

ASHRAE 2020 Virtual Conference ►



2020 ASHRAE Virtual Conference

June 29th - July 2nd, 2020

Track: Fundamentals and Applications

Panel 1 (Intermediate)

The Benefits of Off-Site Construction

Sponsor: 1.5 Computer Applications

Chair: Michael Cooper, P.E., Member, Bernhard, Metairie, LA

Design for Manufacture and Assembly (DfMA) strategies are causing major disruptions in the Engineering and Construction value chain. Off-site activities are now being maximized to minimize on-site work results. The maturation of digital tools has radically altered the value proposition for the design and delivery of built solutions. Critical enablers of this value shift include data-rich 5D BIM models, data analytics, enterprise level supply chain, factory automated processes, just-in-time logistics and lean manufacturing principles. Our panelists will explore how DfMA is now possible, the scale that can be achieved and the compelling value benefits that can be captured.

1. The Benefits of Off-Site Construction

Michael Cooper, P.E., Member, Bernhard, Metairie, LA

2. Project Manager

Robin Bryant, ASHRAE, Fort Myers, FL

3. Construction Manager

Bryan Holcomb, Bernhard, Metairie, LA

Paper Session 3

Phase Change Materials, Energy Recovery Ventilation and Cool Thermal Storage Design Guide

Chair: Vikrant Aute, PhD, Member, University of Maryland, College Park, MD

This session focuses on the integration of phase change materials and thermal storage in various building equipment. The first paper presents a novel ERV coupled with a bio-based PCM. The design of this ERV was optimized using multiphysics analysis, prototyped, tested and results presented. The second paper investigates the impact of sensor response on the predicted effectiveness of fixed-bed-regenerators through numerical and experimental study. The third paper presents the factors that impact the efficacy of PCM integrated with buildings and the corresponding cost and energy savings potential.

1. Design of Energy Recovery Heat Exchanger Coupled with Phase Change Materials for Building Temperature Control
Weihuan Zhao, Sidney Hartz, Dacen Kinser, Marybeth Fuhlman, Parker Walvoord, Matthew Rushing, Sergio Turrubiarres and Carlos Zapata, University of North Texas, Denton, TX

2. Using Bio PCM As Sensible Heat Storage in a Hot Arid Climate: A Case Study
Neda Askari Tari, Maryam Nozaripour and Kristen Parrish, Ph.D., Arizona State University, Tempe, AZ

3. Temperature Measurement Correction for the Determination of the Effectiveness of Fixed-Bed Regenerators for HVAC Applications
Hadi Ramin, Student Member, Easwaran Alabi and Carey Simonson, Ph.D., P.E., Member, University of Saskatchewan, Saskatoon, SK, Canada

Paper Session 9

Ventilation: From Offices to Aircraft

Chair: Nohad Boudani, P.Eng., Member, Sodicom, Beirut, Lebanon

This session highlights the current status and future needs for ventilation codes. The first paper presents a comparison of the office building ventilation codes in Asia Pacific and North America. The second paper highlights the need for dedicated codes for the proper ventilation of areas containing lithium-ion battery operations. The third paper uses transient Computational Fluid Dynamics (CFD) to evaluate the impact of space volume on the dilution of contaminants and occupant exposure. The session concludes with an experimental study that aims at better understanding the dispersion characteristics of airborne pathogens under specified ventilation conditions in a aircraft cabin.

1. Transport and Containment of Infectious Disease Expelled By Coughing in an Aircraft Cabin
Seif Mahmoud, Student Member¹, M.H. Hosni, Ph.D., Fellow ASHRAE¹, Byron Jones, Ph.D., P.E., Fellow ASHRAE¹, William Lindsley, Ph.D.², Dylan Neu³, Ken Mead³, James Bennett, Ph.D., Member³, Kevin Menchaka³, Stephen Martin², Jill Shugar⁴ and Tia McClelland², (1)Kansas State University, Manhattan, KS, (2)Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH), Morgantown, WV, (3)Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH), Cincinnati, OH, (4)Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH), Atlanta, GA

2. Co-Working Space Ventilation Code Study
Yijun Yang, Ph.D., P.E., Associate Member and Daniel Hallett, CEng, The We Company, New York, NY

3. Ventilation and Hazard Considerations of Lithium-Ion Battery Operations: Current Status and Future Needs
Sean O'Hern, Ph.D., P.E., Associate Member, Michael Barry, Ph.D., P.E. and Joel Sipe, Ph.D., P.E., Exponent, Inc., Menlo Park, CA

4. CFD Analysis of Air Change Rate (ACR) and Space Volume on Contaminant Dilution
Kishor Khankari, Ph.D., Fellow ASHRAE, AnSight LLC, Ann Arbor, MI

Paper Session 11

Refrigerants, Components and Systems

Chair: Vikrant Aute, PhD, Member, University of Maryland, College Park, MD

This session presents working fluid trends for absorption as well as conventional vapor compression based systems. The third paper presents a novel vortex tube integrated vapor compression cycle and the fourth paper presents a novel additively manufactured microchannel-based chilled water heat exchanger. Finally, the session concludes with measurement of single and two-phase R134a flow in multi-port tube.

1. Parametric Analysis of Binary Mixtures across the Solution Heat Exchanger of Absorption Refrigeration System

Kadam Sambhaji, Ph.D.¹, Ibrahim Hassan, Ph.D., P.E., Member¹, Aziz Rahman, Ph.D.¹, Athanasios Papadopoulos, Ph.D.² and Panos Seferlis, Ph.D.², (1)Texas A&M University at Qatar, Doha, Qatar, (2)Chemical Process and Energy Resources Institute (CPERI), Thessalonik, Greece

2. Low GWP Refrigerant Trends for Ice Skating Rinks

Stephen Kujak, Member¹, Charles Allgood, Ph.D.² and David Gauvin, Associate Member¹, (1)Trane, La Crosse, WI, (2)Chemours, Wilmington, DE

3. Thermodynamic Performance Analysis of a Novel Vortex Tube Integrated Vapour Compression Cycle

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

4. Measurement of Adiabatic Single and Two-Phase Pressure Drop Behavior of R-134a in Parallel-Port Microchannel Tube

Arindom Joardar, Ph.D., Associate Member¹, Thomas Visalli¹ and Tobias Siemel², (1)Carrier Corporation, Syracuse, NY, (2)Carrier, Syracuse, NY

5. Additively-Manufactured Microchannel Polymer Chilled Water Heat Exchanger

Erfan Rasouli, Ph.D., Adam Strong and Vinod Narayanan, Ph.D., Member, UC Davis WCEC, Davis, CA

Paper Session 17

Experimental Study of Radiant Systems, District Cooling Plants and More

This session explores different technologies used in commercial buildings. The first paper presents an experimental study investigating the differences in heat transfer dynamics in identical spaces conditioned with radiant cooling and all-air systems. The second paper presents an optimization study for district cooling system to minimize the total power consumption of the equipment including fans and pumps.

1. Experimental Study on Cooling Loads of Radiant and All-Air Systems

Ardeshir Moftekhari and Atila Novoselac, Ph.D., Associate Member, University of Texas at Austin, Austin, TX

2. Cooling Water System Online Optimization in District Cooling Plant By Using Digital Twin

Kenichi Matsuoka, CEng¹ and David Hill, CEng², (1)Azbil corporation, Ohi 6-10-19-105, Sinagawa, Tokyo, Japan, (2)Chemstations, 3100 Wilcrest Drive, Suite300, Houston, TX

Paper Session 22

CFD Studies and Building End Use Measurement

This session presents different applications of Computational Fluid Dynamics (CFD) for analyzing the performance of pipes and ducts. The first paper presents a CFD model for the pressure drop prediction in oval ducts that are not yet represented in ASHRAE Duct Database. The second paper presents CFD models for accurate prediction of the formation of hydraulic shock that is helpful in assessing risk of rupture. The session concludes with a presentation on energy use intensities and CO₂ emissions by end use in office buildings based on in-situ measurements.

1. The Use of CFD to Analyze and Predict the Pressure Drop Along Flat Oval Duct Fittings

Erin Drake, Nicole Okamoto, Ph.D. and Ernest Thurlow, Ph.D., San Jose State University, San Jose, CA

2. Intensities Analysis of Energy Use and Co₂ Emission By End Use in Office Building Based on in Situ Measurements

Soo-Yeon Ha, Student Member, Hye-Sun Jin, You-Jeong Kim, Soo-Jin Lee, Sung-Im Kim, Ph.D. and Seung-Yeong Song, Ph.D., Ewha Womans University, Seoul, Korea, Republic of (South)

3. CFD Study of Hydraulic Shock in Two-Phase Anhydrous Ammonia: RP-1569 (T)

Chidambaram Narayanan, Ph.D., ASCOMP AG, Zug, Switzerland

Paper Session 23

Infiltration, Natural Ventilation and Local Weather Prediction

This session focuses on the different aspects of the building envelope. The first paper presents an experimental study to identify the impact of leakage location on infiltration rate and energy consumption in commercial buildings. The second paper presents a deep learning-based approach for improved prediction of local weather.

1. The Effects of Leakage Location on Commercial Building Infiltration Rate

Justin Berquist, P.Eng., Associate Member, Iain MacDonald, Mark Vuotari, Adam Wills, Ph.D., Carsen Banister, Ph.D., Member and Michal Bartko, Ph.D., National Research Council Canada, Ottawa, ON, Canada

2. Analysis of the Effect of Window Design Features on Natural Ventilation

M.W.R. Rangana, M.M.I.D. Manthilake, Ph.D. and M. Anusha Wijewardane, Ph.D., University of Moratuwa, Moratuwa, Sri Lanka

Seminar 5 (Basic)

Controls Hieroglyphics: The YEA Rosetta Stone

Sponsor: 1.4 Control Theory and Application

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

Many YEA (Young Engineers in ASHRAE) do not understand the symbols, abbreviations and acronyms generally used in Controls. But, as in any area of life, clear communication and common understanding among a team pursuing a shared goal are critical to success. Without an understanding of these controls hieroglyphics, a cohesive design process is challenging. The first speaker will share a case study that illustrates the chaos a lack of common understanding can cause on a project. The second will provide a primer to YEA members, equipping them with the Rosetta Stone they need for successful controls communication!

1. Visual Language in BAS Engineering: Translation Needed

Jim Coogan, P.E., Member, Siemens Building Technology, Buffalo Grove, IL

2. Rosetta Stone- Controls Hieroglyphics

Charlotte Dean, P.E., P2S Inc., Long Beach, CA

Seminar 12 (Advanced)

Winners and Winning Solutions from the ASHRAE Great Energy Predictor III Machine Learning Competition

Sponsor: 4.7 Energy Calculations, 1.5 Computer Applications

Chair: Clayton Miller, Ph.D., Member, National University of Singapore, Singapore, Singapore

This seminar provides a formal recognition of the models developed in the ASHRAE-hosted Great Energy Predictor III machine learning competition by giving members from the top three winning teams the opportunity to show their solutions. The winners will discuss the preprocessing, feature engineering, model selection and structure, and post-processing techniques that they used in the competition. In addition, a large overview of results was undertaken by the competition technical team that illustrates the accuracy/complexity balance of the solutions as well as the online resources generated by the competition.

1. Overview Analysis of the Great Energy Predictor (GEP) III Competition Models

Clayton Miller, Ph.D., Member, National University of Singapore, Singapore, Singapore

2. GEP III First-Place Solution - Group-Based Ensembles and Strategic Pre-Processing

Matthew Motoki, Iterable, San Francisco, CA

3. GEP III Second-Place Solution - Intensive Pre-Processing and Huge Xgboost, Lightgbm, Catboost, and Ffnn Ensemble

Rohan Rao, DSc, H2O.ai, Bangalore, India

4. GEP III Third-Place Solution - Xgboost and Lightgbm with Weighted Post-Processing

Xavier Capdepon, Xavier Capdepon, New York, NY

Seminar 22 (Intermediate)

What Can We Learn from Exergy Analysis Outside the Central Plant?

Sponsor: 7.4 Exergy Analysis for Sustainable Buildings (EXER)

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

Exergy analysis complements energy analysis by allowing the comparison of different energy sources and flows in buildings, and also by quantifying the effects of working temperatures. This seminar will focus on the applications of exergy analysis to different aspects in buildings, such as domestic hot water, building envelope, and heating and cooling systems together with the effects of auxiliary components. The seminar will identify the benefits of using exergy analysis to achieve a global optimum with respect to energy, performance and resource use.

1. Exergy-Based Optimization of the Design and Operation of the Hot Water Supply System

Giulio Tonellato¹ and Dolaana Khovalyg, Ph.D., Associate Member², (1)University of Padua, Padua, Italy, (2)Swiss Federal Institute of Technology Lausanne (EPFL), Lausanne, Switzerland

2. An Exergy View of Heat Transportation Cost

Mike Trantham, Member, IMI Hydronic Engineering, Dallas, TX

3. Exergy Losses Associated with Building Envelopes
William Kopko, Member, Johnson Controls, New Freedom, PA

Seminar 31 (Intermediate)

When is "Quiet", Quiet Enough? Understanding Sound Generation in Magnetic Bearing Machines

Sponsor: 8.2 Centrifugal Machines, 2.6 Sound and Vibration

Chair: Trent Hunt, Member, Mechanical Products Intermountain, Salt Lake City, UT

Magnetic Bearing Technology is becoming increasingly common place in the built environment. This presentation will address acoustic testing and rating standards for magnetic bearing chillers and compressors. This includes understanding the sources of sound generation and learning how to isolate magnetic bearing compressor acoustics from the overall sound generation of the chiller. From there, participants will learn how to acoustically plan for magnetic bearing chillers during design and how to "put a stethoscope on your equipment room" to overcome problems in the field if the quiet chiller isn't quiet enough.

1. Magnetic Bearing Centrifugal Chillers: Sound and Vibration Aspects

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

2. Acoustical Planning in System Design and Overcoming Sound Problems after Installation of Your Magnetic Bearing Chiller

Kristan G. Kollevoll, Member, BRD Noise and Vibration Control, Inc., Wind Gap, PA

Seminar 47 (Intermediate)

Climate Change and Urban Heat Island: Recent Trends in Weather Data for Design and Simulation

Sponsor: 4.2 Climatic Information

Chair: Michael Roth, Ph.D., Member, Klimaat Consulting & Innovation Inc, Guelph, ON, Canada

Members are increasingly searching for resources to design for, and in, a changing climate. Hitherto, there has been a reluctance from ASHRAE to endorse or recommend the use of simulated or modelled future weather data. In these discussions, climate change and urban heat island (UHI) are thought of as future occurrences. We present evidence that these changes have already been occurring. An analysis of the type of climatic information presented in ASHRAE publications suffices to demonstrate this. We will examine measured data to demonstrate the impact of climate change and UHI, and how the two effects usually exacerbate each other.

1. Recent Measured Data vs. IPCC Climate Model Predictions: How Do They Match Up?

Parag Rastogi, Ph.D., Member, arbnco Ltd., Glasgow, United Kingdom

2. Recent Trends in ASHRAE Design Conditions and Typical Meteorological Weather Data

Drury Crawley, Ph.D., BEMP, Fellow ASHRAE, BENTLEY SYSTEMS, Washington, DC

3. Recent Trends in Weather Statistics for Design and Annual Calculations

Yu Huang, BEMP, Member, White Box Technologies, Moraga, CA

Seminar 49 (Intermediate)

Occupant-Centric Building Design and Operation: Implementation Case Studies

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

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 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 in particular showcase subtask 4 of the Annex, which focuses on case studies and real world implementation of occupant-centric control.

1. Clustering and Motif Identification-Based Occupant-Centric Control of an Air Handling Unit: Lessons Learned from a Real-World Implementation

Brodie Hobson, Student Member and Burak Gunay, Ph.D., Associate Member, Carleton University, Ottawa, ON, Canada

2. Hvaclearn: A Reinforcement Learning Based Controller for Occupant Centric Thermostat Control

June Young Park, The University of Texas at Austin, Austin, TX

3. An International Survey of Building Operators' Role in Occupant-Centric Building Operation: Preliminary Insights
Michael Kane, Ph.D., Member, Northeastern University, Boston, MA

4. Spatial Optimization and Flex-Based Workspaces: A Big Opportunity for Occupant-Centric Building Controls and Operations?

Clayton Miller, Ph.D., Member, National University of Singapore, Singapore, Singapore

Seminar 55 (Intermediate)

Implementing Guideline 36: The Exciting Journey to Controls Nirvana

Sponsor: 1.4 Control Theory and Application

Chair: Ryan Williams, P.E., Member, High Performance Building Solutions, Jackson, MS

How do we, as Specifying Engineers, Controls Contractors, and Commissioning Authorities implement Guideline 36 best practices in the real world?

1. Beyond the Technical: The Broad Impacts of Implementing Guideline 36

Gregory Cmar, Member, Interval Data Systems, Boston, MA

2. A Designer's and Commissioning Agent's Perspective on Realizing the Energy Savings Potential of Guideline 36

Curtis Fong, P.E., Associate Member, Taylor Engineering, Alameda, CA

3. Control Description Language and Tools

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

4. Controls Nirvana: Our Journey's Destination

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

Seminar 65 (Intermediate)

Shedding Light on the IAQP

Sponsor: SSPC62.1, EHC

Chair: Hoy Bohanon, P.E., Life Member, Hoy Bohanon Engineering, PLLC, Clemmons, NC

The 2019 edition of ASHRAE Standard 62.1 includes updates to the Indoor Air Quality Procedure intended to foster wider adoption of the IAQP with concomitant energy savings relative to the VRP. Recognized impediments to the use of IAQP include lack of knowledge that it exists, perceived complexity, and scattered information about emission rates and cleaner efficiency values. These challenges and the relevance of selected compounds will be reviewed and an overview presented of air cleaning technologies.

1. IAQP: Rationale for Change

Dean Tompkins, Ph.D., P.E., Member, Dean Tompkins Group LLC, Madison, WI

2. How to Apply the IAQP: New Proposed Changes

Marwa Zaatari, Ph.D., Associate Member, enVerid Systems, Needham, MA

3. Cost Effectiveness of Air Cleaning

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

4. Absorbent Air Cleaning

Charles Seyffer, retired, Troy, NY

Track: Grid-Interactive Efficient Built Environment

Paper Session 4

Demand Flexibility and Grid-Interactive Buildings

Chair: Bing Liu, P.E., Fellow ASHRAE, Northwest Energy Efficiency Alliance, Portland, OR

This session focuses on exploring potential of demand flexibility, electric peak load shifting of DC system, and data driven thermal discomfort clustering. The first paper presents approaches to develop personalized models of manual overrides smart-thermostat settings using large-scale of datasets and addresses a need to personalize the changes made during demand response events to maximize demand flexibility and reliability. The second paper discovers a great potential in exploring the coupling of direct current distribution systems with EV battery and solar PV to create grid-interactive efficient buildings with cost-

effectiveness. The findings of this research could help the policy maker to estimate the grid flexibility potentials from the residential sector and help the grid to identify those households with large potential to contribute during demand response events.

1. Data Driven Thermal Discomfort Clustering

Kunind Sharma, Student Member and Michael Kane, Ph.D., Member, Northeastern University, Boston, MA

2. Exploring Electricity Peak Load Shifting and Cost Effectiveness of DC System with Solar PV and EV Battery

Yihao Luo, M.D., OPMP¹, Yi Zhang, Ph.D.¹ and Yi Zhang, Ph.D.², (1)Tsinghua-Berkeley Shenzhen Institute, Tsinghua University, Shenzhen, China, (2)1) Tsinghua -- Berkeley Shenzhen Institute (TBSI), Tower C2, Nanshan Intelligence Park 1001, Xueyuan Blvd., Nanshan District, Shenzhen, China

Paper Session 13

Smart and Efficient Building Envelopes

This session brings together different aspects of grid-interactive efficient buildings, such as building envelopes and thermal storage. The first paper presents a case study based on a single family residential building. The second paper discusses thermal switches and thermal storage for actively managing building envelopes. The third paper discusses opportunities in integrating thermal storage, semi-transparent photovoltaics on double skin facades.

1. Quantifying Grid Interaction Capabilities of Dynamic Building Envelopes

Brenton Kreiger, Kyri Baker, Ph.D. and Wil Srubar III, Ph.D., University of Colorado Boulder, Boulder, CO

2. Smart and Efficient Building Envelopes: Thermal Switches and Thermal Storage for Energy Savings and Load Flexibility

Sven Mumme¹, Diana Hun, Ph.D.², Mikael Salonvaara, Ph.D., Associate Member², Som Shrestha, Ph.D., BEMP, Member² and Nelson James, Ph.D., Affiliate¹, (1)U.S. Department of Energy, Washington, DC, (2)Oak Ridge National Laboratory, Oak Ridge, TN

3. Mechanically ventilated Double Skin Façade integrating Semi-Transparent Photovoltaics, implementing thermal storage for grid interaction

Zisis Ioannidis, Student Member¹, Andreas Athienitis, Ph.D., P.E., Member², Ted Stathopoulos, Ph.D., P.E., Member² and Anamaria Buonomano, Ph.D.³, (1)Centre for Zero Energy Building Studies (CZEBS), Montreal, QC, Canada, (2)Concordia University, Montreal, QC, Canada, (3)University of Naples, Naples, Italy

Seminar 14 (Intermediate)

Grid-Interactive Efficient Buildings: Introduction and Demonstration Projects

Sponsor: 7.5 Smart Building Systems

Chair: Donghun KIM, Ph.D., Lawrence Berkeley National Laboratory, Berkeley, CA

The rapid penetration of renewable energies and growing peak electricity demand on constrained transmission and distribution infrastructure are stressing the grid for balancing and requiring increased load flexibility. Because buildings are the primary consumers of electricity in U.S., they are an ideal source of cost-effective demand flexibility, which can provide a variety of grid services: load shape, shift, shed and shimmy. This session provides introduction and demonstration projects associated with the Grid-interactive Efficient Buildings initiative which focuses on making building equipment more intelligent and grid-responsive in addition to improving the energy efficiency of the overall building.

1. U.S. Department of Energy Buildings Technologies Office's Portfolio on Grid-Interactive Efficient Buildings

Nikitha Radhakrishnan, Ph.D., Pacific Northwest National Laboratory, Richland, WA

2. Scaling of Energy Efficiency and Grid Services to Support the Department of Energy's Grid-Interactive Efficient Buildings Strategy

Srinivas Katipamula, Ph.D., Fellow ASHRAE, Pacific Northwest National Laboratory, Richland, WA

3. Enabling a Clean Energy Future: An Overview of National Renewable Energy Laboratory's Demonstration Projects on Grid-Interactive Efficient Buildings

Xin Jin, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO

4. Optimal Asset Utilization and Operation of Distributed Energy Resources for Building-to-Grid Integration

Michael Starke, Ph.D., Oak Ridge National Laboratory, Oak Ridge, TN

Seminar 20 (Intermediate)

Planning for Reliable Grid Interactive Buildings

Sponsor: 7.5 Smart Building Systems

Chair: Christie Kjellman, Member, Kliewer & Associates, Aliso Viejo, CA

Buildings are now playing an active role in the new electric grid puzzle. Buildings can potentially provide resources to the grid through storage and demand response.

In order for a building to be a reliable option they must be able to have safe communications, orderable devices and cooperative building owners and operators. This session will address roles, security and asset valuations for the grid interactive built environment.

1. Understanding Operator Valuations of Building Services to Provide Grid Services

Jeff Deason, Lawrence Berkeley National Laboratory, Berkeley, CA

2. Energy Flexible Buildings for Resilient Low-Carbon Energy Grids

Michaël Kummert, Ph.D., Member, Polytechnique Montreal, Montreal, QC, Canada

3. Cybersecurity for Automated Demand Response Ready Buildings

Alekhya Vaddiraj, Electric Power Research Institute, Palo Alto, CA

Seminar 21 (Intermediate)

Control for Grid Interactive Buildings: Impacts on Building Efficiency

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

Chair: Michael Brambley, Ph.D., Fellow ASHRAE, Pacific Northwest National Laboratory, Richland, WA

As more variable renewable wind and solar photovoltaic power have been and will likely continue to be added to the electric grid, management of building power demand will be increasingly looked upon as one of the ways to compensate for both diurnal variability of solar power and difficulty to predict stochastic variability of wind power. This seminar explores approaches being used currently and under development for future use to control building demand for this purpose with a special focus on how participation impacts the energy consumption and efficiency of buildings.

1. Why We Need to Simultaneously Deploy Both Energy Efficiency and Grid Services in Commercial Buildings

Srinivas Katipamula, Ph.D., Fellow ASHRAE, Pacific Northwest National Laboratory, Richland, WA

2. The Performance Evaluation of Optimal Demand Responsive A/C Operation in Residential Buildings

Li Song, Ph.D., P.E., Member, University of Oklahoma, Norman, OK

3. Quantifying the Ancillary Service Potentials and Associated Inefficiency in Buildings Using a Modelica-Based Simulation

Xing Lu, Student Member, Texas A&M University, College Station, TX

4. Using a Green Solution to Solve Power Reliability and Economics for Commercial and Industrial Owners

Raj Chudgar, Demand Power Group Inc., Toronto, ON, Canada

5. First Experimental Results of Optimal Load Shifting for Small-Medium Sized Commercial Buildings: Impact on Energy Efficiency

Donghun KIM, Ph.D., Lawrence Berkeley National Laboratory, Berkeley, CA

Seminar 29 (Intermediate)

Timing is Everything in the Modern Grid: Which Measures Do You Apply and When Do You Operate Them?

Sponsor: 7.5 Smart Building Systems, 2.8 Building Environmental Impacts and Sustainability

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

The modern electric grid and renewable energy growth demand that we no longer simply save electricity when it's convenient, but instead focus attention on when that kWh is being saved. There are ever-increasing economic and emissions benefits to reducing building energy demand -- or simply shifting it -- at certain times of day and season. This seminar presents the impacts of timing a building's energy usage, savings, and load shifting. A variety of scenarios will be explored and specific examples given. Building designers and operators, especially HVAC and controls engineers, will learn about these benefits to their future building projects.

1. Applying Building Load Shifting Measures

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

2. Would You Like Some Free Electricity for Your Building?

Shanti Pless, Associate Member, NREL, Golden, CO

3. Better Together: Interactions Between Energy Efficiency and Demand Response and Driving Co-Benefits

Andrew Satchwell, Lawrence Berkeley National Laboratory, Berkeley, CA

Seminar 36 (Intermediate)

The Role Of Variable Refrigerant Flow In Building Electrification And Advancing Demand Response Capabilities

Chair: Badri Patel, Member, Johnson Controls Canada LP, Toronto, ON, Canada

Climate change is a modern-day priority for the international community and many municipalities are acting by creating initiatives to reduce building energy consumption and carbon emissions. Our presenters will discuss how Variable Refrigerant Flow (VRF) systems can be applied to reduce building energy use, discuss the potential and outcome of Phase 2 of a study by Southern California Edison and Energy Solutions on demand response capabilities of VRF systems. Our speakers will also discuss the progress of several legislative initiatives to curb building related carbon emissions and discuss the barriers to electrify building heating systems.

1. Variable Refrigerant Flow Systems: A Synergy between Energy Efficiency and Carbon Reduction

Badri Patel, BEAP, Member, Johnson Controls Canada LP, Toronto, ON, Canada

2. Advancing Demand Response Capability of Variable Refrigerant Flow Controls

Kitty Wang, P.E., Member, Energy Solutions, Oakland, CA

Seminar 37 (Intermediate)

Characterizing the Grid-Interactive Efficient Building Resource: An Introduction to Building Energy Modeling and Demonstration Approaches at Multiple Scales

Sponsor: 7.5 Smart Building Systems

Chair: Jared Langevin, Ph.D., Lawrence Berkeley National Laboratory, Berkeley, CA

Grid-interactive smart buildings are being positioned as a crucial demand-side asset for energy flexibility and peak load reduction. Achieving grid-interactive capabilities in the buildings sector will require advances in modeling and measurement of building operations to characterize grid-interactive efficiency and flexibility measures and quantify their potential to provide grid services at scale. This seminar introduces recent work that quantitatively assesses grid-interactive efficient building operations and their potential benefits at the building- and grid-level. Attendees will gain an understanding of measures for energy efficient and flexible building operations, state-of-the art methods for modeling these measures, and gaps in current modeling capabilities.

1. Behind the Meter: Progress from the Gridoptimal Buildings Initiative on Metrics, Models and Pilots

Alexi Miller, P.E., Member, New Buildings Institute, Portland, OR

2. Grid-Interactive Efficient Buildings: Potential Impacts on Regional Utility System Loads

Jared Langevin, Ph.D., Lawrence Berkeley National Laboratory, Berkeley, CA

3. The National Potential for Load Flexibility: Value and Market Potential through 2030

Ryan Hledik, Brattle Group, San Francisco, CA

Seminar 39 (Intermediate)

Low Cost Sensing Technologies for Grid-Interactive Efficient Buildings

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

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

Sensors are critical enabling devices for building control, operation and performance measurement. It is well-recognized that the cost of sensor and sensor system has been a major market barrier for smart grid-interactive efficient building (GEB) technologies. This seminar introduces several novel low cost sensing technology development that are sponsored by DOE, ARPA-E and EU research projects. These technologies have the potential to significantly reduce the overall sensor system cost; to accelerate the integration of buildings and power grid; and to enable smart building control and operation for improved energy efficiency and indoor environment.

1. Direct-Write Printed Sensors for Low-Cost Electronic Systems

Pooran Joshi, Ph.D., Oak Ridge National Laboratory, Oak Ridge, TN

2. Sleepir: Synchronized Low-Energy Electronically-Chopped Pir Sensors for True Presence Detection with Low Cost

Ya Wang, Ph.D., Texas A&M University, College Station, TX

3. Low Cost Sensor System for for the Assessment of Indoor Environmental Quality

Manuel Gameiro da Silva, Ph.D., Member, University of Coimbra, Coimbra, Portugal

4. Networked Wireless Sensors for Distributed Measurement in Geb Management

Hai Xiao, Ph.D., Clemson University, Clemson, SC

Seminar 46 (Intermediate)

Application of Machine Learning in GEB (Grid-Interactive and Efficient Building) Load Forecasting I

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

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

High-fidelity building load forecasting model is critical for advanced GEB control. Data-driven load forecasting modeling, especially those that use machine learning methods, receives great interest recently due to its cost-effectiveness and scalability. This two seminar series provides an overview (Seminar I) of the current development, limitations, gaps and future trend of the application of machine learning in GEB load forecasting. Seminar I also discusses a general framework and strategies to defy data bias issues. Several case studies (Seminar II) using various machine learning methods are presented to demonstrate the effectiveness and performance of machine learning enabled load forecasting.

1. Machine Learning in Building Load Forecasting

Liang Zhang, Ph.D., Associate Member, National Renewable National Laboratory, Golden, CO

2. Development of Generalized Machine Learning Approach for Forecasting Electricity, Zone Temperature and Zone Airflow

Srinivas Katipamula, Ph.D., Fellow ASHRAE, Pacific Northwest National Laboratory, Richland, WA

3. Active Learning Strategy for High Fidelity Short-Term Data-Driven Building Energy Forecasting

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

Seminar 56 (Basic)

Smart Grid Application Guide: A New Tool for Building Professionals

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

Chair: Steven Bushby, Fellow ASHRAE, NIST, Gaithersburg, MD

As part of the 2018-2019 presidential theme Building Our New Energy Future, ASHRAE partnered with the OpenADR Alliance and the Smart Electric Power Alliance (SEPA) to develop a smart grid guide for building professionals. Now published, the guide is a resource to help building professionals understand what is happening during the transformation to a smart electric grid and the opportunities they can take advantage of now and in the future when making decisions about the design and operation of their buildings. The guide provides a broad overview but also specific, actionable recommendations for building owners and operators.

1. What Buildings Can Provide to the Grid and How to Profit from It?

Jacob Thomas, P.E., GDS Associates, Inc., Marietta, GA

2. Behind-the-Meter Distributed Energy Resources

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

3. Building Design Considerations

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

Seminar 62 (Intermediate)

Micro-Grid Design Considerations: Sizing, Performance, Cost and Code Issues

Sponsor: 6.7 Solar Energy Utilization

Chair: James Leidel, Member, DTE Energy, Detroit, MI

Solar PV and distributed generation resources combine for sustainable-resilient micro-grids for today's facilities. Three presentations offer broad overviews of micro-grid design. The first is a 1MW PV analysis plus the firming power of a gas generator or LiION battery to achieve 8 hours of on-peak demand savings in Michigan. Next, we look at NFPA code issues surrounding alternate energy sources with micro-grids serving healthcare facilities. These issues are broadly applicable across all building types. Lastly, we discuss site evaluation and the integration of micro-grids to best match facility loads, using a successful Wisconsin project to illustrate proper design and control.

1. Evaluating a 1MW Solar PV Micro-Grid for Firm on-Peak Power: Focus on Cost and Performance

James Leidel, Member, DTE Energy, Detroit, MI

2. Evaluating Renewable Energy Micro-Grids for Healthcare Applications: Focus on Code Issues

Krista McDonald Biason, P.E., HGA Architects and Engineers, Minneapolis, MN

3. Building Efficiency and Microgrids: Focus on Control System Interoperability

Jason Heindel, AZZO USA, Fairfield, NJ

Seminar 63 (Basic)

Facilitating the Operation of Smart Buildings through Instrumentation, Monitoring and Data

Sponsor: 7.5 Smart Building Systems

Chair: Kristen Cetin, Ph.D., P.E., Member, Michigan State University, Okemos, MI

In recent years, an increasing number of technologies have become available that support the detailed monitoring of the performance (energy, thermal, lighting, IAQ/IEQ, etc.) of buildings, as well as the ability of buildings to interact with the electric grid. These technologies, including sensor systems, metering infrastructure and their associated data, increase the ability of buildings to flexibly and intelligently operate. This seminar focuses on an overview of current technologies, followed by a case study where technologies are used in an occupied building, and finally a presentation discussing common challenges in the intelligent use of the resulting data from such systems.

1. Overview and Best Practices for Energy Metering in Modern Smart Buildings

Glenn Remington, Member, Consumers Energy, Jackson, MI

2. Case Studies of Integrating Luminaire-Level Occupancy Sensor Signals with HVAC and Plug Loads for Added Savings

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

3. Filling in the Gaps! When Sensors Aren't Enough

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

Seminar 66 (Intermediate)

How Smart Buildings Can Communicate with and Automatically Respond to Smart Grid? Introduction to OpenADR, BACnet, and VOLTTRON

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

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

A key characteristic of smart grid is two-way communication between the utility and its customers. In the new Smart Grid Application Guide, OpenADR, BACnet and VOLTTRON are introduced as key parts of this two-way communication. OpenADR is an open, secure and two-way information exchange model and global Smart Grid standard. BACnet has objects and services that enable building load management and control. VOLTTRON is an open-source and secure execution and communications platform that can be used for buildings-to-grid applications. The two-way communication architecture and basic concepts of OpenADR, BACnet and VOLTTRON will be presented in this session.

1. How OpenADR Affects Building Controls

Rolf Bienert, OpenADR Alliance, San Ramon, CA

2. Implementing Automated Demand Response with BACnet

David Holmberg, Ph.D., Member, NIST, Gaithersburg, MD

3. Delivering Automated Demand Response Using an Opensource IoT-Platform: VOLTTRON

Srinivas Katipamula, Ph.D., Fellow ASHRAE, Pacific Northwest National Laboratory, Richland, WA

Track: HVAC&R Systems and Equipment

Paper Session 1

Advanced Water Heaters, Dehumidification and Water Performance

Chair: Vikrant Aute, PhD, Member, University of Maryland, College Park, MD

This session focuses on the latest technologies in water heating and dehumidification. The first paper presents an experimental study on the performance of tankless coil boilers. The second paper presents modeling and validation of a membrane-based heat and mass transfer device for dehumidification. The session concludes with a case study that evaluates the performance benefits of integrating a flame-assisted fuel cell with a residential water heater.

1. Study on the Performance of Tankless Coil Heating Boilers

Thomas Butcher, Ph.D., Fellow ASHRAE¹, Neehad Islam² and John Levey², (1)Brookhaven National Laboratory, Upton, NY, (2)National Oilheat Research Alliance, Plainview, NY

2. Modeling and Simulation of a Membrane-Based Heat and Mass Exchanger (HMX) Recovering Latent Heat of Dehumidification

Zhiming Gao¹, Navin Kumar, Ph.D.¹, Zhiyao Yang, Student Member², Kyle Gluesenkamp¹, Ahmad Abu-Heiba¹ and Van Baxter, Fellow Life Member¹, (1)Oak Ridge National Laboratory, Oak Ridge, TN, (2)Purdue University, West Lafayette, IN

3. Analysis of a Fuel Cell Hot Water Heater for Combined Heat and Power (VC-20-A007)

Ryan J Milcarek, Ph.D., Member and Rhushikesh Ghotkar, Student Member, Arizona State University, Tempe, AZ

Paper Session 5

Ground Source Heat Pump, Ground Heat Exchanger and Hybrid System

This session focuses on different aspects of ground source heat pumps. The first paper presents a field study to assess the impact of the building type and location on the energy savings potential of ground source heat pumps. The second paper presents detailed experimental evaluation of large diameter shallow bore helical ground-heat exchangers. The session concludes with a simulation-based investigation on the performance of a ground source heat pump coupled with thermal energy storage.

1. Comparative Study on the Impact of Building Type and Location on the System Efficiency and Energy-Saving Potential of a Ground Source Heat Pump System

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

2. Detailed Field Tests of Large Diameter Shallow Bore Helical Ground Heat Exchanger

Antash Najib, Student Member¹, Michael Slater, Member², Russel Hedrick², David Springer², Curtis Harrington, P.E., Member¹, Angelo Zarella, Ph.D.³ and Vinod Narayanan, Ph.D., Member⁴, (1)University of California Davis, Western Cooling Efficiency Center, Davis, CA, (2)Frontier Energy, Inc., Davis, CA, (3)University of Padua, Padova, Italy, (4)University of California, Davis, CA

3. A Simulation-Based Investigation on the Performance of a Hybrid Ground Source Heat Pump System Integrated with Thermal Energy Storage

Defeng Qian, Student Member¹, Zheng O'Neill, Ph.D., P.E., Member² and Xiaobing Liu, Ph.D., Member³, (1)The University of Alabama, Tuscaloosa, AL, (2)University of Alabama, Tuscaloosa, AL, (3)ORNL, Oak Ridge, TN

Paper Session 12

Air Pollutant Control, Ventilation and Energy Efficiency in Tunnel and Underground Stations

Chair: Nohad Boudani, P.Eng., Member, Sodicom, Beirut, Lebanon

This session presents pollutant control and ventilation strategies. The first paper presents a novel photocatalytic air pollution control device for in-situ and continuous operation in HVAC systems. The second paper presents a simulation study for the design of a unique three-tier tunnel ventilation system for a train station. The third paper presents energy efficiency measures for underground train station, particularly focusing on the use of variable frequency drives.

1. The Development of a Continuous, in-Situ Photocatalytic Air Pollutant Control Device (PCD) for HVAC Systems.

Stephanie Shaw, P.Eng., Student Member, David Wood and Bill Van Heyst, P.Eng., University of Guelph, Guelph, ON, Canada

2. Three Tier Tunnel Ventilation System

Om Hari Pande and Rajesh Kumar Jain, Member, Delhi Metro Rail Corp. Limited, New Delhi, India

3. Intelligent Energy Efficiency Measures for Underground Stations

Om Hari Pande, Rajesh Kumar Jain, Member and Mayank Prakash Chauhan, Delhi Metro Rail Corp. Limited, New Delhi, India

Paper Session 14

Advanced Control, Application and Strategy

This session presents advanced modeling and control strategies for the built environment. The first paper presents a modeling study on the use of CO₂ booster system for waste heat recovery in retail space. The second paper presents nationwide energy savings in office buildings with occupant-based controls. The session concludes with an experimental study to evaluate two control strategies for improving performance of cooling coil valves.

1. Nationwide Energy Saving Analysis for Office Buildings with Occupant-Based Building Controls

Zhihong Pang, Student Member¹, Zheng O'Neill, Ph.D., P.E., Member², Yan Chen³, Jian Zhang, Ph.D., Member⁴, Hwakong Cheng, P.E., Member⁵ and Bing Dong, Ph.D., Member⁶, (1)The University of Alabama, Tuscaloosa, AL, (2)University of Alabama, Tuscaloosa, AL, (3)The Pennsylvania State University, University Park, PA, (4)Pacific Northwest National Laboratory, Richland, WA, (5)Taylor Engineering LLP, Tacoma, WA, (6)Syracuse University, Syracuse, NY

2. Evaluation of Cooling Coil Valve Response Performance with Advanced Control

Rodney D. Hurt, Student Member¹, Gang Wang, P.E., Member² and Li Song, Ph.D., P.E., Member¹, (1)University of Oklahoma, Norman, OK, (2)University of Miami, Coral Gables, FL

3. Modelling of a CO₂ refrigerant booster system for waste heat recovery applications in retail for space heating provision

Salvador Acha, Ph.D., Member, Emilio Sarabia, Ph.D., Niccolo Le Brun, Nilay Shah, Ph.D., Christos N. Markides, Ph.D., Victor Soto and Jose M. Pinazo, Imperial College London, London, United Kingdom

Paper Session 15

Integrated HVAC Systems, Cost Effectiveness and Optimized Pump Design

This session focuses on the design and optimization of different HVAC&R equipment. The first paper presents a trade-off analysis on cost savings resulting from the use of water spray cooling vs. the actual cost of water. The second paper presents a novel solar-thermal powered heating, cooling and hot water system integrated with thermal storage. The session concludes with a paper presenting performance validation of radiant systems vs thermo-active building systems.

1. Preliminary Energy Performance Study of an Integrated Heating, Cooling, and Hot Water System with Latent Heat Thermal Energy Storage in Different U.S. Climate Zones

Emmanuel Hakizimana, Li Song, Ph.D., P.E., Member and Hamidreza Shabgard, The University of Oklahoma, Norman, OK

2. Cost Effectiveness Analysis for an Air-Conditioning System with Water Spray Cooling

Kai Han, Ph.D., Member, Trane Technologies, Tyler, TX

3. Application of VFDs to Multiple Pump Sizes in HVAC Systems (T)

Jiajun Liao, Ph.D., Member¹ and David Claridge, Ph.D., P.E., Fellow ASHRAE², (1)Texas A&M University, College Station, TX, (2)Texas A&M University, College Station, TX

Paper Session 20

Combined Heating and Power, Cooling Tower and Ducted Dehumidifier

This session focuses on three different equipment categories commonly used in the built environment. The first paper aims at developing an optimal controller for CHP systems. The second paper presents field evaluation of a water treatment technology for cooling towers. The third paper presents performance comparison of four different configurations for ducted dehumidifiers.

1. Energy and Latent Performance Impacts from Four Different Common Ducted Dehumidifier Configurations

Charles Withers Jr., Florida Solar Energy Center, Cocoa, FL

2. Testing a dynamic controller for CHP system optimal operation under uncertainty

Salvador Acha, Ph.D., Member, Romain Lambert, Ph.D., Niccolo Le Brun, Christos N. Markides, Ph.D. and Nilay Shah, Ph.D., Imperial College London, London, United Kingdom

3. Exploring Water-Energy Nexus at the Building Level

Dolaana Khovalyg, Ph.D., Associate Member and **Amirreza Heidari**, Swiss Federal Institute of Technology Lausanne (EPFL), Lausanne, Switzerland

Seminar 6 (Intermediate)

Optimized Control Systems for Thermal Comfort and Energy Management

Sponsor: 1.13 Optimization

Chair: Omar Abdelaziz, Member, Zewail City of Science and Technology, Giza, Egypt

This seminar begins with a presentation on novel developments in TABS for cooling demand response showing how they are optimized to be used as passive cooling and heat sink for the condenser. Next, a study is presented on model predictive control strategy for optimal operation of the cooling plant with TES and solar PV at a university campus covering numerical challenges and a potential solution. Finally, a hybrid methodology for assessing and ranking residential energy management control algorithms used in smart electric grid is presented to judge their performance related to cost, comfort and energy consumption.

1. Cooling Demand Response Using TABS

Peter Armstrong, Ph.D., P.E., Fellow ASHRAE, Khalifa University of Science and Technology, Masdar City, United Arab Emirates

2. Assessing the Performance of Residential Energy Management Control Algorithms

Farhad Omar, Ph.D., Member, NIST, Gaithersburg, MD

Seminar 13 (Basic)

Low Global Warming Potential Refrigerants for Direct HVAC Applications

Sponsor: ASHRAE MTG.LowGWP

Chair: Helen Walter Terrinoni, Member, Air Conditioning, Heating, and Refrigeration Institute, Skaneateles, NY

Differences in properties of low GWP refrigerants (e.g., low levels of flammability and toxicity) may require changes made to current commercial practices and building codes to minimize risk while meeting climate regulations. Stakeholders are working together to identify and address issues to ensure a safe transition to low global warming potential refrigerants including and beyond research, safety standards and building codes, transportation, handling, maintenance etc.

1. Regulations and Refrigerant Properties

Helen Walter Terrinoni, Member, Air Conditioning, Heating, and Refrigeration Institute, Skaneateles, NY

2. Low Global Warming Potential Refrigerants: Research Update

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

3. Low Global Warming Potential Refrigerants for Direct HVAC Applications

Philip Johnston, Daikin Applied, Minneapolis, MN

Seminar 23 (Intermediate)

Data-Driven Air Quality Control in Buildings: How Close are We and What do We Still Need?

Sponsor: 4.3 Ventilation Requirements and Infiltration, 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, SSPC 62.1, TC 2.4

Chair: Jordan D. Clark, Ph.D., Member, The Ohio State University, Columbus, OH

Airborne pollutant sensors are becoming ubiquitous, more reliable and inexpensive. This suggests the possibility of controlling air quality in smart buildings using real time data from these sensors, rather than the prescriptive methods traditionally employed. This seminar looks at the challenges inherent in doing data-driven air quality control in buildings, as well as the state of the art in hardware, integrating platforms, and theory. A wide array of buildings professionals will give different perspectives on performance of hardware, smart control strategies, retrofitting of existing buildings with control systems and unique applications of low-cost sensors.

1. Lessons Learned from Using Indoor Air Quality Sensors in Research Studies

Woody Delp, Ph.D. and Rengie Chan, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

2. Data-Driven Air Purification

Anthony Abate, AtmosAir Solutions, Fairfield, CT

3. Use of IoT Sensing during Extreme Pollution Events Such as Wildfires

Jovan Pantelic, Ph.D., UC Berkeley, Berkeley, CA

4. Retrofitting Buildings with Sensors and Communication Platforms

Parag Rastogi, Ph.D., Member, arbnco, Glasgow, United Kingdom

Seminar 32 (Intermediate)

Application of Low GWP Refrigerants in Centrifugal Chillers

Sponsor: 8.2 Centrifugal Machines, MTG.LowGWP Lower Global Warming Potential Alternative Refrigerants

Chair: Mark Rogan, Artic Chiller Group, Stuarts Draft, VA

Presenters will share results of recent investigations into the application of alternate refrigerants for chillers with centrifugal-type compressors. Single component and multi-component refrigerant blends are considered; all have significantly lower GWP than the baseline refrigerants they are intended to replace.

Analysis includes energy efficiency and associated impact on life cycle climate performance.

1. Alternative Refrigerants for Centrifugal Chillers

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

2. New Refrigerants for Centrifugal Chillers

Stephen Kujak, Member, Trane, La Crosse, WI

Seminar 38 (Intermediate)

Controls in an Evolving Landscape: The Impact of 5G, Blockchain, Modern Control Sequences, AI and Other Exciting Technologies

Sponsor: 1.4 Control Theory and Application, 1.5 Computer Applications , GPC 36

Chair: Michael Pouchak, P.E., Fellow ASHRAE, Honeywell International, Golden Valley, MN

Controls are changing with exciting new technologies such as 5G, AI, blockchain, standard control sequences, and a new environmental graphical programming language for controls. Modern control systems require knowledge of networks, systems, and "evil" technologies that are being used to compromise high-value mechanical system controls. This seminar features important topics that engineers, consultants, owners and manufacturers will need to understand.

1. Future-Proof Your Building with Modern Control Sequences

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

2. Building Robust Controls, Networks and Secure Systems

Michael Pouchak, P.E., Fellow ASHRAE, Honeywell International, Golden Valley, MN

3. The Future Is Now: A Standard Control Sequence Language

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

4. 5G, Blockchain, Encryption, Evil Technology and the Dark Web

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

5. Transactive Energy Platforms for Building-Grid Interactions and Apps for Construction/Ops

Dane Christensen, Ph.D., Member, NREL, Golden, CO

Seminar 43 (Intermediate)

Design Considerations for Tunnel Ventilation Systems

Sponsor: 5.9 Enclosed Vehicular Facilities

Chair: Yoon Ko, Ph.D., Member, National Research Council Canada, Ottawa, ON, Canada

Tunnel ventilation system design presents unique and challenging problems. This seminar will present various engineering solutions adopted to solve the tunnel ventilation design problems. This seminar will present 1) analysis techniques to design a tunnel ventilation system to accommodate trains pulled by diesel locomotives in rail tunnels; 2) analysis using both CFD and 3D egress modelling for smoke ventilation in tunnels.

1. Tunnel Ventilation Considerations for Diesel Locomotives

Andrew Louie, P.E., Member, WSP, NY, NY

2. Fire Ventilation for Tunnel Occupant Safety Using Coupling Methods between CFD and 3D Egress Modeling

Andre Calado, Member¹ and Robert Faddoul², (1)Jacobs Engineering, NY, NY, (2)Jacobs, NY, NY

3. Framework for Rapid Development of a High-Level Design of a Jet Fan Ventilation System for Road Tunnels

Thomas P. O'Dwyer, P.E., Member¹ and David Hahm, P.E.², (1)McMillen Jacobs Associates, New York, NY, (2)Jacobs Engineering, New York, NY

Seminar 51 (Intermediate)

Cold Climate Heat Pumps: Innovation is Heating Up!

Sponsor: 8.11 Unitary and Room Air Conditioners and Heat Pumps

Chair: Dane Christensen, Ph.D., Member, NREL, Golden, CO

Heating is by far the biggest consumer of energy in buildings, accounting for 25-43% of total energy use. Air source heat pumps have gained popularity in moderate climates due to their high efficiency; however, their performance has traditionally degraded steeply in cold climates. Cold climate heat pumps are designed to maintain capacity and efficiency even in extremely cold climates. This seminar will focus on applications and design considerations of cold climate heat pumps by discussing current installations in the field and research and development prototypes that further improve cold climate heat pump performance.

1. Performance of Cold Climate Heat Pumps in the Field

Tom Marsik, Ph.D., Associate Member¹ and Dane Christensen, Ph.D., Member², (1)Cold Climate Housing Research Center, Fairbanks, AK, (2)NREL, Golden, CO

2. Assessment of Energy Savings and Payback Period for Two Multi-Stage Cold Climate Heat Pumps

Bo Shen, Ph.D., Member, ORNL, Oak Ridge, TN

3. Designing and Testing of a Packaged R-290 Cold Climate Heat Pump with External Flow Reversal

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

Seminar 59 (Intermediate)

Designing Energy Efficient Duct Systems

Sponsor: 5.2 Duct Design

Chair: Stephen Idem, Ph.D., Member, Tennessee Tech University, Cookeville, TN

The impending publication of the ASHRAE Duct Systems Design Guide will enable engineers to design duct systems that minimize the installed cost of the ductwork, minimize system-generated noise, and minimize fan energy. The guide will describe the equal friction and static regain duct design methods. The equal friction method calculates the duct size based on the initial friction loss rate. For the static regain design approach, main ducts and branches are then sized to achieve a balanced pressure loss from section to section. Both duct design approaches use the ASHRAE Duct Fitting Database (DFDB) to calculate fitting loss coefficients.

1. Comparing the Equal Friction and Static Regain Duct Design Methods

Pat Brooks, P.E., Member, SMACNA, Chantilly, VA

2. Computer Modeling Advantages for Accurate Duct Sizing Using $TP=VP+SP$

John Reints, P.E., Member, www.staticregain.net, DeKalb, IL

3. Analysis of Pressure Loss and Flow Distribution in Multi-Branch Duct Systems

Stephen Idem, Ph.D., Member, Tennessee Tech University, Cookeville, TN

Seminar 68 (Intermediate)

Battle of the Nexus: Water vs. Energy in HVAC

Sponsor: 2.8 Building Environmental Impacts and Sustainability

Chair: Adriana Brasoava Roath, P.E., Associate Member, HGA, Minneapolis, MN

Today's built environment is working to reduce water and energy use in building energy systems. However, water and energy systems are interdependent. Water is often used to generate energy, and energy is utilized to collect, treat and distribute water. In this session we will explore opportunities to save both water and energy using heat recovery chillers, cooling towers, fluid coolers and VRF systems.

1. Does Simple Always Equate to More Energy Consumption: The Elegance of Selecting Air or Water Cooled VRF Systems

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

2. Exploring Cooling Towers and Fluid Coolers to Achieve Water and Energy Savings

Adriana Brasoava Roath, P.E., Associate Member, HGA, Minneapolis, MN

3. Potential Impact of Heat Recovery Chillers on Water and Energy Conservation

Joseph Witchger, P.E., Member, HGA, Minneapolis, MN

Track: Multifamily and Residential Buildings

Paper Session 6

Getting Smarter: Data-Driven Prediction and Load Profiles in Residential Buildings

This session addresses research surrounding fault detection and diagnosis measures from smart thermostats in homes, data-driven energy prediction and occupant-dependent end use load profiles in residential buildings. First paper presents a method to transform the raw thermostat modes for HVAC cycling systems to modes that more clearly reflect the overall system operation. The second paper provides a method to predict daily electricity consumption in residential buildings using a unique data-driven method and compare its performance to other methods. The third paper uses large-scale datasets to develop data-driven models to formulate electric load profiles for residential buildings and quantify their ability to provide various grid services. The fourth paper uses data-driven machine learning models to predict building energy performance with TMY and actual weather data.

1. Identifying Thermal Characteristics Using Smart Thermostats for Data-Driven Residential Vulnerability Assessment to Extreme Temperatures

Krissy Govertsen, Associate Member and Michael Kane, Ph.D., Member, Northeastern University, Boston, MA

2. Labeling Modes of Operation and Extracting Features for Fault Detection with Cloud-Based Thermostat Data

Austin Rogers, Ph.D., Affiliate¹, Fangzhou Guo², Bryan Rasmussen, Ph.D., P.E., Member² and Jonathan Martinez², (1)Pacific Northwest National Laboratory, Richland, WA, (2)Texas A&M University, College Station, TX

3. Data-Driven Energy Prediction in Residential Buildings

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

4. Typical Meteorological Year and Actual Weather Data in Data-Driven Machine Learning Models for Residential Building Energy Use

Ehsan Kamel, Ph.D., Associate Member¹ and Shaya Sheikh, Ph.D.², (1)New York Tech (NYIT), Old Westbury, NY, (2)New York Institute of Technology (NYIT), Old Westbury, NY

5. Occupant-Dependent Residential End Use Load Profiles for Demand Response Under High Renewable Energy Scenarios (VC-20-A001)

Niraj Kunwar, Student Member¹, Soham Vanage, Student Member², Emily Peruski², Debrudra Mitra, Student Member¹ and Kristen Cetin, Ph.D., P.E., Member³, (1)Iowa State University, Ames, IA, (2)Michigan State University, East Lansing, MI, (3)Michigan State University, Okemos, MI

Paper Session 18

Residential Buildings Air Leakage, Catalog Houses, and Energy Model

This session focuses on the air leakage testing requirements, a new way to build homes, and energy use predictions in residential buildings. The first paper highlights a field study that compares measured air leakage test values with originally reported values and discusses air leakage test forms for code compliance. The second paper presents an in-depth examination of the characteristics of the typical Swedish Catalog House as well as its performance. The third paper shows energy use of a building in an urban area can be impacted by up to 12% due to differences in urban density. This indicates the importance of weather data in predicting energy consumption of the building.

1. Compliance with Florida's New Residential Building Air Leakage Testing Requirements: A Field Study

Jeff Sonne, Florida Solar Energy Center, Cocoa, FL

2. Uncertainties of Building Energy Model Predictions Due to Spatial Temperature Variations

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

3. Energy Efficiency and the Swedish Catalog House

Anthony Denzer, Ph.D., Member, Civil & Architectural Engineering, University of Wyoming, Laramie, WY, USA, Laramie, WY

Seminar 1 (Basic)

HVAC System Design in Low Load Homes

Sponsor: 6.3 Central Forced Air Heating and Cooling Systems

Chair: Paul Haydock, Associate Member, United Technologies Carrier, Indianapolis, IN

Well-insulated homes have low heat loss and gain and are great for energy savings. Most people think it would be easy to provide HVAC comfort; however, these types of home designs with tight envelopes tend to retain moisture, and take much longer to reach a low sensible heat ratio. A typical size home in America is 2,000 – 2,500 ft² with a design airflow of 1200 CFM. The same size low load only requires 600 CFM.

This session addresses the challenge of low airflow rates in residential dwellings and how to mix the conditioned air to promote even temperatures.

1. Small Ducts for Small Loads

Craig Messmer, P.E., Member, Unico Inc, Arnold, MO

2. Benchmarking Energy and Thermal Comfort Performance of a Small Duct High Velocity System at a Low-Load Home

Hyojin Kim, Ph.D., Member, New Jersey Institute of Technology, Newark, NJ

Seminar 8 (Intermediate)

Insights and Analysis on Moisture Control in Mid- and High-Rise Multifamily Buildings

Sponsor: 1.12 Moisture Management in Buildings, Residential Building Committee

Chair: Jeffery A. Acton, P.E., Acton Partners, LLC, Austin, TX

The demand for growth in the multifamily and residential building industry has also seen requirements for high performance and energy efficient strategies. This seminar reviews moisture-related issues in the design, construction and operation of multifamily and residential construction via case studies to review the risks of no moisture control in high performance multifamily buildings.

1. Moisture Control, Ventilation and Air Tightness in Residential Multi-Family Construction

Donald B. Snell, P.E., Member, Liberty Building Forensics Group, Zellwood, FL

2. Impacts of Ventilation Rates on Latent Loads

Kimberly LLewellyn, Mitsubishi Electric Cooling & Heating, Suwanee, GA

3. Moisture Management During Construction

Peter Marciano, Legacy Buildings, New York City, NY

Seminar 17 (Intermediate)

Multifamily Buildings: IAQ Issues and Responses

Sponsor: Environmental Health Committee

Chair: Hoy Bohanon, P.E., Life Member, Hoy Bohanon Engineering, PLLC, Clemmons, NC

Multifamily buildings are an indoor air quality challenge for several reasons. Individual behaviors cannot be controlled as in an office, school, or other commercial/institutional settings. The construction practices are historically different compounding the issues of air transfer between different dwelling units. This session examines the sources of IAQ issues and provides standardized and better practice solutions.

1. How Requirements in Codes, Standards, and Programs Are Evolving to Improve IAQ in Multifamily

Gayathri Vijayakumar, BEMP, Steven Winter Associates, Inc, Washington, DC

2. IAQ in Social Housing Apartment Buildings: Sources and Solutions

Jeffrey Siegel, Ph.D., Fellow ASHRAE, University of Toronto, Toronto, ON, Canada

Seminar 19 (Intermediate)

Beware! Be Aware of These Common Acoustical Concerns in Multi-Family Buildings

Sponsor: 2.6 Sound and Vibration

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

There are acoustical performance standards for airborne noise, footfall noise, and background noise from mechanical systems. Though some of the most common complaints are associated with fitness activities within the building, walking noise outside the scope of the current metrics, and plumbing noise. Some of these conditions have been incorporated into the ASHRAE 189.1/IgCC Acoustic Control section and need to be considered with your design team that seeks to satisfy this standard.

1. New ASTM Ratings for Impact Noise Insulation

Wayland Dong and Samantha Rawlings, Veneklasen Associates, Inc., Santa Monica, CA

2. The Challenges and Solutions for Fitness Noise in Mixed-Use Buildings

Matthew Golden, Affiliate, Pliteq Inc., Toronto, ON, Canada

Seminar 28 (Basic)

Oops! We Forgot the Engineers and Designers in the Residential Sector, Which Now Has a ‘Wicked’ IEQ Issue

Sponsor: 6.5 Radiant Heating and Cooling

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

Hydronic Radiant Heating has multiple benefits to including increase energy efficiency, indoor environmental quality and economic benefits. The key to success is applying the technology correctly. This session has 2 presentations which explore the impacts of hydronic radiant systems in new and existing homes. In ‘Oops! They Did It Again,’ we will look at the consequences on a system from owner made decisions post design to alter an enclosure design. In ‘Oops! They Forgot the Science,’ it shows how radiant solved issues in existing housing by providing a cost-effective, safe system that improves resiliency of the structure and occupants comfort.

1. Oops! They Did It Again

Robert Bean (Ret), Member, Indoor Climate Consultants Inc., Calgary, AB, Canada

2. Oops! They Forgot the Science

Aura Lee MacPherson, Member¹ and Aaron Stotko, Member², (1)RadiantLink MacPherson Engineering Inc, Regina, SK, Canada, (2)Uponor, Inc., Apple Valley, MN

Seminar 42 (Intermediate)

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

Sponsor: 4.3 Ventilation Requirements and Infiltration

Chair: Sonya Pouncy, Member, Northwest Energy Efficiency Alliance, Portland, OR

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

1. The Relative Performance of Different Ventilation Configurations in Multi-Unit Residential Buildings in North America

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

Seminar 50 (Intermediate)

How does a Type of Filter Affect Energy Consumption?

Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, 2.4 Particulate Air Contaminants and Particulate Contaminant Removal Equipment

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

This seminar provides a description and critical analysis of the efficiency level of various particulate and/or gaseous filters and their impact on energy consumption. Results apply to residential homes/buildings and some office buildings. It was found that particulate and/or gaseous filters greatly improve air quality and consume little energy.

1. Impact of High Efficiency Filters on HVAC Energy Consumption: a Controlled Experimental Study

John Zhang, Ph.D., Member, 3M, St. Paul, MN

2. Filters Don’t Use Energy, Fans Do

Tianyuan Li¹ and Jeffrey Siegel, Ph.D., Fellow ASHRAE², (1)University of Toronto, Toronto, Canada, (2)University of Toronto, Toronto, ON, Canada

3. Gas-Phase Air Cleaning Impact on Energy and IAQ in Office Buildings

Marwa Zaatari, Ph.D., Associate Member, enVerid Systems, Needham, MA

Track: Professional Development

Workshop 1 (Basic)

Crafting an O&M Plan for a Net Zero/Passive House: An Interactive Workshop

Sponsor: 7.6 Building Energy Performance, 7.3 Operation and Maintenance Management

Chair: Mina Agarabi, P.E., Member, Agarabi Engineering PLLC, New York, NY

To have a sustainable, high performance building it is essential to bridge the communication gap among owner, facilities staff and service contractors. This workshop focuses on the elements of an effective Operations and Maintenance Plan. Attendees, working in small groups, will craft a section of an O&M plan for a Net Zero/Passive House building. The groups will then come together, compare their O&M Plans, and engage in an interactive discussion designed to meld the best ideas into a single high-quality document.

1. O&M Plan for a Net Zero/Passive House: An Interactive Workshop

Annie Smith, P.E., Member, Ross & Baruzzini, St. Louis, MO

Debate 1 (Intermediate)

Technical Consultants aren't 'Designers of Record,' so No E&O Insurance is Needed

Sponsor: 1.7 Business, Management & General Legal Education, 7.1 Integrated Building Design, 2.7 Seismic and Wind Resistant Design; 2.8 Building Environmental Impacts; 4.7 Energy Calculations; 4.10 Indoor Environmental Modeling; 7.6 Building Energy Performance; 7.9 Building Commissioning; MTG.BIM

Chair: E. Mitchell Swann, P.E., Member, MDCSystems, Paoli, PA, Mina Agarabi, P.E., Member, Agarabi Engineering PLLC, New York, NY, James Bradburn, P.E., Member, HGA, Minneapolis, MN, Matthew Ryan, J.D., Allensworth & Porter, Austin, TX and Larry Spielvogel, P.E., Fellow Life Member, Consulting Engineer, Bala Cynwyd, PA

Today's buildings are more complex than ever. Demands for higher performance, faster delivery and lower costs have spawned the growth of Energy Modeling, BIM development, in-field photogrammetry, Commissioning and Green consultants. These early-on consultants can have a big impact on final design decisions. Do they have professional liability similar to licensed design professionals? Should they carry PLI? If you've contracted out to consultants, have you verified their capacity to 'handle' the risks associated with the direction they provide? This debate will dig into the potentially dirty details and shifting terrain covered by tech consultants and the "responsible party."

Panel 2 (Intermediate)

It's Not a Hot Potato! Engineers Cannot Delegate Design as They See Fit.

Sponsor: 7.2 HVAC&R Construction & Design Build Technologies, 1.7 Business, Management & General Legal Education

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

Faster project delivery, along with downward pressure on design fees has increased the use of 'delegated design' – the engineer places the responsibility of final design on the contractor. Delegated design is not new, but its use is increasing. Engineers say it is more efficient, improves coordination and yields greater value for owners. Contractors argue it forces them into areas they are not familiar with and not properly compensated for. What do owners expect in technical services to their project? This panel looks at 'delegated design': Is it a responsibility dodge or a path towards a better project?

1. It's Not a Hot Potato!

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

2. The Contractor's Perspective on Delegated Design

Michael Cooper, P.E., Member, Bernhard, Metairie, LA

3. The Design Engineer's Perspective on Delegated Design

Branislav Cvijetinovic, P.Eng., Member, SNC Lavalin, Vancouver, BC, Canada

4. The Manufacturer's Perspective on Delegated Design

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

5. Delegated Design from the Owner's Perspective

Martin Weiland, P.E., Member, US General Services Administration, Washington, DC

6. Delegated Design - the Legal Implications

Matthew Ryan, J.D., Allensworth & Porter, Austin, TX

Seminar 3 (Basic)

Why Company Culture Is Important to Attract and Retain Employees

Sponsor: 7.2 HVAC&R Construction & Design Build Technologies, 1.7 Business, Management & General Legal Education, YEA

Chair: Joe Chin, P.E., Member, Western Allied Mechanical, Inc., Menlo Park, CA

In an increasingly tight labor market, employee retention and recruitment are constantly top of mind for company leadership. As companies throw high salaries and ever-growing snack budgets at this challenge, our discussion will focus on the importance of a meaningful company culture that will keep your superstars and attract the best talent.

1. Why Company Culture Is Important to Recruit and Retain Employees

Marc Remmert, P.E., WGI, Austin, TX

2. A Case Study on Discovering and Living Your Company Culture

Joe Chin, P.E., Member, Western Allied Mechanical, Inc., Menlo Park, CA

3. What YEA Members Are Looking for in Company Culture

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

Seminar 9 (Basic)

Leadership Strategies and Tactics: Utilizing Emotional Intelligence

Sponsor: 1.4 Control Theory and Application

Chair: Chad Moore, P.E., Member, Engineering Resource Group, Jackson, MS

Many ASHRAE members are working to become leaders in their workplace, volunteer organizations and personal lives. This seminar focuses on strategies and tactics, utilizing Emotional Intelligence (EQ) skills to develop leaders. The four EQ skills will be discussed, self-awareness, self-management, social awareness and relationship management. Speakers will share lessons learned as YEA members as they transition from YEA members to individuals with increased leadership responsibilities.

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

Karine Leblanc, Member, US Air Conditionings Distributors, City of Industry, CA

2. Harnessing the Power of EQ in the Built Environment

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

3. EQ Case Study of Myself: Lessons Learned from a Soon to be Former YEA Member

Robert Kraft, Associate Member, Greenheck, Schofield, WI

4. How EQ Can Make or Break a YEA Career

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

Track: Research Summit

Paper Session 2

Occupant-based Control and Occupant Behaviors

There is growing motivation and interest to include occupant-metrics in the control of building equipment. The occupant-based metrics can include occupancy profiles, occupant behavior, thermal comfort as well as the actual and perceived comfort in the indoor environment. The first paper in this session attempts to qualify how a complex control system in a building acts as a barrier for users to effectively interact with it. The second paper presents a study aimed at development of typical occupant profiles in academic buildings in the U.S.

1. Evaluation of a Modern Commercial HVAC Control System in the Context of Occupants' Perceived Control

Connor Brackley, Student Member, Liam O'Brien, Ph.D., P.E., Associate Member and Chantal Trudel, Carleton University, Ottawa, ON, Canada

2. Development of Typical Occupant Profiles in Academic Buildings in the United States

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

Paper Session 8

Next Generation Refrigerants

Chair: Vikrant Aute, PhD, Member, University of Maryland, College Park, MD

This session focuses on multiple aspects of next generation refrigerants, including systematic selection, LCCP assessment, chemical stability and transport phenomenon.

1. Chemical Stability and Materials Compatibility Challenges with R131I (CF₃I)

Stephen Kujak, Member¹, Elyse Sorenson, Associate Member² and Morgan Herried², (1)Trane, La Crosse, WI, (2)Trane, Ingersoll Rand, La Crosse, WI

2. A Methodological Concept for LGWP Refrigerants Selection Based on Multi-Criteria Decision Making (MCDM)

Mohamed Osman¹, Mohamed Abokersh², Omar Huzayyen, Ph.D., Member³, Mohamed Elmorsi, Ph.D., Member¹ and Mohamed R. Zain⁴, (1)American University in Cairo, Cairo, Egypt, (2)Public University of Tarragona, Tarragona, Spain, (3)Faculty of Engineering, Cairo University., Cairo, Egypt, (4)The American University in Cairo, Cairo, Egypt

3. Superheated Condensation of Refrigerant Mixtures R448A and R452A (VC-20-A002)

Tabeel Jacob, Student Member and Brian Fronk, Ph.D., Associate Member, Oregon State University, Corvallis, OR

Paper Session 10

Building Energy Modeling

Chair: Bing Liu, P.E., Fellow ASHRAE, Northwest Energy Efficiency Alliance, Portland, OR

This session focuses on software interoperability and modeling in the context of building energy modeling. The first two papers focus on the challenges faced by gbXML and the opportunities it brings for BIM and BEM tools. The third paper presents enhancements to an existing energy rating and labelling tool. The fourth paper presents a validated model for building energy and indoor air temperature profiles.

1. Obstacles That gbXML Is Facing: Analysis on BIM Software Interoperability Survey

Zhizhang Hu, Student Member¹, Ruiji Sun, Student Member², Weili Xu, Ph.D., Associate Member² and Krishnan Gowri, Ph.D., BEMP, Fellow ASHRAE³, (1)Carnegie Mellon University, Pittsburgh, PA, (2)BuildSimHub, Pittsburgh, PA, (3)Intertek Building Science Solutions, Bothell, WA

2. Improving the Interoperability of gbXML Data Model through Redefining Data Mapping Rules of HVAC Systems and Internal Loads

Ruiji Sun, Student Member¹, Zhizhang Hu, Student Member², Krishnan Gowri, Ph.D., Fellow ASHRAE³ and Weili Xu, Ph.D., Associate Member¹, (1)BuildSimHub, Pittsburgh, PA, (2)Carnegie Mellon University, Pittsburgh, PA, (3)Intertek, Bothell, WA

3. Estimating Hourly Heating and Cooling Loads from Monthly Results

Sébastien Bricdeau, Ph.D., Associate Member, Natural Resources Canada, Ottawa, ON, Canada

4. Validated Trnsys Model for a Building in Marrakech Morocco (VC-20-A003)

Paulo Cesar Tabares - Velasco, Associate Member¹, Fatima Benaddi², Lahcen Boukhattem, Ph.D.² and Brahim Benhamou, Ph.D.², (1)Colorado School of Mines, Golden, CO, (2)Cadi Ayyad University, Marrakech, Morocco

Paper Session 19

Indoor Air Quality and Demand-Controlled Ventilation

Ventilation and indoor air quality are closely related and have a direct impact on the overall building energy consumption. The first paper in this session presents IAQ trends over time in office and school buildings. The second paper focuses on measurement of PM_{2.5} deposition rates under different natural ventilation rates. The third paper presents a novel ventilation approach for achieving both fire safety and energy efficiency in large vertical spaces. The session concludes with a presentation on laboratory testing to evaluate feasibility of low-cost CO₂ sensors for demand-controlled ventilation.

1. Seasonality and Trends in Indoor Air Quality Based on Continuous Monitoring of Office and School Buildings (VC-20-A004)

Samy Clinchard, Salvatore Della Vecchia, Rick Aller, Tomas Novotny, P.Eng., Member and Ulla Haverinen-Shaughnessy, 720 Degrees Ltd, Helsinki, Finland

2. Measuring PM_{2.5} Deposition Rates Under Different Natural Ventilation Rates in Two Classrooms

Cong Liu¹ and Chun Chen, Ph.D., Associate Member², (1)Southeast University, Nanjing, China, (2)The Chinese University of Hong Kong, Hong Kong, China

3. A Novel Ventilation Approach of Large Vertical Space for Achieving Fire Safety and Energy Efficiency (VC-20-A005)

Dahai Qi, Ph.D. and Haohan Sha Sr., Université de Sherbrooke, Sherbrooke, QC, Canada

4. Feasibility of low-cost CO₂ sensors for demand-controlled ventilation — Part 1. Laboratory testing (T)

Justin Berquist, Associate Member and Carsen Banister, Ph.D., Member, National Research Council Canada, Ottawa, ON, Canada

Paper Session 21

Research on Testing and Measurement

This session highlights the latest research on testing and measurement as it pertains to different aspects of the built environment. The first paper presents a validated testbed for simulation of dynamic primary cooling and an ice storage system. The second paper presents the updates to an ANSI/ASHRAE standard for testing ozone removal air-cleaning devices. The third paper presents an analysis of an existing hydrogen concentration measurement technique. The last two papers are updates on ASHRAE research projects RP-1733 and RP-1645 respectively.

1. Development and Validation of a Simulation Testbed for the Intelligent Building Agents Laboratory (IBAL) Using Trnsys

Ojas Pradhan, Student Member¹, Amanda Pertzborn, Ph.D.², Liang Zhang, Ph.D.³ and Jin Wen, Ph.D.¹, (1)Drexel University, Philadelphia, PA, (2)NIST, Gaithersburg, MD, (3)NREL, Golden, CO

2. Modifications to ANSI/Ashrae Standard 145.2 for Testing Ozone Removal Air-Cleaning Devices

Mengjia Tang¹ and Atila Novoselac, Ph.D., Associate Member², (1)The University of Texas at Austin, Austin, TX, (2)University of Texas at Austin, Austin, TX

3. An Update on the Evaluation of Air Mixer Performance (RP-1733) (VC-20-A006)

Hyunjin Park, Student Member, Christian Bach, Ph.D., Associate Member and Omer San, Ph.D., Oklahoma State University, Stillwater, OK

4. Development of New Accelerated Corrosion Test for All-Aluminum Microchannel and Tube and Fin Heat Exchangers II- Chamber Study (1645-RP) (T)

Seifollah Nasrazadani, Ph.D., Member, University of North Texas, Denton, TX

Paper Session 24

Fan Efficacy Analysis and Research Summary from the ASHRAE Research Project RP-1741

Chair: Nohad Boudani, P.Eng., Member, Sodicom, Beirut, Lebanon

Fans are an integral component in any air-moving equipment. This session highlights the latest ASHRAE research from RP-1741 on performance representation of multi-speed fan coil units. The first paper focuses on development of part-load airflow and power models based on data obtained from manufacturers and independent laboratory tests.

1. Using Normalized Airflows and Powers to Model the Performance of Multi-speed Fan Coil Units with Permanent Split Capacitor Fan Motors (RP-1741)(T)

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

Seminar 10 (Intermediate)

Current Research in Long-Term Performance Monitoring and Analysis of Ground-Source Heat Pump Systems

Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: Matt S. Mitchell, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO

The long-term performance of ground source heat pump systems is a topic which is rarely reported in literature, due primarily to the inherent difficulties in accurately measuring system performance over many years. Additionally, the best practices for performing such studies have yet to be determined.

This seminar presents the results from several research studies where the long-term performance of several different ground-source heat pump systems are discussed. The analysis methods used to determine system performance are discussed and the results are presented.

1. Ongoing Research into Long-Term Performance Monitoring of GSHP Systems in IEA HPT Annex 52

Signhild Gehlin, Ph.D., Member, Swedish Centre for Shallow Geothermal Energy, Lund, Sweden

2. GSHP System Performance Research at the University of Stockholm Studenthuset

Jeffrey Spütler, Ph.D., P.E., Fellow ASHRAE, Oklahoma State University, Stillwater, OK

3. Ground Source Heat Pump Systems Thermal Imbalance Research in Residential Buildings in China

Da Yan, Ph.D., Member, Building Energy Research Center, Tsinghua University, Beijing, China

4. Ground Source Heat Pump Systems Serving Ten University Student Housing Buildings: Performance Research

Xiaobing Liu, Ph.D., Member, ORNL, Oak Ridge, TN

Seminar 27 (Basic)

Low-Cost Occupancy Sensors Systems for Residential and Commercial Building HVAC System Controls

Sponsor: 7.5 Smart Building Systems

Chair: Kristen Cetin, Ph.D., P.E., Member, Michigan State University, Okemos, MI

Occupants represent one of the highly variable factors in buildings that can significantly impact their energy use, as the HVAC system is design to adjust the internal conditions and ventilation rates to the presence and/or count of occupants in a space. This presentation will provide an update on the progress of several teams of researchers, who are developing and testing low-cost, high-reliability occupancy sensors that meet stringent cost and reliability requirements across 4 categories, including (A) residential building presence sensing, (B) commercial building occupancy counting, and (C) commercial building CO2 sensing.

1. (Category A): Battery-Free RFID Sensor Network with Spatiotemporal Pattern Network Based Data Fusion System

Anthony Florita, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO

2. (Category B): Development of Vision Based Occupancy Sensing System for HVAC Applications

Michael Gevelber, Ph.D., Member, Boston University, Boston, MA

3. (Category C): Simulation, Testing and Evaluation of Occupancy Sensor Systems

Zheng O'Neill, Ph.D., P.E., Member, Texas A&M University, College Station, TX

Seminar 35 (Intermediate)

An Overview of the Updated ASHRAE Design Guide for Combustion Turbine Inlet Cooling (RP-1762)

Sponsor: 1.10 Cogeneration Systems, 6.9 Thermal Storage , 6.2 District Energy

Chair: Patricia T. Graef, P.E., Fellow ASHRAE, Patricia Graef Consulting, North Fort Myers, FL

Combustion turbine inlet cooling (CTIC) is often used for increasing the capacity and efficiency of CTs during hot weather. CTIC can provide economic and environmental benefits at those times when electric power is in high demand and also is of high value, namely during hot weather. CTIC is a resilient, sustainable, fast-responding and carbon-reducing option. In 1999, ASHRAE published its first design guide for CTIC. Since then much has transpired justifying the need for this updated design guide. It is a useful up-to-date guide for engineers developing preliminary designs and evaluating their performance for twelve commercially proven CTIC technologies.

1. An Overview of the 2020 Ashrae Design Guide for Combustion Turbine Inlet Cooling

Dharam V. Punwani, Fellow ASHRAE, Avalon Consulting, Inc, Naperville, IL

Seminar 40 (Intermediate)

Who Said Thermal Storage Has to be Only in Tanks? Thermal Storage in the Building Envelope

Sponsor: 4.4 Building Materials and Building Envelope Performance

Chair: Marcus V A Bianchi, Ph.D., P.E., Member, National Renewable Energy Laboratory, Golden, CO

With more variable renewable and distributed generation sources integrated into the electrical grid, it becomes more difficult to reliably match supply and demand. Energy storage can play a key role in addressing such mismatch. While typically one considers electro-chemical batteries for storage, thermal energy storage can also be a resource. Most U.S. buildings typically have low thermal mass, so the addition of materials that change phase (phase change materials or PCMs) is an option. This seminar will revisit some of the concepts and challenges to incorporate PCMs in the building envelope.

1. Energy Demand Management in Buildings Using PCM-Integrated Wall

Ravi Kishore, Ph.D., National Renewable Energy Laboratory, Golden, CO

2. Effect of Convective Heat Transfer on PCM Thermal Performance

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

3. Assessment of the Thermal Performance and Heat Transfer Regulation in Building External Walls Equipped with Phase Change Materials (PCM)

Mario Medina, Ph.D., P.E., Member, The University of Kansas, LAWRENCE, KS

Seminar 44 (Intermediate)

The Future of Compression: Novel Compressor Technology

Sponsor: 8.1 Positive Displacement Compressors

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

This seminar will explore the future of compression technologies by exploring recent developments in the field. The presented studies will present the physical attributes and thermodynamic performance of these technologies and their ability to make an impact on compression technologies. This includes advancements in positive-displacement compressors with presented work on the peristaltic compressor and alternative compressors. Additionally, contributions on non-mechanical compression is explored by considering electrochemical compression and chemical looping heat pumping concept.

1. Advancements on Chemical Looping Heat Pump Technology

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

2. Design and Thermodynamic Model Development of a Novel Peristaltic Compressor

Mazharul Islam, Student Member, Oklahoma State University, Stillwater, OK

3. Research Progress of NH₃ Electrochemical Compression

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

Seminar 61 (Intermediate)

Recent Developments In Thermal Response Tests For GSHP

Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: Kristen Cetin, Associate Member, Northwest Energy Efficiency Alliance, Portland, OR

Thermal response tests are typically used to evaluate the ground formation thermal conductivity by interpreting the measured time evolution of the fluid temperature for a constant heat injection rate. This seminar will present recent developments associated with these tests including the use of multi-flow rate tests, the development of a calibration unit for TRT units, and the analysis of some 6,000 tests to determine how test data is affected by weather, groundwater movement, test equipment setup, etc.

1. Multi-Flow Rate Thermal Response Tests

Matt Mitchell, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO

2. Calibration of Thermal Response Test Units

Michel Bernier, Ph.D., Fellow ASHRAE, Polytechnique Montréal, Montréal, QC, Canada

3. How to Collect High-Quality TRT Data

Chad Martin, P.E., Member, Geothermal Resource Technologies Inc., Asheville, NC

Seminar 64 (Intermediate)

ASHRAE Research Updates

Chair: Kristen Cetin, Associate Member, Northwest Energy Efficiency Alliance, Portland, OR

This session explores updates to previously published ASHRAE research. The first presentation evaluates the 2019 ASHRAE Handbook model for rooftop dilution and proposes potential improvements. The second compares eight low-cost particle sensors intended for consumer use in both a laboratory setting and a simulated single-family residential setting.

1. Improving Predictions of Dilution from Rooftop Exhausts (ASHRAE 1823-RP)

Saba Zakeri Shahvari, Student Member and Jordan Clark, Ph.D., Member, The Ohio State University, Columbus, OH

2. Evaluation of Eight Low-Cost Particle Sensors and Consumer Devices in a Test Home and Laboratory (ASHRAE 1756-RP)

Yangyang Zou, Student Member, Andrew May, Ph.D. and Jordan Clark, Ph.D., Member, The Ohio State University, Columbus, OH

Seminar 70 (Intermediate)

Modeling Chilled Beams

Sponsor: 4.10 Indoor Environmental Modeling, 5.3 Room Air Distribution

Chair: Liang Chung Lo, Ph.D., Member, Drexel University, Philadelphia, PA

Chilled beam has seen increasing interests as the fan-less passive cooling's energy-saving potential became attractive. This session provides both theoretical and practical information on the modeling method and strategies on design and validation of using chilled beam in buildings.

1. Perimeter Conditioning Options with Active Chilled Beams in Heating and Cooling

Mike Koupriyanov, P.E., Associate Member, Price Industries Limited, Winnipeg, MB, Canada

2. Experimental and CFD Investigation of Indoor Environments with Coupled Displacement-Ventilation and Passive-Chilled-Beam Systems

Zhu Shi, Student Member, Purdue University, West Lafayette, IN

3. Design Guide for a Coupled System That Combines Displacement Ventilation and Passive Chilled Beams

Qingyan Chen, Ph.D., Life Member and Zhu Shi, Student Member, Purdue University, West Lafayette, IN

4. Measured and Predicted Energy Performance of Active Chilled Beam

Dareum Nam, Ph.D., Associate Member, NREL, Golden, CO

Seminar 71 (Intermediate)

From Frost Growth on Heat Exchangers to Psychrometrics Air Mixing Devices and HVAC Controls: Examples of Industry Research in STBE Journal Available to ASHRAE Members for Free

Sponsor: Science and Technology for the Built Environment - STBE Journal

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

This seminar provides an overview of selected research papers from the STBE journal. The speakers will first introduce an experimental study on frost formation with surface coatings for finned structures. Then an overview of a developed two-control quality factor for assessing the HVAC control loop performance will be discussed. Finally, a comprehensive study on air mixing devices and measurement techniques for psychrometric performance testing will be presented. These are examples of the variety and depth of the cutting-edge technical information and case studies in the HVAC&R industry that ASHRAE members can access through to the STBE articles.

1. Effect of Mixed Hydrophilic and Hydrophobic Surface Coatings on Droplets Freezing and Subsequent Frost Growth during Air Forced Convection Channel Flows

Ellyn Harges and Lorenzo Cremaschi, Ph.D., Member, Auburn University, Auburn, AL

2. Development of Control Quality Factor for HVAC Control Loop Performance Assessment (ASHRAE RP-1587)

Zheng O'Neill, Ph.D., P.E., Member, Texas A&M University, College Station, TX

3. A Literature Review of Air Mixing Devices for Psychrometric Performance Measurement Applications (ASHRAE RP-1733)

Christian K. Bach, Ph.D., Associate Member, Oklahoma State University, Stillwater, OK

Track: Resilient Buildings and Communities

Seminar 2 (Basic)

The Dark Web and Malware: Why We Need to Know More in the Automated World

Sponsor: 1.5 Computer Applications

Chair: Jennifer Lather, Ph.D., Associate Member, University of Nebraska-Lincoln, Omaha, NE

Resiliency in buildings usually means more automated controls and connected sensor grids. In the age of information, it's easy to overlook the dark side of a connected information network. This session will cover the dark web and malware issues for building controls, from what the dark web is to how easy it is to be exposed to malicious attacks. As building engineers and designers, awareness of these vulnerabilities can help us design more robust and resilient systems. This session is meant to help introduce cyber security topics to the HVAC designer and engineer.

1. The Dark Web: Yes, It's Real

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

2. Control System Focused Malware

Brice Williams, SysLogic, Inc., Brookfield, WI

Seminar 7 (Intermediate)

The Next Giant Leaps: Tech Transfers and Carbon Neutral Systems for a Resilient Built Environment

Sponsor: 7.6 Building Energy Performance

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

Management and distribution of water, energy and waste treatment systems has become increasingly challenging due to the effects of climate challenge, rapid urbanization and aging infrastructure. Whether a water crisis in Mexico City or Cape Town, or a power-outage in India or California, the effects are visible. At the same time, we are at a crossroads to take the next steps for global utility infrastructure redevelopment and carbon neutral building systems. Let us consider alternative solutions that best utilize our new technologies, new equipment, and carbon neutral systems to create a resilient and robust infrastructure for the next hundred years.

1. Tech Transfer for a Resilient Built Environment

Omar Hawit, P.E., Member, Terraform, Orange County, CA

2. Resilient Carbon Neutral Building Systems

Sean Lawler, P.E., Member, AEI, Seattle, WA

Seminar 11 (Intermediate)

Impact of the Urban Micro-climate on Buildings and the Indoor Environment

Sponsor: 4.10 Indoor Environmental Modeling

Chair: Shichao Liu, Ph.D., Associate Member, Worcester Polytechnic Institute, Worcester, MA

This session aims to understand how the urban microclimate impacts indoor air quality, ventilation, thermal comfort and energy consumption. In particular, the first presentation will summarize a multi-scale modeling approach to quantify impacts of urban microclimate on indoor air quality and building energy use patterns. Then the impact of different albedo surfaces on the microclimate will be examined in the second presentation. The talk will also demonstrate the change in building energy demand and outdoor thermal comfort. Last, the session will discuss the influence of urban planning on building cross-ventilation together with data-driven models for quick design decision-making.

1. Impacts of Urban Heat Island during Summertime Heatwaves on Indoor Overheating Risks and Building Energy Consumptions

Liangzhu (Leon) Wang, Ph.D., P.E., Member¹, Mohammad Mortezaazadeh, Student Member², Ali Katal¹, Chang Shu, Student Member¹ and Lili Ji¹, (1)Concordia University, Montreal, QC, Canada, (2)Concordia University, Montréal, QC, Canada

2. Quantifying Impacts of Urban Microclimate on Building Indoor Air Quality and Building Energy Use

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

3. Impact of Urban and Building Design on Building Cross-Ventilation Potential in a High-Density City

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

Seminar 15 (Intermediate)

Legionella: Standard 188, Guideline 12 and Other Guidelines

Sponsor: 3.6 Water Treatment, 2.10 Resilience and Security, 8.6 Cooling Towers and Evaporative Condensers

Chair: Alain Trahan, H2O Biotech, Montreal, QC, Canada

Resilient buildings need to ensure their water systems such as Hot Water system, Cooling towers, Fountains, Spas, etc. are not the cause of Legionnaires' disease outbreaks such as the ones that occurred in NYC and too many other municipalities in the past years.

ASHRAE Standard 188 addresses the management of building water systems to minimize the risk of building-associated Legionnaires' disease.

ASHRAE Guideline 12-2000 is being updated to provide specific approaches on how to manage water systems.

We will discuss how these documents will help engineers, building owners and managers ensure they can work towards having safe water systems.

1. History of Standard 188, Guideline 12 and Other Guidelines

William Pearson II, Member, BPEARSON Consulting LLC, Leland, NC

2. ASHRAE Guideline 12 and the Facts about Legionella Growth in Building Water Systems

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

3. Guideline 12 Is a Tool Designed to Support the Preparation of a Water Management Plan Using ANSI/ASHRAE Standard 188

Patrick Racine, P.Eng., Member, Klenzoid Canada - a DuBois Company, GUELPH, ON, Canada

Seminar 25 (Intermediate)

SARS, MERS, Ebola, COVID-19: How to Prepare for the Next Epidemic

Sponsor: 2.9 Ultraviolet Air and Surface Treatment, 9.6 Healthcare Facilities, TC 2.10 Resilience & Security & Environmental Health Committee

Chair: Scott Sherwood, Member, Eco-Care Corporation, Bronx, NY

The recent COVID-19 outbreak has again pushed the REAL concern regarding infectious diseases into the forefront of the public's mind. Media, both new and old, are rife with frightening stories that are causing events to be cancelled months in advance. Facilities that have not been designed with resilience in mind are potentially part of the problem.

Design professionals need guidelines and strategies to prepare facilities for a major infectious disease event, how to operate through the event, and then to sustain operations afterwards ensuring the safety of its occupants.

1. SARS and COVID-19: Responses to the Outbreaks and How They Worked

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

2. Engineering Controls for Infectious Diseases

William P. Bahnfleth, Ph.D., P.E., Fellow ASHRAE, Pennsylvania State University, State College, PA

3. Assessment and Planning for Epidemics: What Makes a Facility Resilient to Outbreaks?

Traci Hanegan, P.E., HFDP, Fellow ASHRAE, Coffman Engineers, Spokane, WA

Seminar 30 (Intermediate)

The Role of Building Automation in Building Resilient Communities

Sponsor: 1.4 Control Theory and Application

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

Community resilience is the sustained ability of a community to use available resources to respond to, to withstand, and to recover from adverse situations. Community resilience is dependent on the ability of the community's network of individual assets to communicate and act in a coordination fashion. The expected role of building automation platforms is growing in resilient communities to include integration of diverse smart systems as well as central management from a remote command and control interface. This seminar will highlight the approaches of some campuses and cities in their utilization of building automation for community resilience.

1. Building Automation Takes Center Stage in the City of San Diego's Municipal Energy Strategy

Lindsey Hawes, The City of San Diego, San Diego, CA

2. From Pilot to Portfolio: How Re-tooling Control Sequences of Existing Buildings Can Accelerate Adaptation and Impact at Scale

Benson Christopher, P.E., Member, The University of Utah, Salt Lake City, UT

Seminar 33 (Intermediate)

Off-Site Construction for Resilient Buildings: Getting the Details Right

Sponsor: 4.4 Building Materials and Building Envelope Performance

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

The promise of off-site construction is in higher quality, faster and potentially less expensive building construction. These attributes lead to more resilient buildings and enable faster housing recovery after disasters. However, achieving this dream is only possible with the right details. These details include the on-site finishing between panels and modules, how to effectively integrate HVAC and water supply, and the financial and logistical details of executing on a project. This session explores both materials and projects with an eye toward enabling best practices so practitioners can learn strategies for getting the details right.

1. Ensuring Continuity of the Building Envelope in Modular and Panelized Construction

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

2. Energy Efficient Design for Offsite Multifamily Construction

Shanti Pless, Associate Member, NREL, Golden, CO

3. Panelized Passive House Multifamily

Paul Grahovac, P.E., Member, Prosoco, Lawrence, KS

Seminar 48 (Intermediate)

Designing for Resilience: Strategies, Equipment and Controls

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

Chair: Gregory Pavlak, Ph.D., Member, The Pennsylvania State University, University Park, PA

Designing for resilience is a multifaceted endeavor that requires considering the unique objectives of a particular site. This seminar explores novel strategies, equipment, and controls for promoting resiliency within the built environment. Attendees will gain insight into potential trade-offs that may exist when designing resilient systems, and will be exposed to new approaches and technologies aimed at reducing the cost of building resilience.

1. Microgrid Component Sizing Considering Building Load Flexibility

Gregory Pavlak, Ph.D., Member, The Pennsylvania State University, University Park, PA

2. Lessons Learned in Designing, Specifying, Installing, and Operating a Whole Building Battery Energy Storage System for Microgrid Demonstration

Glenn Remington, Member, Consumers Energy, Jackson, MI

Seminar 53 (Advanced)

Design Considerations for Resilient Buildings

Sponsor: 4.4 Building Materials and Building Envelope Performance

Chair: Wahid Maref, Ph.D., P.E., Member, ETS, Montreal, QC, Canada

Construction, with all its rapid advances, is facing challenges in responding to a range of different environmental conditions due to climate change.

This seminar aim to assess the potential effects of climate change on the energy and hygrothermal performance and durability of buildings. This seminar will show through the three presentations: The improvement of passive building performance through the time-based thermal resilience metrics; the Net Zero building-grid integration issues and solutions, and discussion on how passive building techniques can handle some of these issues; and the resilience of Canadian homes and small buildings to the effects of climate change.

1. Improvement of Passive Building Performance through the Time-Based Thermal Resilience Metrics

Aylin Ozkan, Ph.D., University of Toronto, Toronto, ON, Canada

2. Passive Buildings As Baseline for the New Grid

Lisa White, PHIUS, Chicago, IL

3. Resilience of Canadian Homes and Small Buildings to the Effects of Climate Change - Risk of Deterioration Due to Condensation within Wall Assemblies

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

Seminar 57 (Intermediate)

Mechanical System Consideration for Tornadoes and Hurricanes

Sponsor: 2.7 Seismic and Wind Resistant Design

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

The presentations in this seminar will cover the latest design considerations with regard to HVAC components and mechanical systems, to survive extreme wind events that include tornados and hurricanes. Existing standards, codes, testing, and state of the art design procedures will be covered.

1. Tornado Shelter Mechanical Design Considerations

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

2. Wind/Hurricane Product Approval

Harold Dubensky, P.E., Member, Johnson Controls, Inc., York, PA

Seminar 69 (Intermediate)

Am I Resilient? Using Building Energy Models to Assess the Resilience of Buildings and Communities

Sponsor: 4.7 Energy Calculations, 2.10 Resilience and Security

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

In order to design buildings and communities to be resilient, one has to assess the energy load requirements of those buildings and communities. In this seminar, speakers will discuss the use of building energy modeling to assess the resilience of buildings and communities for today and considering the effects of climate change.

1. BEM, Lies, and Resilience: What BEM Will (and Won't) Tell You about the Resilience of Your Building

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

2. Using Building Energy Models to Understand the Uncertainty in Assessing Building Resilience

Qi Li, Ph.D., Argonne National Laboratory, Argonne, IL

3. Predicting the Future: Energy Modeling for an Uncertain Climate

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

Track: Zero Energy Buildings and Communities: Opportunities and Challenges

Paper Session 7

Zero Energy Buildings: Embodied Carbon Emissions, Case Study and Energy Codes

Chair: Robert Cox, PE, Member, Jacobs Carter Burgess, Cary, NC

This session covers a broad range of topics to address the barriers and opportunities to achieve zero energy buildings. The first paper explores embodied and operational energy and carbon emissions from a life-cycle perspective. The second paper studies the challenges and progress to adopt a statewide net-zero energy codes in Oregon. In the third paper, a pathway to zero energy buildings through codes were demonstrated through the New York Stretch Code. The fourth paper provides a case study in coupling the energy resources and hybrid heating and cooling systems to optimize the operational schedule.

1. Challenges for Statewide Adoption of Net-Zero Buildings: the Oregon Experience

Mark Heizer, P.E., Member¹ and Blake Shelide, P.E.², (1)Building Codes Division, Dept. of Consumer and Business Services, Salem, OR, (2)Oregon Department of Energy, Salem, OR

2. Embodied vs. Operational Energy and Carbon Emissions of Doe Reference Buildings from a Life-Cycle Perspective

Jay Arehart, Wil Sruhar III, Ph.D., Francesco Pomponi, Ph.D. and Bernardino D'Amico, Ph.D., University of Colorado Boulder, Boulder, CO

3. Reaching Towards Zero: Clearing the Path to Zero Net Energy through Codes

John Arent, P.E., Member, Rahul Athalye, Associate Member and Silas Taylor, NORESO, San Francisco, CA

4. Scheduling of Hybrid Heating and Cooling System Based on Energy Resources for Mixed-Use Multistorey Building

Kuljeet Singh, Ph.D. and Caroline Hachem-Vermette, Ph.D., University of Calgary, Calgary, AB, Canada

Paper Session 16

Role of Occupants and O&M for High Performance Buildings and Beyond

This session focuses on role of occupant behaviors and O&M training programs to advance high performance buildings. First paper introduces an occupant orientation framework model to addresses knowledge, coaching, training, and incentives as methods of encouraging and realizing changes in occupant behaviors which positively affect building performance. The second paper highlights an ASHRAE Research Project RP-1650 regarding the practices and training programs of O&M for high performance buildings. The third paper takes a different perspective to address carbon reduction by presenting a concept that utilizes newly developed adsorption scrubbing techniques to remove indoor air CO₂ from building HVAC systems.

1. A Review of Relevant Practices for O&M of High Performance Buildings (T)

Jaya Mukhopadhyay, Ph.D., Member, Gilbert Kalonde and Loras O'Toole, P.E., Member, Montana State University, Bozeman, MT

2. The Net CO₂ Reduction Potential from Active HVAC Indoor CO₂ Mitigation, Reducing Source Energy Usage, in Comparison with CO₂ Mitigation Directly from Outdoor Air

James Leidel, Member, DTE Energy, Detroit, MI

3. Occupant Orientation (O2) Framework Model

Cristine Gibney, Student Member, The Catholic University of America Architecture and Planning School, Washington, DC

4. A Review of Training Programs for the O&M of High Performance Buildings (T)

Jaya Mukhopadhyay, Ph.D., Member, Gilbert Kalonde and Loras O'Toole, P.E., Member, Montana State University, Bozeman, MT

Seminar 24 (Intermediate)

Energy Performance in Tall Buildings: What Can We Do?

Sponsor: 9.12 Tall Buildings

Chair: Raul Simonetti, Member, Carel Industries SpA, Brugine, Italy

Research has shown that tall buildings are large energy consumers, including both embodied energy and operational energy. Additionally, there are indications that Energy Use Intensity of tall buildings is generally greater than for shorter buildings. This seminar will present a variety of methodologies that can be used during design to optimize the energy consumption in tall buildings as the world is being urbanized and the number of tall buildings worldwide is only expected to increase.

1. How Can the Energy Consumption of Tall, Supertall and Megatall Buildings be Kept at a Minimum or Possibly Net Zero?

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

2. Optimizing Energy Performance of Tall Buildings

Mehdi Jalayerian, P.E., Member, Environmental Systems Design, Inc., Chicago, IL

Seminar 34 (Basic)

Zero-Net Energy Hospitals: Is this a Myth?

Sponsor: 1.4 Control Theory and Application, 7.5 Smart Building Systems, 9.6 Health Care Facilities

Chair: Frank Shadpour, P.E., Fellow ASHRAE, SC Engineers, Inc., San Diego, CA

Zero-Net Energy Hospitals: Is this a myth? Ten years ago, the answer was yes, but today is a different story! Zero-net energy hospitals are achievable but face several obstacles. For instance, how do you commission a zero-net energy hospital with today's technology? How do you ensure cybersecurity for a zero-net energy hospital, which relies heavily on its building automation system and the Cloud to function? In this seminar, we explore "outside-of-the-box" approaches to overcome these obstacles and explore the latest available technology to debunk this myth.

1. Air Change per Hour: Today's Code vs. Reality

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

2. Commissioning a Zero-Net Energy Hospital: The Impossible Become Possible

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

Seminar 45 (Intermediate)

ASHRAE's Latest Guides to Zero Energy Design

Sponsor: 2.8 Building Environmental Impacts and Sustainability

Chair: Fred Betz, Affiliated Engineers, Inc., Madison, WI

This session will present introductions and insights into three ASHRAE zero energy design guides.

ASHRAE, in partnership with the USGBC, AIA and IES, created two Advanced Energy Design Guides, one for K-12 schools and one for Office Buildings. Strategies for achieving the AEDG energy targets will be presented as well as strategies for achieving success without increases in construction costs.

The Net Zero Hospitals guide informs healthcare leaders about the environmental impacts of hospitals and sets out cost effective strategies to zero energy and zero energy cost. Furthermore, the guide assists in establishing zero energy road maps for hospitals.

1. Advanced Energy Design Guides and Zero Energy Targets for K-12 Schools and Office Buildings

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

2. The New Ashrae/REHVA Guide Toward Net Zero Hospitals

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

Seminar 52 (Intermediate)

Zero Energy Buildings and Intelligent Controls

Sponsor: 2.8 Building Environmental Impacts and Sustainability, 1.4 Control Theory and Application

Chair: Alara Apcin, Associate Member, Carrier, Long Beach, CA

This seminar will provide case studies in a variety of environments for net zero, electrification and decarbonization. Key terms and definitions of zero net energy, as well as upcoming state and federal requirements will be discussed.

Controls are central to the operation of a zero energy building. This program will introduce energy savings strategies that connect passive and active technologies, along with occupants, which are crucial to enabling a zero energy building to operate as designed.

1. Zero Energy Buildings in a Campus Setting

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

2. Zero Energy Buildings and Intelligent Controls

Justin Mezzadri, Carrier, Charlotte, NC

3. Achieving Net Zero Energy in a Laboratory

Brett Friedman, P.E., Affiliated Engineers, Inc., Madison, WI

Seminar 54 (Intermediate)

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

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

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

Multifamily is one of the largest growing commercial building sectors. For the past year, ASHRAE, with AIA, USGBC, and IES, have been working on an Advanced Energy Design Guide for multifamily 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 multifamily 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 Advanced Energy Design Guide 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 Multifamily Guide

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

3. Intense Interactions from Plug Loads to Envelope to Occupant Behavior

Stet Sanborn, AIA, Member, Smith Group, San Francisco, CA

4. Marriage of the Envelope, Plug Loads and HVAC Selection and Design

Dan Nall, AIA, Fellow ASHRAE, Daniel Nall Consulting, LLC, New York, NY

Seminar 58 (Basic)

Could Electric Energy Storage Systems Be the Answer for Zero Energy Buildings?

Sponsor: 6.7 Solar Energy Utilization, 2.8 Building Environmental Impacts and Sustainability, 2.5 Global Climate Change

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

Zero energy performance targets are only attainable if renewable energy sources (RES), like photovoltaic (PV) solar or wind are used. However, sunlight and wind are intermittent, sometimes not available when needed or provide energy in excess of the immediate need. An enabling technology to achieve zero performance targets and to provide energy resiliency for buildings is electric storage. This seminar is an introduction to electric storage options, explains the current 'best' economic solutions, and then cites details on the design of a system scheduled to be constructed soon. It offers guidance for the novice as well as the seasoned professional.

1. Renewable Electric Energy Storage for Zero Energy Buildings, Introduction and Technology Overview

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

2. Introduction to Lithium Ion Batteries

Khalid Nagidi, BEAP, Member, Energy Management Consulting Group, Wantagh, NY

3. Case Study of Integrating Electric Storage with Alternative Energy in a School

Svein Morner, Member, HGA, Middleton, WI

Seminar 60 (Intermediate)

Modeling and Optimization of Sustainable Communities

Sponsor: 4.7 Energy Calculations

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

There has been significant research over the last decades on energy efficiency, demand response, and energy modeling. However, much of this effort has been done at the individual building level with less research at the community or university campus level. University campuses are the place where the next generation of engineers and professionals are being trained. Net-zero energy communities (NZEC) also represent unique challenges. This seminar will present: a) Modelica modeling efforts for net zero energy communities and b) co-simulation environment with the capability to perform building energy modeling, renewable energy analysis, and demand and/or consumption optimization for university campuses

1. Whole Campus Energy Modeling for Research and Teaching Purposes

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

2. Co-Simulation Environments for Integrated Energy Modeling, Demand and Resource Optimization

Mohammad Hassan Fathollahzadeh, Student Member, Colorado School of Mines, Golden, CO

3. Modeling a Real-World Net Zero Energy Community

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

Seminar 67 (Intermediate)

Back to the Future on High Efficiency Design and Operation

Sponsor: 4.4 Building Materials and Building Envelope Performance

Chair: Fitsum Tariku, Member, BCIT, Burnaby, BC, Canada

This seminar presents the lessons learned from the past building envelope and high performance buildings designs and operations, and discusses the need for an integrated building envelope and HVAC design approach to maximize energy saving. The contents of the presentations are based on research findings, and analysis of case studies and current practices. The process for successfully developing zero energy buildings and districts; the impact of energy codes on HVAC and envelope design; and the pros and cons of adding insulation on energy and durability performances of envelope systems is discussed in detail in this session.

1. The Evolution of Zero Energy Architecture at the National Renewable Energy Laboratory (NREL)

Ron Judkoff, Member, National Renewable Energy Laboratory, Golden, CO

2. For Better Performance of the Building Envelope: Improvement and Complexity

Wahid Maref, Ph.D., Member, ETS-Montreal, Montreal, QC, Canada

3. HVAC and Envelope: Energy Savings through Integrated Design

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