



# ASHRAE VIRTUAL WINTER CONFERENCE

▶▶▶ February 9-11, 2021

## 2021 ASHRAE Virtual Winter Conference

February 9th - February 11th, 2021

**Tuesday, February 9**

Tuesday, February 9, 10:30 AM - 11:30 AM

**Seminar 1 (Intermediate)**

### **What's in your Toolkit? Laboratory Efficiency for Cutting Edge Labs (LIVE)**

*Track: Energy Conservation*

**Sponsor: 9.10 Laboratory Systems**

*Chair: Jason Atkisson, P.E., Member, Affiliated Engineers, Inc., Madison, WI*

Cutting-edge research often hosts hazards that must be contained effectively to maintain a safe work environment for researchers. As a result, laboratories are complex buildings that can be challenging and costly to operate correctly, typically consuming up to ten times more energy than similar-sized commercial buildings. To guide stakeholders in research facilities to enhance energy efficiency and safety of indoor environments in new or existing laboratories, the Smart Labs Toolkit, the application of risk-based ventilation and an example program with best practices is presented.

**1. Smart Labs Toolkit: A Guide to Enable Labs of the Future**

*Rachel Romero, P.E., Member, National Renewable Energy Laboratory, Golden, CO*

**2. How Occupant Demand for Ventilation Drives Safety and Efficiency in Smart Labs**

*Thomas Smith, Member, 3Flow, Cary, NC*

**3. Argonne's Journey to Smart Labs: Integrating Safety, Sustainability and Operations**

*Catherine Hurley, P.E., Argonne National Laboratory, Lemont, IL*

Tuesday, February 9, 12:00 PM - 1:20 PM

**Seminar 2 (Intermediate)**

### **Air Cleaning for the Indoor Air Quality Procedure (LIVE)**

*Track: Standards, Guidelines and Codes*

**Sponsor: SSPC 62.1**

*Chair: Michael Sherber, P.E., Member, Plasma Air International, Inc., Stamford, CT*

Four separate air cleaning technologies are discussed as ways to comply with the Indoor Air Quality Procedure of Standard 62.1-2019.

**1. Air Filtration Applications for Std. 62.1 Indoor Air Quality Procedure**

*Charles Seyffer, Life Member, retired, Troy, NY*

**2. UVC Applications for Air Cleaning**

*Ashish Mathur, Ph.D., Member, UVDI, Valencia, CA*

**3. Application of Air Cleaners in Std. 62.1-2019**

*Joe Pessa, Associate Member, Dynamic Air Quality Solutions, Princeton, NJ*

#### **4. Controlling Outdoor and Indoor Chemical Contaminants Using Adsorbents and Chemisorbents**

*Chris Muller, Member, Muller Consulting, Lawrenceville, GA*

12:00 PM - 1:20 PM

#### **Seminar 3 (Intermediate)**

### **Lessons from Managing Infrastructure through the COVID Shutdown (LIVE)**

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 7.3 Operation and Maintenance Management**

*Chair: Matthew Mullen, P.E., Member, EMCOR Services New England Mechanical, South Windsor, CT*

COVID-19 changed campus infrastructure management completely... or did it? In this session, campus infrastructure managers share their experiences with the shutdown and reopening at their campuses. Topics will include: Team management for remote work; designating essential workers and maintenance tasks; system turn-back; increased patrols in empty buildings; reliance on Building Automation; technical aspects and retrofits; accommodations for reopening; and yes, watering potted plants.

#### **1. Managing the COVID Campus: Stories from the Empty Halls**

*Orvil Dillenbeck, P.Eng., Member, Canadian Nuclear Laboratories, Chalk River, ON, Canada*

#### **2. Do's and Don'ts of Reopening**

*Aaron Sorrell, Member, General Services Administration (GSA), Boston, MA*

#### **3. Large University Campus Faces Difficult Decisions**

*David Norvell, P.E., BCxP, Member, University of Central Florida, Orlando, FL*

12:00 PM - 1:20 PM

#### **Seminar 4 (Intermediate)**

### **Limiting Humidity to Reduce Building Dampness Health Risks (LIVE)**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: SSPC 62.1**

*Chair: Elliott Horner, Ph.D., Member, UL Environment, Marietta, GA*

ASHRAE's 2019-2024 Strategic Plan extends 80% occupant satisfaction to include a healthy built environment. Excessive indoor moisture has long caused structural and material damage, and increased occupant health risks. In ASHRAE Standard 62.1:2019 (Ventilation for Acceptable IAQ) the humidity limit is a maximum dew point temperature of 15°C (60°F) rather than 65% RH (without reference to any dry bulb temperature). This requires mechanically cooled spaces to have dehumidification components/controls that limit humidity (occupied and unoccupied hours) when outdoor dew point exceeds 60°F (15°C). This impacts systems design and operation to preserve IAQ and prevent damage to building materials.

#### **1. The Health Argument for Sufficient Management of Moisture in Buildings**

*Carl Grimes, HHS, CIEC, Hayward Healthy Home, Monterey, CA*

#### **2. Why the Maximum Humidity Limit Changed from Relative to Absolute (60°F Dew Point) in Std 62.1-2019**

*Lew Harriman, Fellow ASHRAE, Mason-Grant Consulting, Portsmouth, NH*

#### **3. Design Requirements and System Changes to Deal with the Shift to Dew Point**

*Brian Hafendorfer, P.E., Member, Gray Architects & Engineers, P.S.C., Lexington, KY*

12:00 PM - 1:20 PM

**Seminar 5 (Basic)**

**Refrigeration System Design Considerations (LIVE)**

*Track: Refrigeration and Refrigerants*

**Sponsor: 10.1 Custom Engineered Refrigeration Systems**

*Chair: Tom Wolgamot, P.E., Member, DC Engineering, Missoula, MT*

This seminar covers relevant topics for the engineer new to the Refrigeration Industry. It starts with a session describing lessons learned from a design and safety perspective. The second session progresses and provides insights into the various valve types utilized in a refrigeration system and their purposes. The final session provides guidance on the selection of valves used within Transcritical CO2 systems.

**1. Lessons Learned from Refrigeration System Failures**

*Greg Scrivener, Member, Cold Dynamics, Meadow Lake, SK, Canada*

**2. Transcritical CO2 Booster System Operation and Valve Selections**

*Jeff Newel, Hill Phoenix, Conyers, GA*

Tuesday, February 9, 1:30 PM - 2:30 PM

**Seminar 6 (Basic)**

**Fighting the Unseen Killers: Gas-Phase Air Cleaners (LIVE)**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment**

*Chair: Kyung-Ju Choi, Ph.D., Member, Clean & Science, Louisville, KY*

Gaseous contaminants such as formaldehyde, radon, odor, COx, NOx, SOx, O3, VOCs, SVOCs damage the environment and human health. Filtration has a critical role in mitigating such damage. This seminar explains how gas-phase air cleaners work in filtering harmful contaminants.

**1. How Do I Get Rid of All That Stuff in My Air?**

*Matt Middlebrooks, Member, Filtration Group, York, SC*

**2. What's in My Air? Can My Air Cleaner Help Me?**

*Kathleen Owen, Fellow ASHRAE, Owen Air Filtration Consulting, Cary, NC*

**3. What Is in My Gas Phase Filter and Why?**

*Paula Lefasseur, Life Member, LMF Services, LLC, Vancouver, WA*

Tuesday, February 9, 3:00 PM - 4:20 PM

**Seminar 7 (Basic)**

**Building the Next Generation in Building Science: The Solar Decathlon Competition (LIVE)**

*Track: Energy Conservation*

**Sponsor: YEA and Student Activities**

*Chair: Jonathan Smith, Member, Siemens, Kansas City, MO*

The U.S. Department of Energy Solar Decathlon is a collegiate competition that challenges student teams to design high performance buildings that push the boundaries of the industry. Over 20 years, the program and the competitors have learned to execute on teaching building science to students with teams showing their progress. Split into Design Challenge and Build Challenge, the competition values innovative approaches for scaled adoption of high performance design, energy efficiency, energy production and grid integration, as well as overall functionality and appeal. Attendees will learn best practices and also how to create successful teams to meet challenging, realistic goals.

**1. Changing the Industry through Team Development in the Competition**

*Rachel Romero, P.E., Member, National Renewable Energy Laboratory, Golden, CO*

**2. Better Buildings through Better Training and Education**

*Paul Torcellini, Ph.D., P.E., Fellow ASHRAE, National Renewable Energy Laboratory, Golden, CO*

**3. Integrated Design Strategies for High-Performance Zero Energy Buildings: Case Studies of Student Projects**

*Edoarda Corradi Dell'Acqua, Illinois Institute of Technology, Chicago, IL*

3:00 PM - 4:20 PM

### Seminar 8 (Intermediate)

## Lubricant Properties and Their Lubrication in Compressors with Low GWP Refrigerants (LIVE)

*Track: Refrigeration and Refrigerants*

**Sponsor: 3.4 Lubrication**

*Chair: Kristin Sullivan, P.E., Member, Trane Technologies, La Crosse, WI*

In recent years, identification of low GWP refrigerants has intensified due to environmental concerns. The refrigerant transitions involve technical challenges related to lubricant selection. Deploying a new refrigerant into an existing system requires close scrutiny due to several interconnected parameters. Those parameters include system chemistry and properties related to the wear between moving surfaces, which directly relate to the reliability and durability of compressor systems. This seminar covers the history of refrigerants and lubricants, a review of the process for matching refrigerants and lubricants, and a case study on wear performance of R410A alternatives in a compressor system.

### 1. The Lubricant and Low GWP Refrigerant Match Game

*Joe Karnaz, DSc, Member, Shrieve Chemical, Houston, TX*

### 2. Influence of Refrigerant/Lubricant on Compressor's Wear Performance

*Wasim Akram, Ph.D., Associate Member, Trane Technologies, Minneapolis, MN*

3:00 PM - 4:20 PM

### Seminar 9 (Intermediate)

## Mass Transit Ventilation and Infectious Diseases: Transmission and Countermeasures (LIVE)

*Track: Environmental Health Through IEQ*

**Sponsor: 9.3 Transportation Air Conditioning**

*Chair: Gursaran Mathur, Marelli North America, Farmington Hills, MI*

Vehicles instrument panel surface can become contaminated by the front occupants by breathing, talking and coughing. Air conditioning vent outlet airflow will pull air from the panel surface mixing it with potential contaminated air and deliver towards the occupants. Hence, it is necessary to ensure we have virus mitigating strategies to effectively remove viruses from the cabin from automobiles. This seminar consists of technical presentations outlining how the viruses spread in automotive and aircraft cabins using CFD analysis, experimental studies with new hardware designs to eliminate viruses from the automotive cabin; ASHRAE guidelines to address Covid-19.

### 1. COVID-19 Transmission Risk Reduction through Social Distanced Seating in Aircraft Cabins

*James Bennett, Ph.D., Member, CDC/NIOSH, Cincinnati, OH*

### 2. Recommendations to Minimize the Risk of COVID-19 Spread in Marine Applications

*Augusto SanCristobal, Member, Bronswerk Group, Montreal, QC, Canada*

### 3. Elimination of Viruses from Automobile Cabins

*Gursaran Mathur, Marelli North America, Farmington Hills, MI*

### 4. ASHRAE's COVID-19 Guidance Document for Mass Transit

*Donald LeBlanc, National Research Council of Canada, Ottawa, ON, Canada*

3:00 PM - 4:20 PM

### Workshop 1 (Intermediate)

## Science and Technology for the Built Environment: Publishing and Reviewing

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: PEC**

*Chair: Jeffrey Spitler, Ph.D., P.E., Fellow ASHRAE, Oklahoma State University, Stillwater, OK*

Science and Technology for the Built Environment is ASHRAE's peer-reviewed archival research journal. The Editor-in-Chief will discuss the characteristics of papers sought by the journal, common reasons for rejection, the review process, the journal impact factor and other recent developments.

Tuesday, February 9, 4:30 PM - 5:30 PM

**Forum 1 (Intermediate)**

**Advanced Energy Design Guides: Zero Energy and Beyond, What is Next? (LIVE)**

*Track: Energy Conservation*

**Sponsor: 7.6 Building Energy Performance, Advanced Energy Design Guides Steering Committee**

*Chair: Thomas Phoenix, P.E., Presidential Fellow ASHRAE, CPL Architects & Engineers, PC, Greensboro, NC*

The AEDG Steering Committee is looking for input on the current series of zero energy design guides as well as input on what sort of guides the Steering Committee should produce in the future. Possible future topics could include: grid integrated buildings, applying zero energy to existing buildings, building types not currently covered in existing 50% and zero energy series. Representatives from the Steering Committee's four partnering organizations (AIA, ASHRAE, IES, and USGBC) welcome feedback on what efforts would provide the most benefit to moving the industry and buildings towards a more sustainable future.

4:30 PM - 5:30 PM

**Forum 2**

**Feedback from the Public on Current Decarbonization Pathways (LIVE)**

*Track: Energy Conservation*

**Sponsor: 6.10 Fuels and Combustion, 1821**

*Chair: Thomas Neill, Member, Mestek Inc, Southampton, MA*

The objective of this forum is to solicit ASHRAE community feedback and to facilitate open discussion regarding decarbonization and greenhouse gas (GHG) emission reduction pathways for the built environment. The discussion is focused on, but not limited to, building energy efficiency, on-site and off-site renewable energy generation and electric and thermal energy storage, electrification, GHG-neutral energy consumption, the role of renewable fuels, building occupant comfort, policy targets for reductions in greenhouse emissions, theoretical vs applied concepts and costs.

Tuesday, February 9, 6:00 PM - 7:50 PM

**Seminar 10 (Intermediate)**

**Standardizing High Performance: Guideline 36 and Beyond (LIVE)**

*Track: Standards, Guidelines and Codes*

**Sponsor: 1.4 Control Theory and Application**

*Chair: Chariti Young, Member, Automated Logic Corp., Kennesaw, GA*

What if it were possible for every new or retrofitted building to exit the construction process performing optimally? What if installing a building automation system were synonymous with achieving high performance? Guideline 36 is a step in that direction, but early implementation has highlighted some challenges in achieving the vision of high performance for all. In this program, the speakers will discuss some of these challenges, as well as additional work underway to streamline the process of designing, evaluating, implementing, testing, and deploying high performance sequences of operation on the journey to make high performance accessible to every project everywhere.

**1. Guideline 36: The Journey to Success!**

*Hwakong Cheng, P.E., Member, Taylor Engineering LLP, Tacoma, WA*

**2. How Speaking the Same (Computer-Interpretable) Language Helps**

*Michael Wetter, Ph.D., Member, Lawrence Berkeley Lab, Berkeley, CA*

**3. A Standard for That: ASHRAE 231P – Control Description Language**

*Paul Ehrlich, P.E., Member, Building Intelligence Group, Portland, OR*

**4. Better Together: Co-Design for the Win!**

*Veronica Adetola, PNNL, Richland, WA*

6:00 PM - 7:50 PM

**Seminar 11 (Intermediate)**

**Techno-Economic Comparison of Energy Storage Technologies (LIVE)**

*Track: Systems and Equipment*

**Sponsor: 6.9 Thermal Storage, 7.5 Smart Building Systems**

*Chair: Kyle Gluesenkamp, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

Energy storage can improve building resilience and efficiency, reduce energy costs, and reduce grid infrastructure expenditures. In this seminar, we present findings from ongoing research into the performance and affordability of various energy storage strategies. We compare and contrast the technical and economic benefits of several thermal energy storage strategies with electrochemical energy storage technologies (batteries). We provide guidance on design strategies for buildings and systems that incorporate energy storage, present annual simulation results, highlight unique benefits of competing technologies, provide insight into the future trajectory of costs and capabilities, and offer a framework for future research and innovation.

**1. Opportunity for Thermal Storage to Provide Grid Flexibility Today and in the Future**

*Chuck Booten, Ph.D., Associate Member, National Renewable Energy Laboratory, Golden, CO*

**2. Comparing the Economic Performance of Ice Storage and Batteries for Buildings with on-Site PV**

*Jim Braun, Ph.D., P.E., Fellow Life Member, Purdue University, West Lafayette, IN*

**3. Novel Residential Heating and Cooling System Design Using Thermal Storage to Reduce Home Owners Operating Cost Using Time-of-Day Rates**

*Mike Kazmierczak, Ph.D., Member, University of Cincinnati, Cincinnati, OH*

**4. Phase Change Materials and Batteries for Energy Storage in Small HVAC Systems: Design Considerations and Life Cycle Cost Comparisons**

*Jonathan Woolley, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA*

## Wednesday, February 10

Wednesday, February 10, 7:00 AM - 8:50 AM

### Seminar 12 (Intermediate)

#### Thermal Storage for Grid-Friendly Refrigeration (LIVE)

*Track: Refrigeration and Refrigerants*

**Sponsor: 6.9 Thermal Storage**

*Chair: Scott Hackel, P.E., Member, Slipstream, Madison, WI*

Refrigeration systems not only use a tremendous amount of energy, but can also be a significant stress on the grid as they tend to be operating near full-load at peak times. Thermal storage, which has been a well-proven approach to shifting load in HVAC systems, can also be applied to refrigeration systems to provide cost-effective grid services like demand response, load shifting, and load shaping. There are a few different technologies and methods for refrigeration thermal storage. This seminar will cover practices for each based on some of the latest research in the industry.

**1. Options for Thermal Energy Storage in Refrigeration**

*Greg Marsicek Jr., P.E., Associate Member, Slipstream, Madison, WI*

**2. Minimizing Energy Cost in Refrigerated Warehouses with Storage: An Owner's Story**

*Wolf Alex, Lineage Logistics, San Francisco, CA*

**3. Field Testing of Commercial Refrigeration Cases for Demand Response**

*Michael Deru, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO, USA, Golden, CO*

**4. Using Phase Change Material to Add Efficiency, Flexibility, and Resiliency to Refrigeration Systems**

*Brad North, P.E., Viking Cold, Houston, TX*

7:00 AM - 8:50 AM

### Seminar 13 (Intermediate)

#### What Have You Done for Me Lately? BAS Best Practices for O&M Success (LIVE)

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 1.4 Control Theory and Application**

*Chair: Charlotte Dean, P.E., Affiliate, P2S Inc., Long Beach, CA*

What is the role of Operations and Maintenance in the design, specification and delivery of a building automation system project? The speakers will share examples of how to incorporate O&M staff and operational considerations into the design, specification and successful implementation of a BAS project from the perspective of a building owner, system integrator, specifier/consultant and controls vendor.

**1. Where the Rubber Meets the Road: An Owner's Perspective**

*Paul Valente, Chicago Public Schools, Chicago, IL*

**2. Using Data to Drive Action: A System Integrator's Perspective**

*Scott Donovan, Automated Logic, Kennesaw, GA*

**3. Reserve Your Seat at the Table!: A Guide to Operations and Maintenance's Role in the Design, Specification, and Delivery of Your Building Automation System.**

*Ron Bernstein, Member, RBCG Consulting, San Diego, CA*

**4. How a Cloud Connected Building Ensures Operational Excellence and Occupant Satisfaction**

*Joel Desire, Distech Controls, Montreal, QC, Canada*

Wednesday, February 10, 10:00 AM - 10:30 AM

**Keynote (Basic)**

**Women in ASHRAE Keynote: Buildings are Our Best Medicine**

*Chair: Stephanie Taylor, M.D., Member, Building 4 Health, Inc., Stowe, VT*

We are living with tremendous uncertainty due to a mutated virus of the familiar Coronavirus family. Questions about COVID-19 disease transmission, mortality rates and our own immune response have resulted in fear, confusion and a sense of helplessness in many. Thankfully, we have scientific data from studies in microbiology, medicine and the indoor environment that can guide our building management.

Dr. Taylor will present studies on building interventions that optimize human occupants' health and decrease threat of microbial pathogens like COVID-19. Communication between medical and building professionals along with your input will help us fight back and regain our footing.

Wednesday, February 10, 10:30 AM - 11:30 AM

**Seminar 14 (Basic)**

**What You Need to Know About ANSI/ASHRAE Standard 90.4: The Energy Standard for Data Centers (LIVE)**

*Track: Standards, Guidelines and Codes*

**Sponsor: 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment, SSPC 90.4, SSPC 90.1**

*Chair: Joseph Gangemi, Life Member, Data Aire, Orange, CA*

The 2019 version of Standard 90.4 was officially recognized in Standard 90.1 as the Alternate Compliance Path for Data Centers, defined as greater than 10 kW and 20 W/sf power density. Smaller facilities are defined as Computer Rooms, and remain governed by Std. 90.1. Standard 90.4 has already been adopted in the state of Washington, and is pending adoption in other jurisdictions. But it will be widely recognized as Std. 90.1-2019 is adopted, so it is important that designers understand its substantial differences from 90.1, and the advantages it offers for achieving compliance in Mission Critical Data Center designs.

**1. The Origin of ANSI/ASHRAE Std. 90.4, Its Purpose and Format and Using the Electrical Loss Component (ELC) Metric**

*Robert McFarlane, Member, Shen Milsom & Wilke, LLC, New York, OR*

**2. Understanding the Mechanical Load Component (MLC) and Tradeoff Options in ANSI/ASHRAE Std. 90.4**

*Vali Sorell, P.E., Member, Microsoft Corporation, Charlotte, NC*

**3. The Relationship between Standards 90.1 and 90.4, and the Importance of 90.4 to Mission Critical Facilities**

*Timothy Peglow, P.E., Member, MD Anderson, Houston, TX*

Wednesday, February 10, 12:00 PM - 1:00 PM

**Debate 1 (Intermediate)**

**Is Air Change per Hour ( $h^{-1}$ ), cfm/ft<sup>2</sup> or Something Else? (LIVE)**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: MTG.ACR, 9.11 Clean Spaces, TC9.6, TC 9.10, and EHC**

*Chair: Kishor Khankari, Ph.D., Fellow ASHRAE, AnSight LLC, Ann Arbor, MI, James Bennett, Ph.D., Member, CDC/NIOSH, Cincinnati, OH, Joe Zulovich, Ph.D., P.E., Affiliate, University of Missouri, Columbia, MO, Travis English, P.E., Member, Kaiser Permanente, Anaheim, CA and Dan Koenigshofer, P.E., Member, Dewberry, Chapel Hill, NC*

Ventilation airflow requirements are specified in standards, codes and design guidelines in terms of Air changes per hour ( $h^{-1}$ ), cfm/ft<sup>2</sup>, cfm/person, etc. Quantity of supply airflow rate depends on such specification. A group of people who support air change rate thinks it has been working successfully from several decades in making the critical spaces safe, comfortable and healthy.

Another group thinks this legacy practice has a little scientific basis and is a burden on energy efficiency and cost of operation of HVAC systems. This session is an open debate on this issue. Active participation is required from the attendees.

Wednesday, February 10, 1:30 PM - 2:50 PM

### Seminar 15 (Intermediate)

## Building Operation and COVID-19: What is the Standard of Care and Who's Responsible (LIVE)

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 7.3 Operation and Maintenance Management**

*Chair: Matthew Mullen, P.E., Member, EMCOR Services New England Mechanical, South Windsor, CT*

The COVID-19 Pandemic has dramatically impacted how buildings are used and operated in order to secure occupant health. ASHRAE and many other organizations have published guidance for how to operate buildings. Each building is unique and implementing the guidance is not always uniform. So what is the minimum Standard of Care building owners, operators and occupants be accountable to? And what responsibility does each have in implementing the minimum Standard of Care? This seminar will have an owner, operator and lawyer providing their perspective and answers on this crucial topic.

### 1. The Legal Perspective

*Mitchell Swann, P.E., Resolution Management Consultants, Marlton, NJ*

### 2. The Operator's Perspective

*Matthew Mullen, P.E., BEAP, Member, EMCOR Services New England Mechanical, South Windsor, CT*

### 3. The Owner's Perspective

*Holly Dibble, Cushman & Wakefield, Windsor, CT*

1:30 PM - 2:50 PM

### Seminar 16 (Intermediate)

## Dedicated Outdoor Air Systems: Applications, Specification and Commissioning (LIVE)

*Track: Systems and Equipment*

**Sponsor: 8.10 Mechanical Dehumidification Equipment and Heat Pipes, 8.12 Desiccant Dehumidification Equipment and Components**

*Chair: Onieluan Tamunobere, Ph.D., P.E., Associate Member, Heat Pipe Technology, Tampa, FL*

Dedicated Outdoor Air Systems (DOAS) continue to pose industry-wide challenges to specifying and design engineers as well as commissioning agents. In the last three years, the industry has introduced new efficiency metrics such as the Integrated Seasonal Moisture Removal Efficiency (ISMRE), testing procedures (ASHRAE 198), a design guide as well as updates to all accompanying standards. In this seminar, we will review applications for Dedicated Outdoor Air Systems (DOAS); how specifying engineers go about specifying this equipment and finally, best practices in commissioning Dedicated Outdoor Air Systems (DOAS).

### 1. Applications in Dedicated Outdoor Air Systems (DOAS)

*Craig Burg, Member, Desert Aire Corp, Germantown, WI*

### 2. Specifying Dedicated Outdoor Air Systems (DOAS)

*Randy Schrecengost, P.E., BEAP, Member, Stanley Consultants, Austin, TX*

### 3. Commissioning Dedicated Outdoor Air Systems (DOAS)

*Gayle Davis, P.E., Member, Stanley Consultants, Austin, TX*

1:30 PM - 2:50 PM

### Seminar 17 (Intermediate)

## Hotter Cities, Hotter Climates: Modelling and Measuring Urban Heat Island Effects Around the World (LIVE)

*Track: International Design*

**Sponsor: 4.2 Climatic Information**

*Chair: Ralph Muehleisen, Ph.D., P.E., Member, Argonne National Laboratory, Lemont, IL*

Mitigating Urban Heat Island (UHI) or urbanisation-related weather issues is of critical importance for millions of urban dwellers worldwide. It affects building energy consumption and outdoor comfort, and has been associated with increased morbidity and mortality and worsening air quality. This makes quantifying these effects a priority for researchers and practitioners alike. In this



seminar, we present (1) a review of the numerical modelling of urban heat island mitigation, and (2) a case study of blue and green mitigation of urban canyons based on measurements. The speakers will discuss possible mitigation approaches to the problems highlighted.

**1. Cooling Hot Cities: A Systematic and Critical Review of the Numerical Modelling Literature**

*Evyatar Erell, Ph.D., Ben-Gurion University of the Negev, Beersheba, Israel*

**2. Case Studies of Blue and Green Mitigation of Urban Canyons**

*Eric Peterson, Ph.D., P.E., Member, University of Leeds, Leeds, United Kingdom*

1:30 PM - 2:50 PM

**Seminar 18 (Intermediate)**

**New Standard: ASHRAE 221 Overview (LIVE)**

*Track: Standards, Guidelines and Codes*

**Sponsor: 7.3 Operation and Maintenance Management**

*Chair: Matthew Mullen, P.E., Member, EMCOR Services New England Mechanical, South Windsor, CT*

ASHRAE Standard 221 - *Test Method to Field-Measure and Score the Cooling and Heating Performance of an Installed Unitary HVAC Systems*, provides a new and revealing method to score the performance and efficiency of an installed HVAC system in the field. The scores reveal the impact of inherent defects in installation, deferred maintenance and hidden installed system losses. This Standard is written for use by all field professionals including installing contractors, technicians, commissioning and facility personnel, balancers, designers and energy efficiency program participants.

**1. Introduction and Description of ASHRAE STD.221**

*Rob Falke, Member, National Comfort Institute, Avon Lake, OH*

**2. ASHRAE STD.221 Testing and Calculations**

*Peter C. Jacobs, P.E., Member, BuildingMetrics, Incorporated, Boulder, CO*

**3. Uses of ASHRAE STD.221's Installed System Scores**

*Ben Lipscomb, P.E., Associate Member, National Comfort Institute, Whitefish, MT*

Wednesday, February 10, 3:00 PM - 4:20 PM

**Seminar 19 (Advanced)**

**ASHRAE HQ: From Conception to Reception (LIVE)**

*Track: Energy Conservation*

**Sponsor: 9.1 Large Building Air-Conditioning Systems**

*Chair: Dennis Wessel, P.E., Fellow Life Member, AIA, Atlanta, GA*

The new ASHRAE Headquarters is a highly visible project that converted a 1970s vintage building into a Net Zero ready facility. This seminar will take the audience through the process from finding a suitable building, through completion of this highly visible project. During the course of the design of the project, the design team encountered many envelope and system challenges involving the remodel of an older building and the effort to renovate it to meet the requirements of current ASHRAE 90.1 energy goals, as well as the challenge of designing to a stringent list of owner project requirements.

**1. Owner Requirements of Developing a Net Zero Project**

*Ginger Scoggins, P.E., Member, Engineered Designs, Cary, NC*

**2. ASHRAE HQ from an Architects Perspective**

*Gregory Walker, AIA, Houser Walker Architecture, Atlanta, GA*

**3. ASHRAE Headquarters**

*William "Stanton" Stafford, P.E., Member, Integral Group, Atlanta, GA*

3:00 PM - 4:20 PM

**Seminar 20 (Basic)**

**Idle Buildings are the Devil's Playground (LIVE)**

*Track: Environmental Health Through IEQ*

**Sponsor: 1.12 Moisture Management in Buildings, 1.8 Mechanical Systems Insulation , 4.4 Building Materials and Building Envelope Performance**

*Chair: Diana Fisler, Ph.D., Member, ADL Ventures, Centennial, CO*

Buildings operate as a system and perform in a comfortable, safe, and healthy way when well-designed and operated as designed. Sometimes buildings are idled or shut down without proper understanding that this can problems in the building envelope, water systems, and HVAC. Recently, we have experienced unprecedented times related to the pandemic. We saw universities close and reopen, vacated hospital wings and hotels closed while others had few guests. This seminar brings together experts from different areas of building performance to explain the consequences of such idling, and design concerns for idle buildings.

**1. HVAC and Plumbing Systems: What Is the Correct Idle to Minimize Legionella and Other Indoor Environmental Quality Concerns during a Pandemic**

*Donald Snell, P.E., Associate Member, Liberty Building Forensics Group, Atlanta, GA*

**2. Design Conditions for CHW Pipe Insulation Systems to Account for Idle Building Syndrome**

*Gordon Hart, P.E., Member, Artek Engineering, LLC, Shrewsbury, MA*

**3. Idle Buildings, Accelerated Problems**

*Peter Adams, P.Eng., Member, Morrison Hershfield Ltd, Toronto, ON, Canada*

3:00 PM - 4:20 PM

**Seminar 21 (Intermediate)**

**Methods for Improving HVAC Efficiency Globally (LIVE)**

*Track: International Design*

**Sponsor: 8.11 Unitary and Room Air Conditioners and Heat Pumps**

*Chair: Chao Ding, Ph.D., Associate Member, Lawrence Berkeley National Laboratory, Berkeley, CA*

Residential and light commercial air conditioners are widely adopted in the world. Improving energy efficiency can save energy consumption, reduce emission, decrease consumer cost and improve energy security worldwide. Recent global high efficiency designs and best available technologies provide new opportunity to revise and strengthen the energy-efficiency standards and market transformation programs. In this section, three diverse, experienced researches will share their global experience and discuss methods for improving air conditioner energy efficiency.

**1. Setting Long-Term Energy Efficiency Targets Based on Best Available Technology**

*Nihar Shah, Ph.D., P.E., Member, Lawrence Berkeley National Laboratory, Berkeley, CA*

**2. Leapfrogging to Energy-Efficient and Climate-Friendly Air Conditioners: Model Regulation Guidelines**

*Brian Holuj, United Nations Environment Programme, Paris, France*

**3. Raising the Ceiling of Performance: The Global Cooling Prize**

*Iain Campbell, Rocky Mountain Institute, Boulder, CO*

3:00 PM - 4:20 PM

**Seminar 22 (Basic)**

**Your Ethics Tool Box: Building a Framework for Ethical Decision-Making With Case Studies (LIVE)**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 1.7 Business, Management & General Legal Education**

*Chair: Mike Bilderbeck, P.E., Fellow ASHRAE, Pickering, Inc., Memphis, TN*

ASHRAE members are often confronted with ethical issues (whether they realize it or not). This session is part of a continuing program under which ASHRAE members engage in an interactive session where participants are presented with multiple ethics cases, discuss the cases in small groups, and then reveal their decisions. Test your "Ethics IQ" against real cases and receive CE credit in the process.

**1. Case Studies #1 and #2**

*Jennifer Leach, P.E., Member, United Energy Products, Baltimore, MD*

## 2. Case Studies #3 and #4

*Kristin Schaefer, P.E., Member, University of Houston, Houston, TX*

## 3. Case Studies #5 and #6

*Mike Bilderbeck, P.E., Fellow ASHRAE, Pickering, Inc., Memphis, TN*

Wednesday, February 10, 4:30 PM - 5:30 PM

### Forum (Intermediate)

## How to Use Post-Occupancy Data to Design and Operate Resilient Buildings (LIVE)

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 2.10 Resilience and Security**

*Chair: Sama Aghniaey, Ph.D., Student Member, Harris Company, Oakland, CA*

This session focuses on how post-occupancy data available through BMS contributes to designing more resilient buildings and operating current building in a more resilient manner. Opportunities exist in creating the profile of HVAC&R equipment for diagnostic, fault detection, and fault prevention with minimized cost (labor, down time, etc.). There are also opportunities in learning the behavior of building occupants and operating buildings based on their consumption pattern and comfort preferences while minimizing energy consumption (adaptive operation). Data analysis for existing building can also create valuable resources for optimizing design for future buildings (bridging the gap between design and real buildings).

Wednesday, February 10, 6:00 PM - 7:50 PM

### Seminar 23 (Intermediate)

## Indoor Environment Modeling for Pandemic Resiliency (LIVE)

*Track: Environmental Health Through IEQ*

**Sponsor: 4.10 Indoor Environmental Modeling**

*Chair: James Lo, Ph.D., Member, Drexel University, Philadelphia, PA*

COVID-19 has forced us to evaluate the role and ability of ventilation systems to protect people from airborne viruses. Given that a global health crisis seems to occur approximately every four years (such as SARS and H1N1), it now seems apparent that ventilation systems will need to actively contribute to resiliency of our society. In order to assess the benefits of ventilation systems, indoor environmental modeling can provide rapid testing of different options. The presentations in this seminar present different modeling options for different scenarios within ventilated spaces.

### 1. Airborne Infectious Disease Transmissions in Commercial Airplane Cabins

*Qingyan Chen, Ph.D., Life Member, Purdue University, West Lafayette, IN*

### 2. Quantifying the Benefit of Unoccupied Middle Seats on Commercial Flights for Airborne Virus Protection

*Watts Dietrich, NIOSH, DC, DC*

### 3. Quantification of Possibilities and Risks of Airborne Virus Exposure in Public Places By Indoor Fast Fluid Dynamics

*Liangzhu Wang, Concordia University, Montréal, QC, Canada*

### 4. A High Speed Assessment Tool of Mitigation Options to Control Pathogens in Air

*Duncan Phillips, Ph.D., P.E., Associate Member, RWDI, Guelph, ON, Canada*

### 5. Protecting Industrial Workers in a Pandemic

*Duncan Phyfe, Associate Member, Alden Research Laboratory, Holden, MA*

6:00 PM - 7:50 PM

### Seminar 24 (Advanced)

## Safe Transition to Flammable Refrigerants in Commercial Refrigeration Applications (LIVE)

*Track: Refrigeration and Refrigerants*

**Sponsor: 10.7 Commercial Food and Beverage Refrigeration Equipment**

*Chair: Gustavo Pottker, Ph.D., Member, Honeywell, Buffalo, NY*

This session discusses several aspects related to the transition to flammable refrigerants in commercial refrigeration applications. Presenters will walk us through the latest developments in UL and IEC 60335-2-89 product safety standards, share experiences and potential mitigation strategies to deal with flammable refrigerants, as well as report on research activities related to refrigerant leak and ignition events.

**1. A2L and A3 Refrigerants Testing for Reach-in Coolers**

*Xudong Wang, Ph.D., Member, Air-Conditioning, Heating and Refrigeration Technology Institute, Arlington, VA*

**2. Update on Standards Development - IEC 60335-2-89 Commercial Refrigeration**

*Brian Rodgers, Underwriters Laboratories, Northbrook, IL*

**3. Updates on UL 60335-2-89, the Standard for Commercial Refrigerating Appliances and UL 60335-2-40, the Standard for Electrical Heat Pumps, Air-Conditioners, and Dehumidifiers**

*Randall Haseman, UL LLC, Northbrook, IL*

**4. Use of Flammable Refrigerants from an Equipment Manufacturer's Perspective**

*Timothy Anderson, Associate Member, Hussmann, Bridgeton, MO*

**5. Refrigerant Charge Reduction to Mitigate Risks Associated with Flammable Refrigerants**

*Stefan Elbel, Ph.D., Member, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL*

## Thursday, February 11

Thursday, February 11, 7:00 AM - 8:50 AM

### Seminar 25 (Intermediate)

#### **Movement and Control of Airborne Pathogens with HVAC Systems (LIVE)**

*Track: Environmental Health Through IEQ*

**Sponsor: 1.3 Heat Transfer and Fluid Flow, 9.6 Healthcare Facilities, MTG.ACR (Air Change Rate), TC 8.11 Unitary and Room air Conditioners & Heat Pumps**

*Chair: Pratik Deokar, Ph.D., Member, Rheem Manufacturing Company, Carrollton, TX*

Airborne droplet and aerosols have been identified as contributors in transmission of various diseases like COVID-19. This seminar highlights case studies and CFD analysis of airflow patterns' impact on transmission of such airborne contaminants in buildings with higher air flow rates and ways to mitigate it. Also, it highlights the design and performance of a wind tunnel that helped in coronavirus aerosol collection for measurements and inactivation in lower air flow rates applications, such as in portable air purification systems. This seminar also describes pilot study of a novel PECO technology used to destroy airborne viruses in a hospital.

**1. Impact of Airflow Patterns on Transmission of Airborne Contaminants**

*Kishor Khankari, Ph.D., Fellow ASHRAE, AnSight LLC, Ann Arbor, MI*

**2. Experimental Evaluation of Droplet Transmission through Building Air Handling System- a Case Study for COVID-19 Zonal Transmission**

*Kashif Nawaz, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

**3. Mid-Scale Wind Tunnel Testing of Residential Control Technology for Coronavirus Aerosol Collection and Inactivation**

*Christopher Hogan Jr., University of Minnesota, Minneapolis, MN*

**4. Indoor Airborne Transmission of COVID-19 Virus and the Role of Peco Technology to Reduce the Risk of Infection**

*D Goswami, Ph.D., P.E., Fellow ASHRAE, University of South Florida, Tampa, FL*

7:00 AM - 8:50 AM

### Seminar 26 (Intermediate)

#### **Smarter Together: Integrating HVAC and Lighting Control (LIVE)**

*Track: Energy Conservation*

**Sponsor: 1.4 Control Theory and Application, TC 7.5**

*Chair: Scott Hackel, P.E., Member, Slipstream, Madison, WI*

We may have finally reached a stage where lighting and HVAC control can work together, at multiple levels. The timing is good: as the low-hanging fruit of lighting and high-efficiency HVAC is exhausted, our industry increasingly turns to the intelligence of our buildings' controls. And lighting controls, which are increasingly networked broadly throughout a building, present an excellent source of intelligence for HVAC systems to tap into. This presentation will describe a variety of integration approaches, as well as a number of recent real-world experiences with the latest technology.

**1. Power up Your Knowledge: Get Your Smart Buildings Superhero Card**

*Kandice Cohen, Affiliate, Trane, La Crosse, WI*

## **2. Deeper Control Savings: Integrating HVAC with Networked Lighting**

*Scott Hackel, P.E., Member, Slipstream, Madison, WI*

## **3. Integral Vs Integrated: The Story**

*Will Podgorski, Siemens, Buffalo Grove, IL*

## **4. Research Aspects of Integration of Lighting and HVAC and Other Systems**

*Michael Myer, Member, Pacific Northwest National Laboratory, Richland, WA*

Thursday, February 11, 10:00 AM - 11:30 AM

### **Seminar 27 (Intermediate)**

## **MERV 13, HEPA and UVC: What Did Buildings Do During this Pandemic and How to Make your Buildings More Resilient for the Next Outbreak (LIVE)**

*Track: Environmental Health Through IEQ*

**Sponsor: 2.9 Ultraviolet Air and Surface Treatment, 2.10 Resilience and Security**

*Chair: Jason DeGraw, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

ASHRAE buildings have been implementing changes to their ventilation systems based on many different recommendations including the ASHRAE Position Document on Infectious Aerosols and the recommendations of the ASHRAE Epidemic Task Force. This seminar focuses on the two main strategies implemented by buildings: MERV13 Filtration & UVC (Ultraviolet Light) systems as recommended by the ASHRAE Position Document. The seminar also presents the current recommendations by the Chair of the ASHRAE Epidemic Task Force.

### **1. Why MERV 13 and NOT HEPA Filtration**

*Kathleen Owen, Fellow ASHRAE, Owen Air Filtration Consulting, Cary, NC*

### **2. UVC: How to Do It: Design and Installation**

*Scott Sherwood, Member, Eco-Care Corporation, Bronx, NY*

### **3. The Evolving State of COVID-19 HVAC Guidance: What Have We Learned, Where Are We Now, Where Are We Headed?**

*William Bahnfleth, Ph.D., P.E., Presidential Fellow ASHRAE, Penn State, University Park, PA*

Thursday, February 11, 12:00 PM - 1:20 PM

### **Seminar 28 (Intermediate)**

## **Ammonia and Other Natural Refrigerants Standards and Guidance (LIVE)**

*Track: Refrigeration and Refrigerants*

**Sponsor: 10.1 Custom Engineered Refrigeration Systems, Refrigeration Technology Committee**

*Chair: Tom Wolgamot, P.E., Member, DC Engineering, Missoula, MT*

The primary refrigerant used in industrial refrigeration is ammonia because it has superlative efficiency, low cost, ease of use, and distinctive thermophysical characteristics. This seminar reviews the reasons for the use of natural refrigerants and the status of standards and other resources available to apply them safely and effectively.

### **1. Ammonia Standards and Research**

*Eric Smith, IAR, Alexandria, VA*

### **2. IAR Publications**

*Eileen McKeown, IAR, Alexandria, VA*

12:00 PM - 1:20 PM

### **Seminar 29 (Basic)**

## **Avoid the Headlines! Today's Top 10 Security Best Practices for Controls (LIVE)**

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 1.4 Control Theory and Application, 7.5 Smart Building Systems, 1.5 Computer Applications**

*Chair: Chariti Young, Member, Automated Logic Corp., Kennesaw, GA*

Is your controls system an attack vector a bad actor could use to compromise your building operation or company network? Or is it a secured, hardened asset or set of assets protecting your people and property? The truth is that it could be either, depending on how it was deployed, and whether security best practices were considered and are properly applied. Come learn the top 10 cybersecurity best practices that can be implemented today in nearly any commercial controls system to keep you out of the headlines!

### **1. User Accounts and Access Best Practices for Controls**

*Carol Lomonaco, Member, Johnson Controls, Milwaukee, WI*

**2. Controls Deployment Best Practices to Limit Exposure**

*Ken Gilbert, Member, Automated Logic, Kennesaw, GA*

12:00 PM - 1:20 PM

**Seminar 30 (Basic)**

**Controls Standards, Guidelines and Codes: What YEA Need to Know! (LIVE)**

*Track: Standards, Guidelines and Codes*

**Sponsor: 1.4 Control Theory and Application, YEA**

*Chair: Omar Rojas, Member, Russell Sigler, Inc, Brea, CA*

Controls can be daunting for the new and experienced engineers, yet they are a critical component of a building's design and becoming a well-rounded engineer. With so much information available on the matter, it's hard to know where to begin. This seminar will provide an introduction to the guidelines, standards and codes to start you on path to becoming controls savvy. Start from the ground up learning the terms and concepts. Carry on through the standards and guidelines that will help you put concepts into practice. Reach a point where you can understand and prevent code control measures from under-performing.

**1. An Introduction to Building Automation Controls and Communications: Learn to Speak the Language**

*Ron Bernstein, Member, RBCG Consulting, San Diego, CA*

**2. A Beginner's Trail through Guideline 36: Understanding How Control Sequences Can Influence System Design**

*James Del Monaco, P.E., Member, P2S Engineering, San Diego, CA*

**3. Control Measures in Energy Codes: Fantasy Versus Reality**

*Reid Hart, P.E., Life Member, Pacific Northwest National Laboratory, Richland, WA*

12:00 PM - 1:20 PM

**Seminar 31 (Intermediate)**

**Decouple, Optimize And Succeed with DOAS (LIVE)**

*Track: Systems and Equipment*

**Sponsor: 1.4 Control Theory and Application, 8.10 Mechanical Dehumidification Equipment and Heat Pipes**

*Chair: James Coogan, P.E., Associate Member, Siemens Smart Infrastructure, Chicago, IL*

A new, multi-purpose building on an urban university campus is planned to significantly exceed the applicable energy efficiency code. The challenge calls for a design that meets diverse load conditions without waste and an on-line optimization function that dynamically applies heating and cooling elements to best advantage. A Primary Dedicated Outdoor Air System was selected with hydronic heating and cooling fan powered terminals, to deliver comfort and ventilation but expend energy only where and when it's needed. The concept decouples ventilation from thermal conditioning and building pressurization. One talk explains the HVAC design and analysis; the other covers dynamic operation.

**1. Applying DOAS with Secondary Heat and Cooling to Meet HVAC Challenges**

*Andrew Kozak, P.E., Member, Bard Rao + Athanas Consulting Engineers, New York, NY*

**2. Dynamically Optimizing a DOAS: Finding the Bottom**

*James Coogan, P.E., Associate Member, Siemens Smart Infrastructure, Chicago, IL*

Thursday, February 11, 1:30 PM - 2:30 PM

**Workshop 2 (Basic)**

**Best Practices of the Mentor-Mentee Relationship (LIVE)**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: YEA Committee, College of Fellows**

*Chair: Jessica Renner, P.E., Member, Energy Studio, Inc, Omaha, NE*

Mentoring can be a powerful resource for personal and professional growth, not only for mentees, but for mentors as well. Are you working through a challenging new project or moving into a new role? ASHRAE members at any stage of their career will benefit from this interactive workshop. Mentorship does not just happen; it's important to be intentional about finding and nurturing relationships, both with those that fill experience gaps, but also with peers to achieve your highest potential. It's the goal of this workshop to organically connect members to develop their skills, knowledge and confidence to enhance attendees' growth.

**1. Growth through Learning Inc.**

*Ralph Kison, Member, Growth Through Learning Inc., Vancouver, BC, Canada*

Thursday, February 11, 3:00 PM - 4:20 PM

**Seminar 32 (Intermediate)**

**Climate Control Solutions for What is Next, Moving from Hyperscale to The Edge (LIVE)**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment**

*Chair: Herb Villa, Member, Rittal North America, Newark, NJ*

IT is expanding from traditional data centers to very small, localized Edge deployments. Climate control must be able to support this migration. The move to The Edge is driven by the exponential growth of IoT. Supporting a variety of applications, Edge deployments support real time data collection and analysis, allowing near real time reaction to shifting market demands. Employing the same core components (enclosures, power, security), the unique demands at The Edge warrant a renewed review all systems, with this seminar focusing on adapting climate control solutions from the hyperscale arena for use in the Edge space.

**1. Climate Control Solutions for What's Next**

*Suzanne Krantz, Rittal North America, Schaumburg, IL*

3:00 PM - 4:20 PM

**Seminar 33 (Intermediate)**

**Ground Source Heat Pump Systems: GeoMicroDistricts to the Thermal Highway and Beyond (LIVE)**

*Track: Energy Conservation*

**Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications**

*Chair: Roshan Revankar, Melink Solar and Geo, Milford, OH*

This track explores possibilities for wasted energy recovery and increasing multi-building system efficiency using one-pipe convective loops. We demonstrate several ways System Coefficient of Performance can be increased using ground source and GeoMicroDistricts. There will be several sessions that will go over the energy engineering aspects of optimizing GSHP systems using diversity, part load analysis, system COP and system iCOP<sub>kw</sub>, the affinity laws for pumps and fans, and earth thermal properties for heat storage. Specific examples of installed GeoMicroDistricts will be used to demonstrate the technology.

**1. In the Beginning...**

*Garen N. Ewbank, Member, Ewbank Geo Testing, LLC, Fairview, OK*

**2. What Box Do We Use for Ground Source Systems?**

*Cary Smith, Member, Sound Geothermal Corp., Sandy, UT*

3:00 PM - 4:20 PM

### Seminar 34 (Advanced)

## Performance of Alternative Low GWP A2L Refrigerants in Condensers (LIVE)

*Track: Refrigeration and Refrigerants*

**Sponsor: 1.3 Heat Transfer and Fluid Flow, 8.4 Air-to-Refrigerant Heat Transfer Equipment, 8.5 Liquid-to-Refrigerant Heat Exchangers**

*Chair: Kashif Nawaz, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

Due to the emerging attention to the environmental impacts of air conditioning, there has been a continuous effort to evaluate the heat transfer and pressure drop performance of alternative refrigerants that can substitute conventional working fluids like R410A. This seminar will highlight the performance of several low GWP and A2L refrigerants, including zeotropic mixtures of HFC/HFOs, under flow condensation process in heat exchangers. The seminar will also highlight conventionally ignored superheated and subcooled condensation process, challenges associated with condensation of zeotropic mixtures, and a novel modeling framework that will facilitate the design of next generation condensers for alternative refrigerants.

### 1. Thermal-Hydraulic Performance of Alternative Refrigerants Under Flow Condensation

*Kashif Nawaz, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

### 2. In-Tube Condensation of Low Global Warming Potential Refrigerants

*Tabeel Jacob, Ph.D., Student Member, Oregon State University, Corvallis, OR*

3:00 PM - 4:20 PM

### Seminar 35 (Intermediate)

## Sensors and IAQ (LIVE)

*Track: Environmental Health Through IEQ*

**Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment**

*Chair: Brian Krafthefer, P.E., Fellow Life Member, BCK Consulting, Stillwater, MN*

IAQ consists of a variety of different contaminants – particles, bio aerosols, gases, and vapors - and household air pollution is ranked one of the largest burdens of disease. To determine the materials that are in the air one needs accuracy and would like to sense these with one small sensor. This seminar will look at some of the current sensing capabilities for indoor IAQ and try to understand what is needed for one sensor to detect multiple contaminants while trying to minimize energy consumption, which are traditionally competing goals.

### 1. What Did We Learn from Deploying Low-Cost Particle Monitors in 20 Homes?

*Jeffrey Siegel, Ph.D., Fellow ASHRAE, University of Texas at Austin, Austin, TX*

### 2. Metal Oxide Semiconductor Sensors to Measure Volatile Organic Compounds for Ventilation Control

*Pawel Wargocki, Ph.D., Associate Member, Technical University of Denmark, Kongens Lyngby, Denmark*

### 3. Operating Principles of Airborne Pollutant Sensors and Considerations for Sensing Multiple Pollutants.

*Jordan Clark, Ph.D., OSU, Columbus, OH*

## Panel

### Panel (Intermediate)

## The Role of Thermally Driven Heat Pumping and Cooling Systems in the Age of Electrification

*Track: Energy Conservation*

**Sponsor: 8.3 Absorption and Heat Operated Machines, TC 8.3**

*Chair: William Ryan, Ph.D., P.E., Member, University of Illinois at Chicago, Chicago, IL*

This panel discusses the role that thermally driven heat pumping and cooling systems can play, when directly consuming fossil fuels or utilizing waste heat from industrial and CHP systems. In either role, there is an opportunity to reduce source energy consumption and therefore reduce carbon emissions below that of electrically driven systems operating on the current or near term electric grid. These technologies are not common in the North American HVAC market, and the proper evaluation methods are not widely understood by HVAC engineers, making this panel session of value to the ASHRAE membership.

### Panel Member #1

*Brian Fronk, Ph.D., Member, Oregon State University, Corvallis, OR*



## Panel Member #2

*Michael Garrabrant, Member, Stone Mountain Technologies, Inc., Erwin, TN*

## Panel Member #3

*Paul Glanville, P.E., Member, Gas Technology Institute, Des Plaines, IL*

## Panel (Intermediate)

### Advancing Occupant Aspects of Building Energy Codes, Standards and Policy

*Track: Standards, Guidelines and Codes*

#### Sponsor: MTG.OBB Occupant Behavior in Buildings

*Chair: Liam O'Brien, Ph.D., P.E., Associate Member, Carleton University, Ottawa, ON, Canada*

Occupants are recognized to play a major and growing role in building performance. However, they are specified in simple ways in building codes, such as using fixed values and densities. It is common for building codes to implicitly neglect the fact that building design and controls can affect occupant behavior (positively or negatively) and to use relatively outdated schedules and other modeling methods. This panel explores questions like: How do current building codes deal with occupants? How might building codes be enhanced to better reflect the state-of-the-art? This panel is aimed at practitioners, researchers and policy makers.

#### 1.An International Review of Occupant-Related Aspects of Building Energy Codes

*Liam O'Brien, Ph.D., P.E., Associate Member, Carleton University, Ottawa, ON, Canada*

#### 2.Control, Comfort and Codes: Learning Lessons from Occupants

*Julia Day, Ph.D., Associate Member, Washington State University, Pullman, WA*

#### 3.Investigating Setpoints and Plug Load Assumptions in Energy Codes

*Mohamed Ouf, Associate Member, Concordia University, Montreal, QC, Canada*

#### 4.Recent Changes in the U.S Building Energy Codes for Occupancy Centric Controls and Associated Building Energy Modeling Challenges

*Jian Zhang, Ph.D., Member, Pacific Northwest National Laboratory, Richland, WA*

#### 5.Incorporating Occupant-Centric Controls in Sequences of Operation for HVAC Systems

*Burak Gunay, Ph.D., Associate Member, Carleton University, Ottawa, ON, Canada*

## Panel (Intermediate)

### Design Fundamentals of Commercial Kitchens, Part 1

*Track: HVAC&R Fundamentals and Applications*

#### Sponsor: 5.10 Kitchen Ventilation

*Chair: Cherish Samuels, P.E., Associate Member, McDonald's Corporation, Chicago, IL*

From ventilation and make-up air, to heat gain and thermal comfort, commercial kitchens are some of the most difficult spaces to design. Hood selection has an impact on IAQ and energy consumption in the restaurants along with comfort in the kitchen. Increases in cooking capacity or the need for expanded menu flexibility in the kitchen is more commonly being met by specifying unhooded or ventless equipment. This first seminar in a two-part series walks you through some of the most crucial design considerations and equipment selections involved in the planning of ventilation systems for commercial kitchens.

#### 1.Cooking and Exhaust Hood Selection, Optimization Fundamentals

*Derek Schrock, Member, Halton Company, Scottsville, KY*

#### 2.Design Considerations for Unhooded Equipment in Commercial Kitchens

*Jimmy Sandusky, Associate Member, Halton Company, Scottsville, KY*

#### 3.Design Process for Commercial Kitchens

*Jason Greenberg, P.Eng., MGN, Inc., Oakbrook Terrace, IL*

## Panel (Intermediate)

### Design Fundamentals of Commercial Kitchens, Part 2

*Track: HVAC&R Fundamentals and Applications*

#### Sponsor: 5.10 Kitchen Ventilation

*Chair: Cherish Samuels, P.E., Associate Member, McDonald's Corporation, Chicago, IL*

Today, HVAC designers have many HVAC system and product types to choose from. There are also multiple types of exhaust fans available for the removal of grease, heat, smoke and steam from commercial kitchens. Design considerations include mechanical and cooking equipment installed, integrations to other systems on site, codes and safety regulations and proper

commissioning of the system. This second seminar in a two-part series walks you through some of the most crucial design considerations and equipment selections involved in the planning of ventilation systems for commercial kitchens.

**1. Restaurant HVAC Design Strategies for Incorporating Replacement Air**

*Greg DuChane, Member, Trane, Nacogdoches, TX*

**2. Getting Your CKV Ducts in a Row**

*Keith Page, Member, Selkirk Corporation, Grand Rapids, MI*

**3. Exhaust Fans for Commercial Kitchen Ventilation Applications**

*Jessica Harrington, Associate Member, Accurex, Baltimore, MD*

**4. Demand Control Kitchen Ventilation Applications**

*Jason Brown, Associate Member, Melink Corporation, Milford, OH*

## Conference Paper Session

### Conference Paper Session 1 (Intermediate)

#### Energy Master Planning for Resilient Public Communities: Best Practices from Europe and North America

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 7.6 Building Energy Performance**

Public communities, like universities, are a vital element of our infrastructure, as well as the energy consumption and occupant thermal comfort of these buildings. Until recently, public community energy systems planning was addressed without considering community-wide goals. This session presents the best practices for community-level planning with European and North American case studies, based in part on research performed under the International Energy Agency's "Energy in Buildings and Communities Program Annex 73" on developing guidelines to support planning Net Zero Energy Resilient Public Buildings. Each paper reviews energy plans and specific performance targets, critical infrastructure, operational constraints and techno-economic concepts.

**1. Energy Master Planning for Resilient Public Communities: Best Practices from North American Universities (VC-21-003)**

*Laxmi Rao<sup>1</sup>, Juan Ontiveros, P.E., Affiliate<sup>2</sup>, Joseph Yonkoski<sup>3</sup>, Joshua Wauthy<sup>4</sup> and Paul Holt<sup>5</sup>, (1)International District Energy Association, Westborough, MA, (2)University of Texas at Austin, AUSTIN, TX, (3)University of California, CA, (4)University of British Columbia, Vancouver, BC, Canada, (5)Corix Utilities, Vancouver, BC, Canada*

**2. Energy Master Planning for Resilient Public Communities: Best Practices from Austrian University Campuses (VC-21-002)**

*Anna Maria Fulterer, Ph.D.<sup>1</sup>, Ingo Leusbrock, Ph.D.<sup>1</sup>, Gert Widu<sup>2</sup> and Dirk Jäger<sup>2</sup>, (1)Institute for Sustainable Technologies, Gleisdorf, Austria, (2)Bundesimmobiliengesellschaft, Vienna, Austria*

**3. Energy Master Planning for Resilient Public Communities – Best Practices from Denmark (VC-21-001)**

*Anders Dyrelund<sup>1</sup>, Robert Neimeier<sup>2</sup>, Hasmik Margaryan<sup>3</sup> and Anders Moller<sup>4</sup>, (1)Ramboll Energy, Copenhagen, Denmark, (2)Ramboll Energy, US, (3)TaaarnbyForsyning, Denmark, (4)Danish Technical University, Denmark*

### Conference Paper Session 2 (Intermediate)

#### Defining and Quantifying the Resilience of Electrical and Thermal Energy Systems in Critical Infrastructure

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 7.6 Building Energy Performance**

Throughout the history of energy systems, significant disruption of energy supply has degraded critical capabilities and caused a significant social and economic impact on private and public communities. This disruption more severely impacts vital infrastructures such as hospitals, education campuses, military installations, and other mission-critical facilities. The major causes of such disruption are low-probability and high-impact events such as hurricanes, floods, earthquakes, and extreme climates such as the arctic and tropical environment. This session presents metrics for energy resilience, methodologies to assess these metrics, and tools for modeling energy resilience at the community scale.

### **1. Defining, Measuring and Assigning Resilience Requirements to Electric and Thermal Energy Systems (VC-21-004)**

*Alexander M. Zhivov, Ph.D., Member<sup>1</sup>, Andrew Smiger<sup>2</sup>, Michael Fox<sup>3</sup>, Patrick Daniel<sup>4</sup>, Todd Traver<sup>5</sup> and John Benefiel<sup>1</sup>, (1)US Army Engineer Research and Development Center, Champaign, IL, (2)US Army Corps of Engineers PREP, Champaign, IL, (3)US Army Corps of Engineers, Champaign, IL, (4)Fort Leonard Wood, MO, (5)Uptime Institute, Seattle, WA*

### **2. A Tool for Modeling Energy and Resilience for Community-Scale Networks of Buildings and District Systems (VC-21-C001)**

*Michael Patrick O'Keefe<sup>1</sup>, Peter Ellis, Member<sup>1</sup>, Richard Liesen, Ph.D., Member<sup>2</sup>, Alexander Zhivov, Ph.D.<sup>3</sup> and Anthony Latino<sup>4</sup>, (1)Big Ladder Software, Denver, CO, (2)U.S. Army Construction Engineering Research Laboratory, Champaign, IL, (3)U.S. Army Construction Engineering Research Laboratory, (4)SC-B Consulting*

## **Conference Paper Session 3 (Intermediate)**

### **Best Practices for Building Envelopes and HVAC in Extreme Climates**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 7.6 Building Energy Performance**

The resilience of energy systems impacts the primary functionality of critical infrastructures such as hospitals, military installations, and educational campuses during disruptions. The first paper in this session provides a definition of the resilience of mission necessary facilities in extreme climates and offers a methodology to address site-specific requirements. The other articles summarize the experts' discussion during the consultation forum "Thermal Energy Systems Resilience in Cold/Arctic Climates" and research conducted under the IEA EBC Annex 73, Towards Net Zero Energy Resilient Public Communities.

### **1. Requirements for Building Thermal Conditions under Normal and Emergency Operations in Extreme Climates (VC-21-005)**

*Alexander M. Zhivov, Ph.D., Member<sup>1</sup>, William Rose<sup>2</sup>, Raymond Patenaude, P.E.<sup>3</sup> and W. Jon Williams<sup>4</sup>, (1)US Army Engineer Research and Development Center, Champaign, IL, (2)William B. Rose & Associates, Inc., Urbana, IL, (3)Holmes Engineering Group LLC, FL, (4)National Personal Protective Technology Laboratory NIOSH/CDC, Pittsburgh, PA*

### **2. Building Enclosure Testing on Alaska Military Base Projects (VC-21-006)**

*Emmett Leffel, Alaska Thermal Imaging LLC, Palmer, AK*

### **3. Best Practices for HVAC, Plumbing and Heat Supply in Arctic Climates (VC-21-007)**

*Emily Winfield<sup>1</sup>, Thomas Adams<sup>2</sup>, Alexander Zhivov, Ph.D.<sup>3</sup>, Anders Dyrelund<sup>4</sup>, Craig Fredeen<sup>5</sup>, Robin Rader<sup>1</sup> and Oddgeir Gudmundsson<sup>5</sup>, (1)Design Alaska, Anchorage, AK, (2)Danfoss, Denmark, (3)US Army Corps of Engineers, Champaign, IL, (4)Ramboll Energy, Copenhagen, Denmark, (5)Cold Climate Engineering, LLC, AK*

## **Conference Paper Session 4 (Intermediate)**

### **Effective Building Performance Characterization and Commissioning Using BIM and Machine Learning**

*Track: Building Performance and Commissioning for Operation and Management*

Building performance characterization and continuous commissioning over the life-cycle is essential for the optimal operation of buildings and maintaining occupant comfort. To this effect, the Building Information Model (BIM) ecosystem, the Computerized Maintenance Management Systems (CMMS), and, more recently, Machine Learning, are indispensable tools for architects, engineers, and facility managers. This session presents different applications of these ecosystems for efficient operation and management of buildings.

### **BIM-based Life-cycle Design and Commissioning in a Smart Office Building (VC-21-C003)**

*Shiro Tsukami, BCxP, BEAP, BEMP, HBDP, HFDP and OPMP, Member<sup>1</sup>, Hirotaka Kubo<sup>1</sup>, Iwao Hasegawa, Associate Member<sup>1</sup> and Masayuki Ichinose<sup>2</sup>, (1)NIKKEN SEKKEI LTD, Chiyoda-ku Tokyo, Japan, (2)Tokyo Metropolitan University, Hachioji-shi Tokyo, Japan*

### **Estimation of Infiltration in Commercial Buildings Based on Existing CO2 Sensors: An Inverse Approach (VC-21-C004)**

*Zijun Xiong and Burak Gunay, Carleton University, Canada*

### **A Text-mining-based Framework to Provide Room-wise Insights Into the Maintenance Performance of Buildings (VC-21-C002)**

*Pedram Nojedehi<sup>1</sup>, H. Burak Gunay, Ph.D., Associate Member<sup>1</sup> and William O'Brien<sup>2</sup>, (1)Carleton University, Ottawa, ON, Canada, (2)Carleton University, Canada*

### Conference Paper Session 5 (Intermediate)

#### Statistical Models and Machine Learning for Minimizing Energy Costs in Buildings

*Track: Building Performance and Commissioning for Operation and Management*

Robust components, systems, and building energy models are essential for model-based control and building equipment optimization. This session highlights the use of different modeling techniques for optimal building operation and control. The first paper presents a comparison of three control strategies for open cooling towers for a large office building. The second paper presents a clustering approach for a more accurate representation of occupancy schedules in energy modeling. The third paper presents deep reinforcement learning methods to minimize energy costs while maintaining thermal comfort requirements using limited data.

##### Deep Reinforcement Learning for Energy Cost Optimization in Building HVAC Systems (VC-21-C005)

*Zhanhong Jiang, Ph.D.<sup>1</sup>, Michael James Risbeck<sup>2</sup>, Jaume Amores<sup>2</sup>, Vish Ramamurti<sup>2</sup>, Sugumar Murugesan<sup>2</sup>, Kirk H Drees<sup>2</sup> and Young M Lee<sup>2</sup>, (1)Johnson Controls, Inc., Milwaukee, WI, (2)Johnson Controls, United States of America*

##### Use of Domestic Water Consumption as Proxy for Occupancy Level in Building Cooling Energy Model (VC-21-C007)

*Hongxiang Fu, Student Member<sup>1</sup>, Shinwoo Lee<sup>2</sup>, Juan-Carlos Baltazar, Ph.D., BEMP, Member<sup>3</sup> and David E Claridge<sup>3</sup>, (1)Texas A&M University, College Station, TX, (2)Texas A&M University, (3)Texas A&M University, United States of America*

##### Simulation Comparison of Different Cooling Tower Control Strategies (VC-21-C006)

*Birajan Bhandari, Associate Member, Integrated Environmental Solutions Limited, San Francisco Bay Area, CA*

### Conference Paper Session 6 (Intermediate)

#### Energy Efficiency of Buildings: Code-based Post-installation Measurements and of Control Systems for Non-invasive Retrofits

*Track: Building Performance and Commissioning for Operation and Management*

Buildings use a large part of the nation's energy, but can be designed and/or retrofitted, and run to improve their energy efficiency so as to reduce both the running costs and the associated GHG emissions. The first paper explains the long-term effects of energy standards based on 4-year field measurements across 13000+ Canadian residences, the second paper describes how to effectively retrofit existing air handling units in DOD facilities with control systems that implement advanced algorithms for demand-controlled ventilation, the third paper explains the importance of post-installation optimization to achieve optimal energy and thermal comfort performance.

##### Technical Evaluation Of A Retrofitted MVHR System: Design And In-use Performance (VC-21-C010)

*Adam Cornelius O Donovan, Ph.D., Associate Member<sup>1</sup>, Micheál Cantillon-Murphy<sup>2</sup>, Emeline Charles<sup>2</sup>, Nazar Baker<sup>2</sup> and Paul D O' Sullivan<sup>2</sup>, (1)Cork Institute of Technology, Cork, Ireland, (2)Cork Institute of Technology, Ireland*

##### Investigating the Thermal Performance of Canadian Houses Using Smart Thermostat Data (VC-21-C008)

*Aya Doma<sup>1</sup>, Mohamed Ouf, Associate Member<sup>2</sup> and Guy Newsham<sup>3</sup>, (1)Concordia university, (2)Concordia University, Montreal, QC, Canada, (3)Construction Research Centre, National Research Council of Canada, Canada*

##### Multizone Air Handler Controls Retrofit for Energy Efficiency (VC-21-C009)

*Eileen Westervelt, P.E., Member<sup>1</sup>, Christopher Battisti, P.E., Member<sup>2</sup>, Brianna Morton<sup>3</sup> and David Schwenk<sup>4</sup>, (1)USACE ERDC CERL, Champaign, IL, (2)USACE ERDC CERL, Kansas City, MO, (3)USACE ERDC CERL, Champaign, IL, (4)Oak Ridge Institute for Science and Education, Champaign, IL*

### Conference Paper Session 7 (Intermediate)

#### Energy Consumption and Potential Savings in Residential Dwellings

*Track: Building Performance and Commissioning for Operation and Management*

The energy usage of residential dwellings depends on a number of variables. The papers in this session shed light on how the energy usage is influenced by: the people presence pattern (1st paper), the household income (2nd paper), the indoor cooling needs vs. outdoor climate (3rd paper), and the historic importance of a building (4th paper).

##### Evaluation of Energy Consumption and Efficiency in a Historical Residential Home before and after Building Renovations (VC-21-C013)

*Jonathan Ore, Student Member, Davide Ziviani, Ph.D., Member and Eckhard A. Groll, Purdue University, West Lafayette, IN*

##### Cooling Energy Consumption Analysis and Potential Cost Savings in a Residential Unit in the Midwest Region in the US (VC-21-C012)

*Maher Shehadi, Ph.D., Purdue University, United States of America*

##### Residential Occupant-Dependent Appliance Power and Time-of-Use Estimation for Grid Demand Response Applications (VC-21-C014)

*Niraj Kunwar, Student Member<sup>1</sup>, Soham Vanage, Student Member<sup>2</sup>, Emily Peruski<sup>3</sup>, Coleson White<sup>3</sup> and Kristen S. Cetin<sup>3</sup>, (1)Iowa State University, Ames, IA, (2)Michigan State University, East Lansing, MI, (3)Michigan State University*  
**Characteristics of Residential Occupancy Profiles for Different Income Groups in the United States (VC-21-C011)**  
*Debrudra Mitra, Yiyi Chu and Kristen Cetin, Ph.D., P.E., Member, Michigan State University, East Lansing, MI*

### Conference Paper Session 8 (Intermediate)

#### Modelling to Understand and Improve the Energy Efficiency of Buildings

*Track: Building Performance and Commissioning for Operation and Management*

Buildings are complex systems also when it comes down to understanding their energy usage pattern in order to increase the related efficiency. Today, there is a number of reliable modelling tools that allow to anticipate and estimate the energy efficiency of both the current status of and of hypothesized modifications of a building, be they related to the whole building or to just some parts of it. The 1st paper is about whole-building modelling, the 2nd is about combined space and water heating, and the 3rd is about FPTU (fan powered terminal units).

#### A Modularized Urban Scale Building Energy Modeling Framework Designed with an Open Mind (VC-21-C015)

*Xuechen Lei, Ph.D., Associate Member, Jeremy Lerond, Affiliate, Yunyang Ye, Ph.D., Associate Member and Jian Zhang, Ph.D., Member, Pacific Northwest National Laboratory, Richland, WA*

#### Modeling Modern, Residential, Combined Space and Water Heating Systems Using Energyplus (VC-21-C016)

*Aleksandr Fridlyand, Ph.D., Member<sup>1</sup>, Alejandro Baez Guada<sup>1</sup>, Tim Kingston, Member<sup>2</sup> and Paul Glanville, P.E., Associate Member<sup>3</sup>, (1)GTI, Des Plaines, IL, (2)GTI, United States of America, (3)Gas Technology Institute, Chicago, IL*

### Conference Paper Session 9 (Intermediate)

#### Best Operation and Intelligent Control Systems to Enhance Building Energy Efficiency While Guaranteeing the Indoor Desired Conditions

*Track: Building Performance and Commissioning for Operation and Management*

Buildings shelter people, goods and processes from the outdoor conditions because they create an indoor "protected" and proper environment, and this needs to occur at decreasing energy input.

ASHRAE Standard 100, Energy Efficiency in Existing Buildings, (1st paper) provides a methodology to increase the energy efficiency of existing building stock through best operation and maintenance procedures. The 2nd paper extends to the implementation of AI (artificial intelligence) to make buildings fully autonomous and energy-saver. Finally, the 3rd paper focusses on occupant-based control (OBC) for HVAC systems in typical academic buildings.

#### Autonomous Buildings Enable Energy Efficiency (VC-21-C018)

*Troy Harvey, Member, PassiveLogic, Salt Lake City, UT*

#### Applying ASHRAE Standard 100 to Real-World Building Data (VC-21-C017)

*Jamie Elizabeth Kono, P.E., Affiliate<sup>1</sup> and Noriaki Kono<sup>2</sup>, (1)Servidyne, Atlanta, GA, (2)Independent Researcher*

#### Implementation of Occupant-Based Control in Typical Academic Buildings (VC-21-C019)

*Yiyi Chu<sup>1</sup>, Debrudra Mitra<sup>2</sup> and Kristen Cetin, Ph.D., P.E., Member<sup>2</sup>, (1)Michigan State University, East Lansing, MI, (2)Michigan State University, United States of America*

### Conference Paper Session 10 (Intermediate)

#### PV Panels, PCM (Phase-change Materials), and the Effects of the Related Equipment on Building Energy Performances

*Track: Energy Conservation*

The first paper in this session explains how resilience can be obtained by connecting a 1MW PV to a natural gas micro-grid. The second paper describes the effects on a façade thermal performance of the air gaps between the PV panels and the walls required to dissipate the heat generated by BIPV (built-in PV). The third paper focuses on the effects on the building thermal performance of ventilated cavities behind the traditional external claddings. The 4th paper explains the adoption of innovative PCMs (phase-change materials) to retrofit and improve the energy performance of a small office building.

#### An Investigation on the Impact of Retrofitting the Envelope of a Typical Small Office Building with PCM on the Building Energy Efficiency in Different Zones of the US (VC-21-C020)

*Amin Hosseini, Student Member<sup>1</sup>, Pouya Ammari Azar<sup>2</sup> and Kim Yang-Seon<sup>2</sup>, (1)Wichita State university, Wichita, KS, (2)Wichita State university, United States of America*

#### Impact of the Ventilated Cavity on the Thermal Performance of Traditional Wall Structures (VC-21-C023)

*Mohammad Rahiminejad<sup>1</sup> and □Dolaana Khovalyg<sup>2</sup>, (1)École polytechnique fédérale de Lausanne, Lausanne, Switzerland, (2)École polytechnique fédérale de Lausanne, Switzerland*

**Dynamic Thermal Performance of the BIPV Facades (VC-21-C021)**

*Mohammad Rahiminejad<sup>1</sup>, Alexandre Louis Marie Pâris<sup>2</sup> and Dolaana Khovalyg, Ph.D., Associate Member<sup>2</sup>, (1)École polytechnique fédérale de Lausanne, Lausanne, Switzerland, (2)École polytechnique fédérale de Lausanne, Switzerland*

**Evaluating a 1MW Solar PV / Natural Gas Microgrid for Firm on-Peak Power and Resiliency: A Detailed Look at Lifecycle Cost and Performance (VC-21-C022)**

*Jim Leidel, Member, DTE Energy, Detroit, MI*

**Conference Paper Session 11 (Intermediate)**

**Ventilation Strategies to Mitigate the Transmission and Distribution of Airborne Contaminants and Pathogens**

*Track: Environmental Health Through IEQ*

The outbreak of COVID-19 has forced engineers to investigate ways to improve the resilience of building heating, ventilation, and air-conditioning (HVAC) systems to reduce the transmission of infections and contaminants. Conventionally HVAC systems are designed for thermal comfort and improved Indoor Air Quality (IAQ); however, this does not necessarily mitigate contaminant transmission. The papers in this session present different ventilation-based strategies to reduce the transmission and distribution of airborne pollutants and pathogens.

**Effects of Indoor Airflow and Ventilation Strategy on the Airborne Virus Transmission (VC-21-C025)**

*Gen Pei, Student Member<sup>1</sup> and Donghyun Rim, Associate Member<sup>2</sup>, (1)Pennsylvania State University, State College, PA, (2)Pennsylvania State University, University Park, PA*

**Using Dilution Factor to Characterize Aerosol Risk Management in Emergency Scenarios (VC-21-C027)**

*Travis Richard English, Kaiser Permanente, Oakland, CA*

**Comparison of Three Different Ventilation Approaches for an Open Office Space Regarding Pathogen Distribution and Thermal Comfort by CFD (VC-21-C024)**

*Maciej Danielak, Dr.Ing., Associate Member and Oliver Höfert, Dr.Ing., Kampmann, Lingen, Germany*

**Investigating Air Distribution Designs for DOAS Systems to Reduce Cross-Contamination in Open Offices (VC-21-C026)**

*Sama Aghniaey, Ph.D., Student Member<sup>1</sup>, John G. Williams<sup>2</sup> and Luis Rivera<sup>3</sup>, (1)Harris, Oakland, CA, (2)Harris, (3)Harris, design studio, Oakland, CA*

**Conference Paper Session 12 (Intermediate)**

**Novel Sensors, Control Strategies and Computational Methods for Improving Thermal Comfort**

*Track: Environmental Health Through IEQ*

Occupant thermal comfort and Indoor Air Quality (IAQ) are essential criteria for the design of heating, ventilation, air-conditioning (HVAC) systems, and their integration in the building. These metrics are even more critical in constrained spaces such as automotive or aircraft passenger cabins. The first paper in this session presents the monitoring and control capabilities of novel low-cost sensors integrated with building control systems to improve personalized thermal comfort. The second paper investigates thermal comfort and IAQ in widebody aircraft cabins using computational fluid dynamics.

**A Comparison Of Sensing Type And Control Complexity Techniques For Personalized Thermal Comfort (VC-21-C028)**

*Hejia Zhang, Athanasios Tzempelikos, Ph.D., Member, Michael Kim and Xiaoqi Liu, Student Member, Purdue University, United States of America*

**Numerical Investigation on the Effect of Stadium Outer Geometry on Cooling Load (VC-21-C030)**

*E. M. Elbially, Ph.D.<sup>1</sup> and Saud Ghani<sup>2</sup>, (1)Cairo University, Cairo, Egypt, (2)Qatar University, Qatar*

**Dynamic Mesh Analyses of Thermal Comfort of Passengers and IAQ In Wide Body Aircraft Cabins (VC-21-C029)**

*Essam Khalil, Ph.D., P.E., Fellow ASHRAE<sup>1</sup> and Hassan Ali<sup>2</sup>, (1)Cairo University, Cairo, Egypt, (2)Cairo University, Egypt*

**Conference Paper Session 13 (Intermediate)**

**Approaches for Maintaining Effective Ventilation and Avoiding Adverse Air Quality in Work Environments**

*Track: Environmental Health Through IEQ*

The presence of contaminants and volatile organics is a crucial concern for maintaining acceptable air quality in the indoor environment, particularly in less-open spaces such as offices, data centers, and hangars. The papers in this session focus on methods for assessing indoor air quality and computational fluid dynamics to model the dispersion and predict the concentration of contaminants.

**Review of the Effects of Indoor Air Quality on Occupants (VC-21-C033)**

*Mary Isabella Taylor, Student Member and Donghyun Rim, Associate Member, Penn State University, University Park, PA*

**Avoiding Adverse Air Quality in Hyperscale Data Centers Due to Re-entrainment of Diesel Exhaust (VC-21-C031)**

*Brad Cochran, P.E., Member, CPP, Inc, Fort Collins, CO*

**Effective and Efficient Ventilation for a Healthy Work Environment during Aircraft Painting (VC-21-C032)**

*James Bennett, Ph.D., Member, Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH), Cincinnati, OH*

**Conference Paper Session 14 (Intermediate)**

**Applications of Computational Fluid Dynamics to Evaluate and Improve Ventilation**

*Track: Environmental Health Through IEQ*

Computational Fluid Dynamics (CFD) is a useful tool for HVAC&R engineers and has been used to analyze everything from fundamental fluid flow in a channel to airflow around buildings. This session presents different applications of CFD, focusing on optimal ventilation and temperature distribution. The impact of supply airflow rates, exhaust, and makeup air locations are evaluated. A new metric representing the spread of carbon-monoxide is introduced to assess ventilation effectiveness.

**A Combined Study of Heat Transfer and Temperature Distribution Inside Heated Double-Wall Infant Incubator Using CFD (VC-21-C034)**

*Ahmed Yasser, Member<sup>1</sup> and Dr.Hesham Safwat Osman, Member<sup>2</sup>, (1)British university in Egypt, cairo, Egypt, (2)British university in Egypt, Cairo, Egypt*

**CFD Investigation of the Optimal Ventilation System for a Single-Family Room Neonatal Intensive Care Unit (VC-21-C036)**

*Dr.Hesham Safwat Osman, Member<sup>1</sup>, Prof. Ahmed M.R. Elbaz, Ph.D.<sup>2</sup> and Ahmed Hossam Antar, Student Member<sup>3</sup>, (1)British University in Egypt; ASHRAE Cairo Chapter, Cairo, Egypt, (2)British University in Egypt, Cairo, Egypt, (3)ASHRAE Cairo Chapter and ASHRAE BUE (British University in Egypt Student Branch), Cairo, Egypt*

**CFD Analysis of Enclosed Parking Garage Ventilation (VC-21-C035)**

*Kishor Khankari, Ph.D., Fellow ASHRAE, AnSight LLC, Ann Arbor, MI*

**Conference Paper Session 15 (Intermediate)**

**Recent Developments in Vapor Absorption and Vapor Compression Systems**

*Track: HVAC&R Fundamentals and Applications*

Absorption refrigeration has been widely considered an environmentally friendly cooling process. Working fluids for absorption systems and their control has been a research focus for decades. The first paper in this session presents a systematic approach for evaluating different working fluid mixtures for absorption systems. The second paper focuses on using model predictive control of absorption systems. The other papers in this session focus on conventional vapor compression technologies. The third paper focuses on oil retention in unitary split systems with HFC and HFO refrigerants. The fourth paper presents a novel ejector-based refrigeration cycle using propane.

**Investigation of a Novel Ejector-Based R-290 Refrigeration Cycle Architecture (VC-21-C037)**

*Junyan Ren<sup>1</sup>, Riley B. Barta, Student Member<sup>1</sup>, Davide Ziviani, Ph.D., Member<sup>2</sup>, Eckhard A. Groll<sup>1</sup>, David Ladd<sup>3</sup>, Christine Knox<sup>3</sup> and Gagan Salh<sup>3</sup>, (1)Ray W. Herrick Laboratories, Purdue University, United States of America, (2)Ray W. Herrick Laboratories, Purdue University, West Lafayette, IN, (3)Bechtel Oil, Gas & Chemicals, United States of America*

**Study Of Oil Retention In Unitary Split System Gas Lines With HFC And HFO Refrigerants (VC-21-C039)**

*Vatsal Shah, Student Member, James E. Braun and Eckhard A. Groll, Purdue University, West Lafayette, IN*

**Model Predictive Control Performance Assessment of Absorption Refrigeration Cycles Utilizing Different Working Fluids (VC-21-C038)**

*Athanasios Papadopoulos<sup>1</sup>, Alexios-Spyridon Kyriakides<sup>2</sup>, Thomas Prousalis<sup>1</sup>, Ibrahim Hassan, Ph.D., P.E., Member<sup>3</sup> and Panos Seferlis, Ph.D.<sup>1</sup>, (1)Centre for Research and Technology Hellas, Thessaloniki, Greece, (2)Centre for Research and Technology Hellas, Greece, (3)Mechanical Engineering Department, Texas A&M at Qatar, Education City, Qatar*

### **Systematic Assessment of Working Fluid Mixtures for Absorption Refrigeration based on Process and Sustainability Indicators (VC-21-C040)**

*Athanasios Papadopoulos<sup>1</sup>, Alexios-Spyridon Kyriakides<sup>2</sup>, Vassilis Champilomatis<sup>2</sup>, Alexandros Giannakakis<sup>2</sup>, Vergis Kousidis<sup>2</sup>, Mirko Stijepovic<sup>2</sup>, Ibrahim Hassan, Ph.D., P.E., Member<sup>2</sup> and Panos Seferlis, Ph.D.<sup>1</sup>, (1)Centre for Research and Technology Hellas, Thessaloniki, Greece, (2)Centre for Research and Technology Hellas, Greece*

### **Conference Paper Session 16 (Intermediate)**

#### **Air Mixing, Energy Recovery, Duct Sizing, Fire Propagation in Railcars: Descriptions, Analyses and Solutions**

*Track: Systems and Equipment*

This session covers a wide spectrum of topics all related to air flow and energy.

Starting with performance testing of mixing devices (1st paper), the attendee may learn how sensible and latent energy can be recovered by membrane energy recovery devices (2nd paper). The 3rd paper presents an algorithm that can be used to size a round duct for a given friction rate, whereas the 4th paper examines the effect of some environmental conditions on fire propagation between multi-carriage railcars.

#### **Sizing Ducts Based on a Prescribed Friction Rate (VC-21-008)**

*Stephen Idem, Ph.D., Member and Chaitanya Kodali, Tennessee Tech University, Cookeville, TN*

#### **Using Normalized Net Energy Savings to Effectively Size Membrane-Based Energy Recovery Ventilation Systems (VC-21-C042)**

*Sancheyan Pushparajah<sup>1</sup>, Patrick Ryan<sup>2</sup>, Krzysztof Kobus, Ph.D., Member<sup>1</sup> and Jonathan Maisonneuve, Ph.D., Associate Member<sup>1</sup>, (1)Oakland University, Rochester, MI, (2)DTE Energy Co., Detroit, MI*

#### **Fire Propagation in Rail Environments (VC-21-C041)**

*Xinhe (Lily) Liu, Affiliate<sup>1</sup>, Emil Persson<sup>2</sup> and Matthew Bilson<sup>2</sup>, (1)WSP USA, New York, NY, (2)WSP, United States of America*

### **Conference Paper Session 17 (Intermediate)**

#### **Energy Saving by Absorption Heat Pumps and from Increased Knowledge of Condensers and Evaporators**

*Track: Energy Conservation*

Direct-fired absorption heat pumps, providing hot water and A/C, help save energy and money in facilities operating for most of the day, for instance, in full-service restaurant (1st paper). The energy-saving potential stemming from better knowledge of the heat transfer processes occurring in round-tube plate-fin and plate heat exchangers are presented in the 2nd and 3rd paper, respectively.

#### **New Method to Simultaneously Measure Local Heat Transfer Coefficient and Visualize Flow Regimes During Evaporation in the Plate Heat Exchanger - Validation and Accuracy (VC-21-C045)**

*Abdel-Rahman D. Farraj, Student Member and Pega Hrnjak, Ph.D., Fellow ASHRAE, University of Illinois at Urbana-Champaign, Urbana, IL*

#### **Investigation of Heat Transfer Correlation Comparisons in a Commercial Round-Tube Plate-Fin Condenser (VC-21-C044)**

*Timothy Paul Fair, Robert J. Bedard, Anthony J. Bowman, Ph.D. and Hyunjae Park, Marquette University, United States of America*

#### **Demonstrating an Integrated Thermal Heat Pump System for Hot Water and Air-Conditioning at Full Service Restaurants (VC-21-C043)**

*Paul Glanville, P.E., Associate Member<sup>1</sup>, Isaac Mahderekal, Ph.D., Member<sup>2</sup>, Michael Mensinger Jr.<sup>2</sup>, Luke Bingham<sup>3</sup> and Chris Keinath, Ph.D., Member<sup>4</sup>, (1)SMTI, Johnson City, TN, (2)GTI, United States of America, (3)GTI, Chicago, IL, (4)SMTI, United States of America*

### **Conference Paper Session 18 (Intermediate)**

#### **Modelling for the Estimation of Energy Performance of Buildings and Products**

*Track: Building Performance and Commissioning for Operation and Management*

Buildings and HVAC systems are fundamental for the comfort of people and to guarantee the proper space conditions for a variety of processes. The first paper describes the building design methods of Standard 90.1-2016. The second paper explains how the actual consumption values can be measured on-site through sensors and monitoring systems. Papers two and three shed



light on how fan coils can be modelled to predict their energy consumption. Finally, paper #5 presents the updated database of western clothing as used in ANSI/ASHRAE Standard 55-2013 to estimate the comfort level of persons in a conditioned space.

**A Simple Airflow and Power Analysis of Fan-Coil Units with Electronically Commutated Motors (VC-21-009)**

*Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE<sup>1</sup>, Jessica Cramer<sup>1</sup> and Peng Yin, Ph.D., Associate Member<sup>2</sup>, (1)Baylor University, Waco, TX, (2)University of Louisiana at Lafayette, Lafayette, LA*

**Updated Database of Clothing Thermal Insulation and Vapor Permeability Values of Western Ensembles for Use in ASHRAE Standard 55, ISO 7730 and ISO 9920; Results of ASHRAE RP-1760 (VC-21-011)**

*George Havenith, Ph.D.<sup>1</sup>, Simon Hodder, Ph.D.<sup>2</sup>, Kaley Kuklane<sup>3</sup> and Dennis Loveday, Ph.D.<sup>2</sup>, (1)Loughborough University, Loughborough, Leics, United Kingdom, (2)Loughborough University, Loughborough, United Kingdom, (3)Lund University, Lund, Sweden*

**Part-Load Airflow and Power Model of Multi-Speed Fan-Coil Units with Electronically Commutated Motors (VC-21-010)**

*Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE<sup>1</sup>, Jessica Cramer<sup>1</sup> and Peng Yin, Ph.D., Associate Member<sup>2</sup>, (1)Baylor University, Waco, TX, (2)University of Louisiana at Lafayette, Lafayette, LA*

**Challenges with the New ASHRAE 90.1 Performance Rating Method (VC-21-C046)**

*Jagan S. Pillai, P.E., BEMP, Member<sup>1</sup>, Devanshi Dadia<sup>2</sup>, Shivani Shah, Member<sup>2</sup> and Jennifer Chalos<sup>2</sup>, (1)Atelier Ten, New York, NY, (2)Atelier Ten, United States of America*

**Comparison of Modeling Techniques for Predicting Energy and Power Demand in 40 Campus Buildings (VC-21-C047)**

*Vahid AhmadiKalkhorani, Student Member<sup>1</sup> and Jordan Clark, Ph.D., Member<sup>2</sup>, (1)The Ohio State University, Columbus, OH, (2)Ohio State University, Columbus, OH*

## Conference Paper Session 19 (Intermediate)

### Standards and Protocols for Buildings' Energy and Water Usages

*Track: Standards, Guidelines and Codes*

Buildings use not only energy to run their technical systems (HVAC, lighting, etc.) but also water, be it for human consumption, or for HVAC purposes, or for its landscape. This session presents Building Performance Standards (BPS) focusing on building energy usage (1st paper), on performance methods to measure air leakages (2nd paper), and on Performance Measurement Protocols (PMP) to measure water consumption in commercial buildings.

**Implementation and Evaluation of ASHRAE's Water Performance Measurement Protocols (VC-21-012)**

*Gabrielle McMorro<sup>1</sup>, Liping Wang, Ph.D., P.E., Member<sup>1</sup> and Xiaohui Zhou, Ph.D., P.E., Member<sup>2</sup>, (1)University of Wyoming, Laramie, WY, (2)Seventh Wave, Madison, WI*

**Advanced Zonal Infiltration Measurement Method for Multifamily Buildings: A Novel Test Procedure to Determine Air Leakage Through External and Internal Surfaces (VC-21-C048)**

*Tharanga Jayarathne, Student Member<sup>1</sup>, Michael A. Browne<sup>2</sup> and Michael Gevelber, Ph.D., Member<sup>1</sup>, (1)Boston University, Boston, MA, (2)Advanced Building Analysis, Amesbury, MA*

**The Technical Basis Of Building Performance Standards (VC-21-C049)**

*Jim Edelson, Associate Member<sup>1</sup> and Kim Cheslak<sup>2</sup>, (1)New Buildings Institute, Portland, OR, (2)New Buildings Institute, United States of America*

## Conference Paper Session 20 (Intermediate)

### Handling Environmental Effects on Ventilation Systems

*Track: Environmental Health Through IEQ*

Ventilation systems are designed to serve spaces for a variety of purposes which can be grouped as IEQ at large (comfort, health, proper process conditions) or safety. The first and second papers explain how HVAC systems can automatically handle human intervention to their set points while delivering the required IEQ. The third paper, instead, focuses on how fire-detection systems for rail tunnels can control ventilation to guarantee safety notwithstanding the various stimuli that may affect the detection abilities.

**Global Environmental Stimuli and Human-Building Interaction in Open Space Offices: A Swiss Case Study (VC-21-C051)**

*Verena M. Barthelmes, Ph.D.<sup>1</sup>, Caroline Karmann, Ph.D.<sup>1</sup>, Viviana Gonzalez Serrano<sup>1</sup>, Arnab Chatterjee<sup>2</sup>, Marilynne Andersen, Ph.D.<sup>1</sup>, Jan Wienold, Ph.D.<sup>1</sup>, Dusan Licina, Ph.D., Associate Member<sup>1</sup> and Dolaana Khovalyg, Ph.D., Associate Member<sup>2</sup>, (1)EPFL, Switzerland, Fribourg, Switzerland, (2)EPFL, Switzerland, Switzerland*

**Fire Detection and Ventilation Response in Rail Tunnels (VC-21-C050)**

*Andre Calado, Member, Jacobs Engineering, New York, NY*

## **Investigating Occupant Behaviour to Inform Terminal Devices' Control in Mixed-mode Ventilation Buildings (VC-21-C052)**

**Weihao Liu, Student Member<sup>1</sup>, Burak Gunay, Ph.D., Associate Member<sup>1</sup> and Mohamed Ouf, Associate Member<sup>2</sup>, (1)Carleton University, Ottawa, ON, Canada, (2)Concordia University, Montreal, QC, Canada**

## **Conference Paper Session 21 (Intermediate)**

### **Air Filters and Motors in HVAC Systems**

*Track: HVAC&R Fundamentals and Applications*

Air filters play an essential role in the built environment with an increased emphasis on filtering technologies to improve filtering efficiency and capture capabilities. The first paper investigates the use of nanofiber media to filter particles from burning incense. Photocatalytic oxidation (PCO) based air filters are also gaining attention but have been slow to commercialize due to the formation of undesired by-products and unknown health effects. The second paper presents a model that can predict the possibility of by-product types and concentration once the operational conditions for the PCO are known. The remaining papers focus on variable frequency drives (VFD).

### **Experimental Investigation of Induction Motor Power Factor and Efficiency Impacted by Pulse Width Modulation Power and Voltage Controls of Variable Frequency Drives (VC-21-013)**

**Gang Wang, P.E., Member<sup>1</sup> and Zhitao Han<sup>2</sup>, (1)University of Miami, Coral Gables, FL, (2)Northeast Forestry University, Harbin, China**

### **A Technology Review of Harmonics in HVAC Applications (VC-21-C053)**

**Ian Wallace<sup>1</sup>, Theresa Hietpas<sup>2</sup> and Ashish Bendre, Ph.D.<sup>1</sup>, (1)TCI, LLC, Milwaukee, WI, (2)TCI, LLC, United States of America**

### **Gaseous By-Products Generated from UV-PCO Process: A Review (VC-21-C055)**

**Jing Wu, Student Member, Anu Stella Mathews, Ph.D., Member and Lexuan Zhong, Ph.D., P.E., Member, University of Alberta, Edmonton, AB, Canada**

### **Exploring the Long-term Performance of Nanofiber Filter Media Capturing Incense Particles (VC-21-C054)**

**Tongling Xia, Student Member and Chun Chen, Ph.D., Associate Member, The Chinese University of Hong Kong, Hong Kong, China**

## **Conference Paper Session 22 (Intermediate)**

### **Heat Pump Feasibility and Field Issues**

*Track: HVAC&R Fundamentals and Applications*

The first paper in this session presents a study that performed a county-level analysis to identify the economically favorable regions in the U.S. for using ducted air-source heat pumps for space heating in residential buildings. The second paper in this session presents a modified heat pump cycle that aims at providing continuous heating operation even below the freezing point, which was not possible with conventional processes. The third paper presents an experimental study to evaluate the impact of frost among heat exchanger fin types and densities under multiple air moisture conditions.

### **Experimental Evaluation of Frost Development on Tube-Fin Heat Exchangers: Fin Types, Fin Densities, SuperHydrophobic and Icephobic Coatings (VC-21-C058)**

**Sara S. Beaini, Ph.D., Member<sup>1</sup>, Song Li, Associate Member<sup>2</sup>, Daniel Bacellar<sup>3</sup>, Colin Lee<sup>1</sup>, Evan Hess<sup>1</sup>, Dennis Nasuta, Associate Member<sup>4</sup>, Cara Martin, BEMP, Associate Member<sup>3</sup> and James Leverette<sup>5</sup>, (1)Electric Power Research Institute, Palo Alto, CA, (2)Optimized Thermal Systems, College Park, MD, (3)Optimized Thermal Systems, Inc, College Park, MD, (4)Optimized Thermal Systems, Inc, Beltsville, MD, (5)Southern Company Services, Inc., Birmingham, AL**

### **Where Are Today's Residential Heat Pump Technologies Cost-Effective? (VC-21-C059)**

**Brandon Johnson and Sreenidhi Krishnamoorthy, Electric Power Research Institute, Knoxville, TN**

### **Development of a Continuous Heating Technology for Air Source Heat Pumps (VC-21-C057)**

**Naofumi Takenaka<sup>1</sup>, Kazuya Watanabe<sup>2</sup>, Takeshi Hatomura<sup>3</sup>, Shohei Ishimura<sup>1</sup> and Shinichi Wakamoto<sup>3</sup>, (1)Mitsubishi Electric Corporation, Amagasaki, Japan, (2)Mitsubishi Electric Corporation, Shizuoka, Japan, (3)Mitsubishi Electric Corporation, Wakayama, Japan**

### **Assessment of Mini-Split Heat Pump Performance with Non-Condensable Gas in Line-Set (VC-21-C056)**

**Aaron Tam<sup>1</sup> and Ronald Domitrovic<sup>2</sup>, (1)Electric Power Research Institute, Palo Alto, CA, (2)Electric Power Research Institute, United States of America**

## Conference Paper Session 23 (Intermediate)

### Developments in Chiller System Operations

*Track: Refrigeration and Refrigerants*

The first paper in this session presents some generalized key variables to obtain near-optimal condenser water control strategies applicable to typical installations. The second paper presents a review of the operational strategy to reduce the stress and impact of mode transitions in chillers and improve winter and shoulder season operation. The third paper presents data-driven modeling and optimization techniques to accurately predict the performance of chilled-water VAV air-handling units, demonstrating significant energy savings. Finally, the last paper presents a field test of a novel hygroscopic cooling tower technology that can reduce water demand without compromising cooling performance.

#### **Easing Transitions between Flat Plate and Chiller: Strategies to Reduce Chiller Surge and Maintain Building Load Efficiently (VC-21-C063)**

*Bryan Lang, P.E., Member and Chris Jackson, P.E., ETC Group, LLC, Tempe, AZ*

#### **Demonstration of Hygroscopic Cooling Towers for Reduced HVAC Water Consumption (VC-21-C062)**

*Scott Lux<sup>1</sup> and Christopher Martin<sup>2</sup>, (1)U.S. Army ERDC-CERL, Champaign, IL, (2)Energy & Environmental Research Center*

#### **Chilled Water VAV Systems Operation Optimization Using a Two-Level Optimization Approach (VC-21-C060)**

*Rand Talib, Student Member<sup>1</sup>, Nabil Nassif<sup>2</sup> and Mostafa Tahmasebi<sup>2</sup>, (1)University of Cincinnati, Cincinnati, OH, Cincinnati, OH, (2)University of Cincinnati, Cincinnati, OH, United States of America*

#### **Condenser Water Optimization: Don't Let Perfect Be The Enemy Of Good! (VC-21-C061)**

*AbdulQayyum Mohammed<sup>1</sup>, Mohamed Tatari<sup>2</sup> and Neil Wittberg<sup>1</sup>, (1)Go Sustainable Energy LLC, Worthington, OH, (2)Go Sustainable Energy LLC, United States of America*

## Conference Paper Session 24 (Intermediate)

### Superheat Regulation, Radiant Systems and District Energy Systems

*Track: Systems and Equipment*

The first paper in this session presents a novel method for improved superheat control by adding an intermediary heat exchanger to the vapor compression cycle. The second paper demonstrates the use of PCM integrated with a radiant heating system to enhance the operating time. The third paper details a laboratory study that explores a radiant wall system's performance in which pipes are attached to a thermally insulating core. The final paper evaluates a heuristic for network topology optimization for advanced district thermal energy systems to improve the integration of renewable thermal and waste heat sources.

#### **Evaluation of Topology Optimization to Achieve Energy Savings at the Urban District Level (VC-21-C064)**

*Amy Elizabeth Allen<sup>1</sup>, Gregor Henze, Ph.D., P.E., Member<sup>2</sup>, Kyri Baker, Ph.D.<sup>2</sup>, Gregory Pavlak, Ph.D., Member<sup>3</sup> and Michael Murphy<sup>4</sup>, (1)University of Colorado/NREL, United States of America, (2)Department of Civil, Environmental, and Architectural Engineering, University of Colorado-Boulder; Commercial Buildings Research Group, National Renewable Energy Laboratory; Renewable and Sustainable Energy Institute, (3)Department of Architectural Engineering, Pennsylvania State University, State College, PA, (4)Cork Institute of Technology*

#### **Integration of High Temperature Heat Networks with Low Carbon Ambient Loop Systems (VC-21-C065)**

*Ana Catarina Marques, Ph.D.<sup>1</sup>, Chris Dunham<sup>2</sup>, Akos Revesz, Ph.D., Affiliate<sup>1</sup>, Phil Jones, Ph.D.<sup>3</sup> and Graeme Maidment, Ph.D., P.E.<sup>1</sup>, (1)London South Bank University, London, United Kingdom, (2)Carbon Descent Projects, chrisd@carbondescent.org.uk, (3)London South Bank University*

#### **Testing of a Wall Heating and Cooling System with Pipes Attached to Thermally Insulating Core (VC-21-C067)**

*Dušan Petráš, Ph.D., Member, Michal Krajčik and Martin Šimko, Slovak University of Technology, Faculty of Civil Engineering, Slovak Republic*

#### **Superheat Regulation and Efficiency Improvement for Refrigeration Vapor Compression System (VC-21-C066)**

*Mohamad Yehia Itani, P.Eng., Member, Climacond Middle East SAL, Beirut, Lebanon*

#### **Time-Lag Analysis of PCM in Floor Radiant Heating System (VC-21-C068)**

*Jin Chul Park, Ph.D., BEAP, BEMP and HBDP, Member, Seong eun Kim and Sung ho Choi, Chung-Ang University, Seoul, Korea, Republic of (South Korea)*

## Conference Paper Session 25 (Intermediate)

### Building Design: International Perspective

*Track: International Design*

This session highlights applications and lessons learned in building design from an international perspective. The first paper describes applying a new combination HVAC system utilizing exhaust heat recovery in through-wall units for a tenant office building in Japan. This novel system integration yields superior comfort and air quality. The second paper presents a case study

on operational displacement ventilation systems in an auditorium in Beirut. The third paper explains the influence of the new EU Cybersecurity Act on internet-connected HVAC&R products. The article describes how different segments and product groups fall under this legislation now and in the future.

**Displacement Ventilation System for High-Ceiling Auditorium: Design Implementation and Construction Challenges (VC-21-C070)**

*Hassan Chehade Sr., P.Eng., Member<sup>1</sup>, Mohamad Yehia Itani, P.Eng., Member<sup>2</sup> and Adnan Akhdar, P.Eng.<sup>3</sup>, (1)Khatib & Alami, Beirut, Lebanon (Lebanese Republic), (2)Climacond Middle East SAL, Beirut, Lebanon, (3)Dar Al-Handasah, Beirut, Lebanon*

**A New HVAC System for Resiliency and Ecology Utilizing Through-Wall Units on A High-rise Office Building (VC-21-C069)**

*Hirota Kubo, Associate Member<sup>1</sup>, Shiro Tsukami, BCxP, BEAP, BEMP, HBDP, HFDP and OPMP, Member<sup>2</sup>, Iwao Hasegawa, Associate Member<sup>2</sup> and Masayuki Ichinose<sup>3</sup>, (1)NIKKEN SEKKEI LTD, Tokyo, Japan, (2)NIKKEN SEKKEI LTD, Chiyoda-ku Tokyo, Japan, (3)Tokyo Metropolitan University, Hachioji-shi Tokyo, Japan*

**Conference Paper Session 26 (Intermediate)**

**Improving performance of systems and equipment**

*Track: Systems and Equipment*

Anything can be improved to yield better performances, in particular for what regards HVAC systems, about energy and related GHG emissions. This session highlights a study on a higher uptake of renewables in Alberta, Canada to grow fresh produce for a local community while saving on fossil fuels (first paper). The second paper explains how nanofluids can be used to enhance the thermal properties of solar assisted water heaters. The third paper describes the so-called inlet duct effects on the performance of indoor AHUs.

**Thermodynamic Evaluation of Solar Assisted Water Heaters Using Aluminum Oxide Nanofluid (VC-21-C073)**

*Tarashri Anand Tirtha, Student Member<sup>1</sup> and Amir Fartaj, Ph.D., P.E., Member<sup>2</sup>, (1)University of Windsor, Windsor, ON, Canada, (2)University of Windsor, Windsor, ON, Canada*

**Effect of Inlet Duct Design on Fan Performance of Indoor Air Handling Units (ASHRAE RP-1743) (VC-21-C071)**

*Khaled Alghamdi, Student Member<sup>1</sup> and Christian Bach<sup>2</sup>, (1)Oklahoma State University, Stillwater, OK, (2)Oklahoma State University, United States of America*

**Retrofitting a Light Industrial Space with a Renewable Energy-Assisted Hydroponics Facility in a Rural Northern Canadian Community: Design Protocol (VC-21-C072)**

*Artur Udovichenko, Student Member, Brian Fleck, Tim Weis and Lexuan Zhong, Ph.D., P.E., Member, University of Alberta, Edmonton, AB, Canada*

**Seminar**

**Seminar 36 (Intermediate)**

**A Revolution in Buildings: Prefabricated Radiant Structures**

*Track: Systems and Equipment*

**Sponsor: 6.5 Radiant Heating and Cooling**

*Chair: Paul Raftery, Ph.D., Member, University of California, Berkeley, CA*

This seminar describes recent advances in prefabricated structures that incorporate embedded radiant systems, typically as part of an offsite manufacturing process. The seminar will present case study buildings that use either a prefabricated concrete or mass timber slab constructions in Germany, California, and Canada. This integrated design and construction technique has the potential to dramatically improve construction speed and reduce costs associated with installing this low temperature heating and cooling system.

**Integrating Radiant Panels with Offsite Construction**

*Devin Abellon, P.E., Member, Uponor, Phoenix, AZ*

**New Wave: Innovating with Radiant Systems and Prefabricated Mass Timber**

*Stuart Bridgett, Associate Member, Sidewalk Labs, New York, NY*

**Radiant Cooling and Heating in Modular Construction**

*Brendan McDermott, Associate Member, DMA Heating and Cooling Systems Inc., Toronto, ON, Canada*

## Seminar 37 (Basic)

### ASHRAE Conference Crash Course

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: YEA**

*Chair: Rachel Romero, P.E., Member, National Renewable Energy Laboratory, Golden, CO*

First time at an ASHRAE Conference? Been coming for years, but still confused? What is a TC? What is a Standing Committee? Who can attend what? What is the AHR Expo? And why is all this happening at once? This crash course provides all attendees with an introduction to the organization and all the ASHRAE Conference activities, explains how you can get involved, and allows you to ask questions to experienced attendees.

#### **The Ins and Outs of ASHRAE**

*Jessica Renner, P.E., BEMP, Member, Energy Studio, Inc, Omaha, NE*

#### **Make the Most of Your Conference Experience**

*Madison Schultz, P.E., Member, OK BeCo, Oklahoma City, OK*

## Seminar 38 (Intermediate)

### Best Option for Demand Flexible, Grid Interactive Energy Efficient Buildings: Rule Based Algorithmic Controls or Model Predictive Controls?

*Track: Energy Conservation*

**Sponsor: 1.4 Control Theory and Application**

*Chair: Paul Ehrlich, P.E., Member, Building Intelligence Group, Portland, OR*

Grid Interactive Energy Efficient Buildings will require control systems that are able to provide for a safe, comfortable and efficient building environment while at the same time coordinating the operation of the building with the needs of the grid. The use of new technology including model predictive control can provide solutions that are able to both control and estimate future needs using data and simplified building models. On the other hand, traditional control systems, already prevalent in the commercial building stock, utilize rule-based controls that are less flexible and while they can provide grid interaction may be less than optimal.

#### **Why and How You Should Make Model-Based Predictive Control Work for You?**

*Draguna Vrabie, Ph.D., Pacific Northwest National Laboratory, United States of America, Richland, WA*

#### **Foundations of Autonomous Building Systems Using Digital Twin Based Control.**

*Troy Harvey, Member, PassiveLogic, Salt Lake City, UT*

#### **A Use Case Perspective on Building Controls: MPC and Rule Based Methodology and Practice**

*Joseph Noworatzky, Automated Logic / Carrier, Marietta, GA*

## Seminar 39 (Intermediate)

### Bridging Two Worlds: Standards, Guidelines and Codes for Solar Energy Systems in Buildings

*Track: Standards, Guidelines and Codes*

**Sponsor: 6.7 Solar Energy Utilization, 4.5 Fenestration**

*Chair: Ahmed Elatar, Ph.D., Oak Ridge National Laboratory, Oak Ridge, TN*

As buildings rapidly transition toward net-zero energy, carbon neutral performance targets, on-site renewable energy generation will become compulsory. The development of new standards, codes and guidelines for solar energy systems in buildings are the cornerstone for achieving these goals. Through this seminar, the attendees will gain an understanding of (i) regulatory and technical challenges for the development and adoption of standards, guidelines and codes for solar systems in buildings, (ii) the impact of PV windows on building energy performance and occupant comfort and (iii) the recovery time of embodied energy from operational energy savings for popular solar systems.

#### **The Dawn of PV Windows: Is the World of Standards and Codes Ready for Them?**

*Charlie Curcija, Ph.D., Member, Lawrence Berkeley National Lab, Berkeley, CA*

#### **Embodied Energy for Solar Energy Systems in Buildings: Operational Savings and Recovery Time Guidelines**

*Constantinos Balaras, Ph.D., Fellow ASHRAE, National Observatory of Athens (NOA), Athens, Greece*

### Seminar 40 (Intermediate)

## Building-Integrated Photovoltaic Envelope for Cold Climates: Here Comes the Power of the Sun

*Track: International Design*

**Sponsor: 6.7 Solar Energy Utilization, 4.4, 7.6**

*Chair: Costa Kapsis, Ph.D., Associate Member, University of Waterloo, Waterloo, ON, Canada*

As global efforts on the electrification of the built environment intensify, buildings are expected to become flexible and provide different services to the grid, including energy. Building-Integrated Photovoltaic (BIPV) will play a key role to achieve such transformation. In addition to electricity production, BIPV also enhance functions of the building envelope and HVAC while maintaining an aesthetically pleasing architecture. The objective of this seminar is to discuss the technical design and implementation challenges of BIPV for cold climates, through three Canadian case studies. In this seminar, the attendees will gain an understanding of (i)BIPV design (ii)implementation challenges, and (iii)technical solutions.

**BIPV for Net-Zero Energy Institutional Building: Energy Efficiency, Energy Conservation and Solar Energy Generation**

*Andreas Athienitis, Ph.D., P.E., Fellow ASHRAE, Concordia University, Montreal, QC, Canada*

**BIPV for Industrial Buildings: When the Photovoltaic Envelope Becomes Part of the HVAC System**

*Véronique Delisle, Ph.D., Natural Resources Canada, Varennes, QC, Canada*

**BIPV for Convention Center Retrofit: Balancing Solar Gains and Solar Electricity Generation**

*Diego Cueva, Onyx Solar, New York, NY*

### Seminar 42 (Intermediate)

## Controls: Can't We All Just Get Along?

*Track: Building Performance and Commissioning for Operation and Management*

*Chair: James Vallort, P.E., Member, Environmental Systems Design, Chicago, IL*

BAS Integration: the challenges of how to get into the project properly, get it to work at startup and, then, fix it afterwards when it breaks down.

### Seminar 43 (Advanced)

## Current Understanding and Gaps of Stability and Compatibility of Low GWP Refrigerants

*Track: Refrigeration and Refrigerants*

**Sponsor: 3.2 Refrigerant System Chemistry**

*Chair: Brad Boggess, Member, Emerson Climate Technologies, Sidney, OH*

Increasing concerns about the impact of refrigerants on the environment are driving new regulatory policies to restrict and lower the global warming potential (GWP) impact of fluorocarbon refrigerants used in the HVAC&R industry. In response, the industry is developing and examining a new class of lower GWP refrigerants, many of which are potentially less stable chemistry. As this transition moves forward, many questions exist about chemical stability and materials compatibility of these molecules in these applications. This seminar will highlight research of these next-generation refrigerants and how they interact with common materials of construction and chemicals.

**An Update on Low GWP Refrigerant Material Compatibility and Lubricant Research**

*Xudong Wang, Ph.D., Member, Air-Conditioning, Heating and Refrigeration Technology Institute, Arlington, VA*

**A Review of the Compatibility of Low GWP Refrigerants with Plastics, Elastomers and Compressor Materials**

*Rosine Rohatgi, Ph.D., Member, Spauschus Associates Inc., Atlanta, GA*

**A Review of the Thermal Stability of Low GWP Refrigerants and Their Compatibility with Lubricants**

*Rosine Rohatgi, Ph.D., Member, Spauschus Associates Inc., Atlanta, GA*

**Understanding Stability Limits and System Chemistry in Low GWP Refrigerant Applications**

*Joe Karnaz, DSc, Member, Shrieve Chemical, Houston, TX*

### Seminar 44 (Intermediate)

## Decarbonization and Electrification of the Built Environment: Designing Canada's Future Urban Communities

*Track: International Design*

**Sponsor: 6.7 Solar Energy Utilization, 2.5, 7.5**

*Chair: Konstantinos Kapsis, Ph.D., Associate Member, University of Waterloo, Waterloo, ON, Canada*

Communities are built on connections and interactions. As our buildings and cities become more intelligent, these connections and interactions will be critical in mitigating impact on climate change. The objective of this seminar is to provide insights to the deployment of smart grid technologies through two Canadian smart community design case studies. While the communities are in Canada, the innovative strategies and design principles presented can be virtually implemented in urban communities around the globe. In this seminar, the attendees will gain an understanding of (i) smart grid operation principles (ii) design and implementation challenges, and (iii) effective technical solutions.

#### **Transforming a City into an Interactive Grid**

*Dave Turcotte, Natural Resources Canada, Varennes, QC, Canada*

#### **Building the Future through Canada's First Net-Zero Community**

*Milfred Hammerbacher, S2E, St Jacobs, ON, Canada*

### **Seminar 45 (Basic)**

#### **Demystifying Thermal Load Calculations for New HVAC&R Engineers**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 4.1 Load Calculation Data and Procedures**

*Chair: Rachel Spitzer, Associate Member, Cyntergy, Tulsa, OK*

Load calculations are one of the first tasks young engineers are assigned, but they can be intimidating to tackle. This seminar seeks to provide a clear foundation in load calculations for those new to the industry. Topics covered in this seminar include the history of and science supporting load calculations, helpful resources and tips to remember, as well as how to manage uncertainties and common pitfalls to avoid.

#### **Introduction to HVAC Heating and Cooling Loads' Calculations**

*Brian Rock, Ph.D., P.E., Fellow ASHRAE, The University of Kansas, Lawrence, KS*

#### **Resources and Guidelines for Load Calculations**

*Vrunda Patel, Associate Member, Jacobs, Dallas, TX*

#### **Avoiding Pitfalls and Managing Uncertainties: Tips for Better Loads**

*Cindy Cogil, P.E., Member, SmithGroup, Chicago, IL*

### **Seminar 47 (Intermediate)**

#### **Design to Achieve Net-Zero: Data Sharing and Interoperability Between Building Asset, Design, Rating and Analysis Software Tools**

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 7.6 Building Energy Performance, 1.5 Computer Applications**

*Chair: Stephen Roth, P.E., Member, Carmel Software, San Rafael, CA*

The term "building data exchange" has been used for a decade to describe the transfer of data between different software tools used during various stages of building design. The field of data exchange is complex with no single solution that works for all use cases. This seminar will address the following issues related to building data exchange: The current state of data exchange from the perspective of the auditing engineer, how ASHRAE Building EQ takes advantage of interoperability to allow for easier data input and what is being done to improve interoperability schemas so that workflows are smoother between software tools

#### **The State of Building Data Exchange for Energy Analysis**

*Nicholas Long, P.E., Member, National Renewable Energy Laboratory, Golden, CO*

#### **Methods for Reducing the Cost of Delivering Ashrae Building EQ Scores**

*Chris Balbach, P.E., BEMP, Associate Member, Performance Systems Development, Ithaca, NY*

#### **Why BIM and BEM Software Interoperability Is More Important Than Ever and What Is Being Done to Improve It**

*Stephen Roth, P.E., Member, Carmel Software, San Rafael, CA*

### **Seminar 49 (Intermediate)**

#### **Easier Said Than Done: Controlling Air Movement in High-Rise Multifamily Buildings**

*Track: Environmental Health Through IEQ*

**Sponsor: 4.3 Ventilation Requirements and Infiltration**

*Chair: Marianne F Touchie, Ph.D., P.E., Associate Member, University of Toronto, Toronto, ON, Canada*

Providing reliable ventilation throughout multifamily buildings is essential to maintaining acceptable indoor air quality. Driven by stack and wind effects, uncontrolled air movement across the building envelope and between suites makes it difficult to evenly distribute ventilation air to all suites and leads to excessive energy use, thermal comfort issues and challenges with odor, pollutant, sound and pest transmission. This seminar will provide an overview of the suite ventilation and air leakage characteristics in existing North American multifamily buildings and the test methods used to gather these data. Implications of uncontrolled air movement on system design/operation practices will be discussed.

#### **The Relative Performance of Different Ventilation Configurations in Multi-Unit Residential Buildings in North America**

*Duncan Phillips, Ph.D., P.E., Associate Member, RWDI, Guelph, ON, Canada*

#### **Suite Ventilation Characteristics of Ten Existing Canadian Multi-Unit Residential Buildings**

*Craig Wray, P.Eng., Member, Consulting Engineer, Winnipeg, MB, Canada*

#### **Suite-Based Air Leakage Characteristics of New and Old Multi-Unit Residential Buildings**

*Marianne Touchie, Ph.D., P.E., Associate Member, University of Toronto, Toronto, ON, Canada*

### **Seminar 50 (Basic)**

#### **Elevator Noise, Vibration and Energy Efficiency**

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 2.6 Sound and Vibration**

*Chair: Jason Swan, Member, Sandy Brown Associates LLP, London, United Kingdom*

Elevators are a vital component of multi-storey buildings, yet can be a source of excessive noise and vibration if not integrated into the design with care. This seminar will explore the noise and vibration issues with elevators from the perspectives of acousticians, engineers, and manufacturers with insight on construction of elevator shafts, selection of performance and energy efficiency vs cost, and the requirements and effects from the latest good practice standards for elevators.

#### **Elevator Noise and Vibration**

*Erik Müller-Klein, P.E., Member, Tenor Engineering Group, Seattle, WA*

#### **Elevator Energy and Noise**

*Jeff Boldt, P.E., HBDP, Fellow ASHRAE, IMEG Corp., Middleton, WI*

### **Seminar 51 (Intermediate)**

#### **Energy Conservation and Combined Heat and Power: New Technologies for a New World**

*Track: Energy Conservation*

**Sponsor: 1.10 Cogeneration Systems**

*Chair: Blake Ellis, Burns & McDonnell, Kansas City, MO*

The main driver behind Energy Conservation is sustainability of the built environment. While existing design techniques employ a variety of efficiency technologies, buildings will still require energy. Many experts agree that no-Carbon combustion technologies, like CHP, will be necessary for the future electric grid. Today, CHP extends the design options to encompass energy supply, allowing designers more reach in terms of Energy Conservation. This seminar will look at CHP developments that allow integration of renewable energy, examine the life-cycle impact of CHP, and delve into no-carbon fuels that can be employed through highly efficient CHP to power the built environment.

#### **Beyond Standard Practice: All of the Above**

*Richard Sweetser, Life Member, Exergy Partners Corp., Herndon, VA*

#### **Life Cycle Analysis: CHP Provides a Variable Return on Investment and Clear Energy Conservation and Emissions Benefits**

*Gearoid Foley, Member, Integrated CHP Systems Corp., Princeton, NJ*

#### **Research: H2 Fueled CHP As a No-Carbon Highly Efficient Energy Source**

*Bruce Hedman, Dr. Ing., Entropy Research. LLC, Alexandria, VA*

### **Seminar 52 (Intermediate)**

#### **Energy Conservation with Heat Recovery Heat Pumps in New Applications or Old Applications with New Refrigerants**

*Track: Systems and Equipment*

**Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications**

*Chair: Steven Carlson, P.E., Member, XRG Analytics LLC, Milwaukee, WI*



"One system's trash is another system's treasure." Heat Recovery Heat Pump potential applications abound wherever systems operate at different temperatures, using one system's waste heat to provide or supplement the heat source for another system. This session explores HRHP use in central plants, wastewater, geothermal bore field, and industrial applications emphasizing identifying applications and key operating characteristics.

**Applying Heat Recovery Heat Pumps to Commercial Chiller Plants**

*John Michael (Mike) Filler Jr., P.E., HBDP, Member, Johnson Controls, Colorado Springs, CO*

**Applying Heat Recovery Heat Pumps to Wastewater Streams**

*Steve Hamstra, P.E., HBDP, Member, Melink Solar & Geo, Zeeland, MI*

**Applying Heat Recovery Heat Pumps to Geothermal Water Loop Heat Pumps to Limit Wellfield Degradation**

*Howard Newton, Member, Image Engineering, Westlake, TX*

**Applying Hrhps with R410 and Other New Refrigerants in Existing (Old) Applications to Save Energy in Industry (Reference Heat Recovery Heat Pump Operating Experiences, 1994)**

*Frank Pucciano, FEDITC, Tyndall AFB, FL*

**Seminar 53 (Basic)**

**Enhancing and Expanding Point Cloud Collaboration with a Streamlined Workflow, VR and Cloud Visualization**

*Track: Systems and Equipment*

*Chair: Danielle Perelli, Elysium Inc., Southfield, MI*

In the 3D digitalization world, industries such as construction and manufacturing have embraced 3D scanners and point clouds to capture the existing physical world. Now, with VR, companies can not only use this data, but they can experience it. Walk through manufacturing facilities, plants, and beyond in a digitalized environment to plan overhauls, manage facilities, and more. Please join Elysium as we introduce how companies have optimized point clouds to reduce delivery time, decrease manual work, perform more accurate simulations, improve collaboration, convert point clouds to multiple CAD formats, and utilize VR for planning and modeling.

**Enhancing and Expanding Point Cloud Collaboration with a Streamlined Workflow, VR and Cloud Visualization**

*Nate Soulje, Elysium Inc., Southfield, MI*

**Seminar 54 (Intermediate)**

**From Research to Reality: Advances in Liquid Desiccant Technology**

*Track: Systems and Equipment*

**Sponsor: 8.10 Mechanical Dehumidification Equipment and Heat Pipes, 8.12 Desiccant Dehumidification Equipment and Components**

*Chair: Kevin Muldoon, KCC International, Louisville, KY*

Over the last two decades significant advances have been made in the use of liquid desiccants for simultaneous dehumidification and cooling. Modelling by National Renewable Energy Laboratory (NREL) and earlier proof of concept demonstrations have shown potential savings of 30-40% compared to other technologies. In recent years, results of several proofs of concept laboratory and field tests have been reported. Currently, prototypes for Dedicated Outside Air Systems (DOAS) have been tested for performance and reliability, using the AHRI 920 standard. The results of these tests are reported.

**Liquid Desiccant Fundamentals**

*Peter Luttik, Member, 7AC Technologies, Beverly, MA*

**Modeling and Experimental Performance of Internally-Cooled Desiccant-to-Air Membrane Contactors**

*Jason Woods, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO*

**Liquid Desiccant Dedicated Outdoor Air System Laboratory Test Results**

*Jason Warner, Member, Emerson Climate Technologies, Sidney, OH*

**Liquid Desiccant Air Conditioning (LDAC) Systems Demonstration and Reliability**

*Matt Perkins, 7AC Technologies, Beverly, MA*

**Integrating Liquid Desiccants in Roof Top Units (RTUs)**

*Andrew Lowenstein, Ph.D., Member, AIL Research, Hopewell, NJ*

## Seminar 55 (Intermediate)

### Future Smart Building Operations for Load Flexibility

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 7.5 Smart Building Systems, MTG.OBB Occupant Behavior in Buildings**

*Chair: Bing Dong, Ph.D., Member, Syracuse University, Syracuse, NY*

Building consumes a large portion of energy and has significant effect on energy supply and demand system. Grid-interactive efficient buildings (GEB) are essential in the future and provide flexible loads to the smart grid. This seminar provides an overview of the recent GEB research activities that covers: (1) building flexible load through forecasting and optimization, (2) the relationship between energy efficiency and building flexible load, (3) Uncertainty-aware transactive control of multiple buildings with thermal energy storage; and (4) Occupant-centric Buildings-to-grid integration

### Building Load Flexibility Analysis with Real-Time Building Load Prediction and Optimal Cooling System Control Strategy

*Da Yan, Ph.D., Member, Tsinghua University, Beijing, China, People's Republic of*

### Grid-Interactive Efficient Buildings: Does Energy Efficiency Characteristics Increase or Decrease Demand Flexibility from Building Loads?

*Jingjing Liu, P.E., BEAP, LBNL, Berkeley, CA*

### Uncertainty-Aware Transactive Control of Multiple Buildings with Thermal Energy Storage

*Gregory Pavlak, Ph.D., Member, Department of Architectural Engineering, Pennsylvania State University, State College, PA*

### Occupant-Centric Buildings-to-Grid Integration

*Bing Dong, Ph.D., Member, Syracuse University, Syracuse, NY*

## Seminar 56 (Intermediate)

### Health, Humidity and Humidifiers

*Track: Environmental Health Through IEQ*

**Sponsor: 5.11 Humidifying Equipment**

*Chair: Raul Simonetti, Member, Carel Industries SpA, Brugine, Italy*

Recent, and on-going research studies correlate mid-range indoor humidity level with reduced viral and bacterial infections and improved health in both young and elderly building occupants. But how can we guarantee those humidity levels within our buildings? This session first explores the latest science of humidity and health, and then explains how to safely install and run various types of humidification systems to reduce indoor dryness.

### Indoor Humidification Is Key to Controlling COVID-19

*Stephanie Taylor, M.D., Member, Harvard Medical School, Infection Control Consultant, Boston, MA*

### Best Practices for Steam Humidifier Design

*Nicholas Lea, P.Eng., Member, Condair Ltd., Ottawa, ON, Canada*

### Best Practices for Adiabatic Humidifier Design

*Duncan Curd, Member, DriSteeM, Mulmur, ON, Canada*

### Hygiene and Humidification in Ventilation Systems for Health-Care Facilities in Europe

*Raul Simonetti, Member, Carel Industries SpA, Brugine, Italy*

## Seminar 57 (Basic)

### Hot Topics for Secondary Coolants (Brines)

*Track: Refrigeration and Refrigerants*

**Sponsor: 3.1 Refrigerants and Secondary Coolants**

*Chair: Kevin Connor, Member, Dow Inc., Midland, MI*

In many refrigeration applications, heat is transferred to a secondary coolant, which is used to transfer heat without changing state. There are a variety of liquids that can be used and these are known also as heat transfer fluids, brines, or secondary refrigerants. This seminar presents helpful engineering and operating guidance for three different types of secondary coolants: aqueous ammonia, calcium chloride and glycols.

### Validation of Experimental Properties of Ethylene and Propylene Glycol Based Secondary Coolants with ASHRAE Data

*Monika Ignatowicz, P.Eng., KTH Royal Institute of Technology, Stockholm, Sweden*

### Combating Corrosion Problems Caused By Calcium Chloride Secondary Coolants (Brines)

*Kathleen Neault, P.Eng., Member, Refri-Ozone, Grandby, QC, Canada*

### Effective Use of Glycol Based Secondary Coolants

*Kevin Connor, Member, Dow Inc., Midland, MI*

### Seminar 58 (Intermediate)

## How Will Climate Change Affect Standards, Guidelines, and the Way We Design? Part 1: Why Climate Change May Affect the Design of Buildings and Their Systems

*Track: Standards, Guidelines and Codes*

**Sponsor: 2.5 Global Climate Change, 6.7 Solar Energy Utilization , 2.8, 4.1, 4.2, 7.6**

*Chair: Daniel Villa, P.E., Member, Sandia National Laboratories, Albuquerque, NM*

This is part one of a 3-seminar series. Part one will introduce the new ASHRAE Fundamentals Handbook Chapter on Climate Change with a discussion of climate change issues which are anticipated to effect changes in some standards, guidelines and, eventually, codes. It will include a review of the newest climate zone maps with zone creepage, additional climate change related information and an exploration of questions of whether it is good practice to continue using 30-year historic weather data for load calculations in view of rapid climate change.

### **Overview of the New Climate Change Chapter for the 2021 ASHRAE Fundamentals Handbook**

*Janice Means, P.E., Life Member, Lawrence Technological University; ASHRAE, Bloomfield Hills, MI*

### **Safeguarding Assets: Readiness in Capital Projects and Asset Management**

*Ann Kosmal, F.A.I.A., LEED AP BD +C, CPHC, PDC, AIA, U.S. General Services Administration, Washington, DC*

### **Our Design Conditions Are Already Changing**

*Drury Crawley, Ph.D., BEMP, Fellow ASHRAE, Bentley Systems, Inc., Washington, DC*

### Seminar 59 (Intermediate)

## How Will Climate Change Affect Standards, Guidelines, and the Way We Design? Part 2: Application to Loads Calculations and Design Conditions

*Track: Standards, Guidelines and Codes*

**Sponsor: 2.5 Global Climate Change, 6.7 Solar Energy Utilization , 2.8, 4.1, 4.2, 7.6**

*Chair: Drury Crawley, Ph.D., Fellow ASHRAE, Bentley Systems, Inc., Washington, DC*

This seminar is Part 2 of a 3-seminar series. It will cover specific climate effects on the built environment and on loads calculations. The sessions seeks to show what areas are expected to need modification due to the changing climate and what areas do not need change. The session starts with issues specific to 90.1, looks at the effects of climate change on loads calculations, and then turns to the subject of appraising actual changes in design conditions due to climate through statistical analysis.

### **Changing Climate and Its Implications for Our Flagship Standard – 90.1**

*Chris Mathis, Fellow ASHRAE, Mathis Consulting Company, Asheville, NC*

### **Cooling Load Implications of Predicted Future Design Conditions**

*Charles S. Barnaby, Fellow Life Member, Independent Software Developer, Moultonborough, NH*

### **A Statistical Appraisal of Changes in Design Conditions Based on Climate Model Projections**

*Joe Huang, BEMP, Member, White Box Technologies, Inc., Moraga, CA*

### Seminar 60 (Intermediate)

## How Will Climate Change Affect Standards, Guidelines and the Way We Design? Part 3 Decarbonization by Smart Grid and Adaptation to Northern Warming

*Track: Standards, Guidelines and Codes*

**Sponsor: 2.5 Global Climate Change, 6.7 Solar Energy Utilization , 2.8, 4.1, 4.2, 7.6**

*Chair: Parag Rastogi, Ph.D., Associate Member, arbnco Ltd., Glasgow, United Kingdom*

This is Part 3 of a 3-part seminar series. Part 3 looks at specific solutions and problems related to climate change. International standards concerning new building guidelines for the smart grid and their relationship to decarbonization is explored in the first presentation. The second presentation similarly explores how carbon emissions are changing with time in Minnesota and explores how the ASHRAE Smart Grid Guide can be used. The third presentation looks at warming in the Canadian north and associated adaptations that are needed.

### **Electrification and Decarbonization of the Building Sector: An Overview of New Building Codes and Standards**

*Costa Kapsis, Ph.D., Associate Member, the Department of Civil and Environmental Engineering at the University of Waterloo, Waterloo, ON, Canada*

### **Time of Use Emissions in the Buildings Sector: A Case Study in Minnesota and a Smart Grid Toolkit**

*Lee Shaver, Slipstream, Madison, WI*

### **Updating Codes and Guidelines for Adapting Existing Infrastructure to the Changing Climate: A Canadian Perspective**

*Philip Jarrett, Environment and Climate Change Canada, Toronto, ON, Canada*

## Seminar 61 (Intermediate)

### Hybrid Boiler Innovations and Applications for Energy and Cost Savings

*Track: Energy Conservation*

**Sponsor: 6.10 Fuels and Combustion**

*Chair: Aleksandr Fridlyand, Ph.D., Member, Gas Technology Institute, Des Plaines, IL*

Hybrid boilers are an innovative approach for minimizing energy use while maintaining building occupant comfort and potentially reducing life cycle costs. By coupling complementary technologies, each can be operated at optimal conditions to reduce energy use and the system as whole can be right sized to maintain comfort on the coldest days. This seminar will present on case studies and best practices for using non/condensing, gas heat pump, and electric heat pump coupled hybrid boilers for heating applications.

#### **A Hybrid Not of the Plug-in Variety**

*Patrick Villaume, Member, Patterson Kelley, East Stroudsburg, PA*

#### **High-Efficiency Hybrid Boiler Configurations for Condensing Boilers**

*Patricia Rowley, Associate Member, Gas Technology Institute, Des Plaines, IL*

#### **A Case Study on Gas Heat Pump Coupled Hybrid Boiler Retrofit**

*Rav Deol, P.Eng., FortisBC Energy Inc., Surrey, BC, Canada*

## Seminar 62 (Intermediate)

### Improving Refrigeration Safety in Ice Skating Rinks

*Track: Refrigeration and Refrigerants*

**Sponsor: 10.2 Automatic Icemaking Plants and Skating Rinks**

*Chair: Art Sutherland, Accent Refrigeration Systems, Victoria, BC, Canada*

In the fall of 2017, three workers were killed while carrying out maintenance at an ice-skating rink in Fernie, British Columbia. This incident turned the Ice Rink Refrigeration Industry upside down and left a lot of unanswered questions as to the reason and prevention of similar accidents. The three presenters collectively have over 100 years of experience in the ice rink refrigeration industry and all know the details of the Fernie tragedy very well.

#### **What Went Wrong? The Forensic Investigation of the Fernie Refrigeration Incident.**

*Greg Scrivener, Member, LaPorte Engineering Inc., Meadow Lake, SK, Canada*

#### **Improving Refrigeration Safety Through the Use of CO2 Refrigerant**

*Wayne Borrowman, P.Eng., Member, Cimco Refrigeration, Toronto, ON, Canada*

## Seminar 63 (Intermediate)

### Integrated Smart Heating and Cooling Systems

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 6.2 District Energy, 1.10 Cogeneration Systems**

*Chair: Graeme Maidment, Ph.D., P.E., London South Bank University, London, United Kingdom*

Heating and cooling can be controlled individually or can form part of a smart heating and cooling network. By integrating into a low temperature heat networks it's possible to deliver further carbon savings, since heat can be shared between heating and cooling applications and captured from secondary sources. Whilst, the principles of integrated smart heating and cooling energy systems is well described, as it's relatively new, there is an opportunity to bring together learning. This seminar brings together knowledge and understanding of these smart networks by presenting and discussing examples with different levels of complexity and application.

#### **Greenscies**

*Akos Revesz, Ph.D., P.E., London South Bank University, London, United Kingdom*

#### **Ectogrid 1**

*Antony Meanwell, E.ON Control Solutions Ltd., London, United Kingdom*

#### **Cool DH 1**

*Per-Olof Johansson Kallioniemi, Lund University, Lund, Sweden*

#### **Ectogrid**

*Helen Carlström, E.On, Malmo, Sweden*

#### **Cooldh**

*Kerstin Sernhed, Lund University, Lund, Sweden*

### Seminar 64 (Intermediate)

## Integrating Renewable Energy into Residential and Commercial Air Conditioning with Thermal Energy Storage to Resolve Grid and Off-Grid Issues

*Track: Systems and Equipment*

**Sponsor: 6.9 Thermal Storage**

*Chair: Bruce Lindsay, P.E., Life Member, Brevard Public Schools, Melbourne, FL*

Renewable energy is growing and may cause problems for utilities when too much energy is generated or insufficient load is on-line to absorb the energy. Several utilities are paying customers to take wind energy at night using thermal energy storage. At the other end of the spectrum, thermal energy storage is a way to store solar PV when off the grid. This is especially attractive in remote islands subject to hurricanes and fuel delivery disruptions.

**Utility Rate Structures to Accommodate Excess Wind Turbine and Solar PV**

*David Snyder, Associate Member, Centerpoint Energy, Houston, TX*

**Senior Design Project for Solar-Powered Ice Harvester for Residential Air Conditioning for Off-Grid Applications**

*Marc Compere, Ph.D. and Erik Regan, Brevard Public Schools, Melbourne, FL*

**Economics of Solar PV Ice Harvester in Caribbean Island--Diesel, Batteries or Ice?**

*John Constantine, P.E., Member, Alpha MRC Architects Engineers, Merritt Island, FL*

### Seminar 65 (Intermediate)

## International Implications of ASHRAE Moisture Management Standards

*Track: International Design*

**Sponsor: 1.12 Moisture Management in Buildings**

*Chair: Florian Antretter, Member, Fraunhofer IBP, Holzkirchen, Germany*

The interaction between the weather, the building envelope, its systems and its occupants can either lead to moisture accumulation or prevent it. Provisions in various ASHRAE standards aim at reducing moisture related risks. This seminar will present international implications of ASHRAE's moisture management standards on ventilation and building envelope design and showcase their consequences through case studies.

**Higher Confidence in Building Envelope Design through ASHRAE Std. 160 -2016**

*Andre O. Desjarlais, Member, Oak Ridge National Laboratory, Oak Ridge, TN*

**Implementing the New Dew Point Humidity Limit of 15C (60F) Required By ASHRAE Std 62.1-2019**

*Lewis G. Harriman III, Fellow ASHRAE, Mason-Grant Consulting, Portsmouth, NH*

**Lessons Learned Applying the ASHRAE's Moisture Management Standards in a Large Southeast Asia Resort**

*George Dubose, P.E., Member, Liberty Building Forensic Group, Zellwood, FL*

### Seminar 66 (Intermediate)

## Lessons Learned from COVID-19 and what Engineering Measures can be Adopted to Reduce Infection Risks in Restaurants

*Track: Environmental Health Through IEQ*

**Sponsor: 5.10 Kitchen Ventilation, 2.9 Ultraviolet Air and Surface Treatment**

*Chair: Russell Robison, Member, Gaylord Industries, Division of ITW FEG, Tualatin, OR*

With nearly a million foodservice establishments in the US, getting America back to work safely is top of mind. These presenters will help you to understand the airborne epidemiology of COVID-19, and how to mitigate the risks with our restaurant's ventilation systems.

**What Should I Do to Keep Safe from COVID-19?**

*Stephanie Taylor, M.D., Member, Harvard Medical School, Infection Control Consultant, Boston, MA*

**Restaurant Ventilation System Design and Effective Mitigation Methods Addressing Airborne Contaminants for Existing Buildings and New Construction**

*Andrey Livchak, Ph.D., Member, Halton Group Americas, Bowling Green, KY*

**Operating Your Restaurant for the "Unknown" and Keeping up with the Latest Ashrae Guidelines**

*Greg DuChane, Member, Trane, Nacogdoches, TX*

**Equipping Your Restaurant for the "Unknown" with Operational Efficiency and Increased Flexibility**

*Jessica Harrington, Associate Member, Accurex, Baltimore, MD*

## Seminar 67 (Basic)

### Life Safety Dampers, Back to Basics

*Track: Systems and Equipment*

**Sponsor: 5.6 Control of Fire and Smoke**

*Chair: Paul Turnbull, Member, Siemens Building Technologies, Inc., Buffalo Grove, IL*

All but the smallest buildings are required to include life safety dampers to ensure that fire and smoke cannot travel through ductwork and spread to other areas of the building. Life safety dampers are very different from the dampers used for Hvac control. This session will help engineers and installers understand the differences between fire-, smoke-, combination fire/smoke-, and ceiling radiation dampers; the applications for which each is suited; and how to specify these dampers correctly. It also describes different ways that each of these dampers are activated and/or controlled. Installation, testing, and inspection methods and requirements are discussed.

#### What Are Life Safety Dampers?

*Stephen D Carey, Member, TAMCO, Smyrna, TN*

#### Wiring and Controls of Life Safety Dampers

*Larry Felker, Life Member, Belimo Americas, Sparks, NV*

#### Testing and Installation of Life Safety Dampers

*Stephen D Carey, Member, TAMCO, Smyrna, TN*

## Seminar 68 (Intermediate)

### Mechanical Equipment Individual Current Harmonics and Impact on the Building's Electrical Load

*Track: Systems and Equipment*

**Sponsor: 1.11 Electric Motors and Motor Control, 1.9 Electrical Systems , TC 1.9 co-sponsorship**

*Chair: Armin Hauer, Member, ebm-papst, Farmington, CT*

The HVAC&R industry is trending towards variable speed technology such as electronically commutated motors (ECMs), variable frequency drives (VFD) motor solutions, variable speed compressors, chillers, pumps, fans, and variable refrigerant flow systems (VRF). Building owners and engineers are requesting HVAC&R equipment to comply with IEEE 519. The goal of this program is to help our participants avoid harmonics overfiltering and underfiltering. Both excessive and minimal harmonic filtration scenarios can cause issues with electrical and HVAC&R equipment. With industry demands of high energy standards (Title 24, ASHRAE 90.1, IECC), harmonics has emerged as an increasingly critical topic in the building industry.

#### Understanding Induction Motors, VFDs, and Ecms

*Marco Cabibbo, P.E., P2S, Long Beach, CA*

#### Facility Harmonics

*Nicolas S. Rosner, P.E., Member, Eaton, City of Industry, CA*

#### Applying Harmonic Analysis to Power Line Distortion

*Ken Fonstad, Member, Retired, Franklin, IN*

## Seminar 69 (Intermediate)

### Mechanical Equipment Individual Current Harmonics and Impact on the Building's Electrical Load: HVAC&R Fundamentals and Applications Track

*Track: HVAC&R Fundamentals and Applications*

**Sponsor: 1.11 Electric Motors and Motor Control, 1.9 Electrical Systems**

*Chair: Armin Hauer, Member, ebm-papst, Farmington, CT*

The HVAC&R industry is trending towards variable speed technology such as electronically commutated motors (ECMs), variable frequency drives (VFD) motor solutions, variable speed compressors, chillers, pumps, fans, and variable refrigerant flow systems (VRF). Building owners and engineers are requesting HVAC&R equipment to comply with IEEE 519. The goal of this program is to help our participants avoid harmonics overfiltering and underfiltering. Both excessive and minimal harmonic filtration scenarios can cause issues with electrical and HVAC&R equipment. With industry demands of high energy standards (Title 24, ASHRAE 90.1, IECC), harmonics has emerged as an increasingly critical topic in the building industry.

#### Understanding Induction Motors, VFDs, and ECMs.

*Marco Cabibbo, P.E., P2S, Long Beach, CA*

#### Facility Harmonics: HVAC&R Fundamentals and Applications Track

*Nicolas S. Rosner, P.E., Member, Eaton, City of Industry, CA*

**Applying Harmonic Analysis to Power Line Distortion: HVAC&R Fundamentals and Applications**  
*Ken Fonstad, Member, Retired, Franklin, IN*

### **Seminar 70 (Intermediate)**

#### **Modeling of Surfaces Mass Transfer in Indoor Environment**

*Track: Environmental Health Through IEQ*

**Sponsor: 4.10 Indoor Environmental Modeling**

*Chair: Wangda Zuo, Ph.D., Member, University of Colorado, Boulder, CO*

Surface mass transfer plays an important role in indoor environmental quality. However, the surface mass transfer is complex and its effect on emission and chemical reaction are less known. This seminar will show how to use CFD to predict condensation on surfaces, as well as evaluate the impact of ozone reaction at surfaces.

#### **Effect of Indoor Airflow on Surface Mass Transfer and Deposition Velocity of Reactive Chemicals**

*Atila Novoselac, Ph.D., Associate Member, The University of Texas at Austin, Austin, TX*

#### **Predicting Condensation with CFD, Good-Bye Dampness**

*Duncan Phyfe, Associate Member, Alden Research Laboratory, Holden, MA*

### **Seminar 71 (Intermediate)**

#### **New Dogs, New Tricks: Air Flow Control Update**

*Track: Systems and Equipment*

**Sponsor: 9.10 Laboratory Systems, 1.4 Control Theory and Application**

*Chair: James Coogan, P.E., Associate Member, Siemens Smart Infrastructure, Chicago, IL*

Air flow to and from occupied spaces is an essential part of nearly every HVAC system. The quantity of that flow has repercussions in energy use, and indoor environmental quality. HVAC designers continue to increase the attention they pay to air flow control performance and air flow control technology. Whether the space is an office, classroom, surgery suite or laboratory, designers are looking for better combinations of working range, accuracy and stability. Manufacturers respond with new designs for air flow terminals. This seminar updates your knowledge of mechanical arrangements of dampers and sensors available and corresponding performance.

#### **Minimum Airflows on Air Terminal Boxes**

*Justin Garner, P.E., Member, Engineered Air Balance Company, Inc., Houston, TX*

#### **New Technology Expands Laboratory Airflow Control Design Range**

*Paul Fuson, Siemens Smart Infrastructure, Buffalo Grove, IL*

### **Seminar 72 (Intermediate)**

#### **Next Generation Window Technologies for Net Zero Energy Buildings**

*Track: Systems and Equipment*

**Sponsor: 4.5 Fenestration**

*Chair: Charlie Curcija, Ph.D., Member, Lawrence Berkeley National Lab, Berkeley, CA*

In the last couple of decades, several cutting-edge window technologies have been commercialized, enabling buildings to become net zero energy or even net positive energy. These technologies range from highly insulating glazing and frames to solar control glass coatings and dynamic glazing and shading solutions. This seminar will review major advancements in window technologies and the ways they will affect building energy performance, human comfort and future built environment

#### **Performance Criteria for Residential Zero Energy Windows**

*Robert Hart, P.Eng., Associate Member, Lawrence Berkeley National Lab, Berkeley, CA*

#### **Vacuum Glazing**

*Cenk Kocer, Ph.D., University of Sydney, Sydney, Australia*

#### **Exterior Shading As a Means to Control Solar Gain**

*John Gant, Glen Raven Inc, Burlington, NC*

#### **Electrochromic Glazing**

*Luis Fernandes, Ph.D., Lawrence Berkeley National Lab, Berkeley, CA*

### Seminar 73 (Basic)

#### **Noise and Vibration: Commissioning and Remediation**

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 2.6 Sound and Vibration**

*Chair: Erik Miller-Klein, P.E., Member, Tenor Engineering Group LLC, Seattle, WA*

Noise and vibration issues both big and small arise on projects throughout the world on a daily basis. Though the most common evaluation of success is "did we get any complaints", even though commissioning would find these issues earlier. Learn about some examples of issues that were complaints or potential problems and how to look out for these issues on your next project.

#### **The Dangers of Value Engineering Mechanical System Noise Control in a Class a Office; A Case Study on Motor Tonal Noise**

*Paul Bauch, Member, Johnson Controls, York, PA*

#### **When More Is Actually Too Much**

*Reginald Keith, Hoover & Keith Inc., Houston, TX*

#### **Shell and Core Mechanical Risk Assessment for Tenant Improvement Design**

*Erik Miller-Klein, P.E., Member, Tenor Engineering Group LLC, Seattle, WA*

### Seminar 74 (Advanced)

#### **Numerical Challenges in Modeling of Vapor Compression Systems and Components**

*Track: Systems and Equipment*

**Sponsor: 8.1 Positive Displacement Compressors**

*Chair: Margaret Mathison, Ph.D., Member, Iowa State University, Ames, IA*

This seminar will explore the numerical and computational challenges, and the accompanying solutions, associated with modeling vapor compression systems and their components with an emphasis on compressor modeling. Speakers will explain the challenges resulting from the stiffness of the non-linear Ordinary Differential Equations (ODE's) that govern the behavior of positive-displacement compressors. Additionally, an assessment of the most efficient compressor modeling platform will be presented. Finally, a study of the challenges associated with modeling the system dynamics of a complete vapor compression cycle will be presented.

#### **Discussion of the Numerical Methods Used in Positive Displacement Comprehensive Mechanistic Models: Case Study Using the Z-Compressor**

*Craig Bradshaw, Ph.D., Member<sup>1</sup>, Davide Ziviani, Ph.D., Member<sup>2</sup> and Eckhard Groll, Dr.Eng., Fellow ASHRAE<sup>2</sup>, (1)Oklahoma State University, Stillwater, OK, (2)Purdue University, West Lafayette, IN*

#### **Quantitative and Qualitative Evaluation of Various Positive-Displacement Compressor Modeling Platforms**

*Mohsin Tanveer, Student Member and Craig Bradshaw, Ph.D., Member, Oklahoma State University, Stillwater, OK*

#### **Challenges of Charge-Sensitive Dynamic Modeling and Control Scheme Implementations for Heat Pump Applications**

*Tyler Shelly, Student Member, Davide Ziviani, Ph.D., Member, Justin Weibel, Ph.D. and Eckhard Groll, Dr.Eng., Fellow ASHRAE, Purdue University, West Lafayette, IN*

### Seminar 75 (Advanced)

#### **Present and Future Challenges in Ventilation Unique to Tall Buildings Arising from Epidemics, Health Issues and Climate Change**

*Track: Environmental Health Through IEQ*

**Sponsor: 9.12 Tall Buildings, Environmental Health Committee**

*Chair: Dennis Wessel, P.E., Fellow Life Member, AIA, Atlanta, GA*

The recent Covid-19 pandemic caused serious considerations of methods of control of airborne contaminants in all buildings. Control of these pathogens in tall buildings has it's own challenges when considering stack effect and typically heavy occupant densities. This seminar will discuss some of these special challenges and offer possible solutions for reduction of airborne pathogen transmission among occupants.

#### **Post Pandemic HVAC Systems Design Solutions to Improve Indoor Air Quality of Tall Office Building**

*Mehdi Jalayerian, P.E., Member, Environmental Systems Design, Inc., Chicago, IL*

#### **Managing Infiltration in Tall Buildings to Control Energy Loss, Minimize Pathogen Transport and Enhance Air Quality**

*Duncan Phillips, Ph.D., P.E., Associate Member, Rowan Williams Davies & Irwin, Guelph, ON, Canada*

#### **Prioritizing HVAC Strategies for Pandemic and Other Future Threats**

*Luke Leung, P.E., Member, Skidmore, Owings, & Merrill LPP, Chicago, IL*



### Seminar 76 (Intermediate)

## Smart Controls and Optimization for Thermal Storage Systems and Connected Communities

*Track: Energy Conservation*

**Sponsor: 6.9 Thermal Storage**

*Chair: Paulo Tabares Velasco, Ph.D., Associate Member, Colorado School of Mines, Golden, CO*

Smart controls and thermal storage are solutions to increase grid flexibility and reduce energy use but its implementation requires careful planning and coordination. This becomes more challenging in a connected community, as most studies have focused on single building. The aggregation of cooling loads with a campus or connected community provides increased opportunities to achieve cost and energy savings. This session presents four energy conservation applications of optimized controls, with and without thermal storage, across multiple scales - from district cooling plants to residential HVAC. Using example case studies, cost-energy tradeoffs of the optimization scenarios are presented.

### **Controlling Cool Thermal Energy Storage to Increase Grid Penetration of Renewables**

*Amy Van Asselt, Ph.D., Associate Member, Lafayette College, Easton, PA*

### **Holistic Optimization Using Model-Based Approach for Central Chiller Plants in Connected Communities**

*Mohammad Hassan Fathollahzadeh, Student Member, Colorado School of Mines, Golden, CO*

### **Optimizing the Location and Operation of Distributed Thermal Storage in a Diverse Connected Community**

*Karl Heine, Student Member, Colorado School of Mines, Golden, CO*

### **Optimal Phase Change Temperature and Size to Minimize Residential HVAC Energy Cost and Peak Demand**

*Navin Kumar, Ph.D., Oak Ridge National Laboratory, Oak Ridge, TN*

### Seminar 77 (Intermediate)

## Smart Indoor Environmental Models for Data Centers

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 4.10 Indoor Environmental Modeling, 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment**

*Chair: Wangda Zuo, Ph.D., Member, Colorado University at Boulder, Boulder, CO*

This session aims to highlight smart indoor environmental modeling approaches for real-world practice. We will discuss the advantages and disadvantages of full scale CFD modeling and compact models. Then we will illustrate where and when the compact models can be used with examples from real world practices in data centers.

### **It's Always Smart to be Accurate – or Is It?**

*Mark Seymour, Member, Future Facilities, London, United Kingdom*

### **Using Compact Models for Improving IT Equipment Modeling in Data Center Simulations**

*Dustin Demetriou, Ph.D., Member, IBM, Poughkeepsie, NY*

### **A Compact Rack Model for Data Center Modeling**

*James VanGilder, P.E., Member, Schneider Electric, andover, MA*

### Seminar 78 (Intermediate)

## Supplementing Ventilation with Gas-phase Air Cleaning (IEA-EBC Annex 78)

*Track: Environmental Health Through IEQ*

**Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, IEA-EBC Annex 78**

*Chair: Bjarne Wilkens Olesen, Ph.D., Fellow ASHRAE, Intl. Center for Indoor Environment and Energy, Technical University of Denmark, Lyngby, Denmark*

IEA-EBC Annex 78 bring researchers and industry together to investigate the possible energy benefits and increased indoor air quality by using gas phase air cleaners to partial substitute for ventilation (outdoor air). None of existing standards for testing gaseous air cleaners include human bio effluents as a source and the perceived indoor air quality is not used to evaluate the performance. Bio effluents from occupants are an important source of pollution and most criteria for ventilation is based on perceived air quality. There is therefore a need to establish new and more relevant test methods for gaseous air cleaners.

### **Concept for Substituting Ventilation By Gas Phase Air Cleaning: Pros & Cons**

*Bjarne W. Olesen, Ph.D., Fellow ASHRAE, Intl. Center for Indoor Environment and Energy, Technical University of Denmark, Lyngby, Denmark*

### **Gas Phase Air Cleaning Technologies, Needs and Challenges.**

*Pawel Wargocki, Ph.D., Associate Member, Technical University of Denmark, Kongens Lyngby, Denmark*

### **International Standards for Testing of Perceived Air Quality**

*Ito Kazuhide, Ph.D., Member, Faculty of Engineering Sciences, Kyushu University, Kyushu, Japan*

### **International Standards for Testing Gas Phase Air Cleaners.**

*Paolo Tronville, Ph.D., Fellow ASHRAE, Politecnico di Torino, Torino, Italy*

### **Modelling and Long Term Performance of Gas Phase Air Cleaning Technologies**

*Jianshun Zhang, Ph.D., Fellow ASHRAE, Syracuse University, Syracuse, NY*

## **Seminar 79 (Advanced)**

### **Sustainable Approaches for Energy Demand in the Community Scale**

*Track: Energy Conservation*

#### **Sponsor: 4.7 Energy Calculations**

*Chair: Paulo Cesar Tabares-Velasco, Ph.D., Colorado School of Mines, Golden, CO, USA, Golden, CO*

Application of sustainable technologies at the community scale offers many benefits to society and the environment. However, due to the challenges in design and operation, a holistic approach is required to consider demand and supply energy characterization beyond the built environment. It is also important to consider other non-engineering aspects such as community's preference and cultural needs. This seminar will show some examples of how to holistically address these challenges as well as a review on some of the current tools and methodologies available to perform large-scale analysis for today and tomorrow's community-scale design.

#### **Modeling of Sustainable, Smart and Connected Communities**

*Wangda Zuo, Ph.D., Member, University of Colorado Boulder, Department of Civil, Architectural and Environmental Engineering, Boulder, CO*

#### **Holistic Hybrid Renewable Energy Analysis in a Rural Community: Beyond Your Typical Building Energy Simulation**

*Paulo Cesar Tabares-Velasco, Ph.D., Colorado School of Mines, Golden, CO*

#### **Hybrid Renewable Energy Resources Analysis in Rural Communities Using Bottom-up Demand Prediction**

*Mohammad Hassan Fathollahzadeh, Student Member, Colorado School of Mines, Golden, CO*

## **Seminar 80 (Advanced)**

### **System Analysis and Modeling of Variable Refrigerant Flow Systems**

*Track: Systems and Equipment*

*Chair: Heejin Cho, Ph.D., Member, Mississippi State University, Mississippi State, MS*

Variable refrigerant flow (VRF) systems have gained a great attention and popularity in the US recent years. As building designs get sophisticated whether it was due to code and standard or design intention, a deeper understanding of system capability and limitation becomes a key to adopt and integrate VRF systems into advanced energy efficiency building designs. This seminar provides insight into system analysis and modeling techniques for different VRF system configurations. It also discusses performance evaluation of a VRF system in a laboratory environment and modeling techniques with advanced building designs, e.g., net-zero energy buildings.

#### **Performance Analysis and Model Calibration of Air-Source VRF Systems**

*Piljae Im, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

#### **System Design and Modeling Methods for Water-Source Heat Recovery VRF Systems**

*Heejin Cho, Ph.D., Member, Mississippi State University, Mississippi State, MS*

#### **Performance Evaluation and Modeling of Net-Zero Energy Building Design with VRF Systems**

*Dongsu Kim, Ph.D., Associate Member, Hanbat National University, Daejeon, Korea, Republic of (South)*

## **Seminar 81 (Intermediate)**

### **The Impact of COVID-19 on Building Energy Consumption, IAQ and Occupant Behavior**

*Track: Environmental Health Through IEQ*

#### **Sponsor: MTG.OBB Occupant Behavior in Buildings**

*Chair: Bing Dong, Ph.D., Associate Member, Syracuse University, Syracuse, NY*

COVID-19 pandemic dramatically change occupant schedules and behavior, and thus the impacts on building energy consumption and indoor air quality. Understanding such impacts is crucial to ensuring building performance and operations while providing healthy and productive living and working environments. This seminar will provide an overview of such impacts from the following perspective: (1) Linking social-psychological factors with the analysis of energy pattern and home energy

management system, (2) Shelter-in-place on energy use of office buildings, (3) IAQ at home, and (4) Well-being at homes-results from an international survey.

### **Linking Social-Psychological Factors with the Analysis of Energy Pattern and Home Energy Management System during COVID-19**

*Chien-fei Chen, Ph.D., University of Tennessee, Knoxville, TN*

### **What Can We Learn from Impact of Shelter-in-Place on Energy Use of Office Buildings?**

*Tianzhen Hong, Ph.D., Fellow ASHRAE, Lawrence Berkeley National Laboratory, Berkeley, CA*

### **IAQ at Home during the COVID-19 Lockdown**

*Clinton Andrews, Ph.D., P.E., Member, Rutgers University, New Brunswick, NJ*

### **How Work from Home Affects Well-Being during Covid-19: Results from an International Survey**

*Zheng O'Neill, Ph.D., P.E., Member, Texas A&M University, College Station, TX*

## **Seminar 82 (Basic)**

### **The Impacts and Value of ASHRAE Standards and Technology**

*Track: Standards, Guidelines and Codes*

**Sponsor: MTG.IAST Impact of ASHRAE Standards and Technology on Energy Savings/Performance**

*Chair: Daniel Pettway, Life Member, Retired Industry Professional, Chesapeake, VA*

Since its birth 125 years ago, ASHRAE has been dedicated to advancing the arts and science of HVAC/R and the allied fields. Under the guidance of MTG.IAST, a research project was recently completed to systematically assess and document the influence of ASHRAE on research, higher education, industry guidelines, and professional development. This seminar will share major results from the project with recommendations for the future marketing and growth of ASHRAE.

### **Challenges of Defining "the Signal from the Noise".**

*Daniel Pettway, Life Member, Retired Industry Professional, Chesapeake, VA*

### **Summary of ASHRAE Research Project 1848-RP "Assessing the Impact and Value of ASHRAE's Standards and Technology**

*Liping Liu, Ph.D., Associate Member, Lawrence Tech University, Southfield, MI*

### **Applying the Findings of the 1848-RP Report: Speaking up about ASHRAE's Accomplishments**

*Lawrence Markel, Fellow ASHRAE, Oak Ridge National Laboratory, Oak Ridge, TN*

## **Seminar 83 (Advanced)**

### **Thermal Energy Storage in Geothermal Systems**

*Track: Systems and Equipment*

**Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications**

*Chair: Roshan Revankar, Melink Solar and Geo, Milford, OH*

Geothermal Heat Pump systems are expensive primarily due to cost and installation of ground heat exchangers. This session will explore three ways to introduce thermal energy storage in the system design with the goal to reduce the size of ground heat exchanger. The methods presented also explore ways to use off peak rates for low cost system operation. The presenters will share modeling aspects of this design and its use in innovative projects across the US.

### **Dual-Purpose Underground Thermal Battery**

*Xiaobing Liu, Ph.D., Member, ORNL, Oak Ridge, TN*

### **Dual Temperature Borehole Thermal Energy Storage**

*Michel Bernier, Ph.D., Fellow ASHRAE, Polytechnique Montréal, Montréal, QC, Canada*

### **The Integration of PCM Thermal Energy Storage with Ground-Source Heat Pump Applications**

*Stephen Hamstra, P.E., HBDP, Member, Melink Solar and Geo, Milford, OH*

## **Seminar 85 (Intermediate)**

### **Unique and Necessary Approaches and Considerations When Commissioning Commercial Kitchen Ventilation Systems**

*Track: Building Performance and Commissioning for Operation and Management*

**Sponsor: 5.10 Kitchen Ventilation**

*Chair: Jimmy Sandusky, Associate Member, Halton Company, Scottsville, KY*

Commercial kitchen ventilation systems present unique and challenging situations that must be considered during the commissioning process. Beyond the typical HVAC supply and return air distribution, the designer must consider items such as electrical and natural gas interlocks, fire suppression systems and demand control ventilation systems that must be verified to function throughout a range of airflows. This presentation will highlight these items, provide rationale for their importance and present best case practices as part of the commercial kitchen ventilation commissioning process.

#### **Commercial Kitchen Commissioning Fundamentals**

*Francis Kohout, P.E., BCxP, Member, Cyclone Energy Group, Chicago, IL*

#### **Air Balance in the Commercial Kitchen**

*Greg DuChane, Member, Trane, Nacogdoches, TX*

#### **Test and Balance Considerations for the Commercial Kitchen**

*Andy Austin, Melink Corporation, Milford, OH*

### **Seminar 86 (Intermediate)**

#### **Use Of Reflective Technology In Buildings**

*Track: Energy Conservation*

**Sponsor: 4.4 Building Materials and Building Envelope Performance, N/A**

*Chair: David Yarbrough, Ph.D., P.E., Member, R&D Services, Inc., Watertown, TN*

The use, evaluation, and benefits of reflective insulation, radiant barriers and gas-filled panels will be presented. Low-emittance foils and films installed in enclosed spaces provide thermal resistance that are determined by standard test methods. Low-emittance surfaces including coatings in ventilated spaces such as residential attics reduce the heat transfer across the attic air space and duct-work space. Quantitative evaluations are best determined using computer simulations that can include the many factors that impact performance. Panels containing low thermal conductivity gas and low-emittance interior surfaces can provide high thermal resistivity components. The variety of uses of reflective technology will be described.

#### **Overview of Reflective Insulation Technology**

*David Yarbrough, Ph.D., P.E., Member, R&D Services, Inc., Watertown, TN*

#### **Computer Simulation of Attic Radiant Barrier Performance**

*William Miller, Ph.D., P.E., Member, University of Tennessee, Knoxville, TN*

#### **Evaluation of Radiant Barriers and Low-Emittance Coatings**

*Som Shrestha, Ph.D., BEMP, Member, Oak Ridge National Laboratory, Oak Ridge, TN*

### **Seminar 87 (Intermediate)**

#### **What Makes a Compressor a Heat Pump Compressor?**

*Track: Refrigeration and Refrigerants*

**Sponsor: 8.1 Positive Displacement Compressors, 8.2 Centrifugal Machines, 8.11 Unitary and Room Air Conditioners and Heat Pumps**

*Chair: Davide Ziviani, Ph.D., Member, Purdue University, West Lafayette, IN*

Vapor compression technologies heavily rely on high-efficient compressors to meet the heating and cooling load requirements. Advances in manufacturing techniques and computational resources along with refrigerant and energy efficiency requirements are driving the hunt for the next generation compressors. This seminar will focus on design optimizations and challenges of both positive displacement and turbo-compressors for heat pumping applications with particular emphasis on low-GWP refrigerant solutions and alternative integrated solutions.

#### **Turbo Compressors and Low-GWP Refrigerants in Large Commercial and Heat Pump Systems**

*Drew Turner and Leping Zhang, Danfoss TurboCor Compressors, Inc., Tallahassee, FL*

#### **The Thermodynamic Behaviour of Low-GWP Zeotropic Mixtures on Water-Source Heat Pump Equipment**

*Saad Saleem, Student Member<sup>1</sup> and Craig Bradshaw, Ph.D., Member<sup>2</sup>, (1)Oklahoma State University (OSU), Stillwater, OK, (2)Oklahoma State University, Stillwater, OK*

#### **The Case for DC Powered Residential Heat Pumps**

*Jonathan Ore, Student Member, Davide Ziviani, Ph.D., Member and Eckhard Groll, Dr.Eng., Fellow ASHRAE, Purdue University, West Lafayette, IN*

## Seminar 88 (Intermediate)

### Whole Greater Than the Sum: Coupling Building Simulation Techniques

*Track: Energy Conservation*

**Sponsor: 4.10 Indoor Environmental Modeling**

*Chair: Mike Koupriyanov, P.E., Associate Member, Price Industries Limited, Winnipeg, MB, Canada*

There are many tools available to the modern HVAC designer, capable of modeling different aspects of building performance at different levels of detail. Even though there are trade-offs when choosing one tool over another there are applications that require the benefits of more than one tool. This seminar will focus on combining various modelling tools to design data centers and commercial spaces. The combination of various methodologies including CFD, flow network modeling, city building energy models and multizone methods will be presented and the applications and drawbacks of each will be discussed.

#### **Bridging the Scale Divide**

*Mark Seymour, Member, Future Facilities, London, United Kingdom*

#### **Strategizing Building Ventilation System Operations for Energy Saving and Mitigating COVID-19 Infection Risks By Coupling Weather Forecasting and City Building Energy Models**

*Liangzhu Wang, Concordia University, Montréal, QC, Canada*

#### **Coupling Potential-Flow and Flow-Network Models for Fast Data Center Thermal Analysis**

*James VanGilder, P.E., Member, Schneider Electric, andover, MA*

#### **Coupled CFD-Multizone-Modelica Models for Dynamic Simulation of Indoor Environment and HVAC Systems**

*Wangda Zuo, Ph.D., Member, University of Colorado, Boulder, CO*

#### **CFD As a Cutting-Edge Tool in Energy Saving and Cost Reduction**

*Reza Ghias, Ph.D., Member, SIMULATIONPRIME LLC, Rockville, MD*

## Seminar 89 (Basic)

### Window Shading: How to Save Energy while Improving Occupant Comfort and Visual Environmental Quality?

*Track: Energy Conservation*

**Sponsor: 4.5 Fenestration**

*Chair: Mahabir Bhandari, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN*

Window shading systems/attachments have the economic potential to save 800 TBTUs in cooling and heating energy by 2030, while they can also significantly enhance visual environmental quality in terms of glare and outside view preservation. Lack of performance rating mechanisms, including energy savings potential and comfort-related studies of various shading systems, prevent these systems from fully realizing their market potential. Recent developments in characterization and rating of shading systems, including energy performance, glare protection along-with novel combinations of repeatable workflows that allow practitioners to quickly evaluate fenestration systems for their energy performance, visual comfort, and view quality will be presented.

#### **Energy Performance of Window Shading**

*Charlie Curcija, Ph.D., Member, Lawrence Berkeley National Lab, Berkeley, CA*

#### **Roller Shades' Optical Properties and Their Impact on Glare Performance and Outside View**

*Iason Konstantzos, Ph.D., Member, University of Nebraska-Lincoln, Omaha, NE*

#### **How Rating Systems Drive Consumer Education and Energy Savings**

*Stephen Mullaly, Hunter Douglas, Broomfield, CO*

#### **Early-Stage Optimization of Fenestration Design Options for High-Performance Buildings**

*Sagar Rao, Member, Affiliated Engineers, Inc., Madison, WI*