

2019 ASHRAE Annual Conference

June 22nd - June 26th, 2019



<https://www.ashrae.org/kansascity>

The Technical Program along with Committee meetings, Registration, Bookstore, and Speakers Lounge will be held at the Kansas City Marriott and Kansas City Convention Center.

Updated June 20, 2019

Sunday, June 23

Sunday, June 23, 8:00 AM - 9:00 AM

Debate 1 (Intermediate)

Site vs. Source Energy: Which Metric Should Be Used?

Track: Fundamentals and Applications

Room: 2101

Sponsor: 7.6 Building Energy Performance

Chair: Adam Hinge, P.E., Fellow ASHRAE, Sustainable Energy Partnerships, Tarrytown, NY, Barry Abramson, P.E., Member, Servidyne, LLC, Atlanta, GA, Nathaniel Boyd, P.E., Member, University of Central Florida, Orlando, FL, John Constantinide, Member, Alpha MRC Architects Engineers, Merritt Island, FL and Keith Emerson, Retired, Denver, CO

What are the differences between "site" and "source" energy? When benchmarking or comparing energy use for buildings, which metric should be used? Which is a more appropriate indicator of building energy performance or efficiency? Are there particular applications where one is clearly more relevant? Both metrics are distinct in the information provided, but their use may vary depending on the reporting needs of the energy manager. This debate addresses site and source energy metrics, the pros and cons of each metric type, and their uses in energy management.

8:00 AM - 9:00 AM

Panel 1 (Basic)

Integrated A/E Firms vs. MEP Consulting Firms Perspective

Track: Professional Development

Room: 2102B

Chair: David Swain, P.E., Member, Affiliated Engineers, Chicago, IL

The vast majority of design consulting engineers graduate from college and go to work for either an MEP consulting firm or a combined architectural engineering firm. The panel will be moderated by an engineer who has worked for both types of firms with at least three participants: 1) Architect - Integrated Firm, 2) Engineer - Worked for both, and 3) Engineer - Worked for MEP only. The debate will focus on the following topics. 1. Integrated Deadlines vs. Delegated Deadlines: Most architectural companies are using BIM and as such updates for integrated firms are basically in real time, discussing model handover/drawing updates and timelines. 2. Staffing/Workflow: Working behind the curtain of a separate company versus being in the same space at an integrated firm. 3. Internal vs. External Clients: At an integrated A/E firm typically your primary client is your co-workers and the owners you are serving together, at an MEP consulting firm you are primarily marketing to external architects. Discussing the differences associated with that. 4. Finances: At an integrated firm it really doesn't matter if one trade is sunk on a project the firm suffers collectively, working at a consulting firm you can somewhat insulate yourself from losses due to other trade oversights. 5. Career Development: Discussing how your evolution as an engineer is different depending on which type of company you work for. 6. Pros/Cons of each from a personal perspective.

1. Integrated A/E Firms vs. MEP Consulting Firms Perspective, Part 1

Patrick Dempsey, P.E., BEAP, BEMP and HBDP, Member, CannonDesign, Chicago, IL

2. Integrated A/E Firms vs. MEP Consulting Firms Perspective, Part 2

Jason Borowski, P.E., Member, Century Engineering, Chicago, IL

8:00 AM - 9:00 AM

Conference Paper Session 1 (Advanced)

Innovations in Phase Change and Supercritical Heat Transfer

Track: Research Summit

Room: 2204

Chair: Xiaofei Wang, Ph.D., University of Illinois at Urbana-Champaign, Urbana, IL

With the move towards lower GWP refrigerants, it is critical to understand multi-phase and supercritical heat transfer. Phase change heat transfer is at the heart of most refrigeration systems (i.e., through the evaporator and condenser), and supercritical CO₂ bypasses phase change at pressures above the liquid-vapor dome. This session presents cutting edge research of direct relevance to ASHRAE members, including nanolubricant performance in refrigerants, novel additively manufactured structures for phase change, condensation, and supercritical CO₂ cycles.

1. Experimental Investigation of Two-Phase Flow Heat Transfer of R410A and ZnO Nanolubricant Mixture in a Smooth Tube (KC-19-A001)

Pratik S. Deokar, Student Member and Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL

2. Heating of Supercritical Carbon Dioxide in Small Channels (KC-19-A002)

Brian Fronk, Ph.D., Associate Member, Saad Jajja and Jessa Sequeira, Oregon State University, Corvallis, OR

3. Permeability and Rate-of-Rise of Additively-Manufactured Wicking Structures (KC-19-A003)

Jordan Morrow, Student Member, Nihcolas Aponte, Ryan Huber, Student Member, Partha P. Chakraborty, G. A. Riley and Melanie Derby, Ph.D., Member, Kansas State University, Manhattan, KS

8:00 AM - 9:00 AM

Conference Paper Session 2 (Intermediate)

Specialty Buildings: Data Centers and Sports Facilities

Track: Modeling Throughout the Building Life Cycle/Research Summit

Room: 2203

Chair: Gurunarayana Ravi, Lennox International, Frisco, TX

Data centers and recreational sports facilities are known to have a high level of energy consumption. Data centers are also growing faster than the other building sectors. These specialty buildings offer unique opportunities for achieving energy savings in the HVAC systems. This session introduces a new prototype energy model for data centers and presents the findings and analysis of several data center and telecommunication facilities. This session also highlights a new model developed to evaluate weather uncertainties within a dynamic control procedure in sports facilities.

1. Development of a New Prototype Energy Model for Data Centers (KC-19-C001)

Tianzhen Hong, Ph.D., Member and Kaiyu Sun, Member, Lawrence Berkeley National Laboratory, Berkeley, CA

2. Improving Data Center and Telecommunication System HVAC Design from Lessons Learned from Retro-Commissioning (KC-19-C002)

Richard Pavlak, P.E., Fellow ASHRAE and Nicholas Pavlak, Member, Heapy Engineering, Dayton, OH

3. Uncertainties on Cooling Energy Based on Computational Indoor Air Modeling in Sports Facilities (KC-19-A004)

Samah Ben Ayed, Ph.D., Associate Member¹, Donghun KIM, Ph.D.², Jeff Borggaard, Ph.D.³ and Eugene Cliff, Ph.D.³, (1)New Mexico State University, Las Cruces, NM, (2)Purdue University, West Lafayette, IN, (3)Virginia Tech, Blacksburg, VA

8:00 AM - 9:00 AM

Seminar 1 (Intermediate)

Commissioning and Re-Commissioning: The Process and the Practice

Track: Commissioning New & Existing Buildings

Room: 2104A

Sponsor: 7.9 Building Commissioning, 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: William Bradford, P.E., Member, BRPH, Orlando, FL

Commissioning is more than just following ASHRAE Standard 202 and ASHRAE Guideline 0 and 0.2; it is about forming a team that will help each other turn over a complex system to the owner. The first portion of this program illustrates the importance of teamwork when beginning the commissioning process. The second portion includes some examples of these complex systems being commissioned, primarily geothermal heat pump systems, and compares and contrasts them to simpler systems, showing the positives and negatives of each. Lessons learned and best practices are provided.

1. Commissioning Is a Team Effort: A Roadmap to Customer Satisfaction

David Meyers, AIA, Burns & McDonnell, St. Louis, MO

2. Commissioning and Re-Commissioning Complex and Simple Geothermal Heat Pump Systems: Similarities, Differences and Critical Items

Michael Kuk, OPMP, CPMP and BEAP, Member, CERx Solutions LLC, Montgomery, IL

8:00 AM - 9:00 AM

Seminar 2 (Intermediate)

Net-Zero Hospital Guidebook (ASHRAE/RHEVA)

Track: Fundamentals and Applications

Room: 2105

Sponsor: 9.6 Healthcare Facilities

Chair: Travis English, P.E., Member, Kaiser Permanente, Anaheim, CA

Did you know that the average hospital in Germany uses 85 kBtu/sf-year, while the average North American hospital uses 95 kBtu/sf-year in natural gas? The ASHRAE/RHEVA Guidebook towards Net Zero Hospital Buildings aims to provide practical guidance for engineers, hospital owners, and regulators in both Europe and North America. This session shows an update on the bench-marking, the processes, and the challenges that hospitals face in addressing the energy needs of the coming decade.

1. Towards Net Zero: European Context and the Process of Towards Net Zero

David Eldridge Jr., P.E., HBDP, BEMP and BEAP, Member, Grumman/Butkus Associates, Evanston, IL

2. Towards Net Zero: International Bench Marking and the Implications to US Hospitals

Heather Burpee, University of Washington Integrated Design Lab, Seattle, WA

3. Towards Net Zero: Smart Measures for Net Zero

Frank Mills, Member, Frank Mills Consulting, Leyland, United Kingdom

8:00 AM - 9:00 AM

Seminar 3 (Basic)

Ready, Set, Grow: Establishing Your New Business

Track: Professional Development

Room: 2104B

Chair: Pam Duffy, Member, Spark One Solutions, LLC, Dallas, TX

In this session, attendees will learn how to establish and grow a new business. The session will cover defining a vision for your business, the technicalities of setting up a new business, and growing your business and brand reputation.

1. Ready: Developing and Defining Your Vision

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

2. Set: Business and Fiscal Structure (a.k.a The Boring Stuff)

Karen Lane, Lane Accounting Solutions, Smithville, MT

3. Grow: Building a (Positive) Reputation for Your New Business

Pam Duffy, Member, Spark One Solutions, LLC, Dallas, TX

8:00 AM - 9:00 AM

Seminar 4 (Basic)

Using Analytics and Big Data to Optimize Your HVAC Systems

Track: Optimization in HVAC&R

Room: 2103C

Sponsor: 6.1 Hydronic and Steam Equipment and Systems, 1.4 Control Theory and Application

Chair: David Lee, P.Eng., Member, Armstrong Fluid Technology, Toronto, ON, Canada

Big data and analytics are changing all industries including HVAC. Equipment and buildings are smarter than ever due to the ubiquitous adoption of IoT sensors, the ability to process massive amounts of data, and the dramatic drop in the costs of data storage. This seminar will look at what data should be collected and how it is helping to drive optimized HVAC operation of buildings.

1. The Transformation of HVAC through Information and Analytics

Mark Gallagher, Member, Armstrong Fluid Technologies, Toronto, ON, Canada

2. Analytics and Optimization Strategies for HVAC: From Device to Overall Building Systems

Brent Waluzak, P.E., Siemens, Tampa Bay, FL

Sunday, June 23, 9:45 AM - 10:45 AM

Conference Paper Session 3 (Intermediate)

Building Energy Modeling in Large Institutions and Schools

Track: Modeling Throughout the Building Life Cycle/Research Summit

Room: 2203

Chair: Wade H. Conlan, P.E., Member, Hanson Professional Services, Maitland, FL

Creation or continuous maintenance of large fleets of building energy models could be challenging. This session outlines efforts to construct a streamlined process for quality assurance of energy-use breakdowns for large institutions and presents a large-scale simulation framework to investigate the fault impacts associated with HVAC systems in the secondary school. This session also examines poor indoor environmental quality in schools including high-performance schools.

1. First Steps to Maintain a Large Fleet of Building Energy Models (KC-19-C003)

Daniel Villa, P.E., Member¹, Joshua New, Ph.D., Member², Gerald R. Gallegos, P.E.³, Mark Adams², Aaron Garrett, Ph.D.⁴,

Thushara Gunda, Ph.D.³ and William Peplinski¹, (1)Sandia National Laboratories, Albuquerque, NM, (2)Tunation, LLC,

Knoxville, TN, (3)Sandia National Laboratories, Albuquerque, NM, (4)Jacksonville State University, Jacksonville, AL

2. Simulation-Based Nationwide Fault Impact Analysis for the Secondary School in U.S. (KC-19-C004)

Yanfei Li, Ph.D., Associate Member¹ and Zheng O'Neill, Ph.D., P.E., Member², (1)The University of Alabama, Tuscaloosa, AL, (2)University of Alabama, Tuscaloosa, AL

3. IEQ in High-Performance Urban Elementary Schools (KC-19-A005)

Emily Oldham, Associate Member¹ and Hyojin Kim, Ph.D., Member², (1)DLR Group, Washington, DC, (2)Catholic University of America, Washington, DC

9:45 AM - 10:45 AM

Conference Paper Session 4 (Intermediate)

Research on Fundamental HVAC&R Systems

Track: Research Summit

Room: 2204

Chair: Samir Traboulsi, Dr.Eng, Fellow Life Member, Thermotrade/Ranec, Beirut, Lebanon

This session highlights research on fundamental HVAC&R systems, including vapor compression cycles, commercial freezers, and compact heat exchangers. Research includes improvement in energetic performance of a vapour compression cycle, experimental investigation to compare the thermal and hydraulic performance of a conventional finned-tube evaporator coil with spiral finned coils for a commercial freezer, and offset-strip fin compact heat exchangers.

1. Thermodynamic Analysis of a Vortex Tube Integrated Subcritical Vapour Compression Cycle (KC-19-C005)

Akhilesh Arora, Ph.D., Associate Member, Delhi Technological University, Delhi, India

2. Performance of Spiral and Plain Finned-Tube Evaporator Coils for Novel Defrost System in Commercial Freezers (KC-19-A006)

Mostafa Elsharqawy, Ph.D., P.E.¹, Punnoose Abraham¹, Sameh Saad, Ph.D.² and Kazi Ahmed², (1)University of Guelph, Guelph, ON, Canada, (2)Betterfrost Technologies Inc., Toronto, ON, Canada

3. Three-Dimensional Computations for Forced Convection of Air in Offset-Strip Fin Channels: Effects of Fin Offset Length (KC-19-C006)

Dantong Shi, Kuan-Ting Lin, Milind A. Jog, Ph.D. and Raj M. Manglik, Ph.D., Member, University of Cincinnati, Cincinnati, OH

9:45 AM - 10:45 AM

Seminar 5 (Intermediate)

ASHRAE's New Residential Indoor Air Quality Guide: Best Practices for Construction and O&M

Track: Occupant Health & Safety

Room: 2102B

Sponsor: Environmental Health Committee

Chair: Lawrence Schoen, P.E., Fellow ASHRAE, Schoen Engineering Inc, Columbia, MD

Achieving good IAQ throughout the lifespan of a home requires a commitment to indoor air quality when buying, renting, and designing and maintaining that focus throughout construction, operation and maintenance. Residential buildings are built differently than commercial and institutional buildings. The Guide addresses single- and multifamily dwellings. It includes best practices to achieve excellent IAQ and information and tools that residents, home designers and builders can use to integrate IAQ into dwellings. Attendees learn about the breadth and depth of this Guide, some examples of easy steps to improve Residential IAQ and selected misconceptions.

1. Residential Envelopes and Moisture Control

Lawrence Schoen, P.E., Fellow ASHRAE, Schoen Engineering Inc, Columbia, MD

2. Whole Dwelling Ventilation, Exhaust and Filtration

Amy Musser, P.E., CPMP, BEMP and BEAP, Member, Vandemusser Design, LLC, Asheville, NC

9:45 AM - 10:45 AM

Seminar 6 (Intermediate)

Diet and Exercise for Healthy High Performing Buildings

Track: Commissioning New & Existing Buildings

Room: 2101

Sponsor: 9.10 Laboratory Systems, 7.9 Building Commissioning

Chair: Christine Reinders-Caron, Member, Iowa State University, Ames, IA

Buildings are complex spaces when it comes to energy monitoring and acoustic performance. This session will address monitoring energy use, remote analytics, how acoustical performance is codified and tested in the design and commissioning process with examples in high performing buildings and in critical environments.

1. Making Smart Buildings Brilliant

Kelsey Leslie, P.E., Member, Paladin, Inc., Lexington, KY

2. Exercise Your Building for Healthy Performance

Vanessa Freidberg, P.E., Member, Siemens, Austin, TX

3. Keeping Your Building on a Healthy Diet

Morgan Hilk, Associate Member, Environmental Systems Design Inc, Chicago, IL

9:45 AM - 10:45 AM

Seminar 7 (Advanced)

Learning from Designers of Radiant Buildings

Track: Radiant Heating & Cooling

Room: 2104B

Sponsor: 6.5 Radiant Heating and Cooling

Chair: Ongun Kazanci, Ph.D., International Centre for Indoor Environment and Energy, Technical University of Denmark, Kgs. Lyngby, Denmark

Whenever a relatively unfamiliar technology grows in popularity within an industry, there is a diverse range of design approaches taken, and a lack of commonly accepted best practices. This is true for radiant heating and cooling systems today, and this diversity has energy and cost performance implications. We explore this in the seminar through the results of 11 in-depth interviews with experienced radiant designers, and a detailed investigation of the performance and costs of various design options.

1. Current Practice for Design and Control of High Thermal Mass Radiant Cooling Systems and Opportunities for Future Improvements

Jonathan Woolley, Center for the Built Environment, University of California, Berkeley, CA

2. Construction and Energy Costs of Radiant Systems in the California Bay Area

Jingjuan (Dove) Feng, Ph.D., P.E., Member, TRC Advanced Energy Services, Oakland, CA

9:45 AM - 10:45 AM

Seminar 8 (Intermediate)

What's New in Laboratory Ventilation? ASHRAE'S New Publication "Classification of Laboratory Ventilation Design Level"

Track: Occupant Health & Safety

Room: 2105

Sponsor: 9.10 Laboratory Systems

Chair: Kelley Cramm, P.E., Member, Henderson Engineers, Lenexa, KS

Come hear about this new document which provides guidance on laboratory ventilation and why it's important in protecting laboratory users against harmful exposure to hazardous materials.

1. Safety Dictates the Lab Ventilation Design Level

Thomas Smith, Member, 3Flow, Cary, NC

2. Using Lab Ventilation Design Level in Day-to-Day Operations

Ellen Sweet, Cornell University, Ithaca, NY

9:45 AM - 10:45 AM

Workshop 1 (Basic)

"Slide Rules" for Engineers: Presentation Design Best Practices for Technical Professionals

Track: Professional Development

Room: 2104A

Chair: Mark P. Malkin, P.E., University of Wisconsin-Madison, Madison, WI

Discover best practices for designing your presentation slides, and avoid overuse of bullets and text. ASHRAE members often face the challenge of communicating highly technical information to an audience. Don't make your audience read and listen at the same time. Follow these "slide rules" to become a more effective communicator. Create engaging presentations and help everyone understand and more easily retain your information.

1. "Slide Rules" for Engineers: Presentation Design Best Practices for Technical Professionals

Joy Altwies, Ph.D., P.E., Member, University of Wisconsin-Madison, Madison, WI

9:45 AM - 10:45 AM

Workshop 2 (Intermediate)

Unlocking Optimization for HVAC&R

Track: Optimization in HVAC&R

Room: 2103C

Sponsor: 1.13 Optimization

Chair: David Yashar, Ph.D., Member, National Institute of Standards and Technology, Gaithersburg, MD

Optimization techniques continue to advance and adapt to the quest for maximized energy efficiency and performance, cost minimization, or to find the best design for a given engineering problem. These optimization techniques can be employed in typical HVAC&R applications such as: equipment design, building design, or equipment and/or building controls. In this workshop, we will discuss available optimization techniques and how they can be effectively applied to equipment design, building design, and controls. Related engineering optimization tools is presented with examples to demonstrate proper use of optimization techniques in HVAC&R applications.

1. Optimization for Building Equipment

Khaled Saleh, Ph.D., P.E., Member, Daikin, Houston, TX

2. Optimization Building Controls

Christopher Laughman, Ph.D., Member, Mitsubishi Electric Research Laboratories, Cambridge, MA

Sunday, June 23, 11:00 AM - 12:30 PM

Conference Paper Session 5 (Intermediate)

HVAC is for People: Thermal Comfort and Adaptive Controls

Track: Research Summit

Room: 2204

Chair: Hyojin Kim, Ph.D., Member, Catholic University of America, Washington, DC

This session focuses on the impacts of HVAC design on people, including artificial neural network models to predict the thermal demand, treatment of air supply using herbal medicines, international thermal comfort standards in terms of their specifications for adaptive thermal comfort model application and control strategies that can save energy and maintain thermal comfort at the same time.

1. Personalized Thermal Demand Prediction Algorithm Based on Wrist Temperature and Heart Beat (KC-19-C007)

Linhao Li, Delos Living LLC, New York, NY

2. Ayurvedic Management of Diseases Caused Due to Continuous Usage of Air-Conditioning (KC-19-C008)

Reena Arora, Dr.Eng¹, Akhilesh Arora, Ph.D., Associate Member² and Raghunandan Sharma, M.D.³, (1)Ayurvedic Clinic, Delhi, India, (2)Delhi Technological University, Delhi, India, (3)Ayurplanet Ayurveda, London, United Kingdom

3. A Review of Adaptive Thermal Comfort Implementation in International Thermal Comfort Standards (KC-19-A007)

Ongun Berk Kazanci, Ph.D., Associate Member¹, Daniel Coakley, Ph.D., Member² and Bjarne Olesen, Ph.D., Presidential Member¹, (1)International Centre for Indoor Environment and Energy, Technical University of Denmark, Kgs. Lyngby, Denmark, (2)Mitsubishi Electric R&D Centre Europe BV, Livingston, United Kingdom

4. Air Conditioner Control Strategy Based on Thermal Comfort Improvement Model (KC-19-C009)

Hsiao-Yuan Wu, Ph.D.¹, Hung-Wen Lin, Ph.D., Member², Guan-Wen Chen², Deqing Moo³ and Yin-Chun Tsai⁴, (1)Creativity Lab, Industrial Technology Research Institute, Chutung, Hsinchu, Taiwan, (2)Industrial Technology Research Institute, Hsinchu, Taiwan, (3)University of Malaya, Kuala Lumpur, Malaysia, (4)National Tsing Hua University, Hsinchu, Taiwan

11:00 AM - 12:30 PM

Conference Paper Session 6 (Intermediate)

Unitary, Room Air Conditioners and Refrigeration Cycles

Track: Research Summit

Room: 2203

Chair: Ahmed Elatar, Ph.D., ORNL, Oak Ridge, TN

This session presents up-to-date information on refrigeration split systems, adsorption refrigeration systems, and refrigerant migration. This first presentation provides high-quality reference data for refrigerant and oil charge measurements in residential fin-tube heat exchangers for split systems, while the second presentation considers large refrigerant migration during off cycles. The third paper presents the work that has been done as part of ASHRAE RP1733 and 1743 to improve air conditioner's efficiency due to larger flow rates. In the final presentation, adsorption refrigeration systems are gaining considerable importance for application in transport industries.

1. Study of Heat Exchanger Inlet Air Velocity Distribution for Ducted Tests in a Psychrometric Chamber (KC-19-C010)

Abraham J. Lee, Student Member, Christian K. Bach, Ph.D. and Craig R. Bradshaw, Ph.D., Member, Oklahoma State University, Stillwater, OK

2. Potency of Cyclic Degradation Coefficient in Characterizing Dynamic Air Conditioner Operation (KC-19-C011)

Rohit Dhumane¹, Jiazhen Ling, Ph.D., Member¹, Vikrant Aute, PhD, Member¹, Reinhard Radermacher, Ph.D., Fellow ASHRAE¹, Allen Kirkwood² and Jack Esformes², (1)University of Maryland, College Park, MD, (2)Carrier Corporation, Indianapolis, IN

3. Improvement of Unitary Equipment and Heat Exchanger Testing Methods (ASHRAE RP 1733/43) (KC-19-C012)

Md Yeam Hossain, Student Member, Christian Bach, Ph.D., Associate Member, Omer San, Ph.D. and Romit Maulik, Oklahoma State University, Stillwater, OK

11:00 AM - 12:30 PM

Seminar 9 (Intermediate)

Automated Fault Detection and Diagnostics Software for Cx, RCx and MBCx

Track: Commissioning New & Existing Buildings

Room: 2101

Sponsor: 7.5 Smart Building Systems, 7.9 Building Commissioning

Chair: Xiaohui Zhou, Ph.D., Member, Slipstream, Madison, WI

There have been major developments in the past few years in commercially available automated fault detection and diagnostics (AFDD) software, used for detecting sub-optimal system performance in the commercial buildings. They have been used successfully in commissioning (Cx), retro-commissioning (RCx), and monitoring-based commissioning (MBCx). These tools can pinpoint then prioritize efficiency and cost saving opportunities, track savings, easy to integrate with existing building automation systems and some provide it as a Software-as-a Service (SaaS) option. This seminar will focus on discussing the applications of AFDD software as a useful tool for Cx, RCx, and MBCx.

1. How AFDD Tools Can Support Commissioning Teams

Nick Gayeski, Ph.D., Member, KGS Buildings, Inc, Cambridge, MA

2. AFDD for Retro-Commissioning

Adam Regnier, Kinetic Buildings, Philadelphia, PA

3. AFDD for Monitoring-Based Commissioning

Peter Serian, Member, CopperTree Analytics, Surrey, BC, Canada

4. A Commissioning Agent's Perspective on AFDD

Sadie Joy, P.E., Associate Member, kW Engineering, Oakland, CA

11:00 AM - 12:30 PM

Seminar 10 (Advanced)

Occupant Behavior Analysis and Application Based on Large-Scale Datasets

Track: Research Summit

Room: 2103C

Sponsor: MTG.OBB Occupant Behavior in Buildings

Chair: Bing Dong, Associate Member, University of Texas at San Antonio, San Antonio, TX

Current worldwide efforts by researchers and engineers on occupant behavior have achieved plenty outcomes including data collection, model establishment, model evaluation, simulation integration, etc. Most current research deals with research objects within room or buildings. With the application scale enlarged, from the data collection, model establishment to application scenarios, the research methodology needs to be redesigned accordingly. This seminar will cover an overview of the investigation of occupant behavior research at a large scale based on datasets from HVAC operation, mobile position and residential thermostats. The research helps develop ASHRAE standards and/or guidelines for building design and operation.

1. Data Mining for Occupant Behavior from Large Scale Operation Data of VRF Systems

Da Yan, Building Energy Research Center, Tsinghua University, Beijing, China

2. A Preview of Human-Thermostat Interactions from a Manufacturer's Dataset

Jing Yang, Carnegie Mellon University, Philadelphia, PA

3. Derive and Quantify Urban Scale Occupancy Profiles Based on Mobile Position Data

Bing Dong, Ph.D., Associate Member, University of Texas at San Antonio, San Antonio, TX

4. Findings from Consumer-Grade IAQ Measurements in Residential and Commercial Buildings

Clinton Andrews, Ph.D., P.E., Member, Rutgers University, New Brunswick, NJ

11:00 AM - 12:30 PM

Seminar 11 (Intermediate)

Optimization for Next Generation Systems

Track: Optimization in HVAC&R

Room: 2105

Sponsor: 1.13 Optimization

Chair: Christopher Laughman, Ph.D., Member, Mitsubishi Electric Research Laboratories, Cambridge, MA

The dual trends of improving building energy performance and the ongoing transition to low-GWP fluids make this a time of significant change for the HVAC&R industry, in which systems with new working fluids must be designed that have lower installed energy consumption. Modern optimization technology can provide a systematic and efficient path to achieving these objectives at both the system and building level. This seminar will provide three case studies of this optimization technology to a range of applications.

1. Multi-Objective Design Optimization of Air-Cooled Condensers Operating with Low-GWP Refrigerants

Omar Abdelaziz, Member, CLEAT Consulting, Knoxville, TN

2. Optimization of Air-to-Refrigerant Evaporator with Low-GWP Refrigerants

Piotr Domanski, Ph.D., Fellow ASHRAE, National Institute of Standards and Technology, Gaithersburg, MD

3. Operation Optimization of Grid-Interactive Efficient Buildings for the Grid with High Penetrations of Renewables

Zheng O'Neill, Ph.D., P.E., Member, University of Alabama, Tuscaloosa, AL

11:00 AM - 12:30 PM

Seminar 12 (Intermediate)

Thermodynamics of Frost Formation

Track: Fundamentals and Applications

Room: 2104B

Sponsor: 1.1 Thermodynamics and Psychrometrics

Chair: Ayyoub Mehdizadeh Momen, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN

In this session the thermodynamics of the frost formation and frost inhibition techniques in HVAC&R systems will be discussed.

1. How to Prevent Frost and Ice Formation in Industrial Freezers

S.a. Sherif, Ph.D., Fellow Life Member, University of Florida, Gainesville, FL

2. Impact of Surface Morphology on the Frost Growth Rate: A Thermodynamic Prospective

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

3. Density of Frost on Super-Hydrophobic and Super-Hydrophilic Surfaces Under Air Forced Convective Operating Conditions

Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL

11:00 AM - 12:30 PM

Seminar 13 (Intermediate)

The Role of Gas Filtration on Improving IAQ

Track: Occupant Health & Safety

Room: 2104A

Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment

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

The technology of removing gaseous contaminants from the air and maintaining acceptable IAQ is becoming increasingly important for the health and well-being of mankind. The objective of the seminar is to provide the basic principles of air cleaning technologies, how to apply them, and to improve IAQ using the technologies.

1. Potential of Air Cleaning for Improving Indoor Air Quality

Jensen Zhang, Ph.D., Member, Syracuse University, Syracuse, NY

2. The Role of Gas-Phase Air Filtration Improving for Improving IAQ: Case Studies

Christopher Muller, Member, Purafil, Filtration Group, Doraville, GA

3. IAQ: Keep the Oxygen, Lose the Pollutants

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

11:00 AM - 12:30 PM

Seminar 14 (Intermediate)

Understanding the 2018 ENERGY STAR Score Updates

Track: Modeling Throughout the Building Life Cycle

Room: 2102B

Sponsor: 7.6 Building Energy Performance

Chair: Amanda Webb, Ph.D., Associate Member, University of Cincinnati, Cincinnati, OH

In August 2018, the U.S. EPA updated the performance metrics for its ENERGY STAR Portfolio Manager tool for the first time in over a decade. While this update aligned the ENERGY STAR models with the most recent building performance data, it resulted in a substantial score drop for most building types. Some buildings previously considered high performers may no longer achieve that recognition. This seminar examines these updates from the perspectives of several ENERGY STAR stakeholder groups: program managers at the U.S. EPA, commercial building owners and consultants, municipal benchmarking programs, and the research community.

1. Updating EPA's Energy STAR Metrics with New Market Data

Cindy Jacobs, U.S. Environmental Protection Agency, Washington, DC

2. The New Energy STAR Scores: Evaluating the Impact on Buildings

Barry Abramson, P.E., CPMP and BEAP, Member, Servidyne, LLC, Atlanta, GA

3. Energy Benchmarking and How Technology and Scoring Changes Affect the User Experience

Jesse Fields, City of Kansas City Missouri, Kansas City, MO

4. Building Benchmarking from a Research Perspective

Ketaki Agale, University of Cincinnati, Cincinnati, OH

Sunday, June 23, 1:30 PM - 3:00 PM

Technical Paper Session 1 (Intermediate)

Cooling and Thermal Comfort Strategies

Track: Systems & Equipment in the Built Environment

Room: 2203

Chair: Jon Cohen, Member, ChemTreat, Inc., Richmond, VA

This session presents a series of studies on strategies to achieve thermal comfort. The first presentation is an uncertainty analysis of a numerical performance model of a downdraft evaporative fabric cooling tower was conducted. The second presentation is research assessing the indoor air quality and comfort in recently completed high-rise social housing buildings. The third study adopts a performance-based approach and a CFD modeling tool FDS to evaluate the potential fire hazard posed by this innovative technology. The third study was done to illustrate the impact of water use can have on plant operating cost and tower fan control.

1. Uncertainty Analysis of a Numerical Performance Model for an Inflatable Fabric Evaporative Cooling Tower (KC-19-001)

Stephen Idem, Ph.D., Member¹, Steven Duong², Robert Craven³ and Steve Garner³, (1)Tennessee Tech University, Cookeville, TN, (2)Nissan Inc., Smyrna, TN, (3)LTA Projects, Cookeville, TN

2. Achieving Health and Comfort in High-Rise Residential Buildings by Using Dynamic-Hybrid Air Permeable Ceiling (KC-19-002)

Mohd Firrdhaus Mohd Sahabuddin, Student Member¹ and Cristina Gonzalez-Longo², (1)University of Strathclyde, GLASGOW, United Kingdom, (2)The University of Strathclyde, Glasgow, United Kingdom

3. Fire Hazard Analysis of Energy-Saving High-Volume Low-Speed Fan System in Large Spaces (KC-19-003)

Xiaolei Chen, Ph.D.¹ and Frank Wang, P.E.², (1)California State University, Los Angeles, CA, (2)Jensen Hughes, Anaheim, CA

1:30 PM - 3:00 PM

Technical Paper Session 2 (Intermediate)

Studies in Loads and Sequences for Optimized Performance

Track: Optimization in HVAC&R

Room: 2204

Chair: Jaya Mukhopadhyay, Ph.D., Member, Montana State University, Bozeman, MT

This session presents four studies on loads and sequence applications. The first paper studied convective heat transfer coefficient at exterior building surface is crucially important for calculating air-conditioning load precisely. The second paper analyzed optimal sequencing of chillers and boilers based on short-term energy demand forecasts represents an untapped opportunity to improve the energy efficiency of central heating and cooling plants. The third paper presents an analysis of occupancy and occupancy-related data gathered from an academic office building. The primary result of the fourth paper is the Radiant Performance Explorer / Heat Balance (RPEHB), a PC-based Windows application that derives and displays comfort results for multiple positions within an arbitrarily shaped room. RPEHB draws on and unifies work from several prior ASHRAE research projects.

1. Analysis on Applicability and Feasibility of Popularizing Naphthalene Sublimation Technique in Island-Reef Areas (KC-19-004)

Jingchao Xie, Ph.D., HBDP¹, Yaping Cui¹, Jiaping Liu¹ and Jianping Wang², (1)Beijing University of Technology, Beijing, China, (2)Naval Institute of Engineering Design & Research, Beijing, China

2. Load Forecasting and Equipment Sequencing in a Central Heating and Cooling Plant: A Case Study (KC-19-005)

H. Burak Gunay, Ph.D., Associate Member¹, Araz Ashouri, Ph.D., Associate Member² and Weiming Shen, Ph.D.², (1)Carleton University, Ottawa, ON, Canada, (2)National Research Council Canada, Ottawa, ON, Canada

3. A Preliminary Analysis on the Use of Low-Cost Data Streams for Occupancy Count Estimation (KC-19-006)

H. Burak Gunay, Ph.D., Associate Member¹, Araz Ashouri, Ph.D., Associate Member², Weiming Shen², Guy Newsham, Ph.D.² and William O'Brien, Ph.D., Member¹, (1)Carleton University, Ottawa, ON, Canada, (2)National Research Council Canada, Ottawa, ON, Canada

4. Development of a Unified Tool for Analysis of Room Loads and Conditions (KC-19-007)

Charles S. Barnaby, BEMP, Fellow ASHRAE¹ and Peter Simmonds, Ph.D., Fellow ASHRAE², (1)Consultant, Moultonborough, NH, (2)Buildings and Systems Analytics LLC, Emnet, CA, United Kingdom

1:30 PM - 3:00 PM

Seminar 15 (Intermediate)

Indoor Relative Humidity: Evaluating Dry Air and Measures of Health

Track: Research Summit

Room: 2103C

Sponsor: 5.11 Humidifying Equipment

Chair: Brian Gilligan, P.E., GSA - Office of Federal High Performance Buildings, Washington, DC

The US General Services Administration studied four well-functioning office buildings and measured significantly higher level of stress and poorer sleep quality in occupants who spent the majority of time in conditions of very dry or humid air. We then engaged subject matter experts to help us interpret these findings. We will share the results of our project and a range of research on the influence of relative humidity on health. The panel will engage the audience in a discussion on next steps to further understand this relationship, and, to improve indoor environments to enhance occupant health.

1. Wellbuilt for Wellbeing: IAQ, Stress and Sleep in Four Federal Office Buildings

Brian Gilligan, P.E., GSA - Office of Federal High Performance Buildings, Washington, DC

2. Patients as Bioindicators

Stephanie Taylor, M.D., Member, Harvard Medical School, Infection Control Consultant, Boston, MA

3. Doing Due Diligence in Research and Data Analysis

Steve Taylor, P.E., Fellow ASHRAE, Taylor Engineering, Alameda, CA

1:30 PM - 3:00 PM

Seminar 16 (Intermediate)

Multiscale Building Energy Modeling, Part 11

Track: Modeling Throughout the Building Life Cycle

Room: 2102B

Sponsor: 4.7 Energy Calculations, 1.5 Computer Applications

Chair: Daniel Macumber, Member, National Renewable Energy Laboratory, Golden, CO

Models of the existing building stock are an emerging application of multiscale building energy modeling. These models have many valuable applications from fault detection and diagnostics, goal setting for campuses and cities, infrastructure planning for utilities, and national scale technology assessments. This seminar focuses on classification of model types, sources of validation data, strategies for calibration, and best practices. These techniques are necessary to increase stakeholder confidence in the quality of models for decision making purposes. Calibration of models has the potential to close the modeling loop and improve the accuracy of building energy modeling in other applications.

1. Building Energy Model Assimilation and Calibration with Real World Sensor Data

Zheng O'Neill, Ph.D., P.E., Member, University of Alabama, Tuscaloosa, AL

2. Classification and Approach to Multi-Scale Building Energy Modeling

Daniel Villa, P.E., Member, Sandia National Laboratories, Albuquerque, NM

3. City-Scale Building Energy Modeling and Calibration

Tianzhen Hong, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

4. Development and Validation of a National-Scale Building Stock Energy Model

Anthony Fontanini, National Renewable Energy Laboratory, Golden, CO

1:30 PM - 3:00 PM

Seminar 17 (Intermediate)

Next Level Challenges (Renovations, Special Systems and Acoustics)

Track: Commissioning New & Existing Buildings

Room: 2101

Sponsor: 7.9 Building Commissioning, 6.6 Service Water Heating Systems, 2.6 Sound and Vibration

Chair: Alonzo Blalock, P.E., Member, Jacobs Engineering, Fort Worth, TX

This seminar discusses some unique commissioning case studies, new requirements associated with acoustics and how the international community addresses some of these challenges. Systems which include domestic hot water in high rise buildings and replacement of air handlers in an ongoing operating multi-story building have challenges. This seminar looks at commissioning testing for mechanical and acoustic systems, and how the results of testing helps identify issues. This seminar provides a summary of how acoustical commissioning is codified internationally and dive into the details of how to do and document the new 189.1 Acoustical Control commissioning and inspections.

1. Commissioning a High-Rise Hotel, Hybrid Domestic Water Heating System Prior to Occupancy

Norman Nelson, P.E., Life Member, Jacobs Engineering Group, Portland, OR

2. Testing Processes for Multi-Story Building with Replacement of AHUs and Common Relief

Clay Wiedner, Member, Ross & Baruzinni, Inc., St. Louis, MO

3. How to Acoustical Commission & Inspect in Accordance with ASHRAE 189.1

Erik Miller-Klein, P.E., Member, A3 Acoustics, LLP, Seattle, WA

4. Acoustical Commissioning Around the World

Jason Swan, Member, Sandy Brown Associates, LLP, London, United Kingdom

1:30 PM - 3:00 PM

Seminar 18 (Basic)

The Technical Engineers Pathway to Career Growth: A Geek's Guide to Success

Track: Professional Development

Room: 2105

Sponsor: 1.4 Control Theory and Application

Chair: David Kahn, P.E., Member, City and County of Denver, Denver, CO

This seminar is for those who are or want to be an engineering subject matter expert. Learn the tricks of gaining technical expertise. A control systems engineer will be used to illustrate the needed knowledge base, resources available for gaining the expertise and using technology as a learning tool. The value of a mentor to navigate the technical and business arena and how to find a mentor, maximizing the mentor experience. EQ or emotional quotient is a better predictor to success than IQ. Learn what EQ is and how to maximize yours.

1. Subject Matter Expert: What You Need to Know and Where to Find It

Gaylen Atkinson, Life Member, Atkinson Electronics, Inc, Retired, Salt Lake, UT

2. The Delicate Balance of Mentoring: Giving Mentees the Opportunity to Create Themselves

James Delmonaco, P.E., Member, P2S Engineering, San Diego, CA

3. Emotional Quotient and Career Success

Bud Gaines, P.E., Life Member, Mtech, Denver, CO

1:30 PM - 3:00 PM

Seminar 19 (Intermediate)

What's Loss Got to Do with It?: Analysis of Indicator Diagrams of Positive Displacement Compressors

Track: Research Summit

Room: 2104B

Sponsor: 8.1 Positive Displacement Compressors, 1.2 Instruments and Measurements , 8.2 Centrifugal Machines

Chair: Margaret Mathison, Ph.D., Member, Iowa State University, Ames, IA

This seminar explores how experimentally collected indicator diagrams (pressure-volume curves) can be used to minimize losses in positive displacement compressors. This analysis is particularly relevant for optimizing the energy efficiency of compressors being modified to operate with new, low-GWP refrigerants. Experimental results for spool, screw, and scroll compressors are used to illustrate how data can be reduced and used to calculate losses. The presenters also explores how operating conditions and compressor speeds impact these losses, and how the results can be used to predict the efficiency improvements possible through improved designs.

1. Leveraging Loss Analysis to Explore Novel Attributes and Critical Features for Maximum Efficiency in Spool Compressors

Craig Bradshaw, Ph.D., Member, Oklahoma State University, Stillwater, OK

2. Experimental Analyses of Indicated and Mechanical Losses in Screw Compressors

Davide Ziviani, Ph.D., Member, Purdue University, West Lafayette, IN

3. Experimental Setup and Analysis of Indicated Losses in Scroll Compressors

Kirill Ignatiev, Ph.D., Member, Emerson Climate Technologies, Sidney, OH

1:30 PM - 3:00 PM

Seminar 20 (Intermediate)

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

Track: Professional Development

Room: 2104A

Sponsor: 1.7 Business, Management & General Legal Education

Chair: Michael Bilderbeck, P.E., Fellow ASHRAE, Pickering Firm, 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 three 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

Scott Fanning, P.E., Member, Fanning, Fanning & Associates, Inc., Lubbock, TX

2. Case Studies 2

Jennifer Leach, P.E., Member, Patterson-Kelley, East Stroudsburg, PA

3. Case Studies 3

Michael Bilderbeck, P.E., Fellow ASHRAE, Pickering Firm, Memphis, TN

Sunday, June 23, 3:15 PM - 4:45 PM

Seminar 21 (Intermediate)

Heat Exchangers Circuit Optimization

Track: Systems & Equipment in the Built Environment

Room: 2101

Sponsor: 1.13 Optimization, 8.4 Air-to-Refrigerant Heat Transfer Equipment

Chair: Omar Abdelaziz, Member, CLEAT Consulting, Knoxville, TN

This seminar presents state-of-the-art in heat exchanger circuit optimization. The seminar starts by demonstrating practical examples for heat exchanger circuit optimization in wind tunnel applications. We then examine a novel decision diagram formulation and compare it with previous binary constrained formulations. A practical example is demonstrated using the mixed integer programming solver CPLEX showing 9% average increase in capacity. Finally, we explore the novel integer permutation-based Genetic Algorithm (IPGA) for solving the tube-fin heat exchanger circuitry optimization problem. This IPGA is then used to design optimal circuitry under various airflow maldistribution profiles showing 2.4-14.6% increase in heat exchange capacity

1. Dry Cooler Application in a Wind Tunnel

Stanislav Perencevic, Member, Guentner Germany, Fürstenfeldbruck, Germany

2. Heat Exchanger Circuitry Design By Decision Diagrams

Christopher Laughman, Ph.D., Member¹ and Vikrant Aute, PhD, Member², (1)Mitsubishi Electric Research Laboratories, Cambridge, MA, (2)University of Maryland, College Park, MD

3. Tube-Fin Heat Exchanger Circuitry Optimization for Robust Performance Under Airflow Maldistribution

Zhenning Li, Student Member, University of Maryland, College Park, MD

Monday, June 24

Monday, June 24, 8:00 AM - 9:30 AM

Technical Paper Session 3 (Intermediate)

Studies in Particles, Friction and Desiccant Applications in HVAC

Track: Optimization in HVAC&R

Room: 2102B

Chair: Jon Cohen, Member, ChemTreat, Inc., Richmond, VA

This session discusses applications in HVAC related to particles, friction calculations and use of desiccants. The first paper discusses a new dynamic laboratory test method has been developed for air cleaners and air cleaning systems used in industrial pulse cleaned dust collection applications. The next paper analyzes the Particle Swarm Optimization method, one of the simplest methods to apply in the solution of HVAC engineering design optimization problems. The third paper offers an integrated equation that can be used to calculate duct/pipe friction loss by hand. The fourth paper studies membrane liquid desiccant air-conditioning systems implement Liquid-to-air membrane energy exchangers to meet the latent or dehumidification loads in buildings.

1. A New Algorithm to Measure the Convergence of PSO with an Application to Hydronic Design in Buildings (KC-19-008)

Ramiro Bravo, Ph.D., Member¹ and Forrest Flocker², (1)University of the Permian Basin, ODESSA, TX, (2)University of the Permian Basin, Odessa, TX

2. Performance Evaluation of a Three-Fluid Liquid Desiccant Membrane Air-Conditioning System (KC-19-009)

Mohamed Abdel-Salam, Ph.D., Associate Member¹, Devin Storle² and Carey Simonson, Ph.D., P.E., Member², (1)Enbridge, Toronto, ON, Canada, (2)University of Saskatchewan, Saskatoon, SK, Canada

8:00 AM - 9:30 AM

Conference Paper Session 7 (Intermediate)

Radiating Heating/Cooling, Renewable Energy and Beyond

Track: Research Summit

Room: 2203

Chair: Samir Traboulsi, Dr.Eng, Fellow Life Member, Thermotrade/Ranec, Beirut, Lebanon

This session highlights a hybrid geothermally active building system, an analysis of load shifting, energy use and comfort using radiant ceiling panels, a solar powered reefers and an investigation of a solid oxide fuel cell in a residential furnace.

1. Integrated Sizing Methodology for a Hybrid Geotabs Building (KC-19-C013)

Eline Himpe, Ph.D., Mohsen Sharifi, Jelle Laverge, Ph.D. and Rana Mahmoud, Gent University, Gent, Belgium

2. Radiant Ceiling Panels: An Analysis of Load Shifting, Energy Use, and Comfort in a Laboratory House Setting (KC-19-C014)

James Haile, P.E. and David Springer, Frontier Energy, Inc., Davis, CA

3. Solar Powered Reefers: An Opportunity (KC-19-A008) (WITHDRAWN)

Chilukuri Maheshwar, CEng, Life Member, Anglo Eastern Maritime Academy, Navi Mumbai, India

4. Investigation of a Solid Oxide Fuel Cell in a Residential Furnace during Rapid Thermal Cycling (KC-19-A009)

Ryan J Milcarek, Ph.D., Member¹, Mengyuan Chu² and Jeongmin Ahn, Ph.D.², (1)Arizona State University, Tempe, AZ, (2)Syracuse University, Syracuse, NY

5. Effect of Climate Change and Extreme Weather Events on the Thermal Conditions of Canadian Multi-Unit Residential Buildings (KC-19-A010)

Hua Ge and Fuad Mutasim Baba, Concordia University, Montreal, QC, Canada

8:00 AM - 9:30 AM

Conference Paper Session 8 (Intermediate)

Urban Building Simulations

Track: Research Summit

Room: 2204

Chair: Dru Crawley, Ph.D., P.E., Fellow ASHRAE, Bentley Systems Inc., Washington, DC

Building energy consumption is highly influenced by weather conditions. This session presents studies weather conditions and its impact on urban environment, including the impact of microclimate and macroclimate on building energy consumption, modeling urban microclimate of extreme weather, dimensionless CFD analysis, and weather predictions comparison on urban building energy consumption.

1. Impact of Microclimate and Macroclimate on Building Energy Consumption (KC-19-C015)

Carlo Bianchi, Ph.D., Student Member, Jermy Thomas, Student Member and Amanda Smith, Associate Member, University of Utah, Salt Lake City, UT

2. Modeling Urban Microclimates of Extreme Weathers by Integrating City Fast Fluid Dynamics and City Building Energy Model (KC-19-A011)

Liangzhu (Leon) Wang, Ph.D., P.E., Member, Ali Katal and Mohammad Mortezaazadeh, Student Member, Concordia University, Montréal, QC, Canada

3. Dimensionless CFD Analysis of Reynolds Independence and Similarity in Urban and Built Environment Airflows (KC-19-A012)

Chang Shu, Student Member and Liangzhu (Leon) Wang, Ph.D., P.E., Member, Concordia University, Montreal, QC, Canada

4. City-Scale High-Resolution WRF-UCM Urban Weather Predictions Compared to a Dense Network of Ground-Based Weather Station Data for Assessment of Urban Building Energy Consumption (KC-19-C016)

Soham Vanage, Student Member, Elham Jahani, Student Member, Kristen Cetin, PhD, PE, Associate Member, David Jahn and William Gallus, Ph.D., Iowa State University, Ames, IA

5. The Influence of Role Models on the Sustainability of the Engineering Profession in the UK: A Case Study (KC-19-C017)

Ina Colombo, Ph.D., London South Bank University, London, United Kingdom

8:00 AM - 9:30 AM

Seminar 22 (Intermediate)

Frost Control Strategies for Air-to-Air Energy Recovery

Track: Systems & Equipment in the Built Environment

Room: 2104A

Sponsor: 5.5 Air-to-Air Energy Recovery

Chair: Kristin Sullivan, P.E., Member, Ingersoll Rand, La Crosse, WI

Energy recovery is becoming more of an essential part of today's HVAC solutions in buildings. Frost accumulation inside heat and energy recovery devices is among the biggest challenges that face energy/heat recovery ventilators. In climates with severe winter conditions, frost build-up may block the airflow channels of energy exchangers. This creates additional air pressure drop and may potentially damage the device or reduce indoor air quality. Frost control must be taken into consideration when designing and specifying an energy recovery device in certain climates. This session addresses strategies to avoid frost accumulation and common defrost strategies across the industry.

1. Frost Formation and Defrost Strategies for Fixed-Plate Heat and Energy Recovery Ventilators

Mo Afshin, P.Eng., Member, CORE Energy Recovery Solutions, Vancouver, BC, Canada

2. Heat Pipe Under Frosting Conditions

Marc Tardif, P.Eng., Member, Innergytech Inc., Drumminville, QC, Canada

3. Frost Prevention Methods on Energy Recovery Wheels

Tom Rice, Member, FlaktGroup SEMCO, Columbia, MO

8:00 AM - 9:30 AM

Seminar 23 (Intermediate)

Secrets of (Controls Implementation) Success

Track: Commissioning New & Existing Buildings

Room: 2105

Sponsor: 1.4 Control Theory and Application

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

The goal of the commissioning process is to result in a project that operates as intended. At the end of the day, if the controls aren't working properly, the project is doomed to failure. So what are the secrets to a successful controls implementation? From design, through the submittal process, to operator involvement and turnover, there are some common misses and mistakes that will undermine success and some best practices that can make all the difference. Come learn the secrets!

1. Don't Forget the Handlebars When Assembling the Bike: The Importance of Controls-Centric Mechanical Design

Brandon Gill, P.E., Member, Taylor Engineering, Alameda, CA

2. Submittal Review for Success: Looking for the Right Stuff

Chris Miller, P.E., Associate Member, P2S Inc., Long Beach, CA

3. Begin with the End in Mind: Operator Engagement for Operational Success

Stanley Chandler, Control Service Company, Kansas City, MO

8:00 AM - 9:30 AM

Seminar 24 (Intermediate)

The Art and Science of Reducing Flow to Improve Safety and Stop Wasting Energy in Labs

Track: Occupant Health & Safety

Room: 2103C

Sponsor: 9.10 Laboratory Systems, 5.3 Room Air Distribution

Chair: Carol A. Donovan, Member, NV5, Boston, MA

Laboratory airflow control systems serve as the primary means of protecting people working with hazardous airborne materials. Proper control of airflow is critical to minimizing occupational exposure below safe limits and minimizing contaminant migration and surface contamination. The laboratory environment serves as a secondary means to support safe and productive workspaces. Several factors including the locations and types of air supply diffusers and exhaust grills, location and strength of contaminant generation rate, and obstructions to airflow can impact contaminant accumulation, dilution and removal. This session will present techniques that can reduce airflow, minimize energy consumption and improve safety.

1. Use of Airflow to Mitigate Risk of Exposure to Hazardous Airborne Materials Generated in Labs

Thomas Smith, Member, 3Flow, Raleigh, NC

2. Use of Computational Fluid Dynamics Analysis to Optimize Laboratory Airflow, Safety and Energy Efficiency
Kishor Khankari, Ph.D., Fellow ASHRAE, AnSight LLC, Ann Arbor, MI
3. New Technologies to Control Airflow Distribution in Labs to Minimize Flow and Maximize Safety
Philip Sloan, DuctSox Corp, Dubuque, IA

8:00 AM - 9:30 AM

Seminar 25 (Intermediate)

The Climate Aloft: Designing for Tall Buildings

Track: Fundamentals and Applications

Room: 2101

Sponsor: 9.12 Tall Buildings, 4.2 Climatic Information

Chair: Luke Leung, P.E., Member, Skidmore, Owings, & Merrill LPP, Chicago, IL

The climate outside a tall building can change dramatically and in surprising ways as one moves away from the ground. This series of seminars showcases the challenges experienced, why the changes come about, some simple and state-of-the-art tools to estimate the exterior conditions, and the opportunities that height affords for building design.

1. Evaluating Environmental Conditions Aloft Using Analytical Tools and Observational Data

Michael Roth, Ph.D., Member, Klimaat, Guelph, ON, Canada

2. Vertical Temperature Conditions and Their Effect on Heating and Cooling Load Calculations

Peter Simmonds, Ph.D., Fellow ASHRAE, Building and Systems Analytics LLC, Emneth, CA, United Kingdom

3. Investigating Climatic Design Values at Elevated Heights by High-Resolution Numerical Weather Modeling

Xin Qiu, Ph.D., Member, SLR / Novus Environmental Inc., Guelph, ON, Canada

4. Managing Building Microclimate on Observation Decks and Natural Ventilation at the Top of Tall through Mega Tall Buildings

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

8:00 AM - 9:30 AM

Seminar 26 (Intermediate)

The Process for Zero Energy Office Buildings: The Next ASHRAE Advanced Energy Design Guide

Track: Optimization in HVAC&R

Room: 2104B

Sponsor: 2.8 Building Environmental Impacts and Sustainability

Chair: Tom Phoenix, P.E., Presidential Fellow Life Member, CPL (Clark Patterson Lee), Greensboro, NC

ASHRAE has just released the next Advanced Energy Design Guide. This zero energy guide focuses on what is needed to achieve zero energy in office buildings. The session will focus on the EUI targets focusing on the selection and design of the HVAC systems. It will also cover lighting, plug loads, and envelope design as it applies to the HVAC system to ensure that the office building can be built to the zero energy target. How-to tips and practical advice will be presented as well as successful zero energy case studies.

1. Overview of the AEDG Series and a Look Towards the Future

Tom Phoenix, P.E., BEMP and BEAP, Presidential Fellow Life Member, CPL (Clark Patterson Lee), Greensboro, NC

2. The Process of Creating the Zero Energy Office Guide

Paul Torcellini, Ph.D., P.E., Member, National Renewable Energy Laboratory, Golden, CO

3. Marriage of the Envelope and HVAC Selection and Design

Daniel Nall, P.E., HBDP, CPMP and BEMP, Fellow Life Member, Daniel Nall, Consultant, LLC, Princeton, NJ

4. A Deep Dive into HVAC Systems for Zero Energy Buildings

Ronnie Moffitt, P.E., Member, Trane, Inc., Lexington, KY

Monday, June 24, 9:45 AM - 10:45 AM

Technical Paper Session 4 (Basic)

ASHRAE 125th Anniversary: Retrospect on Geothermal Heat Pumps and Refrigerant Properties

Track: Fundamentals and Applications

Room: 2203

Sponsor: Historical Committee

Chair: Jeff Haberl, Ph.D., Fellow ASHRAE, Texas A & M University, College Station, TX

This session explores the pivotal waypoints in the development of the industry over the past 70 years. It also presents examples of installations, and provides best practices for ground source heat pump designs which are one of the best pathways to achieving net-zero energy buildings and homes. This session reviews the chronological variations in handbooks published from 1981 to 2017 and the properties of refrigerants published in the handbooks over time.

1. Geothermal Heat Pumps: Simply Efficient (KC-19-010)

Lisa Meline, P.E., Member¹ and Stephen Kavanaugh, Member², (1)Meline Engineering Corporation, Sacramento, CA, (2)University of Alabama, Tuscaloosa, AL

2. Chronological Variations in ASHRAE Handbook Refrigerant Thermodynamic and Transport Properties from 1981 to 2017 (KC-19-011)

Paul Nagy, Student Member and Michael Pate, Ph.D., Life Member, Texas A&M University, College Station, TX

9:45 AM - 10:45 AM

Conference Paper Session 9 (Intermediate)

Evaluation of Duct Design and Fan-Coil Units

Track: Research Summit

Room: 2204

Chair: Hyojin Kim, Ph.D., Member, Catholic University of America, Washington, DC

This session focuses on duct design and the performance and control of fan coil units. The first study develops an inlet duct design guideline with reduced length for inclusion in the AHRI and ASHRAE testing standards that reduces the risk of false testing failures and will lead higher integrity of the testing results at different laboratories. Performance measurements were made on 321 fan-coil units installed in university residence halls and one commercial building in different locations in Texas. This paper investigated the energy saving potential of modulation control of hydronic fan-coil units (FCUs) relative to traditional on-off control.

1. Effect of Inlet Duct Design on Fan Performance of Indoor Air Handling Unit (KC-19-A013)

Md Yeam Hossain, Student Member¹, Christian K. Bach, Ph.D.¹, Ardiyansyah Yatim, Associate Member² and Omer San, Ph.D.¹, (1)Oklahoma State University, Stillwater, OK, (2)University of Indonesia, Depok, Indonesia

2. A Field Evaluation of the Airflow Performance of Fan-Coil Units (KC-19-A014)

Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE¹ and Peng Yin, Ph.D., Associate Member², (1)Baylor University, Waco, TX, (2)University of Louisiana at Lafayette, Lafayette, LA

3. Comparison of Hydronic Fan-Coil Unit Energy Consumption with Modulation and On-Off Controls (KC-19-A015)

Peng Yin, Ph.D., Associate Member¹, Zahra Sardoueinassab¹ and Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE², (1)University of Louisiana at Lafayette, Lafayette, LA, (2)Baylor University, Waco, TX

9:45 AM - 10:45 AM

Seminar 27 (Basic)

The ASHRAE 2019-2024 Strategic Plan: What and Why

Track: Professional Development

Room: 2105

Sponsor: Planning

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

Since the 1980s, ASHRAE has engaged in strategic planning to help direct its efforts. The current strategic plan took effect in July 2014, five years ago. Over the past two years, the ASHRAE Board of Directors, supported by the Planning Committee, has developed a new plan for the next five year period beginning in July 2019. This seminar presents the background of the new plan, the initiatives contained in the new plan, and the process for implementing and monitoring it.

1. Development of the New ASHRAE Strategic Plan

William McQuade, P.E., Member, Air Conditioning, Heating and Refrigeration Institute, Arlington, VA

2. ASHRAE Strategic Plan Initiatives: What and Why

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

3. Implementing and Monitoring the New Strategic Plan

M. Dennis Knight, P.E., Fellow ASHRAE, Whole Building Systems, LLC, Mt. Pleasant, SC

9:45 AM - 10:45 AM

Seminar 28 (Intermediate)

Balancing Energy and Effectiveness

Track: Modeling Throughout the Building Life Cycle

Room: 2101

Sponsor: 4.10 Indoor Environmental Modeling

Chair: Gang Tan, Ph.D., P.E., Member, University of Wyoming, Laramie, WY

It is critical to balance the energy and effectiveness in building and system design or real operation. Modeling helps understand the part-load operation under off-design conditions and operational optimization. Combining academic research and industrial practices of modeling, this seminar presents: 1) a study of CFD based simulation to show the interaction between the energy efficiency and cooling effectiveness in data centers for identifying a business-appropriate balance, and 2) an optimization to determining the best location for a thermostat that plays an important role in energy performance and thermal comfort considering the HVAC system and the thermal comfort are mutually dependent.

1. Energy Efficient or Effective Data Center Cooling: Is It Either/Or?

Mark Seymour, Member, Future Facilities, London, United Kingdom

2. Optimization on Thermostat Location in an Office Room Using a Coupled Simulation of Indoor Airflow and HVAC System

Wangda Zuo, Ph.D., Member, Colorado University at Boulder, Boulder, CO

9:45 AM - 10:45 AM

Seminar 29 (Advanced)

Controlling High Thermal Mass Radiant Buildings

Track: Radiant Heating & Cooling

Room: 2102B

Sponsor: 6.5 Radiant Heating and Cooling

Chair: David Desjardins, Member, Viega LLC, Nashua, NH

Controlling high thermal mass radiant buildings has been and continues to be a topic of much discussion in the industry. There are a wide variety of approaches taken today. This seminar focuses on this topic, discussing and demonstrating the performance of a publicly available sequences of operation for controlling these systems, including results from energy simulations as well as real-world implementations in two large commercial office buildings in California.

1. Controlling High Thermal Mass Radiant Buildings: Publicly Available Sequences of Operation

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

2. Controlling High Thermal Mass Radiant Buildings: Implementation of Publicly Available Sequences of Operation for Radiant Systems in Two Field Study Sites

Carlos Duarte, Student Member, University of California, Berkeley, CA

9:45 AM - 10:45 AM

Seminar 30 (Intermediate)

Evaluating Automated Fault Detection and Diagnostics Tools for Commissioning New and Existing Buildings

Track: Commissioning New & Existing Buildings

Room: 2104B

Sponsor: 7.5 Smart Building Systems, 7.9 Building Commissioning

Chair: Jin Wen, Ph.D., Member, Drexel University, Philadelphia, PA

AFDD tools are significant components during a commissioning process, especially for RCx and MBCx. Many AFDD tools exist in the market and new AFDD strategies are being developed from research activities. However, there is a lack of data, testbed, and testing method that can be used to evaluate AFDD tools. How to estimate energy and indoor environment impacts from an AFDD process also lacks consensus. In this seminar, teams from three national laboratories will discuss their ongoing projects funded by the U.S. Department of Energy Building Technology Office, which focus on generating data and developing methods for evaluating AFDD tools.

1. Evaluating the Performance Building Fault Detection and Diagnostics Algorithms and Tools

Guanjin Lin, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

2. A Building Simulation Emulator with HVAC Fault Injection Capability for Testing AFDD Methods and Fault Impact Analysis

Vrabie Draguna, Ph.D., Member, Pacific Northwest National Laboratory, Richland, WA

3. Fault Tests on an Occupancy Emulated Small Office Building

Piljae Im, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN

9:45 AM - 10:45 AM

Seminar 31 (Basic)

How Much Sound Do Active Chilled Beams Make?

Track: Systems & Equipment in the Built Environment

Room: 2103C

Sponsor: 2.6 Sound and Vibration, 5.3 Room Air Distribution

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

Active chilled beams continue to gain in popularity among building owners and designers as effective and efficient devices that help to not only maintain space temperature and comfort but also minimize operating costs and occupant complaints. One of the reasons they have been chosen is their relatively low noise levels. ASHRAE has developed Standard 200 to define test methods to describe chilled beam performance, including sound levels. This session will provide an overview of active chilled beams, how they are tested for sound, and provide a case study of a project where sound levels were a factor to be addressed.

1. Active Chilled Beam Basics

Nick Searle, Member, Titus, Plano, TX

2. New ASHRAE 200 Acoustical Testing Requirements

Karl L. Peterman, P.E., Member, Swegon North America, Markham, ON, Canada

3. Chilled Beam Sound Case Study

Erik Miller-Klein, P.E., Member, A3 Acoustics, LLP, Seattle, WA

9:45 AM - 10:45 AM

Seminar 32 (Intermediate)

New ASHRAE Cleanroom Design Guide, Part 1: Fundamentals

Track: Fundamentals and Applications

Room: 2104A

Sponsor: 9.11 Clean Spaces

Chair: Philip Naughton, Member, Applied Materials Inc, Austin, TX

ASHRAE TC 9.11 Clean Spaces, and experts from around the world crafted a comprehensive and authoritative ASHRAE Cleanroom Design Guide. This seminar covers the latest information on fundamentals of contamination control, cleanroom air management, particle theory, and application of CFD. Seminar Part 2 will continue the introduction of the cleanroom design guide with applications.

1. Cleanroom Design Guide Introduction

Wei Sun, P.E., Fellow ASHRAE, Engsysco Inc, Ann Arbor, MI

2. Fundamentals of Contamination Control in Cleanrooms: Transport, Capture and Control

R Vijayakumar, Ph.D., Fellow ASHRAE, Aerfil, Liverpool, NY

3. Cleanroom Design: Air Management and Environmental Control

Philip Naughton, Member, Applied Materials Inc, Austin, TX

Monday, June 24, 11:00 AM - 12:00 PM

Panel 2 (Basic)

Flooding Design: What Do You Need to Know?

Track: Occupant Health & Safety

Room: 2102B

Sponsor: 2.7 Seismic and Wind Resistant Design

Chair: James Carlson, Fellow ASHRAE, Seismic Source International, Omaha, NE

Buildings can be subjected to hydrodynamic (flowing water) pressures during floods. These pressures can result in displaced floating fuel tanks. Flood resistance thus requires that structural and non-structural components be durable, resistant to flood forces (including buoyancy) and resistant to deterioration caused by inundation with floodwater. Location above the flood protection level is generally the best way to protect service equipment, such as HVAC, plumbing, duct systems and electrical equipment. The municipality may require certification from a licensed professional that the standards for resistance to flood damage are met.

1. Application

James Tauby, P.E., Fellow ASHRAE, Mason Industries, New York, NY

2. Flooding

Robert Simmons, P.E., Member, Petra Seismic Design, Houston, TX

3. Manufacturer

Patrick Marks, P.E., Fellow ASHRAE, Johnson Controls, New Freedom, PA

11:00 AM - 12:00 PM

Conference Paper Session 10 (Intermediate)

Experimental Data and Modeling of Air Distribution Systems

Track: Research Summit

Room: 2204

Chair: Gurumarayana Ravi, Lennox International, Frisco, TX

This session presents several papers on empirical modeling of VAV fan coil units for building energy calculations, air leakage analysis and modeling in parallel fan-powered terminal units, and automatic fault detection of AHUs using an online machine learning algorithm.

1. Empirical Modeling of Variable Air Variable Water Fan Coil Units in Cooling Mode for Building Energy Calculations (KC-19-A016)

Peng Yin, Ph.D., Associate Member¹, Tanjebul Alam, Student Member¹ and Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE², (1)University of Louisiana at Lafayette, Lafayette, LA, (2)Baylor University, Waco, TX

2. Air Leakage Analysis and Modeling in Parallel Fan-Powered Terminal Units Using EnergyPlus (KC-19-A017)

Zahra Sardoueinassab¹, Peng Yin, Ph.D., Associate Member² and Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE³, (1)APTIM, Baton Rouge, LA, (2)University of Louisiana at Lafayette, Lafayette, LA, (3)Baylor University, Waco, TX

3. Automatic Fault Detection and Diagnosis of Air Handling Unit Using an Online Machine Learning Algorithm (KC-19-A018)

Majid Karami and Liping Wang, Ph.D., P.E., Member, University of Wyoming, Laramie, WY

11:00 AM - 12:00 PM

Conference Paper Session 11 (Intermediate)

Sensitivities and Uncertainties in Building Energy Modeling and Performance

Track: Research Summit

Room: 2203

Chair: Parag Rastogi, Member, arbnco Ltd., Glasgow, United Kingdom

Building energy modeling and simulation analysis play a key role in technology assessment and energy efficiency analysis. This session focuses on a sensitivity analysis of optimal energy in buildings to environment parameters, a methodology to evaluate sensitive levels of inputs for commercial building models. Presented here also includes a methodology to evaluate a model-based home envelope performance using measurements of its indoor and outdoor temperatures and HVAC on/off status.

1. Sensitivity Analysis of Optimal Energy in Buildings to Environment Parameters (KC-19-A019)

Samah Ben Ayed, Ph.D., Associate Member¹, Jeff Borggaard, Ph.D.² and Eugene Cliff, Ph.D.², (1)New Mexico State University, Las Cruces, NM, (2)Virginia Tech, Blacksburg, VA

2. Methodology to Evaluate Sensitive Levels of Inputs for US Commercial Building Models (KC-19-A020)

Yunyang Ye¹, Kathryn Hinkelman¹, Wangda Zuo, Ph.D., Member¹ and Gang Wang, P.E., Member², (1)University of Colorado, Boulder, CO, (2)University of Miami, Coral Gables, FL

3. Model-Based Home Envelope Performance Evaluation: A Use Case of Data from Connected Thermostats (KC-19-A021)

Li Song, Ph.D., P.E., Member, Junke Wang, Student Member and Choon Yik Tang, Ph.D., University of Oklahoma, Norman, OK

11:00 AM - 12:00 PM

Seminar 33 (Intermediate)

Existing Building Commissioning: The Nitty Gritty

Track: Commissioning New & Existing Buildings

Room: 2101

Sponsor: 7.9 Building Commissioning

Chair: Tracey Whaley, P.E., Member, AECOM, Greenwood Village, CO

The formal EBCx process includes risks and rewards we don't encounter in new construction. This session aims to deliver keys to contracting professional services, scoping, risk management, and investigation strategies for developing a successful existing building commissioning project.

1. Existing Building Commissioning: The Nitty Gritty

Tracey Jumper, Member, Jump-Start Building Commissioning LLC, Selma, TX

2. The Value of Commissioning Study

Tom Poeling, P.E., Member, U.S. Engineering Company, Westminster, CO

11:00 AM - 12:00 PM

Seminar 34 (Intermediate)

Microbial Risks in the Built Environment: "Legionella" Commissioning and Supplemental Disinfection of Building Water Systems

Track: Systems & Equipment in the Built Environment

Room: 2104B

Sponsor: 3.6 Water Treatment

Chair: Helen Cerra, Member, ChemTreat, Inc., Glen Allen, VA

With increasing numbers of reported cases of Legionnaires' disease, ANSI/ASHRAE Standard 188-2018 "Legionellosis: Risk Management for Building Water Systems" requires the implementation of a water management program which includes the design and operation of building water systems. Part of this design requirement is to properly decontaminate a potable water system before occupancy. After the building is in operation, control measures, such as supplemental disinfection, may be needed to reduce the risk of Legionella amplification. This session reviews methods for decontamination of water systems before building start up, and the application of supplemental disinfection as an ongoing control strategy.

1. Decontamination of Building Water Systems in the Age of "Legionella"

Janet Stout, Ph.D., Associate Member, Special Pathogens Laboratory, Pittsburgh, PA

2. Supplemental Disinfection: Evaluation of the Potable Water Supplemental Disinfection Technologies

Joseph Ham, Member, Eldon Water, Inc., Novi, MI

11:00 AM - 12:00 PM

Seminar 35 (Intermediate)

New ASHRAE Cleanroom Design Guide, Part 2: Applications

Track: Fundamentals and Applications

Room: 2105

Sponsor: 9.11 Clean Spaces

Chair: Philip Naughton, Member, Applied Materials Inc, Austin, TX

ASHRAE TC 9.11 Clean Spaces and experts from around the world crafted a comprehensive and authoritative ASHRAE Cleanroom Design Guide. Seminar Part 1 reviewed cleanroom fundamentals. This seminar covers cleanroom standards and cleanliness classifications; cleanroom testing, certification, and commissioning; and applications in select industries: semiconductors, pharmaceutical, biotechnology and healthcare and food preparation.

1. Cleanroom Standards: Cleanroom Testing, Certification and Commissioning

Vincent Sakraida, P.E., BR+A Consulting Engineers, St. Louis, MO

2. Cleanroom Applications in Semiconductors and Microelectronics

Philip Naughton, Member, Applied Materials Inc, Austin, TX

3. Cleanroom Applications in Biotechnology, Pharmaceutical and Food Preparation

Gary Shamshoian, P.E., Member¹ and Vincent Sakraida, P.E.², (1)BEST Technology, Inc., San Jose, CA, (2)BR+A Consulting Engineers, St. Louis, MO

11:00 AM - 12:00 PM

Seminar 36 (Basic)

Professional Skills Highlights from Distinguished Lecturers

Track: Professional Development

Room: 2103C

Chair: Madison Schultz, P.E., Member, OK BeCo, Oklahoma City, OK

Two ASHRAE Distinguished Lecturers will provide abbreviated versions of their most popular topics on professional development.

1. How to Use Emotional Intelligence to Become a Better Leader Professionally and Personally

Karine Leblanc, Member, US Air Conditioning Distributors, Los Angeles, CA

2. Time Management for the Perpetually Busy Engineer

Pam Duffy, Member, Spark One Solutions, LLC, Dallas, TX

11:00 AM - 12:00 PM

Seminar 37 (Intermediate)

Radiant Cooling and Heating Using Ground Source Heat Pumps

Track: Radiant Heating & Cooling

Room: 2104A

Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: Michael Kuk, Member, CERx Solutions LLC, Montgomery, IL

Radiant cooling and heating systems are a natural match to ground-source heat pumps as their temperature ranges for heating and cooling are very moderate and allow highly efficient operation. The application of a high-mass radiant heat transfer system with predictive control significantly reduces peak HVAC loads and reduces energy use.

1. Radiant Cooling/Heating and Ground Source Heat Pumps: A Great Match!

Stephen Hamstra, P.E., HBDP, Member, Melink Solar & Geo, Cincinnati, OH

2. Radiant Heating and Cooling with a Geothermal Open Loop System: A Case Study

Greg Tinkler, Member, Page, Houston, TX

Monday, June 24, 2:15 PM - 3:45 PM

Debate 2 (Advanced)

College of Fellows Debate: Does Climate Change Pose a Liability Risk to Engineers?

Track: Professional Development

Room: 2101

Sponsor: 1.7 Business, Management & General Legal Education, College of Fellows

Chair: Mitchell Swann, P.E., MDC Systems, Paoli, PA, Don Beaty, P.E., Fellow ASHRAE, DLB Associates, Eatontown, NJ, Katherine Hammack, P.E., Fellow ASHRAE, Ernst & Young LLP, Tysons, VA, Beth Tomlinson, P.E., Member, TDKA, St. Paul, MN, Pete Conry, AIA, McDonald's Corp., Chicago, IL, Dru Crawley, Ph.D., P.E., Fellow ASHRAE, Bentley Systems Inc., Washington, DC and Karen Erger, J.D., Lockton Companies, Kansas City, MO

In our last debate we delved into "expected" and "predicted" building performance. Perfection as it turns out, is not a reasonable expectation. But shouldn't a "cognizant professional" be practicing prudent care? Fifty percent of the climate change issue is change. Sometimes changes can be anticipated, sometimes not. How much clairvoyance should a professional have? How much should a designer anticipate the impact of climate change on a project or is the future unknowable, even to ASHRAE? Come hear our two teams debate the risks of climate change and help decide which way the wind is blowing.

College of Fellows Debate: Does Climate Change Pose a Liability Risk to Engineers?

E. Mitchell Swann, P.E., Member, MDCSystems, Paoli, PA

Tuesday, June 25

Tuesday, June 25, 8:00 AM - 9:30 AM

Conference Paper Session 12 (Intermediate)

Alternative Refrigerants: Low GWP Refrigerants and Ionic Liquids

Track: Research Summit

Room: 2204

Chair: Wade H. Conlan, P.E., Member, Hanson Professional Services, Maitland, FL

This session presents recent research regarding low GWP refrigerant replacements and ionic liquids. System performance results with this new refrigerant will be presented for a 100 RT air-cooled packaged water chiller (R410A, R32, R452B). The second talk highlights a surface ice slurry generator. Absorption measurements of hydrofluorocarbons (R-134a, R-125 and R-32) and hydrofluoroolefins (R-1234yf and R-1234ze (E)) in a polyolester oil were performed. The two talks focusing on ionic liquids investigate the role of atom substitution on the solubility of a series of difluoromethane molecules (CHF₂-X) as a and the solubility and diffusivity of NH₃ in imidazolium based ionic liquids.

1. Performance of a Novel R410A Replacement in an Air-Cooled Chiller (KC-19-C018)

Kenneth Schultz, Ph.D., Member, Ingersoll Rand, La Crosse, WI

2. Theoretical and Experimental Studies of Ice Slurries (Green Secondary Refrigerant) Using PG and MEG as Antifreezes (KC-19-A022)

Rajinder Singh, Ph.D., Member, Pusa Institute of Technology, New Delhi, India

3. Solubilities and Diffusivities of HFC and HFO Refrigerants in a Synthetic Polyol Ester Lubricant Oil (KC-19-A023)

Ana Rita C. Morais, Ph.D.¹, Luke B. Simoni, Ph.D.², Aaron M. Scurto, Ph.D.³ and Mark Shiflett, Ph.D., P.E.¹, (1)University of Kansas, Lawrence, KS, (2)The Chemours Company, Wilmington, DE, (3)The University of Kansas, Lawrence, KS

4. Investigating the Thermodynamic and Transport Properties of Hydrofluorocarbon: Ionic Liquid Mixtures with Applications Towards Refrigerant Gas Separations (KC-19-A024)

Mark Shiflett, Ph.D., P.E., David Minnick, Ph.D. and Ana Rita Morais, Ph.D., University of Kansas, Lawrence, KS

5. Thermodynamic and Kinetic Analysis of Ammonia in Ionic Liquids for Absorption Refrigeration (KC-19-A025)

Tugba Turnaoglu and Mark B. Shiflett, Ph.D., P.E., University of Kansas, Lawrence, KS

8:00 AM - 9:30 AM

Conference Paper Session 13 (Intermediate)

Chiller Optimization and VFD Controls

Track: Research Summit

Room: 2102B

Chair: Parag Rastogi, Member, arbnco Ltd., Glasgow, United Kingdom

This session explores optimization and control strategies for chillers and VFDs. For chillers, research includes multi-objective genetic algorithm optimization solver to minimize the annual energy/initial/life cycle cost, or any combination of those costs and the result of using different machine learning methods to predict the chiller power shows that the model can predict the performance of the chiller with a high level of accuracy. For VFDs, Research includes simulations of motor efficiency with VFDs, which is validated by the measured efficiency, and experiments on a VFD-motor drive system to investigate the VFD efficiency and additional motor power loss at the rated frequency.

1. Two-Objective Genetic Algorithm Optimization of Chilled Water Plant Design (KC-19-A026)

Nabil Nassif, Ph.D., P.E., Member¹, Nihal Al Raees, Student Member² and Fouad Al Rifaie², (1)University of Cincinnati, Cincinnati, OH, (2)North Carolina A&T State University, Greensboro, NC

2. Smart Integrated Optimization Technique for Large Chilled Water Systems (KC-19-A027)

Mostafa Tahmasebi, Student Member, Nabil Nassif, Ph.D., P.E., Member and Rand Talib, Ph.D., Student Member, University of Cincinnati, Cincinnati, OH

3. An Approach for Motor Efficiency with Variable Frequency Drives (KC-19-A028)

Gang Wang, P.E., Member¹, Zufen Wang¹, Zhitao Han, Ph.D.² and Li Song, Ph.D., P.E., Member³, (1)University of Miami, Miami, FL, (2)Northeast Forestry University, Harbin, China, (3)University of Oklahoma, Norman, OK

4. The Impacts of Variable Frequency Drives on Drive System Efficiency (KC-19-A029)

Gang Wang, P.E., Member¹, Zhitao Han, Ph.D.² and Zufen Wang¹, (1)University of Miami, Miami, FL, (2)Northeast Forestry University, Harbin, China

8:00 AM - 9:30 AM

Conference Paper Session 14 (Intermediate)

Improved Ventilation for Healthcare Facilities and Disease Transmission

Track: Occupant Health & Safety

Room: 2203

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

Healthcare facilities and disease transmission have unique requirements for their designs to ensure occupant health and safety. This session evaluates the impact of cooling loads on the performance of displacement ventilation, proposes a simplified design for airborne infection isolation rooms, and highlights a research project conducted to explore an isolation system that can be stored in a small space and deployed in flight to limit the speed of infectious airborne. This session also discusses important safety-oriented code requirements that tend to be overlooked in mechanical design.

1. Performance of Displacement Ventilation for Hospital Patient Rooms with Varying Cooling Loads (KC-19-C019)

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

2. Designing Simplified Airborne Infection Isolation Rooms to Reduce Infection Rate in Future Pandemics (KC-19-C020)

Merethe Cecilie Lind, CEng, Affiliate¹, Trond Thorgeir Harsem, P.Eng., Member¹, Bård Venås, Dr.Eng., Affiliate¹, Petri Kalliomäki, CEng, Affiliate², Anders Welde Vikan, CEng, Affiliate¹ and Hannu Koskela, Ph.D., Affiliate², (1)Norconsult AS, Sandvika, Norway, (2)Turku AMK, Turku, Finland

3. Infectious Passenger Isolation System for Aircraft (KC-19-C021)

Byron Jones, Ph.D., P.E., Fellow ASHRAE¹, Ian Darrah¹, James Bennett, Ph.D., Member², Kenneth Mead, Ph.D., P.E., Member³ and Mohammad Hosni, Ph.D., Fellow ASHRAE¹, (1)Kansas State University, Manhattan, KS, (2)National Institute for Occupational Safety and Health, Cincinnati, OH, (3)U.S. Public Health Service National Institute for Occupational Safety and Health, Cincinnati, OH

4. Codes, Standards and OSHA Regulations Impacting Occupant Health and Safety in Buildings (KC-19-C022)

Stephen W. Duda, P.E., HFDP, HBDP and BEAP, Fellow ASHRAE, Ross & Baruzzini, Saint Louis, MO

8:00 AM - 9:30 AM

Seminar 38 (Intermediate)

Building Energy Efficiency at the System Level

Track: Systems & Equipment in the Built Environment

Room: 2104B

Sponsor: 7.6 Building Energy Performance, SSPC 90.1

Chair: Harold Jepsen, Associate Member, Legrand, Pleasant Grove, UT

While there has been significant progress in improving energy efficiency at the whole building and individual equipment levels, focusing on building systems is increasingly necessary to achieve deeper energy savings. A first step toward enhancing systems efficiency is strengthening measurement and verification of systems-level improvements, which requires a degree of consensus on the types of system-level metrics to deploy that would quantify and benchmark building system efficiency. This seminar discusses opportunities to improve building systems efficiency through standards, technologies and policies that support the development and application of system-level metrics.

1. Developing System-Level Key Performance Indicators

Tianzhen Hong, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

2. Benefits of Total System Performance Ratio: An HVAC System-Level Metric

Supriya Goel, Pacific Northwest National Laboratory, Richland, WA

3. Measuring and Standardizing Packages for Systems-Level Energy Savings

Paul Mathew, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

8:00 AM - 9:30 AM

Seminar 39 (Advanced)

Model-Predictive Control for HVAC System Optimization

Track: Optimization in HVAC&R

Room: 2103C

Sponsor: 7.5 Smart Building Systems, 7.6 Building Energy Performance

Chair: Eric Yang, P.E., Member, Energy Systems Group, Washington, DC

Model-predictive control (MPC) based optimization approaches present a promising solution for increasing the operational efficiency of HVAC systems. This seminar discusses MPC optimization technologies, including a novel MPC approach, a field evaluation study, and a framework for performance benchmarking. Using a dynamic data-driven model or physical-based model and disturbance forecast to predict HVAC system performance, this provides a given objective and taking into consideration future events. It combines the models with the real-time data from the building automation system (BAS) to determine the optimal control setpoints and feedback to the BAS to minimize energy consumption or costs.

1. Adaptive Model-Based Predictive Control for HVAC

Draguna Vrabie, Ph.D., Member, Pacific Northwest National Laboratory, Richland, WA

2. Field Evaluation of Model-Predictive Optimized Control System in Commercial Buildings

Guanjing Lin, Ph.D., Associate Member, Lawrence Berkeley National Laboratory, Berkeley, CA

3. A Framework for Comparing Model Predictive Control Solutions: Needs and Approach

David Blum, Lawrence Berkeley National Laboratory, Berkeley, CA

8:00 AM - 9:30 AM

Seminar 40 (Intermediate)

Overcoming Common Misconceptions in Water Treatment

Track: Optimization in HVAC&R

Room: 2101

Sponsor: 3.6 Water Treatment, 8.6 Cooling Towers and Evaporative Condensers

Chair: Jon Cohen, Member, ChemTreat, Naperville, IL

There are many common misconceptions around the water treatment of various hydronic systems affecting performance. Please come hear about how properly designed water treatment systems and component design with water treatment in mind, can be used to optimize hydronic system performance. Presentations will identify how these design changes can be applied to potable, steam, heating, chilled and cooling systems, which can decrease operating costs, improve performance and optimize water use efficiency.

1. Water Conditions and the Potential Effects on Our Piping Systems and Components

Jeff Ramey, United Technologies, Carrier Corporation, Syracuse, NY

2. Steam, Heating and Chilled: Common Misconceptions Overcoming Optimum End User Operation

Joshua Ince, P.Eng., Member, Eldon Water Inc, West Chester, OH

3. Strategies for Optimizing Water Treatment in Cooling Towers

Henry A. Becker, Member, Earthwise Environmental, Wood Dale, IL

4. Cooling Tower Sump-Piping Design and Operational Practices That Affect Water Treatment Efficiency

Gary Harbison, Harbison, Oakland, CA

8:00 AM - 9:30 AM

Seminar 41 (Intermediate)

Radiant Heating and Cooling Systems: Dispelling the Myths with Facts and Research

Track: Radiant Heating & Cooling

Room: 2105

Sponsor: 6.5 Radiant Heating and Cooling

Chair: Fred Bauman, P.E., Fellow Life Member, University of California, Berkeley, CA

As engineers, owners and contractors continue to explore the use of radiant heating and cooling systems in residential and commercial applications, some may feel apprehensive due to misconceptions about how these systems function. This seminar addresses common myths surrounding radiant systems and explore different facets of radiant research.

1. The Myths and Facts of Radiant Heating and Cooling Systems

Bjarne Olesen, Ph.D., Presidential Member, International Centre for Indoor Environment and Energy, Technical University of Denmark, Kgs. Lyngby, Denmark

2. Surface Heat Transfer Coefficients of Radiant Systems

Jun Shinoda, Student Member, Technical University of Denmark, Lyngby, Denmark

3. Ceiling Panels with Phase Change Materials as an Alternative to TABS in Renovation Projects

Ongun Berk Kazanci, Ph.D., Associate Member, International Centre for Indoor Environment and Energy, Technical University of Denmark, Kgs. Lyngby, Denmark

4. SMART Sensing: Scanning Mean Radiant Temperature Sensor for Characterizing Radiant Environments

Forrest Meggers, Princeton University, Princeton, NJ

8:00 AM - 9:30 AM

Seminar 42 (Intermediate)

Why Did the Heat Cross That Thermal (Dynamic) Bridge?

Track: Modeling Throughout the Building Life Cycle

Room: 2104A

Sponsor: 4.4 Building Materials and Building Envelope Performance

Chair: Paulo Tabares, Ph.D., Associate Member, Colorado School of Mines, Golden, CO

Many energy standards, heat loss calculations and whole building simulations overlook thermal bridging or use simplified building envelope details when calculating the overall thermal performance of a wall. This often neglects significant contributions to heat loss such as intersections between building envelope components, window to wall connections, floor interface and others that have thermally conductive materials bypassing the thermal insulation. This seminar will show through the presentations: 1) the importance to include dynamic thermal bridging in building energy and hygrothermal simulations, and 2) examples of buildings with different types of thermal bridges.

1. The Dynamic and Static Behavior of Selected Steel Wall Assemblies

Mehdi Ghobadi, Ph.D., National Research Council Canada, Ottawa, ON, Canada

2. Effect of Dynamic Modeling of Thermal Bridges on the Energy Performance of Residential Buildings for Cold Climates

Hua Ge, Concordia University, Montreal, QC, Canada

3. Dynamic vs. Static Analysis of Thermal Bridges in Walls

Achilles Karagiozis, Ph.D., Member, Owens Corning, Granville, OH

4. Dynamic Modelling of 3-Dimensional Thermal Bridges: Energy and Moisture Impact

Florian Antretter, Member, Fraunhofer-Institut für Bauphysik, Valley, Germany

Tuesday, June 25, 9:45 AM - 10:45 AM

Seminar 43 (Intermediate)

Advances in Ceiling Fans for Comfort Cooling

Track: Research Summit

Room: 2104B

Sponsor: 2.1 Physiology and Human Environment, Standard 55, Standard 216

Chair: Gwelen Paliaga, P.E., Member, TRC Advanced Energy Services, Oakland, CA

Ceiling fan use for comfort cooling is growing in popularity as part of low energy HVAC solutions in commercial and industrial applications. While ceiling fans are a well-known technology, there has been very little research data to support engineered solutions. Ceiling fan technology is also innovating. This seminar will cover recent advances in ceiling fan research and applications including results of large research efforts, new standards (ASHRAE Standard 216P), and example application case studies in new and existing buildings.

1. What Air Speeds Can I Expect for a Given Fan and Room? Predicting Indoor Air Speeds Based on Full Scale Laboratory Measurements

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

2. Ceiling Fans in Practice

Jim Bradburn, P.E., BEMP, Member, HGA Architects and Engineers, Minneapolis, MN

3. The Importance of Air Movement for Comfort When Occupants' Activity Levels Change

Hui Zhang, Ph.D., Member, University of California, Berkeley, CA

9:45 AM - 10:45 AM

Seminar 44 (Intermediate)

ASHRAE Research Overview for Lower GWP Flammable Refrigerants

Track: Research Summit

Room: 2103C

Sponsor: MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants, 1.1 Thermodynamics and Psychrometrics , 1.3, 8.5, 8.4, 8.11

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

This seminar provides updates on the recent technological and implementation developments in regards to lower GWP refrigerants. The discussion will include research topics from recently completed and on-going ASHRAE research projects (RP 1806, 1807 and 1808).

1. Flammable Refrigerants Post-Ignition Simulation and Risk Assessment (Overview of RP- 1806)

Phillip Johnson, P.E., Member, Daikin Applied, Staunton, VA

2. Guidelines for Flammable Refrigerant Handling, Transporting and Storing (Overview of RP-1807)

Dutch Usetlon, P.E., Fellow Life Member, Lennox Industries Inc., Carrollton, TX

3. Servicing and Installing Equipment Using Flammable Refrigerants: Assessment of Field-Made Mechanical Joints (Overview of RP- 1808)

Brian Fricke, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN

9:45 AM - 10:45 AM

Seminar 45 (Intermediate)

Building Envelope Cx x4: The Value, Requirements, Case Studies and Research

Track: Commissioning New & Existing Buildings

Room: 2105

Sponsor: 7.9 Building Commissioning

Chair: James Vallort, Fellow ASHRAE, Environmental Systems Design, Inc., Denver, CO

The building enclosure accounts for approximately 30% of the primary energy consumed in residential and commercial buildings. How can the building envelope commissioning process improve the quality of the envelope when deadlines, budgets and training are common variables to a project? Join our three experts as they discuss the value, requirements, case studies and research of this commissioning process officially adopted under LEED v4.

1. Building Envelope Commissioning: The Value Proposition

Tim Zelazny, AIA, Environmental Systems Design, Inc., Chicago, IL

2. The Value of Bexx Divided By 10: Snapshots in Reality

Fiona Aldous, Member, WJE, Boca Raton, FL

3. Understanding the Value of Building Enclosure Commissioning through a Performance Metric

Simon Pallin, Ph.D., Associate Member, Oak Ridge National Laboratory, Oak Ridge, TN

9:45 AM - 10:45 AM

Seminar 46 (Intermediate)

Controls and Indoor Air Quality

Track: Research Summit

Room: 2204

Sponsor: Publication and Education Council

Chair: Reinhard Radermacher, Ph.D., Life Member, University of Maryland, College Park, MD

This session presents recent papers in ASHRAE's journal "Science and Technology for the Built Environment". Session topics touch upon recent research in virtual measurements, machine learning and high efficiency filters.

1. Virtual Measurements of the Air Properties in AHUs or Virtual Re-Calibration of Sensors

Radu Zmeureanu, Ph.D., Life Member, Concordia University, Montreal, QC, Canada

2. Machine Learning vs. Hybrid Machine Learning Model for Optimal Operation of a Chiller

Cheol-Soo Park, Ph.D., Seoul National University, Seoul, Korea, Republic of (South)

3. IAQ and Energy Implications of High Efficiency Filters in Residential Buildings: A Review (RP-1649)

Masih Alavy, Student Member, University of Toronto, Toronto, ON, Canada

9:45 AM - 10:45 AM

Seminar 47 (Intermediate)

Modeling Transient Events, Part 2: The Indoor Environment

Track: Modeling Throughout the Building Life Cycle

Room: 2101

Sponsor: 4.10 Indoor Environmental Modeling, 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

Chair: Duncan Phylfe, Associate Member, Alden Research Laboratory, Holden, MA

This two part seminar session will look at transient flow modeling. Part 2 focuses on the indoor environment. In Part 2, engineers use computational fluid dynamics (CFD) to analyze transient indoor flows in a range of application, such as building cooling with PCM and hybrid ventilation, resilient data centers with compact models, library document and artwork protection. Engineers are able to harness critical data through the use of these modeling tools to improve the robustness and resilience of the designs. This seminar provides insights to the accurate modeling and into the selection of the analysis tools.

1. Improving Prescriptive Design Using Transient CFD Simulations

Michael Carl, P.Eng., Member, RWDI, Guelph, ON, Canada

2. A Compact Cooling-Unit Model for Transient Data Center Simulations

James W. VanGilder, P.E., Member, Schneider Electric, Andover, MA

3. Sub-Scale Modeling of High-Rise Building with Hybrid Ventilation Free Cooling and Phase Change Material Thermal Storage

Liangzhu (Leon) Wang, Ph.D., P.E., Member, Concordia University, Montreal, QC, Canada

9:45 AM - 10:45 AM

Seminar 48 (Basic)

Radiant at Work: Case Studies Featuring Radiant Heating and Cooling in Large-Scale Office Buildings

Track: Radiant Heating & Cooling

Room: 2104A

Sponsor: 6.5 Radiant Heating and Cooling

Chair: Devin Abellon, P.E., Member, Uponor, Phoenix, AZ

While some design professionals may reserve radiant heating and cooling for specialty applications, such as lobbies and atria, more and more engineers, architects, building owners and contractors are recognizing the opportunity to incorporate radiant as part of an energy-efficient design solution on large office buildings. This session will highlight two specific case studies.

1. Pearl River Tower: Design and Post-Occupancy Performance of the Radiant Ceiling System

Luke Leung, P.E., Member, Skidmore, Owings, & Merrill LPP, Chicago, IL

2. SFO CAC: The Beauty of Working Together

Noah Zallen, P.E., Member, Integral Group, Oakland, CA

9:45 AM - 10:45 AM

Seminar 49 (Intermediate)

Residential Standards Update: ASHRAE 90.2 and 62.2

Track: Fundamentals and Applications

Room: 2203

Chair: Iain Walker, Ph.D., Fellow ASHRAE, Lawrence Berkeley National Laboratory, Berkeley, CA

This seminar gives an overview of the two key ASHRAE residential standards -- 62.2 and 90.2 -- and provides a summary of recent updates and changes. Standard 62.2 is the most used and only ANSI-approved residential ventilation standard in the country. The 2019 version is just hitting the streets now, including the first substantial changes that address multifamily dwellings. ASHRAE has recently published 90.2-2018. The new 90.2 is a leadership standard that seeks to deliver residential building energy performance that is at least 50% more efficient than the energy efficiency defined by the 2006 IECC.

1. What's New in 62.2

Paul Francisco, Member, University of Illinois at Urbana-Champaign, Champaign, IL

2. The New ASHRAE Standard 90.2-2018 for High Performance Residential Buildings

Theresa Weston, Ph.D., Member, DuPont, Richmond, VA

9:45 AM - 10:45 AM

Workshop 3 (Intermediate)

Targeting What? Best Practices for Setting Performance Goals

Track: Systems & Equipment in the Built Environment

Room: 2102B

Chair: Jim Edelson, Associate Member, New Buildings Institute, Portland, OR

This workshop presents leading edge thinking for setting energy performance targets. Best practices for benchmarking energy, water, and indoor environmental quality in commercial buildings are drawn from a broad range of sources. This workshop looks at how these benchmarks are used primarily for establishing Energy Use Intensity goals and targets for the performance of commercial buildings. A set of current application use-cases across North America is examined covering both public and private sector buildings. Practices for establishing both standard performance targets and high-performance/zero energy targets will be presented for discussion in the workshop.

1. Performance Goals in ASHRAE's Performance Measurement Protocols and Standard 100

Bruce Hunn, Ph.D., Fellow ASHRAE, ASHRAE, Atlanta, GA

2. A Methodology for Consistent Zero Energy Building Targets

Kevin Carbonnier, Ph.D., New Buildings Institute, Portland, OR

Tuesday, June 25, 11:00 AM - 12:30 PM

Conference Paper Session 15 (Intermediate)

Building Modeling and Controls

Track: Modeling Throughout the Building Life Cycle/Research Summit

Room: 2203

Chair: Eric Yang, P.E., Member, Energy Systems Group, Washington, DC

This session covers a broad range of research topics in terms of building energy modeling and simulations, calibrations and energy codes. Presented here are a real-time platform for assessment of chiller-side demand response strategies, an algorithmically generated chiller performance curves for building energy simulation, barriers to energy controls in energy codes, modelling moisture sources due to air leakage, and enhancing building energy model calibration with inverse modeling. Come and learn the cutting edge research and studies on energy modeling and simulations!

1. A Real-Time Platform for Assessment of Chiller-Side Demand Response Strategies (KC-19-C023)

Fan Feng, Student Member¹, Zheng O'Neill¹ and Peng Xu², (1)University of Alabama, Tuscaloosa, AL, (2)Tongji University, Shanghai, China

2. Algorithmically Generated Chiller Performance Curves for Building Energy Simulation (KC-19-A030)

Jeremy Lerond, Affiliate, Pacific Northwest National Laboratory, Seattle, WA

3. Barriers to Energy Controls Delivering Real Savings (KC-19-A031)

Reid Hart, P.E., Member and Michael Rosenberg, Fellow ASHRAE, Pacific Northwest National Laboratory, Richland, WA

4. Modelling Moisture Sources Due to Air Leakage with the Hamt Extension for EnergyPlus (KC-19-C024)

Florian Antretter, Member¹ and Simon Pallin, Ph.D., Associate Member², (1)Fraunhofer-Institut für Bauphysik, Valley, Germany, (2)Oak Ridge National Laboratory, Oak Ridge, TN

5. Enhancing Building Energy Model Calibration with Physics-based Inverse Modeling (KC-19-A032)

Han Li, Associate Member¹, Tianzhen Hong, Ph.D., Member² and Marina Sofos³, (1)Lawrence Berkeley National Laboratory, Berkeley, CA, (2)LBNL, Berkeley, CA, (3)U.S. Department of Energy, Washington, DC

11:00 AM - 12:30 PM

Conference Paper Session 16 (Intermediate)

Indoor Environmental Quality and Chemical Emissions

Track: Research Summit

Room: 2204

Chair: Ahmed Elatar, Ph.D., ORNL, Oak Ridge, TN

Indoor environmental quality is critical for many applications, including aircrafts, indoor environments and chemical safety. This session includes reducing exposures of aircraft painters to hazardous metals and organics motivates design and operation of hangar ventilation systems in purpose-built facilities traditional high efficiency filtration systems, field exposure measurements in an aircraft cabin, chemical emissions from fused filament fabrication 3D printers and human chemical exposure levels from flame retardants.

1. Ventilation Design Considerations for Occupant Health in Aircraft Painting Facilities Under OSHA Requirements (KC-19-C025)

James Bennett, Ph.D., Member, National Institute for Occupational Safety and Health, Cincinnati, OH

2. Development of a Semi-Empirical Model for Predicting the Pressure Drop of Nanofiber Air Filters (KC-19-C026)
Chun Chen, Ph.D., Associate Member, Ye Bian and Li Zhang, Ph.D., The Chinese University of Hong Kong, Hong Kong, China

3. Influence of Source Location and Ventilation Rates on Contaminant Dispersion Pattern in an Aircraft Cabin (KC-19-A033)

James Bennett, Ph.D., Member¹, Veronica Dos Santos Teixeira², Yuanhui Zhang³ and Shamia Hoque, Ph.D., Associate Member⁴, (1)National Institute for Occupational Safety and Health, Cincinnati, OH, (2)The Dow Chemical Company - Charlotte Operations, Fort Mill, SC, (3)University of Illinois at Urbana-Champaign, Urbana, IL, (4)University of South Carolina, Columbia, SC

4. Particle and Chemical Emissions from 3D Printers and Their Potential Health Impacts (KC-19-A034)

Qian Zhang, Ph.D.¹, Aika Davis, Ph.D.¹, Marilyn Black, Ph.D.¹ and Rodney Weber, Ph.D.², (1)Underwriters Laboratories Inc., Marietta, GA, (2)Georgia Institute of Technology, Atlanta, GA

5. A Study of Chemical Exposure from Consumer Products Used in Residential Environments (KC-19-A035)

Aika Davis, Ph.D., Member¹, Debra Harris, Ph.D.² and Marilyn Black, Ph.D.¹, (1)Underwriters Laboratories Inc., Marietta, GA, (2)Baylor University, Waco, TX

11:00 AM - 12:30 PM

Seminar 50 (Basic)

How the Blockchain Will Affect You and Your Work in HVAC&R and Buildings: Don't Get Left Behind, It's Happening Now!

Track: Fundamentals and Applications

Room: 2105

Sponsor: 1.5 Computer Applications, MTG.BIM Building Information Modeling

Chair: Tim Dwyer, CEng, Fellow ASHRAE, UCL Institute for Environmental Design and Engineering (IEDE), London, United Kingdom

Blockchain is likely to disrupt the way that you, as a professional, work in the very near future. In the world of buildings and HVAC&R, blockchain will affect you if trying to assure the quality of a product, project, or building operation. Blockchain provides a publicly secure digital record that is virtually impossible to falsify. This seminar will provide a brief history of blockchain and explain its concept and application so that you can understand the basics sufficiently to be able to discuss it with others and consider how it might be usefully applied.

1. Blockchain Basics

Bruce Billedeaux, P.E., Member, Maverick Technologies A Rockwell Automation Company, Portage, MI

2. Why Blockchain Is the Real Deal and Impacts Everyone

Don Beaty, P.E., Fellow ASHRAE, DLB Associates, Eatontown, NJ

3. How Blockchain Technology Can Be Used for HVAC Equipment Maintenance

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

4. Blockchains for the Internet of Things: Preventing Forgery and Tampering of Identities

Devu Manikantan Shila, Ph.D., United Technologies Research Center, West Hartford, CT

11:00 AM - 12:30 PM

Seminar 51 (Intermediate)

Low Mass Radiant Systems

Track: Radiant Heating & Cooling

Room: 2101

Sponsor: 6.5 Radiant Heating and Cooling, 6.1 Hydronic and Steam Equipment and Systems, SSPC 55, TC7.4

Chair: Robert Bean, P.L.(Eng.), Member, Indoor Climate Consultants Inc., Calgary, AB, Canada

This overview will look at the fundamentals and applications of low mass radiant systems such as ceiling panels and "radiant waves" including their design, installation, control and operation.

1. The Fundamentals of Low Mass Radiant System Design

Michael O'Rourke, Member, Barcol Air USA, Denver, CO

2. Controls for Low Mass Hydronic Radiant Systems (Radiant Panels)

Peter Simmonds, Ph.D., Fellow ASHRAE, Building and Systems Analytics LLC, Emneth, CA, United Kingdom

3. Application of Low Mass Radiant Systems: Case Study and Lessons Learned

Eric J. Fontaine, Member, vanZelm Engineers, Hartford, CT

4. Cost Effective Application of Low Mass Radiant Systems

Tim McGinn, P.Eng., Member, McGinn Technical Services, Calgary, AB, Canada

11:00 AM - 12:30 PM

Seminar 52 (Intermediate)

Modeling Transient Events, Part 1: External Factors Which Affect the Indoor Environment

Track: Modeling Throughout the Building Life Cycle

Room: 2103C

Sponsor: 4.10 Indoor Environmental Modeling, 9.9 Mission Critical Facilities, Data Centers, Technology Spaces and Electronic Equipment

Chair: Duncan Phyfe, Associate Member, Alden Research Laboratory, Holden, MA

This two-part seminar session looks at transient flow modeling. Part 1 focuses on external environments and large views of concern. In Part 1, engineers will use computational fluid dynamics (CFD) or experiments to analyze transient external flows in a wide range of applications; such as: stadium, parking garage, building wind pressure, chemical dispersion, and thermal management. Engineers are able to harness critical data through the use of these modeling tools to improve the robustness and resilience of the designs. This seminar provides insights to the accurate modeling and into the selection of the analysis tools.

1. Modeling Transient Event of Underground Parking Garage

Mohammad Heidarinejad, Ph.D., P.E., Associate Member, Illinois Institute of Technology, Chicago, IL

2. CFD Modeling of Natural and Mechanical Ventilation of a Stadium

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

3. Introducing the Urban-Scale Chlorine Dispersion Experiments and Its Implications on Indoor Health Assessment

Yang-Seon Kim, Ph.D., Member, Wichita State University, Wichita, KS

4. Process of Using Virtual Wind Tunnel for Wind-Building Interaction Investigations

James Lo, Student Member, National Institute of Standards and Technology, Gaithersburg, MD

5. Modeling the Transient Event of Data Center Cooling during the Power Outage

Wangda Zuo, Ph.D., Member, University of Colorado, Boulder, CO

11:00 AM - 12:30 PM

Seminar 53 (Intermediate)

Novel Optimization Techniques for Water Heating Using Sorption Systems

Track: Optimization in HVAC&R

Room: 2104A

Sponsor: 8.3 Absorption and Heat Operated Machines

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

This seminar covers information on optimization of any sorption system used for water heating, whether for domestic hot water, space heating, or industrial applications. Presentation may include but not limited to current appliance developments, case studies, simulation studies, source efficiency, operating cost, carbon emission studies, system analysis, and research issues focusing on system optimization that are sufficiently new or different and will be of interest to the ASHRAE membership.

1. Comparison and Optimization of Absorption Heat Pump vs. Conventional Water Heaters

Chris Keinath, Ph.D., Member, Stone Mountain Technologies, Inc., Johnson City, TN

2. Optimization of a Chemisorption Heat Pump with Buffer Tank for Residential Heating Applications

Zhiyao Yang, Student Member, Oak Ridge National Laboratory, Oak Ridge, TN

3. Optimization Framework to Maximize Absorption Water Heater Energy Efficiency

Ahmad Abu-Heiba, Oak Ridge National Laboratory, Oak Ridge, TN

11:00 AM - 12:30 PM

Seminar 54 (Advanced)

Optimal Chilled Water Plant Design and Operation: What a "Smart Valve" Can Do for You

Track: Systems & Equipment in the Built Environment

Room: 2104B

Sponsor: 7.5 Smart Building Systems, 1.4 Control Theory and Application , 7.9 Building Commissioning

Chair: Scott Hackel, Slipstream, Madison, WI

Pressure independent control valves (PICV) have been used in optimizing chilled water plant design and operations. New "smart valves" added more sensing and metering capability as well as intelligent control and cloud connectivity on top of the PICVs, making them more "smart." However, many engineers still struggle in understanding when and how to use them properly in design and operation. This seminar will objectively discuss the applications for PICV and smart valves.

1. What Is a Smart Valve?

Jon Hildebrand, BELIMO Aircontrols (USA), Inc., Danbury, CT

2. Smart Valves for Full System Optimization

Jeff Creighton, Member, FlowEnergy, LLC, Woodlinville, WA

3. Practical Applications for Pressure Independent and Smart Control Valves

Steve Taylor, P.E., Fellow ASHRAE, Taylor Engineering, Alameda, CA

11:00 AM - 12:30 PM

Seminar 55 (Intermediate)

System Efficiency

Track: Research Summit

Room: 2102B

Sponsor: 5.7 Evaporative Cooling, 7.7 Testing and Balancing , Publication and Education Council

Chair: Reinhard Radermacher, Ph.D., Fellow Life Member, University of Maryland, College Park, MD

This session presents recent papers from ASHRAE's journal "Science and Technology for the Built Environment". Session topics cover recent research in energy anomaly detection in buildings, oil retention in microchannels, improving efficiency of heat pumps and load-based testing methodology for air conditioning equipment.

1. Load-Based Testing Methodology for Fixed-Speed and Variable-Speed Unitary Air Conditioning Equipment

Andrew Hjortland, Ph.D., Member, Johnson Controls, Inc., Norman, OK

2. Oil Retention in Microchannel Heat Exchangers of an R134a Refrigeration System and Effects on Their Energy Performance and System Cop (ASHRAE RP-1564)

Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL

3. Detection and Interpretation of Anomalies in Building Energy Use through Inverse Modelling

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

4. Improving System Efficiency for a Variable-Capacity/Variable-Blower-Speed Residential Heat Pump System with Multizone Ductwork

Mark Modera, Ph.D., P.E., Fellow ASHRAE, University of California, Davis, CA

Tuesday, June 25, 1:30 PM - 3:00 PM

Seminar 56 (Intermediate)

Radiant Solutions in All Shapes and Sizes

Track: Radiant Heating & Cooling

Room: 2101

Sponsor: 6.5 Radiant Heating and Cooling

Chair: Devin Abellon, P.E., Member, Uponor, Phoenix, AZ

For years, radiant heating and cooling systems were largely reserved for very specific applications, from residential bathrooms and basements to commercial atria. Today, however, as engineers gain a better understanding for how radiant systems can be used to provide optimum thermal human comfort, its usage is expanding to a wide array of applications. This seminar covers a diverse mix of radiant heating and cooling case studies, demonstrating its viability in both residential and commercial spaces.

1. American University Washington College of Law: Large-Scale Radiant Ceiling Panel Application

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

2. Residential Case Study: Radiant vs. Forced Air and Compliance with ASHRAE Standard 55

Robert Bean, P.L.(Eng.), Member, Indoor Climate Consultants Inc., Calgary, AB, Canada

3. Cold Tube Singapore: Outdoor Low Temperature Radiant Cooling Pavilion in the Hot Humid Tropics without Condensation Using IR Transparent Insulated Radiant Panels

Forrest Meggers, Princeton University, Princeton, NJ

4. Research Laboratory Renovation Highlighting Radiant Cooling and Displacement Ventilation Technologies

Michael McDermott, Grumman Butkus Associates, Chicago, IL

Tuesday, June 25, 3:15 PM - 4:45 PM

Seminar 57 (Intermediate)

Impacts of a Record-Breaking Wet Summer on Building Construction and Operation

Track: Occupant Health & Safety

Room: 2101

Sponsor: 1.12 Moisture Management in Buildings, Residential Building Committee

Chair: Ed Light, Member, Building Dynamics, LLC, Ashton, MD

The Washington D. C./Baltimore region experienced record-breaking rainfall and sustained humidity during the summer of 2018. This caused moisture to exceed levels needed to initiate mold growth in wood-frame apartment buildings under construction and in a university residence hall with limited humidity control. This seminar discusses factors contributing to this unprecedented mold growth, impacts and response actions.

1. Impacts of Extensive Mold Growth in Buildings Where HVAC Systems Have Limited Dehumidification

Ed Light, Member, Building Dynamics, LLC, Ashton, MD

2. Humidity-Related Mold Growth: HVAC Control Options

Rick Meetre, P.E., Building Dynamics, LLC, Ashton, MD

3. Restoration of Rain-Damaged Construction

Paul Haas, Member, Building Dynamics, LLC, West Palm Beach, FL

Wednesday, June 26

Wednesday, June 26, 8:00 AM - 9:30 AM

Conference Paper Session 17 (Intermediate)

Ground Source Heat Pumps and Novel Geothermal Systems

Track: Radiant Heating & Cooling/Research Summit

Room: 2203

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

It is well known that ground source heat pump systems have the potential for significant energy savings and have demonstrated superior performance compared to conventional HVAC systems. The first three talks focus on improving ground source and hybrid heat pumps. The last two talks consider the role of geothermal energy on geothermal desiccant wheels and air conditioners.

1. Long-Term Monitoring and Simulation of a Vertical Closed-Loop Ground Source Heat Pump System Used in the Cold Climate of the U.S. (KC-19-C027)

Rui Miao, Student Member and Yao Yu, Ph.D., BEMP and BEAP, Associate Member, North Dakota State University, Fargo, ND

2. Ground-Source Heat Pump with Parallel Flow Horizontal Ground Loop and Dry Liquid Cooler (KC-19-A036)

Gaoyang Hou, Student Member, Hessam Taherian, Ph.D., Member and Longjun Li, University of Alabama at Birmingham, Birmingham, AL

3. A Desiccant Wheel Application with Condenser Water Cooling and Low Grade Geothermal Energy in Humid Climates (KC-19-A037)

Jiajun Liao, Student Member, Texas A&M University, College Station, TX

4. Design and Construction of Geothermal CO₂ Air Conditioner (KC-19-C028)

Paul Kalinowski, Associate Member, Dennis Nasuta, Associate Member and Cara Martin, BEMP, Associate Member, Optimized Thermal Systems, Inc., Beltsville, MD

8:00 AM - 9:30 AM

Conference Paper Session 18 (Intermediate)

Novel Control Research and Strategies

Track: Research Summit

Room: 2204

Chair: Davide Ziviani, Ph.D., Member, Purdue University, West Lafayette, IN

Novel control strategies highlighted in this session include model-free real-time optimization of energy efficiency using the extremum seeking control, for three kinds of cold climate heat pump systems, model predictive control for HVAC and water heating, and a new break-point statistical formulation is proposed to model building heating hot water systems.

1. Real-Time Optimization of Energy Efficiency for Cold Climate Heat Pumps with Extremum Seeking (KC-19-A038)

Yaoyu Li, Ph.D., Member and Wenyi Wang, University of Texas, Dallas, TX

2. Identifying Models of HVAC Systems Using Arimax (KC-19-A039)

Fan Feng, Student Member and Zheng O'Neill, Ph.D., P.E., Member, University of Alabama, Tuscaloosa, AL

3. Machine Learning in a Model Predictive Controller for the Management of the Domestic Hot Water Systems (KC-19-C029)

Louis-Gabriel Maltais, Student Member and Louis Gosselin, Ph.D., P.E., Member, Université Laval, Quebec City, QC, Canada

4. Break-Point Statistical Formulations for Whole Building Heating Hot Water Consumption Modeling (KC-19-A040)

Hongxiang Fu, Student Member, David E. Claridge, Ph.D., P.E., Fellow ASHRAE and Juan-Carlos Baltazar, Ph.D., P.E., BEMP, Member, Texas A&M University, College Station, TX

8:00 AM - 9:30 AM

Seminar 58 (Basic)

Be a Better Human: Top 10 Soft Skills to Take Your Career to the Next Level

Track: Professional Development

Room: 2101

Sponsor: 1.7 Business, Management & General Legal Education

Chair: Rex Scare, P.E., Member, Armstrong International Inc, Three Rivers, MI

In school you learn facts; at work you're taught how to do your job. This session highlights the important skills needed to master the human side of business. Based on observations from years in the engineering/construction industry, this interactive session dives into the top 10 soft skills that can make you a better teammate, communicator, and business partner. We discuss common situations seen in engineering offices and answer questions: How do technically-minded people effectively communicate? How do you accept fault for a mistake? Is it possible to maintain a work/life balance when there is so much work to be done?

1. Be a Better Human: Top 10 Soft Skills to Take Your Career to the Next Level - A

Robin Broder, Henderson Engineers, Lenexa, KS

2. Be a Better Human: Top 10 Soft Skills to Take Your Career to the Next Level - B

Erica Jones, MMC Corp., Overland Park, KS

3. Be a Better Human: Top 10 Soft Skills to Take Your Career to the Next Level - C

Jessica Mangler, P.E., Member, Affiliated Engineers, Inc., Seattle, WA

4. Be a Better Human: Lessons Learned in Mastering Soft Skills

Jennifer Leach, P.E., Member, Patterson-Kelley, East Stroudsburg, PA

8:00 AM - 9:30 AM

Seminar 59 (Intermediate)

Energy Systems Integration and Smart Grid-Ready Buildings: All You Need to Know to Be a Good Grid Citizen

Track: Systems & Equipment in the Built Environment

Room: 2105

Sponsor: 6.7 Solar Energy Utilization, 7.5 Smart Building Systems , 2.5, 2.8

Chair: Janice Means, P.E., Life Member, Lawrence Technological University, Southfield, MI

As the built environment is moving towards decarbonisation, the electric grid will require new design and operation considerations to integrate increasingly high levels of renewable energy. The grid also incorporates intelligent buildings capable of managing their own loads and storage capacity to 1) reduce their energy use and peak power demand, and 2) support grid flexibility and grid services that will have increasing value to grid operators. The objective of this seminar is discussing the technical challenges and available solutions regarding energy systems integration, distribution intelligence, the role of buildings, and steps required to operate in a smart-grid environment.

1. Smart Grid-Ready Buildings: Enabling Tools and Solutions

Glenn Remington, Member, Consumers Energy, Jackson, MI

2. Smart Grid Distribution Intelligence: Towards a Resilient, "Self-Healing" Grid

Andy Haun, Schneider Electric, Andover, MA

3. Integration of Renewable Energy Systems: Opportunities and Challenges

Aaron Bloom, Energy Systems Integration Group, St. Paul, MN

8:00 AM - 9:30 AM

Seminar 60 (Intermediate)

Heat Exchanger Fundamentals and Design Innovations

Track: Fundamentals and Applications

Room: 2103C

Sponsor: 8.4 Air-to-Refrigerant Heat Transfer Equipment

Chair: Jun Wang, Ph.D., Member, Sanhua International, Houston, TX

Air flow and air-side heat transfer often limit the performance of heat exchangers, this seminar will address some of these challenges. It starts with a passive (interleaved) circuitry approach to address air flow maldistribution in evaporators to improve heat exchanger effectiveness. Then, a novel local heat transfer coefficient measurement technique is introduced. Better understanding of local heat transfer coefficient would be very helpful for a heat exchanger design and innovation. Lastly, a new way of design optimization and manufacturing an air-to-refrigerant heat exchanger will be presented.

1. Application of Passive Circuitry Arrangement to Improve the Heat Exchange Effectiveness

Davide Ziviani, Ph.D., Member, Purdue University, West Lafayette, IN

2. Quantification of Local Air-Side Heat Transfer through an Absorption-Based Color Change Coatings

Stefan Elbel, Ph.D., Member, Creative Thermal Solutions and University of Illinois at Urbana-Champaign, Urbana, IL

3. Shape-Optimized, Additively Manufactured Air-to-Refrigerant Heat Exchanger Performance for Condenser and Evaporator Applications

Yunho Hwang, Ph.D., Fellow ASHRAE, University of Maryland, College Park, MD

8:00 AM - 9:30 AM

Seminar 61 (Intermediate)

PIC Valve Technologies, Applications, and Commissioning

Track: Commissioning New & Existing Buildings

Room: 2104A

Sponsor: 7.9 Building Commissioning, 6.1 Hydronic and Steam Equipment and Systems

Chair: Roger Lautz, P.E., Member, Affiliated Engineers, Inc., Madison, WI

We are at the advent of a movement in the hydronics industry with the introduction of Pressure Independent Control Valves similar to VAV boxes of the 80s. There are different technologies available in the market; each with benefits that need to be understood to be applied properly. This program will educate the attendees about the proper application of PIC valves as well as what testing, balancing, and commissioning is required to assure the performance is achieved for the life of the system.

1. An Overview of PICVs

Roger Lautz, P.E., HFDP, Member, Affiliated Engineers, Inc., Madison, WI

2. Flow Metering Style Picvs

Robert Walker, Member, BELIMO Aircontrols (USA), Inc., Danbury, CT

3. Balanced Pressure Globe Style Picvs

Edwin Hipolito, Danfoss, Baltimore, MD

4. Cartridge Style Picvs

Jerry Martin, Griswold Controls, Irvine, CA

5. Pressure Regulator Style Picv

Brent Waluzak, P.E., Siemens, Tampa Bay, FL

8:00 AM - 9:30 AM

Seminar 62 (Basic)

Predictive Analytics for HVAC Engineers: What Is in the Box?

Track: Modeling Throughout the Building Life Cycle

Room: 2102B

Sponsor: 1.5 Computer Applications

Chair: Krishnan Gowri, Ph.D., Fellow ASHRAE, BIM2BEM Solutions, Bothell, WA

New machine learning and AI techniques are widely adapted for data discovery. The software industry has effectively used predictive analytics for retail marketing, computer system performance, network reliability among many other successful applications. Building energy use and HVAC equipment performance data from building automation systems can be used for predicting energy use intelligently with the new techniques. This session brings together three diverse, experienced researchers in the field of machine learning and building energy management applications.

1. Urban-Scale Natural Ventilation with Physics-Informed Machine Learning Prediction

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

- 2. Integrating BEM with Data and Machine Learning: Challenges and Perspectives**
Adrian Chong, Ph.D., Member, National University of Singapore, Singapore, Singapore
- 3. Great Energy Predictor Shootout II: Revisited**
Clayton Miller, Ph.D., National University of Singapore, Singapore, Singapore

8:00 AM - 9:30 AM

Seminar 63 (Intermediate)

Radiant Buildings Post Occupancy: Indoor Environmental Quality, Energy and Operational Performance

Track: Radiant Heating & Cooling

Room: 2104B

Sponsor: 6.5 Radiant Heating and Cooling, 2.1 Physiology and Human Environment

Chair: Devin Abellon, P.E., Member, Uponor, Phoenix, AZ

In our industry, there are often claims made about the performance of a particular HVAC system or solution without supporting evidence. In this seminar, we present findings regarding the performance of buildings with radiant systems in a range of categories (indoor environmental quality, thermal comfort, energy, etc.) using post-occupancy objective and subjective measurements in real buildings. We compare the results to buildings with other system types.

1. Comparing Temperature and Acoustic Satisfaction in Sixty Radiant and All-Air Buildings

Fred Bauman, P.E., Fellow ASHRAE, University of California, Berkeley, CA

2. On the Path to Zero Energy: Using Radiant to Reduce Energy Use

Kevin Carbonnier, Ph.D., New Buildings Institute, Portland, OR

3. How Do Radiant Systems Perform in Terms of IEQ and Occupant Productivity and Health?

Ongun Kazanci, Ph.D., International Centre for Indoor Environment and Energy, Technical University of Denmark, Kgs. Lyngby, Denmark

4. Occupant Indoor Environmental Satisfaction and Operational Implications in Radiant Buildings

Megan Dawe, Student Member, University of California, Berkeley, CA

Wednesday, June 26, 9:45 AM - 10:45 AM

Panel 3 (Intermediate)

BIM Blast: Breaking the Curve

Track: Modeling Throughout the Building Life Cycle

Room: 2102B

Sponsor: 7.1 Integrated Building Design, SPC-224P

Chair: Mitchell Swann, P.E., MDC Systems, Paoli, PA

A few years ago the talk of BIM was mostly "Brave New World". Some considered it the "bleeding edge" of AEC technology. Well, in the last 5 to 7 years, BIM has gone from the bleeding edge to being the core of the blade. This panel discussion reviews recent industry BIM developments, like ASHRAE Standard 224 "Application of Building Information Modeling". Our crew will hit the topic from all sides: design, construction, operations and legal. Come find out where we're at, where we're going, and how to see around the curve.

1. Application of Building Information Modeling

Dennis Knight, P.E., Fellow ASHRAE, Whole Building Systems, LLC, Mt. Pleasant, SC

2. Integration on a Grand Scale

Roger Grant, National Institute of Building Services, Washington, DC

3. Modeling a Changing Landscape

Roger Grant, National Institute of Building Services, Washington, DC

4. Staying Out of Trouble

Tracy James, J.D., Hamilton Stephens Steele + Martin, PLLC, Charlotte, NC

9:45 AM - 10:45 AM

Conference Paper Session 19 (Intermediate)

Occupancy Sensors and Schedules

Track: Modeling Throughout the Building Life Cycle/Research Summit

Room: 2204

Chair: Eric Yang, P.E., Member, Energy System Group, Washington, DC

This session investigates occupancy sensors and schedules for energy savings in the built environment, including Wi-Fi infrastructure to infer occupant counts through a machine learning approach, occupant-centric control framework to adjust indoor conditions in response to occupants' bio-signals and thermal sensation feedback, drastic shifts in occupancy in university buildings, and determining residential occupancy schedules.

1. Inferring Occupant Counts from Wi-Fi Data through Random Forest (KC-19-A041)

Zhe Wang, Ph.D. and Tianzhen Hong, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

2. Bio-Sensing and Reinforcement Learning Approaches for Occupant-Centric Building Control (KC-19-C030)

Chenlu Zhang, Zhiang Zhang, Student Member and Vivian Loftness, Carnegie Mellon University, Pittsburgh, PA

3. Defining Typical Occupancy Schedules and Behaviors in Residential Buildings Using the American Time Use Survey (KC-19-C031)

Debrudra Mitra, Student Member, Kristen Cetin, PhD, PE, Associate Member, Paul Kremer, Member, Jayde Lovejoy and Yiyi Chu, Iowa State University, Ames, IA

9:45 AM - 10:45 AM

Conference Paper Session 20 (Basic)

Smart Building Systems: Case Studies

Track: Systems & Equipment in the Built Environment

Room: 2104B

Chair: Michael Sherber, P.Eng., Member, PlasmaAir, Stamford, CT

In HVAC systems, air handling units (AHU) are used to condition air based on comfort for occupants or controlled environmental requirements. Faults in AHUs, such as air or water leakage, can occur due to failures in equipment, actuators, or sensors and feedback controllers. This session highlights a data-driven leakage detection methodology for the fault detection of AHU steam and chilled water valve leakage on a campus. It also outlines two interactive control algorithms by conducting an in-situ and comparative study in a regular shared office space during cooling season. The session concludes with a case study that demonstrates the use of text analytics on computerized maintenance management system databases to benchmark the operational performance of commercial buildings.

1. Data-Driven Leakage Detection in Air-Handling Units on a University Campus (KC-19-C032)

Megan McHugh, Student Member and Zoltan Nagy, Ph.D., Associate Member, The University of Texas at Austin, Austin, TX

2. An Interactive Building Control for the Integrative HVAC System Featuring Personalized Cooling in Office Buildings (KC-19-C033)

Siliang Lu, Student Member¹, Erica Cochran Hameen, Ph.D.¹ and Yue Zou, Ph.D., P.E., CPMP, Member², (1)Center for Building Performance and Diagnostics, School of Architecture, Carnegie Mellon University, Pittsburgh, PA, (2)Donghua University, Shanghai, China

3. Using Text Analytics on Operator Logbooks for Performance Benchmarking: A Case Study (KC-19-C034)

Saptak Dutta, Student Member, Burak Gunay, Ph.D., Associate Member and Scott Bucking, Ph.D., Associate Member, Carleton University, Ottawa, ON, Canada

9:45 AM - 10:45 AM

Conference Paper Session 21 (Intermediate)

Thermal Energy Storage

Track: Research Summit

Room: 2203

Chair: Jaya Mukhopadhyay, Ph.D., Member, Montana State University, Bozeman, MT

This session investigates innovations in thermal energy storage. Cool thermal energy storage systems enable the decoupling of the electrical demand associated with cooling systems from the demand for cooling. The current study is part of a project dedicated to design a tankless SDWH system that benefits from the advantages of the PCM and overcome the drawbacks of the sensible water storage tanks. a case study testing two wall assembly panels is shown as an example to demonstrate the ability of the test chamber to successfully conduct full and half thermal cycle tests on the PCM walls.

1. Model Predictive Control of Cool Thermal Energy Storage Under Different Electricity Rate Structures (KC-19-C035)

Amy Van Asselt, Ph.D., Associate Member, Lafayette College, Easton, PA

2. Modeling and Analysis of Compact Evacuated Tube with PCM for a Tank-Less Solar Water Heating System (KC-19-C036)

Mohamed Osman¹, Mohamed Abokersh², Omar Huzayyin, Ph.D., Member³ and Mohamed Elmorsi, Ph.D., Member¹, (1)American University in Cairo, Cairo, Egypt, (2)Public University of Tarragona, Tarragona, Spain, (3)Cairo University, Cairo, Egypt

3. Experimental Test Chamber for Testing Innovative PCM Building Envelope Assemblies in Full Scale Applications (KC-19-A042)

Sajith Wijesuriya, Student Member and Paulo Cesar Tabares Velasco, Ph.D., Associate Member, Colorado School of Mines, Golden, CO

9:45 AM - 10:45 AM

Seminar 64 (Intermediate)

Demystifying Cooling Tower Water Treatment

Track: Systems & Equipment in the Built Environment

Room: 2105

Sponsor: 2.8 Building Environmental Impacts and Sustainability, 7.6 Building Energy Performance

Chair: Mike Pascual, P.E., Associate Member, ESD, San Francisco, CA

Cooling towers can be the largest water consumers in commercial buildings, but they also represent one of the best sources for water conservation. Proper cooling tower water management is the key, but it is often treated as an art with mixtures of unknown chemicals and significant blowdown (i.e. wasted) water. There are several alternative water treatment systems available today, but which work, and which are not worth the effort? This session will review cooling tower impacts, several of these technologies, and provide results of recent technology field tests showing promising results.

1. Current Challenges with Cooling Towers

Rafi Karim, P.E., Member, Affiliated Engineers, Inc., Pasadena, CA

2. Alternative Water Treatment Systems

Jesse Dean, National Renewable Energy Laboratory, Golden, CO

3. Chemical Free Water Treatment

Michael Deru, Ph.D., Member, NREL, Golden, CO

9:45 AM - 10:45 AM

Seminar 65 (Basic)

"Legionella:" How To Protect Maintenance Workers

Track: Occupant Health & Safety

Room: 2101

Chair: Lan Chi Nguyen Weekes, P.Eng., Member, College La Cite, Ottawa, ON, Canada

The prevention of "Legionella" bacteria contamination has focused on the building occupants or on the passersby that inhale the droplets containing the bacteria. This session shifts the focus on exposure to maintenance workers from systems that might harbor Legionella bacteria. Their exposure is often overlooked when ventilation systems are designed and operated. This session discusses the: 1) education of the maintenance workers about the potential for exposure and proper protection, and 2) design aspects of HVAC equipment and systems needed to prevent growth or to control exposure to maintenance workers.

1. "Legionella": How to Prevent and Control Growth through Systems Design

Lan Chi Nguyen Weekes, P.Eng., Member, College La Cite, Ottawa, ON, Canada

2. "Legionella": Education and Protection of Maintenance Workers

Donald Weekes, Member, Self, Ottawa, ON, Canada

9:45 AM - 10:45 AM

Seminar 66 (Basic)

YEA Controls FUNDamentals: What to Know about Careers in Controls and the Basics of BAS

Track: Professional Development

Room: 2104A

Sponsor: 1.4 Control Theory and Application

Chair: Elise Backstrom, Associate Member, Exyte U.S, Inc., Phoenix, AZ

Many engineers are unfamiliar with what the controls industry is actually like, they are confused by gibberish when they learn it, when in the real world controls can be understandable and functional. TC1.4 wants to reach out to these engineers, especially YEA members and make sure they understand the fundamentals of controls in the hope that this will spark interest in the industry. Specifically for this seminar focusing on the understanding of career options in the building controls industries and the basics of building automation systems.

1. Choose Your Own Adventure: Controls Career Options

Chariti Young, Member, Automated Logic, Kennesaw, GA

2. Are You in Control(s)?

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

9:45 AM - 10:45 AM

Workshop 4 (Intermediate)

Filter Forecast: The Future of Filtration

Track: Occupant Health & Safety

Room: 2103C

Sponsor: 2.4 Particulate Air Contaminants and Particulate Contaminant Removal Equipment

Chair: Kathleen Owen, Fellow ASHRAE, Owen Air Filtration Consulting, Cary, NC

Nano-particle filtration and the energy cost of using air filters: two critical pieces of the future of filtration. Ultrafine particles (below 100 nm) are now known to influence health (and equipment), but our current filter testing does not tell us how well our filters work. On another front, filters are believed to impact energy usage in buildings. Is this true and how much do they use? Bring your topics for open discussion about how air filtration can help the future and HVAC systems can improve indoor air quality.

1. How Much Will Clean Air Cost You?

R Vijayakumar, Ph.D., Fellow ASHRAE, Aerfil, Liverpool, NY

2. Measuring Air Filter Efficiency Down to Single-Digit Nanometer Size

Paolo Tronville, Ph.D., Member, Politecnico di Torino, Torino, Italy

Wednesday, June 26, 11:00 AM - 12:30 PM

Conference Paper Session 22 (Intermediate)

Building Envelope and Fenestration Performance

Track: Research Summit

Room: 2204

Chair: D. Charlie Curcija, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

Fenestration and opaque envelope contribute to a significant energy consumption in conditioned built environments. This session highlights best practices of dynamic shading, a simplified strategy on fenestration performance modeling, and a study on operable windows. This session also presents unmanned aerial vehicles application in building envelope thermal energy assessment.

1. Best Practices for Full-Scale Testing and Energy Savings, Daylighting and Visual Comfort Evaluation of Dynamic Shading (1710-RP) (KC-19-C037)

Niraj Kunwar, Student Member, Kristen Cetin, PhD, PE, Associate Member and Ulrike Passe, AIA, Associate Member, Iowa State University, Ames, IA

2. Window Enhancements in Prototype Buildings (KC-19-A043)

Chitra Nambiar, Associate Member, Supriya Goel, Michael Rosenberg, Fellow ASHRAE and Jian Zhang, Ph.D., Member, Pacific Northwest National Laboratory, Richland, WA

3. Occupant Window Usage and Cooling Energy Consumption: A Case Study (KC-19-C038)

Jayson Bursill, Student Member, William O'Brien, Ph.D., Member and Ian Beausoleil-Morrison, Carleton University, Ottawa, ON, Canada

4. Unmanned Aerial Vehicles Application in Building Envelope Thermal Energy Assessment in Saudi Arabia (KC-19-C039)

Ayman Youssef, P.E., Member, Ahmed Awfi and Faisal Al Musa, Saudi Aramco, Dhahran, Saudi Arabia

11:00 AM - 12:30 PM

Seminar 67 (Intermediate)

An Alternative View of Radiant Heating and Cooling Systems via Exergy Analysis

Track: Radiant Heating & Cooling

Room: 2203

Sponsor: 7.4 Exergy Analysis for Sustainable Buildings (EXER)

Chair: Wangda Zuo, Ph.D., Member, University of Colorado, Boulder, CO

To evaluate and improve the performance of radiant heating and cooling systems, Exergy analysis is a valuable tool for determining energy savings as well as reducing the carbon footprint of heating systems. This seminar will demonstrate the procedure and benefits of applying exergy analysis for the radiant heating and cooling systems.

1. What Are the Differences between Air-Based and Radiant Systems in Terms of Exergy?

Ongun Kazanci, Ph.D., International Centre for Indoor Environment and Energy, Technical University of Denmark, Kgs. Lyngby, Denmark

2. Applying Exergy to Radiant Cooling System for the Reduction of Chilled Water Generation

Brian Meneghan, Carrier Corporation, Malta, NY

3. Exergy View of Radiant Heating Panels

Mike Trantham, Member, IMI Flow Design, Dallas, TX

11:00 AM - 12:30 PM

Seminar 68 (Intermediate)

Ground Source Heat Pump System Design

Track: Systems & Equipment in the Built Environment

Room: 2101

Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: Harrison Skye, Ph.D., Member, National Institute of Standards and Technology, Gaithersburg, MD

Ground-source heat pump (GSHP) systems can significantly reduce energy consumption compared to conventional cooling and heating systems. GSHPs also generally lower maintenance costs. However high first costs, and space limitations constrain the implementation of GSHPs commercial and residential buildings. This seminar presents design case studies, optimization, and use of hybrid systems to increase the energy and cost performance of GSHP systems.

1. GSHP Design for Building Retrofits: Three Case Studies

Ed Lohrenz, GEOptimize Inc., Winnipeg, MB, Canada

2. Optimizing Energy Conservation Measures to Reduce Geothermal Heat Exchanger Size

Brendan Hall, P.E., Member, CHA Consulting, Syracuse, NY

3. Hybrid GSHP System Design for Two Buildings in Diverse Climates

Suhasini Pyarasani, P.E., Member, Consulting Engineers, Sac, CA

11:00 AM - 12:30 PM

Seminar 69 (Basic)

Occupant-Centric Building Design and Operation: State of the Art and Challenges

Track: Occupant Health & Safety

Room: 2104B

Sponsor: MTG.OBB Occupant Behavior in Buildings

Chair: Zoltan Nagy, Ph.D., Associate Member, The University of Texas at Austin, Austin, TX

Occupants are one of the greatest influences of building energy use. Even with modern automation, emerging evidence suggests that occupants are often dissatisfied with automation and may intervene. The new IEA-EBC Annex 79 explores the tradeoff between building automation and manual systems to optimize occupant comfort and health, and energy efficiency. This seminar will cover an overview of the Annex research plan, showcase the state-of-the art, and highlight future research and standardization/guidelines. Our objective is to make this proposal a rolling seminar for the annual conference, adapted to specific tracks, to report the progress of the Annex.

1. Annex 79 and Definitions and State-of-the-Art of Implemented Occupant-Centric Controls

Zoltan Nagy, Ph.D., Associate Member, The University of Texas at Austin, Austin, TX

2. Occupant-Centric Controls Trust and Management

Michael Kane, Ph.D., Member, Northeastern University, Boston, MA

3. Understanding the Link between Indoor Environmental Quality, Building Interfaces and Human Behavior

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

4. Case Study Implementation of Occupant-Centric Controls

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

11:00 AM - 12:30 PM

Seminar 70 (Intermediate)

Poor Performance Guaranteed: Problems with Oversized Air Conditioning Equipment

Track: Systems & Equipment in the Built Environment

Room: 2102B

Sponsor: 7.2 HVAC&R Construction & Design Build Technologies, 7.8 Owning and Operating Costs

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

Oversized single zone air conditioning units often lead to extremely poor space comfort and high humidity. A "bigger is better" philosophy is not always better and can lead to many comfort and operational problems. A psychometric analysis demonstrates the oversized impact on space comfort. Common design and operational reasons that drive oversizing is presented based upon actual field experiences. This session presents the results from NIST research that shows oversized residential cooling systems can lead to greater discomfort. Real world commercial case studies showing successful retrofit strategies without replacing equipment is presented.

1. The Unit Has Enough Capacity so Why Is Everyone so Uncomfortable?

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

2. "We Have Mold on the Flag" and Other Commercial Case Studies

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

3. Why Is Our House Uncomfortable When the New System Is Bigger than the Old One?

Wes Davis, Affiliate, Air Conditioning Contractors of America, Arlington, VA

11:00 AM - 12:30 PM

Seminar 71 (Advanced)

Refrigerant Flammability Fundamentals

Track: Fundamentals and Applications

Room: 2103C

Sponsor: 3.1 Refrigerants and Secondary Coolants

Chair: Barbara Minor, Member, The Chemours Company, Wilmington, DE

Concerns about the impact of refrigerants on climate change 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 flammable. A key delineation in flammability is the 2L lower flammability class which exhibit lower burning velocity. This seminar explores burning velocity in detail, include experimental approaches to measure and also to predict burning velocity.

1. Burning Velocity Predictive Tools

Gregory Linteris, Ph.D., Associate Member, National Institute of Standards and Technology, Gaithersburg, MD

2. Evaluation of Experimental Methods for Burning Velocity of Flammable Refrigerants

Gregory Linteris, Ph.D., Associate Member, National Institute of Standards and Technology, Gaithersburg, MD

11:00 AM - 12:30 PM

Seminar 72 (Intermediate)

The Role of Residential Indoor Environments in Allergic Disease

Track: Occupant Health & Safety

Room: 2104A

Sponsor: Environmental Health Committee

Chair: Kevin Kennedy, MPH, CIEC, Associate Member, Children's Mercy Kansas City, Kansas City, MO

Allergic diseases are surprisingly common, chronic health conditions. The primary location where the vast majority of people are exposed to allergens and other substances is in their home. This means it is important to understand home environments and how a home's systems function and interact. How we occupy our homes plays a crucial role in both environmental exposure and management of allergic disease. This seminar provides an overview of what is understood about home environmental exposure and the importance of identifying the relationships between identified sources of contaminants and the housing systems, and conditions that may be contributing to exposure.

1. Allergic Disease and Health Effects in Indoor Environments

Jay Portnoy, M.D., Children's Mercy Kansas City, Kansas City, MO

2. Working with Physicians to Solve Indoor Environmental Problems in Homes

Jennifer Lowry, M.D., Children's Mercy Kansas City, Kansas City, MO

3. Assessing Residential Environments: What Should You Do?

Elliott Horner, Ph.D., Member, UL Environment, Marietta, GA

4. Environmental Interventions for Allergic Disease Management: What Works

Kevin Kennedy, MPH, CIEC, Associate Member, Children's Mercy Kansas City, Kansas City, MO

11:00 AM - 12:30 PM

Seminar 73 (Intermediate)

Thermal Stratification for Comfort, Air Quality and Energy Implication

Track: Fundamentals and Applications

Room: 2105

Sponsor: 2.1 Physiology and Human Environment

Chair: Shichao Liu, Ph.D., Associate Member, Worcester Polytechnic Institute, Worcester, MA

Thermal stratification caused by vertical temperature difference is highly related to occupants' thermal comfort, air quality and energy consumption of buildings. ASHRAE 55 and 62 specify the maximum allowed vertical temperature difference and ventilation effectiveness for stratified environments respectively. This seminar reports the latest results on how thermal stratification influences thermal comfort, air quality, and energy efficiency through laboratory human-subject and physical experiments, and field studies in lecture theaters. The design and operation challenges for stratified environments is discussed. The seminar also presents new guidelines and ventilation strategies to enhance thermal comfort, indoor air quality and energy efficiency.

1. Local Thermal Discomfort Caused By Temperature Stratification

Shichao Liu, Ph.D., Associate Member, Worcester Polytechnic Institute, Worcester, MA

2. Stratification Effect on the Perception and Satisfaction with the Indoor Environmental Quality in Lecture Theatres

Junjing Yang, Ph.D., National University of Singapore, Singapore, Singapore

3. Coupling UFAD and Personalized Ventilation Systems for Enhanced Thermal Comfort, IAQ and Energy Efficiency

Chandra Sekhar, Ph.D., Fellow ASHRAE, National University of Singapore, Singapore, Singapore

4. All-Air Systems with Overhead Supply Diffusers Applied for Space Heating: Design and Operation Challenges

Atila Novoselac, Ph.D., Member, University of Texas at Austin, Austin, TX