2021 ASHRAE Virtual Winter Conference

February 9th - February 11th, 2021

Tuesday, February 9

Tuesday, February 9, 10:00 AM - 11:00 AM

Student Program

Orientation to the Virtual Winter Conference

Sponsor: Other

Learn what to expect from this year's ASHRAE Winter Conference, how it differs from the typical year, and how to get the most out of it.

Orientation to the Virtual Winter Conference
Jane Opoien, *Willdan, Minnetonka, MN*

Orientation to the Virtual Winter Conference
Megan Tosh, P.E., Member, *Integrated Environmental Solutions, Atlanta, GA*

Orientation to the Virtual Winter Conference
Jared Larson, *MacPherson Engineering Inc, Regina, SK, Canada*

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

Seminar 1 (Intermediate)

What's in Your Toolkit? Laboratory Efficiency for Cutting Edge Labs

Track: Energy Conservation

Sponsor: 9.10 Laboratory Systems

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

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

Learning Objectives:

1. Understand the steps to developing a Smart Labs Program: Plan, Assess, Optimize, Manage, Working with Scientists
2. Understand the tools and resources available to aid implementers with doing risk-based ventilation analysis
3. Learn about the top technologies for Smart Lab implementation that enhance ventilation effectiveness
4. Understand experiences of working on Smart Labs to improve safety and efficiency
5. Understand the steps to developing a Smart Labs Program: Plan, Assess, Optimize, Manage, Working with Scientists
6. Understand the tools and resources available to aid implementers with doing risk-based ventilation analysis
7. Identify factors that drive the demand for ventilation.
8. Understand how ventilation modulate flow to meet changes in demand.

1. Smart Labs Toolkit: A Guide to Enable Labs of the Future
Rachel Romero, P.E., Member, *National Renewable Energy Laboratory, Golden, CO*

2. How Occupant Demand for Ventilation Drives Safety and Efficiency in Smart Labs
Thomas Smith, Member, *3Flow, Cary, NC*

3. Argonne's Journey to Smart Labs: Integrating Safety, Sustainability and Operations
Catherine Hurley, P.E., *Argonne National Laboratory, Lemont, IL*

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

Seminar 2 (Intermediate)

Air Cleaning for the Indoor Air Quality Procedure WITH LIVE Q&A

Track: Standards, Guidelines and Codes

NY PDH

Sponsor: SSPC 62.1

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

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

Learning Objectives:

1. Provide a review of common building design procedures for gas phase filters, provide examples of the types of products available and review the benefits of gas phase filters therein.
2. Provide an overview of the correct application of UVC lamp systems for different applications.
3. Provide the audience with the potential applications for air cleaning technology based on Std. 62.1-2019. Describe how air cleaners can produce ozone and the UL 2998 "zero ozone" standard. Describe PM 10 & PM 2.5 air cleaner MERV ratings Describe the air cleaning requirements for the IAQP
4. This presentation will Provide an overview of the different types of chemical gas-phase filtration media in common use. Describe examples of performance testing using ASHRAE and ISO test methods, and how this type of air filtration can be used for compliance with the provisions of ASHRAE Standard 62.1-2019.
5. Understanding contaminants of outdoor and indoor origin that must be addressed per the current Standard.
6. Types of air filtration media products that are available to address the aforementioned contaminants.
7. Understand the role of the germicidal UV technology in controlling the spread of infectious diseases in the built environment
8. Provide an overview of relevant industry standards and guidelines and technical material on UV systems and applications
9. Understand basics of UV technology
10. Become Cognizant of the changes the the ASHRAE Standard 62.1 regarding Air Cleaners
11. Utilize Newer Technology to help protect the public health and provide the best Indoor Air Quality possible
12. Understand the basics of applying gas-phase air filtration through the use of adsorbents and chemisorbents.
13. Describe the most common delivery systems used for these filtration media.
14. Understand how the various delivery systems can be integrated into common HVAC systems.

1. Air Filtration Applications for Std. 62.1 Indoor Air Quality Procedure
Charles Seyffer, Life Member*, retired, Troy, NY*

2. UVC Applications for Air Cleaning
Ashish Mathur, Ph.D., Member*, UVDI, Valencia, CA*

3. Application of Air Cleaners in Std. 62.1-2019
Joe Pessa, Associate Member*, Dynamic Air Quality Solutions, Princeton, NJ*

4. Controlling Outdoor and Indoor Chemical Contaminants Using Adsorbents and Chemisorbents
Chris Muller, Member*, Muller Consulting, Lawrenceville, GA*

12:00 PM - 1:20 PM

Seminar 3 (Intermediate)

Lessons from Managing Infrastructure through the COVID Shutdown WITH LIVE Q&A

Track: Building Performance and Commissioning for Operation and Management

NY PDH

Sponsor: 7.3 Operation and Maintenance Management

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

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

Learning Objectives:

1. Identify key activities undertaken during the COVID-19 pandemic to maintain campus infrastructure
2. Assimilate the stories of others to validate their own experiences
3. Share some of their own stories of managing through the crisis
4. Be better prepared to continue managing campus infrastructure as the pandemic either continues or abates.
5. Identify key activities undertaken during the COVID-19 pandemic to maintain campus infrastructure
6. Assimilate the stories of others to validate their own experiences
7. Understand the pitfalls and common mistakes of reopening
8. Be able to apply lessons learn to improve their own reopening process.

1. Managing the COVID Campus: Stories from the Empty Halls
***Orvil Dillenbeck, P.Eng., Member**, Canadian Nuclear Laboratories, Chalk River, ON, Canada*

2. Do's and Don'ts of Reopening
***Aaron Sorrell, Member**, General Services Administration, Boston, MA*

3. Large University Campus Faces Difficult Decisions
***David Norvell, P.E., BCxP, Member**, University of Central Florida, Orlando, FL*

12:00 PM - 1:20 PM

Seminar 4 (Intermediate)

Limiting Humidity to Reduce Building Dampness Health Risks WITH LIVE Q&A

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

NY PDH

Sponsor: SSPC 62.1

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

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

Learning Objectives:

1. • Understand how excess moisture has been shown to affect occupant health.
2. • Understand why Std 62.1 now requires designers to limit indoor humidity to less than a 15°C (60F) dew point temperature during both occupied and unoccupied hours, in buildings and spaces air
3. • Understand the unexpected difference in RH between cool surfaces near cold HVAC components vs, RH as measured in the air in occupied spaces.
4. • Understand the system design implications with the new dew point limit of 60°F (15°C).
5. ¥ Understand why Std 62.1 now requires designers to limit indoor humidity to less than a 15°C (60F) dew point temperature during both occupied and unoccupied hours, in buildings and spaces air conditioned by mechanical cooling equipment.
6. ¥ Understand the unexpected difference in RH between cool surfaces near cold HVAC components vs, RH as measured in the air in occupied spaces.
7. After attending this session, the attendees will understand the system design implications with the new dew point limit of 60°F (15°C).
8. After attending this session, the attendees will understand the differences in analysis required for dew point vs. relative humidity for mechanically cooled zones within buildings.

1. The Health Argument for Sufficient Management of Moisture in Buildings
***Carl Grimes, HHS, CIEC**, Hayward Healthy Home, Monterey, CA*

2. Why the Maximum Humidity Limit Changed from Relative to Absolute (60°F Dew Point) in Std 62.1-2019
***Lew Harriman, Fellow ASHRAE**, Mason-Grant Consulting, Portsmouth, NH*

3. Design Requirements and System Changes to Deal with the Shift to Dew Point
***Brian Hafendorfer, P.E., Member**, Gray Architects & Engineers, P.S.C., Lexington, KY*

12:00 PM - 1:20 PM

Seminar 5 (Basic)

Refrigeration System Design Considerations WITH LIVE Q&A

Track: Refrigeration and Refrigerants

NY PDH

Sponsor: 10.1 Custom Engineered Refrigeration Systems

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

This seminar covers relevant topics for the engineer new to the refrigeration industry. It starts with a presentation describing lessons learned from a design and safety perspective. It ends with guidance on the selection of valves used within transcritical CO2 systems.

Learning Objectives:

1. Explain how refrigeration systems can fail and some of the risks and hazards associated with their failure.
2. Consider the maintenance and operation requirements needed to sustain safe systems.
3. Introduce the various types of valves and their functions within an Industrial Refrigeration System
4. Know the role of the high pressure control valve, flash tank, and flash gas bypass valve in Transcritical CO2 systems and the basis for the sizing.

What Went Wrong? The Forensic Investigation of the Fernie Refrigeration Incident.

Gregory Scrivener*, Laporte Engineering, Calgary, AB, Canada*

3. Transcritical CO2 Booster System Operation and Valve Selections

Jeff Newel, Member*, Hill Phoenix, Conyers, GA*

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

Seminar 6 (Basic)

Fighting the Unseen Killers: Gas-Phase Air Cleaners

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

NY PDH

Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment

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

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

Learning Objectives:

1. Understand the basics of how gas-phase air cleaners work.
2. Learn how current methods remove/clean air contaminants using various Gas-Phase Air Cleaners in residences, schools and office buildings.
3. Understand the gaseous contaminants that impact on human health and environment.
4. Provide information that assesses IAQ including non-human issues such as damage to equipment.
5. Learn how current methods remove/clean air contaminants using various Gas-Phase Air Cleaners in residences, schools and office buildings
6. Provide information that assesses IAQ including non-human issues such as damage to equipment.
7. . Understand the basics of how gas-phase air cleaners work.
8. . Learn how current methods remove/clean air contaminants using various Gas-Phase Air Cleaners in residences, schools and office buildings.

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

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

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

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

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

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

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

Seminar 7 (Basic)

Building the Next Generation in Building Science: The Solar Decathlon Competition WITH LIVE Q&A

Track: Energy Conservation

Sponsor: YEA and Student Activities

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

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

Learning Objectives:

1. Define the challenges facing the net zero industry in terms of technologies and costs
2. Know about the Solar Decathlon program and its work to move the building science industry
3. Understand the successes of the student competition in advancing the net zero residential and commercial building industry
4. Understand innovative technologies used by a student team in their design to meet net zero requirements
5. Define the challenges facing the net zero industry in terms of technologies and costs
6. Know about the Solar Decathlon program and its work to move the building science industry
7. Learn about the Solar Decathlon program and its work to move the building science industry
8. Understand the successes of the student competition in advancing the net zero residential and commercial building industry
9. Understand innovative technologies used by a student team in their design to meet net zero requirements

1. Changing the Industry through Team Development in the Competition
Rachel Romero, P.E., Member*, National Renewable Energy Laboratory, Golden, CO*

2. Better Buildings through Better Training and Education
Paul Torcellini, Ph.D., P.E., Fellow ASHRAE*, National Renewable Energy Laboratory, Golden, CO*

3. Integrated Design Strategies for High-Performance Zero Energy Buildings: Case Studies of Student Projects
Edoarda Corradi Dell'Acqua*, Illinois Institute of Technology, Chicago, IL*

3:00 PM - 4:20 PM

Seminar 8 (Intermediate)

Lubricant Properties and Their Lubrication in Compressors with Low GWP Refrigerants WITH LIVE Q&A

Track: Refrigeration and Refrigerants

Sponsor: 3.4 Lubrication

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

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

Learning Objectives:

1. Understand the relationships between lubricants and refrigerants used to qualify candidates.
2. Define lubricant options for newer low GWP refrigerant candidates.
3. Explain how refrigerant/lubricant fluids interact with moving parts of the compressor system.
4. Understand the refrigerant/lubricant evaluation process when component wear is a reliability concern.
5. Understand the relationships between lubricant and refrigerants used to qualify candidates.

6. Define lubricant options for newer low GWP refrigerants

1. The Lubricant and Low GWP Refrigerant Match Game
***Joe Karnaz, DSc, Member**, Shrieve Chemical, Houston, TX*

3. Influence of Refrigerant/Lubricant on Compressor's Wear Performance
***Wasim Akram, Ph.D., Associate Member**, Trane Technologies, Minneapolis, MN*

3:00 PM - 4:20 PM

Seminar 9 (Intermediate)

Mass Transit Ventilation and Infectious Diseases: Transmission and Countermeasures WITH LIVE Q&A

Track: Environmental Health Through IEQ sponsored by Ebtron

Sponsor: 9.3 Transportation Air Conditioning
Chair: Gursaran Mathur, Marelli North America, Farmington Hills, MI
Vehicles instrument panel surface can become contaminated by the front occupants by breathing, talking and coughing. Air conditioning vent outlet airflow will pull air from the panel surface mixing it with potential contaminated air and deliver towards the occupants. Hence, it is necessary to ensure we have virus mitigating strategies to effectively remove viruses from the cabin from automobiles. This seminar consists of technical presentations outlining how the viruses spread in automotive and aircraft cabins using CFD analysis, experimental studies with new hardware designs to eliminate viruses from the automotive cabin; and ASHRAE guidelines to address COVID-19.

Learning Objectives:

1. Viruses spread within an automobile, mass transit and aircraft cabins and impact on occupants.
2. Understand the mechanism of airborne infectious disease transmission
3. Overview of numerical and experimental studies on spread of the viruses within the control volume along with new hardware design to eliminate these viruses
4. Review of ASHRAE TC 9.3 guidelines for addressing COVID-19 in mass transit
5. better understand exposure effects of social distanced seating in aircraft cabins
6. analyze the results of tracer studies in aircraft cabins
7. Describe the ASHRAE Guidelines for Mass Transit.
8. Explain the factors affecting safety of using mass transit in a period of Covid 19 pandemic

1. COVID-19 Transmission Risk Reduction through Social Distanced Seating in Aircraft Cabins
***James Bennett, Ph.D., Member**, CDC/NIOSH, Cincinnati, OH*

2. Recommendations to Minimize the Risk of COVID-19 Spread in Marine Applications
***Augusto SanCristobal, Member**, Bronswerk Group, Montreal, QC, Canada*

3. Elimination of Viruses from Automobile Cabins
***Gursaran Mathur**, Marelli North America, Farmington Hills, MI*

4. ASHRAE's COVID-19 Guidance Document for Mass Transit
***Donald LeBlanc, P.Eng., Member**, National Research Council of Canada, Ottawa, ON, Canada*

3:00 PM - 4:20 PM

Workshop 1 (Intermediate)

Science and Technology for the Built Environment: Publishing and Reviewing

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell
Sponsor: PEC
Chair: Jeffrey Spitler, Ph.D., P.E., Fellow ASHRAE, Oklahoma State University, Stillwater, OK
Science and Technology for the Built Environment is ASHRAE's peer-reviewed archival research journal. The Editor-in-Chief will discuss the characteristics of papers sought by the journal, common reasons for rejection, the review process, the journal impact factor and other recent developments.

Learning Objectives:

1. Better understand the scope of the journal.

2. Better understand the requirements for rigor, originality, and significance in journal papes.
3. Better understand common reasons for rejecting papers.
4. Better understand the review process and how to respond to review comments.

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

Forum 1 (Intermediate)

Advanced Energy Design Guides: Zero Energy and Beyond, What Is Next?

Track: Energy Conservation

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

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

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

4:30 PM - 5:30 PM

Forum 2

Feedback From the Public on Current Decarbonization Pathways

Track: Energy Conservation

Sponsor: 6.10 Fuels and Combustion, 1821

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

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

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

Seminar 10 (Intermediate)

Standardizing High Performance: Guideline 36 and Beyond WITH LIVE Q&A

Track: Standards, Guidelines and Codes

Sponsor: 1.4 Control Theory and Application

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

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

Learning Objectives:

1. Understand some common challenges with using Guideline 36 today and the various efforts underway to overcome them.
2. Describe the current state of the Control Description Language and its potential integration and benefits in various control workflows.
3. Understand how to participate in the creation of Standard 231P and describe the potential benefits of the Standard.
4. Understand the application of control co-design for improved design and delivery of high performing buildings and controls.
5. Understand the status of the Control Description Language.
6. Understand how the Control Description Language can be used by energy modelers and control engineers, the Guideline 36 Committee, mechanical designers and control providers.

7. Understand how to participate in the creation of Standard 231P and describe the potential benefits of the Standard.
8. Describe the current state of the Control Description Language and its potential integration and benefits in various control workflows.

1. Guideline 36: The Journey to Success!
Hwakong Cheng, P.E., Member*, Taylor Engineering LLP, Tacoma, WA*
2. How Speaking the Same (Computer-Interpretable) Language Helps
Michael Wetter, Ph.D., Member*, Lawrence Berkeley National Laboratory, Berkeley, CA*
3. A Standard for That: ASHRAE 231P – Control Description Language
Paul Ehrlich, P.E., Member*, Building Intelligence Group, Portland, OR*
4. Better Together: Co-Design for the Win!
Veronica Adetola*, Pacific Northwest National Laboratory, Richland, WA*

6:00 PM - 7:50 PM

Seminar 11 (Intermediate)

Techno-Economic Comparison of Energy Storage Technologies WITH LIVE Q&A

Track: Systems and Equipment

Sponsor: 6.9 Thermal Storage, 7.5 Smart Building Systems
Chair: Kyle Gluesenkamp, Ph.D., Member, Oak Ridge National Laboratory, Oak RIdge, TN
Energy storage can improve building resilience and efficiency, reduce energy costs and reduce grid infrastructure expenditures. In this seminar, findings from ongoing research into the performance and affordability of various energy storage strategies is presented. The technical and economic benefits of several thermal energy storage strategies is compared and contrasted with electrochemical energy storage technologies (batteries). Guidance is provided on design strategies for buildings and systems that incorporate energy storage, present annual simulation results, highlight unique benefits of competing technologies, provide insight into the future trajectory of costs and capabilities and offer a framework for future research and innovation.

Learning Objectives:

1. Communicate the importance of energy storage in buildings for reducing energy costs, enhancing grid reliability, transitioning toward efficient all-electric heating systems, and enabling broader adoption of intermittent renewable generation.
2. Identify benefits and challenges with different energy storage strategies in different buildings types and applications.
3. Understand the advantages and disadvantages of battery storage and phase change thermal energy storage for small HVAC systems.
4. Outline critical needs for future research and technology innovation for thermal energy storage.
5. Communicate the importance of energy storage in buildings for reducing energy costs, enhancing grid reliability, transitioning toward efficient all-electric heating systems, and enabling broader adoption of intermittent renewable generation
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7. Communicate the importance of energy storage in buildings for reducing energy costs, enhancing grid reliability, transitioning toward efficient all-electric heating systems, and enabling broader adoption of intermittent renewable generation.
8. Identify benefits and challenges with different energy storage strategies in different buildings types and applications.
9. Understand the advantages and disadvantages of battery storage and phase change thermal energy storage for small HVAC systems.
10. a PhD candidate in Architecture (Building Science) at UC Berkeley, affiliate researcher at Lawrence Berkeley National Laboratory, and president of Emanant Systems – a consultancy focused on
11. Identify benefits and challenges with different energy storage strategies in different buildings types and applications.
12. Understand the advantages and disadvantages of battery storage and phase change thermal energy storage for small HVAC systems.

1. Opportunity for Thermal Storage to Provide Grid Flexibility Today and in the Future
Chuck Booten, Ph.D., Associate Member*, National Renewable Energy Laboratory, Golden, CO*
2. Comparing the Economic Performance of Ice Storage and Batteries for Buildings with On-Site PV
Jim Braun, Ph.D., P.E., Fellow Life Member*, Purdue University, West Lafayette, IN*
3. Novel Residential Heating and Cooling System Design Using Thermal Storage to Reduce Home Owners' Operating Cost Using Time-of-Day Rates

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

4. Phase Change Materials and Batteries for Energy Storage in Small HVAC Systems: Design Considerations and Life Cycle Cost Comparisons
Jonathan Woolley, Ph.D., Member*, Lawrence Berkeley National Laboratory, Berkeley, CA*

Wednesday, February 10

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

Seminar 12 (Intermediate)

Thermal Storage for Grid-Friendly Refrigeration WITH LIVE Q&A

Track: Refrigeration and Refrigerants
Sponsor: 6.9 Thermal Storage
Chair: Scott Hackel, P.E., Member, Slipstream, Madison, WI
Refrigeration systems not only use a tremendous amount of energy, but can also be a significant stress on the grid as they tend to be operating near full-load at peak times. Thermal storage, which has been a well-proven approach to shifting load in HVAC systems, can also be applied to refrigeration systems to provide cost-effective grid services like demand response, load shifting, and load shaping. There are a few different technologies and methods for refrigeration thermal storage. This seminar covers practices for each based on some of the latest research in the industry.

Learning Objectives:

1. Understand how to determine and implement the optimum cooling schedule given any objective (e.g. minimize emissions, maximize efficiency, minimize costs)
2. Know the advantages and disadvantages of different thermal energy storage and control methods.
3. Describe the magnitude of energy savings demand response, and load shifting potential from using thermal storage in refrigeration.
4. Understand the benefit of including phase change materials in a refrigeration system.
5. Describe the magnitude of energy savings demand response, and load shifting potential from using thermal storage in refrigeration
6. Describe the advantages and disadvantages of different thermal energy storage and control methods
7. Understand how to determine and implement the optimum cooling schedule given any objective (e.g. minimize emissions, maximize efficiency, minimize costs)
8. Describe the advantages and disadvantages of different thermal energy storage and control methods
9. Describe the magnitude of energy savings demand response, and load shifting potential from using thermal storage in refrigeration
10. Understand how to determine and implement the optimum cooling schedule given any objective (e.g. minimize emissions, maximize efficiency, minimize costs)
11. Know the advantages and disadvantages of different thermal energy storage and control methods
12. How TES enables owners to control refrigeration load on demand and realize net reduction in usage or kWh consumption.
13. How PCM is configured and positioned in the freezer to absorb heat infiltration while utilizing thermal density gradients to protect food via natural convection heat flow.

1. Options for Thermal Energy Storage in Refrigeration
Greg Marsicek Jr., P.E., Associate Member*, Slipstream, Madison, WI*

2. Minimizing Energy Cost in Refrigerated Warehouses with Storage: An Owner's Story
Woolf Alex*, Lineage Logistics, San Francisco, CA*

3. Field Testing of Commercial Refrigeration Cases for Demand Response
Michael Deru, Ph.D., Member*, National Renewable Energy Laboratory, Golden, CO, USA, Golden, CO*

4. Using Phase Change Material to Add Efficiency, Flexibility and Resiliency to Refrigeration Systems
Brad North, P.E.*, Viking Cold Solutions, Houston, TX*

7:00 AM - 8:50 AM

Seminar 13 (Intermediate)

What Have You Done for Me Lately? BAS Best Practices for O&M Success WITH LIVE Q&A

Track: Building Performance and Commissioning for Operation and Management

Sponsor: 1.4 Control Theory and Application

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

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

Learning Objectives:

1. Explain the importance of consistency and keeping current with technology and security in smart buildings.
2. Explain the importance of people, process, & technology to the operational success of a BAS.
3. Explain the importance of O&M in the design process and how to properly specify components that will lead to to the operational success of a BAS.
4. Explain how creating a digital twin on the cloud with out-of-the-box dashboards will increase the overall efficiency of the construction industry, increasing transparency between the different stakeholders and identifying problems before they become critical.
5. Explain the importance of consistency and keeping current with technology and security in smart buildings.
6. Understand some of the challenges for consolidating controls technology in a large government enterprise.
7. Explain the importance of people, process, & technology to the operational success of a BAS
8. Explain how critical turning data into actionable information that is aligned with your challenges and goals.
9. Explain the importance of O&M in the design process and how to properly specify components that will lead to the operational success of a BAS
10. Describe how to incorporate O&M staff and considerations into the design and specification of a BAS project.
11. Better understand the benefits of using digital twins for operation and maintenance purposes
12. Understand the challenges to be overcome in order to propose a more autonomous and intelligent building management system for increased efficiency.

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

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

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

Scott Donovan*, Automated Logic, Kennesaw, GA*

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

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

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

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

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

Keynote (Basic)

Women in ASHRAE Keynote: Buildings are Our Best Medicine

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

The past 12 months have brought to the forefront our need for buildings to shelter us from not only outdoor elements, but also from invisible indoor things such as viruses. While we struggle to answer questions about COVID-19 transmission, effective prevention strategies and even our own immune response to this Coronavirus, we thankfully have scientific data from studies in microbiology, medicine and the indoor environment that can guide our building management.

Dr. Taylor will also discuss her path from medicine to building science to clarify the essential role of your work in protecting the health of all building users.

Buildings Are Our Best Medicine

Stephanie Taylor, M.D., Member*, ASHRAE Epidemic Task Group and Environmental Health Committee, Atlanta, GA*

10:00 AM - 11:30 AM

Student Program

Career Panel

Sponsor: Other

Learn what jobs may await with a career related to ASHRAE! This is an open forum for you to ask questions to professionals spanning multiple industry sectors.

Wednesday, February 10, 11:00 AM - 12:00 PM

Seminar 14 (Basic)

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

Track: Standards, Guidelines and Codes

NY PDH

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

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

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

Learning Objectives:

1. Be aware of the existence, and understand the applicability, of ANSI/ASHRAE Standard 90.4.
2. Understand the new Design Metrics in Std. 90.4 – namely the MLC and ELC, how to use them, and the tradeoffs allowed between and within them.
3. Understand how Std. 90.4 relates to Std. 90.1, how 90.4 differs, and where each should be used in the Information Technology industry.
4. Recognize the differences between the 2016 and 2019 versions of Std. 90.4, and the further changes being considered, and be in a position to comment on Addenda as they are published for public review.
5. Be aware of the existence, and understand the applicability, of ANSI/ASHRAE Standard 90.4.
6. Understand the new Design Metrics in Std. 90.4 - namely the MLC and ELC, how to use them, and the tradeoffs allowed between and within them.
7. Understand how Std. 90.4 related to Std. 90.1, how 90.4 differs, and where each should be used in the Information Technology industry.
8. Understand how 90.1 references 90.4 for use in various buildings and projects.
9. Opportunities to use 90.4 to support Essential Facilities.

1. The Origin of ANSI/ASHRAE Std. 90.4, Its Purpose and Format and Using the Electrical Loss Component Metric
Robert McFarlane, Member*, Shen Milsom & Wilke, LLC, New York, OR*

2. Understanding the Mechanical Load Component and Tradeoff Options in ANSI/ASHRAE Std. 90.4
Vali Sorell, P.E., Member*, Microsoft Corporation, Charlotte, NC*

3. The Relationship between Standards 90.1 and 90.4, and the Importance of 90.4 to Mission Critical Facilities
Timothy Peglow, P.E., Member*, MD Anderson, Houston, TX*

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

Debate 1 (Intermediate)

Is Air Change per Hour (h^{-1}), cfm/ft^2 or Something Else?

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

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

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

Ventilation airflow requirements are specified in standards, codes and design guidelines in terms of air changes per hour (h^{-1}), cfm/ft^2, cfm/person, etc. Quantity of supply airflow rate depends on such specification. A group of people who support air change rate thinks it has been working successfully for several decades in making the critical spaces safe, comfortable and healthy. Another group thinks this legacy practice has a little scientific basis and is a burden on energy efficiency and cost of operation of HVAC systems. This session is an open debate on this issue. Active participation is required from the attendees.

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

Seminar 15 (Intermediate)

Building Operation and COVID-19: What Is the Standard of Care and Who's Responsible WITH LIVE Q&A

Track: Building Performance and Commissioning for Operation and Management

Sponsor: 7.3 Operation and Maintenance Management

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

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

Learning Objectives:

1. Identify the primary distinctions between "Standard of Care" and "Duty of Care".
2. Identify three primary areas where the design process interfaces with potential COVID-type risks in operating and maintaining a facility.

1. The Legal Perspective

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

2. The Operator's Perspective

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

3. The Owner's Perspective

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

1:30 PM - 2:50 PM

Seminar 16 (Intermediate)

Dedicated Outdoor Air Systems: Applications, Specification and Commissioning WITH LIVE Q&A

Track: Systems and Equipment

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

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

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

Learning Objectives:

1. Understand key requirements for how to effectively incorporate and apply Dedicated Outdoor Air Systems (DOAS) in any building type.
2. Describe what changes have been made to ASHRAE 198 and AHRI 920 standards to incorporate new equipment variations.
3. Understand how to effectively communicate design requirements to contractors and specifying engineers.

4. Understand testing methods to verify Dedicated Outdoor Air Systems (DOAS) perform as designed.
5. a. Provide some different ways DOAS equipment can be specified with a level of information required to construct the project in conformance with codes and reasonable design practice.
6. b. Discuss aspects of specifying DOAS performance that is free of ambiguity so contractors and their suppliers can discern the design intent
7. Understand testing methods to verify Dedicated Outdoor Air Systems (DOAS) perform as designed
8. Explain the commissioning process specific to DX-DOAS equipment.

1. Applications in DOAS
Craig Burg, Member*, Desert Aire Corp, Germantown, WI*

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

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

1:30 PM - 2:50 PM

Seminar 17 (Intermediate)

Hotter Cities, Hotter Climates: Modelling and Measuring Urban Heat Island Effects Around the World WITH LIVE Q&A

Track: International Design

Sponsor: 4.2 Climatic Information, 2.8 Building Environmental Impacts and Sustainability
Chair: Ralph Muehleisen, Ph.D., P.E., Member, Argonne National Laboratory, Lemont, IL
Mitigating Urban Heat Island (UHI) or urbanisation-related weather issues is of critical importance for millions of urban dwellers worldwide. It affects building energy consumption and outdoor comfort, and has been associated with increased morbidity and mortality and worsening air quality. This makes quantifying these effects a priority for researchers and practitioners alike. In this seminar, we present (1) a review of the numerical modelling of urban heat island mitigation, and (2) a case study of blue and green mitigation of urban canyons based on measurements. The speakers discuss possible mitigation approaches to the problems highlighted.

Learning Objectives:

1. Overview of current state of research into the effectiveness of key UHI mitigation techniques.
2. Understand the effect of UHI on practical outcomes such as building energy consumption and outdoor thermal comfort.
3. Understand how the intensity of the UHI may vary between precincts and microclimates within a metropolitan area.
4. Understand how the time of daily maximum and minimum temperatures is delayed within an UHI.
5. Understand the effect of the UHI on practical outcomes such as building energy consumption and outdoor thermal comfort.
6. Understand how the time of daily maximum and minimum temperatures is delayed within an UHI.
7. Understand how the intensity of the urban heat island may vary between precincts and microclimates within a metropolitan area.
8. Understand how the time of daily maximum and minimum temperatures are delayed within an urban heat island.
9. Understand how the combination of radiation, heat and humidity can be stressful, and how these can be mitigated.

1. Cooling Hot Cities: A Systematic and Critical Review of the Numerical Modelling Literature
Evyatar Erell, Ph.D.*, Ben-Gurion University of the Negev, Beersheba, Israel*

2. Case Studies of Blue and Green Mitigation of Urban Canyons
Eric Peterson, Ph.D., P.E., Member*, University of Leeds, Leeds, United Kingdom*

1:30 PM - 2:50 PM

Seminar 18 (Intermediate)

New Standard: ASHRAE 221 Overview WITH LIVE Q&A

Track: Standards, Guidelines and Codes

Sponsor: 7.3 Operation and Maintenance Management

Chair: Matthew Mullen, P.E., Member, EMCOR Services New England Mechanical, South Windsor, CT
ASHRAE Standard 221 - *Test Method to Field-Measure and Score the Cooling and Heating Performance of an Installed Unitary HVAC Systems*, provides a new and revealing method to score the performance end efficiency of an installed HVAC system in the field. The scores reveal the impact of inherent defects in installation, deferred maintenance and hidden installed system losses. This standard is written for use by all field professionals including installing contractors, technicians, commissioning and facility personnel, balancers, designers and energy efficiency program participants.

Learning Objectives:

1. Understand how this new standard enables its users to score the performance and efficiency of an HVAC system as installed in a building.
2. Become familiar with the testing protocols and calculations used in ASHRAE 221 to reveal the effects of performance and efficiency deterioration as HVAC systems are installed and maintained in the field.
3. Discover how a wide variety of HVAC professionals can apply ASHRAE 221 as installing contractors, technicians, commissioning and facility personnel, balancers, designers and energy efficiency program implementers.
4. Use knowledge offered in this seminar to consider how you can apply ASHRAE 221 principles to identify opportunities to improve performance of HVAC systems.
5. Understand how this new standard enables its users to score the performance and efficiency of an HVAC system as installed in a building.
6. Become familiar with the testing protocols and calculations used in ASHRAE 221 to reveal the effects of performance and efficiency deterioration as HVAC systems are installed and maintained in the field.
7. Discover how a wide variety of HVAC professionals can apply ASHRAE 221 as installing contractors, technicians, commissioning and facility personnel, balancers, designers and energy efficiency program implementers.

1. Introduction and Description of ASHRAE Std. 221
***Rob Falke, Member**, National Comfort Institute, Avon Lake, OH*

2. ASHRAE Std. 221 Testing and Calculations
***Peter C. Jacobs, P.E., Member**, BuildingMetrics, Incorporated, Boulder, CO*

3. Uses of ASHRAE Std. 221's Installed System Scores
***Ben Lipscomb, P.E., Associate Member**, National Comfort Institute, Whitefish, MT*

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

Seminar 19 (Advanced)

ASHRAE HQ: From Conception to Reception WITH LIVE Q&A

Track: Energy Conservation

Sponsor: 9.1 Large Building Air-Conditioning Systems

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

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

Learning Objectives:

1. Define the advantage of having a well done Owner's Project Requirements (OPR) document available in the solicitation of a highly qualified design team.
2. Explain the interaction needed between Owner, Architect and Engineer in order to make a complex project successful
3. Discuss the challenges associated with renovating an older building to achieve an aggressive energy target required by the building owner
4. Provide a greater understanding of the requirements of the new ASHRAE Net Zero Energy Design Guide for Office Buildings
5. Thru this case study the attendees will be able to understand the challenges associated with renovating an older building to achieve an aggressive energy target required by the building owner.
6. This presentation will provide architects and engineers alike a greater understanding of the requirements of the new ASHRAE Net Zero Energy Design Guide for Office Buildings
7. Architects will be provided with information regarding the requirements of a building envelope to meet window-to-wall ratio requirements of ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.

1. Owner Requirements of Developing a Net Zero Project
Ginger Scoggins, P.E., Member*, Engineered Designs, Cary, NC*
2. ASHRAE HQ from an Architects Perspective
Gregory Walker, AIA*, Houser Walker Architecture, Atlanta, GA*
3. ASHRAE Headquarters
William "Stanton" Stafford, P.E., Member*, Integral Group, Atlanta, GA*

3:00 PM - 4:20 PM

Seminar 20 (Basic)

Idle Buildings are the Devil's Playground WITH LIVE Q&A

Track: Environmental Health Through IEQ sponsored by Ebtron

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

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

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

Learning Objectives:

1. Explain some of the consequences of unplanned vacating of buildings.
2. Describe mitigation to be taken to avoid IEQ concerns resulting from idle buildings
3. Explain why buildings must be considered as a system when placed idled.
4. Explain why a well-designed building might become unhealthy during poorly planned shutdowns.
5. Explain what is Idle Building Syndrome (IBS)
6. Explain the design conditions for CHW pipe insulation systems
7. Explain how to design a CHW pipe insulation system to prevent surface condensation
8. Understand general considerations for placing historic buildings in an idle state
9. Understand some of the risks associated with having a building unoccupied for an extended time

1. HVAC and Plumbing Systems: What Is the Correct Idle to Minimize Legionella and Other Indoor Environmental Quality Concerns during a Pandemic
Donald Snell, P.E., Associate Member*, Liberty Building Forensics Group, Atlanta, GA*
2. Design Conditions for CHW Pipe Insulation Systems to Account for Idle Building Syndrome
Gordon Hart, P.E., Member*, Artek Engineering, LLC, Shrewsbury, MA*
3. Idle Buildings, Accelerated Problems
Peter Adams, P.Eng., Member*, Morrison Hershfield Ltd, Toronto, ON, Canada*

3:00 PM - 4:20 PM

Seminar 21 (Intermediate)

Methods for Improving HVAC Efficiency Globally WITH LIVE Q&A

Track: International Design

Sponsor: 8.11 Unitary and Room Air Conditioners and Heat Pumps

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

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

Learning Objectives:

1. Discuss international approaches promoting the room air conditioner efficiency.
2. Explain how efficiency design and best available technology affect the international standards and policies.
3. Describe the opportunities and best practices for air conditioner efficiency improvement.
4. Describe how ambitious policies help overcome the market failure.
5. Discuss international approaches promoting room air conditioner efficiency.
6. Explain how efficiency design and best available technology affect international standards and policies.
7. Describe the opportunities and best practices for air conditioner efficiency improvement.
8. draw insights on the practical ceiling of performance of RAC's gained through the testing phase of the global cooling prize
9. describe the market failure in this segment and why we need ambitious policy signals to help overcome this failure

1. Setting Long-Term Energy Efficiency Targets Based on Best Available Technology
Nihar Shah, Ph.D., P.E., Member*, Lawrence Berkeley National Laboratory, Berkeley, CA*

2. Leapfrogging to Energy-Efficient and Climate-Friendly Air Conditioners: Model Regulation Guidelines
Brian Holuj*, United Nations Environment Programme, Paris, France*

3. Raising the Ceiling of Performance: The Global Cooling Prize
Iain Campbell*, Rocky Mountain Institute, Boulder, CO*

3:00 PM - 4:20 PM

Seminar 22 (Basic)

Your Ethics Tool Box: Building a Framework for Ethical Decision-Making with Case Studies WITH LIVE Q&A

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

Sponsor: 1.7 Business, Management & General Legal Education

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

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

Learning Objectives:

1. understand that decisions to ethical issues are often "situational"
2. understand that decisions to ethical questions may depend on the perspective of the decider
3. understand an engineer's "priorities of loyalty"
4. understand that lapses in proper ethical behavior can have long-reaching consequenses
5. Understand that decisions to ethical issues are often "situational"
6. Apply a heightened awareness of ethical issues in day- to-day job functions
7. Understand an engineer's "priorities of loyalty"
8. Apply a heightened awareness of ethical issues in day- to-day job functions.
9. Understand that lapses in proper ethical behavior can have long-reaching consequences

1. Case Studies #1 and #2
Jennifer Leach, P.E., Member*, United Energy Products, Baltimore, MD*

2. Case Studies #3 and #4
Kristin Schaefer, P.E., Member*, University of Houston, Houston, TX*

3. Case Studies #5 and #6
Mike Bilderbeck, P.E., Fellow ASHRAE*, Pickering, Inc., Memphis, TN*

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

Forum 3 (Intermediate)

How to Use Post-Occupancy Data to Design and Operate Resilient Buildings

Track: Building Performance and Commissioning for Operation and Management

Sponsor: 2.10 Resilience and Security

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

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

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

Seminar 23 (Intermediate)

Indoor Environment Modeling for Pandemic Resiliency WITH LIVE Q&A

Track: Environmental Health Through IEQ sponsored by Ebtron

Sponsor: 4.10 Indoor Environmental Modeling

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

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

Learning Objectives:

1. Understand the mechanism of airborne infectious disease transmission
2. Learn how computational fluid dynamics and its variants could be a great tool for the study
3. Understand impacts of airborne infectious disease prevention strategies
4. Understand the method to determine the risks of airborne virus transmission
5. Understand the mechanism of airborne infectious disease transmission
6. Learn how computational fluid dynamics could be a great tool for the study
7. To understand how stirred tank modeling works and how it applies to ventilated environments.
8. To evaluate the relative benefits of multi-zone models vs. single zone.
9. To explain the relative benefits of UVGI, air distribution options and filtration on the protection within spaces.
10. Learn how computational fluid dynamics and its variants could be a great tool for the study
11. Understand impacts of airborne infectious disease prevention strategies

1. Airborne Infectious Disease Transmissions in Commercial Airplane Cabins
Qingyan Chen, Ph.D., Life Member*, Purdue University, West Lafayette, IN*

2. Quantifying the Benefit of Unoccupied Middle Seats on Commercial Flights for Airborne Virus Protection
Watts Dietrich*, NIOSH, DC, DC*

4. A High Speed Assessment Tool of Mitigation Options to Control Pathogens in Air
Duncan Phillips, Ph.D., P.E., Associate Member*, RWDI, Guelph, ON, Canada*

5. Protecting Industrial Workers in a Pandemic
Duncan Phyfe, Associate Member*, Alden Research Laboratory, Holden, MA*

6:00 PM - 7:50 PM

Seminar 24 (Advanced)

Safe Transition to Flammable Refrigerants in Commercial Refrigeration Applications WITH LIVE Q&A

Track: Refrigeration and Refrigerants

Sponsor: 10.7 Commercial Food and Beverage Refrigeration Equipment

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

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

Learning Objectives:

1. Obtain updates on the latest safety requirements for the use of low-GWP refrigerant and understand the implementation dates for such requirements.
2. Develop understanding for different ways to reduce refrigerant charge and be able to assess different system architectures with respect to their potential to result in low refrigerant charge levels
3. Understand the new UL safety requirements for manufacturers to allow them to use charge sizes of greater than 150 grams (0.33 lb) for A2L and A3 refrigerants. Understand the safety aspects of the design and testing requirements of commercial refrigerators using flammable refrigerants.
4. Develop understanding for different ways to reduce refrigerant charge and be able to assess different system architectures with respect to their potential to result in low refrigerant charge levels
5. understand flammable refrigerant testing
6. understand the latest research
7. The current status of IEC 60335-2-89 IEC SC61C WG4
8. What are the charge limits for flammable refrigerants in IEC 60335-2-89 3rd edition
9. What is the compliance criteria for Annex CC
10. Obtain updates on the latest safety requirements for the use of low-GWP refrigerants
11. Understand the implementation dates for such requirements
12. Develop understanding for different ways to reduce refrigerant charge and be able to assess different system architectures with respect to their potential to result in low refrigerant charge levels
13. Identify different ways to reduce refrigerant charge and be able to assess different system architectures with respect to their potential to result in low refrigerant charge levels

1. A2L and A3 Refrigerants Testing for Reach-In Coolers
Xudong Wang, Ph.D., Member, *Air-Conditioning, Heating and Refrigeration Technology Institute, Arlington, VA*

2. Update on Standards Development: IEC 60335-2-89 Commercial Refrigeration
Brian Rodgers, *Underwriters Laboratories, Northbrook, IL*

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

4. Use of Flammable Refrigerants from an Equipment Manufacturer's Perspective
Timothy Anderson, Associate Member, *Hussmann, Bridgeton, MO*

5. Refrigerant Charge Reduction to Mitigate Risks Associated with Flammable Refrigerants
Stefan Elbel, Ph.D., Member, *University of Illinois at Urbana-Champaign, Urbana-Champaign, IL*

Thursday, February 11

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

Seminar 25 (Intermediate)

Movement and Control of Airborne Pathogens with HVAC Systems WITH LIVE Q&A

Track: Environmental Health Through IEQ sponsored by Ebtron

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

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

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

Learning Objectives:

1. Describe the importance of airflow patterns in indoor spaces, and the role of HVAC design parameters on spread of airborne contaminants.

2. Describe the role of air movement in virus carriers (aerosols) from zone to zone, and the various types of air handling approaches to mitigate the effect.
3. Understand how to design virus aerosol inactivation measurement experiments, including virus titer in aerosolized suspension.
4. Understand how the PECO technology can filter out viruses as well as destroy them on the filter surface.
5. Describe the importance of airflow patterns in indoor spaces, and the role of HVAC design parameters on spread of airborne contaminants.
6. Learn how Computational Fluid Dynamics (CFD) can help in design and optimization of HVAC systems
7. Role of air movement in virus carriers (aerosols) from zone to zone
8. Various types of air handling approaches to mitigate the effect.
9. Describe the importance of airflow patterns in indoor spaces, and the role of HVAC design parameters on spread of airborne contaminants.
10. Describe the role of air movement in virus carriers (aerosols) from zone to zone, and the various types of air handling approaches to mitigate the effect.
11. Understand how to design virus aerosol inactivation measurement experiments, including virus titer in aerosolized suspension.
12. Is COVID-19 primarily an airborne transmission?
13. Does conventional HVAC system help reduce the risk of infection or does it become a spreader?
14. Role of PECO Technology in reducing the risk of infection.

1. Impact of Airflow Patterns on Transmission of Airborne Contaminants
Kishor Khankari, Ph.D., Fellow ASHRAE, *AnSight LLC, Ann Arbor, MI*

2. Experimental Evaluation of Droplet Transmission through Building Air Handling System: A Case Study for COVID-19 Zonal Transmission
Kashif Nawaz, Ph.D., Member, *Oak Ridge National Laboratory, Oak Ridge, TN*

3. Mid-Scale Wind Tunnel Testing of Residential Control Technology for Coronavirus Aerosol Collection and Inactivation
Christopher Hogan Jr., *University of Minnesota, Minneapolis, MN*

4. Indoor Airborne Transmission of COVID-19 Virus and the Role of PECO Technology to Reduce the Risk of Infection
D Goswami, Ph.D., P.E., Fellow ASHRAE, *University of South Florida, Tampa, FL*

7:00 AM - 8:50 AM

Seminar 26 (Intermediate)

Smarter Together: Integrating HVAC and Lighting Control WITH LIVE Q&A

Track: Energy Conservation

Sponsor: 1.4 Control Theory and Application, TC 7.5

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

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

Learning Objectives:

1. Detail the steps that building personnel, designers, and engineers need to focus on when they integrate lighting with building systems.
2. Identify some of the common pitfalls and challenges for multi-system integration.
3. Describe the newest ways that multiple building systems can be seamlessly controlled.
4. Quantify the energy impacts of an integral HVAC, Lighting, and Shading system.
5. - Learn how multiple building systems can be seamlessly controlled through integration in brand new ways based on electrifying technological advancements.
6. - Discover how the new system architecture of networked lighting controls allows us to solve problems we’ve never been able to address before. An evolution of technology leading to a revolution in how buildings are operated.
7. Detail the steps that building personnel, designers, and engineers need to focus on when they integrate lighting with building systems.
8. Understand the energy impacts of retrofitting control of HVAC in integration with networked lighting.

9. Understand the differences between an Integral and Integrated Solution
10. Understand the effectiveness and efficiencies of an integral HVAC, Lighting, and Shading control system
11. Specify an integral solution

1. Power up Your Knowledge: Get Your Smart Buildings Superhero Card
***Kandice Cohen, Affiliate**, Trane, La Crosse, WI*

2. Deeper Control Savings: Integrating HVAC with Networked Lighting
***Scott Hackel, P.E., Member**, Slipstream, Madison, WI*

3. Integral vs. Integrated: The Story
***Will Podgorski**, Siemens, Buffalo Grove, IL*

4. Research Aspects of Integration of Lighting and HVAC and Other Systems
***Michael Myer, Member**, Pacific Northwest National Laboratory, Richland, WA*

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

Student Program

Grant and Design Competition Presentations

Sponsor: Other

Hear from the top-rated grant application recipients and the winners of the design competitions about what makes a successful project.

10:00 AM - 11:30 AM

Seminar 27 (Intermediate)

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

Track: Environmental Health Through IEQ sponsored by Ebtron

NY PDH

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

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

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

Learning Objectives:

1. To understand the different strategies to upgrade the buildings filtration system better understand the use of filtration to remove microorganism containing particles.
2. Understand how to design & install UVC systems in Existing HVAC systems.
3. Discuss the strategies and technologies that design professionals need to consider combatting infectious disease outbreaks.
4. Understand the ASHRAE Position Document of Infectious Aerosols (April 2020).
5. To understand the different strategies to upgrade the buildings filtration system better understand the use of filtration to remove microorganism containing particles.
6. Discuss the strategies and technologies that design professionals need to consider combatting infectious disease outbreaks.
7. Understand simple design of UVC for Ac units and supply ductwork
8. Understand the importance of Safety with UVC systems

3. The Evolving State of COVID-19 HVAC Guidance: What Have We Learned, Where Are We Now, Where Are We Headed?
***William Bahnfleth, Ph.D., P.E., Presidential Fellow ASHRAE**, Penn State, University Park, PA*

1. Why MERV 13 and NOT HEPA Filtration
***Kathleen Owen, Fellow ASHRAE**, Owen Air Filtration Consulting, Cary, NC*

2. UVC: How to Do It: Design and Installation
Scott Sherwood, Member, *Eco-Care Corporation, Bronx, NY*

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

Seminar 28 (Intermediate)

Ammonia and Other Natural Refrigerants Standards and Guidance WITH LIVE Q&A

Track: Refrigeration and Refrigerants

Sponsor: 10.1 Custom Engineered Refrigeration Systems, Refrigeration Technology Committee

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

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

Learning Objectives:

1. Understand the reasons for prolific use of ammonia in industrial refrigeration
2. Understand the sources codes and standards for ammonia system design
3. Understand the scope and purpose for CO2 and Hydrocarbon Standards in development
4. Understand the resources available to aid in design, construction and operation of natural refrigeration systems.
5. Understand the resources available to design, construct, own, and maintain ammonia refrigeration systems.
6. Understand the reasons for the prolific use of ammonia in industrial refrigeration.
7. Understand the scope and purpose for CO2 and Hydrocarbon Standards under development.
8. Understand the reasons for prolific use of ammonia in industrial refrigeration
9. Understand the sources codes and standards for ammonia system design

1. Ammonia Standards and Research
Eric Smith, *IIAR, Alexandria, VA*

2. IIAR Publications
Eileen McKeown, *IIAR, Alexandria, VA*

12:00 PM - 1:20 PM

Seminar 29 (Basic)

Avoid the Headlines! Today's Top 10 Security Best Practices for Controls WITH LIVE Q&A

Track: Building Performance and Commissioning for Operation and Management

NY PDH

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

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

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

Learning Objectives:

1. Describe security best practices for building automation system user account management.
2. Describe security best practices for building automation system remote access.
3. Describe the value of using a security checklist for building automation system installation.
4. Describe security best practices for building automation server and database configuration.
5. Describe security best practices for building automation system user account management.
6. Describe security best practices for building automation system remote access.
7. Define and understand common cyber security threats of today.
8. Describe the role of a BAS server and how it interacts with the BAS network as well as the building network.
9. Define best practices when for a BAS network and how to best secure a BAS server.

1. User Accounts and Access Best Practices for Controls
***Carol Lomonaco, Member**, Johnson Controls, Milwaukee, WI*
2. Controls Deployment Best Practices to Limit Exposure
***Ken Gilbert, Member**, Automated Logic, Kennesaw, GA*

12:00 PM - 1:20 PM

Seminar 30 (Basic)

Controls Standards, Guidelines and Codes: What YEA Need to Know! WITH LIVE Q&A

Track: Standards, Guidelines and Codes
Sponsor: 1.4 Control Theory and Application, YEA
Chair: Omar Rojas, Member, Russell Sigler, Inc, Brea, CA
Controls can be daunting for the new and experienced engineers, yet they are a critical component of a building's design and becoming a well-rounded engineer. With so much information available on the matter, it’s hard to know where to begin. This seminar provides an introduction to the guidelines, standards and codes to start you on path to becoming controls savvy. Start from the ground up learning the terms and concepts. Carry on through the standards and guidelines that will help you put concepts into practice. Reach a point where you can understand and prevent code control measures from under-performing.

Learning Objectives:

1. Understand the basic terminology and concepts of controls systems in buildings.
2. Identify the ASHRAE standards and guideline that will help successful control implementation.
3. Recognize common controls measures mandated by energy codes.
4. Understand methods for preventing controls from failing their intent on the field.
5. Understand the basic terminology and concepts of controls systems in buildings.
6. Identify the ASHRAE standards and guideline that will help successful control implementation.
7. Understand what guidelines are available to aid in the design of controls.
8. Understand how controls can influence the design from the onset of the project.

1. An Introduction to Building Automation Controls and Communications: Learn to Speak the Language
***Ron Bernstein, Member**, RBCG Consulting, San Diego, CA*
2. A Beginner’s Trail through Guideline 36: Understanding How Control Sequences Can Influence System Design
***James Del Monaco, P.E., Member**, P2S Inc., San Diego, CA*
3. Control Measures in Energy Codes: Fantasy vs. Reality
***Reid Hart, P.E., Life Member**, Pacific Northwest National Laboratory, Richland, WA*

12:00 PM - 1:20 PM

Seminar 31 (Intermediate)

Decouple, Optimize and Succeed with DOAS WITH LIVE Q&A

Track: Systems and Equipment

NY PDH

Sponsor: 1.4 Control Theory and Application, 8.10 Mechanical Dehumidification Equipment and Heat Pipes
Chair: James Coogan, P.E., Associate Member, Siemens Smart Infrastructure, Chicago, IL
A new, multi-purpose building on an urban university campus is planned to significantly exceed the applicable energy efficiency code. The challenge calls for a design that meets diverse load conditions without waste and an on-line optimization function that dynamically applies heating and cooling elements to best advantage. A primary DOAS was selected with hydronic heating and cooling fan powered terminals, to deliver comfort and ventilation but expend energy only where and when it's needed. The concept decouples ventilation from thermal conditioning and building pressurization. One talk explains the HVAC design and analysis; the other covers dynamic operation.

Learning Objectives:

1. Identify and understand the HVAC system architecture for DOAS primary air handling units and secondary fan powered units.
2. Design DOAS to maintain indoor relative humidity and indoor air quality, applying ASHRAE standards 62.1 and 55.
3. Recognize projects that can benefit from this type of system.
4. Devise algorithmic solutions to the dynamic energy optimization problem.

5. Identify and understand the HVAC system architecture for DOAS primary air handling units and secondary fan powered units.
6. Design DOAS to maintain indoor relative humidity and indoor air quality, applying ASHRAE standards 62.1 and 55.
7. Recognize projects that can benefit from this type of system.

1. Applying DOAS with Secondary Heat and Cooling to Meet HVAC Challenges
***Andrew Kozak, P.E., Member**, Bard Rao + Athanas Consulting Engineers, New York, NY*

2. Dynamically Optimizing a DOAS: Finding the Bottom
***James Coogan, P.E., Associate Member**, Siemens Smart Infrastructure, Chicago, IL*

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

Workshop 2 (Basic)

Best Practices of the Mentor-Mentee Relationship

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

Sponsor: YEA Committee, College of Fellows

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

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

Learning Objectives:

1. Accelerate mentee learning, confidence, and competence building and advancement, as well as avoid or be aware of challenges and areas of unconscious incompetence
2. Have a trusted advisor and go-to resource for professional and personal issues
3. Interactions, growth, and learning between generations – e.g. Boomers and Millennials
4. ASHRAE members and their company's receive a "value-add" benefit from the association membership
5. structure mentor/mentee sessions to work through a challenging technical issue, demanding project or have a trusted advisor for coaching and support.
6. use mentoring/mentee sessions to build X-generational relationships that enrich and benefit both parties professionally and personally.

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

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

Seminar 32 (Intermediate)

Climate Control Solutions for What Is Next, Moving from Hyperscale to The Edge WITH LIVE Q&A

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

NY PDH

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

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

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

Learning Objectives:

1. Discuss Edge trends and applications and define the basic requirements of an Edge installation vs hyperscale deployments

2. Introduce Edge Installation and Cooling criteria to successfully plan for these new installation environments and conditions.
3. Insure compliance with ASHRAE Thermal Guidelines and resources
4. Review cooling choices and solutions
5. Describe Edge trends and applications and define the basic requirements of an Edge installation vs. hyperscale deployments
6. Understand Edge installation and cooling criteria to successfully plan for these new installation environments and conditions
7. Understand cooling choices for Edge installations and ASHRAE resources available to help plan for Edge installation

1. Climate Control Solutions for What's Next
***Suzanne Krantz**, Rittal North America, Schaumburg, IL*

3:00 PM - 4:20 PM

Seminar 33 (Intermediate)

Ground Source Heat Pump Systems: GeoMicroDistricts to the Thermal Highway and Beyond WITH LIVE Q&A

Track: Energy Conservation

Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications
Chair: Roshan Revankar, Melink Solar and Geo, Milford, OH
This session explores possibilities for wasted energy recovery and increasing multi-building system efficiency using one-pipe convective loops. We demonstrate several ways system coefficient of performance can be increased using ground source and GeoMicroDisticts. There will be several presentations that will go over the energy engineering aspects of optimizing GSHP systems using diversity, part load analysis, system COP and system $iCOP_{kW}$, the affinity laws for pumps and fans, and earth thermal properties for heat storage. Specific examples of installed GeoMicroDistricts are used to demonstrate the technology.

Learning Objectives:

1. Describe one pipe convective geothermal systems
2. Understand the use of engineering principles, diversity, thermal storage, climate profiles/rules, wasted energy recovery, and affinity laws, into a renewable and recoverable energy distribution and collection system
3. Apply low cost system design to district geothermal systems
4. Explain the utilization of ground loops as thermal storage battery
5. Describe one pipe convective geothermal systems.
6. Understand the use of engineering principles, diversity, thermal storage, climate profiles/rules, wasted energy recovery, and affinity laws, into a renewable and recoverable energy distribution and collection system.
7. Explain the utilization of ground loops as thermal storage battery.

1. In the Beginning…
***Garen N. Ewbank, Member**, Ewbank Geo Testing, LLC, Fairview, OK*
2. What Box Do We Use for Ground Source Systems?
***Cary Smith, Member**, Sound Geothermal Corp., Sandy, UT*

3:00 PM - 4:20 PM

Seminar 34 (Advanced)

Performance of Alternative Low GWP A2L Refrigerants in Condensers WITH LIVE Q&A

Track: Refrigeration and Refrigerants
Sponsor: 1.3 Heat Transfer and Fluid Flow, 8.4 Air-to-Refrigerant Heat Transfer Equipment , 8.5 Liquid-to-Refrigerant Heat Exchangers
Chair: Kashif Nawaz, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN
Due to the emerging attention to the environmental impacts of air conditioning, there has been a continuous effort to evaluate the heat transfer and pressure drop performance of alternative refrigerants that can substitute conventional working fluids like R410A. This seminar highlights the performance of several low GWP and A2L refrigerants, including zeotropic mixtures of HFC/HFOs, under flow condensation process in heat exchangers. The seminar also highlights conventionally ignored

superheated and subcooled condensation process, challenges associated with condensation of zeotropic mixtures, and a novel modeling framework that will facilitate the design of next generation condensers for alternative refrigerants.

Learning Objectives:

1. Explain why condensation heat transfer is important in for air conditioning systems.
2. Explain the potential of refrigerants blends to replace R410A.
3. Understand the significance of coupled heat and mass transfer during condensation of zeotropic refrigerant mixtures.
4. Introduce a novel modeling framework to predict superheated condensation effects of low GWP mixtures.
5. Understand the significance of coupled heat and mass transfer during condensation of zeotropic refrigerant mixtures
6. Introduce a novel modeling framework to predict superheated condensation effects of low GWP mixtures.
7. Understand the significance of coupled heat and mass transfer during condensation of zeotropic refrigerant mixtures.
8. Introduce a novel modeling framework to predict superheated condensation effects of low GWP mixtures.

1. Thermal-Hydraulic Performance of Alternative Refrigerants Under Flow Condensation
Kashif Nawaz, Ph.D., Member*, Oak Ridge National Laboratory, Oak Ridge, TN*

2. In-Tube Condensation of Low Global Warming Potential Refrigerants
Tabeel Jacob, Ph.D., Student Member*, Oregon State University, Corvallis, OR*

3:00 PM - 4:20 PM

Seminar 35 (Intermediate)

Sensors and IAQ WITH LIVE Q&A

Track: Environmental Health Through IEQ sponsored by Ebtron

Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment

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

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

Learning Objectives:

1. Describe particle sensors and their applications.
2. Describe particle sensors and their applications.
3. Provide usage of multiple sensors in the indoor environment.
4. Describe how cost, energy requirements, sensitivity, selectivity and size play roles in multiple sensors.
5. Describe the role of sources in indoor particle concentrations in residences.
6. Explain why filters did not make a big difference in indoor particle concentrations in this investigation.
7. Describe the challenges and opportunities of low-cost particle monitors for indoor air quality research and air cleaning control.

1. What Did We Learn from Deploying Low-Cost Particle Monitors in 20 Homes?
Jeffrey Siegel, Ph.D., Fellow ASHRAE*, University of Texas at Austin, Austin, TX*

2. Metal Oxide Semiconductor Sensors to Measure Volatile Organic Compounds for Ventilation Control
Pawel Wargocki, Ph.D., Associate Member*, Technical University of Denmark, Kongens Lyngby, Denmark*

3. Operating Principles of Airborne Pollutant Sensors and Considerations for Sensing Multiple Pollutants
Jordan Clark, Ph.D.*, OSU, Columbus, OH*

Panel

Panel 2 (Intermediate)

Advancing Occupant Aspects of Building Energy Codes, Standards and Policy

Track: Standards, Guidelines and Codes

Sponsor: MTG.OBB Occupant Behavior in Buildings

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

Learning Objectives:

1. Understand the impacts of occupants on building performance
2. Understand how occupants are currently considered in building codes in North American and around the world
3. Understand potential ways to enhance and update building codes to better represent occupant behaviors
4. After attending this session, the attendees will be able to understand the impacts of occupants on building performance.
5. After attending this session, the attendees will be able to identify potential ways to assess and learn about occupant behaviors in response to comfort and other issues.
6. Compare modelling assumptions used in energy code provisions to data collected from existing buildings
7. Investigate the effect of plug load assumptions on energy simulations compliant with different versions of the Canadian energy code
8. Explain ASHRAE Standard 90.1 requirements related to occupancy behavior for its prescriptive and performance compliance paths.
9. Understand the challenges of modeling the energy impacts of occupancy centric controls through whole building simulations.
10. Describe occupant-centric control strategies
11. Understand key occupant-centric control metrics
12. Apply occupant information in sequences of operation for HVAC systems

An International Review of Occupant-Related Aspects of Building Energy Codes
Liam O'Brien, Ph.D., P.E., Associate Member*, Carleton University, Ottawa, ON, Canada*

Control, Comfort and Codes: Learning Lessons from Occupants
Julia Day, Ph.D., Associate Member*, Washington State University, Pullman, WA*

Investigating Setpoints and Plug Load Assumptions in Energy Codes
Mohamed Ouf, Associate Member*, Concordia University, Montreal, QC, Canada*

Recent Changes in the U.S. Building Energy Codes for Occupancy-Centric Controls and Associated Building Energy Modeling Challenges
Jian Zhang, Ph.D., Member*, Pacific Northwest National Laboratory, Richland, WA*

Incorporating Occupant-Centric Controls in Sequences of Operation for HVAC Systems
Burak Gunay, Ph.D., Associate Member*, Carleton University, Ottawa, ON, Canada*

Panel 3 (Intermediate)

Design Fundamentals of Commercial Kitchens, Part 1

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell
Sponsor: 5.10 Kitchen Ventilation
Chair: Cherish Samuels, P.E., Associate Member, McDonald's Corporation, Chicago, IL
From ventilation and make-up air, to heat gain and thermal comfort, commercial kitchens are some of the most difficult spaces to design. Hood selection has an impact on IAQ and energy consumption in the restaurants along with comfort in the kitchen. Increases in cooking capacity or the need for expanded menu flexibility in the kitchen is more commonly being met by specifying unhooded or ventless equipment. This first panel in a two-part series walks you through some of the most crucial design considerations and equipment selections involved in the planning of ventilation systems for commercial kitchens.

Learning Objectives:

1. understand the pros and cons of various types of commercial kitchen hoods
2. understand the impact that appliance, hood and HVAC systems can have on staff comfort
3. Identify when commercial cooking equipment can be installed without an exhaust hood and applicable model codes and standards related to unhooded equipment installation.
4. Identify proper design strategies to minimize negative impacts associated with unhooded equipment.
5. Understand that kitchen ventilation design is an iterative process.
6. Know the importance of getting equipment heat gain right.
7. The more the designer knows about how the restaurant operates, the better the design will be.

Cooking and Exhaust Hood Selection, Optimization Fundamentals
***Derek Schrock, Member**, Halton Company, Scottsville, KY*

Design Considerations for Unhooded Equipment in Commercial Kitchens
***Jimmy Sandusky, Associate Member**, Halton Company, Scottsville, KY*

Design Process for Commercial Kitchens
***Jason Greenberg, P.Eng.**, MGN, Inc., Oakbrook Terrace, IL*

Panel 4 (Intermediate)

Design Fundamentals of Commercial Kitchens, Part 2

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell
Sponsor: 5.10 Kitchen Ventilation
Chair: Cherish Samuels, P.E., Associate Member, McDonald's Corporation, Chicago, IL
Today, HVAC designers have many HVAC system and product types to choose from. There are also multiple types of exhaust fans available for the removal of grease, heat, smoke and steam from commercial kitchens. Design considerations include mechanical and cooking equipment installed, integrations to other systems on site, codes and safety regulations and proper commissioning of the system. This second panel in a two-part series walks you through some of the most crucial design considerations and equipment selections involved in the planning of ventilation systems for commercial kitchens.

Learning Objectives:

1. To understand which type of exhaust fans apply best to which kitchen applications
2. To be able to design to meet the code requirements of each type of grease-rated exhaust fan as well as the particular application
3. To learn the available options for energy savings with commercial kitchen exhaust fans
4. Understand what DCKV is.
5. Where DCKV can be applied.

Getting Your CKV Ducts in a Row
***Keith Page, Member**, Selkirk Corporation, Grand Rapids, MI*

Exhaust Fans for Commercial Kitchen Ventilation Applications
***Jessica Harrington, Associate Member**, Accurex, Baltimore, MD*

Demand Control Kitchen Ventilation Applications
***Jason Brown, Associate Member**, Melink Corporation, Milford, OH*

Restaurant HVAC Design Strategies for Incorporating Replacement Air (WITHDRAWN)
***Greg DuChane, Member**, Trane, Nacogdoches, TX*

Conference Paper Session

Conference Paper Session 1 (Intermediate)

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

Track: Building Performance and Commissioning for Operation and Management
Sponsor: 7.6 Building Energy Performance
Chair: Rupesh Iyengar, Ph.D., Member, Services Consultants, Bengaluru, India
Public communities, like universities, are a vital element of our infrastructure, as well as the energy consumption and occupant thermal comfort of these buildings. Until recently, public community energy systems planning was addressed without considering community-wide goals. This session presents the best practices for community-level planning with European and North American case studies, based in part on research performed under the International Energy Agency's "Energy in Buildings and Communities Program Annex 73" on developing guidelines to support planning Net Zero Energy Resilient Public Buildings. Each paper reviews energy plans and specific performance targets, critical infrastructure, operational constraints and techno-economic concepts.

Learning Objectives:

1. Consider and integrate locally available sources into an Energy Master Plan

2. Describe differences in Energy Master Plan development for renovation and new campus
3. Describe which technologies are most important in a cost effective, resilient low carbon community
4. Describe how campus owners and local communities involved in planning can identify profitable, resilient low carbon energy projects
5. Describe how campus owners and local communities can implement and finance identified projects and realize the benefit

Energy Master Planning for Resilient Public Communities: Best Practices from Austrian University Campuses (VC-21-002)
Anna Maria Fulterer, Ph.D.[1]*, Ingo Leusbrock, Ph.D.*[1]*, Gert Widu*[2] *and Dirk Jäger*[2]*, (1)Institute for Sustainable Technologies, Gleisdorf, Austria, (2)Bundesimmobiliengesellschaft, Vienna, Austria*

Energy Master Planning for Resilient Public Communities: Best Practices from North American Universities (VC-21-003)
Laxmi Rao[1]*, Juan Ontiveros, P.E., Affiliate*[2]*, Joseph Yonkoski*[3]*, Joshua Wauthy*[4] *and Paul Holt*[5]*, (1)International District Energy Association, Westborough, MA, (2)University of Texas at Austin, AUSTIN, TX, (3)University of California, CA, (4)University of British Columbia, Vancouver, BC, Canada, (5)Corix Utilities, Vancouver, BC, Canada*

Energy Master Planning for Resilient Public Communities: Best Practices from Denmark (VC-21-001)
Anders Dyrelund[1]*, Robert Neimeier*[2]*, Hasmik Margaryan*[3] *and Anders Moller*[4]*, (1)Ramboll Energy, Copenhagen, Denmark, (2)Ramboll Energy, US, (3)TaarnbyForsyning, Denmark, (4)Danish Technical University, Denmark*

Conference Paper Session 2 (Intermediate)

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

Track: Building Performance and Commissioning for Operation and Management
Sponsor: 7.6 Building Energy Performance
Chair: Farhan Mehboob, S Mehboob & Company, Karachi, Pakistan
Throughout the history of energy systems, significant disruption of energy supply has degraded critical capabilities and caused a significant social and economic impact on private and public communities. This disruption more severely impacts vital infrastructures such as hospitals, education campuses, military installations and other mission-critical facilities. The major causes of such disruption are low-probability and high-impact events such as hurricanes, floods, earthquakes and extreme climates such as the arctic and tropical environment. This session presents metrics for energy resilience, methodologies to assess these metrics and tools for modeling energy resilience at the community scale.

Learning Objectives:

1. Describe why resilience needs to be handled contextually and how to apply it.
2. Define and apply the concept of a design basis threat for a resilience assessment.

Defining, Measuring and Assigning Resilience Requirements to Electric and Thermal Energy Systems (VC-21-004)
Alexander M. Zhivov, Ph.D., Member[1]*, Andrew Stniger*[2]*, Michael Fox*[3]*, Patrick Daniel*[4]*, Todd Traver*[5] *and John Benefiel*[1]*, (1)US Army Engineer Research and Development Center, Champaign, IL, (2)US Army Corps of Engineers PREP, Champaign, IL, (3)US Army Corps of Engineers, Champaign, IL, (4)Fort Leonard Wood, MO, (5)Uptime Institute, Seattle, WA*

A Tool for Modeling Energy and Resilience for Community-Scale Networks of Buildings and District Systems (VC-21-C001)
Michael Patrick O'Keefe[1]*, Peter Ellis, Member*[1]*, Richard Liesen, Ph.D., Member*[2]*, Alexander Zhivov, Ph.D.*[3] *and Anthony Latino*[4]*, (1)Big Ladder Software, Denver, CO, (2)U.S. Army Construction Engineering Research Laboratory, Champaign, IL, (3)U.S. Army Construction Engineering Research Laboratory, (4)SC-B Consulting*

Conference Paper Session 3 (Intermediate)

Best Practices for Building Envelopes and HVAC in Extreme Climates

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell
Sponsor: 7.6 Building Energy Performance
Chair: Som Shrestha, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN

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

Learning Objectives:

1. Provide an overview of USACE air leakage testing results in Alaska, and opportunities in building envelope testing strategies.
2. Identify key air leakage pathways and retrofit opportunities from lessons learned in ten years of thermal imaging and testing USACE projects in Alaska.
3. Define important building envelope commissioning strategies and construction types necessary in achieving airtight construction in new and retrofit construction.
4. Define resiliency and its importance in building design features.
5. Evaluate resilient features for commercial buildings.
6. Identify best practices for mechanical and plumbing systems within commercial buildings in arctic climates.

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

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

Building Enclosure Testing on Alaska Military Base Projects (VC-21-006)

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

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

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

Conference Paper Session 4 (Intermediate)

Effective Building Performance Characterization and Commissioning Using BIM and Machine Learning

Track: Building Performance and Commissioning for Operation and Management

Chair: Billy Austin, Shultz Engineering Group, Charlotte, NC

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

Learning Objectives:

1. Discover how the application of text-mining to CMMS (computerized maintenance management system) data can be used to uncover unexpected trends and relationships about faults in buildings.
2. classify the maintenance work-orders in terms of temporal and spatial variables, and also order classification
3. Explain how to continuously monitor infiltration rates of commercial buildings using CO2 sensing data.
4. Describe how the proposed inverse-based method addresses the limitations of conventional airtightness tests.
5. explain an overview of BIM-based FM tool
6. explain an importance of BIM-based Life-cycle Design and Commissioning in a Smart Office Building

A Text-Mining-Based Framework to Provide Room-Wise Insights into the Maintenance Performance of Buildings (VC-21-C002)

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

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

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

BIM-Based Life-Cycle Design and Commissioning in a Smart Office Building (VC-21-C003)

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

Conference Paper Session 5 (Intermediate)

Statistical Models and Machine Learning for Minimizing Energy Costs in Buildings

Track: Building Performance and Commissioning for Operation and Management

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

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

Learning Objectives:

1. Compare the various controls strategies for cooling towers
2. Understand the effect of Condenser water loop temperature on the performance of a cooling tower
3. explain that domestic cold water can be used as proxy for occupancy level for building energy inverse modeling
4. explain that the schedule made from domestic water use may better account for the use of chilled water consumption than a weekday/weekend schedule or day-of-week schedule.
5. Design deep Q learning algorithms to optimize the energy cost in building HVAC systems
6. Evaluate the performance of deep reinforcement learning algorithms via simple simulation platforms

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

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

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

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

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

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

Conference Paper Session 6 (Intermediate)

Energy Efficiency of Buildings: Code-Based Post-Installation Measurements of Control Systems for Non-Invasive Retrofits

Track: Building Performance and Commissioning for Operation and Management

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

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

Learning Objectives:

1. Discuss which multizone configuration is the most inefficient and why.
2. Discuss two pieces of equipment needed to convert a constant volume multizone system into a variable volume system.
3. Estimate the Thermal properties for residential buildings using smart Thermostat Data.
4. Describe how the Building's Attributes affects it's Thermal Behavior.
5. Describe how the in-use performance of MVHR systems are assessed
6. Provide an overview of the design objectives for MVHR systems in Ireland
7. Describe some of the common in-use issues that influence the performance of MVHR systems

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

***Eileen Westervelt, P.E., Member**[1], Christopher Battisti, P.E., Member[2], Brianna Morton[3] and David Schwenk[4], (1)USACE ERDC CERL, Champain, IL, (2)USACE ERDC CERL, Kansas City, MO, (3)USACE ERDC CERL, Champaign, IL, (4)Oak Ridge Insitiute for Science and Education, Champaign, IL*

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

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

Technical Evaluation of a Retrofitted MVHR System: Design and in-Use Performance (VC-21-C010)
Adam Cornelius O Donovan, Ph.D., Associate Member[1], *Micheál Cantillon-Murphy*[2], *Emeline Charles*[2], *Nazar Baker*[2] *and Paul D O' Sullivan*[2], *(1)Cork Institute of Technology, Cork, Ireland, (2)Cork Institute of Technology, Ireland*

Conference Paper Session 7 (Intermediate)

Energy Consumption and Potential Savings in Residential Dwellings

Track: Building Performance and Commissioning for Operation and Management

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

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

Learning Objectives:

1. Impact of financial condition on occupancy profile.
2. Who spends higher time in residential building, low income occupant or high income occupant?
3. Know about the distribution of power consumption and duration of residential appliances
4. Learn the use of appliance power data to simulate their electricity profile
5. Learn more about potential savings in electrical bills related to cooling load supply in residential houses in the mid-west region of the US
6. Identify possible variables effecting the cooling load demand and the resulting electrical bills associated with such variables

Characteristics of Residential Occupancy Profiles for Different Income Groups in the United States (VC-21-C011)
Debrudra Mitra, *Yiyi Chu and Kristen Cetin, Ph.D., P.E., Member, Michigan State University, East Lansing, MI*

Residential Occupant-Dependent Appliance Power and Time-of-Use Estimation for Grid Demand Response Applications (VC-21-C014)
Niraj Kunwar, Student Member[1], ***Soham Vanage, Student Member***[2], *Emily Peruski*[3], *Coleson White*[3] *and Kristen S. Cetin*[3], *(1)Iowa State University, Ames, IA, (2)Michigan State University, East Lansing, MI, (3)Michigan State University*

Cooling Energy Consumption Analysis and Potential Cost Savings in a Residential Unit in the Midwest Region in the US (VC-21-C012)
Maher Shehadi, Ph.D., *Purdue University, United States of America*

Evaluation of Energy Consumption and Efficiency in a Historical Residential Home before and after Building Renovations (VC-21-C013)
Jonathan Ore, Student Member, *Davide Ziviani, Ph.D., Member and Eckhard A. Groll, Purdue University, West Lafayette, IN*

Conference Paper Session 8 (Intermediate)

Modelling to Understand and Improve the Energy Efficiency of Buildings

Track: Building Performance and Commissioning for Operation and Management

Chair: Andy Cochrane, Member, Industrial Air Inc., Greensboro, NC

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

Learning Objectives:

1. Explain what Lumped Heat Capacity model for a tankless combi is
2. Describe the advantages and limitations of the LHC model
3. describe the general workflow of the proposed modular urban scale building energy modeling framework
4. describe how existing modeling tools and stock datasets can be utilized in the proposed modular urban scale building energy modeling framework

Modeling Modern, Residential, Combined Space and Water Heating Systems Using EnergyPlus (VC-21-C016)
Aleksandr Fridlyand, Ph.D., Member[1], *Alejandro Baez Guada*[1], *Tim Kingston, Member*[2] *and Paul Glanville, P.E., Associate Member*[3], *(1)GTI, Des Plaines, IL, (2)GTI, United States of America, (3)Gas Technology Institute, Chicago, IL*

A Modularized Urban Scale Building Energy Modeling Framework Designed with an Open Mind (VC-21-C015)
__Xuechen Lei, Ph.D., Associate Member__, Jeremy Lerond, Affiliate, Yunyang Ye, Ph.D., Associate Member and Jian Zhang, Ph.D., Member, Pacific Northwest National Laboratory, Richland, WA

Conference Paper Session 9 (Intermediate)

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

Track: Building Performance and Commissioning for Operation and Management

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

Buildings shelter people, goods and processes from the outdoor conditions because they create an indoor "protected" and proper environment, and this needs to occur at decreasing energy input. The first paper on ASHRAE Standard 100, Energy Efficiency in Existing Buildings, provides a methodology to increase the energy efficiency of existing building stock through best operation and maintenance procedures. The second paper extends to the implementation of artificial intelligence to make buildings fully autonomous and energy-saver. Finally, the third paper focuses on occupant-based control for HVAC systems in typical academic buildings.

Learning Objectives:

1. use typical academic building models with integrated occupancy schedules to evaluate energy saving measures
2. make informed decisions in applying appropriate control strategies to optimize building energy systems, as well as predict energy use and demand
3. Understand ENERGY STAR and Standard 100 benchmarking systems.
4. Understand the impact of climate zone and property type on building benchmarking performance.
5. Understand the problems with model-free control methods as applied to building controls.
6. Define Deep Digital Twins and how they support an autonomous buildings platform and identify the benefits of this approach.

Implementation of Occupant-Based Control in Typical Academic Buildings (VC-21-C019)
__Yiyi Chu__[1], Debrudra Mitra[2] and Kristen Cetin, Ph.D., P.E., Member[2], (1)Michigan State University, East Lansing, MI, (2)Michigan State University, United States of America

Applying ASHRAE Standard 100 to Real-World Building Data (VC-21-C017)
__Jamie Elizabeth Kono, P.E., Affiliate__[1] and Noriaki Kono[2], (1)Servidyne, Atlanta, GA, (2)Independent Researcher

Autonomous Buildings Enable Energy Efficiency (VC-21-C018) (WITHDRAWN)
__Troy Harvey, Member__, PassiveLogic, Salt Lake City, UT

Conference Paper Session 10 (Intermediate)

PV Panels, Phase-Change Materials and the Effects of the Related Equipment on Building Energy Performance

Track: Energy Conservation

Chair: Rupesh Iyengar, Ph.D., Member, Services Consultants, Bengaluru, India

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

Learning Objectives:

1. understand the intermittent and variable nature of solar PV, and comprehend the value and performance comparison between LiION battery system and gas generators as used in combination with solar PV.
2. comprehend the varying carbon intensity of the USA eGrid regions and how to use this information to compare the carbon performance of various distributed generation resources.
3. understand the design considerations for sizing a solar PV + firming solutions for a reliable firm power solution.
4. Provide an overview of dynamically change of thermal and electrical performance of the ventilated BIPV facade
5. Describe the difference in the thermal performance of the forced and naturally ventilated air-space behind the PV panels
6. Describe the influential factors that can affect the amount of heat flux passing through the wall core
7. Explain the advantage of using a ventilated air-space behind traditional external claddings

8. recognize the impact of Passive refurbishment of a small office building with PCM on energy consumption.
9. Understand the importance of selectin PCM type and thickness in different zones of the U.S.

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

Dynamic Thermal Performance of the BIPV Facades (VC-21-C021)
***Mohammad Rahiminejad**[1], Alexandre Louis Marie Pâris[2] and Dolaana Khovalyg, Ph.D., Associate Member[2], (1)École polytechnique fédérale de Lausanne, Lausanne, Switzerland, (2)École polytechnique fédérale de Lausanne, Switzerland*

Impact of the Ventilated Cavity on the Thermal Performance of Traditional Wall Structures (VC-21-C023)
***Mohammad Rahiminejad**[1] and □Dolaana Khovalyg[2], (1)École polytechnique fédérale de Lausanne, Lausanne, Switzerland, (2)École polytechnique fédérale de Lausanne, Switzerland*

An Investigation on the Impact of Retrofitting the Envelope of a Typical Small Office Building with PCM on the Building Energy Efficiency in Different Zones of the US (VC-21-C020)
***Amin Hosseini, Student Member**[1], Pouya Ammari Azar[2] and Kim Yang-Seon[2], (1)Wichita State university, Wichita, KS, (2)Wichita State university, United States of America*

Conference Paper Session 11 (Intermediate)

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

Track: Environmental Health Through IEQ sponsored by Ebtron
Chair: Nohad Boudani, PEng, Member, Sodicom, Beirut, Lebanon

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

Learning Objectives:

1. Understand how a VAV-Based HVAC and air distribution system causes cross-infection in an open office space
2. Compare the performance of a VAV-based traditional system with a proposed DOAS and radiant-based system in reducing cross-infection in an office space
3. understand more problem of pathogen distribution in office room and indoor comfort
4. critical analysis of different ventilation strategies of open space office room
5. Understand a basic framework for characterizing aerosol risk assessment of systems and options.
6. Perform basic calculations of aerosol risk.
7. Describe the effects of ventilation strategy (mixing and displacement ventilation) and air change rate on the dispersion of exhaled aerosols from the infector.
8. Understand the influence of aerosol emission mode (breathing and talking) and personal distance on the human exposure to the exhaled virus.

Investigating Air Distribution Designs for DOAS Systems to Reduce Cross-Contamination in Open Offices (VC-21-C026)
***Sama Aghniaey, Ph.D., Student Member**[1], John G. Williams[2] and Luis Rivera[3], (1)Harris, Oakland, CA, (2)Harris, (3)Harris, design studio, Oakland, CA*

Comparison of Three Different Ventilation Approaches for an Open Office Space Regarding Pathogen Distribution and Thermal Comfort by CFD (VC-21-C024)
***Maciej Danielak, Dr.Ing., Associate Member** and Oliver Höfert, Dr.Ing., Kampmann, Lingen, Germany*

Using Dilution Factor to Characterize Aerosol Risk Management in Emergency Scenarios (VC-21-C027)
***Travis Richard English**, Kaiser Permanente, Oakland, CA*

Effects of Indoor Airflow and Ventilation Strategy on the Airborne Virus Transmission (VC-21-C025)
***Gen Pei, Student Member**[1] and Donghyun Rim, Associate Member[2], (1)Pennsylvania State University, State College, PA, (2)Pennsylvania State University, University Park, PA*

Conference Paper Session 12 (Intermediate)

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

Track: Environmental Health Through IEQ sponsored by Ebtron

Chair: Arthur Giesler, PermAlert, Colleyville, TX

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

Learning Objectives:

1. To understand IAQ in Aircraft cabins
2. To undertand the computational fluid dynamics applications in thermal comfort
3. Explain the effect of outer facade shape on stadium cooling load
4. Apply CFD modelling on stadium cooling load calculation
5. Provide an overview of the integration of low-cost sensors and building control system.
6. Describe the comparison of using low-cost sensing network and using conventional wall thermostat during building thermal controls.

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

Essam Khalil, Ph.D., P.E., Fellow ASHRAE[1] *and Hassan Ali*[2]*, (1)Cairo University, Cairo, Egypt, (2)Cairo University, Egypt*

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

E. M. Elbialy, Ph.D.[1] *and Saud Ghani*[2]*, (1)Cairo University, Cairo, Egypt, (2)Qatar University, Qatar*

A Comparison of Sensing Type and Control Complexity Techniques for Personalized Thermal Comfort (VC-21-C028)

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

Conference Paper Session 13 (Intermediate)

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

Track: Environmental Health Through IEQ sponsored by Ebtron

Chair: Nivedita Jadhav, Argo Solutions, Thane, India

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

Learning Objectives:

1. 1. Describe the relative importance of ventilation configuration, volumetric airflow rate, and airflow velocity in aircraft painting operations.
2. 2. If you were tasked with designing a ventilation system to convert an existing maintenance hangar into a painting hangar, how would you apply the information from this seminar?
3. Understand the detrimental impacts or adverse re-entrainment of diesel exhaust in Hyperscale Data Centers.
4. Properly evaluate the design of the diesel generator exhaust to minimize the re-entrainment of the exhaust into Hyperscale Data Center air intakes.
5. Understand the advantages and disadvantages for testing methodologies for environmental effects on occupant's perception and function
6. Evaluate neurological activity approaches to determine environmental effects

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

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

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

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

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

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

Conference Paper Session 14 (Intermediate)

Applications of Computational Fluid Dynamics to Evaluate and Improve Ventilation

Track: Environmental Health Through IEQ sponsored by Ebtron

Chair: Ashu Gupta, tba, tba, India

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

Learning Objectives:

1. Evaluate the impact of HVAC configuration on ventilation effectiveness of enclosed parking garage ventilation system.
2. Understand how CFD analyses can help in optimizing the performance of the enclosed parking garage ventilation system.
3. Figure out the optimal types and locations of supply outlets and exhaust inlets to be used in single-family room neonatal intensive care units (SFR NICUs)
4. Compute the Air Diffusion Performance Index (ADPI) and Air Change Effectiveness (ACE) for any space using a Computational Fluid Dynamics Software
5. Understand how incubator is important for infants
6. understand how the incubator wall heater will give an extra comfortable and safety for the baby

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

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

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

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

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

***Ahmed Yasser, Member**[1] and **Dr.Hesham Safwat Osman, Member**[2], (1)British university in Egypt, cairo, Egypt, (2)British university in Egypt, Cairo, Egypt*

Conference Paper Session 15 (Intermediate)

Recent Developments in Vapor Absorption and Vapor Compression Systems

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

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

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

Learning Objectives:

1. 1. Describe operating and sustainability indicators used for assessment of working fluids in absorption refrigeration systems
2. 2. Distinguish between the steady-state performance of different working fluids used in absorption refrigeration
3. 1. Describe the main features of model-predictive control for absorption refrigeration systems
4. 2. Distinguish between the dynamic responses of different working fluids used in absorption refrigeration processes
5. Qualitatively understand how oil retention in gas lines affects the performance of a HVAC&R system
6. Gain an understanding of how to measure oil retention in vertical and horizontal gas lines of a vapor compression cycle
7. Describe operating and sustainability indicators used for assessment of working fluids in absorption refrigeration systems
8. Describe the main features of model-predictive control for absorption refrigeration systems
9. Describe how oil retention in gas lines affects the performance of a HVAC&R system

Systematic Assessment of Working Fluid Mixtures for Absorption Refrigeration based on Process and Sustainability Indicators (VC-21-C040)
Athanasios Papadopoulos[1], *Alexios-Spyridon Kyriakides*[2], *Vassilis Champilomatis*[2], *Alexandros Giannakakis*[2], *Vergis Kousidis*[2], *Mirko Stijepovic*[2], *Ibrahim Hassan, Ph.D., P.E., Member*[2] *and Panos Seferlis, Ph.D.*[1], *(1)Centre for Research and Technology Hellas, Thessaloniki, Greece, (2)Centre for Research and Technology Hellas, Greece*

Model Predictive Control Performance Assessment of Absorption Refrigeration Cycles Utilizing Different Working Fluids (VC-21-C038)
Athanasios Papadopoulos[1], *Alexios-Spyridon Kyriakides*[2], *Thomas Prousalis*[1], *Ibrahim Hassan, Ph.D., P.E., Member*[3] *and Panos Seferlis, Ph.D.*[1], *(1)Centre for Research and Technology Hellas, Thessaloniki, Greece, (2)Centre for Research and Technology Hellas, Greece, (3)Mechanical Engineering Department, Texas A&M at Qatar, Education City, Qatar*

Study of Oil Retention in Unitary Split System Gas Lines with HFC and HFO Refrigerants (VC-21-C039)
Vatsal Shah, Student Member, *James E. Braun and Eckhard A. Groll, Purdue University, West Lafayette, IN*

Investigation of a Novel Ejector-Based R-290 Refrigeration Cycle Architecture (VC-21-C037)
Junyan Ren[1], *Riley B. Barta, Student Member*[1], *Davide Ziviani, Ph.D., Member*[2], *Eckhard A. Groll*[1], *David Ladd*[3], *Christine Knox*[3] *and Gagan Salh*[3], *(1)Ray W. Herrick Laboratories, Purdue University, United States of America, (2)Ray W. Herrick Laboratories, Purdue University, West Lafayette, IN, (3)Bechtel Oil, Gas & Chemicals, United States of America*

Conference Paper Session 16 (Intermediate)

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

Track: Systems and Equipment
Chair: Scott Peach, P.E., Member, SP Engineering Inc., Mobile, AL

This session covers a wide spectrum of topics all related to air flow and energy. The first paper presents an algorithm that can be used to size a round duct for a given friction rate. The attendee may learn how sensible and latent energy can be recovered by membrane energy recovery devices (second paper). The third paper examines the effect of some environmental conditions on fire propagation between multi-carriage railcars.

Learning Objectives:

1. provide examples of environmental factors that can influence railcar fire propagation
2. explain the three phases of a fire curve
3. Describe the membrane-based ERV system, and the latent energy savings of the system.
4. Describe the need for optimal sizing of the membrane area to yield maximum net latent energy per unit of ERV membrane area.
5. Provide examples of environmental factors that can influence railcar fire propagation
6. Explain the three phases of a fire curve
7. Describe the membrane-based ERV system, and the latent energy savings of the system

Fire Propagation in Rail Environments (VC-21-C041)
Xinhe (Lily) Liu, Affiliate[1], *Emil Persson*[2] *and Matthew Bilson*[2], *(1)WSP USA, New York, NY, (2)WSP, United States of America*

Using Normalized Net Energy Savings to Effectively Size Membrane-Based Energy Recovery Ventilation Systems (VC-21-C042)
Sancheyan Pushparajah[1], *Patrick Ryan*[2], *Krzysztof Kobus, Ph.D., Member*[1] *and* ***Jonathan Maisonneuve, Ph.D., Associate Member***[1], *(1)Oakland University, Rochester, MI, (2)DTE Energy Co., Detroit, MI*

Sizing Ducts Based on a Prescribed Friction Rate (VC-21-008)
Stephen Idem, Ph.D., Member *and Chaitanya Kodali, Tennessee Tech University, Cookeville, TN*

Conference Paper Session 17 (Intermediate)

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

Track: Energy Conservation
Chair: Christine Reinders-Caron, Member, Iowa State University, Omaha, IA
Direct-fired absorption heat pumps, providing hot water and A/C, help save energy and money in facilities operating for most of the day, for instance, in full-service restaurant (1st paper). The energy-saving potential stemming from better knowledge of the

heat transfer processes occurring in round-tube plate-fin and place heat exchangers are presented in the 2nd and 3rd paper, respectively.

Learning Objectives:

1. Define the benefits of thermal heat pumps as applied to commercial water heating.
2. Understand some of the design tradeoffs when sizing the heat pump component in an integrated system.
3. Understand the difference between the three zone and the five zone model.
4. Apply this five zone model to commercial heat exchanges
5. Measure local heat transfer coefficient in the plate heat exchanger.
6. Visualize flow regime in plate heat exchangers.

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

Paul Glanville, P.E., Associate Member[1]*, Isaac Mahderekal, Ph.D., Member*[2]*, Michael Mensinger Jr.*[3]*, Luke Bingham*[3] *and Chris Keinath, Ph.D., Member*[4]*, (1)Gas Technology Institute, Chicago, IL, (2)Gas Technology Institute, Davis, CA, (3)GTI, Chicago, IL, (4)SMTI, Johnson City, TN*

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

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

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

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

Conference Paper Session 18 (Intermediate)

Modelling for the Estimation of Energy Performance of Buildings and Products

Track: Building Performance and Commissioning for Operation and Management

Chair: Bert Phillips, UNIES Ltd., Winnipeg, MB, Canada

Buildings and HVAC systems are fundamental for the comfort of people and to guarantee the proper space conditions for a variety of processes. The first paper describes the building design methods of Standard 90.1-2016. The second paper explains how the actual consumption values can be measured on-site through sensors and monitoring systems. Papers two and three shed light on how fan coils can be modelled to predict their energy consumption. Finally, paper #5 presents the updated database of western clothing as used in ANSI/ASHRAE Standard 55-2013 to estimate the comfort level of persons in a conditioned space.

Learning Objectives:

1. Assess the energy savings of fan-coil units with electronically commutated motors.
2. Understand the need for detailed performance models for fan-coil units.
3. assess which type of model is more accurate and/or cost efficient in predicting the commercial building cooling load modeling and prediction.
4. learn how to use smart meter data to calibrate physics-based models to improve the accuracy.
5. Understand the new Performance Rating Method in ASHRAE 90.1-2016
6. Limitations faced by authors in implementing the new PRM approach
7. Describe the part-load performance of fan-coil units with electronically commutated motors.
8. Distinguish the difference between the part-load performance of fan-coil units with permanent split capacitor and electronically commutated motors.
9. Understand why the existing tables with clothing insulation required updating, given the development of manikins to a greater level of sophistication.
10. Be able to apply standard 55 in conditions where the person is not static, or the air movement exceeds 0.2 m.s-1.

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

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

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

Vahid AhmadiKalkhorani, Student Member[1] *and Jordan Clark, Ph.D., Member*[2]*, (1)The Ohio State University, Columbus, OH, (2)Ohio State University, Columbus, OH*

Challenges with the New ASHRAE 90.1 Performance Rating Method (VC-21-C046)
Jagan S. Pillai, P.E., BEMP, Member[1]*, Devanshi Dadia*[2]*, Shivani Shah, Member*[2] *and Jennifer Chalos*[2]*, (1)Atelier Ten, New York, NY, (2)Atelier Ten, United States of America*

Part-Load Airflow and Power Model of Multi-Speed Fan-Coil Units with Electronically Commutated Motors (VC-21-010)
Dennis O'Neal, Ph.D., P.E., Fellow ASHRAE[1]*, Jessica Cramer*[1] *and Peng Yin, Ph.D., Associate Member*[2]*, (1)Baylor University, Waco, TX, (2)University of Louisiana at Lafayette, Lafayette, LA*

Updated Database of Clothing Thermal Insulation and Vapor Permeability Values of Western Ensembles for Use in ASHRAE Standard 55, ISO 7730 and ISO 9920; Results of ASHRAE RP-1760 (VC-21-011)
George Havenith, Ph.D.[1]*, Simon Hodder, Ph.D.*[2]*, Kalev Kuklane*[3] *and Dennis Loveday, Ph.D.*[2]*, (1)Loughborough University, Loughborough, Leics, United Kingdom, (2)Loughborough University, Loughborough, United Kingdom, (3)Lund University, Lund, Sweden*

Conference Paper Session 19 (Intermediate)

Standards and Protocols for Buildings' Energy and Water Usages

Track: Standards, Guidelines and Codes

Chair: Nohad Boudani, PEng, Member, Sodicom, Beirut, Lebanon

Buildings use not only energy to run their technical systems (HVAC, lighting, etc.) but also water, be it for human consumption, or for HVAC purposes, or for its landscape. This session presents building performance standards focusing on building energy usage (first paper), on performance methods to measure air leakages (second paper) and on performance measurement protocols to measure water consumption in commercial buildings.

Learning Objectives:

1. Contribute to and support technical development of building performance standards
2. Understand the difference between using a energy-based metric and an emissions-based metric for measuring compliance with a building performance standard
3. Describe the proposed Zonal Multipoint Pressure Testing (ZMPT) method and how it uses airflow and pressure data to calculate external and internal infiltration in buildings.
4. Identify the basic state of the art pressurization infiltration testing methods and distinguish between them and the proposed Zonal Multipoint Pressure Testing (ZMPT) method.
5. Describe the procedures for testing the water PMP in various buildings.
6. Explain what the challenges are in conducting experiments following the PMP.

The Technical Basis of Building Performance Standards (VC-21-C049)
Jim Edelson, Associate Member[1] *and Kim Cheslak*[2]*, (1)New Buildings Institute, Portland, OR, (2)New Buildings Institute, United States of America*

Advanced Zonal Infiltration Measurement Method for Multifamily Buildings: A Novel Test Procedure to Determine Air Leakage through External and Internal Surfaces (VC-21-C048)
Tharanga Jayarathne, Student Member[1]*, Michael A. Browne*[2] *and Michael Gevelber, Ph.D., Member*[1]*, (1)Boston University, Boston, MA, (2)Advanced Building Analysis, Amesbury, MA*

Implementation and Evaluation of ASHRAE's Water Performance Measurement Protocols (VC-21-012)
Gabrielle McMorrow, Associate Member[1]*, Liping Wang, Ph.D., P.E., Member*[1] *and Xiaohui Zhou, Ph.D., P.E., Member*[2]*, (1)University of Wyoming, Laramie, WY, (2)Seventh Wave, Madison, WI*

Conference Paper Session 20 (Intermediate)

Handling Environmental Effects on Ventilation Systems

Track: Environmental Health Through IEQ sponsored by Ebtron

Chair: Scott Peach, P.E., Member, SP Engineering Inc., Mobile, AL

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

Learning Objectives:

1. Apply proposed framework to mixed-mode ventilation buildings to optimize control sequences and save energy

2. Optimize window operations in mixed-mode ventilation buildings with manually operable windows
3. Explain the current limitations of fire detection devices within the rail tunnel environment
4. Describe the comparative performance of different technologies based on live testing
5. Describe key motivations behind human-window and human-blinds controls from a user perspective
6. Describe the link between subjective self-reported motivations behind human-building interactions and evidence from objective measurements (based on the specific case study)

Investigating Occupant Behavior to Inform Terminal Devices' Control in Mixed-Mode Ventilation Buildings (VC-21-C052)
__Weihao Liu, Student Member__[1], Burak Gunay, Ph.D., Associate Member[1] and Mohamed Ouf, Associate Member[2], (1)Carleton University, Ottawa, ON, Canada, (2)Concordia University, Montreal, QC, Canada

Fire Detection and Ventilation Response in Rail Tunnels (VC-21-C050)
__Andre Calado, Member__, Jacobs Engineering, New York, NY

Global Environmental Stimuli and Human-Building Interaction in Open Space Offices: A Swiss Case Study (VC-21-C051)
__Verena M. Barthelmes, Ph.D.__[1], Caroline Karmann, Ph.D.[1], Viviana Gonzalez Serrano[1], Arnab Chatterjee[2], Marilyne Andersen, Ph.D.[1], Jan Wienold, Ph.D.[1], Dusan Licina, Ph.D., Associate Member[1] and Dolaana Khovalyg, Ph.D., Associate Member[2], (1)EPFL, Switzerland, Fribourg, Switzerland, (2)EPFL, Switzerland, Switzerland

Conference Paper Session 21 (Intermediate)

Air Filters and Motors in HVAC Systems

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

Learning Objectives:

1. Provide an overview of gaseous by-products generated from the UV-PCO process
2. Explore the correlations between PCO by-products and operational conditions
3. Understand the causes and effects of harmonics in common types of variable frequency drives used in chillers and air handlers – the standard 6-pulse diode front end drive.
4. Compare today's most effective harmonic mitigation technologies, which include passive harmonic filters, active harmonic filters, and active front end drives
5. Demonstrate the impact of the VFD output PWM power on the motor power factor and efficiency
6. Demonstrate the impact of the variable VFD output voltage on the motor efficiency

Gaseous By-Products Generated from UV-PCO Process: A Review (VC-21-C055)
__Jing Wu, Student Member__, Anu Stella Mathews, Ph.D., Member and __Lexuan Zhong, Ph.D., P.E., Member__, University of Alberta, Edmonton, AB, Canada

A Technology Review of Harmonics in HVAC Applications (VC-21-C053)
__Ian Wallace__[1], Theresa Hietpas[2] and Ashish Bendre, Ph.D.[1], (1)TCI, LLC, Milwaukee, WI, (2)TCI, LLC, United States of America

Experimental Investigation of Induction Motor Power Factor and Efficiency Impacted by Pulse Width Modulation Power and Voltage Controls of Variable Frequency Drives (VC-21-013)
__Gang Wang, P.E., Member__[1] and Zhitao Han[2], (1)University of Miami, Coral Gables, FL, (2)Northeast Forestry University, Harbin, China

Conference Paper Session 22 (Intermediate)

Heat Pump Feasiblity and Field Issues

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell
Chair: Vikrant Aute, Member, University of Maryland, College Park, MD
The first paper presents a study that performed a county-level analysis to identify the economically favorable regions in the U.S. for using ducted air-source heat pumps for space heating in residential buildings. The second paper presents a modified heat

pump cycle that aims at providing continuous heating operation even below the freezing point, which was not possible with conventional processes. The third paper presents an experimental study to evaluate the impact of frost among heat exchanger fin types and densities under multiple air moisture conditions.

Learning Objectives:

1. Describe the effects of non-condensables in refrigerant line set
2. Identify possible pathways for non-condensables to enter the refrigerant line set
3. Describe a refrigerant circuit serving to perform continuous heating
4. Explain the optimal way to control the pressure of the refrigerant for defrosting
5. Understand the economic viability of residential air-source heat pumps for customers in different regions of the United States.
6. Understand how electric utilities can prioritize heat pumps in their building space heating electrification efforts.
7. Understand the performance impact, under frosting conditions, for tube-fin heat exchangers with different fin patterns.
8. Understand the performance impact, under frosting conditions, for tube-fin heat exchangers with superhydrophobic and icephobic coatings.
9. Learn about frost testing conditions matrix to evaluate frost development in different environments and coil types.

Assessment of Mini-Split Heat Pump Performance with Non-Condensable Gas in Line-Set (VC-21-C056)
Aaron Tam[1] *and* ***Ronald Domitrovic***[2]*, (1)Electric Power Research Institute, Palo Alto, CA, (2)Electric Power Research Institute, United States of America*

Development of a Continuous Heating Technology for Air Source Heat Pumps (VC-21-C057)
Naofumi Takenaka[1]*, Kazuya Watanabe*[2]*, Takeshi Hatomura*[3]*, Shohei Ishimura*[1] *and Shinichi Wakamoto*[3]*, (1)Mitsubishi Electric Corporation, Amagasaki, Japan, (2)Mitsubishi Electric Corporation, Shizuoka, Japan, (3)Mitsubishi Electric Corporation, Wakayama, Japan*

Where Are Today's Residential Heat Pump Technologies Cost-Effective? (VC-21-C059)
Brandon Johnson *and Sreenidhi Krishnamoorthy, Electric Power Research Institute, Knoxville, TN*

Experimental Evaluation of Frost Development on Tube-Fin Heat Exchangers: Fin Types, Fin Densities, SuperHydrophobic and Icephobic Coatings (VC-21-C058)
Sara S. Beaini, Ph.D., Member[1]*, Song Li, Associate Member*[2]*, Daniel Bacellar*[3]*, Colin Lee*[1]*, Evan Hess*[1]*, Dennis Nasuta, Associate Member*[4]*, Cara Martin, BEMP, Associate Member*[3] *and James Leverette*[5]*, (1)Electric Power Research Institute, Palo Alto, CA, (2)Optimized Thermal Systems, College Park, MD, (3)Optimized Thermal Systems, Inc, College Park, MD, (4)Optimized Thermal Systems, Inc, Beltsville, MD, (5)Southern Company Services, Inc., Birmingham, AL*

Conference Paper Session 23 (Intermediate)

Developments in Chiller System Operations

Track: Refrigeration and Refrigerants

Chair: Bert Phillips, UNIES Ltd., Winnipeg, MB, Canada

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

Learning Objectives:

1. Think critically about condenser water set-point control in existing and new chilled water systems
2. Get a general idea of condenser water set-point control best-practices for a few building types and weather regions.
3. Describe the process of accurate HVAC component modeling
4. Designing an optimization algorithm to optimize the performance of HVAC systems that will lead to energy savings
5. Gain an appreciation for key factors that affect cooling tower water use and operating cost (i.e. achievable cycles of concentration, source water quality, water supply and sewer charges, and consumable costs for working fluid maintenance)
6. Understand the pros and cons of using a hygroscopic fluid versus water in a cooling tower (pro: save blowdown water and some of the evaporative water, inherent microbiological control, relatively insensitive to water quality; con: limited to closed circuit applications, evaporative water savings dependent on weather and operating schedule, need further refinement of dissolved solids control)
7. Explain how lift and load relationships affect the likelihood of chiller surge.
8. Explain how temporary setpoint resets can improve equipment operations and ease mode transitions.

Condenser Water Optimization: Don't Let Perfect be the Enemy of Good! (VC-21-C061)
AbdulQayyum Mohammed, P.E., Member[1], *Mohamed Tatari*[2] *and Neil Wittberg*[1], *(1)Go Sustainable Energy LLC, Worthington, OH, (2)Go Sustainable Energy LLC, United States of America*

Chilled Water VAV Systems Operation Optimization Using a Two-Level Optimization Approach (VC-21-C060)
Rand Talib, Student Member[1], *Nabil Nassif*[2] *and Mostafa Tahmasebi*[2], *(1)University of Cincinnati, Cincinnati, OH, Cincinnati, OH, (2)University of Cincinnati, Cincinnati, OH, United States of America*

Demonstration of Hygroscopic Cooling Towers for Reduced HVAC Water Consumption (VC-21-C062)
Scott Lux[1] *and Christopher Martin*[2], *(1)U.S. Army ERDC-CERL, Champaign, IL, (2)Energy & Environmental Research Center*

Easing Transitions between Flat Plate and Chiller: Strategies to Reduce Chiller Surge and Maintain Building Load Efficiently (VC-21-C063)
Bryan Lang, P.E., Member *and* ***Chris Jackson, P.E.***, *ETC Group, LLC, Tempe, AZ*

Conference Paper Session 24 (Intermediate)

Superheat Regulation, Radiant Systems and District Energy Systems

Track: Systems and Equipment

Chair: Anoop Peediayakkan, tba, kuwait, Kuwait

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

Learning Objectives:

1. Application of PCM with better accumulation capacity than hot water in floor radiant heating system
2. Design and Construction of the Existing Floor Radiant Heating System (Hot Water) and PCM Radiant Heating System
3. Comparison of Thermal Storage (Hot Water vs PCM) in Heating Condition (on-off) Comparison of Time-lag, Floor Surface Temperature and Indoor Air Temperature
4. Identify an alternative method to controlling the evaporator superheat in the refrigeration vapor compression cycle since this function is carried out in traditional systems by the thermostatic expansion valve or electronic expansion valve.
5. Describe an alternative method for superheat control associated with the refrigeration vapor compression cycle.
6. Apply the tested wall system in a room under summer and winter conditions
7. Describe the thermal output of the tested system in heating and cooling mode
8. Provide an overview of the potential benefits of the radiant wall system tested
9. understand how to integrate high and low temperature heat networks
10. describe the benefits of ambient temperature networks
11. Define advanced district thermal energy systems and identify potential benefits of such systems relative to building-level heating and cooling systems, and earlier generations of district thermal energy systems.
12. explain the potential benefits of network topology optimization in the context of district thermal energy systems.

Time-Lag Analysis of PCM in Floor Radiant Heating System (VC-21-C068)
Jin Chul Park, Ph.D., BEAP, BEMP and HBDP, Member, *Seong eun Kim and Sung ho Choi, Chung-Ang University, Seoul, Korea, Republic of (South Korea)*

Superheat Regulation and Efficiency Improvement for Refrigeration Vapor Compression System (VC-21-C066)
Mohamad Yehia Itani, P.Eng., Member, *Climacond Middle East SAL, Beirut, Lebanon*

Testing of a Wall Heating and Cooling System with Pipes Attached to Thermally Insulating Core (VC-21-C067)
Dušan Petráš, Ph.D., Member, *Michal Krajčík and Martin Šimko, Slovak University of Technology, Faculty of Civil Engineering, Slovak Republic*

Integration of High Temperature Heat Networks with Low Carbon Ambient Loop Systems (VC-21-C065)
Ana Catarina Marques, Ph.D.[1], *Chris Dunham*[2], *Akos Revesz, Ph.D., Affiliate*[1], *Phil Jones, Ph.D.*[3] *and Graeme Maidment, Ph.D., P.E.*[1], *(1)London South Bank University, London, United Kingdom, (2)Carbon Descent Projects, chrisd@carbondescent.org.uk, (3)London South Bank University*

Evaluation of Topology Optimization to Achieve Energy Savings at the Urban District Level (VC-21-C064)
Amy Elizabeth Allen, P.E., Associate Member[1], *Gregor Henze, Ph.D., P.E., Member*[2], *Kyri Baker, Ph.D.*[2], *Gregory Pavlak, Ph.D., Member*[3] *and Michael Murphy*[4], *(1)University of Colorado/NREL, Boulder, CO, (2)Department of Civil, Environmental, and Architectural Engineering, University of Colorado-Boulder; Commercial Buildings Research Group, National Renewable Energy Laboratory; Renewable and Sustainable Energy Institute, (3)Pennsylvania State University, State College, PA, (4)Cork Institute of Technology*

Conference Paper Session 25 (Intermediate)

Building Design: International Perspective

Track: International Design

Chair: Rupesh Iyengar, Ph.D., Member, Services Consultants, Bengaluru, India

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

Learning Objectives:

1. explain the A/C system of a latest office building in Tokyo,Japan.
2. describe a new through-wall air conditioners designed to achieve superior comfort and air quality, where the interior breathes.
3. Design a displacement ventilation system for high ceiling auditoriums.
4. Describe the various criteria and parameters which would define a successful displacement ventilation system

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

Hirotaka Kubo, Associate Member[1]*, Shiro Tsukami, BCxP, BEAP, BEMP, HBDP, HFDP and OPMP, Member*[2]*, Iwao Hasegawa, Associate Member*[2] *and Masayuki Ichinose*[3]*, (1)NIKKEN SEKKEI LTD, Tokyo, Japan, (2)NIKKEN SEKKEI LTD, Chiyoda-ku Tokyo, Japan, (3)Tokyo Metropolitan University, Hachiouji-shi Tokyo, Japan*

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

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

Conference Paper Session 26 (Intermediate)

Improving Performance of Systems and Equipment

Track: Systems and Equipment

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

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

Learning Objectives:

1. Design the indoor environment for plant growth in indoor farming facilities.
2. Provide an overview of the main challenges for the applicability of hydroponic facilities in remote northern communities.
3. Identify some alternative inlet duct configurations to the standard inlet duct configuration but with reduced lengths.
4. Identify some effects that might affect the repeatability of equipment testing.
5. Explain the level of performance enhancement of a flat plate solar collector deploying nanofluid
6. Distinguish various losses occurring in a solar collector during its operation
7. Understand the underlying problems involved in a flat-plate solar collector

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

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

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

Khaled Alghamdi, Student Member[1] *and Christian Bach*[2]*, (1)Oklahoma State University, Stillwater, OK, (2)Oklahoma State University, United States of America*

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

Tarashri Anand Tirtha, Student Member[1] *and Amir Fartaj, Ph.D., P.E., Member*[2]*, (1)University of Windsor, windsor, ON, Canada, (2)University of Windsor, Windsor, ON, Canada*

Seminar 36 (Intermediate)

A Revolution in Buildings: Prefabricated Radiant Structures

Track: Systems and Equipment

Sponsor: 6.5 Radiant Heating and Cooling

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

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

Learning Objectives:

1. Define how projects requiring prefabrication can leverage radiant heating and cooling technology.
2. Describe why prefabricated radiant structures are important tools for the construction industry in the 21st Century.
3. Explain how modular buildings and radiant heating and cooling increase building resiliency and efficiency.
4. Describe the time and cost benefits of integrating mechanical services into pre-fabricated panels.
5. Define how projects requiring prefabrication can leverage radiant heating and cooling technology.
6. Describe why prefabricated radiant structures are important tools for the construction industry in the 21st Century.
7. Explain how modular buildings and radiant heating and cooling increase building resiliency and efficiency.
8. Explain how radiant heating and cooling can integrate into a modular building system
9. Describe the benefits of modular pre-cast building with integrated radiant
10. Apply the concept of radiant cooling to modern modular building systems

Integrating Radiant Panels with Offsite Construction
Devin Abellon, P.E., Member*, Uponor, Centennial, CO*

New Wave: Innovating with Radiant Systems and Prefabricated Mass Timber
Stuart Bridgett, Associate Member*, Sidewalk Labs, New York, NY*

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

Seminar 37 (Basic)

ASHRAE Conference Crash Course

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

Sponsor: YEA

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

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

Learning Objectives:

1. Understand ASHRAE's organizational structure
2. Understand Standing Committees and Technical Committees
3. Understand ASHRAE Conference Social and Networking Events
4. Understand the AHR Expo
5. Understand ASHRAE’s Organizational Structure
6. Understand Standing Committees and Technical Committees
7. Understand YEA
8. Understand ASHRAE Conference Social and Networking Events
9. Understand the AHR Expo

The Ins and Outs of ASHRAE
Jessica Renner, P.E., BEMP, Member*, Energy Studio, Inc, Omaha, NE*

Make the Most of Your Conference Experience
Madison Schultz, P.E., Member, *OK BeCo, Oklahoma City, OK*

Seminar 38 (Intermediate)

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

Track: Energy Conservation

Sponsor: 1.4 Control Theory and Application

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

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

Learning Objectives:

1. After this presentation the participants will be better informed to make choices on design method-ology, in particular, the benefits of MPC and Rule Based Controls and what questions that must be addressed in choosing the methodology for practical implementation.
2. What are autonomous building systems, and how do digital twin based control systems work.
3. Understand the characteristics of model based predictive control for high performing grid interactive efficient buildings, and implementation options.
4. Understand the concepts of a grid interactive energy efficient buildings and why the ability to have demand flexibility is critical for a more resilient and sustainable grid.
5. Describe the main characteristics of model based predictive control methods.
6. Describe the types of models that can be used to make predictions.
7. Explain what are the characteristics of a grid-interactive efficient building.

Why and How You Should Make Model-Based Predictive Control Work for You?
Draguna Vrabie, Ph.D., *Pacific Northwest National Laboratory,, Richland, WA*

Foundations of Autonomous Building Systems Using Digital Twin Based Control (WITHDRAWN)
Troy Harvey, Member, *PassiveLogic, Salt Lake City, UT*

A Use Case Perspective on Building Controls: MPC and Rule-Based Methodology and Practice (WITHDRAWN)
Joseph Noworatzky, *Automated Logic / Carrier, Marietta, GA*

Seminar 39 (Intermediate)

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

Track: Standards, Guidelines and Codes

Sponsor: 6.7 Solar Energy Utilization, 4.5 Fenestration

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

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

Learning Objectives:

1. Identify regulatory and technical challenges for the development and adoption of standards, guidelines and codes for solar systems in buildings
2. Have a comprehensive understanding of the impact of PV windows on building energy performance and occupant comfort
3. Estimate the recovery time of embodied energy from operational energy savings for popular solar systems
4. Better evaluate the economic model for building-integrated photovoltaic systems

5. Estimate the recovery time of embodied energy from operational energy savings for popular solar systems
6. Identify regulatory and technical challenges for the development and adoption of standards, guidelines and codes for solar systems in buildings

The Dawn of PV Windows: Is the World of Standards and Codes Ready for Them?
Charlie Curcija, Ph.D., Member*, Lawrence Berkeley National Laboratory, Berkeley, CA*

Embodied Energy for Solar Energy Systems in Buildings: Operational Savings and Recovery Time Guidelines
Constantinos Balaras, Ph.D., Fellow ASHRAE*, National Observatory of Athens (NOA), Athens, Greece*

Seminar 40 (Intermediate)

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

Track: International Design

Sponsor: 6.7 Solar Energy Utilization, 4.4, 7.6

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

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

Learning Objectives:

1. Develop a comprehensive understanding of what Building-Integrated Photovoltaic (BIPV) is.
2. Provide an overview of technical solutions for effectively designing, implementing and operating BIPV.
3. Identify the key requirements for integration of BIPV systems with HVAC and the building envelope.
4. Describe how BIPV affects building operations and performance, and building interaction with the grid.
5. Develop a comprehensive understanding of what Building-Integrated Photovoltaic (BIPV) is.
6. Provide an overview of technical solutions for effectively designing, implementing and operating BIPV.
7. Identify the key requirements for integration of BIPV systems with HVAC and the building envelope.
8. Describe how BIPV affects building operations and performance, and building interaction with the grid.
9. Provide an overview of technical solutions for effectively designing, implementing and operating BIPV.
10. Identify the key requirements for integration of BIPV systems with HVAC and the building envelope.
11. Provide an overview of technical solutions for effectively designing, implementing and operating BIPV.
12. Describe how BIPV affects building operations and performance, and building interaction with the grid.

BIPV for Net-Zero Energy Institutional Building: Energy Efficiency, Energy Conservation and Solar Energy Generation
Andreas Athienitis, Ph.D., P.E., Fellow ASHRAE*, Concordia University, Montreal, QC, Canada*

BIPV for Industrial Buildings: When the Photovoltaic Envelope Becomes Part of the HVAC System
Véronique Delisle, Ph.D.*, Natural Resources Canada, Varennes, QC, Canada*

BIPV for Convention Center Retrofit: Balancing Solar Gains and Solar Electricity Generation
Diego Cuevas*, Onyx Solar, New York, NY*

Seminar 43 (Advanced)

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

Track: Refrigeration and Refrigerants

Sponsor: 3.2 Refrigerant System Chemistry

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

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

Learning Objectives:

1. Understand what work has been completed in the area of the Compatibility of Low GWP Refrigerants with Plastics, Elastomers and Compressor Materials and Thermal Stability of Low GWP Refrigerants and their Compatibility with Lubricants. Also, what knowledge gaps exists here within
2. To see test data & conclusions on thermal and chemical stability of low GWP refrigerants with lubricants and their long-term compatibility with materials commonly used in air-conditioning and refrigeration systems.
3. Understand the importance of maintaining chemical stability within refrigeration and air conditioning systems.
4. Determine measurable differences between the stability of current HFC refrigerants and lower GWP candidates.
5. understand the current research scope
6. understand the planned future work
7. 1. Provide an overview of existing studies on the compatibility of low GWP refrigerants with plastics, elastomers and compressor materials.
8. 2. Identify issues and knowledge gaps regarding the compatibility of low GWP refrigerants with plastics, elastomers and compressor materials.
9. 1. Provide an overview of existing studies on the thermal and chemical stability of low GWP refrigerants with lubricants
10. 2. Identify issues and knowledge gaps regarding the thermal and chemical stability of low GWP refrigerants with lubricants
11. Understand the importance of maintaining chemical stability within refrigeration and air conditioning systems.
12. Determine measurable differences between the stability of current HFC refrigerants and lower GWP candidates.

An Update on Low GWP Refrigerant Material Compatibility and Lubricant Research
Xudong Wang, Ph.D., Member*, Air-Conditioning, Heating and Refrigeration Technology Institute, Arlington, VA*

A Review of the Compatibility of Low GWP Refrigerants with Plastics, Elastomers and Compressor Materials
Rosine Rohatgi, Ph.D., Member*, Spauschus Associates Inc., Atlanta, GA*

A Review of the Thermal Stability of Low GWP Refrigerants and Their Compatibility with Lubricants
Rosine Rohatgi, Ph.D., Member*, Spauschus Associates Inc., Atlanta, GA*

Understanding Stability Limits and System Chemistry in Low GWP Refrigerant Applications
Joe Karnaz, DSc, Member*, Shrieve Chemical, Houston, TX*

Seminar 44 (Intermediate)

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

Track: International Design

Sponsor: 6.7 Solar Energy Utilization, 2.5, 7.5

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

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

Learning Objectives:

1. identify regulatory and technical challenges for the implementation of smart grid technologies
2. recognize the effective integration of distributed energy resources (DER) to support the grid
3. showcase innovative, scalable solutions to limit the energy and environmental footprint of communities
4. develop a comprehensive understanding of necessary steps taken to address energy poverty
5. identify technical challenges for the implementation of smart grid technologies
6. recognize the effective integration of distributed energy resources (DER) to support the grid
7. recognize the effective integration of distributed energy resources (DER) to support the grid
8. showcase innovative, scalable solutions to limit the energy and environmental footprint of communities

Transforming a City into an Interactive Grid
Dave Turcotte*, Natural Resources Canada, Varennes, QC, Canada*

Building the Future through Canada's First Net-Zero Community
***Milfred Hammerbacher**, S2E, St Jacobs, ON, Canada*

Seminar 45 (Basic)

Demystifying Thermal Load Calculations for New HVAC&R Engineers

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell
Sponsor: 4.1 Load Calculation Data and Procedures
Chair: Rachel Spitler, Associate Member, Cyntergy, Tulsa, OK
Load calculations are one of the first tasks young engineers are assigned, but they can be intimidating to tackle. This seminar seeks to provide a clear foundation in load calculations for those new to the industry. Topics covered in this seminar include the history of and science supporting load calculations, helpful resources and tips to remember, as well as how to manage uncertainties and common pitfalls to avoid.

Learning Objectives:

1. Understand the purpose of performing HVAC&R load calculations well.
2. Understand the basic fundamental thermal sciences behind load calculations.
3. Understand the development and application of the various calculation techniques.
4. Identify which codes and standards have an impact on load calculations.
5. Understand the purpose of performing HVAC&R load calculations well
6. Understand the fundamental thermal sciences, etc. behind load calculations
7. Understand the development and application of the various calculation techniques
8. identify which AHRAE codes and Standards are used for Load Calculations.
9. locate sections from ASHRAE Handbooks used for identifying specific loads for load calculation.

Introduction to HVAC Heating and Cooling Loads' Calculations
***Brian Rock, Ph.D., P.E., Fellow ASHRAE**, The University of Kansas, Lawrence, KS*

Resources and Guidelines for Load Calculations
***Vrunda Patel, Associate Member**, Jacobs, Dallas, TX*

Avoiding Pitfalls and Managing Uncertainties: Tips for Better Loads
***Cindy Cogil, P.E., Fellow ASHRAE**, SmithGroup, Chicago, IL*

Seminar 47 (Intermediate)

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

Track: Building Performance and Commissioning for Operation and Management
Sponsor: 7.6 Building Energy Performance, 1.5 Computer Applications
Chair: Stephen Roth, P.E., Member, Carmel Software, San Rafael, CA
The term "building data exchange" has been used for a decade to describe the transfer of data between different software tools used during various stages of building design. Field of data exchange is complex with no single solution that works for all use cases. This seminar addresses the following issues related to building data exchange: The current state of data exchange from the perspective of the auditing engineer, how ASHRAE Building EQ takes advantage of interoperability to allow for easier data input and what is being done to improve interoperability schemas so that workflows are smoother between software tools.

Learning Objectives:

1. Describe why BIM and building analysis software interoperability is important for designing energy efficient buildings.
2. Describe what steps are being taken to improve interoperability schemas so information can seamlessly be transferred between different software tools.
3. Describe how the ASHRAE Building EQ rating system is taking advantage of data interoperability.
4. Talk about some of the different interoperability schemas for building energy analysis, commercial building energy audits, and residential energy audits and how they differ.
5. understand the difference between structured and unstructured data.
6. understand how a use case can be used to determine which parts of the dataset are required.

7. After attending this session, attendees will be able to explain how data standards can improve the efficiency of calculating "credentialed" energy savings.
8. After attending this session, attendees will be able to describe the schemas that support residential and commercial energy audits.
9. Describe why BIM and building analysis software interoperability is important for designing energy efficient buildings.
10. Describe what steps are being taken to improve interoperability schemas so information can seamlessly be transferred between different software tools.

The State of Building Data Exchange for Energy Analysis
***Nicholas Long, P.E., Member**, National Renewable Energy Laboratory, Golden, CO*

Methods for Reducing the Cost of Delivering ASHRAE Building EQ Scores
***Chris Thomas**, Performance Systems Development, Ithaca, NY*

Why BIM and BEM Software Interoperability Is More Important Than Ever and What Is Being Done to Improve It
***Stephen Roth, P.E., Member**, Carmel Software, San Rafael, CA*

Seminar 49 (Intermediate)

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

Track: Environmental Health Through IEQ sponsored by Ebtron
Sponsor: 4.3 Ventilation Requirements and Infiltration
Chair: Marianne F Touchie, Ph.D., P.E., Associate Member, University of Toronto, Toronto, ON, Canada
Providing reliable ventilation throughout multifamily buildings is essential to maintaining acceptable indoor air quality. Driven by stack and wind effects, uncontrolled air movement across the building envelope and between suites makes it difficult to evenly distribute ventilation air to all suites and leads to excessive energy use, thermal comfort issues and challenges with odor, pollutant, sound and pest transmission. This seminar provides 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 is discussed.

Learning Objectives:

1. Discuss how to use building depressurization techniques, fan-compensated flow measurements, and differential tracer gas methods to assess component air leakage, ventilation system performance, and inter-suite pollutant transport.
2. Describe the effects of building configuration and mechanical system design intent as well as weather and occupant operational decisions on actual suite ventilation.
3. Discuss the consequences of uncontrolled air flow in apartment buildings.
4. Explain the opportunities to improve suite ventilation in existing buildings.
5. Describe how to use building depressurization techniques, fan-compensated flow measurements, and differential tracer gas methods to assess component air leakage, ventilation system performance, and inter-suite pollutant transport.
6. Describe the effects of building configuration and mechanical system design intent as well as weather and occupant operational decisions on actual suite ventilation.
7. Describe the consequences of uncontrolled air flow in apartment buildings and explain the opportunities to improve suite ventilation in existing buildings.
8. Understand how different ventilation configurations in MURBS are impacted by stack effect.
9. Describe the different behavior within apartment suites associated with occupant activities like opening a window.
10. Consider the strength of pressures present in tall apartment buildings.
11. describe the metrics used to quantify air leakage.
12. describe the influence that interzonal air leakage has on whole-suite air leakage

Suite Ventilation Characteristics of Ten Existing Canadian Multi-Unit Residential Buildings
***Craig Wray, P.Eng., Member**, Consulting Engineer, Winnipeg, MB, Canada*

Relative Performance of Different Ventilation Configurations in Multi-Unit Residential Buildings in North America
***Duncan Phillips, Ph.D., P.E., Associate Member**, RWDI, Guelph, ON, Canada*

Suite-Based Air Leakage Characteristics of New and Old Multi-Unit Residential Buildings
***Marianne Touchie, Ph.D., P.E., Associate Member**, University of Toronto, Toronto, ON, Canada*

Seminar 50 (Basic)

Elevator Noise, Vibration and Energy Efficiency

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

Sponsor: 2.6 Sound and Vibration
Chair: Jason Swan, Member, Sandy Brown Associates LLP, London, United Kingdom
Elevators are a vital component of multi-story buildings, yet can be a source of excessive noise and vibration if not integrated into the design with care. This seminar explores the noise and vibration issues with elevators from the perspectives of acousticians, engineers, and manufacturers with insight on construction of elevator shafts, selection of performance and energy efficiency vs cost, and the requirements and effects from the latest good practice standards for elevators.

Learning Objectives:

1. Estimate whether elevator noise will be an issue on your client's projects.
2. Evaluate measures to mitigate elevator noise during design.
3. Understand potential measures to reduce elevator noise post-design.
4. Understand 90.1 and other energy codes, and what they require for elevators, and what they may require in the future.
5. Understand 90.1 and other energy codes, what they require for elevators escalators and fastwalks, and what they may require in the future
6. Understand the generic energy efficiency of different elevator types for motion, lighting, ventilation; and how the frequency of movement affects which features save the most energy.

Elevator Noise and Vibration
Erik Miller-Klein, P.E., Member*, Tenor Engineering Group, Seattle, WA*

Elevator Energy and Noise
Jeff Boldt, P.E., HBDP, Fellow ASHRAE*, IMEG Corp., Middleton, WI*

Seminar 51 (Intermediate)

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

Track: Energy Conservation
Sponsor: 1.10 Cogeneration Systems
Chair: Blake Ellis, Burns &McDonnell, Kansas City, MO
The main driver behind energy conversation is sustainability of the built environment. While existing design techniques employ a variety of efficiency technologies, buildings will still require energy. Many experts agree that no-carbon combustion technologies, like CHP, will be necessary for the future electric grid. Today, CHP extends the design options to encompass energy supply, allowing designers more reach in terms of energy conservation. This seminar looks at CHP developments that allow integration of renewable energy, examine the life-cycle impact of CHP, and delve into no-carbon fuels that can be employed through highly efficient CHP to power the built environment.

Learning Objectives:

1. Understand the role of CHP in the low/no Carbon electric grid of the future
2. Describe the concept of Hybrid microgrids
3. Explain the life cycle benefits of CHP
4. Describe the latest developments in non-carbon power generation
5. Describe the concept of Hybrid microgrids
6. Understand the role of CHP in the low/no Carbon electric grid of the future
7. Explain the life cycle benefits of CHP
8. Understand the impact of utility tariff structure on CHP cost savings
9. Apply one method of valuing resilience

Beyond Standard Practice: All of the Above
Richard Sweetser, Life Member*, Exergy Partners Corp., Herndon, VA*

Life Cycle Analysis: CHP Provides a Variable Return on Investment and Clear Energy Conservation and Emissions Benefits
Gearoid Foley, Member*, Integrated CHP Systems Corp., Princeton, NJ*

Seminar 52 (Intermediate)

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

Track: Systems and Equipment
Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications

Chair: Steven Carlson, P.E., Member, XRG Analytics LLC, Milwaukee, WI
"One system's trash is another system's treasure." Heat recovery heat pump potential applications abound wherever systems operate at different temperatures, using one system's waste heat to provide or supplement the heat source for another system. This session explores HRHP use in central plants, wastewater, geothermal bore field, and industrial applications emphasizing identifying applications and key operating characteristics.

Learning Objectives:

1. Review the locations for heat recovery heat pumps relative to typical chiller/boiler plant layouts, along with their benefits, limitations and considerations.
2. Describe the characteristics that are conducive to the application of heat recovery heat pumps to wastewater streams
3. Define technical attributes in moving heat rejection from a cooling dominated Geothermal bore field to meeting a heating load with a Heat Recovery Heat Pump
4. Provide an overview of proven Heat Recovery Heat Pump applications reinvented with modern refrigerant systems.
5. Describe locations for heat recovery chillers relative to the main chiller plant
6. List and explain several design considerations for heat recovery chillers in commercial buildings
7. Describe the characteristics that are conducive to the application of heat recovery heat pumps to wastewater streams.
8. Describe the characteristics that are conducive to the application of heat recovery heat pumps to wastewater streams.
9. Understand Hybrid Geothermal Systems with Large Tonnage Chiller Applications for Heat Recovery.
10. Understand the Dynamics of Chiller Applications in Reverse Cycle.

Applying Heat Recovery Heat Pumps to Commercial Chiller Plants
***Mike Filler Jr., P.E., HBDP, Member**, Turntide Technologies, Colorado Springs, CO*

Applying Heat Recovery Heat Pumps to Wastewater Streams
***Steve Hamstra, P.E., HBDP, Member**, Melink Solar & Geo, Zeeland, MI*

Applying Heat Recovery Heat Pumps to Geothermal Water Loop Heat Pumps to Limit Wellfield Degradation
***Howard Newton, Member**, Image Engineering, Westlake, TX*

Applying HRHPs with R410 and Other New Refrigerants in Existing (Old) Applications to Save Energy in Industry (Reference Heat Recovery Heat Pump Operating Experiences, 1994)
***Frank Pucciano, Life Member**, FEDITC, Tyndall AFB, FL*

Seminar 53 (Basic)

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

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

Learning Objectives:

1. Save time modeling full size environments through automatic extraction and integrated modeling toolkits.
2. Efficiently increase the level of detail with a direct connection to AUTODESK REVIT.
3. Enhance global collaboration by leveraging cloud servers for point cloud visualization or through virtual reality meetings.
4. Maximize a point cloud workflow while leveraging fewer software packages.
5. Save time modeling full size environments through automatic extraction and integrated modeling toolkits.
6. Enhance global collaboration by leveraging cloud servers for point cloud visualization or through virtual reality meetings.

Enhancing and Expanding Point Cloud Collaboration with a Streamlined Workflow, VR and Cloud Visualization
***Nate Soulje**, Elysium Inc., Southfield, MI*

Seminar 54 (Intermediate)

From Research to Reality: Advances in Liquid Desiccant Technology

Track: Systems and Equipment

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

Chair: Kevin Muldoon, KCC International, Louisville, KY

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

Learning Objectives:

1. Understand the fundamentals that drive the performance of liquid desiccant systems
2. Understand the basic configurations in which liquid desiccant heat exchangers can be applied
3. Understand the test processes for liquid desiccant DOAS systems
4. Understand the performance of DOAS systems with liquid desiccant heat exchangers as tested in the laboratory as compared to related modelled performance
5. Understand the fundamentals that drive the performance of liquid desiccant systems
6. Understand the basic configurations in which liquid desiccant heat exchangers can be applied
7. Understand the fundamentals that drive the performance of liquid desiccant systems
8. Understand the basic configurations in which liquid desiccant heat exchangers can be applied
9. Understand the implications for testing Liquid desiccant DOAS systems.
10. Understand the performance of DOAS systems with liquid desiccant heat exchangers
11. Understand the basic configurations in which liquid desiccant heat exchangers can be applied

Liquid Desiccant Fundamentals
Peter Luttik, Member*, 7AC Technologies, Beverly, MA*

Modeling and Experimental Performance of Internally-Cooled Desiccant-to-Air Membrane Contactors
Jason Woods, Ph.D., Member*, National Renewable Energy Laboratory, Golden, CO*

Liquid Desiccant Dedicated Outdoor Air System Laboratory Test Results
Jason Warner, Member*, Emerson Climate Technologies, Sidney, OH*

Liquid Desiccant Air Conditioning Systems Demonstration and Reliability (WITHDRAWN)
Matt Perkins*, 7AC Technologies, Beverly, MA*

Integrating Liquid Desiccants in Roof Top Units
Andrew Lowenstein, Ph.D., Member*, AIL Research, Hopewell, NJ*

Seminar 55 (Intermediate)

Future Smart Building Operations for Load Flexibility

Track: Building Performance and Commissioning for Operation and Management

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

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

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

Learning Objectives:

1. Understand what is the grid-interactive efficient building.
2. Learn various approaches to achieve load flexibility to satisfy grid needs
3. Learn methods to integrate grid signals into HVAC control schemes
4. Learn methods, tools and data to model and evaluate GEB strategies and their impacts on energy and indoor thermal comfort.
5. Explain the grid-interactive efficient building
6. Describe various approaches to achieve load flexibility to satisfy grid needs

7. Describe methods, tools and data to model and evaluate GEB strategies and their impacts on energy and indoor thermal comfort
8. Learn metrics used for measuring demand flexibility in grid-interactive efficient buildings
9. Learn methods and results used for evaluating energy efficiency's influence on demand flexibility in a "case study"
10. Learn various approaches to achieve load flexibility to satisfy grid needs
11. Learn methods to integrate grid signals into HVAC control schemes
12. Understand what is the grid-interactive efficient building.
13. Learn various approaches to achieve load flexibility to satisfy grid needs

Building Load Flexibility Analysis with Real-Time Building Load Prediction and Optimal Cooling System Control Strategy
Da Yan, Ph.D., Member*, Tsinghua University, Beijing, China, People's Republic of*

Grid-Interactive Efficient Buildings: Does Energy Efficiency Characteristics Increase or Decrease Demand Flexibility from Building Loads?
Jingjing Liu, P.E., BEAP*, Lawrence Berkeley National Laboratory, Berkeley, CA*

Uncertainty-Aware Transactive Control of Multiple Buildings with Thermal Energy Storage
Gregory Pavlak, Ph.D., Member*, Pennsylvania State University, State College, PA*

Occupant-Centric Buildings-to-Grid Integration
Bing Dong, Ph.D., Member*, Syracuse University, Syracuse, NY*

Seminar 56 (Intermediate)

Health, Humidity and Humidifiers

Track: Environmental Health Through IEQ sponsored by Ebtron
Sponsor: 5.11 Humidifying Equipment
Chair: Raul Simonetti, Member, Carel Industries SpA, Brugine, Italy

Recent and on-going research studies correlate mid-range indoor humidity level with reduced viral and bacterial infections and improved health in both young and elderly building occupants. But how can we guarantee those humidity levels within our buildings? This session first explores the latest science of humidity and health, and then explains how to safely install and run various types of humidification systems to reduce indoor dryness.

Learning Objectives:

1. To understand the role of proper indoor humidification in preventing indoor pathogens spread
2. To understand how to properly design, install and operate steam humidification systems
3. To understand how to properly design, install and operate adiabatic systems
4. To understand the preventive maintenance required to guarantee a proper level of hygiene inside the humidification chamber
5. Understand new metrics and understand research on human health as a building performance metric
6. Identify key factors and systems affecting spread of airborne pathogens
7. Differentiate between steam and evaporative humidifier systems.
8. Describe common considerations for steam humidifier applications.
9. Understand the difference between direct room and ducted humidifier applications.
10. Understand the preventive maintenance required to guarantee a proper level of hygiene inside the humidification chamber
11. Learn hygiene-related requirements for humidification systems

Indoor Humidification Is Key to Controlling COVID-19
Stephanie Taylor, M.D., Member*, Harvard Medical School, Infection Control Consultant, Boston, MA*

Best Practices for Steam Humidifier Design
Nicholas Lea, P.Eng., Member*, Condair Ltd., Ottawa, ON, Canada*

Best Practices for Adiabatic Humidifier Design
Duncan Curd, Member*, DriSteem, Eden Priairie, MN*

Hygiene and Humidification in Ventilation Systems for Health-Care Facilities in Europe
Raul Simonetti, Member*, Carel Industries SpA, Brugine, Italy*

Seminar 57 (Basic)

Hot Topics For Secondary Coolants (Brines)

Track: Refrigeration and Refrigerants

Sponsor: 3.1 Refrigerants and Secondary Coolants

Chair: Kevin Connor, Member, Dow Inc., Midland, MI

In many refrigeration applications, heat is transferred to a secondary coolant, which is used to transfer heat without changing state. There are a variety liquids that can be used and these are known also as heat transfer fluids, brines or secondary refrigerants. This seminar presents helpful engineering and operating guidance for three different types of secondary coolants: aqueous ammonia, calcium chloride and glycols.

Learning Objectives:

1. Explain why it is important to choose the appropriate corrosion inhibitor additives for calcium chloride based secondary coolants
2. Explain why aqua ammonia has been gaining popularity as a secondary coolant.
3. Explain why experimental specific heat capacity results for propylene glycol do not compare with available theoretical values at low temperatures
4. Explain how impurities and formulation chemistry affect the performance and safety attributes of glycol based heat transfer fluids.
5. obtain an overview about the latest experimental data for glycol solutions understand the effect of corrosion inhibitors on thermal properties
6. learn that experimental viscosity results are lower than current ASHRAE references learn that experimental thermal conductivity data are higher than current ASHRAE references
7. learn that experimental specific heat capacity data are contradicting with current ASHRAE references and simplified linear models should not be applied
8. the importance of choosing the right additive for your secondary coolant
9. the importance of commissioning your secondary coolant after a project
10. the importance of maintenance and follow up
11. Explain how to select a glycol based secondary coolant for effective system operation and freeze protection
12. Explain how impurities and formulation chemistry affect the performance and safety attributes of glycol based secondary coolants

Validation of Experimental Properties of Ethylene and Propylene Glycol Based Secondary Coolants with ASHRAE Data
Monika Ignatowicz, P.Eng.*, KTH Royal Institute of Technology, Stockholm, Sweden*

Combating Corrosion Problems Caused By Calcium Chloride Secondary Coolants (Brines)
Kathleen Neault, P.Eng., Member*, Refri-Ozone, Grandby, QC, Canada*

Effective Use of Glycol Based Secondary Coolants
Kevin Connor, Member*, Dow Inc., Midland, MI*

Seminar 58 (Intermediate)

How Will Climate Change Affect Standards, Guidelines and the Way We Design? Part 1: Why Climate Change May Affect the Design of Buildings and Their Systems

Track: Standards, Guidelines and Codes

Sponsor: 2.5 Global Climate Change, 6.7 Solar Energy Utilization , 2.8, 4.1, 4.2, 7.6

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

This is part one of a 3-seminar series. Part one introduces the new ASHRAE Fundamentals Handbook Chapter on Climate Change with a discussion of climate change issues which are anticipated to effect changes in some standards, guidelines and, eventually, codes. It will include a review of the newest climate zone maps with zone creepage, additional climate change related information and an exploration of questions of whether it is good practice to continue using 30-year historic weather data for load calculations in view of rapid climate change.

Learning Objectives:

1. Describe the content areas in the new Climate Change Chapter to be published in the 2021 ASHRAE Fundamentals Handbook.
2. Explain the relationships and distinct differences between sustainability objectives and climate readiness objectives.
3. Explain the relevance of the observed and expected changes in climate from the National Climate Assessment to professional practice and to safeguard assets.
4. Describe how the climate design conditions are changing.

5. Describe the content areas in the new Climate Change Chapter to be published in the 2021 ASHRAE Fundamentals Handbook.
6. Understand the need for climate change literacy for design and operation of buildings and HVAC&R systems.
7. Explain the relationships and distinct differences between sustainability objectives and climate readiness objectives.
8. Provide overview of how to discuss the topic effectively with different stakeholders from clients to other consulting disciplines.
9. Describe the content areas in the new Climate Change Chapter to be published in the 2021 ASHRAE Fundamentals Handbook
10. Describe how the climate design conditions are changing

Overview of the New Climate Change Chapter for the 2021 ASHRAE Fundamentals Handbook
Janice Means, P.E., Life Member*, Lawrence Technological University;, Bloomfield Hills, MI*

Safeguarding Assets: Readiness in Capital Projects and Asset Management
Ann Kosmal, F.A.I.A., LEED AP BD +C, CPHC, PDC, AIA*, U.S. General Services Administration, Washington, DC*

Our Design Conditions Are Already Changing
Drury Crawley, Ph.D., BEMP, Fellow ASHRAE*, Bentley Systems, Inc., Washington, DC*

Seminar 59 (Intermediate)

How Will Climate Change Affect Standards, Guidelines and the Way We Design? Part 2: Application to Loads Calculations and Design Conditions

Track: Standards, Guidelines and Codes
Sponsor: 2.5 Global Climate Change, 6.7 Solar Energy Utilization , 2.8, 4.1, 4.2, 7.6
Chair: Drury Crawley, Ph.D., Fellow ASHRAE, Bentley Systems, Inc., Washington, DC
This seminar is part two of a three-seminar series. It will cover specific climate effects on the built environment and on loads calculations. The sessions seeks to show what areas are expected to need modification due to the changing climate and what areas do not need change. The session starts with issues specific to 90.1, looks at the effects of climate change on loads calculations, and then turns to the subject of appraising actual changes in design conditions due to climate through statistical analysis.

Learning Objectives:

1. Describe areas where Standard 90.1 may need to change to better address climate change.
2. Describe some of the ways that climate change might impact minimum energy codes, especially in extremely hot climates.
3. Describe the impact of predicted climate change on cooling load calculations.
4. Describe the change in design conditions in recent decades.
5. Identify the uncertainties that impact cooling load calculations in addition to dry-bulb temperature.
6. Understand design priorities beyond concern for having sufficient cooling capacity.

Changing Climate and Its Implications for Our Flagship Standard – 90.1
Chris Mathis, Fellow ASHRAE*, Mathis Consulting Company, Asheville, NC*

Cooling Load Implications of Predicted Future Design Conditions
Charles S. Barnaby, Fellow Life Member*, Independent Software Developer, Moultonborough, NH*

A Statistical Appraisal of Changes in Design Conditions Based on Climate Model Projections
Joe Huang, BEMP, Member*, White Box Technologies, Inc., Moraga, CA*

Seminar 60 (Intermediate)

How Will Climate Change Affect Standards, Guidelines and the Way We Design? Part 3: Decarbonization By Smart Grid and Adaptation to Northern Warming

Track: Standards, Guidelines and Codes
Sponsor: 2.5 Global Climate Change, 6.7 Solar Energy Utilization , 2.8, 4.1, 4.2, 7.6
Chair: Parag Rastogi, Ph.D., Associate Member, arbnco Ltd., Glasgow, United Kingdom
This is part three of a three-part seminar series. Part three looks at specific solutions and problems related to climate change. International standards concerning new building guidelines for the smart grid and their relationship to decarbonization is explored in the first presentation. The second presentation similarly explores how carbon emissions are changing with time in Minnesota and explores how the ASHRAE Smart Grid Guide can be used. The third presentation looks at warming in the Canadian north and associated adaptations that are needed.

Learning Objectives:

1. Identify regulatory and technical challenges for the development and adoption of carbon neutral-enabling technologies.
2. Familiarize with international initiatives for the development and adoption of new building-related standards and codes to tackle climate change.
3. Understand the potential for buildings, distributed energy resources, and smart grid technologies to contribute to reduced carbon emissions from the grid.
4. Describe impacts climate change has already had in the Canadian North, and institutional responses to them.
5. Identify regulatory and technical challenges for the development and adoption of carbon neutral-enabling technologies.
6. Familiarize with international initiatives for the development and adoption of new building-related standards and codes to tackle climate change.
7. Identify regulatory and technical challenges for the development and adoption of carbon neutral-enabling technologies.
8. Familiarize with international initiatives for the development and adoption of new building-related standards and codes to tackle climate change.
9. Understand the potential for buildings, distributed energy resources, and smart grid technologies to contribute to reduced carbon emissions from the grid.

Electrification and Decarbonization of the Building Sector: An Overview of New Building Codes and Standards
Costa Kapsis, Ph.D., Associate Member, *University of Waterloo, Waterloo, ON, Canada*

Time of Use Emissions in the Buildings Sector: A Case Study in Minnesota and a Smart Grid Toolkit
Lee Shaver, *Slipstream, Madison, WI*

Updating Codes and Guidelines for Adapting Existing Infrastructure to the Changing Climate: A Canadian Perspective
Philip Jarrett, *Environment and Climate Change Canada, Toronto, ON, Canada*

Seminar 61 (Intermediate)

Hybrid Boiler Innovations and Applications for Energy and Cost Savings

Track: Energy Conservation

Sponsor: 6.10 Fuels and Combustion

Chair: Aleksandr Fridlyand, Ph.D., Member, Gas Technology Institute, Des Plaines, IL

Hybrid boilers are an innovative approach for minimizing energy use while maintaining building occupant comfort and potentially reducing life cycle costs. By coupling complementary technologies, each can be operated at optimal conditions to reduce energy use and the system as whole can be right sized to maintain comfort on the coldest days. This seminar presents case studies and best practices for using non/condensing, gas heat pump, and electric heat pump coupled hybrid boilers for heating applications.

Learning Objectives:

1. Understand what HVAC hybridization can mean for facilities all across the world if applied correctly.
2. Understand the products involved in a hybrid HVAC system.
3. Understand the impact of return water temperature on condensing boiler heating efficiency
4. Describe best approach in designing with currently available commercially heat pumps
5. Understand what HVAC hybridization can mean for facilities all across the world if applied correctly.
6. Understand the products involved in a hybrid HVAC system.
7. Describe best approach in designing with currently available commercial heating equipment
8. Understand what HVAC hybridization can mean for facilities all across the world if applied correctly.
9. Understand the products involved in a hybrid HVAC system.
10. Understand the impact of return water temperature on condensing boiler heating efficiency.
11. avoid potential efficiency penalties with operation of gas heat pumps
12. understand the additional components that may be required in hybrid systems.

A Hybrid Not of the Plug-in Variety
Patrick Villaume, Member, *Patterson Kelley, East Stroudsburg, PA*

High-Efficiency Hybrid Boiler Configurations for Condensing Boilers
Patricia Rowley, Associate Member, *Gas Technology Institute, Des Plaines, IL*

A Case Study on Gas Heat Pump Coupled Hybrid Boiler Retrofit
Rav Deol, P.Eng., *FortisBC Energy Inc., Surrey, BC, Canada*

Seminar 64 (Intermediate)

Integrating Renewable Energy into Residential and Commercial Air Conditioning with Thermal Energy Storage to Resolve Grid and Off-Grid Issues

Track: Systems and Equipment

Sponsor: 6.9 Thermal Storage

Chair: Bruce Lindsay, P.E., Life Member, Brevard Public Schools, Melbourne, FL

Renewable energy is growing and may cause problems for utilities when too much energy is generated or insufficient load is on-line to absorb the energy. Several utilities are paying customers to take wind energy at night using thermal energy storage. At the other end of the spectrum, thermal energy storage is a way to store solar PV when off the grid. This is especially attractive in remote islands subject to hurricanes and fuel delivery disruptions.

Learning Objectives:

1. Understand the problems with independent producers generating too much power during off-peak periods and how this can be a problem for wind turbines, solar PV and other renewable energy markets.
2. Describe how a solar PV panel can provide air conditioning at night when the sun is no longer shining and how thermal energy storage makes this possible.
3. Too much renewable energy can be problem for the grid. It can also be a problem when off the grid. Explain how a thermal energy storage system can be sized to maximize renewable energy production.
4. Solar PV with ice storage is one option for off-grid systems. Explain how the costs and maintenance compare for diesel generators and batteries.
5. Learn about the economic challenges faced within small islands within the Caribbean and the strives some local governments have made to become self sufficient and meet key climate change goals.
6. Have a better understanding of the local economics and challenges faced and how some local governments within the Caribbean have made changes to move into a "Green" Future and become sustainable and self sufficient and encourage growth within their economies and the technology which is current being used and what the future will bring to small islands .

Senior Design Project for Solar-Powered Ice Harvestor for Residential Air Conditioning for Off-Grid Applications
Marc Compere, Ph.D. *and* ***Erik Regan****, Brevard Public Schools, Melbourne, FL*

Economics of Solar PV Ice Harvestor in Caribbean Island: Diesel, Batteries or Ice?
Keiron Nanan, Member*, Temp Tec Limited, Charlieville, ON, Trinidad and Tobago*

Utility Rate Structures to Accommodate Excess Wind Turbine and Solar PV -- WITHDRAWN
David Snyder, Associate Member*, Centerpoint Energy, Houston, TX*

Seminar 65 (Intermediate)

International Implications of ASHRAE Moisture Management Standards

Track: International Design

Sponsor: 1.12 Moisture Management in Buildings

Chair: Florian Antretter, Member, Fraunhofer IBP, Holzkirchen, Germany

The interaction between the weather, the building envelope, its systems and its occupants can either lead to moisture accumulation or prevent it. Provisions in various ASHRAE standards aim at reducing moisture related risks. This seminar presents international implications of ASHRAE's moisture management standards on ventilation and building envelope design and showcase their consequences through case studies.

Learning Objectives:

1. Understand the impact of ignoring moisture control in building envelopes.
2. Understand that Std 62.1 now requires designers to limit indoor humidity to less than a 15°C (60F) dew point temperature
3. Understand how to use the maximum dew point temperature of 15°C (60F) as an indoor humidity limit in determining acceptable indoor air quality.
4. Understand how to use other indicators as surrogates to indoor dampness problems
5. Understand the impact of ignoring moisture control in building envelopes.
6. How does Standard 160 work.
7. How does this standard lead to more durable envelope solutions.
8. 1. Understand that Std 62.1 now requires designers to limit indoor humidity to less than a 15°C (60F) dew point temperature.

9. 1. Understand that the dew point limit applies during unoccupied hours as well as occupied hours, whenever the outdoor humidity is higher than a 15°C (60°F) dew point.
10. Understand challenges to using RH as a measure of moisture control success.
11. Understand ow some International Standards use RH as a measure of success.

Higher Confidence in Building Envelope Design through ASHRAE Std. 160 -2016
***Andre O. Desjarlais, Member**, Oak Ridge National Laboratory, Oak Ridge, TN*

Implementing the New Dew Point Humidity Limit of 15C (60F) Required By ASHRAE Std 62.1-2019
***Lewis G. Harriman III, Fellow ASHRAE**, Mason-Grant Consulting, Portsmouth, NH*

Lessons Learned Applying the ASHRAE's Moisture Management Standards in a Large Southeast Asia Resort
***George Dubose, P.E., Member**, Liberty Building Forensic Group, Zellwood, FL*

Seminar 66 (Intermediate)

Lessons Learned from COVID-19 and What Engineering Measures Can be Adopted to Reduce Infection Risks in Restaurants

Track: Environmental Health Through IEQ sponsored by Ebtron
Sponsor: 5.10 Kitchen Ventilation, 2.9 Ultraviolet Air and Surface Treatment
Chair: Russell Robison, Member, Gaylord Industries, Division of ITW FEG, Tualatin, OR
With nearly a million foodservice establishments in the US, getting America back to work safely is top of mind. These presenters will help you to understand the airborne epidemiology of COVID-19, and how to mitigate the risks in restaurant ventilation systems.

Learning Objectives:

1. You will be able to use new metrics and understand research on human health as a building performance metric.
2. Identify key factors and systems affecting spread of airborne pathogens in a restaurant.
3. ASHRAE recommended commercial building (restaurant) operating guidelines – DILUTE, CLEAN, CONTAIN, EXHAUST
4. To recognize the potential for changes in cooking with changing consumer demand and identify commercial kitchen ventilation equipment which can aid in operational cost savings to the owner
5. Understand new metrics and understand research on human health as a building performance metric
6. Identify key factors and systems affecting spread of airborne pathogens in a restaurant
7. Identify ASHRAE recommended commercial building (restaurant) operating guidelines
8. Identify key factors and systems affecting spread of airborne pathogens in a restaurant.
9. Understand mitigation strategies used to reduce transmission airborne infection and learn how to apply them in a restaurant environment
10. Identify the main areas of interest in ASHRAE recommendations - Dilute, Exhaust, Contain, Clean
11. Exposure to resources like the Restaurant IAQ Checklist & Operating recommendations

What Should I Do to Keep Safe from COVID-19?
***Stephanie Taylor, M.D., Member**, Harvard Medical School, Infection Control Consultant, Boston, MA*

Restaurant Ventilation System Design and Effective Mitigation Methods Addressing Airborne Contaminants for Existing Buildings and New Construction
***Andrey Livchak, Ph.D., Member**, Halton Group Americas, Bowling Green, KY*

Operating Your Restaurant for the "Unknown" and Keeping up with the Latest Ashrae Guidelines
***Greg DuChane, Member**, Trane, Nacogdoches, TX*

Equipping Your Restaurant for the “Unknown” with Operational Efficiency and Increased Flexibility
***Jessica Harrington, Associate Member**, Accurex, Baltimore, MD*

Seminar 67 (Basic)

Life Safety Dampers, Back to Basics

Track: Systems and Equipment
Sponsor: 5.6 Control of Fire and Smoke
Chair: Paul Turnbull, Member, Siemens Building Technologies, Inc., Buffalo Grove, IL
All but the smallest buildings are required to include life safety dampers to ensure that fire and smoke cannot travel through ductwork and spread to other areas of the building. Life safety dampers are very different from the dampers used for HVAC control. This session helps engineers and installers understand the differences between fire-, smoke-, combination fire/smoke-,

and ceiling radiation dampers; the applications for which each is suited; and how to specify these dampers correctly. It also describes different ways that each of these dampers are activated and/or controlled. Installation, testing and inspection methods and requirements are discussed.

Learning Objectives:

1. Identify the differences between Fire-, Smoke-, Combination Fire/Smoke-, and Ceiling dampers, and understand where each type of life safety damper is used.
2. Describe which types of dampers are required by different sections of the building codes.
3. Understand the controls associated with each type of life safety damper.
4. Explain how each type of life safety damper is to be installed and tested.
5. Identify the differences between Fire-, Smoke-, Combination Fire/Smoke-, and Ceiling dampers, and understand where each type of life safety damper is used.
6. Describe which types of dampers are required by different sections of the building codes.
7. Find wiring diagrams for actuated smoke and fire and smoke dampers.
8. Be able to describe the basic functions of actuated life safety dampers.
9. Explain the basics of how each type of life safety damper is to be installed.
10. Explain the how each type of life safety damper is field tested.

What Are Life Safety Dampers?
Stephen D Carey, Member*, TAMCO, Smyrna, TN*

Wiring and Controls of Life Safety Dampers
Larry Felker, Life Member*, Belimo Americas, Sparks, NV*

Testing and Installation of Life Safety Dampers
Stephen D Carey, Member*, TAMCO, Smyrna, TN*

Seminar 68 (Intermediate)

Mechanical Equipment Individual Current Harmonics and Impact on the Building's Electrical Load

Track: Systems and Equipment

Sponsor: 1.11 Electric Motors and Motor Control, 1.9 Electrical Systems , TC 1.9 co-sponsorship

Chair: Armin Hauer, Member, ebm-papst, Farmington, CT

The HVAC&R industry is trending towards variable speed technology such as electronically commutated motors (ECMs), variable frequency drives (VFD) motor solutions, variable speed compressors, chillers, pumps, fans, and variable refrigerant flow systems (VRF). Building owners and engineers are requesting HVAC&R equipment to comply with IEEE 519. The goal of this program is to help our participants avoid harmonics overfiltering and underfiltering. Both excessive and minimal harmonic filtration scenarios can cause issues with electrical and HVAC&R equipment. With industry demands of high energy standards (Title 24, ASHRAE 90.1, IECC), harmonics has emerged as an increasingly critical topic in the building industry.

Learning Objectives:

1. Understand the general theory and basics of motors, VFDs, and ECMs
2. Identify the cause of power line distortion, the difference between harmonic voltage distortion and current distortion, and where each of these are used in IEEE 519-2014.
3. Determine if an HVAC&R system non-linear profile in a facility will pass or fail the requirements of IEEE 519-2014.
4. HVAC&R trade to holistically approach potential harmonics alongside electrical engineers and VFD manufactures. And, learn about the technology used to mitigate harmonic distortion.
5. Understand the general theory and basics of motors, VFDs, and ECMs
6. Determine if an HVAC&R system non-linear profile in a facility will pass or fail the requirements of IEEE 519-2014.
7. HVAC&R trade to holistically approach potential harmonics alongside electrical engineers and VFD manufactures. And, learn about the technology used to mitigate harmonic distortion.
8. Be able to describe the relationship between harmonic current and harmonic voltage
9. Tell what harmonic distortion is the main objective of IEEE 519-2014.

Facility Harmonics
Nicolas S. Rosner, P.E., Member*, Eaton, City of Industry, CA*

Applying Harmonic Analysis to Power Line Distortion
Ken Fonstad, Member*, Retired, Franklin, IN*

Seminar 69 (Intermediate)

Mechanical Equipment Individual Current Harmonics and Impact on the Building's Electrical Load: HVAC&R Fundamentals and Applications Track

Track: HVAC&R Fundamentals and Applications sponsored by Honeywell

Sponsor: 1.11 Electric Motors and Motor Control, 1.9 Electrical Systems

Chair: Armin Hauer, Member, ebm-papst, Farmington, CT

The HVAC&R industry is trending towards variable speed technology such as electronically commutated motors (ECMs), variable frequency drives (VFD) motor solutions, variable speed compressors, chillers, pumps, fans, and variable refrigerant flow systems (VRF). Building owners and engineers are requesting HVAC&R equipment to comply with IEEE 519. The goal of this program is to help our participants avoid harmonics overfiltering and underfiltering. Both excessive and minimal harmonic filtration scenarios can cause issues with electrical and HVAC&R equipment. With industry demands of high energy standards (Title 24, ASHRAE 90.1, IECC), harmonics has emerged as an increasingly critical topic in the building industry.

Learning Objectives:

1. Understand the general theory and basics of motors, VFDs, and ECMs.
2. Identify the cause of power line distortion, the difference between harmonic voltage distortion and current distortion, and where each of these are used in IEEE 519-2014.
3. Determine if an HVAC&R system non-linear profile in a facility will pass or fail the requirements of IEEE 519-2014.
4. HVAC&R trade to holistically approach potential harmonics alongside electrical engineers and VFD manufactures. And, learn about the technology used to mitigate harmonic distortion.
5. Understand the general theory and basics of motors, VFDs, and ECMs.
6. Determine if an HVAC&R system non-linear profile in a facility will pass or fail the requirements of IEEE 519-2014.
7. HVAC&R trade to holistically approach potential harmonics alongside electrical engineers and VFD manufactures. And, learn about the technology used to mitigate harmonic distortion.
8. Describe the relationship between current and voltage distortion in a facility.
9. Describe the responsibility of the customer of a public electric utility and the public electric utility to maintaining the quality of the power grid.
10. What would you say if a VFD manufacturer said that his VFD conforms to IEEE 519-2014?

Facility Harmonics: HVAC&R Fundamentals and Applications Track
Nicolas S. Rosner, P.E., Member*, Eaton, City of Industry, CA*

Applying Harmonic Analysis to Power Line Distortion: HVAC&R Fundamentals and Applications
Ken Fonstad, Member*, Retired, Franklin, IN*

Seminar 70 (Intermediate)

Modeling of Surfaces Mass Transfer in Indoor Environment

Track: Environmental Health Through IEQ sponsored by Ebtron

Sponsor: 4.10 Indoor Environmental Modeling

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

Surface mass transfer plays an important role in indoor environmental quality. However, the surface mass transfer is complex and its effect on emission and chemical reaction are less know. This seminar shows how to use CFD to predict condensation on surfaces, as well as evaluate the impact of ozone reaction at surfaces.

Learning Objectives:

1. Tell effective CFD simulation strategies in modeling surface condensation
2. Understand flow dynamics along surfaces to deal with condensation
3. Show how the HVAC design and operation impact: near surface velocity, mass transfer, and indoor surface reactions.
4. Explain the impact of ozone reaction at surfaces
5. Show how the HVAC design and operation impact: near surface velocity, mass transfer, and indoor surface reactions.
6. Explain the impact of ozone reaction at surfaces.
7. Tell effective CFD simulation strategies in modeling surface condensation
8. Understand flow dynamics along surfaces to deal with condensation

Effect of Indoor Airflow on Surface Mass Transfer and Deposition Velocity of Reactive Chemicals
Atila Novoselac, Ph.D., Associate Member*, The University of Texas at Austin, Austin, TX*

Predicting Condensation with CFD, Good-Bye Dampness
Duncan Phyfe, Associate Member*, Alden Research Laboratory, Holden, MA*

Seminar 71 (Intermediate)

New Dogs, New Tricks: Air Flow Control Update

Track: Systems and Equipment

Sponsor: 9.10 Laboratory Systems, 1.4 Control Theory and Application

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

Air flow to and from occupied spaces is an essential part of nearly every HVAC system. The quantity of that flow has repercussions in energy use, and indoor environmental quality. HVAC designers continue to increase the attention they pay to air flow control performance and air flow control technology. Whether the space is an office, classroom, surgery suite or laboratory, designers are looking for better combinations of working range, accuracy and stability. Manufacturers respond with new designs for air flow terminals. This seminar updates your knowledge of mechanical arrangements of dampers and sensors available and corresponding performance.

Learning Objectives:

1. Apply the concept of sensor turndown to air terminal sizing
2. Evaluate mechanical characteristics of terminals in terms of accuracy and operating range
3. Compare air flow sensing designs in terms of project requirements and HVAC capability
4. Design an air delivery system that takes advantage of a Variable Aperture Damper
5. Demonstrate a basic understanding of terminal unit airflow measurement technologies currently available in the marketplace.
6. Demonstrate a basic understanding of measuring low terminal unit airflows both in the laboratory as well as in the field.
7. Demonstrate a basic understanding of the differences between the low airflow capabilities of the various terminal unit airflow measurement technologies.
8. Apply the concept of sensor turndown to air terminal sizing and evaluate mechanical characteristics of terminals in terms of accuracy and operating range.
9. Compare air flow sensing designs in terms of project requirements and HVAC capability.
10. Evaluate mechanical characteristics of terminals in terms of accuracy and operating range.

Minimum Airflows on Air Terminal Boxes
Justin Garner, P.E., Member*, Engineered Air Balance Company, Inc., Houston, TX*

New Technology Expands Laboratory Airflow Control Design Range
Paul Fuson*, Siemens Smart Infrastructure, Buffalo Grove, IL*

Seminar 72 (Intermediate)

Next Generation Window Technologies for Net-Zero Energy Buildings

Track: Systems and Equipment

Sponsor: 4.5 Fenestration

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

In the last couple of decades, several cutting-edge window technologies have been commercialized, enabling buildings to become net-zero energy or even net-positive energy. These technologies range from highly insulating glazing and frames to solar control glass coatings and dynamic glazing and shading solutions. This seminar reviews major advancements in window technologies and the ways they will affect building energy performance, human comfort and future built environment.

Learning Objectives:

1. Expert review of the advances in window and shading technologies
2. Achieving net zero energy building performance through the deployment of the next generation window and shading technologies
3. Thermal and visual comfort implications from high performance windows and window shading systems
4. Identify barriers to the deployment of the next generation of window technologies
5. Describe how window performance impacts residential building energy use
6. Explain how climate zones impacts window performance needs
7. explain the Vacuum Glazing technology fundamental topics of interest.
8. describe and distinguish the Vacuum Glazing technology relative to other insulating technologies.
9. show good confidence in Vacuum Glazing applications.
10. Know Exterior Window Shade Products and recognize the benefits that they deliver to building owners in regard to control of sun light and heat.
11. Know that AERC is an organization which rates and certifies the Energy Performance of Exterior Window Shades, in regard to an Annual Energy Rating, U Value, and Solar Heat Gain Coefficient.

Performance Criteria for Residential Zero Energy Windows
***Robert Hart, P.Eng., Associate Member**, Lawrence Berkeley National Laboratory, Berkeley, CA*

Vacuum Glazing
***Cenk Kocer, Ph.D.**, University of Sydney, Sydney, Australia*

Exterior Shading As a Means to Control Solar Gain
***John Gant**, Glen Raven Inc, Burlington, NC*

Electrochromic Glazing
***Luis Fernandes, Ph.D.**, Lawrence Berkeley National Laboratory, Berkeley, CA*

Seminar 73 (Basic)

Noise and Vibration: Commissioning and Remediation

Track: Building Performance and Commissioning for Operation and Management

Sponsor: 2.6 Sound and Vibration

Chair: Erik Miller-Klein, P.E., Member, Tenor Engineering Group LLC, Seattle, WA

Noise and vibration issues both big and small arise on projects throughout the world on a daily basis. Though the most common evaluation of success is "did we get any complaints", even though commissioning would find these issues earlier. Learn about some examples of issues that were complaints or potential problems and how to look out for these issues on your next project.

Learning Objectives:

1. Understand how noise and vibration issues arise in buildings even with best practices.
2. Explain how current standards provide guidance for some, but not all noise and vibration performance expectations.
3. Apply knowledge from these case studies and engineering remediation results for your future projects.
4. Describe how cutting edge equipment and techniques can solve common in-field problems.
5. Understand how noise and vibration issues arise in buildings even with best practices.
6. Explain how current standards provide guidance for some, but not all noise and vibration performance expectations.
7. Apply knowledge from these case studies and engineering remediation results for your future projects.

The Dangers of Value Engineering Mechanical System Noise Control in a Class a Office; A Case Study on Motor Tonal Noise
***Paul Bauch, Member**, Johnson Controls, York, PA*

Shell and Core Mechanical Risk Assessment for Tenant Improvement Design
***Erik Miller-Klein, P.E., Member**, Tenor Engineering Group LLC, Seattle, WA*

When More Is Actually Too Much (WITHDRAWN)
***Reginald Keith**, Hoover & Keith Inc., Houston, TX*

Seminar 74 (Advanced)

Numerical Challenges in Modeling of Vapor Compression Systems and Components

Track: Systems and Equipment

Sponsor: 8.1 Positive Displacement Compressors

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

This seminar explores the numerical and computational challenges, and the accompanying solutions, associated with modeling vapor compression systems and their components with an emphasis on compressor modeling. Speakers explain the challenges resulting from the stiffness of the non-linear ordinary differential equations that govern the behavior of positive-displacement compressors. Additionally, an assessment of the most efficient compressor modeling platform is presented. Finally, a study of the challenges associated with modeling the system dynamics of a complete vapor compression cycle is presented.

Learning Objectives:

1. Describe the operation of a z-compressor and explain the relative performance differences between explicit and semi-implicitly adaptive ODE solvers.
2. Describe the mechanistic chamber model approach and explain why it is used for the performance evaluation of positive displacement compressors.
3. Explain the quantitative and qualitative differences, for compressor modeling, between MATLAB®, Modelica®, PDSim and GT-Suite.
4. Explain the need for dynamic simulations to gauge effects of system charge and heat pump control strategies, and understand the numerical challenges of creating and initializing these simulations.

5. Describe the operation of a z-compressor and explain the relative performance differences between explicit and semi-implicitly adaptive ODE solvers.
6. Describe the mechanistic chamber model approach and explain why it is used for the performance evaluation of positive displacement compressors.
7. Describe the mechanistic chamber model approach and explain why it is used for the performance evaluation of positive displacement compressors.
8. Explain the quantitative and qualitative differences, for compressor modeling, between MATLAB®, Modelica®, PDSim and GT-Suite.

Discussion of the Numerical Methods Used in Positive Displacement Comprehensive Mechanistic Models: Case Study Using the Z-Compressor
__Craig Bradshaw, Ph.D., Member__[1], Davide Ziviani, Ph.D., Member[2] and Eckhard Groll, Dr.Ing., Fellow ASHRAE[2], (1)Oklahoma State University, Stillwater, OK, (2)Purdue University, West Lafayette, IN

Quantitative and Qualitative Evaluation of Various Positive-Displacement Compressor Modeling Platforms
__Mohsin Tanveer, Student Member__ and Craig Bradshaw, Ph.D., Member, Oklahoma State University, Stillwater, OK

Challenges of Charge-Sensitive Dynamic Modeling and Control Scheme Implementations for Heat Pump Applications
__Tyler Shelly, Student Member__, Davide Ziviani, Ph.D., Member, Justin Weibel, Ph.D. and Eckhard Groll, Dr.Ing., Fellow ASHRAE, Purdue University, West Lafayette, IN

Seminar 75 (Advanced)

Present and Future Challenges in Ventilation Unique to Tall Buildings Arising from Epidemics, Health Issues and Climate Change

Track: Environmental Health Through IEQ sponsored by Ebtron
Sponsor: 9.12 Tall Buildings, Environmental Health Committee
Chair: Dennis Wessel, P.E., Fellow Life Member, AIA, Atlanta, GA
The recent COVID-19 pandemic caused serious considerations of methods of control of airborne contaminants in all buildings. Control of these pathogens in tall buildings has its own challenges when considering stack effect and typically heavy occupant densities. This seminar discusses some of these special challenges and offer possible solutions for reduction of airborne pathogen transmission among occupants.

Learning Objectives:

1. Describe the different strengths of stack effect and wind forces acting on air movement in buildings.
2. Understand how the HVAC system interacts with stack and wind driven flows.
3. Evaluate what sort of HVAC configuration works best in taller buildings to control indoor air quality and energy loss.
4. Describe how best to control airflow in taller buildings.
5. 2. Qualitative compare the HVAC systems solutions for tall office buildings that improves ventilation effectiveness.
6. 3. HVAC systems solutions that prioritizes indoor air quality management to reduce pathogen migration
7. Describe the different strengths of stack effect and wind forces acting on air movement in buildings.
8. Understand how the HVAC system interacts with stack and wind driven flows.
9. Evaluate what sort of HVAC configuration works best in taller buildings to control indoor air quality and energy loss.
10. Potential route of infectious diseases spread in tall buildings
11. Defense use air quality against a holistic of health threats in the coming decades

Post Pandemic HVAC Systems Design Solutions to Improve Indoor Air Quality of Tall Office Building
__Mehdi Jalayerian, P.E., Member__, Environmental Systems Design, Inc., Chicago, IL

Managing Infiltration in Tall Buildings to Control Energy Loss, Minimize Pathogen Transport and Enhance Air Quality
__Duncan Phillips, Ph.D., P.E., Associate Member__, Rowan Williams Davies & Irwin, Guelph, ON, Canada

Prioritizing HVAC Strategies for Pandemic and Other Future Threats
__Luke Leung, P.E., BEMP, Member__, Skidmore, Owings, & Merrill LPP, Chicago, IL

Seminar 76 (Intermediate)

Smart Controls and Optimization for Thermal Storage Systems and Connected Communities

Track: Energy Conservation
Sponsor: 6.9 Thermal Storage
Chair: Paulo Tabares Velasco, Ph.D., Associate Member, Colorado School of Mines, Golden, CO

Smart controls and thermal storage are solutions to increase grid flexibility and reduce energy use but its implementation requires careful planning and coordination. This becomes more challenging in a connected community, as most studies have focused on single building. The aggregation of cooling loads with a campus or connected community provides increased opportunities to achieve cost and energy savings. This session presents four energy conservation applications of optimized controls, with and without thermal storage, across multiple scales - from district cooling plants to residential HVAC. Using example case studies, cost-energy tradeoffs of the optimization scenarios are presented.

Learning Objectives:

1. Describe how cool thermal energy storage could enable increased generation from renewables
2. Explain the cost-energy tradeoffs of various thermal storage systems at the building and community scales
3. Apply a methodology to optimize distributed thermal storage system design and control
4. Describe a holistic, model-based approach for electric power demand minimization of central chiller plants in connected communities
5. Demonstrate a methodology to optimize distributed thermal storage system design and control.
6. Provide a holistic, model-based approach for electric power demand minimization of central chiller plants in connected communities.
7. Describe how cool thermal energy storage could enable increased generation from renewables.
8. Describe a holistic, model-based approach for electric power demand minimization of central chiller plants in connected communities
9. Apply a methodology to optimize distributed thermal storage system design and control
10. Apply a methodology to optimize distributed thermal storage system design and control
11. Explain the cost-energy tradeoffs of various thermal storage systems at the building and community scales
12. Describe how cool thermal energy storage could enable increased generation from renewables
13. Explain the cost-energy tradeoffs of various thermal energy storage systems at the building and community scales
14. Apply a methodology to optimize distributed thermal storage system design and control

Controlling Cool Thermal Energy Storage to Increase Grid Penetration of Renewables
Amy Van Asselt, Ph.D., Associate Member*, Lafayette College, Easton, PA*

Holistic Optimization Using Model-Based Approach for Central Chiller Plants in Connected Communities
Mohammad Hassan Fathollahzadeh, Student Member*, Colorado School of Mines, Golden, CO*

Optimizing the Location and Operation of Distributed Thermal Storage in a Diverse Connected Community
Karl Heine, Student Member*, Colorado School of Mines, Golden, CO*

Optimal Phase Change Temperature and Size to Minimize Residential HVAC Energy Cost and Peak Demand
Navin Kumar, Ph.D.*, Oak Ridge National Laboratory, Oak Ridge, TN*

Seminar 77 (Intermediate)

Smart Indoor Environmental Models for Data Centers

Track: Building Performance and Commissioning for Operation and Management

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

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

This session aims to highlight smart indoor environmental modeling approaches for real-world practice. The advantages and disadvantages of full scale CFD modeling and compact models are discussed. Then, an explanation of where and when the compact models can be used with examples from real world practices in data centers is presented.

Learning Objectives:

1. Understand when to use compact models when modeling the data center cooling.
2. Describe the primary benefit of the compact rack model over previous black-box approaches.
3. Explain how compact models can maintain accuracy and integrity for making engineering decisions.
4. Explain the primary characteristics of IT equipment that are necessary to include when developing compact models.
5. Understand when to use compact models when modeling the data center cooling.
6. Explain how compact models can maintain accuracy and integrity for making engineering decisions.
7. Understand when to use compact models when modeling data center cooling
8. Explain the primary characteristics of IT equipment that are necessary to include when developing compact models.
9. Explain how compact models can maintain accuracy and integrity for making engineering decisions
10. Distinguish between “compact” and “detailed” rack models.
11. Describe the primary benefit of the compact rack model over previous black-box approaches.

It's Always Smart to be Accurate – or Is It?
Mark Seymour, Member*, Future Facilities, London, United Kingdom*

Using Compact Models for Improving IT Equipment Modeling in Data Center Simulations
Dustin Demetriou, Ph.D., Member*, IBM, Poughkeepsie, NY*

A Compact Rack Model for Data Center Modeling
James VanGilder, P.E., Member*, Schneider Electric, Andover, MA*

Seminar 78 (Intermediate)

Supplementing Ventilation with Gas-phase Air Cleaning (IEA-EBC Annex 78)

Track: Environmental Health Through IEQ sponsored by Ebtron

Sponsor: 2.3 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, IEA-EBC Annex 78

Chair: Bjarne Wilkens Olesen, Ph.D., Fellow ASHRAE, Intl. Center for Indoor Environment and Energy, Technical University of Denmark, Lyngby, Denmark

IEA-EBC Annex 78 bring researchers and industry together to investigate the possible energy benefits and increased indoor air quality by using gas phase air cleaners to partial substitute for ventilation (outdoor air). None of existing standards for testing gaseous air cleaners include human bio effluents as a source and the perceived indoor air quality is not used to evaluate the performance. Bio effluents from occupants are an important source of pollution and most criteria for ventilation is based on perceived air quality. There is therefore a need to establish new and more relevant test methods for gaseous air cleaners.

Learning Objectives:

1. Describe how the use of gas phase air cleaning may increase indoor air quality and reduce energy use in buildings
2. Distinguish between the different type of air cleaning technologies
3. Explain the concept of perceived air quality and how it is measured
4. Describe the concept of testing and modelling of gas phase air cleaners
5. Describe how the use of gas phase air cleaning may increase indoor air quality and reduce energy use in buildings
6. Distinguish between the different type of air cleaning technologies
7. Explain the concept of perceived air quality and how it is measured
8. describe different air cleaning technologies
9. discuss challenges associated with using gas-phase air cleaners
10. Identify main international standards for testing gas phase air cleaners
11. Explain what are the typical output data provided by standardized test methods for gas phase air cleaners
12. Understanding the role of air cleaning in improving IAQ
13. Understand the method to apply models to predict the long-term performance of air cleaners
14. understand the outline of sensory test
15. know the progress of international standardization for sensory test

Concept for Substituting Ventilation By Gas Phase Air Cleaning: Pros and Cons
Bjarne W. Olesen, Ph.D., Fellow ASHRAE*, Intl. Center for Indoor Environment and Energy, Technical University of Denmark, Lyngby, Denmark*

Gas Phase Air Cleaning Technologies, Needs and Challenges
Pawel Wargocki, Ph.D., Associate Member*, Technical University of Denmark, Kongens Lyngby, Denmark*

International Standards for Testing Gas Phase Air Cleaners.
Paolo Tronville, Ph.D., Fellow ASHRAE*, Politecnico di Torino, Torino, Italy*

Modelling and Long Term Performance of Gas Phase Air Cleaning Technologies
Jianshun Zhang, Ph.D., Fellow ASHRAE*, Syracuse University, Syracuse, NY*

International Standards for Testing of Perceived Air Quality
Ito Kazuhide, Ph.D., Member*, Faculty of Engineering Sciences, Kyushu University, Kyushu, Japan*

Seminar 79 (Advanced)

Sustainable Approaches for Energy Demand in the Community Scale

Track: Energy Conservation

Sponsor: 4.7 Energy Calculations

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

Application of sustainable technologies at the community scale offers many benefits to society and the environment. However, due to the challenges in design and operation, a holistic approach is required to consider demand and supply energy characterization beyond the built environment. It is also important to consider other non-engineering aspects such as community's preference and cultural needs. This seminar shows some examples of how to holistically addresses these challenges as well as a review on some of the current tools and methodologies available to perform large-scale analysis for today and tomorrow's community-scale design.

Learning Objectives:

1. Define multi-level approach to enable flexible modeling of the interconnected systems
2. List available tools for holistic community-scale energy analysis with a focus on bottom-up and top-down approaches for community energy modeling
3. Provide a holistic approach for hybrid renewable energy analysis and modeling in indigenous communities in the U.S.
4. Define the steps required to develop electric demand profile for residential, commercial, and industrial sectors
5. Define multi-level approach to enable flexible modeling of the interconnected systems
6. List available tools for holistic community-scale energy analysis with a focus on bottom-up and top-down approaches for community energy modeling
7. Provide a holistic approach for hybrid renewable energy analysis and modeling in indigenous communities in the U.S.
8. Define the steps required to develop electric demand profile for residential sector
9. List available tools for holistic community-scale energy analysis with a focus on bottom-up and top-down approaches for community energy modeling
10. Provide a holistic approach for hybrid renewable energy analysis and modeling in indigenous communities in the U.S.

Modeling of Sustainable, Smart and Connected Communities
Wangda Zuo, Ph.D., Member*, University of Colorado Boulder, Department of Civil, Architectural and Environmental Engineering, Boulder, CO*

Holistic Hybrid Renewable Energy Analysis in a Rural Community: Beyond Your Typical Building Energy Simulation
Paulo Cesar Tabares-Velasco, Ph.D.*, Colorado School of Mines, Golden, CO*

Hybrid Renewable Energy Resources Analysis in Rural Communities Using Bottom-up Demand Prediction
Mohammad Hassan Fathollahzadeh, Student Member*, Colorado School of Mines, Golden, CO*

Seminar 80 (Advanced)

System Analysis and Modeling of Variable Refrigerant Flow Systems

Track: Systems and Equipment

Chair: Heejin Cho, Ph.D., Member, Mississippi State University, Mississippi State, MS

Variable refrigerant flow (VRF) systems have gained a great attention and popularity in the US recent years. As building designs get sophisticated whether it was due to code and standard or design intention, a deeper understanding of system capability and limitation becomes a key to adopt and integrate VRF systems into advanced energy efficiency building designs. This seminar provides insight into system analysis and modeling techniques for different VRF system configurations. It also discusses performance evaluation of a VRF system in a laboratory environment and modeling techniques with advanced building designs, e.g., net-zero energy buildings.

Learning Objectives:

1. Define various types of VRF system design and capabilities
2. Explain performance analysis and model calibration of air-source VRF systems
3. Describe design and modeling methods for water-source heat recovery VRF systems
4. Explain design and modeling aspects of VRF Systems in net-zero energy building design
5. Learn the energy savings potentail of VRF systems
6. Learn the impact of calibrated modeling
7. Evaluate the performance of a net-zero energy building design with air source variable refrigerant flow heat pump and heat recovery systems.
8. Understand that the variable refrigerant flow heat recovery system can effectively reduce cooling, heating, and fan energy consumption, and this further help reduce capacities of on-site power generation systems
9. Understand appropriate assumptions (e.g., economic base data, and service data) need to be carefully considered in early design stages because LCCA of NZEBs involves the varied effect on economic performance under specific circumstances when advanced HVAC systems are applied for the NZEB design.

Performance Analysis and Model Calibration of Air-Source VRF Systems
Piljae Im, Ph.D., Member*, Oak Ridge National Laboratory, Oak Ridge, TN*

System Design and Modeling Methods for Water-Source Heat Recovery VRF Systems
Heejin Cho, Ph.D., Member*, Mississippi State University, Mississippi State, MS*

Performance Evaluation and Modeling of Net-Zero Energy Building Design with VRF Systems
Dongsu Kim, Ph.D., Associate Member*, Hanbat National University, Daejeon, Korea, Republic of (South)*

Seminar 81 (Intermediate)

The Impact of COVID-19 on Building Energy Consumption, IAQ and Occupant Behavior

Track: Environmental Health Through IEQ sponsored by Ebtron

Sponsor: MTG.OBB Occupant Behavior in Buildings

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

COVID-19 pandemic dramatically change occupant schedules and behavior, and thus the impacts on building energy consumption and indoor air quality. Understanding such impacts is crucial to ensuring building performance and operations while providing healthy and productive living and working environments. This seminar provides an overview of such impacts from the following perspective: 1) linking social-psychological factors with the analysis of energy pattern and home energy management system, 2) shelter-in-place on energy use of office buildings, 3) IAQ at home, and 4) well-being at homes-results from an international survey.

Learning Objectives:

1. Understand the linkage between social-psychological factors with IAQ and Energy in residential buildings during COVID-19
2. Understand the impact of shelter-in-place on energy use of office buildings
3. Understand the impact of COVID-19 on IAQ in residential homes
4. Provide an overview of how work from home affects well-being during COViD-19
5. Understand energy justice issues, low-income households' energy burdens and energy pattern across different income groups during COVID-19
6. Understand demographics, social-psychological and perceived technological attribute factors influencing home energy management system (HEMS) adoption intention and willingness to pay
7. Understand how to use the socio-technical integration perspective to promote energy transitions away from fossil-fuel-based systems for diverse populations
8. Learn actual energy use in office buildings during pandemic
9. Understand why office buildings even at low occupancy level still consume significant amount of energy and how to improve building design and operations to reduce such energy waste.
10. Understand the impact of COVID-19 on IAQ in residential homes
11. Provide an overview of how work from home affects well-being during COViD-19
12. have an overview of how work from home affects well-being during COVID-19
13. understand the impact of COVID-19 on IAQ in residential homes

Linking Social-Psychological Factors with the Analysis of Energy Pattern and Home Energy Management System during COVID-19
Chien-fei Chen, Ph.D.*, University of Tennessee, Knoxville, TN*

What Can We Learn from Impact of Shelter-in-Place on Energy Use of Office Buildings?
Tianzhen Hong, Ph.D., Fellow ASHRAE*, Lawrence Berkeley National Laboratory, Berkeley, CA*

IAQ at Home during the COVID-19 Lockdown
Clinton Andrews, Ph.D., P.E., Member*, Rutgers University, New Brunswick, NJ*

How Work from Home Affects Well-Being during COVID-19: Results from an International Survey
Zheng O'Neill, Ph.D., P.E., Member*, Texas A&M University, College Station, TX*

Seminar 82 (Basic)

The Impacts and Value of ASHRAE Standards and Technology

Track: Standards, Guidelines and Codes

Sponsor: MTG.IAST Impact of ASHRAE Standards and Technology on Energy Savings/Performance

Chair: Daniel Pettway, Life Member, Retired Industry Professional, Chesapeake, VA

Since its birth 125 years ago, ASHRAE has been dedicated to advancing the arts and science of HVAC&R and the allied fields. Under the guidance of MTG.IAST, a research project was recently completed to systematically assess and document the influence of ASHRAE on research, higher education, industry guidelines, and professional development. This seminar will share major results from the project with recommendations for the future marketing and growth of ASHRAE.

Learning Objectives:

1. Describe the impact of ASHRAE Standards on government regulations.
2. Understand the influence of ASHRAE Standards on design, testing, and rating guidelines in the HVAC/R industry.
3. Describe ASHRAE's support for academia and higher education.
4. Learn about the professional development seminars, short courses, training, and certification programs ASHRAE offers to the industry.
5. Describe the impact of ASHRAE Standards on government regulations.
6. Understand the influence of ASHRAE Standards on design, testing, and rating guidelines in the HVAC&R industry.
7. Describe ASHRAE's support for academia and higher education.

Challenges of Defining "the Signal from the Noise"
Daniel Pettway, Life Member*, Retired Industry Professional, Chesapeake, VA*

Summary of ASHRAE Research Project 1848-RP "Assessing the Impact and Value of ASHRAE's Standards and Technology"
Liping Liu, Ph.D., Associate Member*, Lawrence Tech University, Southfield, MI*

Applying the Findings of the 1848-RP Report: Speaking up about ASHRAE's Accomplishments
Lawerence Markel, Fellow ASHRAE*, Oak Ridge National Laboratory, Oak Ridge, TN*

Seminar 83 (Advanced)

Thermal Energy Storage in Geothermal Systems

Track: Systems and Equipment
Sponsor: 6.8 Geothermal Heat Pump and Energy Recovery Applications
Chair: Roshan Revankar, Melink Solar and Geo, Milford, OH
Geothermal heat pump systems are expensive primarily due to cost and installation of ground heat exchangers. This session explores three ways to introduce thermal energy storage in the system design with the goal to reduce the size of ground heat exchanger. The methods presented also explore ways to use off peak rates for low cost system operation. The presenters share modeling aspects of this design and its use in innovative projects across the US.

Learning Objectives:

1. Understand the application of phase-change material (PCM) to ground-source heat pump systems.
2. Apply a new design of borehole heat exchanger that is integrated with thermal energy storage to enable flexible electric load.
3. Design ground heat exchanger patterns more effectively and reduce borefield size.
4. Distinguish PCM types and effective use for thermal heating and cooling applications.
5. Understand the application of phase-change material (PCM) to ground-source heat pump systems.
6. Apply a new design of borehole heat exchanger that is integrated with thermal energy storage to enable flexible electric load.
7. Understand the concept of a Dual Temperature Borehole Thermal Energy Storage (DT-BTES)system
8. Describe the advantages of charging a DT-BTES overnight to reduce GHG emissions.
9. Understand the application of phase-change material (PCM) to ground-source heat pump systems
10. Distinguish PCM types and effective use for thermal heating and cooling applications

Dual-Purpose Underground Thermal Battery
Xiaobing Liu, Ph.D., Member*, Oak Ridge National Laboratory, Oak Ridge, TN*

Dual Temperature Borehole Thermal Energy Storage
Michel Bernier, Ph.D., Fellow ASHRAE*, Polytechnique Montréal, Montréal, QC, Canada*

The Integration of PCM Thermal Energy Storage with Ground-Source Heat Pump Applications
Stephen Hamstra, P.E., HBDP, Member*, Melink Solar and Geo, Milford, OH*

Seminar 85 (Intermediate)

Unique and Necessary Approaches and Considerations When Commissioning Commercial Kitchen Ventilation Systems

Track: Building Performance and Commissioning for Operation and Management
Sponsor: 5.10 Kitchen Ventilation

Chair: Jimmy Sandusky, Associate Member, Halton Company, Scottsville, KY
Commercial kitchen ventilation systems present unique and challenging situations that must be considered during the commissioning process. Beyond the typical HVAC supply and return air distribution, the designer must consider items such as electrical and natural gas interlocks, fire suppression systems and demand control ventilation systems that must be verified to function throughout a range of airflows. This session highlights these items, provide rationale for their importance and present best case practices as part of the commercial kitchen ventilation commissioning process.

Learning Objectives:

1. Identify items and milestones that are critical to the commercial kitchen ventilation system commissioning process.
2. Describe the complexity and multi-phase aspects of commissioning a commercial kitchen ventilation system for both new construction and existing facilities.
3. Describe the necessary information to convey on mechanical drawings to ensure proper commissioning of the commercial kitchen can take place.
4. Identify common field installation issues, ranging from design considerations, HVAC supply and return air distribution, electrical wiring, interlocks, and related fire suppression systems.
5. List the equipment and components that must be reviewed and tested as part of the commissioning process for a complete Commercial Kitchen Ventilation (CKV) system.
6. Understand how a DCKV system operates so that it can be properly tested as part of it commissioning.
7. Understand the various airflows common in a commercial restaurant and their interactions
8. Identify what is important to portray in schedules like air balance & equipment schedules
9. Describe the necessary information to convey on mechanical drawings to ensure proper commissioning of the commercial kitchen can take place.
10. Identify common field installation issues.

Commercial Kitchen Commissioning Fundamentals
Francis Kohout, P.E., BCxP, Member*, Cyclone Energy Group, Chicago, IL*

Air Balance in the Commercial Kitchen
Greg DuChane, Member*, Trane, Nacogdoches, TX*

Test and Balance Considerations for the Commercial Kitchen
Andy Austin*, Melink Corporation, Milford, OH*

Seminar 86 (Intermediate)

Use of Reflective Technology in Buildings

Track: Energy Conservation
Sponsor: 4.4 Building Materials and Building Envelope Performance, N/A
Chair: David Yarbrough, Ph.D., P.E., Member, R&D Services, Inc., Watertown, TN
The use, evaluation and benefits of reflective insulation, radiant barriers and gas-filled panels is presented. Low-emittance foils and films installed in enclosed spaces provide thermal resistance that are determined by standard test methods. Low-emittance surfaces including coatings in ventilated spaces, such as residential attics reduce the heat transfer across the attic air space and duct-work space. Quantitative evaluations are best determined using computer simulations that can include the many factors that impact performance. Panels containing low thermal conductivity gas and low-emittance interior surfaces can provide high thermal resistivity components. The variety of uses of reflective technology is described.

Learning Objectives:

1. describe the components, evaluation, and applications of reflective insulations.
2. describe the components, evaluations, and applications of radiant barriers.
3. describe how computer simulations are used to evaluate radiant barrier performance and use results obtained for different climate zones.
4. describe how the use of low-emittance materials contribute to the performance of hybrid and advanced insulations.
5. explain the components, evaluation, and applications of reflective insulations.
6. discuss the factors that impact the performance of reflective insulation assemblies in bilidings.
7. better understand the benefits of radiation control using radiant barrier systems in attics.
8. better understand hybrid insulation and radiant barrier systems that are viable system options in cold climates.

Overview of Reflective Insulation Technology
David Yarbrough, Ph.D., P.E., Member*, R&D Services, Inc., Watertown, TN*

Computer Simulation of Attic Radiant Barrier Performance
***William Miller, Ph.D., P.E., Member**, University of Tennessee, Knoxville, TN*

Evaluation of Radiant Barriers and Low-Emittance Coatings
***Som Shrestha, Ph.D., BEMP, Member**, Oak Ridge National Laboratory, Oak Ridge, TN*

Seminar 87 (Intermediate)

What Makes a Compressor a Heat Pump Compressor?

Track: Refrigeration and Refrigerants

Sponsor: 8.1 Positive Displacement Compressors, 8.2 Centrifugal Machines , 8.11 Unitary and Room Air Conditioners and Heat Pumps

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

Vapor compression technologies heavily reply on high-efficient compressors to meet the heating and cooling load requirements. Advances in manufacturing techniques and computational resources along with refrigerant and energy efficiency requirements are driving the hunt for the next generation compressors. This seminar focuses on design optimizations and challenges of both positive displacement and turbo-compressors for heat pumping applications with particular emphasis on low-GWP refrigerant solutions and alternative integrated solutions.

Learning Objectives:

1. Understand what makes water-water heat pumps utilizing turbo compressor technology a viable alternative
2. Understand the limitations with the technology operating temperatures, range and how they can be addressed
3. Describing how for refrigerants having a low temperature glide, design changes may not be necessary in heat pump equipment in order to make them energy efficient
4. Understand the challenges facing the retrofit process of appliances and devices from AC to DC power
5. Understand what makes water-water heat pumps utilizing turbo compressor technology a viable alternative.
6. Understand how dual cooling/heating ‘symbiosis’ application opportunities utilizing this technology influence viability vs single factor
7. Understand how staged approach with compressors optimized to the operating temperatures and refrigerant influence viability and payback
8. Describe how low GWP, zeotropic refrigerants mixtures in counter-flow water-to-refrigerant heat exchangers can improve system performance
9. • Describe the four component thermodynamic heat pump model developed to explore this phenomenon by simulating “drop-in” alternatives of R410A in existing heat pump equipment

Turbo Compressors and Low-GWP Refrigerants in Large Commercial and Heat Pump Systems
***Drew Turner** and Leping Zhang, Danfoss Turbocor Compressors, Inc., Tallahassee, FL*

The Thermodynamic Behaviour of Low-GWP Zeotropic Mixtures on Water-Source Heat Pump Equipment
***Saad Saleem, Student Member**[1] and Craig Bradshaw, Ph.D., Member[2], (1)Oklahoma State University (OSU), Stillwater, OK, (2)Oklahoma State University, Stillwater, OK*

The Case for DC Powered Residential Heat Pumps
***Jonathan Ore, Student Member**, Davide Ziviani, Ph.D., Member and Eckhard Groll, Dr.Ing., Fellow ASHRAE, Purdue University, West Lafayette, IN*

Seminar 88 (Intermediate)

Whole Greater Than the Sum: Coupling Building Simulation Techniques

Track: Energy Conservation

Sponsor: 4.10 Indoor Environmental Modeling

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

There are many tools available to the modern HVAC designer, capable of modeling different aspects of building performance at different levels of detail. Even though there are trade-offs when choosing one tool over another there are applications that require the benefits of more than one tool. This seminar focuses on combining various modelling tools to design data centers and commercial spaces. The combination of various methodologies including CFD, flow network modeling, city building energy models and multizone methods are presented and the applications and drawbacks of each is discussed.

Learning Objectives:

1. Understand the ROI of simulation in compare to the whole project and how to justify the use of simulation
2. Describe the primary benefit of the combined PFM-FNM approach over traditional CFD.

3. Explain the method to calculate indoor COVID-19 infection risks
4. Learn different strategies for coupling the airflow models and building energy system models
5. 1. Understand when to use multiple flow simulation techniques in modeling the data center cooling performance.
6. 2. Explain why coupled models can better predict overall system performance in both normal (steady state) and cooling failure operation.
7. 1. Know how high is the airborne infection risk of COVID-19 in a building of your city.
8. 2. Know how to mitigate COVID-19 indoor airborne transmission risks by different strategies and how effective they are
9. Distinguish between flow network modeling (FNM), potential flow modeling (PFM), and traditional CFD.
10. Describe the primary benefit of the combined PFM-FNM approach over traditional CFD.
11. Learn different strategies for coupling the airflow models and building energy system models
12. Understand the usage of coupled models for airflow and building energy system.

Bridging the Scale Divide
Mark Seymour, Member*, Future Facilities, London, United Kingdom*

Strategizing Building Ventilation System Operations for Energy Saving and Mitigating COVID-19 Infection Risks By Coupling Weather Forecasting and City Building Energy Models
Liangzhu Wang*, Concordia University, Montréal, QC, Canada*

Coupling Potential-Flow and Flow-Network Models for Fast Data Center Thermal Analysis
James VanGilder, P.E., Member*, Schneider Electric, Andover, MA*

Coupled CFD-Multizone-Modelica Models for Dynamic Simulation of Indoor Environment and HVAC Systems
Wangda Zuo, Ph.D., Member*, University of Colorado, Boulder, CO*

Seminar 89 (Basic)

Window Shading: How to Save Energy while Improving Occupant Comfort and Visual Environmental Quality?

Track: Energy Conservation
Sponsor: 4.5 Fenestration
Chair: Mahabir Bhandari, Ph.D., Member, Oak Ridge National Laboratory, Oak Ridge, TN

Window shading systems/attachments have the economic potential to save 800 TBTUs in cooling and heating energy by 2030, while they can also significantly enhance visual environmental quality in terms of glare and outside view preservation. Lack of performance rating mechanisms, including energy savings potential and comfort-related studies of various shading systems, prevent these systems from fully realizing their market potential. Recent developments in characterization and rating of shading systems, including energy performance, glare protection along-with novel combinations of repeatable workflows that allow practitioners to quickly evaluate fenestration systems for their energy performance, visual comfort, and view quality is presented.

Learning Objectives:

1. Energy savings potential of window attachment/shades systems in residential and commercial buildings.
2. Window attachment energy rating system (AERC rating), what is it and how do you benefit from it?
3. Understanding visual comfort from window shading
4. Learn combination of repeatable workflows that allow practitioners to quickly evaluate simple and complex fenestration systems for – their energy performance, visual comfort, and objective view quality.
5. Explain visual comfort from window shading
6. Understand the way optical properties affect comfort and view
7. Explain the key benefits that a window attachment rating system can provide to industry members.
8. Describe the key components of consumer education and utility rebates that encourage adoption and proper use of energy saving window attachments.

Energy Performance of Window Shading
Charlie Curcija, Ph.D., Member*, Lawrence Berkeley National Laboratory, Berkeley, CA*

Roller Shades' Optical Properties and Their Impact on Glare Performance and Outside View
Iason Konstantzos, Ph.D., Member*, University of Nebraska-Lincoln, Omaha, NE*

How Rating Systems Drive Consumer Education and Energy Savings
Stephen Mullaly*, Hunter Douglas, Broomfield, CO*

Early-Stage Optimization of Fenestration Design Options for High-Performance Buildings
Sagar Rao, Member*, Affiliated Engineers, Inc., Madison, WI*