



Building Energy Smart Technologies Research Center

September 2023 Newsletter

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Updates from the BEST Center

Summer Quarterly Report

The August 2023 BEST Center quarterly report was distributed to Industry Advisory Board (IAB) members and faculty on 8/15/2023. Highlights from the prior quarter include:

- Research products from 2022-2023 funded projects include one published peer reviewed manuscript, eight manuscripts planned for submission, five presentations presented at conferences, seven planned conference presentations, and one master's thesis.
- Summaries of 2022-2023 funded projects.
- Fall 2023 career fair information for CU Boulder and CCNY.

IAB members and faculty can access the quarterly report by logging into the [BEST Center website](#) and navigating to the [Governance and Marketing](#) page in the members-only section of the website.

Upcoming IAB Meetings

Planning for the [November 2023 IAB Meeting](#) in New York City is underway. Registration for all attendees, including faculty, students, IAB members, and guests is required and available at [Eventbrite](#). The meeting agenda is available on the BEST Center website. A hotel block is reserved at the Aloft Harlem, and a link for booking rooms in the hotel block will be distributed to faculty, students, and IAB members shortly and is available on the [IAB Meetings](#) page of the members-only section of the website. The last day to book rooms in the hotel block is **11/5/2023**.

Monthly virtual IAB meetings are scheduled for October 16th, and November 20th at 9AM MT. These meetings will focus on reporting final research output from last year's funded projects, kicking off FY 2023-2024 projects, and discussing research ideas in prep for the New York IAB meeting at the end of November. If you have an agenda item or idea for a presentation to be given during these meetings, please contact the BEST Center manager, Nick Clements (nicholas.clements@colorado.edu), the IAB Chair, Sachin Nehete (sachin.nehete@rheem.com), and Vice Chair, Silvia Khurram (khurrams@coned.com).

A calendar of meetings, including meeting agendas and minutes, is available for BEST Center IAB members on the [IAB Meetings](#) page of the members-only section of the website.

New Affiliate, PAE Engineers

In the last month, [PAE Engineers](#) joined the BEST Center as an affiliate. PAE Engineers is an engineering consulting firm offering MEP, lighting, and sustainability design services. The [PAE Living Building](#) is the world's first developer-driven Living Building located in Portland, OR.

Student Highlight: [Madison Likins-White, CU Boulder](#)

1. Tell us about your background and how you got to where you are today.

I am originally from Tulsa, Oklahoma and received my Bachelor of Science in Mechanical Engineering from Oklahoma State University. I decided to pursue a Master of Science in Mechanical Engineering after reading an article about the new HVAC system designed for the Sistine Chapel. My love for art, engineering, and education led me to Texas A&M to do so. I then worked as a design engineer for an HVAC company in Austin, Texas where I obtained my Professional Engineering license. I moved to Denver, Colorado in 2021 to start my PhD so I could further my education and escape the Texas heat.



2. What got you interested in research, and why are you interested in the BEST Center research you are doing?

My interest in research, and more specifically building research, began after reading about the new HVAC system being designed for the Sistine Chapel about 10 years ago. I decided to further my education through research-centric programs so that I could learn more in-depth about building design and how it impacts and is impacted by art. While obtaining my master's degree, I fell into the world of building energy simulation and decided to focus my research on that topic when I realized its importance in climate change mitigation.

3. Where do you see your project going in the future, and/or how will working on this project help you career in academia and/or industry?

I hope that my project can lead to an accessible method to evaluate window thermal performance and improve retrofit analysis for both commercial and residential buildings. I also hope that the simulation of window performance in energy models can be enhanced to better understand energy consumption of buildings over their entire life cycle.

4. What are your career ambitions?

I hope to work in academia to inspire a new generation of young engineers to work in the building energy field and develop a love for research and learning.

5. What is an interesting fact about you?

I started figure skating when I was 24 and I am close to landing an axel now!

In the coming year, Madison will be working on the BEST Center project “Evaluation of Field Methods for Assessment of Architectural Window Degradation” with Prof. John Zhai and Robert Tenent (NREL). Student profiles are linked to on the [People](#) page of the BEST Center website.

Research Highlights

BEST Center Publications

- David Garraway, S M Abdur Rob, Geoffrey Turbeville, Prathap Ramamurty, Jorge E. Gonzalez-Cruz (2023). Development of Electrified Transcritical R744 Heat Pump Systems for Northeastern Winter Markets. *Proceedings of the ASME 2023 17th International Conference on Energy Sustainability*. ES2023-107045. <https://doi.org/10.1115/ES2023-107045>.

The main objective of this work is to develop a commercially feasible R744 HP system for the multi-family building sector for cold climates. The motivation behind this effort is the urgent need to bring into the markets, an efficient, low global warming potential air source heat pump system for cold-climates. It will aid in electrifying space heating, an essential strategy to decarbonize our society. We plan to address the efficiency of space heating for colder climates like the Northeast while being affordable and attractive to customers with existing gas or oil-powered systems. Our strategy aims to focus on optimizing the system using transcritical R744, this primarily means a revamp of various components, particularly the gas cooler. Gas coolers have been a challenge in terms of optimization with lower COPs than that of the more commonly used refrigerants. We have conducted an assessment of the viability of a staggered tubes design which allows for more efficient heat transfer between the R744 and air. This is quite important as the refrigerant operates at a much higher temperature (about 220–250°F) than seen in hydrofluorocarbon systems. Lowering the outlet temperature on the gas cooler side is a major step in providing a suitable design to be used in both residential and commercial buildings.

Other Recent Publications

- Juan P. Montoya-Rincon, Jorge E. Gonzalez-Cruz, Michael P. Jensen (2023). Evaluation of Power Transmission Lines Hardening Scenarios Using a Machine Learning Approach. *ASME J. Risk Uncertainty Part B*, 9(3): 031106. <https://doi.org/10.1115/1.4063012>.
 - Juan P. Montoya-Rincon, Said A. Mejia-Manrique, Shams Azad, Masoud Ghandehari, Eric W. Harmsen, Reza Khanbilvardi, Jorge E. Gonzalez-Cruz (2023). A socio-technical approach for the assessment of critical infrastructure system vulnerability in extreme weather events. *Nature Energy*, 8: 1002-1012. <https://doi.org/10.1038/s41560-023-01315-7>.
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Faculty and Building Industry News

Faculty News

- [Wil Srubar named as nominee for 2023 Pritzker Emerging Environmental Genius Award \(CU Boulder\)](#)

“Associate Professor Wil Srubar has been nominated for the 2023 Pritzker Environmental Genius Award for his research re-imagining sustainable building materials.

Srubar is part of the Department of Civil, Environmental and Architectural Engineering and the Material Science and Engineering Program at CU Boulder. His lab conducts major research into biomimetic and living materials that have the potential to drastically reduce environmental pollution caused by construction activities around the globe.”

- [NREL Windows Research Clearly Making a Difference \(NREL\)](#)

“The NREL team developed the scientific basis and current industry standard for the evaluation of dynamic electrochromic windows. The team is now iterating on that success to expand to other emerging window technologies including high thermal performance technologies, such as vacuum insulating glass, advanced multipane constructions, and photovoltaic technologies.

Recently, NREL has also begun to define enhanced methods for the evaluation of the durability of existing window technologies and is working with partners to help improve current industry practice in this area.”

- [Prometheus Materials reveal sound-absorbing qualities in bio-concrete \(Longmont Leader\)](#)

“Prometheus Materials, a Longmont-based company, that is developing a bio-concrete solution made of algae to combat the environmental impact of traditional concrete, which accounts for approximately 7% of the Earth's CO2 emissions, revealed that its proprietary bio-concrete recently tested to absorb sound 12 times more effectively than traditional concrete.”

- [NREL Researchers Review How Buildings Across United States Do – and Could – Use Energy \(NREL\)](#)

Buildings are responsible for 40% of total energy use in the United States, including 75% of all electricity use and 35% of the nation's carbon emissions. Although today's decarbonization efforts often focus on renewable electricity or electric vehicles, decarbonizing the building stock is also essential.

To facilitate decarbonization of the U.S. building stock, researchers at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) have created a new, meticulously researched data set that details how buildings do—and could—use energy. This data set, called the End-Use Load Profiles, reveals the massive climate impacts that improvements to the U.S. building stock could have.

IAB Member News

- [Xcel Energy proposes adding unprecedented renewable energy and storage to advance Colorado's clean energy goals \(Xcel Energy\)](#)

“Xcel Energy—Colorado today announced a plan that will continue to transform the state's energy mix, meeting customers' energy needs while continuing to lead the clean energy transition and providing affordable, reliable service. The company's Clean Energy Plan proposes to double the amount of renewable energy on the system and invests up to \$15 billion across Colorado, while taking advantage of \$10 billion in Inflation Reduction Act tax credit benefits to reduce costs and support customers, communities, and workers in the state.”

- [Con Edison Breaks Ground on Brooklyn Clean Energy Hub \(Con Edison\)](#)

“A key piece to the region’s clean energy future is rising in Brooklyn’s Vinegar Hill neighborhood on the banks of the East River. Con Edison is building the Brooklyn Clean Energy Hub, a transmission substation that will strengthen New York’s power grid, help meet the region’s growing demand for electricity, and serve as a gateway for offshore wind power. Utilizing renewable energy sources, the hub will serve as a critical plug-in point for future offshore wind infrastructure. The hub will be able to accommodate up to 1,500 megawatts or enough electricity to power 750,000 homes.”

- [New Belimo Retrofit Program Designed to Boost Efficiency \(ACHR News\)](#)

“Belimo, a manufacturer of field devices for the energy-efficient control of HVAC systems, has launched its RetroFIT+ program, designed to help customers maximize building efficiency and contribute to a greener future.

RetroFIT+ is the next iteration of the Belimo retrofit program, which offers online resources, including a product-selection tool, as well as personal support to provide quick and easy access to HVAC replacement solutions for actuators, valves, and sensors, the company said in a press release. The replacement solutions ensure that systems function reliably with the proper control of hydronic loops and air distribution, and they boost the performance and efficiency of building systems, enhance comfort levels, reduce carbon emissions, and can deliver significant energy savings, the company said.”

- [Electric Vehicle Charging Demand Needs: A Comprehensive Approach \(Mead & Hunt\)](#)

“In recent years, electric vehicles (EV) have gained a lot of momentum, with an increasing number of individuals, businesses, and organizations recognizing the benefits of transitioning to more sustainable transportation options. As a result, many facilities are faced with the growing demand for EV charging infrastructure. However, incorporating this infrastructure can be complex and challenging.

One of the foremost challenges facilities face is accurately predicting the amount of charging infrastructure necessary. While fleet operations can often ascertain the direct number of EVs through client/operator discussions, this is not always feasible for other use cases. Many facilities lack precise data on the number of EV users, be it employees or visitors. In such scenarios, a more sophisticated approach is required.

Building Industry News

- [Struggling to design green buildings amid shifting legal, tech landscape \(Harvard Gazette\)](#)

“The push to prepare American cities and towns for greater climate resilience has become more urgent in recent years as scientific evidence of warming mounts and extreme weather events grow more common. Officials in many states, including Massachusetts and New York, are enacting new rules requiring developers and property owners to change or reduce the type or amount of energy used in their buildings, to incorporate certain construction materials and technology while excluding others, and to plan for rising seas and stormwater runoff.

These rules are adding extra costs to projects and sometimes require using relatively unproven technologies. And the rapidly shifting scientific, regulatory, and technological landscapes mean that even the most forward-thinking projects can soon be rendered obsolete, which is what happened with One

Vanderbilt, a skyscraper near Grand Central Station. The project, intended to be an environmental showpiece, faced potential retrofitting of its innovative green heating-power system by the time it opened in 2021 because of newly adopted city climate regulations.”

- [Can America’s canals double as solar farms? \(Canary Media\)](#)

“A coalition of environmental groups is urging the federal government to consider carpeting its canals with solar panels. The concept was pioneered in India a decade ago and will soon be tested in California for the first time. Early research suggests that suspending solar arrays over canals can not only generate electricity in land-constrained areas but may also reduce water evaporation in drought-prone regions.”

- [Device makes hydrogen from sunlight with record efficiency \(Rice University\)](#)

“Rice University engineers can turn sunlight into hydrogen with record-breaking efficiency thanks to a device that combines next-generation halide perovskite semiconductors with electrocatalysts in a single, durable, cost-effective and scalable device.

The new technology is a significant step forward for clean energy and could serve as a platform for a wide range of chemical reactions that use solar-harvested electricity to convert feedstocks into fuels.”

- [G.M. Will Add Backup Power Function to Its Electric Vehicles \(New York Times\)](#)

“As extreme weather events lead to more power outages, the carmaker said it would equip all its electric vehicles to act as sources of emergency power.”

- [Colorado establishes new standards for large buildings to use less energy, reduce costs for owners and tenants \(CDPHE\)](#)

“Colorado’s Air Quality Control Commission established new energy performance standards for large buildings. Buildings are one of Colorado’s top five sources of greenhouse gas emissions that cause climate change. The new rule provides flexible options for owners of large buildings to meet standards to decrease energy use and reduce greenhouse gas pollution. The state anticipates these building performance standards will reduce energy bills for tenants and long-term operating costs for building owners.”

- [Will Record Heat Push Cities Toward Climate Resilience Tech? \(Government Technology\)](#)

“This summer’s sizzling air in the U.S. — part of an extraordinary global heat wave — has put the spotlight on climate resilience technologies, all those tools meant to protect residents from the immediate pains of unhealthy temperatures and related punishments from Mother Nature.

Optimism grew this summer, at least among those working in climate resilience technology, that the heat and the media coverage of it would lead to more spending in this particular part of the government technology space. Even so, they maintain serious concerns that the money meant for climate resilience won’t find its mark, or that the best tools won’t gain enough funding.”

- [Study finds heat pumps more efficient than gas or oil \(TechXplore\)](#)

“A study by Oxford University researchers has found that despite widespread questions about its efficiency, an alternative—heat pumps—in fact operate more efficiently and with lower pollution than gas and fuel systems.

In a paper published in Joule, researchers say studies conducted in several countries confirm heat pump efficiency “is significantly higher than fossil fuel and electric resistive heating systems.”

- [AI pilot programs look to reduce energy use and emissions on MIT campus \(MIT News\)](#)

“Smart thermostats have changed the way many people heat and cool their homes by using machine learning to respond to occupancy patterns and preferences, resulting in a lower energy draw. This technology — which can collect and synthesize data — generally focuses on single-dwelling use, but what if this type of artificial intelligence could dynamically manage the heating and cooling of an entire campus? That’s the idea behind a cross-departmental effort working to reduce campus energy use through AI building controls that respond in real-time to internal and external factors.”

- [AI control tech to improve coefficient of performance of air source heat pumps \(pv magazine\)](#)

“Scientists from the Pusan National University in South Korea have developed an artificial neural network (ANN)-based optimum control logic (OCL) system for optimizing performance and operation of air source heat pumps (ASHPs). The proposed technology offers the advantage of bypassing the need to control the compressor of the heat pump.

In the paper “Performance improvement of air-source heat pump via optimum control based on artificial neural network,” published in Energy Reports, the Korean group explained that the OCL system is able to identify the parameters that increase the system performance, without changing the main components of the system, which in turn reduces system costs.”

- [Developing City Action Plans for Building Decarbonization \(TheCityFix\)](#)

“City officials tasked with reducing and eliminating greenhouse gas emissions from their communities face a tricky task in estimating building emissions as they work to prevent the most harmful impacts of climate change. The biggest challenge is that there isn’t consensus on an internationally accepted definition of Net Zero-Energy Buildings (NZEBS) and Zero-Carbon Buildings (ZCBs), as they are defined variously across geographies and government agencies. Complicating matters more, these definitions are updated from time to time by the International Energy Agency. At present, there is a worrisome potential that interchangeable use and unclear interpretations will result in different objectives, policy directions and outcomes for building decarbonization.”

Upcoming Conferences & Meetings

- [Transition AI: New York](#), New York, NY, Oct 19, 2023

“Transition-AI is the leading B2B event for energy practitioners and artificial intelligence experts. The conference series brings together business leaders across the energy sector who are building AI teams, integrating AI into new products, and using AI to streamline operations.

Building off its inaugural Transition-AI: Boston event, Post Script Media is reconvening experts to discuss the role of autonomous technologies in the energy transition. The New York event will explore utility and industrial use cases, the role AI can play in furthering renewable project development and asset management, its impact on DER integration and marketplaces, and other emerging applications that will shape and optimize our electricity system.”

BEST Center faculty **Prof. Kyri Baker** will be speaking at this event.

- [2023 Decarbonization Conference for the Built Environment](#), Washington DC, Oct 25-27, 2023

“The conference will focus on educating attendees on methods to decrease carbon emissions, both embodied and operational, in order to reduce the impact of buildings on the climate crises. The conference program will address current and future governmental policies and regulations for which

engineers, architects, owners and operators need to be aware of to address environmentally-responsible building requirements.”

- [10th ACM International Conference on Systems for Energy Efficient Buildings, Cities, and Transportation \(BuildSys '23\)](#), Istanbul, Turkey, Nov 15-16, 2023

“Advances in the effective integration of networked sensors, building controls, and physical infrastructure are transforming our society, allowing the formation of unprecedented built environments and interlocking physical, social, cyber challenges. Moreover, built environments, including buildings and critical urban infrastructure, account for over half of society's energy consumption and are the mainstay of our nation's economy, security and health. As a result, there is a broad recognition that systems optimizing explicitly for the built environment are particularly important in improving our society, and represent the foundation for emerging "smart cities”.

[RLEM Workshop 2023](#) will be held in conjunction with ACM BuildSys'23.

- [ASHRAE 2024 Winter Conference](#), Chicago, IL, Jan 20-24, 2024

Nick Clements will be attending both technical committee meetings and the AHR Expo for networking with prospective IAB members.

- [2024 ASHRAE International Conference on Building Decarbonization](#), Madrid, Spain, Apr 17-19, 2024

“This 3rd ASHRAE topical conference provides a unique opportunity for professionals to share information, exchange ideas and collaborate on the design, construction, ownership and operation of facilities that have a minimal or neutral impact on the environment in terms of carbon footprint. Our primary objective is to enrich the knowledge base while fostering global collaborations in decarbonization efforts, ultimately leading to a sustainable future for our planet. Join us at this groundbreaking event and be a part of the solution towards a greener, more sustainable built environment.”

- [IBPSA-USA SimBuild 2024](#), Denver, CO, May 21-23, 2024

“SimBuild 2024 marks the 20th anniversary of the first SimBuild conference, held in 2004. The theme of the conference is “Celebrating Two Decades of SimBuild.” Join us as we commemorate IBPSA-USA's contributions to sustainability and building performance simulation and look toward the future. The program will highlight the work of IBPSA-USA and its members and provide a platform to envision the future of simulation, as we explore emerging technologies, trends, and strategies that will continue to drive building performance excellence in the years ahead.”

- [2024 ASHRAE Annual Conference](#), Indianapolis, IN, June 22-26, 2024

“Legislative initiatives, electrification, artificial intelligence and other technological and social forces are impacting ASHARE members across all aspects the built environment,” said technical conference chair Brian Fronk. “The program tracks for the 2024 ASHRAE Annual Conference in Indianapolis seek to explore the challenges and opportunities in responding to these changes, while continuing to focus on core HVAC&R fundamentals, equipment and research and development.”

Important Dates: 11/22/2023: Abstracts and technical papers due, 3/15/2023: Final conference papers due

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