiting power density and usability in active applications. Conventional approaches to enhance power density, such as high-thermal conductivity additives or fins, increase cost and weight while reducing PCM mass. This study explores advanced heat exchanger surfaces to improve TES performance by increasing the surface-area-to-volume ratio via additive manufacturing. A triply periodic minimal surface is designed and implemented as a macro-encapsulation for a commercial PCM in an air-to-PCM heat exchanger. Experimental testing measured the device's charge and discharge performance using conditioned air. Thermal round trip storage efficiency was between 95-78% with overall performance being primarily dependent on the inlet temperature difference from the melting temperature. The pumping power required for operation is a primary challenge, which is a low at higher temperature differences (7-40% thermal power) but becomes prohibitively high at low temperature differences (>100% thermal power). The basic design process and experimental results are presented, highlighting the potential for high-surface area designs.