



**2011 ASHRAE Annual Conference
June 25-29, 2011 Montreal**

The entire technical program is approved for PDHs. In addition, sessions indicated with icons have been submitted for approved for:



NY PDHs



AIA Learning Units



GBCI LEED AP Credits

Revised June 13, 2011

Changes since last version:

ASHRAE Foundation session added Sunday, 3:00 pm – 4:00 pm, free session.

Seminar 50, the first two presenters switched their order of presentation.

Seminar 7, two new replacement speakers are listed.

Sunday, 06/26
8:00 AM-9:30 AM

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Technical Paper Session 1 (Advanced)



Getting the Most Out of Building Energy Assessments

Track: Commissioning

Room: Hampstead

Chair: Sarah E. Maston, P.E., Member, Advanced Building Performance, Hudson, MA

The papers in this session present methodologies and techniques for estimating potential energy savings from building-commissioning and by conducting building energy audits or assessments.

1. The Nearest Neighborhood Method to Improve Uncertainty Estimates in Statistical Building Energy Models (ML-11-001)

Lei Yafeng, Ph.D., P.E.¹, T. Agami Reddy, Ph.D., P.E., Fellow ASHRAE² and Kris Subbarao, Ph.D., Member³, (1)Nexant, Inc., Houston, TX, (2)Arizona State University, Tempe, AZ, (3)Pacific Northwest National Laboratory, Richland, WA

Accurate estimation of uncertainty in energy use predictions from statistical models finds applications in a number of diverse areas of interest to building energy professionals. Some examples are in the determination of measured energy savings in monitoring and verification (M&V) projects, in continuous commissioning and in automated

fault detection wherein improper building or equipment performance are to be detected. All these applications generally involve identifying a baseline statistical model representative of energy use prior to the retrofit (or to energy use under fault-free operation), and then ascertaining the energy savings (or the penalty for faulty operation) as the difference between the measured post-retrofit energy use and the corresponding model-predicted value. Unfortunately, the model residual outliers are ill-behaved and estimates of the uncertainty in the energy savings tend to be unrealistic. Developing a general methodology for determining more realistic, robust and credible estimates of the uncertainty in energy savings would be of great value, and this is the objective of this paper.

The proposed approach is to determine the uncertainty from “local” system behavior rather than from global statistical indices of the model fit such as root mean square error and other measures as is the current practice. This is done using the non-parametric nearest neighborhood points approach which is well known in traditional statistics. The methodology is applicable to any type of statistical model approach such as regression, time series, neural networks, and could be coded into a computer package that can be appended to existing M&V analysis programs. Two case study examples using daily building energy use data serve to illustrate the proposed methodology. The ultimate benefit of such a reliable and statistically defensible method is to lend more credibility to the determination of risk associated with energy savings from energy efficiency projects, and thereby induce financial agencies to become more involved in “white tag” and allied certification programs.

2. Energy Assessments of Building Sites: Methodology and Techniques (ML-11-002)

Alexander Zhivov, Ph.D., Member¹, Jorma Pietilainen, Associate Member², Fritz Schmidt, Dr.Ing.³, Erja Reinikainen⁴ and Alfred W. Woody, P.E., Fellow Life Member⁵, (1)U.S. Army Corps of Engineers, Champaign, IL, (2)VTT Technical Research Centre of Finland, Espoo, Finland, (3)Ennovatis GmbH, Tunnelstrasse 14, Germany, (4)Olof Granlund Oy, Heksinki, Finland, (5)Ventilation/Energy Applications, PLLC, Norton Shores, MI

Analysis of nonresidential building structures shows that many buildings of this type are characterized by high energy consumption. Administrative/office buildings and production and maintenance facilities pose specific challenges to those seeking improved energy management and building energy performance. Common to all these buildings is that questions of energy consumption are generally seen as secondary to the improvement of comfort and/or functionality. This is most pronounced within the existing building stock. Decisions to retrofit a building are often made because of dissatisfaction concerning the comfort level, or as a consequence of changes in building use or in processes performed in the building. The primary goal of the retrofit is to improve these conditions. Good technologies that meet these requirements are currently available. The objectives of the International Energy Agency Energy conservation in Buildings and Community Systems (ECBCS) Programme Annex 46 is to provide tools and guidelines to identify energy conservation opportunities in buildings and to improve the indoor environment of these buildings in energy-efficient retrofitting projects. Among tools developed within this project is the Energy and Process Assessment Protocol, which provides an energy assessment methodology and procedure suitable for different types of sites, including a variety of different non-industrial buildings with energy requirements dominated by climate and industrial buildings, which have high energy loads dominated by internal processes and high ventilation requirements per its floor space. This paper presents the energy assessment methodology for a single building or a large building stock, along with examples of typical energy wastes and inefficiencies in different types of buildings and typical processes.

3. Establishing Building Recommissioning Priorities and Potential Energy Savings from Utility Energy Data (ML-11-003)

Kevin P. Hallinan, Ph.D.¹, Phil Brodrick, Student Member¹, J. Kelly Kissock, Ph.D., P.E., Member¹, Robert J. Brecha, Ph.D.¹ and Jessica Nothridge, Student Member¹, (1)University of Dayton, Dayton, OH

An energy reduction program for commercial buildings is implemented for a SW Ohio natural gas utility. The aim of this study is to demonstrate that historical utility data for individual building customers, along with knowledge of pertinent building information (square footage, year built, number of floors, height of floors, wall construction type, and use type) available in County Auditor databases, could be used to identify the best candidate buildings for recommissioning in terms of energy savings and simple payback. A study is completed for all natural gas customers of a utility in Montgomery and Clinton Counties in Ohio. A total of 1200 candidate buildings for

recommissioning are identified. These buildings have: i). seen increases in heating or non-weather dependent energy over time; or ii). have large baseline energy intensities indicative of combined heating/cooling year round. For these buildings, individual energy reports are created and shared with the building owners. For a subset of buildings, on-site recommissioning evaluations were used to confirm estimates derived from utility data alone.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Conference Paper Session 1



Discovering Data Center Energy; Use with Dynamic Modeling, Working with Standard 90.1; and a New Energy Reuse Metric

Track: HVAC Applications

Room: Westmount

Sponsor: 09.09 Mission Critical Facilities, Technology Spaces and Electronic Equipment

Chair: Nick Gangemi, P.E., Member, Data Aire, Penfield, NY

Energy conservation and modeling of that use is critical in data center designs starting yesterday. A dynamic model development is discussed to help predict how the cooling equipment is operated off-design and its impact on the energy consumption. Thus far, most facilities have gone without economizers and provided little exposure for designers to Standard 90.1. This session walks through applying the standard to data centers. Finally, the energy reuse effectiveness metric (ERE) is discussed; the development and application of the metric.

1. Development of a Dynamic Energy Use Modeling Tool for Data Center Cooling Infrastructure (ML-11-C001)

Dustin W. Demetriou, Student Member¹, H. Ezzat Khalifa, Ph.D., Fellow ASHRAE¹, Roger Schmidt, Member² and Madhusudan Iyengar, Ph.D., Member², (1)Syracuse University, Syracuse, NY, (2)IBM, Poughkeepsie, NY
Data center design point operation is rarely realized and most data center cooling equipment is operated off-design, which has a significant effect on the energy consumption. This paper addresses the development and validation of a thermo-hydraulic model based on an existing ~6 MW data center and chiller plant located in Poughkeepsie, New York. Inherent in this model is the ability to capture off-design operation of the cooling infrastructure caused by changes in ambient conditions, operating strategies and fluctuations in IT load. Collected data is used for validation showing agreement within 5% in the aggregate, at a number of off-design operating conditions.

3. Navigating ASHRAE SSPC 90.1,-2010 Requirements for Economizers in Datacom (ML-11-C003)

David Quirk, P.E., Member, Verizon Wireless, Basking Ridge, New Jersey

ASHRAE/IESNA Standing Special Project Committee (SSPC)-90.1, Energy Standard for Buildings Except for Low-Rise Residential Buildings, has amended the Standard to include Data Centers within the scope of the 2010 edition following approval of Addenda AQ, despite published opposition from ASHRAE TC9.9 voting members (ASHRAE TC9.9 votes, 2010). Addenda BU was also approved, as requested by ASHRAE TC9.9, which establishes some specific criteria for data centers, including some key exemptions for economizers (ASHRAE 90.1 actions, 2010). As a result, any jurisdictions that adopt the 2010 edition of SSPC-90.1 for their energy code compliance will result in a substantial change for the datacom industry. Prior to this change, the Datacom industry was left to its own devices and discretion on energy efficiency strategies, which has been gaining significant momentum in recent years resulting in rapid and noteworthy innovation on the energy efficiency front (Google blog, 2010). The changes introduced within 90.1 raise concern over the possible squelching of innovation brought about by prescriptive based industry standards. There is even greater concern over the potential for unintended consequences brought about by the prescriptive requirements and subsequent enforcement from AHJ's on process cooling facilities, many of which serve a critical mission. One such prescriptive requirement is the application of economizers in many cases for Datacom facilities. Thus far, most Datacom facilities have gone without economizers, so there is little experience by end-users or design professionals alike on applying and operating economizers in mission critical facilities where extremely high availability and reliability are core requirements

(ASHRAE TC9.9 member's survey, 2010). Aside from the potential concerns surrounding gaseous and particulate contamination from the introduction of large quantities of outside air (ASHRAE TC9.9 2009), there are also real concerns related to the design, construction, and operation of economizers that can result in unacceptable failure conditions (Quirk, 2010). This is not to detract from the numerous successful installations of economizers within Datacom facilities today, only to draw caution to the application given the additional complexities involved. Fortunately there are some exceptions to economizers for specific types of Datacom facilities, in addition to the alternative compliance paths within 90.1. This paper will attempt to outline the essential decision making processes for the application of economizers in Datacom facilities as well as outline how to navigate ASHRAE SSPC-90.1 paths to energy code compliance for Datacom facilities.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Seminar 1 (Intermediate)



Alternative Thermodynamic Cycles and Systems for Increased Sustainability

Track: *Alternative Technologies*

Room: *Verdun*

Sponsor: *01.01 Thermodynamics and Psychrometrics*

Chair: *Sriram Somasundaram, Ph.D., Fellow ASHRAE, Navigant Consulting, Richland, WA*

As the public has become more aware of the economic and environmental implications of energy systems, funding for alternative energy systems has started to increase. This seminar examines the thermodynamic basics of three alternative energy systems, discusses implications for their application, and examines their potential contribution to a more sustainable built environment and transportation systems.

1. Innovations in Development and Implementation of CO₂ Cycles

Thomas Kuehn, Ph.D., Fellow ASHRAE, University of Minnesota, Minneapolis, MN

In a combined CO₂ sequestration (i.e., permanent storage) and geothermal energy production system, CO₂ from a fossil fuel power plant or industrial source (e.g., ethanol plant) is injected into deep geologic formations. A fraction of the injected and geothermally heated CO₂ is brought back to the surface to drive a turbine and electricity generator, before being returned to the subsurface. The heat is replenished by the Earth's natural heat flow, while the CO₂ is trapped within a geologic structure at great depth (0.6 to 3 km).

2. Analysis of an Efficient Organic Rankine Cycle for Power Generation

Samuel Sami, Ph.D., P.E., Fellow ASHRAE, TransPacific Energy, Inc., Carlsbad, CA

This talk focuses on a Rankine cycle and improved organic refrigerants which are particularly useful in driving an electric power generating system and which are highly suited to a wide range of heat sources for providing vapor regeneration of the refrigerants. The heat source may, for example, be exhaust combustion products of a fuel-fired device, hot liquid from a solar collector, geothermal wells, warm ocean waters or a number of other heat sources which typically represent heat sources the heat from which is not captured to provide useful energy or work.

3. An Adsorption System to Integrate with the Recent Development of Emission Control for Heavy-Duty Vehicles

Yongfang Zhong, Ph.D., Associate Member, Penn State University - Behrend, Erie, PA

The recent development to control the emissions of large diesel engines has provided opportunities for heat-driven cooling methods in vehicles. An adsorption air-conditioning system is therefore proposed in this work for heavy-duty truck application. Hence, this system can not only reduce engine emissions but also improve the overall energy efficiency. A lumped parameter model of the system using zeolite-water as its working pair is developed. The dynamic performance of the system and a parametric study on adsorbent mass transfer, operating temperatures and cycle operating periods are presented.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Seminar 2 (Intermediate)



BIM Load Calculations: Pain or Pleasure? Phase 2 of the Case Study Involving the ASHRAE HQ

Building

Track: Engineering Tools

Room: Lachine

Sponsor: 04.01 Load Calculation Data and Procedures

Chair: Glenn Friedman, P.E., Member, Taylor Engineering, Alameda, CA

BIM, building information modeling, is a tool to enhance the efficiency of integrated building design including HVAC design. This seminar looks at two different attempts to create building HVAC load calculations using current BIM technology and examines the barriers and success. The ASHRAE HQ building is the example used in the Load Calculations Chapter of the ASHRAE Handbook. Since this example is published and sets a load calculation baseline for comparison, this same example is used for this seminar.

1. BIM to Load Example Using the ASHRAE HQ Building

Steve Bruning, P.E., Fellow ASHRAE, Newcomb & Boyd, Atlanta, GA

This session looks at the experience of using one of the commercially available BIM software tools to perform a load calculation. It describes the method, the steps involved, the difficulties encountered and the outcome of this journey.

2. BIM Data Exchange for Loads: Understanding the Analytical Model

Christopher Wilkins, P.E., Member, Hallam-ICS, South Burlington, VT

This session will describe the steps required to create an analytical model from an architectural model which is necessary to enable export of the architectural data in either gbXML or IFC format. A key learning objective is to define the difference between the architectural model and the analytical model and to make clear why the analytical model is needed. A specific example of export to a commercial load and energy program will be used to demonstrate this.

3. BIM Load Calculations - Pain or Pleasure? A Case Study Involving the ASHRAE Headquarters Building

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

This session looks at the experience of using BIM to go directly to a load calculation. It describes the method, the steps involved, the difficulties encountered and the outcome of this journey.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Seminar 3 (Intermediate)



Challenges in Connecting Commercial and Retail Buildings to the Smart Grid

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 07.05 Smart Building Systems

Chair: Meli Stylianou, CanmetENERGY, Varennes, QC, Canada

Operating buildings to achieve comfort is challenging in the best of times, therefore it could be perceived as an insurmountable difficulty to use these buildings as assets to the electrical grid while still maintaining the occupants happy. This seminar seeks to address issues related to the integration of commercial and retail buildings into an interactive electrical network and present case studies of buildings that have successfully implemented automated demand response strategies. The issues addressed include communication between the building and the grid and the alternative control strategies that can be initiated to lower electrical demand following signals from the grid.

1. Impact of Automatic Demand Response (ADR) in Retail Buildings

Mark Schembri, Loblaw Properties Limited, Toronto, ON, Canada

The Loblaw Properties Limited (LPL) Demand Response Project is a 10-megawatt Demand Reduction initiative. The 10 megawatts that LPL has contracted to reduce are applicable for all four seasons. Load reduction is the primary method decreasing the energy used. Loblaw has installed intelligent controllers at up to 100 LPL owned grocery stores across Ontario. Each one of these controllers has the ability to accept instructions from a central control authority and control pre-specified loads (primarily lighting and air conditioning) in the stores. The server in the central control authority will monitor the hourly electricity prices posted by the Independent Electricity System Operator (IESO). The building automation system of each facility takes appropriate control actions to reduce the loads in the stores. This session presents how standardized communications between electricity supply and energy management systems within facilities has worked and lessons learned to date.

2. Can Commercial Buildings Act as a Generator Participating in Ancillary Services Markets on the Smart Grid?

Sila Kiliccote, Lawrence Berkeley National Laboratory, Berkeley, CA

Three major challenges related to representing buildings as a generator to the Independent Systems Operators (ISO) so that they can directly participate in the demand/supply chain as a generator are: 1) Establishing a secure and scalable communication between individual buildings and the electricity grid, 2) Resource management issues and representation of resources and assets to the electricity grid, and 3) End use characterization. The presentation will outline the issues related with each of the challenges and provide insights on how these challenges are being overcome in an ongoing field test. For the communication challenges, the speaker will describe how OpenADR is being used to communicate automated generation control signals through the California ISO's automated dispatch system with details on security and scalability. For resource challenges, pseudo generation concept will be outlined and overcoming instructing pseudo generation challenges will be described. Finally, a framework for end use characterization for commercial and industrial loads will be developed. Examples of loads that are best suited for ancillary services will be presented. The presenter will provide real life experiences from a pilot study that is currently underway.

3. Fully Automated Demand Response Case Study: Bell Trinity Square

Meli Stylianou, CanmetENERGY, Varennes, QC, Canada

The capability of commercial buildings to respond to pricing or reliability signals is dependent on the ability of their control systems to modify the operation of their electromechanical systems in a way that propagates the reduction from the conditioned space to the central mechanical system. This presentation will describe the results from the implementation of a fully automatic demand response capability at the Bell Trinity Square building in downtown Toronto.

4. Demand Response 2.0: Automating Demand Response to Leverage Energy Load as a Strategic Opportunity

Clay Collier, Akuacom, San Rafael, CA

Demand Response (DR) 2.0 goes beyond traditional DR in that it requires both timely communications of supply side information (e.g. prices, dispatch levels, etc.) from grid entities (i.e. Utilities, ISO's and service providers) and the automated response to such information by the loads that are consuming the electricity. A brief survey will be given that outlines the various opportunities for owners of load that can automate their energy consumption based upon information received from the grid. In addition this presentation will give a survey of issues related to both the communications of information and the automation of the load response to that information based upon years of experience in deploying systems based upon OpenADR. The presentation will finally give a brief update of the Smart Grid standardization efforts around OpenADR.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Seminar 4 (Intermediate)



High Efficiency Space and Water Heating: The Combination Approach

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 06.06 Service Water Heating Systems

Chair: Fred Goldner, Member, Energy Management Research Associates, East Meadow, NY

Combination Systems provide an interesting and exciting opportunity for high efficiency space and water heating in one package. With Canada publishing a new standard for rating combination systems (CSA P.9) and TC6.06 reopening the ASHRAE Standard for rating combination systems (SPC 124) combination systems have an increasing opportunity. This seminar discusses several types of combination systems in terms of their design, rating, application, and performance. Laboratory testing and preliminary field results from a 400 home combination system installation is also discussed.

1. Testing Combination Systems to CSAP.9

Rosalyn Cochrane, NRCAN, Ottawa, ON, Canada

In Canada, a new test standard, the CSAP.9, for combination space and water heating systems has been developed and this new test is somewhat different than that which has been used by others to evaluate this class of appliances. This seminar presentation will discuss the main differences between the CSAP.9 and the ASHRAE 124-2007, provide the results of laboratory tests, from different system configurations, that have been conducted to the new test standard, and compare the CSAP.9 results to the results that would be expected from separate appliances having the minimum allowed efficiencies or their rated Combined Annual Efficiency.

2. Designing a Highly Efficient Combination Space/Water Heating System

Martin Thomas, Member, CANMET Energy Technology Centre, Ottawa, ON, Canada

Designing a single efficient appliance has its own difficulties and these can be compounded when developing integrated multi-function appliances. In a combination space and water heating appliance, achieving high efficiency in water heating mode is relatively straightforward, whereas, in space heating mode care must be used to select the most appropriate operating modes such that the efficiency can be maximized, while maintaining end-user comfort. This presentation provides some insights into the design of a highly efficient combination system and then discusses the results of testing the system to the ASHRAE 124-2007 and the new CSA P.9 Performance Test Standards.

3. The Performance of Residential Combination Hydronic Systems

Thomas Butcher, Ph.D., Member, Brookhaven National Laboratory, Upton, NY

There are many options for the configuration of hydronic systems to meet both the space heating and hot water loads of homes. Having a single combustion source and associated heat exchanger, may improve the economics of very high efficiency appliances. This presentation describes the results of an evaluation of a wide range of combination systems using a direct input/output measurement method. The resulting performance curves are matched with different load profiles to calculate annual fuel use and efficiency. Beyond steady state efficiency, low load performance and the idle-state energy requirements are shown to be important determinants of the annual efficiency.

4. Designing a Standard Set of Specifications for Combination System Installation

Ben Schoenbauer, Associate Member, Center for Energy and Environment, Minneapolis, MN

Combination systems can be made with a wide range of components, controls, and complexity. Most current installs are field engineered and it can be difficult for an installer and a homeowner to know how well the system was designed and installed. In support of a project planning to install 400 combination systems a laboratory setting was used to test several systems and then create a standard set of specifications for combination systems to ensure a

good installation. This talk will also look at the first round of installs and how the standard install specifications helped the system design and installation process.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Seminar 5 (Intermediate)



Numerical Methods for Predicting Outdoor Dispersion from Exhaust Stacks

Track: Engineering Tools

Room: Lasalle

Sponsor: 04.03 Ventilation Requirements and Infiltration, 09.10 Laboratory Systems

Chair: Michael Ratcliff, Ph.D., P.E., Member, RWDI, Redlands, CA

Exhaust stacks emit pollutants that may be re-entrained into building outside air intakes, thus potentially creating indoor air pollution problems. These issues can be important for central plants, boiler exhausts, kitchen exhausts, and laboratories. Numerical methods, ranging from simple algebraic equations to computational fluid dynamics (CFD) have long been available as an alternative to wind tunnel modeling of exhaust stacks and dispersion of pollutants. This seminar explores recent trends and the current state of the art in numerical methods. CFD and simple equations are covered. Comparisons are made to some wind tunnel modeling as well.

1. Updated Dispersion Model for the ASHRAE Applications and Lab Design Handbooks

Brad Cochran, Member, CPP, Fort Collins, CO

The plume dispersion modeling techniques described in both Chapter 44 of the 2007 ASHRAE Handbook – HVAC Applications and the 2001 Laboratory Design Guide have been (will be) significantly upgraded in their next versions. While the new equations are slightly more complex, they increase the accuracy of the downwind concentration predictions. This will enhance the design engineers ability to define a safe and energy efficient laboratory exhaust system. This presentation will describe these updated equations and the impact that they will have on subsequent downwind dispersion calculations.

2. CFD Approaches to Predicting Dilution from Exhaust Stacks in Urban Areas

Ted Stathopoulos, Ph.D., P.E., Member¹, Mauricio Chavez¹ and Ali Bahloul, Ph.D.², (1)Concordia University, Montreal, QC, Canada, (2)IRSST(Institut de recherche Robert-Sauve en sante et en securite du travail), West Montreal, QC, Canada

There has been an increasing interest towards air quality within densely built urban areas. One common problem in such zones is the re-ingestion of effluents released from rooftop stacks by re-entering either the same building or an adjacent building. This may be detrimental to the health of residents or workers in the building. Unfortunately this phenomenon cannot be examined using the current dilution models, e.g. ASHRAE, since its formulations are based on a simple isolated building. This seminar will present the progress made in the computational fluid dynamics (CFD) approach for the evaluation of dilution from exhaust stacks for simple and complex building configurations. This approach provides detailed information of flow field and pollutant transport by solving the flow equations in the entire domain. Intensive comparisons between CFD and wind tunnel experimental data are made in order to evaluate the accuracy of the numerical approach. Dilution on the roof level of an emitting building are presented for three cases: an isolated emitting building; the same with a high-rise building placed upstream; as previously, with an additional third building downstream. The presentation will offer valuable suggestions regarding the use of CFD for dilution evaluations including parameters that may be more critical to achieve a better representation of the computational results.

3. Evaluation of Several Simple Numerical Methods Against Wind Tunnel Modeling

Michael Ratcliff, Ph.D., P.E., Member, RWDI, Redlands, CA

There have been a number of simple algebraic models for predicting exhaust dilution and dispersion from stacks on building roofs. These have appeared in ASHRAE Handbooks and also in an appendix of ASHRAE Standard 62.1 (Acceptable Indoor Air Quality). This presentation will compare the methods to results from wind tunnel modeling for a variety of test cases, including laboratories, health care central utility plants, and commercial buildings. In general, the results show that the numerical models are stricter than wind tunnel modeling. This has been the

expected trend over the years. However, there are cases where the numerical models are too strict. This may point to areas for future development.

Sunday, June 26, 2011, 8:00 AM-9:30 AM

Seminar 6 (Basic)



Specify, Implement and Maintain: Three Strategies for Successful ERV Projects

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 05.05 Air-to-Air Energy Recovery

Chair: Carol Marriott, P.Eng., Member, Carol Marriott Consulting, Minneapolis, MN

The successful use of air-to-air energy recovery ventilation (AAERV) technologies to save money and create superior indoor environments depends on a number of factors to ensure that you get the most out of your high performance HVAC systems. Firstly, AHRI certifies the performance of energy recovery ventilation (ERV) components using AHRI Standard 1060 and ASHRAE Standard 84, both of which have been updated with new provisions. Secondly, there are a number of projects that use ERV in a variety of interesting ways and where AAERV has been used effectively in and around Montreal and Quebec. Finally, best practices for maintaining AAERV system performance are presented.

1. AHRI 1060, Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Heat Equipment

Eric Chen, Member, Air-Conditioning, Heating, and Refrigeration Institute, Arlington, VA

AHRI certifies the performance of Energy Recovery Ventilation components using AHRI Standard 1060 and ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers. Both of these standards have undergone updates in the last two years which necessitate a thorough review to ensure compliance with new provisions. This session provides an overview of the updated AHRI 1060 and will help participants understand the process that ERV manufacturers must follow to certify their units through AHRI and the assurances that this certification provides to consumers.

2. Successful Air-to-Air Energy Recovery Ventilation Applications in Quebec

Sebastien Charbonneau, Dr.Eng., Member, BPR, Montreal, QC, Canada

There are a number of projects that use ERV in a variety of interesting ways. This presentation will look at a variety of different types of applications and we will look at successful projects (case studies) from the local engineering community where AAERV has been used effectively in and around Montreal and Quebec.

3. Maintenance Considerations for Air-to-Air Energy Recovery Ventilation Equipment

Paul Pieper, Member, Venmar CES, St-Leonard-d'Aston, QC, Canada

Air-to-air energy recovery equipment is being used on many, many more projects due to recent standards and codes changes. To ensure long life and trouble free operation, this presentation will review best practices for operating and maintaining some of the most common commercially available air-to-air energy recovery technologies.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Technical Paper Session 2 (Intermediate)



Improving Residential Hot Water Heater Energy Efficiency

Track: HVAC Systems and Equipment

Room: Outremont

Chair: Gary Debes, Member, SNC-Lavalin Project Services, Kansas City, KS

The papers in this session paper discusses the challenges in applying a linear model for predicting the daily efficiency of a water heater and the simulation of different domestic hot water (DHW) systems to study their fuel consumptions, green house gas (GHG) emissions and 30-year lifecycle costs.

1. Energy and Environmental Analysis of Residential Hot Water Systems; A Study for Ontario, Canada (ML-11-004)

Gurjot Gill¹ and Alan S. Fung, Ph.D., P.E.¹, (1)Ryerson University, Toronto, ON, Canada

The objective of this paper is to simulate different domestic hot water (DHW) systems to study their fuel consumptions, green house gas (GHG) emissions and 30-year lifecycle costs. In the first part, using TRNSYS simulation model, tests are performed for seventeen different DHW systems. These systems include two-panel solar-based systems with electric and gas back up tanks, modulating gas combo boiler, on-demand gas water heater, as well as conventional electric and gas hot water tanks. Results showed that DHW system with solar preheat and electrical secondary with timers is the best system for energy consumption and GHG emissions. It uses 1.22 MWh of electricity and produces 266 kg (586 lbs) of GHG emissions. DHW system with high efficiency on demand modulating gas combo boiler with gray water heat recovery is the best system in terms 30-year life cycle cost (CAN\$12,332, US\$11,839). In the second part, hybrid water heating system for Net Zero Energy Healthy Housing project located in Toronto was simulated using TRNSYS model and sensitivity analysis was performed. The purpose of the sensitivity analysis was to study the effects of various components in the hybrid model on electricity consumption and GHG emissions per year. In total 96 different scenarios of the hybrid models were tested. The results concluded that hybrid system with gray water heat recovery unit achieves 80% reduction in electricity cost and GHG emissions, when compared with conventional systems without gray water heat recovery unit. Payback period for the hybrid system is lowest while having 225L daily hot water demand and auxiliary set point temperature at 60°C (140°F). It was also concluded that hybrid system results are not sensitive to the pre-heat tank size.

2. Input-Output Approach to Predicting the Energy Efficiency of Residential Water Heaters- Testing of Gas Tankless and Electric Storage Water Heaters (ML-11-005)

William M. Healy, Ph.D., Member¹, Tania Ullah¹ and John Roller¹, (1)National Institute of Standards and Technology, Gaithersburg, MD

A study was conducted to evaluate the potential for using a linear relationship between the power input to a residential water heater and the output of thermal energy in hot water for rating the unit's energy efficiency of the unit. This approach has the potential for simplifying the currently used test method while providing information that can be used to predict performance under different demands. A gas tankless water heater and an electric storage water heater were tested under a range of output rates, and linear relationships were developed for each system. The equations were then used to predict the input required to provide particular output rates demanded by the user. The accuracy of these models was assessed against five different 24-hour simulated use tests, consisting of the approach from the current test method and alternative profiles that involved more draws of hot water and varying amounts of daily hot water removed from the water heaters. Discrepancies between predicted water heater efficiencies and measured efficiencies indicate that a linear model relating input rate and output rate may not be appropriate for fully describing residential water heater performance. This paper discusses the challenges in applying a linear model for predicting the daily efficiency of a water heater.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Conference Paper Session 2



Computer Room Cooling? Liquid Cooling Shifts the Focus to Cooling the Equipment

Track: HVAC Applications

Room: Westmount

Sponsor: 09.09 Mission Critical Facilities, Technology Spaces and Electronic Equipment

Chair: Rick Pavlak, P.E., Member, Heapy Engineering, Dayton, OH

This session focuses on alternative methods of removing heat generated from data center server operation. Recent ASHRAE publications sponsored by TC 9.9 Mission Critical Facilities and Electronic Equipment Rooms focus the goal of providing an acceptable server inlet air condition, not cooling the computer room. This focus is different than the general focus on conditioning the interior building spaces for human comfort. Papers focus on alternative cooling strategies that use liquid cooling heat transfer applications to capture and remove the heat generated by the data center servers. If a data center mechanical system is to be achieving a net zero design the power used to cool the servers will need to be reduced substantially. Alternative cooling methods must be developed and deployed to achieve the goal.

1. Use of Passive, Rear-Door Heat Exchangers to Cool Low to Moderate Heat Loads (ML-11-C004)

Kailash Karki, Ph.D.¹, Shlomo Novotny², Amir Radmehr¹ and Suhas Patankar¹, (1)Innovative Research, Inc., Plymouth, MN, (2)Vette Corp.

Passive, water-cooled, rear-door heat exchangers (RDHx) are typically considered for cooling high heat load racks in data centers. A RDHx extracts the heat from the air discharging from IT server racks and reduces its temperature. In this study, we investigate the use of RDHx for cooling racks with low to moderate heat loads (between 3 and 8 kW). At these heat loads, although the energy savings by installing RDHx on each rack are significant relative to traditional air cooling, and could be as high as 90% over the energy it takes to run the air movers, installing RDHx on each rack may not be cost effective in CAPEX compared to traditional design. This paper explores the possibility of installing RDHx on alternating racks and combining the use of RDHx with under-floor cooling. The results have been obtained using TileFlow, a CFD package for airflow modeling in data centers. The layout considered is a raised-floor data center cooled by CRAC units and RDHx. The CRAC units will be turned off when cooling is provided solely by RDHx. The first configuration studied involves no under-floor cooling. The RDHx are installed on alternate racks. In this configuration, the air exhausting from a rack tends to flow towards the front face of the rack and is drawn in by the servers. Thus, for a rack without RDHx, the inlet temperatures are unacceptably high. This configuration is unworkable, but the results provide guidance for modifications that might lead to a successful solution. The results of the first configuration showed that for this idea to work, the hot air recirculation must be eliminated. One possibility is to place vertical barriers on top of the racks to force the exhaust air to exit through the openings at the end of the hot aisle. In this configuration, the hot air from the racks without RDHx mixes with the cold air from the racks with RDHx. By changing the ratio of the racks with and without the RDHx, the temperature of this air can be brought to acceptable range. This ratio along with the water flow rate and water inlet temperature will be varied to determine the upper limit on the heat load that can be cooled. Another configuration considered involves combination of RDHx with under-floor cooling. For a give rack heat load, the amount of under-floor airflow will be varied to arrive at an optimum combination

2. Energy Efficient and Lower Capital Cost:: An Alternative Data Center Cooling Strategy (ML-11-C005)

William Tschudi, P.E., Member¹ and Phil Hughes², (1)Lawrence Berkeley National Laboratory, Berkeley, CA, (2)Clustered Systems, Palo Alto, CA

A standard air cooled data center is a rare phenomenon. Generally each one is individually designed, with hundreds of different component combinations. They can also be energy hogs. Cooling loads in older data centers was typically 100% or more of IT load. While energy efficiency has improved recently and Power Utilization Effectiveness (PUE) – the ratio of total energy use to the IT equipment energy use - of 1.2 and better are being

designed, we are approaching the limit of air system cooling capability. While liquid cooling systems can provide further improvement, previous liquid systems have been too complex, delicate, expensive, and unreliable. This paper describes a novel cooling approach that provides savings in energy use with lower capital cost. In first section of this paper we review the physics of cooling with air and compare it with water and refrigerant cooling. We also trace the heat flow in the various systems from the point of generation to its rejection to ambient. This will highlight the points of resistance and the methods used to overcome them. Much work is being done in order to overcome the deficiencies of liquid cooling systems. In the second section of the paper a sampling of the design strategies being pursued will be presented. A description of a “direct touch” cooling system using pumped refrigerant will be discussed in detail. This technology was developed in part under a grant from the California Energy Commission. This alternative cooling system is simple to adopt, can be used with industry standard servers, is robust, and requires no special training to administer. Above all, it allows extensive standardization. It can reduce both energy consumption and capital expenditure by up to 50% and increase power density up to 100 times. It becomes practical to put a small data center in a wiring closet and a petaflop computing system in a cubicle. Systems are noiseless and virtually room neutral for thermal input. Results from formal testing of air and this direct touch based system which were sponsored by the Department of Energy will be presented. This data will be used as a basis for the creation of a TCO (total cost of ownership) analysis. Finally, a proposed future data center design combining the learnings from recent initiatives on cooling with this technology, DC power, and virtualization will be presented to illustrate overall energy saving potential.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Conference Paper Session 3



Renewable Energy Technologies for Achieving “Net-Zero” Energy Design

Track: Net Zero Buildings

Room: Mont Royal

Chair: James Vallort, Member, Environmental Systems Design, Chicago, IL

The papers present design strategies and technologies including solar photovoltaic, solar thermal, a wind turbine, biomass stoves and other renewable energy strategies to design net zero energy and low energy buildings.

1. Renewable Energy Design and Performance of LEED EB Platinum Building for Zero Energy Performance (ML-11-C006)

Kevin P. Hallinan, Ph.D.¹ and Jessica L. Minor, Student Member¹, (1)University of Dayton, Dayton, OH

This paper is a case study of the Melink manufacturing facility and offices and their quest to become net zero. Melink is a LEED EB Platinum Certified building. Renewable energy technologies on site include solar photovoltaic, solar thermal, a wind turbine, biomass stoves and ground source heat pumps. Through energy efficient building design, added renewable energy technologies and optimized building control; net zero energy building performance is attainable. This paper will discuss the existing building operations, the efforts toward net zero energy performance and an energy management plan to achieve zero energy performance.

2. Achieving Passivhaus Standard in North America: Lessons Learned (ML-11-C007)

James Scott Brew, Rocky Mountain Institute, Boulder, CO

To help mitigate climate change, the incremental approach to making homes and buildings "less bad" or 30% better than code is not going to work. We need aggressive, actionable solutions now. The Passive House approach (Passivhaus in German) is one of the world's most aggressive, proven approaches to radical energy reduction and thermal comfort by design. The Passive House standard to radically low energy home and building design has roots in Sweden, Germany, Canada and the US. While much of the approach to good, low-energy and passive design is well known, it is still seldom practiced. This session will introduce and explore the Passive House standard design approach and requirements as well as demonstrate its application to retrofit projects in the North American context. Drawing from expertise of the early Passive House projects in the US and Germany as well as on the ground experience of more recent successful and unsuccessful Passive House projects in North America, a journey toward the best practices in design application, cost and certification will be discussed. A brief review of the

various products and systems incorporated in US projects to meet the aggressive requirements of passive house will also be introduced. This session intends to use interactive discussion to engage the audience and ensure a productive learning environment for participants.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Seminar 7 (Intermediate)



Emerging Wireless Technologies for HVAC Applications

Track: Alternative Technologies

Room: Verdun

Sponsor: 07.05 Smart Building Systems, 01.05 Computer Applications

Chair: Xiaohui Zhou, Ph.D., Member, Iowa Energy Center, Energy Resource Station, Ankeny, IA

Using wireless technologies for building controls could be cost-effective and convenient; however, traditional wireless devices required either a power wire or batteries which require maintenance as well as proper disposal. The first part of this session will discuss employing the “energy harvesting” concept as a power solution to wireless sensor networks. Self-powered wireless sensors and actuators using energy that created from slight changes in motion, pressure, light, temperature or vibration will be introduced. Research and field application examples are given to show that this technology can produce the sustainable power generation sufficient to operate a multitude of wireless sensors for building applications. The second speaker discusses a retrofit project using wireless sensors and ZigBee protocol to expand the existing direct digital control (DDC) system capability, and evaluate HVAC system performance via automated fault diagnostics and neural nets.

1. Emerging Wireless Technology: No Wires. No Batteries. No Limits

Keith Garris, EnOcean Inc., Cottonwood Heights, UT

More than 1 million energy harvesting wireless sensors & switches have been installed in building automation systems (BAS) in North America and Europe. Energy harvesting eliminates the need pull wires or replace batteries. Advances in the technology now enable self-powered actuators, for example water valves or variable air vents common in HVAC industries. This presentation will describe sources of energy suitable for harvesting, energy budgets and appropriate devices, tradeoffs and considerations when depending upon ambient energy, and scalability into common BAS/IT systems such as BACnet or IP networks.

2. Utilizing Wireless Sensors in Automated Fault Diagnostics to Optimize and Commission a Dual Duct System

Louis-Nicolas Hamer, P.E., SCL Elements Inc., Montreal, QC, Canada

This session will discuss wireless technology added as part of a retrofit to extend direct digital control (DDC) control, capability and data collection to existing building controls. The building automation system (BAS) had DDC oversight on major equipment and stand alone pneumatic zone controllers. The pneumatic controllers were updated with wireless pneumatic controllers. The wireless system gateway incorporated open protocols to tie monitoring and control points into the DDC system. Trend data was collected, exported and evaluated via automated fault diagnostics and neural nets. The data and diagnostics were used to commission the system, create data needed for evaluation and rebate justification and to maintain the optimized state of control moving forward.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Seminar 8 (Intermediate)

Role of Technology in Shaping the History of the United States

Track: Professional Skills

Room: Hampstead

Sponsor: 01.11 Electric Motors and Motor Control

Chair: David Zimmerman, P.E., Member, Rollie Johnson, Inc., St. Lois, MO

This session examines the evolution of the United States from colonial days through the revolution and establishment of the Country. It explores the relationship between the U.S. economy and technology through 2010 and follows with an extrapolation of our continued journey to a sustainable future.

1. Role of Technology in Shaping the History of the United States

Bill Coad, P.E., Presidential Fellow Life Member, Coad Engineering Enterprises, St Louis, MO

This presentation will examine the evolution of the United States from colonial days, through the revolution and establishment of the Country. It will explore the relationship between the U.S. economy and technology through 2010 and follow with an extrapolation of our continued journey to a sustainable future.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Seminar 9 (Basic)



Selecting Fans for Minimum Energy Usage

Track: HVAC Systems and Equipment

Room: Lachine

Sponsor: 05.01 Fans

Chair: John Murphy, Ph.D., Member, Jogram Inc, New Philadelphia, OH

As the emphasis on zero net energy buildings intensifies, selecting fans which use the minimum energy becomes more critical. This seminar reviews the current status of minimum energy standards. A major point will be that the selection of fans must be done using total pressure.

1. How to Use the Full Energy Potential of Fans

John Cermak, Ph.D., Member, ACME Engineering & Manufacturing Corp., Tulsa, OK

A fan is a device transforming energy from the motor into energy in the air handled by the fan. A traditional approach recognizes the fan static pressure as useful pressure to match the pressure drop across the fan/duct system. That approach uses only a portion of the energy the fan exerts into the air. Understanding the full extent of available energy delivered into the air by the fan leads to selecting fans at lower power and sound. The typical examples of fan selections would demonstrate an immediately available source of energy reduction to power a fan.

2. Determining Required System Pressure (It's Always Total)

John Murphy, Ph.D., Member, Jogram Inc, New Philadelphia, OH

Determining the required system pressure is not merely adding up the total system losses. The total pressure at all points in the system must be determined. Failure to do so will not only result in the wrong answer, it will invariably lead to excess power being used. A typical ventilation system will be used to illustrate this concept.

Sunday, June 26, 2011, 9:45 AM-10:45 AM

Forum 1 (Intermediate)

What Should Be in a Moisture Management Chapter in the ASHRAE Handbook?

Track: Commissioning

Room: Lasalle

Sponsor: 01.12 Moisture Management in Buildings

Chair: Alex McGowan, P.Eng., Member, Levelton Consultants Ltd., Victoria, BC, Canada

Many aspects of equipment performance and the interaction between the weather, the building envelope, its systems and its occupants will either lead to moisture accumulation or prevent it. Moisture accumulation can lead to decay, corrosion, and mold growth, among other things. At present, the guidance for these issues are spread among various handbook chapters, and some issues are not addressed at all in the Handbooks. This forum solicits input from ASHRAE members on the value of a separate chapter specifically written to address moisture management in buildings, including design, construction, operation and maintenance and commissioning.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Technical Paper Session 3 (Intermediate)

Improvements in Heat Pump Performance and Simulation

Track: HVAC Systems and Equipment

Room: Outremont

Chair: Renison Tisdale, P.E., Member, Vansant & Gusler, Inc., Norfolk, VA

As part of a two-part paper, one paper describes extensive tests performed on a 3-ton split system heat pump in heating mode at various operating conditions. The second part describes simulations performed and compared to the tests and the various improvements discovered to improve the modeling approach. A third paper discusses improvements in heat pump performance by means of a new technology.

1. The Impact of Refrigerant Charge, Air Flow and Expansion Devices on the Measured Performance of an Air-Source Heat Pump, Part 1 (ML-11-006)

James E. Braun, Ph.D., P.E., Fellow ASHRAE¹, Bo Shen, Ph.D., Member² and Eckhard A. Groll, Ph.D., Fellow ASHRAE¹, (1)Purdue University, West Lafayette, IN, (2)Oak Ridge National Laboratory, Oak Ridge, TN

This paper describes extensive tests performed on a 3-ton R-22 split heat pump in heating mode. The tests contain 150 steady-state performance tests, 18 cyclic tests and 18 defrost tests. During the testing work, the refrigerant charge level was varied from 70 % to 130% relative to the nominal value; the outdoor temperature was altered by three levels at 17 °F (-8.3 °C), 35 °F (1.7 °C) and 47 °F (8.3 °C); indoor air flow rates ranged from 60% to 150% of the rated air flow rate; and the expansion device was switched from a fixed-orifice to a thermal expansion valve. Detailed performance data from the extensive operation range were presented and compared, including COPs, cyclic degradation coefficients, etc

2. Modeling Improvements for Air Source Heat Pumps using Different Expansion Devices at Varied Charge Levels, Part 2 (ML-11-007)

James E. Braun, Ph.D., P.E., Fellow ASHRAE¹, Bo Shen, Ph.D., Member² and Eckhard A. Groll, Ph.D., Fellow ASHRAE¹, (1)Purdue University, West Lafayette, IN, (2)Oak Ridge National Laboratory, Oak Ridge, TN

This paper describes steady-state performance simulations performed on a 3-ton R-22 split heat pump in heating mode. In total, 150 steady-state points were simulated, which covers refrigerant charge levels from 70 % to 130% relative to the nominal value, the outdoor temperatures at 17 °F (-8.3 °C), 35 °F (1.7 °C) and 47 °F (8.3 °C), indoor air flow rates from 60% to 150% of the rated air flow rate, and two types of expansion devices (fixed orifice and thermal static expansion valve). A charge tuning method, which is to calibrate the charge inventory model based on measurements at two operation conditions, was applied and proved to improve the system simulation accuracy significantly in an extensive range of charge levels. Meanwhile, we reveal the effects of suction line accumulator in modeling a heat pump system using either a fixed orifice or thermal expansion valve. At last, we identify the issue of refrigerant mass flow mal-distribution at low charge levels and propose an improved modeling approach.

3. Using an Optimizer to Improve Heat Pump Performance (ML-11-008)

Mingsheng Liu, Ph.D., P.E., Member¹, Bin Zheng, Ph.D., P.E.², Chad Ballain³ and Jinrong Wang³, (1)University of Nebraska, Omaha, NE, (2)DTL Controls, LLC, Omaha, NE, (3)Omaha Public Power District, Omaha, NE

Heat pumps below 5 tons are ubiquitous. Such heat pumps are usually equipped with constant speed compressors and blowers. The issues of using a constant speed heat pump include unsatisfactory humidity control, fluctuations in room temperature, compressor short cycling, noise, and high energy demand and consumption. This paper presents a new technology that addresses the common issues and improves the energy performance of a heat pump. The technology is named "Heat Pump Optimizer". Optimizer consists of a controller, a temperature sensor, and a variable frequency drive. It varies the compressor and indoor fan capacities with the air conditioning system loads. This solves the inherent heat pump issues caused by oversized heat pumps without affecting a user's ability to control room temperature. The technology has been applied in four water source heat pumps in a dormitory building. The heat pumps have been running with optimizers for seventeen months. As shown by the data, with the

use of Optimizers, indoor comfort is greatly improved, the number of compressor cycles is reduced by up to 70%, the noise level is reduced by 50%, the electricity demand and consumption are reduced by up to 50%.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Conference Paper Session 4



Improving Indoor Air Quality

Track: HVAC Applications

Room: Westmount

Sponsor: 04.10 Indoor Environmental Modeling, 09.06 Healthcare Facilities, 09.01 Large Building Air-Conditioning Systems

Chair: Megan Tosh, P.E., Associate Member, Stan Weaver Company, Orlando, FL

Quality of indoor air is essential in all HVAC applications. More extensive care is given to improving the indoor air quality of facilities where there is high risk of communicable disease. Different methods of fresh air delivery to a space require varying techniques of modeling to determine effectiveness and air quality. Advancements in the development of filtration media can aid in the improvement of air quality. This session reviews critical applications, modeling methods, refrigerant safety and techniques for improving the filtration industry all with the purpose of improving indoor air quality.

1. Application of ASHRAE Standard 15-2010 with Respect to Multi-Evaporator Split Air-Conditioning Systems (ML-11-C008)

Stephen W. Duda, P.E., Member, Ross & Baruzzini, Inc., St. Louis, MO

Multi-evaporator split air-conditioning systems are receiving increased attention in the marketplace. These multi-evaporator systems are characterized by a significant amount of field refrigerant piping, many evaporators on a common refrigerant network with one or two condensing units, and safety concerns related to the potential for refrigerant leaks. This paper examines limitations imposed on such systems by ASHRAE Standard 15-2010, explores some ambiguity not specifically covered by the Standard, attempts to give guidance in proper application of the Standard, and identifies areas where further study or research is needed. The author was a member of SSPC 15 for eight years.

2. Energy Saving Using Mixed Air In Rooms Conditioned by Chilled Ceiling Displacement Ventilation System (ML-11-C009)

Kamel Abou Ghali, Ph.D., Member¹, Walid M. Chakroun, Ph.D., P.E., Fellow ASHRAE² and Nesreen Ghaddar, Ph.D., Member¹, (1)American University of Beirut, Beirut, Lebanon, (2)Kuwait University, Kuwait, Kuwait

The aim of the work is to study the impact of introducing the return air concept into rooms conditioned by chilled ceiling displacement ventilation (CC/DV) system to save energy while limiting a time-dependent return fraction based on room load in order to maintain an acceptable air quality in the breathing zone. A transient coupled thermal and contaminant transport model is developed to assess the indoor air quality based on predicted levels of carbon dioxide concentrations in the radiant-cooled space under varying load conditions. Experiments are performed to validate the developed transient model predictions of air quality expressed in the level of CO₂ concentration in a space with two external walls conditioned by CC/DV system in Kuwait Climate. Measurements are recorded in time of the air temperature and carbon dioxide concentration at selected location in the room and are compared with values predicted by the model. The experimental results agreed well with the contaminant transport model predictions. The maximum errors in predicted CO₂ concentrations are less than ± 25 ppm for the room with internal load only and ± 35 ppm in the room with external load. For the experimental room load profile at peak of 65 W/m², a maximum acceptable fraction of the exhaust air to be mixed with the supply air reached 32% while the air quality up to the breathing zone remained below the recommended ASHRAE standard 62.1 (2007) of less than 700 ppm. The use of the mixed system resulted in 18.5% less energy consumption when compared to the 100% fresh air system over a period of operation of six hours.

3. Application of Nanofibrous Membranes with Antimicrobial Agents (ML-11-C010)

Andrea Gregg, Student Member¹ and Julia Keen, Member¹, (1)Kansas State University, Manhattan, KS

Nanofibers are classified as fibers with diameters less than 1 micrometer. These fibers can be layered to form nanofibrous membranes and these membranes offer great potential in the aerosol filtration industry. The membranes' smaller fiber diameters and pore sizes within the membranes offer increased levels of filtration of smaller particulate. Antimicrobial agents can be incorporated into the membrane to inhibit fungal and bacterial growth on the membrane's surface. This report evaluates nanofibrous membranes with antimicrobial agents and their potential in various applications, where bacterial and fungal growth would have a detrimental effect on the space.

4. HVAC Design to Reduce Risk of Communicable Disease in Child Care Center Infant and Toddler Rooms (ML-11-C011)

Larry Dlugosz, Ph.D., Member¹ and Wei Sun, P.E., Member², (1)Walter Reed Army Medical Center, Washington, DC, (2)Engsysco Inc., Ann Arbor, MI

Child care centers (CCCs) need well-designed, high-quality ventilation to protect very young children from viral and bacterial diseases. Children younger than 2 years of age are at higher risk for influenza-related complications and have a higher rate of hospitalization compared to older children. Children aged 2 to 4 years are more likely to require hospitalization or urgent medical evaluation for influenza compared with older children and adults. Infants and toddlers are vulnerable to common communicable illnesses such as influenza and diarrhea and more serious diseases such as meningitis and hepatitis due to viral shedding, limited immunity, and multiple exposure opportunities in densely populated activity rooms (i.e., >1 child/ 35 sq ft.) with unique microbial niches. Specific hazards, risks and recommendations for implementing environmental controls including designs for optimum HVAC effectiveness at reducing concentrations of airborne/surface microorganisms, through optimized placement of supply diffusers and return grilles, proper ACH rate, contaminated air source control (such as at diaper change area), use of HEPA filters and UV(C) disinfection, and increased outside air, etc. will be presented.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Seminar 10 (Intermediate)



Commissioning: New Buildings without It and at an Existing Major Airport Terminal

Track: Commissioning

Room: Lasalle

Sponsor: 07.09 Building Commissioning

Chair: Mike Eardley, P.E., Member, Cannon Design, Boston, MA

One presentation describes the faulty performance of a private school, three new schools in a suburban school district, and a hospital. In each case the mechanical systems did not operate per the owner's requirements and failed to provide the proper occupancy conditions. The other presentation addresses how energy savings with under a two year payback was accomplished at an airport terminal and what measures were effective through existing building commissioning.

1. Existing Building Commissioning of a Major Airport Terminal

David Claridge, Ph.D., P.E., Fellow ASHRAE¹ and Wei Guanghua¹, (1)Energy Systems Lab at Texas A&M University, College Station, TX

Airport terminals are complex environments that involve high people traffic, large open areas, jet aircraft, food service, hotels, and a myriad of other services and functions. This presentation will discuss how energy savings with under a two year payback was accomplished and what measures were effective through existing building commissioning. The HVAC system optimization reduced electricity usage by 10%, and slashed chilled water consumption by 25% and hot water by an astonishing 49%. The savings equaled the investment in 15 months, which resulted in a \$4M net gain in 3 years.

2. Case Studies of the Problems and the Solutions of New Buildings without Commissioning

Gerald J. Kettler, P.E., Life Member, AIR Engineering and Testing, Dallas, TX

This presentation describes the faulty performance of a private school, three new schools in a suburban school district, and a hospital. In each case the mechanical systems did not operate per the owner's requirements and failed to provide the proper occupancy conditions. In the hospital case, it severely damaged the air handler. All three cases involved both design and construction issues.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Seminar 11 (Intermediate)

Panel Discussion: How to Meet ASHRAE Standards 55, 62, 90, and 189.1 in a Healthy, Sustainable Building

Track: HVAC Applications

Room: Cote St Luc

Sponsor: Environmental Health Committee, GPC10

Chair: Hal Levin, Fellow ASHRAE, Building Ecology Research Group, Santa Cruz, CA

Those who want to address sustainability and health must not only comply with the relevant ASHRAE standards, they must understand the interactions among various indoor environmental factors that affect the performance of the building and the health and well-being of the occupants. The recently published ASHRAE Guideline 10-2011 identifies and discusses interactions among various indoor environmental factors (IAQ, thermal conditions, noise and light) that must be considered when designing healthy, sustainable buildings. Panelists -- three current chairs and one immediate past-chair -- represent the four most relevant standards project committees addressing the interactions between and among the indoor environmental implications of the four standards.

1. Standard 55 and Healthy, Sustainable Buildings

Gwelen Paliaga, Associate Member, Taylor Engineering, LLC, Alameda, CA

The speakers will respond to questions from the chair and the audience.

2. Standard 62.1 and Healthy, Sustainable Buildings

Roger Hedrick, Architectural Energy Corp., Boulder, CO

The speakers will respond to questions from the chair and the audience.

3. Standard 90.1 and Healthy, Sustainable Buildings

Mick Schwedler, P.E., Member, Trane, La Crosse, WI

The speakers will respond to questions from the chair and the audience.

4. Standard 189.1 and Healthy, Sustainable Buildings

Dennis Stanke, P.E., Fellow ASHRAE, The Trane Company, La Crosse, WI

The speakers will respond to questions from the chair and the audience. Dennis will say at least one amusing thing and pretend to be modest.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Seminar 12 (Intermediate)



Methodologies for Determining Environmental Impacts of Buildings

Track: Engineering Tools

Room: Lachine

Sponsor: 02.08 Building Environmental Impacts and Sustainability, 07.06 Building Energy Performance

Chair: Andrew Price, P.E., Member, Stanley Consultants, Muscatine, IA

Energy and water use in buildings have impacts that extend beyond the building site. Site consumption impacts primary fuel consumption, greenhouse gas emissions, and global water resources. This seminar provides an overview of different methodologies that may be useful for determining the impact of building operation on primary energy consumption, associated greenhouse gas emissions, and water depletion. In addition, the seminar provides insights on characterizing and evaluating the water/energy nexus. The challenges and approaches to providing rational and equitable comparisons of different technology and fuel choice options, especially renewable energy options, are discussed.

1. Water Impacts from Source to Tap

Gary Klein, Member, Affiliated International Management, LLC, Ek Grove, CA

In 2005, California began a serious look at the water-energy-greenhouse gas relationship in the state. Saving water saves energy. Saving energy saves water, both where there are cooling towers on buildings and at thermal power plants which use water for cooling. You save more in Southern California than in Northern California because of the energy attached to imported water. Saving water used outdoors is good (pumping, treatment and delivery), saving water used indoors is better (no waste removal, treatment and discharge) and saving hot water is still better (no energy to heat the water too). This session will build on the work done by the California Energy Commission by presenting information on both sides of the connection: energy for water and water for energy. It will also give ideas on how to account for the relationship at a local level.

2. Alternative Methods of Comparing Building Energy Performance

Neil P. Leslie, P.E., Member, Gas Technology Institute, Des Plaines, IL

This presentation will provide an overview of alternative methodologies, descriptors, and boundary conditions associated with building energy consumption. Uses, limitations, and challenges associated with site energy, source (full-fuel-cycle) energy, and energy cost calculation methodologies will be explored.

3. Determining Greenhouse Gas Emissions Associated with Building Operations

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

This seminar will provide an overview of different methodologies that may be useful for determining the impact of building operation on primary energy consumption, associated greenhouse gas emissions, and water depletion.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Seminar 13 (Intermediate)



Quest for Building Information: Real Time Monitoring of Solar Systems to Shed Light on Building Operation

Track: Alternative Technologies

Room: Verdun

Sponsor: 06.07 Solar Energy Utilization

Chair: Ram Narayanamurthy, Member, PVTSOLAR, Berkeley, CA

Technology advancement is enabling us to better understand how building systems are working in real time in real installations. This is particularly true for solar energy systems, which are expected to service buildings owners for 30 years or more. Solar energy systems are in many cases part of zero- and low-energy buildings, which need to be monitored for building performance. In many cases, government incentives are also tied into actual system performance, which again requires real time system monitoring. This seminar discusses how monitoring of solar energy systems is also shedding light on building operation and assisting us in validating many concepts of zero energy building design.

1. Thermal Solar Collector Monitoring

Christian Vachon, P.Eng., Member, Enerconcept Technologies inc., Magog, QC, Canada

Solar Air Collectors are widely used to channel renewable solar energy for heating and ventilation applications such as pre-heating of ventilation air, paint drying booths, process heat, etc. The seminar will discuss some of these application and present data from actual commercial applications. The seminar will illustrate avoided energy use along with impact of parasitic loads, leading to a discussion of appropriate and inappropriate uses.

2. Drake Landing Solar Community Monitoring: 52 Systems Monitored

Raja Djebbar, Ph.D., P.E., Member, Natural Resources Canada, Ottawa, ON, Canada

Drake Landing Solar Community is North America's first large-scale seasonal storage solar heating system and the first in the world to provide 80% of the space heating requirements from solar energy. One of the most important and unique aspects of this project located in Okotoks 16 km south of Calgary, Alberta, Canada, has been the

implementation of an integral, detailed, long-term monitoring plan. With the monitoring underway not only has the performance of the solar system been accurately documented, but the team has been able to identify deficiencies and correct them in a timely fashion, to ensure optimal results. Positive interest generated by the project has been remarkable. Its world-record performance celebrated in May 2010 has been the subject of numerous television, radio and print reports. This presentation discusses the overall energy performance of Drake Landing system completing the fourth year of operation. Performance of the system main system components, including the 2,293 m² (1.5 megawatt) solar collector loop and the 33,700 m³ borehole thermal energy storage (BTES) field, will be reported. Space heating load monitoring results of the 52 Drake Landing energy-efficient single detached homes will also be discussed.

3. Design and Monitoring of a Net-Zero Triplex

Michel Bernier, P.Eng., Member, École Polytechnique de Montréal, Montréal, QC, Canada

This presentation will report on the design of a net-zero energy triplex (3 story building containing 3 housing units) located in Montréal. The highly insulated building contains thermal solar collectors for domestic hot water heating and a 14 kWp array for electricity production. Simulations indicated that this building would be net-zero on an annual basis. Early commissioning and monitoring efforts on the building indicated a few deficiencies associated with the installation.

4. Monitoring of Low Energy Home Production Communities with Integrated Solar

Ram Narayanamurthy, Member, PVTSOLAR, Berkeley, CA

An integrated solar energy system to provide electricity, hot water, home heating, cooling and ventilation has been adopted by production home builders at community scale. Each home is equipped with a monitoring system as a standard part of the solar energy system. The monitoring shows both thermal and electrical production of the solar system, which is less than 2.2 KW. These homes operate at HERS 55 or less with a majority of them less than 40 HERS, which is approaching near zero, especially for production homes. The information gathered from the monitoring not only shows the electrical and thermal production of solar, but also provides great insights into the thermal capacity of these homes, HVAC system operation and hot water needs. The seminar will present some of these results, and discuss how we can provide for whole building monitoring and to assist in shaping consumer behavior to operate zero energy homes.

Sunday, June 26, 2011, 11:00 AM-12:30 PM

Seminar 14 (Basic)



Using Building Energy Information in a Smart Grid World

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 07.05 Smart Building Systems, SPC201P

Chair: John I. Ruiz, Johnson Controls Inc., Milwaukee, WI

As part of the Energy Independence and Security Act (EISA) of 2007, NIST was given primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems. ASHRAE and NEMA accepted the challenge to develop this standard and established SPC 201P to develop a Smart Grid Facility Information Model that creates a common basis for electrical energy consumers to describe, manage and communicate electrical energy consumption and forecasts. This seminar presents background information on the development of this standard and a vision on how this standard will be applied within smart homes and buildings.

1. Smart Grid: A Building – Utility Partnership

Steven T. Bushby, Fellow ASHRAE, National Institute of Standards and Technology, Gaithersburg, MD

While the build-out of the US electricity grid is considered one of the greatest engineering achievements of the 20th century, it was designed to deliver energy from large central power plants to non-responsive loads. With the increasing use of electrical devices and the advent of electric vehicles the electric grid is being stressed at peak usage times and underutilized at off-peak usage times. To improve the reliability of the electric grid, it is becoming

smart by sharing information with responsive loads. This presentation will provide an overview of the transition to a smart grid and the role that buildings play. The presentation will address efforts by the US government to advance the development of the smart electrical grid and it will introduce work within ASHRAE to define a standard information model that will enable buildings be a collaborative partner in the future smart grid.

2. Emerging Tools for Using Energy Consumption Information

Jessica Granderson, Ph.D., Lawrence Berkeley National Laboratory, Berkeley, CA

Information and monitoring systems are of critical importance in achieving optimal low-energy building performance. Advanced monitoring and control technologies with high energy saving potential are widely available in the commercial market, yet are underutilized, resulting in enormous missed opportunities. Two fundamental barriers are 1) little understanding as to how the technologies actually perform once installed, and 2) uncertainty in the reliability and magnitude of savings attributable to process tools, and advanced controls. This presentation focuses on research findings from an EIS state of the technology assessment and business case. EIS are broadly defined as performance monitoring software, data acquisition hardware, and communication systems used to store, analyze, and display building energy data. Depending on a number of factors, EIS can save up to 30% in whole-building energy.

3. Smart Microgrids: Metering, Monitoring and Making Sense of Energy Data From Buildings

Rajesh Gupta, Ph.D., University of California, San Diego, San Diego, CA

The University of California at San Diego provides an excellent testbed to characterize and understand energy consumption of buildings at the scale of a small town with over 45,000 residents. With a goal of being energy self-sustaining, either on or off the electric grid by mid 2011, UCSD is using this data to plan its energy conservation measures and its distributed generation needs. This presentation will present data collected from four selected buildings that are archetypes of diverse buildings from residence halls to data centers. Our detailed observations identify the primary components of the baseline energy use and the sources of peaks in energy consumption. Surprisingly, computing accounts for a large fraction of the baseline energy use in a majority of the buildings, thus giving insights in how to significantly reduce power consumption by creating effectively duty-cycled buildings.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Conference Paper Session 5



Modeling Building Material Properties to Reduce Energy Consumption

Track: Engineering Tools

Room: Lachine

Chair: Andrew Rhodes, Southland Industries, Dulles, VA

The papers examine the uses of building materials and systems and how modeling the systems can improve the buildings' energy usage. Papers address how the uses of phase change materials can lead minimize space temperature fluctuations which in turn will reduce heating and cooling loads as well as how modeling the properties of building materials can lead to the reduction in the building's energy usage.

1. Thermal Performance of Uninsulated and Partially Filled Wall Cavities (ML-11-C012)

El Hassan Ridouane, Ph.D., Member¹ and Marcus Bianchi, Ph.D., Associate Member¹, (1)National Renewable Energy Laboratory, Golden, CO

Wall cavities are widely present in the construction of low rise homes since wood framing is the most common type of construction for residential buildings in the United States. The primary function of such wall construction is to provide a stable frame to which interior and exterior wall coverings can be attached and by which a roof can be supported. The existence of wall cavities increases the thermal resistance of the enclosure, particularly when they are filled with insulating material. Several design guides provide data for prediction of the thermal resistance

of uninsulated wall cavities of varying internal geometries. However, U-value coefficients provided in these guides do not account for partially insulated cavities or for variations in aspect ratio. Whole building energy simulation tools, like DOE2 or Energy Plus, use simplified, 1-D characterization of building envelopes. For the most part, this characterization assumes a fixed thermal resistance over the range of temperatures experienced by the enclosure. In reality, the thermal resistance is dominated by convection and radiation and is a function of several parameters, including the temperatures and emissivities of the cavity surfaces and the aspect ratio of the cavity. This study describes detailed CFD modeling to evaluate the thermal performance of uninsulated or partially filled wall cavities accounting for conduction through framing, convection, and radiation. The resulting correlations can serve as input for DOE2 and Energy Plus modeling of older homes, where the walls are either uninsulated or partially insulated due to the settling of the insulating material. Parameters of the study are the ambient temperature outdoors, emissivity of the cavity surfaces, cavity aspect ratio, and height of the insulation level. The outcomes of this study provide: An understanding of the thermal performance of uninsulated or partially insulated wall cavities, which is an essential aspect of energy conservation in residential buildings. Accurate input for whole building simulations models like DOE2 and Energy Plus in various climate zones. Recommendations on retrofit measures.

2. An Iterative Enthalpy Method to Overcome the Limitations in ESP-R's PCM Solution Algorithm (ML-11-C013)

Dahai Zhang, Student Member¹, Sridhar Sadasivam, Student Member², Fabio Almeida, Student Member¹ and Alan S. Fung, Ph.D., P.E.¹, (1)Ryerson University, Toronto, ON, Canada, (2)Indian Institute of Technology Madras, Chennai, India

The use of phase change material (PCM) in the interior walls and ceilings of a building to increase the thermal comfort of occupants, to reduce the auxiliary energy consumption is well known. In this paper, the existing numerical methods to simulate PCM embedded in the interior walls are reviewed and two forms of the apparent heat capacity method are explained in detail. The first formulation is a non-iterative temperature formulation which suffers from the requirement of extremely small time steps to produce accurate results during phase change. The second formulation is an iterative enthalpy formulation which through the use of an iterative correction scheme at every time step, can produce fairly accurate results for comparatively much larger time step values.

An in-house MATLAB code for performing simple building simulations with PCM embedded in the interior walls has been developed. The MATLAB code uses the finite volume method with a Crank Nicholson time stepping scheme to solve the governing energy equations. The MATLAB PCM module uses the iterative enthalpy method to accurately model phase change. On the other hand, the open source building simulation software ESP-r uses the non-iterative temperature formulation of the apparent heat capacity method to model phase change. A comparison of the MATLAB and ESP-r phase change modules is attempted in this paper.

The standard BESTEST Case 600 from the ASHRAE manual is modelled in both MATLAB and ESP-r. It is found that the room air temperature profiles match very closely without any PCM. However there is significant discrepancy between the two temperature profiles when PCM is introduced in the walls. It was however found that the discrepancy reduced drastically as the time step in ESP-r was reduced, keeping the MATLAB time step value as the same. In fact it is found that the results from ESP-r matched with the MATLAB results only when the time step was reduced to as low as 1 or 2 minutes. However the MATLAB time step value was maintained at 1 hour and changing this value did not cause any significant change in results. Since building simulations are typically long term/yearly simulations, it might be extremely demanding in terms of computer memory and time to perform simulations with small time steps of the order of 1 or 2 minutes. Thus the MATLAB simulation tool could be very useful in obtaining accurate results with phase change material without compromising on computational time.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Conference Paper Session 6

Utilizing Refrigerant Management Strategies with Lower Global Warming Potential

Track: Refrigeration

Room: Hampstead

Chair: Daniel Dettmers, Member, IRC, U.W. Madison, Madison, WI

The papers examine alternate refrigerants and systems configuration employing a range of natural and conventional refrigerants to reduce the direct global warming impact of refrigerants.

1. A Microchannel Evaporator for Domestic Refrigerators (ML-11-C014)

Ty Newell, Ph.D., P.E., Member¹, Benjamin Newell² and Alexander Long², (1)Newell Instruments, Urbana, IL, (2)Newell Instruments, Urbana, IL, USA, Urbana, IL

A microchannel evaporator has been developed for domestic refrigerators with relatively dense, thin fins. Experimental test results in an 18 cubic foot (510 liter) top mount refrigerator produced equivalent performance to that of the original fin-tube evaporator. The prototype evaporator constructed with copper microchannel tubing and copper fin stock weighed the same as the original aluminum tube-fin evaporator it replaced. The microchannel evaporator was found to reduce the refrigerator's refrigerant charge by 60% of the refrigerant charge. Frost studies indicate good performance with 200 grams of accumulated frost. Test results showing the refrigerator's performance at low, medium and high ambient temperatures, varying refrigerant charge levels and the effect of frost will be included in the presentation.

2. Comparison of Energy Efficiency of Systems with Natural Refrigerants (ML-11-C015)

Anatolii Mikhailov¹, Hans Ole Matthiesen¹ and Serdar Suindykov², (1)Danfoss A/S, Kolding, Denmark, (2)Danfoss, Trevoix Cédex, France

In this paper a comparative study of different configurations of refrigeration systems are presented. The main focus of the study was on the comparison of energy efficiency and TEWI between the different configurations employing a range of natural and conventional refrigerants. The study was done by means of simulation software. According to the study, the correct configuration of systems with natural refrigerants not only reduces the direct global warming impact, but also improves the energy efficiency. The study indicates that in comparison with two independent R404A systems for supermarket applications an NH₃/CO₂ cascade system has better performance in all ambient conditions, while a CO₂ booster system proves to have the best performance in moderate to cold climates. A R290/CO₂ cascade system has similar performance to the reference system (heat reclaimed not considered). Even though comparative data from most types of real systems are scarce, available studies confirm the theoretical simulations.

3. Experimental Study of R-134a Alternative in Supermarket Refrigeration System (ML-11-C016)

Barbara Minor, Member¹, Frank Rinne, Ph.D.² and Kahtan Salem, Ph.D.³, (1)DuPont, Wilmington, DE, (2)DuPont, Isenburg, Germany, (3)tebeg, Wurzburg, Germany

HFC refrigerants such as R-404A have come under scrutiny due to high global warming potential and relatively high leak rates in supermarket systems. In Europe, several design modifications such as cascade systems and new refrigerant choices are being investigated. One of the leading options is to employ a cascade system using CO₂ on the low temperature refrigeration side and R-134a in medium temperature. R-134a has higher efficiency than R-404A and about one third the GWP. To make even greater gains in GWP reduction, a new lower GWP refrigerant has been developed that may be retrofittable in the medium temp R-134a circuit with minimal to no system changes. This refrigerant has less than half the GWP of R-134a and is also non-flammable, so can be used in existing supermarket systems with large charge sizes without concern for flammability. Toxicity has also been fully characterized and it is anticipated it will be an ASHRAE class A1 refrigerant. This presentation will show results of experimental performance testing compared to an R-134a baseline in a supermarket system.

4. Environmental and Performance Results for Low GWP AC Fluid Candidates (ML-11-C017)

Thomas J. Leck, Ph.D., Member, Du Pont Refrigerants, Wilmington, DE

Testing of new refrigerant fluids for use in air conditioning and heat pump applications has been ongoing, and new data on system performance with candidate fluids has been developed and will be presented and discussed.

Concerns about global climate change precipitated the development of a new class of refrigerants, hydrofluoroolefins (HFOs), which have substantially lower direct global warming potential than commercial HFC refrigerant fluids. The molecule HFO-1234yf has been adopted by global automobile manufacturers to replace R-134a in auto AC applications, but this new refrigerant does not have the capacity or physical properties to allow it to be used in residential and light commercial AC designs. We have developed some novel candidate refrigerant blends that have been predicted by theoretical cycle modeling to be possible candidates for use in AC systems that are designed for refrigerant R-410A. Now, in addition to theoretical calculations, actual system tests have been conducted in several different types of AC systems. The results of this test work are reviewed herein. In addition will be presented discussion of some of the trade offs associated with the new candidate refrigerants, including flammability, temperature glide, and environmental properties.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Seminar 15 (Intermediate)

Alternative Fuels for Heating Equipment

Track: Alternative Technologies

Room: Verdun

Sponsor: 06.10 Fuels and Combustion

Chair: Raymond Albrecht, P.E., Member, Consultant, Westerlo, NY

Boilers and furnaces are attractive target applications for the displacement of petroleum with alternative fuels. Presented are the technology advances behind the latest generation of cord wood and pellet boilers that achieve far greater efficiency levels and far lower pollutant emissions. Gasification, two-stage combustion, thermal storage, and advanced controls contribute significantly to these developments. Also discussed are combustion test results with alternative liquid fuels including biodiesel, straight vegetable oil, levulinates derived from waste wood, coal-to-liquids fuels, and gas-to-liquid fuels.

1. High Performance Biomass Combustion

Nathan Russell, New York State Energy Research and Development Authority, Albany, NY

Homeowners have been motivated to shift away from fossil fuels for many reasons such as energy independence, high energy costs, and using green energy. However, typical wood-fired hydronic equipment is very low performing when compared to fossil-fired equipment- efficiencies are less than half and emissions are orders of magnitude higher. This talk will focus on the state of the technology and how to significantly improve its performance.

2. Combustion Performance of a Wide Range of Alternative Liquid Boiler Fuels

Thomas Butcher, Ph.D., Member, Brookhaven National Laboratory, Upton, NY

Stationary oil burners are capable of firing a wide range of alternative fuels. However, for any candidate fuel issues such as basic emissions, flame stability, miscibility, storage stability, and materials compatibility must be considered. The presentation discusses the results of laboratory tests with a very wide range of alternative fuels including biodiesel (to B-100), straight vegetable oil, CTL and GTL fuels, fatty acids derived from waste grease, and levulinates derived from acid hydrolysis of wood waste.

3. Laboratory Evaluation of 20% Biodiesel Fuel Blends in Heating Oils

S. Win Lee, Ph.D., Canmet Energy Ottawa Research Center, Ottawa, ON, Canada

Fine particulate emissions from combustion sources are a significant issue which may impact the fuels that are burned in heating applications in the future. In this paper the issues associated with measurement of fine particulates are discussed along with the results of the conversion from petroleum to biodiesel blends.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Seminar 16 (Intermediate)



Considerations with Using Reclaimed and Harvested Waters in Water Conservation Efforts

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 03.06 Water Treatment, SPC 191 - Water Conservation

Chair: Scott Mayes, Member, LAKOS, Olathe, KS

Everyone wants to save water, but how to do it without “robbing Peter to pay Paul.” Information is provided to help: 1) identify the opportunities for water savings in your building, 2) avoid potential water treatment headaches with scaling, corrosion and biological issues associated with trying to use reclaimed waters, 3) address health and worker/pedestrian safety associated with water conservation, 4) how to identify special equipment and piping requirements, and 5) payback and cost justification examples. If you are interested in saving water in your building, this seminar is a must.

1. Considerations with Using Reclaimed and Harvested Waters in Your Water Conservation Efforts

Dan Weimar, Member, NCH, Charlotte, NC

Reclaim Water, also called Reuse Water, Gray Water and Recycle Water, is becoming an increasingly popular topic around the water fountain. Demand for fresh water is at an all time high and the pressure exerted from a continuing population increase has placed strains on our water supply and its quality. The added stress on today’s infrastructure to satisfy this growth by producing more electricity, water, wastewater capacity and fuels is not going away. This presentation discusses the pros and cons of water conservation using reclaimed sources.

2. Responding to the Challenge of Using Reclaimed Water in Recirculating Cooling Water Systems

Robert S. Walicki, Ph.D., Associate Member¹ and Philip Yu, Associate Member¹, (1)Nalco, Naperville, IL

Reclaimed water can be used to drastically reduce reliance on municipal water and therefore is an attractive option for improving water conservation. However, using reclaimed water can present challenges over and above those seen when using traditional makeup sources for cooling water systems. This paper will provide observations from a successful implementation of using reclaimed water and will address water savings and the treatment strategies employed to insure optimal operation.

3. Non-Chemically Treated Cooling Tower Water: You've Paid for It Once, Now Use It Twice (Or More)!

Leon Shapiro, J.D., VRTX Technologies, Las Vegas, NV

Water conservation is becoming increasingly important in many parts of the world. The use of reclaimed water as well as alternate on-site water sources in place of potable water for certain uses in building operations not only makes sense, but is becoming mandatory. Both ASHRAE Standard 189.1 and the proposed ASHRAE Standard 191, as well as various local ordinances and codes mandate their use in place of potable water for various purposes. This presentation will explore the use of non-chemically treated cooling water as an alternate on-site water source for applications such as landscape irrigation and toilet/urinal flushing; and provide examples of this usage. This presentation will also explore regional implications for the successful implementation of such alternate on-site water source strategies.

4. Using Condensate and Other Sources of Clean Water to Cut a Building's Water Consumption 25-50%

Tom Van Horn, Associate Member, Universal Water Group, Seattle, WA

Water conservation is becoming an important part of the sustainability strategy of corporations, communities, and building owners around the globe. Water is scarce in many areas, and combined water/sewer rates are rising rapidly—double digit annual increases in rates are not infrequent. HVAC and refrigeration condensate can be utilized, along with clean (waste) water from other sources in a building, to offset potable water use—reducing water consumption by as much as 50%. Condensate can be redirected to offset cooling tower makeup water, to supplement irrigation water, or to provide water for lavatory flushing. Particularly when integrated into a complete system that captures, stores, and redirects condensate and other clean water to a variety of applications, the water

savings can be considerable. This presentation will provide an overview of condensate/water recovery systems in use and under development today and will review water sources, uses, and recovery economics.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Seminar 17 (Intermediate)



Hybrid Ground Source Heat Pump Systems

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 06.08 Geothermal Heat Pump and Energy Recovery App

Chair: Frank Pucciano, Member, Capture Energy Solutions, Lilburn, GA

This seminar is designed to explain the engineering requirements of a hybrid ground source heat pump system. It will demonstrate predictable performance that results from detailed assessment versus rule of thumb. It will also provide the attendee insight into tools that are available to insure a well designed system.

1. Computer Modeling for Ground Heat Exchanger Design

Ed Lohrenz, Member, Geo-Xergy Systems, Inc., Winnipeg, MB, Canada

A conventional gas boiler / chiller system can be properly designed and specified by simply calculating the peak heating and cooling loads of the design days. When designing a ground coupled heat pump (GCHP) system, however, peak loads by themselves are inadequate. Accurate hourly, monthly and annual energy load calculations are needed to optimize the size and configuration of a ground heat exchanger (GHX) and to ensure the long term sustainability of the system. This presentation illustrates the pitfalls of a "rule of thumb" approach to the design of a GHX and the benefits of accurate building energy modeling and GHX modeling.

2. Three Hybrid Ground Source Heat Pump Systems in Both Heating and Cooling Dominated Climates

Scott P. Hackel, P.E., Associate Member, Energy Center of Wisconsin, Madison, WI

This presentation will document the monitoring and study of three hybrid ground source heat pump systems in both heating and cooling dominated climates. The presentation will discuss lessons learned and other resources for engineers interested in installing a hybrid system in one of their buildings.

3. Fine Tuning a Hybrid Ground Source Heat Pump System

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

Once the specifications are written, the drawings published, the building completed, and the final punch list submitted it doesn't mean that your design is going to function just as you planned. For a high performance building, Hybrid GeoExchange systems and most conventional systems need to be tuned to the actual field conditions. Weather, occupancy, actual diversity, control interaction with the HVAC system, and other issues all may affect your system's performance and have unintended results. This seminar explores these issues and presents some "Lessons Learned" for your consideration.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Seminar 18 (Intermediate)



New High Quality Solar Data Sources and Analysis Methods for High Resolution Weather

Applications: Part 1

Track: HVAC Applications

Room: Westmount

Sponsor: 04.02 Climatic Information

Chair: Norman J. Bourassa, Associate Member, Lawrence Berkeley National Lab, Berkeley, CA Steve Cornick, P.Eng., National Research Council Canada, Ottawa, ON, Canada

The quality and amount of data available from meteorological satellites has opened up multiple opportunities to improve the development of new solar radiation model methodologies. These new methodologies have created advances in weather data engineering applications for the modeling and design of energy efficient buildings. This

seminar describes the National Solar Radiation Data Base (NSRDB), and describes detailed information on the use of satellite-derived solar radiation data in applications that created high quality weather files for California and Canada.

1. Review of the National Solar Radiation Data Base (NSRDB)

J. Neal Lott, Associate Member, National Oceanic and Atmospheric Administration, Asheville, NC

The 1991 - 2005 NSRDB contains hourly solar radiation (including global, direct, and diffuse) and meteorological data for 1,454 stations. This update builds on the 1961-1990 NSRDB, which contains data for 239 stations. The update includes the conventional time series for NSRDB ground stations as well as a one-tenth-degree gridded data set that contains hourly solar records for 8 years (1998 - 2005) for the United States (except Alaska above 60° latitude) for about 100,000 pixel locations (at a nominal 10-km-by-10-km pixel size).

2. Use of Satellite-Derived Solar Radiation in Updating California Energy Commission's Standard Weather Files

Joe Huang, Member, White Box Technologies, Moraga, CA

The California Energy Commission has recently updated and expanded the number of standard weather files for use in the Title-24 Building Energy Standards compliance calculations and the assessment of the Energy Commission solar renewable energy programs. A key aspect of this work is to incorporate gridded hourly solar radiation values derived from satellite observations using the Perez model. This paper will describe the methodology used to produce the new CZ2010 weather files, compare them to other "typical year" weather files developed for California locations, and evaluate the satellite-derived solar radiation against the available ground observations.

3. Satellite-Derived Solar Radiation Data for Canada

Robert Morris, Member, Environment Canada, Toronto, ON, Canada

A large data set providing global horizontal and direct normal solar radiation estimates at one hour time intervals has recently been generated on a 10 km grid spacing for all of Canada south of 58N for the period 1998-2008. This 11-year data set was derived from GOES geostationary satellite imagery using the Perez model and is similar to data sets recently produced for the U.S. This presentation discusses the characteristics of the data set including comparisons with in-situ solar radiation observations. The plans for public access and incorporation of this solar data into Canadian hourly CWEEDS and CWEC typical year weather files for building energy applications is also presented.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Seminar 19 (Intermediate)



Latest Data Center Environmental Guidelines

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 09.09 Mission Critical Facilities, Technology Spaces and Electronic Equipment

Chair: Jeff Trower, Data Aire Inc., Huntington Beach, CA

ASHRAE TC 9.9 has recently published updated environmental guidelines for data centers that will affect the operation and design of data centers. These guidelines which are supported by the IT equipment manufacturers are critically important for operating a data center reliably and in the most energy-efficient manner.

1. IT Equipment Power Trends to 2020

Roger Schmidt, Member, IBM, Poughkeepsie, NY

TC9.9 provides guidance on trends for power consumption by IT equipment. A recently released update enables planning for future data center requirements and provides insight into the factors influencing power trends. A historical look at past trends will also be provided to demonstrate the value in considering the trends.

2. Expanded T and H Environmental Guidelines for Data Centers

Robin Steinbrecher, Intel, New York, NY

The environmental guidelines first published by TC9.9 in 2004 provided data center planners, designers and ITE purchasers with a cohesive set of environmental parameters which ITE manufacturers committed to design to. They also described how and where to measure critical thermal parameters within the data center. With the great emphasis on computing efficiency many data centers are using or considering use of free-cooling techniques. To enable innovation within the data center and the capability for closer to year-round use of these techniques, TC9.9 has added new classes for ITE data-center products. The implications on IT equipment design and usage of these new classes will be provided.

3. Gaseous Contamination Limits for Data Centers

Prabjit Singh, Ph.D., Member, IBM, Poughkeepsie, NY

The recent increase in the corrosion-related hardware failure rates in data centers located in regions polluted with high levels of sulfur-bearing gases led to the recommendation that in addition to temperature and humidity, dust and gaseous contamination should also be monitored and controlled. The corrosion-related failure mechanisms afflicting today's hardware and the environmental corrosion severity levels at which these failures occur will be described.

Sunday, June 26, 2011, 1:30 PM-3:00 PM

Seminar 20 (Advanced)



Operation-oriented Flexible Building System Modeling

Track: Engineering Tools

Room: Lasalle

Sponsor: 04.07 Energy Calculations

Chair: Wangda Zuo, Ph.D., Associate Member, Lawrence Berkeley National Laboratory, Berkeley, CA

Conventional building simulation program are not well suited to address integration challenges of very low energy buildings. It is difficult and time-consuming to model an innovative building system which does not exist in current tools. In addition, it is also hard to reuse the models developed in building design for the building operation. To meet the needs of fast prototyping and operation-oriented modeling, it is possible to use equation-based object-oriented modeling languages. Using the non-proprietary Modelica language as an example, this seminar presents the fundamental features of equation-based languages. It explains why this technology opens new applications for design, optimization and operation of buildings.

1. Next Generation Modeling for Building Systems Using Modelica

Michael Wetter, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

Conventional building simulation program are not well suited to address integration challenges of very low energy buildings. In the modeling community, there is a clear trend toward equation-based, acausal modeling languages. These languages describe in a declarative way the physics and the control logic, but they do not describe how to compute a solution to the equations that describe the underlying physics and control logic. This is in contrast to building simulation program that describe step by step how to compute a solution. This seminar presents the fundamental features of equation-based languages, and explains why this technology opens new applications for design, optimization and operation of buildings. Next, it describes the use of Modelica, an equation-based language, to analyze the performance of modern building systems that are beyond what can be simulated with the simulation programs that are currently in use by the buildings industry.

2. A Modelica-Based Dynamic Fault Simulator for Air Handler Units

Zheng O'Neill, Ph.D., Member, United Technologies Research Center, East Hartford, CT

Building HVAC systems often consume in excess of 20% more electrical energy than was the design intent largely because of equipment performance degradation (e.g. filter or heat exchanger fouling), equipment failures, or detrimental interactions among subsystems such as cooling and then reheating of conditioned air. Identifying the root causes of efficiency losses is challenging because a gradual erosion of performance can be difficult to detect. Furthermore, diagnostic algorithm performance is limited by available fault ground truth data. An analytical

framework and model-based simulation capability is desired to develop fault ground truth data that can be used to deploy robust diagnostics for building HVAC systems. A Modelica-based dynamic fault simulator was developed for Air Handler Units (AHU). This simulator is able to dynamically simulate a variety of faults from subcomponents including economizer, valves, heating and cooling coils, and fans. Control oriented faults at local loop are also covered by this simulator. Development of this fault simulator and testing results will be discussed in this talk.

3. Evaluation and Optimization of Control System for Water Side Economizer

Wangda Zuo, Ph.D., Associate Member, Lawrence Berkeley National Laboratory, Berkeley, CA

Water side economizer is used to provide free cooling for buildings. The challenge in practice is how to control the system so that the benefit of water side economizer can be maximized. The control of water side economizer is difficult since the system is nonlinear and the performance curves of equipments (e.g. chiller, pump and fan) are nonlinear. In addition, the wet bulb temperature is changing with time and location. This seminar presents how to use Modelica-based modeling technique for the evaluation and optimization of a water side economizer system. The simulation results show that one can optimize the control sequence and parameters to significantly reduce energy consumption and chiller operation time. Then the optimized control sequence and parameters can be used as a good starting point for the tuning of control system in building commissioning.

Sunday, June 26, 2011, 3:00 PM-4:00 PM

Seminar (Basic)

Giving Knows No Borders

Track: Professional Skills

Room: Lachine

Sponsor: ASHRAE Foundation

Chair: Jeff Lydenberg, PG Calc, Cambridge, MA

OPEN SESSION. No badge required. No PDHs awarded. As ASHRAE travels to Canada for the 2011 Annual Conference, what better time to address the unique circumstances of charitable giving across country lines? ASHRAE is a testament to how freely goods, services and ideas flow across international borders. Charitable donations, likewise, flow from one county to the other. Cross-border donations and grants are steadily increasing and becoming an important source of support for non-governmental organizations. Join us in Montreal for a discussion of issues regarding Canadians making gifts to support U.S. charities such as ASHRAE and likewise how Americans can make gifts to Canadian charities. We'll also touch on the issues of charitable giving for citizens of other countries as well.

Sunday, June 26, 2011, 3:00 PM-4:00 PM

Forum (Advanced)

Gas Measurements in Buildings: Who's Fooling Whom?

Track: Professional Skills

Room: Hampstead

Sponsor: 02.03 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, GPC27P

Chair: William Lull, Member, Garrison/Lull Inc., Princeton Junction, NJ

OPEN SESSION: no badge required; no PDHs awarded; presented during the TC's meeting. ASHRAE Guideline 27P, Measurement Procedures for Gaseous Contaminants in Commercial Buildings, is nearing completion. This forum is to discuss member measurement experiences, good and bad. The hope is to identify the important aspects of making measurements to highlight in the Guideline, so users can get meaningful results.

Monday, 06/27

8:00 AM-9:30 AM

Monday, June 27, 2011, 8:00 AM-9:30 AM

Technical Paper Session 4 (Intermediate)



Improving Residential Building Energy Performance

Track: Net Zero Buildings

Room: Hampstead

Chair: Bill Dean, National Research Council of Canada, Saskatoon, SK, Canada

The papers in this session examine residential energy usage and energy end-use breakdown to analyze energy reduction strategies. Several findings from the energy analysis are presented such as evaluation of energy use changes over time and occupant behavior. The papers also present recommendations for improving residential energy savings.

1. Targeting Residential Energy Reduction for City Utilities Using Historical Electrical Utility Data and Readily Available Building Data (ML-11-009)

Kevin P. Hallinan, Ph.D.¹, Austin Mitchell, Ph.D.², Robert J. Brecha¹ and J. Kelly Kissock¹, (1)University of Dayton, Dayton, OH, (2)Carnegie Mellon University, Pittsburgh, PA

Energy use data for the eight-year period 2003-2010 was analyzed for over 1200 single family residences in the Village of Yellow Springs, Ohio. Electricity, natural gas, residential building, and weather databases are merged to permit determination of the energy intensity of each home in the village. The energy use intensity for each home is disaggregated into weather independent and weather dependent electric and natural gas use. This use is compared to typical baseline, cooling, and heating energy use for the region. From this comparison, priority homes are identified for energy reduction investment. Collective potential low cost energy reduction is estimated for the community. Energy reduction of greater than 41% is determined to be easily achievable. Finally, a process is established, beginning with individual home energy report cards, for turning the analysis and predictions into energy reduction action.

2. Energy Performance, Comfort and Lessons Learned from a Near Net-Zero Energy Solar House (ML-11-010)

William T. O'Brien, Ph.D., Student Member¹, Matt Doiron, P.Eng.¹ and Andreas Athienitis, Ph.D., P.E., Member¹, (1)Concordia University, Montreal, QC, Canada

This paper examines the performance of a Canadian near net-zero energy solar house, known as ÉcoTerra, located near Montreal. The total energy consumption and energy end-use breakdown are presented and several findings from the energy analysis are discussed such as the importance of occupant behavior, occupant comfort and the improvements that could lead to achieving full net-zero energy performance. It was demonstrated that large reductions in energy consumption can be achieved with little effect on comfort. Occupants affect the loads significantly and need to be educated and given specific feedback about their energy use patterns in order to help them adjust their behavior for energy efficiency. Although already far below the typical home in energy consumption (about 90%), this paper shows how ÉcoTerra could consume even less energy and how similar houses could be designed or upgraded to achieve net zero energy.

3. TRCA-BILD Archetype Sustainable House: Overview of Monitoring System and Preliminary Results for Mechanical Systems (ML-11-011)

Dahai Zhang, Student Member¹, Rupayan Barua, Student Member¹ and Alan S. Fung, Ph.D., Member¹, (1)Ryerson University, Toronto, ON, Canada

A comprehensive monitoring system has been developed and implemented in the Archetype Sustainable House (ASH) built at the Kortright Centre for Conservation of the Toronto and Region Conservation Authority (TRCA) in Vaughan, Ontario, Canada. Over 300 sensors of various types covering sufficient energy monitoring details have been installed and calibrated in the twin houses. Data of interest, such as air temperature/relative humidity/flow rate, water temperature/flow rate, natural gas consumption, solar radiation, soil temperature/moisture and power consumption of individual component, are being collected for energy analysis. An expandable distributed data

acquisition (DAQ) system has been adopted for monitoring and control purpose. LabVIEW platform is used to carry out data processing and post-analysis. Equations to evaluate mechanical systems performance were developed and implemented into the monitoring software. All data are recorded in the Structured Query Language (SQL) database. Preliminary results of the performance of several equipment are reported and some practical problems associated with the Heating, Ventilation and Air Conditioning (HVAC) system configurations are documented.

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 21 (Intermediate)



Energy Recovery Issues in Dedicated Outdoor-Air Systems

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 08.10 Mechanical Dehumidification Equipment and Heat Pipes

Chair: Stanley Mumma, Ph.D., P.E., Fellow ASHRAE, Penn State University, University Park, PA

Dedicated outdoor-air systems (DOAS) are becoming increasingly popular. They are used to condition outdoor air being brought into a building for ventilation and humidity control. Energy recovery is commonly used to improve the performance of these systems. This seminar addresses several issues related to applying energy recovery in a DOAS.

1. Applying Air-to-Air Energy Recovery in a Dedicated OA System

John Murphy, Member, Trane, LaCrosse, WI

This presentation will discuss several issues related to applying air-to-air energy recovery in a dedicated OA system. Topics include a review of the changes to the requirements of ASHRAE Standard 90.1-2010, a discussion of balanced versus unbalanced flow, and a discussion of sizing for reserve capacity and the impact on performance of the energy recovery device.

2. Pros and Cons of Operating a Dedicated OA System Enthalpy Wheel Continuously

Stanley Mumma, Ph.D., P.E., Fellow Life Member, Penn State University, University Park, PA

This presentation will discuss proper DOAS EW control considering heating/humidification and cooling/dehumidification energy use, fan energy use, wheel cleaning, wheel frost protection, and coil freeze protection with an emphasis on maximizing the free cooling opportunities. This subject is important since most energy analysis software and many manufacturers have overlooked these important issues.

3. Vapor Compression Cycle Energy Recovery for Dedicated Outdoor Air System Units

Craig Burg, Associate Member, Desert Aire Corp., Milwaukee, WI

Several methods exist for utilizing the heat created in Dedicated Outdoor Air System Units. This presentation will discuss applications and conditions where hot gas reheat provides for energy efficiency and the controls required. Supply air temperatures at part load and the sensible load of different building types and zones will be presented. Other efficient methods for utilizing the total heat of rejection will also be discussed.

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 22 (Intermediate)



Innovations in Applying Natural Ventilation in Healthcare Facilities

Track: Alternative Technologies

Room: Verdun

Sponsor: 09.06 Healthcare Facilities

Chair: Michael Meteyer, P.E., Member, Cogdell Spencer ERDMAN, Madison, WI

Pursuit of more sustainable healthcare facilities includes innovative methods for providing ventilation that improves the well-being of patients and staff while reducing the energy consumption. Attend this seminar to obtain new ideas regarding natural ventilation applied to the unique circumstances in healthcare facilities. Also, come find out more on how to evaluate wind and temperature criteria for natural ventilation designs, as well as, learning from recent case studies of natural ventilation in UK hospitals.

1. Natural Ventilation: Climate, Wind Pressure and Stack Effect

John Carter, Member, CPP, Inc., Fort Collins, CO

Local climate statistics are used to determine if natural ventilation is a realistic option. Natural ventilation is driven by pressure differences across the building envelope caused by wind pressure and temperature differences between indoor and outdoor air (stack effect). Techniques to assess natural ventilation potential and the physics governing wind and temperature driving mechanisms will be discussed.

2. Natural Ventilation in North American Healthcare

Bob Gulick, P.E., Member, M+NLB, San Francisco, CA

Natural ventilation of occupied spaces has been increasingly employed as a sustainable, energy conserving strategy in non-healthcare facilities. When used, natural ventilation has proven to reduce energy consumption. However, applying natural ventilation in a North American healthcare setting carries a higher standard of performance by controlling airborne infections. This presentation will discuss means of employing natural ventilation while maintaining airborne infection control. We will discuss the basics; the hurdles; pathogen sources, both internal and external; specific susceptible populations; and a hierarchy of spaces within a healthcare facility that have natural ventilation potential.

3. New Low Energy Ventilation and Cooling Design Approaches Using Natural Ventilation in the UK

Frank A. Mills, Member, SKM, Manchester, United Kingdom

Whilst the UK has always allowed natural ventilation in hospitals for ventilation, the target to develop zero carbon hospitals by 2019 has led to new research efforts to develop new ways of achieving comfort and infection control using natural ventilation as the primary 'zero carbon' system and in some cases as part of hybrid low carbon HVAC solutions. This paper describes the latest thinking in this area and shows how new and existing hospitals can benefit from such an approach with results of study and simulation work and completed project monitored usage. Refurbishment and upgrade works present new opportunities for low carbon solutions and major cost reductions of existing hospitals whilst improving infection control and the patient health experience.

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 23 (Basic)



Issues Update: North American Building Codes and Political Realities

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: Advocacy Committee

Chair: Ronald Jarnagin, Member, Pacific Northwest National Laboratory, Richland, WA

This session presents four perspectives on the current status of code-related activities in North America (Canada, United States and Mexico), and provides an opportunity for a discussion of trends and opportunities for ASHRAE and ASHRAE members. Efficient buildings save money and protect the environment, and as a result, building codes are attracting attention as low-cost, high-impact tools. However, political realities and on-the-ground compliance constraints continue to hamper progress toward greater building efficiency in some jurisdictions. This session updates members on the current status of building codes in North America, and the policy context that will affect building efficiency improvements.

1. Codes in Canada: Provinces vs. Federal; Public Buildings vs. Private; and Voluntary Initiatives

Diane Green, Member, National Research Council IRC-CCC, Ottawa, ON, Canada

This presentation examines Codes in Canada: Canada's Building Codes and Its Coordinated Codes Development System. It presents an overview of Canada's Building Codes and its coordinated codes development system. The

origins and legal basis of the codes, as well as what is anticipated for the not-so-distant future, will also be addressed.

2. Building Codes in Mexico: Hot Spots of Activity and Potential

José Luis Frías Lavalle, Member, DHIMEX, Mexico City, Mexico

This session presents on building codes in Mexico, and discusses the current areas of high activity and potential.

3. Policy Barriers and Opportunities for Greater Building Efficiency: What's Happening in the USA

Cliff Majersik, Institute for Market Transformation, Washington, DC

This session presents policy barriers and opportunities for greater building efficiency in the United States of America.

4. ASHRAE Activities and Initiatives: Who Are the Players and What Are We Doing?

Ronald Jarnagin, Member, Pacific Northwest National Laboratory, Richland, WA

This session presents ASHRAE activities and initiatives and discusses the context in which they were developed.

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 24 (Intermediate)



Modeling Protocols for Building Energy Simulations for Code Compliance and Other Regulatory Programs

Track: Engineering Tools

Room: Lachine

Sponsor: 04.07 Energy Calculations

Chair: Joe Huang, Member, White Box Technologies, Moraga, CA

Building energy simulations are being used more and more for energy code compliance, building energy labeling, and green building certification. To maintain consistency in the process, protocols that define the modeling rules, e.g., the building's internal conditions and operating schedules, are essential. Standard 90.1's Appendix G and COMNET are prime examples of such protocols. The purpose of this seminar is to describe the current status of such protocols, and how they may impact the work of members doing building energy simulations.

1. COMNET: Standardizing Procedures for Calculating Building Energy Performance

Charles Eley, P.E., Member, Chair, COMNET Standing Committee, San Francisco, CA

COMNET (Commercial Energy Services Network) has published the Modeling Guidelines and Procedures (MGP) which build on the Performance Rating Method of Standard 90.1 to standardize the procedures for calculating building energy performance for the purposes of federal tax deductions, green building ratings, and asset ratings of commercial buildings. The MGP is written as a software specification and includes criteria based on Standard 140-2007. Default time-of-use tariffs are provided. The general modeling procedures are supported by a list of over 500 building descriptors. For each building descriptors, a definition is provided, restrictions are presented describing the proposed design, and rules are specified for the baseline building. The current MGP supports 90.1-2001 for tax credits and 90.1-2007 for green building ratings. Additional baselines are being developed for 90.1-2010, Building EQ and other baseline standards.

2. An Introduction to ASHRAE 90.1 ECB

Jason Glazer, P.E., Member, GARD Analytics, Inc., Arlington Heights, IL

The ECB (Energy Cost Budget) Method is an alternative option to the prescriptive provisions of ASHRAE Standard 90.1 that uses building energy simulations to demonstrate that the proposed building design has an energy performance equivalent to that of a code-compliant reference building. The ECB section of ASHRAE 90.1 contains requirements for the simulation program, and a general protocol for how to model a building for code compliance, with more detailed modeling rules presented in Appendix G. This presentation will describe the present status of the ECB Method, and discuss the incorporation of the modeling protocol in currently available building energy simulation software tools.

3. Shaping the Future of Regulation, Resources, and Quality Control for Building Energy Modeling

Aleka Pappas, Member, Enermodal Engineering Inc, Denver, CO

Building energy modeling practitioners today are something of pioneers in the wild west of this growing field. They are accustomed to working with little or ineffective oversight, regulation, or assistance in the struggle to provide accurate, useful design assistance and building energy ratings for their clients in a timely and cost-effective manner. What should the A&E community consider as we work to certify energy modelers? What tools and resources should be made available to modelers to further standardize results and provide quality assurance for those that hire them? Is there a holy grail of energy modeling tools? What would it look like? Is there value in having a variety of tools available? To what standards should energy modelers be held?

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 25 (Intermediate)



Performance of Shading Devices in Commercial Buildings

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 04.05 Fenestration

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

Shading devices, such as interior venetian blinds, roller shades, draperies, exterior louvers, double facades, etc., represent excellent opportunities to maximize energy savings in commercial buildings. These systems can be automated and intelligently controlled, provided we know exactly what we want to control and optimize. This seminar presents an overview of the current state of the art and identifies future areas for research and development.

1. Field Measurements of Energy Impact of Shading Devices

Christian Kohler, Member, LBNL, Berkeley, CA

We will discuss the impact of shading systems in commercial buildings on heating, cooling and lighting energy consumption. The effect of shading placement (indoor vs outdoor) will be demonstrated as well as impact on visual comfort.

2. State of the Art Thermal Modeling of Complex Fenestration Systems

Aziz Laouady, Ph.D., Natural Resources Canada, Ottawa, ON, Canada

Complex fenestration systems (CFS) have become standard elements in façade design of current buildings. CFS include, for example, various types of solar shadings devices to control illumination, solar heat gains, glare, and view-out, semi-transparent insulation to increase thermal resistance, electrically-heated glazing to control moisture condensation on the internal surfaces of windows, maintain view-out, and provide local secondary space heating, and photovoltaic elements imbedded in glazing layers to produce electrical energy on site. This seminar presents the state of art models to compute the thermal performance of multilayer CFS. Model validation studies for the prediction of the total U-factor will also be presented.

3. A User Friendly Computer Program for the Solar/Thermal Analysis of Glazing Systems with Shading Devices

John Wright, Ph.D., Member, University of Waterloo, Waterloo, ON, Canada

This seminar presentation gives an overview of a new computer program that permits the user to analyse a complex window system consisting of various glazing layers and shading devices. Solar radiation and heat transfer (convective and longwave) are tracked in the multi-layer system using new methods recently documented in the ASHRAE Transactions. The glazing system can include any combination of tints, coatings, fill gases and fill gas mixtures. Available shading layers include venetian blinds (any slat angle), pleated drapes (any fullness), roller blinds and insect screens. Venetian blinds can be located on the indoor side, between panes or on the outdoor side. Relatively few data are required to describe any of the layers and libraries for each layer type have been compiled. The analysis framework is sufficiently general that additional shading layer types can be readily added. The

weather can include any combination of beam/diffuse solar radiation and indoor/outdoor radiant and air temperatures. The Solar Heat Gain Coefficient and U-factor (plus several other indices of merit) can be calculated for any weather condition. Processing speed is virtually instantaneous and a graphical interface facilitates the assembly of multi-layers systems and the interpretation of results.

4. Dynamic Shading in Commercial Buildings: Analysis and Case Studies

Athanasios Tzempelikos, Purdue University, West Lafayette, IN

Dynamic facades include controlled shading devices and integration with lighting controls and thermal control systems. Shading should be considered as an integral part of façade design in modern buildings. This seminar presents the background and analysis of dynamic (controlled) shading for commercial building facades. Emphasis is placed on the impact of dynamic shading on energy demand and human comfort. Modeling case studies and existing applications of different office buildings in North America will be presented.

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 26 (Basic)



The Prevention of Condensation Problems in Mechanical Insulation Systems

Track: Refrigeration

Room: Westmount

Sponsor: 01.08 Mechanical Systems Insulation, 01.12 Moisture Management in Buildings

Chair: Charlie Petty, Member, Lamtec Corporation, Mt. Bethel, PA

Condensation, whether on the outer surface of insulation or vapor retarders on refrigeration pipes and equipment, or on the pipes and equipment itself, is a problem that can be dangerous and damaging, and costly to rectify. Many critical aspects of design and operation are often misunderstood or overlooked, contributing to the problems. This seminar covers the factors that must be considered, and the approaches that must be taken, to prevent condensation problems.

1. Factors Influencing the Likelihood of Surface Condensation on Mechanical Systems Insulation

Jim Young, Member, ITW Insulation Systems, Midland, MI

The factors that will be discussed in this presentation include: Insulation thickness; Insulation thermal conductivity; Jacket type; Wind speed; Ambient temperature; and Ambient relative humidity. It is important to understand all the factors that influence the potential for surface condensation to occur in mechanical system insulation. Unless there is an awareness of these factors and knowledge of how to deal with them, there is a risk of unwanted condensation occurring, and the resulting ill effects being experienced.

2. Prevention of Condensation Problems in Insulated Chilled Water Pipes Located in Unconditioned Spaces in Hot and Humid Climates

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

The following areas of concern will be discussed in the presentation: Water vapor permeability and permeance; Low permeance jacket vs. low permeance insulation; Mold and mildew prevention; Importance of proper installation technique and workmanship; Importance of construction schedule; and Importance of insulation system maintenance during and after construction. Unconditioned spaces present extra challenges for the insulation used in mechanical systems. These conditions are very demanding of the design, materials and techniques employed in the insulation and vapor retarder components. Workmanship and maintenance are very important, yet often not given adequate attention.

3. A Methodology to Measure Thermal Performance of Pipe Insulation At Below Ambient Temperatures and Its Practical Impact In Condensation Control

Lorenzo Cremaschi, Ph.D., Associate Member, Oklahoma State University, Stillwater, OK

The following aspects of the research project will be discussed: Description of the apparatus and method being developed under current a ASHRAE Research Project; Thermal conductivity of insulation materials at below-

ambient operating temperatures: important new data to be obtained; and How design for condensation control will benefit from this research. This research project (RP 1356) has a primary focus of establishing a test to determine the thermal performance of insulation materials at below-ambient temperatures. The data and knowledge obtained in this work should prove valuable for the design of insulation for prevention of surface condensation in chilled water and other systems.

Monday, June 27, 2011, 8:00 AM-9:30 AM

Seminar 27 (Intermediate)



Toward Net Zero Energy Refrigeration

Track: Refrigeration

Room: Lasalle

Sponsor: 10.08 Refrigeration Load Calculations, 10.05 Refrigerated Distribution and Storage Facilities

Chair: Michele Friedrich, P.E., Member, PECEI, Portland, OR

How low can you go toward net-zero refrigeration? Buildings that have refrigeration systems have a big challenge to get to net-zero energy designs. This seminar presents how low can you go with current refrigeration technologies in refrigerated storage; tradeoffs between lowering green house gases and energy efficiency in supermarket design; and how much land is needed for renewables to get to net-zero for industrial refrigeration plants.

1. Strategies for Low Greenhouse Gas Emissions and Energy Consumption in Supermarket Refrigeration Systems

Edward A. Vineyard, P.E., Member, Oak Ridge National Laboratory, Oak Ridge, TN

The purpose is to present information on strategies to minimize global warming emissions for supermarket refrigeration systems by reducing energy consumption, leak rates, and through the use of low global warming potential (GWP) refrigerants. The presentation will focus on the tradeoffs between using a low GWP refrigerant, reducing leak rates through advanced systems, such as secondary loop, and reducing energy consumption with improved designs, such as display cases with doors.

2. Minimizing Energy Usage: Best Practice Design for a Refrigerated Warehouse

Ryan Hoest, Member, VACOM Technologies, San Luis Obispo, CA

Seminar will discuss simulation results quantifying the potential minimum annual electric energy use of a cold storage facility implementing currently available technologies and best practice design.

3. The Net Zero Food Plant

Douglas Reindl, Ph.D., P.E., Fellow ASHRAE, University of Wisconsin-Madison, Madison, WI

As efforts grow to curb energy use and reduce costs the concept of “net-zero” buildings has garnered a great deal of attention recently. The focus of net-zero has been focused primarily on residential and commercial buildings thus far. There is little information on the feasibility of net-zero on an industrial scale. The potential of creating a net-zero food production plant is investigated using various electricity generating methods including solar, wind, and anaerobic digestion. As solar and wind resources vary depending on location, six international cities were chosen as simulation sites representing a large array of climates. A relatively large facility manufacturing ice cream with a typical amount of production waste was chosen as the investigation site. Results of the analysis show that large amounts of land are required to generate enough renewable energy to power the plant, and it is still grid dependent when those renewable resources are unavailable.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Technical Paper Session 5 (Intermediate)

Understanding Electrical Equipment Heat Gain

Track: HVAC Applications

Room: Westmount

Chair: Deep Ghosh, Southern Co., Atlanta, GA

In order to properly size the HVAC equipment for a building or industrial setting, engineers need to have an accurate estimate of the rate at which heat is added to the structure's environment. RP 1104 and RP 1395 were projects aimed at improving the means of estimating the rate of environmental heat gain from indoor power distribution equipment. The main goal of this session is to build a power loss model that can predict the rate of heat gain from power panelboards and uninterruptible power supply systems.

1. Heat Gain from Power Panelboards (RP-1395) (ML-11-012)

Emilio C. Piesciorovsky¹ and Warren White, Ph.D., Member¹, (1)Kansas State University, Manhattan, KS

In order to properly size the HVAC equipment for a building or industrial setting, engineers need to have an accurate estimate of the rate at which heat is added to the structure's environment. RP 1104 and RP 1395 were projects aimed at improving the means of estimating the rate of environmental heat gain from indoor power distribution equipment. The main goal of this paper is to build a power loss model that can predict the rate of heat gain from power panelboards. The rate of heat dissipated from a panelboard depends upon the power loss of the breakers, fusible switches, motor starters, and bus bars. Information collected from measurements and published literature is used to build the power loss models for the panelboard components. Using these component models, the power panelboard loss model is created based on the sum of the component power losses. A portion of the paper is devoted to illustrating panelboard construction details. Finally, the power panelboard loss model is used in a heat gain example, demonstrating the model's use. The information in this paper is based on findings resulting from RP 1395.

2. Heat Gain from Uninterruptible Power Supplies (RP-1395) (ML-11-013)

Warren White, Ph.D., Member¹ and Emilio Piesciorovsky¹, (1)Kansas State University, Manhattan, KS

In order to size the HVAC equipment for facilities using uninterruptible power supplies (UPS), an accurate estimate of the heat load produced by these devices is required. A model for the power dissipation of UPS is presented. The basis of the power loss model is the UPS efficiency. Different UPS configurations are classified and a corresponding efficiency, which is a function of load, is presented. A total of five different configurations are illustrated and a total of four different efficiency models are provided. The data used in the models are obtained from a publically sponsored study. The models are compared with UPS efficiency information obtained from manufacturer websites and the agreement between the efficiency models and the manufacturer data is shown to be reasonable. The power loss models were part of the work scope for RP-1395.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Conference Paper Session 7



Design Strategies for Net-Zero Energy Residential Buildings

Track: Net Zero Buildings

Room: Mont Royal

Chair: Harry Enck, Member, Commissioning & Green Building Solutions, Inc., Buford, GA

This session examines sustainable technologies, processes, and ideas available for the residential market. The papers examine technical and economic potential for reducing the building energy usage as well as the cost benefit by applying alternate energy strategies for the buildings and as well as options for automobiles to reduce the overall carbon footprint.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Seminar 28 (Basic)



Back to Basics: Airflow in Unitary Systems

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 08.11 Unitary and Room Air Conditioners and Heat Pumps

Chair: Don A. Schuster, P.E., Member, UTC Carrier Corp., Tyler, TX

The main purpose of this Back to Basics seminar is to discuss airflow as it applies to unitary system applications. The standard methodology for defining air flow from a fan, coil and unitary equipment perspective is reviewed. How to tie together and make sense of all the various definitions is presented. In addition, the effect of elevation and local conditions on airflow and system performance are examined. After this discussion, the specific unitary application of zoned systems where defining airflow is vital is presented. As size of zones change and demand from each zone changes, airflow will be impacted and will directly affect the operating point of the entire system.

1. Actual Airflow or Standard Airflow: Why Can't We All Speak the Same Language?

Raymond Rite, Ph.D., Member¹ and Roy Crawford, Ph.D., P.E., Member², (1)Ingersoll Rand - Residential Solutions, Tyler, TX, (2)University of Texas at Tyler, Tyler, TX

Throughout the industry there continues to be confusion about how to define airflow: actual airflow or standard airflow or both? When you say standard air flow do you mean moist or dry air? How do you use these concepts to capture the effect of elevation on system performance? How do you reconcile the “volumetric flow device” known as the fan with the “mass flow device” known as the heat exchanger? The method of test standard used by fan engineers has specific definitions of standard air flow. Coil engineers have their own definitions. These are not the same. The engineer applying these two devices must span this divide. How can system engineers make everybody get along? In this “Back to Basics” seminar the test standards and ratings standards of interest will be reviewed and a methodology will be presented to make everything mesh together.

2. Application of Zoned Systems in Residential Applications

Craig S. Messmer, P.E., Member, Unico, Inc., St. Louis, MO

Most people accept that zone control improves comfort and efficiency but if not correctly designed it could adversely affect the operation of the mechanical equipment. How one applies a zone control system depends on the type of system being used. This presentation describes the various strategies for zoning and how it is a matter of proper balance to make it work. How the designer achieves this balance will depend on the number of zones; the capacity modulation capabilities of the equipment; space requirements; and lastly designer preference. There are many different ways to achieve this balance but all of them share the same basic principles.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Seminar 29 (Intermediate)



Bridging the Disconnect between HVAC and Refrigeration Design in an Ice Arena

Track: Refrigeration

Room: Verdun

Sponsor: 10.02 Automatic Icemaking Plants and Skating Rinks

Chair: Wayne Borrowman, P.Eng., Member, CIMCO Refrigeration, Delta, BC, Canada

The HVAC system of a typical ice arena was traditionally designed with little or no coordination between the design of the ice refrigeration system, yet the design and operation of the HVAC system can significantly impact the refrigeration system operation. Similarly, many ice refrigeration systems now provide heat recovery for building heating yet the amount of real energy saved is often only a small fraction of what is available because of lack of integration with the HVAC system. This seminar highlights the challenges and successes in fully integrating the ice refrigeration and HVAC systems.

1. Innovative Refrigeration Systems for Ice Rink Applications

Benoit Rodier, P.Eng., CIMCO Refrigeration, Montreal, QC, Canada

Well designed HVAC and Ice Refrigeration systems do not automatically result in an efficient Ice Arena. The most efficient Arenas today are a result of innovative design and integration of both the HVAC and Ice Refrigeration systems. Further it is necessary to re-design the Ice Refrigeration System into an Energy Centre where heat is removed, stored and delivered to various systems in a facility when it is needed. Several examples of successful integration in facilities will be highlighted.

2. Integration of HVAC Systems for Ice Arenas

Kenneth Jewer, P.Eng., Member, SNC-LAVALIN INC. – BAE-NEWPLAN GROUP LIMITED, Mount Pearl, NF, Canada

The most Efficient Ice Arena complexes today need more than an efficient HVAC system. To significantly reduce the total building energy consumption the HVAC system must be designed from the ground up and integrally linked to an innovative Ice Refrigeration System. The author will highlight a successfully integrated project.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Seminar 30 (Intermediate)



CHP Done Right for Net Zero Energy Buildings

Track: HVAC Systems and Equipment

Room: Lasalle

Sponsor: 01.10 Cogeneration Systems

Chair: Timothy Wagner, Ph.D., Member, Energy Systems Program Office at United Technologies Research Center, Hartford, CT

ASHRAE Vision 2020 states, “A net zero site energy building produces as much energy as it uses when measured at the site”. Achieving net zero energy status under this definition for most commercial, institutional and industrial facilities is not possible without using combined heat and power (CHP) to some degree. The issue is how to design and deliver CHP systems that meet the building thermal and power load profiles, comply with code requirements and be economically viable. This seminar covers best practices in CHP design and implementation to achieve net site zero energy buildings for the future.

1. Thermal – Power – Electric Grid Optimization of CHP Systems

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

Net zero site energy buildings require significant onsite production of power and thermal energy. The annual onsite energy production requirement is often far greater than can be economically produced by wind or solar energy. Combined heat and power (CHP) remains the best means of closing the energy gap between energy efficiency, what renewables economically achieve and the net zero energy goals. Best practices must be promulgated throughout the industry to consistently deliver the power and thermal energy at the right time and at the right price. This seminar will present best design and operating practices focusing on mid-atlantic and northeast United States and eastern Canada.

2. Pragmatic CHP Policy Considerations

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

Achieving net zero site energy buildings (NZEB) often depends as much on public policy considerations than on engineering design. Applying wind and solar energy with combined heat and power (CHP) systems to commercial and institutional buildings requires a firm understanding of federal, state and local rules, regulations, rate tariffs and incentives. Understanding the current and future policy trends is an essential element in engineering net zero site energy buildings. This seminar will focus on public policies that enhance the use of CHP to achieve NZEB operation, focusing on mid-atlantic and northeast United States and eastern Canada.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Seminar 31 (Intermediate)



Integrated Project Delivery: A Case Study

Track: Engineering Tools

Room: Lachine

Sponsor: TC7.2 HVAC&R Contractors and Design Build

Chair: Michael McLaughlin, P.E., Associate Member, Southland Industries, Dulles, VA

Integrated project delivery (IPD) is a proven approach for efficiently designing and building a facility for owners and an effective method for architects, engineers and contractors to garner the highest quality for the best value and schedule. To date, IPD has mostly been applied to private-sector projects rather than public-sector ones, which are often hampered by lowest cost-bid contracting rules and an inability to adopt integrated contracts where the risks and rewards are shared among the all primary project stakeholders. This seminar reveals the prescription for success behind the \$1.6 billion UCSF Medical Center project which resulted in a highly collaborative, integrated, BIM centric project that maintained scope, quality and performance for this facility.

1. Integrated Project Delivery for a Major University Medical Center

Raj Daswani, P.E., Member¹, Tad Smith² and Paul Switenki, P.E., Member¹, (1)Arup, San Francisco, CA, (2)ACCO Engineered Systems, San Leandro, CA

Integrated Project Delivery (IPD) is quickly emerging as a proven approach for efficiently designing and building a facility for owners and for those within the architecture, engineering and construction industry searching for ways to garner the highest quality for the best value and schedule. To date, IPD has mostly been applied to private-sector projects rather than public-sector ones, which are often hampered by lowest cost-bid contracting rules and an inability to adopt integrated contracts where the risks and rewards are shared among the all primary project stakeholders, including the owner, architect, contractor and key subcontractors. UCSF Medical Center decided to break new ground and employ IPD principles and practices for its new \$1.6 billion hospital complex for children, women and cancer patients at Mission Bay in San Francisco. By adopting an integrated and highly collaborative approach, combined with Building Information Modeling (BIM), UCSF Medical Center seeks to reduce the cost and schedule of its Mission Bay complex, while maintaining scope, quality and performance of what will be a world-class facility centered on the compassionate care of patients and their families. This presentation focuses on the collaboration between the MEP engineers, the contractor and mechanical subcontractors to integrate the design with the construction detailing efforts. Subcontractors modeled the building while engineers provided design direction (calculations etc) and end result was a single model that is being used for fabrication of this world class facility. We discuss how we worked with the design assist and design build subcontractors on the project, exchanging models, who did what and how we used this model for agency submission (OSHPD) and approvals.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Forum 2 (Intermediate)

Update on the Energy Targets for Commercial Buildings

Track: Net Zero Buildings

Room: Hampstead

Sponsor: Advocacy Committee, Commercial Buildings Energy Targets Ad Hoc

Chair: Don Brandt, Member, Trane Co, Phoenix, AZ

Provide ASHRAE members with an update on the progress of the Ad Hoc Committee Report on Commercial Buildings Energy Targets to Tech Council. The work statement for modeling and research of ultimate EUI targets will be discussed and reviewed. The definition of EUI will be formalized.

Monday, June 27, 2011, 9:45 AM-10:45 AM

Forum 3 (Intermediate)

What Updates Are Needed in Standard 30? (MOT for chillers)

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 08.02 Centrifugal Machines, 09.01 Large Building Air-Conditioning Systems

Chair: Phillip Johnson, P.E., Member, McQuay International, Staunton, VA

SPC 30 has formed to make revisions to Standard 30-1995R, Method of Testing Liquid-Chilling Packages. The committee would like suggestions and feedback regarding needed improvements to the standard. What changes to chillers and testing methods have occurred in the last 16 years? Attendees are encouraged to review the following related or similar standards prior to the forum: AHRI Standard 550/590-2003, EN 14511 Part 3, and ISO/NP 19298 (draft at development stage 10.99 as of January 2011).

Monday, June 27, 2011, 11:00 AM-12:00 PM

Technical Paper Session 6 (Intermediate)



Radiant Floor Heating Design and Control: Key Factors for Low Energy Buildings in Cold

Climates

Track: HVAC Applications

Room: Westmount

Sponsor: 04.04 Building Materials and Building Envelope Performance, 06.05 Radiant Heating and Cooling

Chair: Pam Androff, Associate Member, Mitsubishi Electric, Atlanta, GA

Improvements to the ASHRAE design procedure for in-slab-heating systems for cold climates are offered based on numerical models and experimentation results. An alternative to mechanical radiant heat is passive solar, and the predictive control of the mechanical heating (radiant and dynamic fenestration) is discussed. The goal is to showcase the radiant heat capabilities for cold climates.

1. Development of a Design Procedure for In-Floor-Heated Slab Foundations In a Cold Climate (ML-11-014)

H.M. Soliman, Ph.D., P.E., Member¹, S.J. Ormiston, Ph.D., P.E., Member¹ and M.K. Guyot¹, (1)University of Manitoba, Winnipeg, MB, Canada

A two-dimensional steady-state numerical model was developed for in-floor-heated slab-on-grade foundations. The model allows for various placements of insulation including bottom, edge (both outside and inside the footing) and skirt. The model was validated by comparing results with previous numerical and experimental results.

Comparisons were also made with the design procedure recommended by ASHRAE (2008) for calculating the panel surface temperature, the heating tube outer wall temperature, the downward and edge heat losses and the heating tube water average temperature for in-floor-heated slab-on-grade floors.

2. Predictive Control of Radiant Floor Heating and Transmitted Irradiance in a Room with High Solar Gains (ML-11-015)

José A. Candanedo, Student Member¹, Amelie` Allard, Student Member¹ and Andreas Athienitis, Ph.D., P.E., Member², (1)Building, Civil and Environmental Engineering, Concordia University, Montréal, QC, Canada, (2)Concordia University, Montreal, QC, Canada

Passive solar heating can significantly contribute to reducing the heating load of a house in a cold climate.

However, a careful design approach and predictive or anticipatory control strategies are needed to take advantage of solar heat gains while maintaining adequate thermal comfort conditions. While the use of thermal mass enables

the capture, storage and gradual release of thermal energy, anticipatory control (based on weather forecast and estimates of other loads) can significantly contribute to keeping the occupants comfortable. This paper deals with the application of predictive control techniques in a zone with high solar heat gains, for the coordinated control of: (a) a radiant floor heating system and (b) a dynamic fenestration system with automatically controlled solar transmittance. The implementation and testing of advanced control strategies is facilitated through a simple transfer function model, obtained from a more complex thermal network model. The effect of modifying the set-point curve depending on the expected solar radiation is also examined, as well as the impact of weather forecast inaccuracies.

Monday, June 27, 2011, 11:00 AM-12:00 PM

Conference Paper Session 8

Improving Performance of Refrigeration Systems

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 02.08 Building Environmental Impacts and Sustainability

Chair: Jeff Traylor, P.E., Member, EMCOR Facilities Services, Durham, NC

The papers examine strategies to improve the performance of refrigeration systems. Also, the papers investigate the thermal performance of technologies, including a two-stage variable speed air source heat pump and trends in coil designs that are more compact with higher capacities for heat transfer.

1. Part Load Performance of a Two-Stage Variable Capacity Air Source Heat Pump System in Cooling Mode (ML-11-C020)

Amir Alizadeh Safa, Student Member¹, Alan S. Fung, Ph.D., P.E.¹ and Wey Leong, Ph.D., P.E.¹, (1) Ryerson University, Toronto, ON, Canada

A comprehensive monitoring system has been implemented in the Archetype Twin Houses at Kortright center in Vaughan, Ontario, Canada to investigate the thermal performance of a variety of sustainable housing technologies. Among these technologies includes a two-stage variable speed air source heat pump (ASHp) system in House A of the twin houses. Using monitored data from a data acquisition system (DAQ) every five seconds for a one month period in August 2010, a part load cooling efficiency curve is developed and compared with the manufacturer's specifications. To develop a cooling performance curve for a variable speed compressor air source heat pump, collected data for various operating conditions including the outdoor temperature and relative humidity, the ASHP supply and return temperatures and relative humidity's, the supply air velocity, and the power consumption of the entire system is measured.

2. Benefits of Reduced Diameter Copper Tubes in Evaporators and Condensers (ML-11-C021)

John C. Hipchen¹ and Robert D. Weed², (1) Exel Consulting Group, Palatine, IL, (2) Copper Development Association, New York, NY

Demands for higher energy efficiencies in both residential and commercial refrigeration and air conditioning systems have resulted in a trend toward coil designs that are more compact with higher capacities for heat transfer. Traditional copper tube / aluminum fin coil manufacturing technology remains prevalent throughout the industry and, when modified for smaller diameter copper tubes of 5mm or less, significant improvements in heat transfer can be achieved. Coupled with internal enhancements to the copper tubes such as microgrooves, condenser and evaporator designs can be smaller, more efficient and operate at higher pressures to accommodate new refrigerants. Higher efficiency coils require less space and can help lower costs related to the overall packaging of a refrigeration or air conditioning system. This paper demonstrates the impact of smaller diameter copper tubes and compares heat transfer results with common tube diameters of 7mm and above. Both simulated and actual performance data is shown as well as energy-efficient design options that are available with smaller diameter copper tubes. Copper components also offer antimicrobial properties and these advantages are discussed. In many air conditioning and refrigeration applications, the growth of bacteria and microbes is a concern. Data from bacteria studies is shown that supports the use of copper components where antimicrobial properties are required. Recent registration of copper alloys with the U.S. Environmental Protection Agency is discussed as well.

Monday, June 27, 2011, 11:00 AM-12:00 PM

Seminar 32 (Basic)



HVAC Design Checklists that Work

Track: Engineering Tools

Room: Lachine

Chair: Joel Primeau, P.Eng., Member, GENIVAR, Ottawa, ON, Canada

Pilots have always used checklists. Physicians are now really embracing them, checklists are saving lives AND money. HVAC designers use checklists to verify the completeness of their work. Checklists can do much more than catching omissions. Checklists can streamline the design process by aligning the efforts of the designers towards a single goal. Good, effective checklists can optimize the design process, minimize errors and omissions, reduce design time and facilitate better communication between stakeholders. This session teaches attendees how to develop and use effective checklists that will help design better HVAC systems, more cost effectively.

1. Design Checklists That Work

Joel Primeau, P.Eng., Member, GENIVAR, Ottawa, ON, Canada

HVAC engineers are being asked to do much more than ever before. Buildings have to be more efficient, be easier to maintain, leave a smaller environmental footprint and be healthier. And designers have to deliver completed these complex design packages in shorter periods of time. Engineers are also asked to be part of integrated design teams; disrupting their traditional design processes. In the resulting tumult of the new design consulting firm, engineers make mistakes more frequently. Errors and omissions are usually corrected by the engineer through change orders, addenda, or redesigns. These fixes are costly to the engineer, to the architect, to the contractor or to the owner. Over time, the accumulation of these errors will affect adversely affect the reputation of the engineer. Most errors and omissions CAN be prevented through a more rigorous design process. However, most design firms don't know exactly where to start in implementing effective changes to their design process. Additionally, many engineers don't easily embrace changes, even when they know they are necessary. All engineering firms use checklists to audit their own work. Most checklists are long, sometimes repetitious and always tedious lists of design activities. Most firms use checklists to catch omissions at the very end of the design effort, instead of using better, more effective checklists throughout the entire design process. This seminar teaches that the various phases of the design process are really a continuum of activities to ensure quality of design. The work completed in each phase must be verified and corrected before moving on to subsequent phases of design. Checklists play a crucial role in measuring and guiding the quality of the work at the end of every phase or sub-phase of the design process. Essentially, checklists prevent errors from being carried from one phase to the next. Effective and timely checklists contain the errors and omissions inside a phase of activities where the fix is inexpensive and affects a minimum of stakeholders. Checklists assist the HVAC engineer to be more innovative while being more frugal with the level of effort needed. Good checklists allow greater quality at lower cost. The seminar "HVAC Design Checklists that work" will teach engineers the design process and how checklists can improve the quality of the solution, while reducing the number of billable hours spent on the design.

Monday, June 27, 2011, 11:00 AM-12:00 PM

Seminar 33 (Intermediate)



Mission Critical Data Centers: Keeping Contamination at Bay

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 09.09 Mission Critical Facilities, Technology Spaces and Electronic Equipment, TC 2.4, 02.03

Gaseous Air Contaminants and Gas Contaminant Removal Equipment

Chair: Christopher O. Muller, Member, Purafil Inc., Doraville, GA

Passage of various “lead-free” regulations have resulted in increased sensitivities of printed circuit boards, surface mounted components, hard disk drives, computer workstations, servers and other devices to the effects of corrosive airborne contaminants. Data centers in (non-industrial) urban locations are reporting failures of servers and hard disk drives resulting in increased warranty costs and potential loss of confidence by customers. This seminar describes the effects of gaseous and particulate contamination on electronic hardware and the monitoring techniques used to verify recommended environmental severity levels. A program for the assessment, control and monitoring of data center contamination is detailed.

1. Gaseous Contamination in Mission-Critical Data Centers

Prabjit Singh, Ph.D., Member, IBM, Poughkeepsie, NY

Recent increases in corrosion-related hardware failure rates in data centers in regions with high ambient levels of sulfur-bearing gases led to recommendations that in addition to temperature and humidity, particulate and gaseous contamination should also be monitored and controlled. The corrosion-related failure mechanisms afflicting today’s hardware and the environmental corrosion severity levels at which these failures occur will be described. The modification of ANSI/ISA Standard 71.04-1985 to include the requirement that the silver corrosion rate, along with the copper corrosion rate, be less than 300 angstroms/month so that atmospheric corrosion is not a factor in hardware failures will be justified.

2. Controlling Gaseous and Particulate Contamination in Data Centers

Christopher O. Muller, Member, Purafil Inc., Doraville, GA

The EU directive “on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment” (RoHS) was implemented in July 2006, and was the first of many similar regulations that have been passed. Research has shown that printed circuit boards made using lead-free materials can be more susceptible to corrosion and it has been reported that many lead-free products will creep corrode in high sulfur environments. Now data centers in many urban locations have reported failures of servers and hard disk drives due to sulfur corrosion. In the corrosion of electronic components, sulfur oxides, active sulfur compounds, oxides of nitrogen, and inorganic chlorides are the primary culprits. Particulates and gaseous contaminants can be drawn in through the building's air handling system(s) causing corrosion of electronics. This presentation will discuss application of gas-phase and particulate filtration for the data center environment. General aspects of data center design and air filtration technology will be presented with descriptions of various filters and systems and where these may be employed within the data center environment to provide for enhanced air cleaning.

Monday, June 27, 2011, 11:00 AM-12:00 PM

Forum 4 (Intermediate)

Challenges in Making Green Buildings a Way of Life

Track: Professional Skills

Room: Hampstead

Sponsor: ASHRAE Associate Society Alliance

Chair: Kent Peterson, P.E., Presidential Fellow Life Member, P2S Engineering, Inc., Long Beach, CA

Changing the ways we design, build and operate our buildings and infrastructure is the most powerful way we can address the environmental challenges facing the planet. Green buildings have many positives including improved human health and productivity, increased building value, good return on investment, etc. With many tangible and intangible benefits, it is surprising that obstacles still persist. Perceived higher cost and complexity, lack of awareness actual benefits of green construction, cost of documentation, short-term budget horizons, perceived long wait for payback and difficulty to quantify the benefits are obstacles facing the green buildings. In this forum, international speakers from around the world will share their experience in respective countries. Are these real obstacles or just myths will be the focus of discussion.

Monday, June 27, 2011, 11:00 AM-12:00 PM

Forum 5 (Intermediate)

How Will ASHRAE Standards affect Future Hydronic System Design?

Track: HVAC Systems and Equipment

Room: Lasalle

Sponsor: 06.01 Hydronic and Steam Equipment and Systems

Chair: Bill Coad, P.E., Presidential Fellow Life Member, Coad Engineering Enterprises, St Louis, MO

This forum explores how Standards 189.1 and 90.1 affect hydronic system design. We seek input from HVAC designers to determine best practices to meet the goals for the design of high performance green buildings. Early hot water systems used very large pipes because it was thought this was necessary to ensure adequate circulation and heat retention. We then moved to high temperature hot water and steam to minimize pipe size and project costs. Do we go now back to low temperature hot water systems with the larger pipe size? Have we hit an energy reduction plateau at 25 KBTU/sq ft annually with our current technologies or can we go lower?

Monday, June 27, 2011, 11:00 AM-12:00 PM

Forum 6 (Advanced)

Water/Energy Nexus: How to Study the Interrelationship of Water and Energy Consumption

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 08.06 Cooling Towers and Evaporative Condensers, SCP191

Chair: Jon J. Cohen, Member, H-O-H Water Technology, Palatine, IL

There are many current and future standards on energy and water conservation, such as 90.1, 189.1 and 191. Much debate continuously surfaces as to energy and water cost interrelation. A Research Topic Acceptance Request (RTAR) is being developed and input from ASHRAE membership is needed to further develop the project.

Tuesday, 06/28
8:00 AM-9:30 AM

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Conference Paper Session 9



Alternate Heating, Cooling and Domestic Water Heating Technologies to Reduce Building Energy

Usage

Track: Alternative Technologies

Room: Verdun

Chair: Chuck Curlin, P.E., Member, Shultz Engineering Group, Charlotte, NC

Solar thermal applications for domestic hot water heating are generally some of the most cost effective applications of alternative energy. The papers focus on alternate strategies, specifically solar thermal and fuel cell technology to reduce the energy consumption of heating, cooling and domestic water heating systems.

1. Energy and Exergy Analysis of Integrating Compound Parabolic Collectors (CPC) with Lithium Bromide (Li-Br) Absorption Chiller for Building Heating and Cooling to Achieve Net Zero Buildings (ML-11-C022)

Yang Hu, Student Member¹, Laura Schaefer, Ph.D., Associate Member² and Volker Hartkopf, Ph.D.¹, (1)Center for Building Performance and Diagnostics, Carnegie Mellon University, Pittsburgh, PA, (2)University of Pittsburgh, Pittsburgh, PA

According to Department of Energy, Building Energy Book (2009), In United States, commercial and residential buildings consume 39.9 % primary energy and contribute 39 % of total CO₂ emissions. In the operation of buildings, 41.8 % of building energy consumption is provided for building cooling, heating, domestic hot water and ventilation for commercial buildings, while in residential buildings, this percentage increases to 60 %. In order to achieve net zero buildings, significant effort should be focused on the research and development in the building integrated renewable energy technologies. In this paper, a solar thermal driven absorption cooling and heating technology is presented, analyzed to provide cooling and heating to a building, Intelligent Workplace South Zone in Carnegie Mellon University. The system includes 50 m² proposed compound parabolic collectors (CPC), a 16 kW two stage lithium bromide (Li-Br) absorption chiller for cooling and a 20 kW heat exchanger for heating. Compound parabolic collector can absorb both the direct and diffuse sunlight and does not need tracking device or control. Thus CPCs are used today as one alternative type of solar collector compared to parabolic trough solar collector to achieve high temperature fluid for solar thermal application with low initial cost. The CPC heat transfer model is presented, validated and integrated with two stage absorption chiller model in Energy Equation Solver (EES). The temperature, enthalpy, entropy, mass flow rate, mass fraction of lithium bromide and specific flow exergy of critical points in each component of the solar absorption system are presented in steady state operation. The exergy destruction in each component is calculated. From the results, the exergy destructions for solar collector, generator, absorber, and heat exchangers are significantly larger than those in evaporator, condenser and expansion valves. This paper is useful in understanding the energy and exergy performance of compound parabolic collector with lithium bromide absorption chiller to provide cooling and heating. Keywords: energy and exergy , compound parabolic collectors, absorption chiller, EES simulation

2. Phase Change Material Selection in the Design of a Latent Heat Energy Storage System Coupled with a Domestic Hot Water Solar Thermal System (ML-11-C023)

Robynne E. Murray¹, Louis Desgrosseilliers¹, Gina Marin¹, Alex Safatli¹, Nicholas Osbourne¹, Jeremy Stewart¹, Dominic Groulx, Ph.D.¹ and Mary Anne White¹, (1)Dalhousie University, Halifax, NS, Canada

Solar thermal for domestic hot water heating is one of the most cost effective and efficient areas of alternative energy exploitation. However, one of the most significant barriers to further deployment of solar thermal applications is the space and weight required for storage of the energy collected; adding solar hot water systems to existing buildings frequently encounter these obstacles. This paper summarizes the development of a means of storing heat from solar thermal systems in a more space/weight efficient manner using phase change materials (PCMs) for latent heat energy storage. PCMs are advantageous for daily energy storage due to their high storage density and isothermal operation. Such a thermal storage system has three components: heat exchange from the solar heated glycol to the PCM (charging), storage of latent heat energy in the PCM, and heat exchange from the PCM to the domestic hot water (discharging). In this system, charging and discharging are simultaneous, however the time scales differ, with a charging time of 6 to 8 hours (i.e., sun light hours) and discharging time as low as 20 minutes (i.e., domestic hot water demand). A melting temperature range of 42 to 48°C and solidification temperature range of 35 to 40°C were targeted by studying solar data from an existing solar hot water system in Halifax, Nova Scotia. Many salt hydrate and organic PCMs were considered, based on appropriate melting point, toxicity and cost. The most promising were tested using differential scanning calorimeter (DSC) and several were ruled out due to significant hysteresis (solidification occurring at too low a temperature to return the stored heat). Lauric acid was chosen for the PCM and its physical properties were determined (melting and solidification temperatures of 43 and ~ 40°C). Due to the low thermal conductivity of PCMs, a design to enhance heat transfer from the hot glycol to the domestic water via the PCM was developed. A variety of fin designs were investigated using computational and physical methods. COMSOL Multiphysics was used to model and test possible fin configurations, and some were tested using a small-scale experimental setup which simulated a solar thermal system with a draw for domestic hot water. The selected design will be built and installed by early 2011 in an existing large scale solar thermal system on an apartment building in Halifax. The entire system will be instrumented in order to acquire continuous data about this first tested prototype.

3. A New Class of Highly Efficient, Green Refrigeration Compressor (ML-11-C024)

Bamdad Bahar¹ and Richard L. Williams¹, (1)Xergy Inc, Georgetown, DE

A new class of refrigeration compressor, leveraging electrochemical (fuel-cell) technology, is described that is highly efficient and "green". It utilizes non-GHG working fluid(s) and is motor-less, scalable, modular and noise-less. It is technologically transformational and industrially disruptive. Theoretical COP provisions are in excess of 9. Such refrigeration and cooling devices could be deployed in any number of applications, in a cost-effective manner: electronics, commercial AC, residential refrigerators/AC, automotive AC. The device provides small-volume, lightly pressurized hydrogen from electricity, in a sealed unit to drive a motor-less, active refrigeration cycle. It leverages existing proton-exchange-membrane technology, and hydrogen's excellent thermodynamic characteristics including its ability to co-exist with other fluids. The technology is compared to conventional refrigeration systems such as thermo-electric devices and electro-mechanical systems. Examples of operating systems are provided.

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Conference Paper Session 10



Displacement Ventilation: Preliminary Findings from a Canadian Research Team

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 05.03 Room Air Distribution

Chair: Michel Tardif, Member, CanmetENERGY, Ottawa, ON, Canada

There are a growing number of buildings in Canada designed with displacement ventilation systems. Existing guidelines have already reported that displacement ventilation is well suited for the cooling season but what about the performance of such systems during the heating season? This session provides the latest research findings from a Canadian research team on displacement ventilation in cold climate. From laboratory to field studies, the four papers highlight some interesting design features, IEQ concerns and performance of displacement ventilation systems.

1. Experimental Study of the Temperature and Velocity Fields Produced by a Displacement Ventilation Diffuser (ML-11-C025)

Laurent Magnier, Student Member¹, Radu Zmeureanu¹ and Dominique Derome, Member², (1)Concordia University, Montreal, QC, Canada, (2)EMPA, Dübendorf, Switzerland

Displacement Ventilation (DV), while promising for indoor air quality and energy savings, presents a risk of draft discomfort at ankle level. In this experimental study, the air velocity and temperature in a DV jet are measured at several heights (from 0.02 m to 0.26 m), in the vertical longitudinal plan through the centre of the diffuser, and in the vertical transversal plan at 2.16 m from the diffuser. The experimental procedure as well as measured profiles of velocity and temperature are presented. Correlations based on the measured profiles are also discussed.

2. In-Situ Performance of Displacement Ventilation System in a Canadian School with Radiant Heating System (ML-11-C026)

Boualem Ouazia, Member¹, Michel Tardif¹, Alexandra Thompson¹, Iain Macdonald¹ and Daniel Booth¹, (1)National Research Council Canada, Montreal, QC, Canada

Previous research has shown that stratified ventilation systems (UFAD and DV) work well for regions where buildings require year-round cooling; however there are a growing number of buildings using this approach in Canada, where buildings require heating during winter months. This paper presents detailed results from one field study conducted in a school equipped with a combination of displacement ventilation and radiant heating system. The results show that the measured contaminant removal effectiveness is better than that predicted in previous studies for heating conditions. In addition, key predictors of thermal comfort are also generally within limits set by ASHRAE standards.

3. Comparison of Energy Model Abstractions for Stratified Air Distribution Systems (ML-11-C027)

Iain Macdonald, Ph.D.¹ and Julian Rimmer¹, (1)National Research Council Canada, Montreal, QC, Canada

Stratified air distribution systems are increasingly being installed in Canadian buildings. Field studies have shown that existing guidelines for their design are often not followed leading to oversizing of systems. Simulation offers a design mechanism whereby the performance of a system can be predicted. This reduces the uncertainty over performance and increases the likelihood that the designed system will perform as intended and be correctly sized. In recent years several approaches and models have been developed to model stratified air distribution systems in energy simulation programs. Predictions will be compared to a CFD model and future work will compare these to measured data.

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Seminar 34 (Intermediate)



Celebrating High Temperature Cooling and Low Temperature Heating

Track: HVAC Applications

Room: Westmount

Sponsor: 06.01 Hydronic and Steam Equipment and Systems

Chair: Mike McDermott, Associate Member, ESD, Chicago, IL

This seminar provides an energetic retirement celebration for the fatigued low temperature chilled water system designs with 44F and hot water system designs with 180F that we have been applying to code minimum buildings for the last 50 years. Speakers explore the shift of cooling systems to high temperature supply to chilled beams in excess of 55F and heating systems to low temperature radiation of less than 120F scoring. Presented are the fundamentals and applications of high temperature cooling and low temperature heating hydronic systems, including central plant options, room air distribution, controls, energy performance, IAQ and acoustics.

1. Indoor Environmental Quality and High Temperature Radiant Cooling and Low Temperature Radiant Heating Systems

Bjarne Olesen, Ph.D., Fellow ASHRAE, Technical University of Denmark, Lyngby, Denmark

This seminar will introduce concept of radiant high temperature cooling and low temperature heating systems followed by a discussion of the following key hydronic system design components affecting room air distribution and comfort considerations.

2. Hydronic System Concepts and Design Considerations for Radiant High Temperature Radiant Cooling and Low Temperature Radiant Heating

Peter Simmonds, Ph.D., Fellow ASHRAE, IBE Consulting Engineers, Sherman Oaks, CA

This seminar will focus on passive chilled and heating hydronic design concepts and its applications. We will explore design considerations for room air distribution and hydronic component locations. Case studies of various applications will be explored with energy, thermal comfort and IAQ performance validation.

3. Case Study: Loyola University Information Commons, Chicago, Illinois

Donald J. McLauchlan, P.E., Member¹ and Steven Maze, Associate Member¹, (1)Elara Engineering Services, Hillside, IL

This seminar will focus on a case study of Loyola Information Commons building in Chicago, Illinois which was awarded First Place in the ASHRAE Society New Building Institutional category for its high performance green design elements of radiant chilled ceilings, fin tube wall radiation at high glass, under floor air distribution (UFAD), natural ventilation double wall envelope and air to air hydronic heat recovery. We will explore the combination of synergistic hydronic system design concepts and operational issues focusing on lessons learned.

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Seminar 35 (Intermediate)



Do I Really Need CFD?

Track: Engineering Tools

Room: Lachine

Sponsor: 04.10 Indoor Environmental Modeling

Chair: James VanGilder, P.E., Member, APC by Schneider Electric, Billerica, MA

When you think of airflow modeling, you generally think of CFD. However, CFD might not always be the most efficient tool for the job and other options such as zonal, multizone network, and potential-flow modeling techniques which may provide sufficient accuracy with much less cost and effort. And, when you do need CFD, is it all the same? This seminar describes airflow modeling approaches and provides examples of their application – from the simplest to the most cutting-edge techniques.

1. Is a Multizone Model What You Want, Need, and Can Afford?

Amy Musser, Ph.D., P.E., Member, Vandemusser Design, PLLC, Asheville, NC

Multizone network airflow models offer a means of modeling airflow and contaminant transport in buildings that is fundamentally different from CFD. Multizone models offer advantages such as less input time, lower computing power requirements, and widely available public domain tools. This makes them an attractive tool for analyzing inter-zonal airflows at the whole-building scale. However, there are some things that these models inherently cannot do, and CFD is a better choice for those situations. This seminar will review how multizone models work, compare and contrast with CFD, and identify situations where multizone modeling can be the more appropriate modeling tool.

2. Network and Potential Flow Modeling with Data Center Applications

James VanGilder, P.E., Member, APC by Schneider Electric, Billerica, MA

Many practical airflow and heat transfer applications can be handled using the relatively simple techniques of flow and thermal networks. Such models are easily programmed into a spreadsheet and generally rely on the assumption of 1-D airflow or heat transfer and utilize empirical correlations. Potential flow theory provides a method to produce relatively sophisticated 3-D flow and temperature fields much faster and easier than full CFD. While results are “more approximate than CFD”, solutions often run in “real time” or “near real time”. Network and potential-flow modeling examples based on data center applications are shown.

3. Combined Multizone and CFD Capabilities in CONTAM

Liangzhu (Leon) Wang, Concordia University, Montreal, QC, Canada

CONTAM is a multizone airflow network computer program for building ventilation and indoor air quality analysis. The program was recently enhanced to incorporate CFD capabilities for both external and internal environmental analysis. The external CFD link predicts wind pressure coefficients and contaminant concentrations for airflow paths at the building surface. The ability to embed a single CFD zone within a network model enables the detailed modeling of a zone, in which the well-mixed multizone assumption is too broad but uses the multizone approach for the rest of a building. Examples will be presented demonstrating the use of these new features.

4. What Flavor of CFD Do I Need for My Project?

Ray Sinclair, Ph.D., RWDI, Guelph, ON, Canada

Modeling specialists are asked by their clients to perform CFD studies for a wide range of indoor and outdoor issues to inform design decisions on health, safety and comfort in buildings. Often the client is unaware that “not all CFD is the same” and that, in fact, there is a rather wide range of methods, and assumptions on boundary conditions, choices of mathematical models for turbulence, and empirical coefficients. The seminar will clarify what fundamental things clients need to know about CFD and it will illustrate applications of various flavors of CFD in actual design projects.

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Seminar 36 (Intermediate)



Energy Efficiency and Performance of Multiple Plenum Fans in Arrays

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 05.01 Fans, 02.06 Sound and Vibration Control, 05.09 Enclosed Vehicular Facilities

Chair: Asesh Raychaudhuri, P.E., Member, US Dept. of Veterans Affairs, Washington, DC

Systems with multiple fans in an array have been in use for many years in the form of parallel fan system. Direct drive plenum fans in arrays seem to be gaining popularity in recent years as the supply air fan systems in air handling unit (AHU) applications. This session addresses the advantages and disadvantages of plenum fans in arrays compared to the conventional air-handling unit fan systems in relation to energy efficiency, noise, vibration and other related parameters.

1. Plenum Fans in Arrays: General

Rad Ganesh, Ph.D., Member, Twin City Fan Companies, Plymouth, MN

Fan Array Systems (FAS) have been in use for many years as parallel fan systems but in recent years small direct drive plenum fans in a array seem to be gaining popularity as supply air fan systems in AHU applications. This presentation will discuss pros and cons on Conventional Air-Handling system and FAS.

2. Comparison of Air-Handling Units with Fans in Array and Conventional Systems

Larry Hopkins, P.E., Member, Huntair Inc, Tualatin, OR

Engineers have traditionally designed building air-handling systems around having one of three fan types or systems. This presentation will describe the result of the study conducted on four units each with a different fan system.

3. Application Considerations for Direct-Drive Plenum Fan Arrays in Air-Handling Applications

Dustin Meredith, P.E., Member, Trane, Lexington, KY

Direct drive plenum fans are becoming attractive fan type for many AHU applications. This discussion will highlight a number of application considerations including energy efficiency, acoustics and vibration.

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Seminar 37 (Intermediate)

Ethical Challenges in the Real World: Case Studies, Part 1

Track: Professional Skills

Room: Hampstead

Sponsor: 01.07 Business, Management & General Legal Education, College of Fellows

Chair: Michael Connor, P.E., Member, Connor Engineering Solutions, Alpharetta, GA

Four ethical challenges from real world examples are presented. The attendees will break up into teams of 10 to 20 each to discuss the ethical challenges and propose a course of action. The discussions will be facilitated on the floor by members of the College of Fellows. After a brief discussion by the teams, their resolutions will be read along with the real world outcome.

1. When Is an Engineer Obligated to "Blow the Whistle?"

Michael Connor, P.E., Member, Connor Engineering Solutions, Alpharetta, GA

You are an engineer charged with commissioning a biological containment facility. The impact of failure to properly design, construct and commission this facility can have devastating effects on the health, safety and welfare of the public. You observe that many corners are being cut that put money in the design/builder's pocket. The cut corners are indisputable observations when compared to the signed contract. You also suspect, but do not have first hand knowledge of, an inappropriate relationship between the Owner's representative and the Design/Builder's project manager. The Owner is a State agency. You suspect that there is an inappropriate

relationship because your observations are being dismissed by the owner's representative and refuses to enforce the contract. When do you blow the whistle? If so to whom?

2. A PE Learns that a Client Did Not Secure the Necessary Code Approvals When Constructing a Building. What Must He Do to Satisfy His Ethical Obligations?

Warren Hahn, P.E., Member, Hahn Engineering, Tampa, FL

On a new project, should an engineer report a unpermitted old project?

3. An HVAC Engineer Uncovers a Software Program that Is Giving Inaccurate Information Concerning the Building Cooling Load

Michael Bilderbeck, P.E., Member, Pickering, Inc., Memphis, TN

Is an engineer's responsibility, when discovering a software glitch, to his architect client or to the building owner who is affected by the defect?

4. Minor Changes Raise Major Questions

Warren Hahn, P.E., Member, Hahn Engineering, Tampa, FL

Is it ethical for engineer A to make minor changes to the signed documents prepared and revised by engineer B without consulting with engineer B?

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Seminar 38 (Intermediate)



Indoor Air Quality Research

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 04.10 Indoor Environmental Modeling, ASHRAE HVAC&R Research Journal, 07.06 Building Energy Performance

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

Presentations include three papers on indoor air quality, recently published in the ASHRAE HVAC&R Research Journal. Topics range from aircraft IAQ to the use of UV radiation and contaminant distribution issues.

1. Disinfection Performance of Ultraviolet Germicidal Irradiation Systems for the Microbial Contamination on an Evaporative Humidifier

Shinsuke Kato, Ph.D., Fellow ASHRAE, University of Tokyo Institute of Industrial Science, Tokyo, Japan

Humidifiers have been used not only to maintain a comfortable indoor environment, but also to prevent respiratory diseases from worsening due to extremely low humidity. Some evaporative humidifiers (EHs) that have been considered energy efficient have been reported to have problem with microbial contamination. In this study, the microbial contaminations of an EH were verified and both the germicidal effects and limitations of in-duct ultraviolet germicidal irradiation (ID-UVGI) systems against the contaminations were investigated. A numbers of bacteria and fungi were isolated from the surfaces and drain water of the EH, and airborne microbes that were likely dispersed from the contaminated EH were also detected. Based on the results of monitoring microbes for approximately six month's ID-UVGI operation, we found that microbial contamination was reduced, but that microbes could still be consistently isolated from the surfaces and drain water. This was likely due to internal contamination of the EH in locations beyond the reach of the ultraviolet C-band (UVC) irradiation. Methods to overcome the limitations of this ID-UVGI system for EH disinfection are thus required.

2. Impact of Moving Objects on Contaminant Concentration

Qingyan Chen, Ph.D., Fellow ASHRAE, Purdue University, West Lafayette, IN

Moving objects can disturb stratified flow and contaminant concentration gradient in an inpatient ward with displacement ventilation. This investigation uses computational fluid dynamics (CFD) to study the effect of objects moving, such as a visitor or caretaker walking, the changing of sheets on a patient's bed, and the swinging of an entrance door for up to four seconds, on the contaminant concentration distributions in a single inpatient ward. The

CFD was validated by using the measured distributions of air velocity, air temperature, and contaminant concentration from the mockup of an inpatient ward. The contaminant was assumed to be breathed out by the patient lying on the bed. The results show that moving objects can cause a 10 to 90 second swing in the contaminant concentration distribution. The averaged concentration change in the breathing levels in the ward was generally less than 25%, so the risk level should remain the same. The closer the location of the moving object to the contaminant source, the larger was the change in the contaminant concentration. The displacement ventilation with 4 ach in an inpatient ward with a moving object can still produce the same air quality level as overhead mixing ventilation with 6 ach.

3. Fine Particle Dispersion in a Commercial Aircraft Cabin

Jeremy Beneke, Member¹ and Byron Jones, Ph.D., P.E., Fellow ASHRAE¹, (1)Institute for Environmental Research (IER) at Kansas State University (KSU), Manhattan, KS

The spread of particles or contaminants in aircraft cabins is of interest due to the large number of passengers and their close proximity to each other. This close proximity causes concern about the spread of disease and contaminants among passengers. To understand the aircraft cabin environment and the dispersion of fine particles, an experimental study was conducted in an 11-row wide-body aircraft cabin mockup. The experiment focused on the longitudinal dispersion of particles throughout the cabin. The data show the regions close to the source experience higher levels of exposure and higher levels of variation, while locations farther from the source show lower exposure levels and less variation. The variations close to the source likely stem from the interaction of the quick injection burst of particles with chaotic airflow. Particles released in the second row were detected at all locations in the cabin mockup, but there was roughly a 37% decrease in concentration with each successive row in the longitudinal direction from the release location.

Tuesday, June 28, 2011, 8:00 AM-9:30 AM

Seminar 39 (Intermediate)

Walk-in Coolers: Measuring and Modeling Performance

Track: Refrigeration

Room: Lasalle

Sponsor: 10.07 Commercial Food and Beverage Cooling Display and Storage, Refrigeration Committee

Chair: Cynthia Gage, Ph.D., Fellow ASHRAE, U.S. Environmental Protection Agency, Durham, NC

Walk-in coolers and freezers are used predominately for food sales and service facilities, and are typically modular with cooling provided by remote or self-contained refrigeration equipment. Recently DOE began a rule-making process to develop performance standards for walk-in coolers and freezers. Substantial opportunities for energy efficiency lie in understanding the contributions of the various cooling loads associated with walk-ins, as well as the performance impacts of utilizing evaporator fan speed control strategies. This seminar reports on recent research and modeling analyses on this understudied area of refrigeration.

1. Application of DPIV and CO₂ Tracer Gas in Visualizing and Measuring Infiltration Rates in Walk-Ins

Homayun Navaz, Ph.D., Member, Kettering University, Flint, MI

Walk-in coolers are widely used for food storage and infiltration accounts for more than 50% of the cooling load. However, insofar there is no robust technology to precisely measure the infiltration rate of walk-in coolers during the door opening period. Furthermore, the infiltration rate of walk-in coolers due to small openings and unsealed (or poorly sealed) areas has never been accurately measured. We refer to this process as “natural infiltration”. In addition, there has not been any flow visualization of the infiltration or discharge process that is the velocity profile at the doorway. The lack of a methodology to measure the infiltration rate into walk-in coolers during the door opening has prompted the initiation of this project. The project also examines the correctness of the speculations about the velocity profile during the infiltration via particle image velocimetry flow visualization.

2. Understanding the Infiltration Phenomenon and Key Contributing Factors

Kristina Kamensky, Student Member, Prismitech, Flint, MI

There is no robust technology to precisely measure the infiltration rate of walk-in coolers. Upon systematic and direct measurement of the infiltration rate, those operating conditions that could reduce the infiltration rate can be

identified. This project will provide the manufacturers with a tool and a protocol that can be used to find the infiltration rate into walk-in coolers very accurately through direct measurements of the concentration of a tracer gas.

3. Lab Analysis of Cooling Loads and Effects of Evaporator Fan Speed Variations on Performance of Walk-Ins

Ramin Faramarzi, P.E., Member, Southern California Edison, Irwindale, CA

Walk-ins refer to refrigerated spaces, less than 3,000 square feet, which provide short term storage of perishable food products. These systems are typically designed to run evaporator fans continuously at their maximum speed. Refrigerated walk-ins are a major user of energy; up to 20% of the refrigeration energy consumed in a 50,000 square foot supermarket comes from refrigerated walk ins. Substantial opportunities for energy efficiency lie in understanding the contributions of the various cooling loads associated with walk-ins, as well as the performance impacts of utilizing evaporator fan speed control strategies. This project analyzes the cooling loads and variable speed evaporator fan impacts on refrigerated walk-in coolers. Analysis included quantification of the contributions of various cooling loads (infiltration, conduction, internal heat gains from fans, lighting, etc) and quantification of the performance impacts of variable evaporator speed controls on different refrigeration system configurations (fixed capacity, variable capacity). Performance impacts in question include energy usage, defrost characteristics, and product temperatures.

4. Walk-In Performance Modeling and Validation of Simplified Performance Rating Methods

Bryan R. Becker, Ph.D., P.E., Fellow ASHRAE¹, Brian A. Fricke, Ph.D., Member² and Bryan C. Sartin¹,

(1)University of Missouri-Kansas City, Kansas City, MO, (2)Oak Ridge National Laboratory, Oak Ridge, TN

There is considerable potential for energy savings through the use of high efficiency walk-in cooler/freezer refrigeration systems. The acceptance and use of a performance based standard for walk-in coolers and freezers will provide the most effective market system to achieve these energy savings. Therefore, the objective of this project was to substantiate and provide support for AHRI Standard 1250/1251, 'Standard for Performance Rating of Walk-In Coolers and Freezers', by analyzing model load profiles and monitored data from field sites. Energy simulations were also performed to examine the AHRI 1250/1251 rating methodology versus walk-in performance in seven climates.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Technical Paper Session 7 (Basic)



Prevention of Compressor Short Cycling in Direct-Expansion (DX) Rooftop Units Part 1 and 2

Track: Refrigeration

Room: Westmount

Chair: Daniel Dettmers, Member, IRC, U.W. Madison, Madison, WI

This session presents papers on the theoretical analysis and simulation as well as field investigations on preventing compressor short cycling in DX rooftop units.

1. Prevention of Compressor Short-Cycling in Direct-Expansion (DX) Rooftop Units Part 1: Theoretical Analysis & Simulation (ML-11-016)

Mingsheng Liu, Ph.D., P.E., Member¹ and Xiufeng Pang, Ph.D., Associate Member², (1)University of Nebraska, Omaha, NE, (2)Lawrence Berkeley National Laboratory, Berkeley, CA

Compressor "short-cycling", recognized in the DX Rooftop Unit (RTU) operation, has not yet been successfully resolved. It drastically reduces the compressor reliability and degrades the system efficiency. This paper presents an advanced control algorithm to address this issue with minimized initial cost. It is based on the fundamental vapor compression theory that different evaporating temperatures will produce varied refrigeration effects. Elimination of the compressor short cycling can be achieved by extending supply air temperature control band to

match building load condition. Simulation results show short-cycling to be completely eliminated with comparable or improved energy performance under various operating conditions.

2. Prevention of Compressor Short-Cycling in Direct-Expansion (DX) Rooftop Units Part 2: Field Investigation (ML-11-017)

Mingsheng Liu, Ph.D., P.E., Member¹ and Xiufeng Pang, Ph.D., Associate Member², (1)University of Nebraska, Lincoln, NE, (2)Lawrence Berkeley National Laboratory, Berkeley, CA

An advanced control algorithm has been demonstrated in a companion paper. It aims to address the compressor short cycling challenge associated with traditional DX Rooftop Unit (RTU) operation. This paper presents the results of implementing this advanced control algorithm in a real building. The comparison of system performance between the improved control algorithm and the conventional control algorithm is also demonstrated. A newly installed DX RTU was selected and field investigation showed that the conventional control algorithms caused serious compressor short cycling. By implementing the advanced control algorithm, the compressor short-cycling had been completely eliminated along with a 15% total electricity savings.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Conference Paper Session 11



New Research and Tools for Solar Energy Collection Optimization

Track: Alternative Technologies

Room: Verdun

Sponsor: 06.07 Solar Energy Utilization

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

New solar collection systems and analytic tools are being developed or used in new ways to move toward zero energy goals. This session includes: a numerical analysis of a solar wall using a thermal diode to regulate and optimize passive solar heating and cooling; a newly-devised tool for optimizing combined solar electrical production and thermal water heating based on their integrated life cycle analysis; and an energy simulation of geometric shapes of individual housing units and site/street layout to optimize collection of solar irradiation for passive heating and daylight or conversion to electricity to reach neighborhood net zero energy use.

1. Design of Solar-Optimized Neighborhoods (ML-11-C028)

Caroline Hachem, Ph.D., Student Member¹, Andreas Athienitis, Ph.D., P.E., Member¹ and Paul Fazio¹, (1)Concordia University, Montreal, QC, Canada

Neighbourhoods can be designed to achieve net-zero energy consumption for a set of houses with optimized form, arranged in different layouts. To achieve this, two house surfaces need to be typically optimized – near-south facing roofs which may be covered with solar systems and facades that can be the basis for passive solar design. The study presented in the paper evaluates the effects of two major parameters affecting solar energy utilization potential of different housing units' assemblages. The parameters are geometric shapes of individual units and site layout. Shapes include rectangular shape and L shapes with different values of the angle enclosed between the wings of this shape. Site layouts include a straight road and south and north facing semi-circular roads. Two-story single family housing units, located in mid-latitude climate are considered throughout the study. The *EnergyPlus* simulation package is used to simulate nine configurations consisting of combinations of the parameter values. The objective is to optimize the design of urban settlements for the exploitation of solar irradiation that can be used for passive heating and daylight, or conversion to electricity. Effects are evaluated as the change from reference configurations of the response parameters – radiation on equatorial-facing facades, which includes incident solar radiation and solar radiation transmitted by the fenestration of such facades, and electricity production potential of building integrated photovoltaic (BIPV) covering complete near south facing roof surfaces. The reference shape is rectangle and the reference layout is a straight road. Results indicate that the irradiation of façades and roof surfaces per unit area is primarily governed by the surface orientation relative to south, with some local variation of façade irradiation due to mutual shading of surfaces and units. Total energy generation is governed by active roof surface area which is affected by both shape and orientation. Maximizing the south roof area is extremely

important especially that floor plan area is usually determined by residential needs. A significant increase in total electricity generation (up to 50%) can be achieved in some housing units of certain configurations, compared to the reference. Variation of surface orientation, particularly in curved layouts enables the spread of peak electricity generation over up to six hours. The shift of peak load may be economically beneficial as a result of reduction in the load on the electric grid due to more even distribution of the electricity production over the day.

2. SolOpt: A Novel Approach to Solar Rooftop Optimization (ML-11-C029)

Lars J. Lisell¹, Ian Metzger¹ and Jesse Dean¹, (1)National Renewable Energy Laboratory, Golden, CO
Traditionally Photovoltaic Technology (PV) and Solar Hot Water Technology (SHW) have been designed with separate design tools, making it difficult to determine the appropriate mix of PV and SHW. A new tool developed at the National Renewable Energy Laboratory changes how the analysis is conducted through an integrated approach based on the life cycle cost effectiveness of each system. With 10 inputs someone with only basic knowledge of the building can simulate energy production from PV and SHW, and predict the optimal sizes of the systems. The user can select from four optimization criteria currently available: Greenhouse Gas Reduction, Net-Present Value, Renewable Energy Production, and Discounted Payback Period. SolOpt provides unique analysis capabilities that aren't currently available in any other software programs. Validation results with industry accepted tools for both SHW and PV are presented .

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Seminar 40 (Basic)



An Overview of Proposed Standard SPC 191: The Efficient Use of Water in Buildings

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 02.08 Building Environmental Impacts and Sustainability, 08.06 Cooling Towers and Evaporative Condensers

Chair: John Swift Jr., P.E., Member, Cannon Design, Boston, MA

This seminar provides an overview of the first draft of this proposed standard. This standard is intended to provide baseline requirements for the design of buildings, site, and mechanical systems that minimize the volume of water required to operate HVAC systems, plumbing systems and irrigation systems.

1. Water Efficiency

John Swift Jr., P.E., Member, Cannon Design, Boston, MA

Provide an overview of the first draft of this standard. This standard is intended to provide baseline requirements for the design of buildings, site, and mechanical systems that minimizes the volume of water required to operate HVAC systems, plumbing systems, and irrigation systems.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Seminar 41 (Intermediate)



Controls: Heat Exchanger Simulation

Track: Engineering Tools

Room: Lachine

Sponsor: 01.04 Control Theory and Application, HVAC&R Research Journal

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

Presentations include two papers on indoor air quality, recently published in the ASHRAE HVAC&R Research Journal. Topics include nucleate pool boiling of refrigerants, and a method for measuring and predicting the inlet

air flow distribution using particle image velocimetry (PIV) with a computational fluid dynamics (CFD) model which highlights the source and magnitude of air side maldistribution.

1. An Experimental and Computational Study of Approach Air Distribution for a Finned-Tube Heat Exchanger

David Yashar, Ph.D., P.E., Member, The National Institute of Standards and Technology, Gaithersburg, MD
The distribution of air flow approaching a finned-tube heat exchanger is one of the predominant factors influencing the heat exchanger's performance. This paper describes a method for measuring and predicting the inlet air flow distribution using Particle Image Velocimetry (PIV) and a Computational Fluid Dynamics (CFD) model, and highlights the source and magnitude of air side maldistribution. The studied case was a single-slab, four-depth-row, louvered-fin heat exchanger installed vertically in a horizontal duct. The measured data showed that the air approaching this very simple test case generally maintained velocities of 1.25 ms^{-1} (4.1 fts^{-1}) to 1.35 ms^{-1} (4.4 fts^{-1}), but certain portions of the coil were completely obstructed resulting in no air flow, and other portions realized velocities of over 1.7 ms^{-1} (5.6 fts^{-1}). A CFD model of the air flow through this heat exchanger was developed based on a momentum resistance modeling approach. The CFD results agreed well with the PIV measurements, predicting the local velocities within 3 % over most of the domain and within 10 % in areas with the largest velocity gradients.

2. Pool Boiling of R-134a and R-123 on Smooth and Enhanced Tubes, Average Heat Transfer Coefficient Analysis

Evraam Gorgy, Ph.D., Member, Kansas State University Institute For Environmental Research, Manhattan, KS
This paper presents information about nucleate pool boiling of R-134a and R-123 on TBIHP and TBILP tubes, respectively, as well as on smooth tubes. Data were taken at a saturation temperature of $4.44 \text{ }^{\circ}\text{C}$. The test tubes' outer diameter was 19.05 mm (0.75 in.) and had lengths of 1 m (39.37 in.). Tubes were water heated with an insert in the water passage. A new analytical method known as enthalpy-based heat transfer analysis (EBHT) was introduced and used to determine the refrigerant heat transfer coefficient. The present study provided one of the widest heat flux ranges studied with this type of tubes and showed significant structure to the pool boiling curve, which had not been traditionally observed. The experimental data of the smooth tubes were compared against the Cooper and Stephan-Abdelsalam correlations.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Seminar 42 (Intermediate)

Ethical Challenges in the Real World: Case Studies, Part 2

Track: Professional Skills

Room: Hampstead

Sponsor: 01.07 Business, Management & General Legal Education, College of Fellows

Chair: Michael Connor, P.E., Member, Connor Engineering Solutions, Alpharetta, GA

This is a continuation of Seminar 37 that began at 8:00. Four ethical challenges from real world examples are presented. The attendees will break up into teams of 10 to 20 each to discuss the ethical challenges and propose a course of action. The discussions will be facilitated on the floor by members of the College of Fellows. After a brief discussion by the teams, their resolutions will be read along with the real world outcome.

1. When Is An Engineer Obligated to "Blow the Whistle"?

Michael Connor, P.E., Member, Connor Engineering Solutions, Alpharetta, GA

See Seminar 37 for a description of the scenarios that are covered in this session.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Seminar 43 (Intermediate)



Net-Zero Energy Design with Thermal Energy Storage Systems

Track: HVAC Systems and Equipment

Room: Cote St Luc

Sponsor: 06.09 Thermal Storage

Chair: Moncef Krarti, Member, University of Colorado, Boulder, CO

In this seminar, the use of both passive and active thermal energy storage (TES) systems to design zero-energy buildings (ZEBs) is discussed. In particular, speakers will provide some design guidelines as well as operating strategies on how to use TES systems for ZEBs as well as to reduce carbon emissions through peak load shifting options to reduce the reliance on the most pollutant power generation plants. The first speaker will provide some design guidelines for including TES systems in ZEB design while the second speaker will discuss control and operating strategies to use TES systems to shift thermal loads to avoid significant electrical peak demands for ZEBs.

1. Zero-Energy Buildings and TES Systems: Case Studies

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

In this presentation, definitions and general design guidelines for of Zero-Energy Buildings are discussed. Moreover, the applications of thermal storage systems including passive and active systems to ZEBs are presented. The presentation would also provide a series of case studies including actual performance of ZEBs.

2. Operating of Both Passive and Active TES Systems

Gregor P. Henze, Ph.D., P.E., University of Colorado, Boulder, CO

In this presentation, operating challenges of Thermal Energy Storage (TES) systems are first discussed. Then, some of the proven control strategies for TES systems are presented with some specific application examples. In particular, measured data are presented to show the performance of various TES control strategies including optimized operating sequences suitable for passive and active TES systems.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Forum 7 (Intermediate)

Introducing ASHRAE Standard 193

Track: HVAC Systems and Equipment

Room: Lasalle

Sponsor: 06.03 Central Forced Air Heating and Cooling Systems, 09.05 Residential and Small Building Applications

Chair: Michael R. Lubliner, Member, Washington State University Extension Energy Program, Olympia, WA

One of the most important predictors of a building's energy efficiency is its HVAC system. Air that is not delivered to areas as specified in the building design is air that is not being used efficiently. Standard 62.2, limits allowable air leakage between garages and houses due to leaks in the forced air HVAC system, while Standard 152 includes HVAC system air leakage in estimates of distribution system efficiency for residential buildings. Neither of these standards provides a way to determine the tightness of specific HVAC components. It is the aim of Standard 193 to provide an accurate and repeatable method of testing the airtightness of HVAC "boxes" as a standardized laboratory test procedure where results maybe used for comparison purposes. Standard 193 can be used for a variety of HVAC system types that move less than 3000 cfm (1400 L/s), Standard 193 tests results may be used by cognizant authorities who wish to regulate the air leakage of HVAC equipment and by contractors and installers that wish to specify equipment based on known leakage characteristics.

Tuesday, June 28, 2011, 9:45 AM-10:45 AM

Forum 8 (Intermediate)

Moving Closer to Net Zero Buildings with the IAQ Procedure of Standard 62.1-2010

Track: *Net Zero Buildings*

Room: *Mont Royal*

Sponsor: *02.03 Gaseous Air Contaminants and Gas Contaminant Removal Equipment, SSPC 62.1, SPC 189P, TRG 4.1IAQP, 02.04 Particulate Air Contaminants and Particulate Contaminant Removal Equipment*

Chair: *Christopher O. Muller, Member, Purafil Inc., Doraville, GA*

This forum presents and discusses the current status of the Indoor Air Quality Procedure of Standard 62.1-2010 - specifically as related to its potential for significant energy savings when used to determine outside air ventilation rates for HVAC systems. This forum solicits input as to what can be done to validate the IAQ Procedure and make it more useful to the engineering community when designing "net zero" energy buildings.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Conference Paper Session 12



Alternative for Data Center Cooling and Demand Ventilation Control Strategies

Track: *HVAC Applications*

Room: *Westmount*

Chair: *Wayne Lawton, P.E., Member, Merrick and Co., Aurora, CO*

This session has three papers. The first paper addresses alternative cooling alternatives for cooling strategies for data centers that reduce the amount of energy required. The second paper presents occupancy based control strategy for VAV systems and shows how they comply with ASHRAE Standard 62.1. The third paper presents demand control methods that meet ASHRAE Standards 62.1, 90.1 and 189.1.

1. Occupancy Based Control Strategy for Variable Air Volume (VAV) Terminal Box Systems (ML-11-C030)

Guopeng Liu, Ph.D., P.E., Member¹ and Michael Brambley, Ph.D., Fellow ASHRAE¹, (1)Pacific Northwest National Laboratory, Richland, WA

Terminal box (TB) is the key component in the VAV systems. The minimum airflow set point of the VAV TB is an important factor for thermal comfort, IAQ and energy consumption. The newly developed occupancy based control resets the minimum airflow set point for each TB based on the actual zone occupancy number and ASHRAE ventilation standard. Differentiated from existing motion sensors, the building occupancy sensors can count the occupancy number in each room and transfer it to BAS in real time. This paper presents the system architecture, improved control sequence, sensor technology and energy savings analysis.

2. Psychrometric Bin Analysis for Alternative Cooling Strategies in Data Centers (ML-11-C031)

Ian Metzger¹, Caleb Rockenbaugh, P.E., Member¹, Otto VanGeet, P.E.¹, Jesse Dean¹ and Chuck Kurnik¹, (1)National Renewable Energy Laboratory, Golden, CO

Data centers are significant energy users and require continuous cooling to maintain high levels of computing performance. The majority of data centers have direct-expansion cooling which typically accounts for approximately 50% of the energy usage of data centers. However, using typical meteorological year 3 (TMY3) weather data and a simple psychrometric bin analysis, alternative cooling strategies using a combination of economizer, evaporative, and supplemental DX cooling have been shown to be applicable in all climate zones in the United States. Average data center cooling energy savings across the U.S. was approximately 80%. Analysis of cooling energy savings is presented for various ASHRAE climate zones. The psychrometric bin analysis is conducted for the ASHRAE recommended and allowable operating environment zones, as well as, a modified allowable operating environment. Control strategies are discussed. Finally, examples of energy efficient data centers using alternative cooling strategies are presented.

3. Demand Control Ventilation Methods to Meet ASHRAE Standards (ML-11-C032)

Hoy Bohanon, Member, WorkingBuildings LLC, Winston Salem, NC

ASHRAE standards 90.1-2010 and 189.1-2009 require demand control ventilation (DCV) in some cases. ASHRAE standard 62.1-2010 allows demand control ventilation but places restrictions upon its application. Many existing installations do not comply with the requirements of ASHRAE Standard 62.1-2010 yet there is pressure to reduce ventilation using various techniques including carbon dioxide based demand control. This paper addresses what is required and what strategies and technologies can be used to meet the requirements of the all the standards. Many past approaches to DCV cannot be used if one is to try to comply with ASHRAE 62.1-2010. These approaches are identified and new approaches are listed that will meet the requirements of all three standards.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Conference Paper Session 13



Improving the Efficiency of Ground Source Heat Pump Systems

Track: *Alternative Technologies*

Room: *Verdun*

Chair: *Gregory Dobbs, Ph.D., Member, Penn State University, Philadelphia, PA*

In this session contributed papers on ground source heat pumps (GSHP) are presented. Ground source heat pumps are finding increasing use as part of the total system solution in green buildings. The papers involve experimental and modeling efforts on the value proposition and technology options.

1. Building on Experience with Hybrid Ground-Source Heat Pump Systems (ML-11-C033)

Amanda Pertzborn, Student Member¹ and Scott P. Hackel, P.E., Associate Member², (1)University of Wisconsin - Madison, Solar Energy Laboratory, Madison, WI, (2)Energy Center of Wisconsin, Madison, WI

Ground-source heat pump systems have recently grown to become a preferred choice for many high performance buildings, due primarily to providing some of the highest levels of efficiency of any heating/cooling system. If future goals for net-zero energy buildings hold, there will be additional interest in these systems as building designers are required to move away from using fossil fuels to provide heat. However, ground-source systems are not yet a mainstream choice, due to its large installed cost. One commonly expressed solution to this problem is the hybrid ground-source heat pump (HyGSHP) system, in which a supplemental heat rejection or extraction device (e.g. cooling tower) is used to cut the peak capacity required from the loop and thereby decrease the cost of the system. Hybrid systems are growing more prevalent, but there continues to be a need for additional information on the design and operation of these systems.

A project was undertaken to monitor actual HyGSHP systems, both in heating- and cooling-dominated buildings, to bring benchmark (and improve where necessary) existing models and operational practices for these systems. We monitored three HyGSHP systems: two cooling-dominated systems in Las Vegas and one heating-dominated system in Wisconsin. This data has been used to validate a HyGSHP model (including validation of individual model components such as the DST ground heat exchanger model).

Both the data and the system model were then used to study these three installations and draw conclusions about their design and operation, including documenting lessons learned. Results demonstrate the cost-effectiveness of the general hybrid strategy, from a life-cycle standpoint, in comparison to other ground-source and conventional systems. Results also show the impact of some design decisions (both good and bad), as well as impacts of operational changes that could save additional energy in the future. The project will conclude in the near future with the release of the general HyGSHP model – as freeware – for use by the engineering community.

2. An Analytical Method to Calculate Borehole Fluid Temperatures for Time-scales from Minutes to Decades (ML-11-C034)

Johan Claesson, Ph.D.¹ and Saqib Javed, P.E., Student Member², (1)Chalmers University of Technology, Gothenburg, Sweden, (2)Chalmers University of Technology, Gothenberg, Sweden

Knowledge of borehole exit fluid temperature is required to optimize the design and performance of ground source heat pump systems. The borehole exit fluid temperature depends upon the prescribed heat injection and extraction rates. This paper presents a method to determine the fluid temperature of a single or a multiple borehole heat exchanger for any prescribed heat injection or extraction rate. The fluid temperature, from minutes to decades, is determined using step response functions. An analytical radial solution is used for shorter times. A finite line-source solution is used for longer times. The line-source response function has been reduced to one integral only. The derivative, the weighting function, is given by an explicit formula both for single boreholes and any configuration of vertical boreholes.

3. Transcritical CO₂ for Air Conditioning with Ground Source Exchange (ML-11-C035)

Iyabo Lawal, Student Member¹, David H. Archer, Ph.D.¹ and Yang Hu, Student Member¹, (1)Carnegie Mellon University, Pittsburgh, PA

Global warming has significant environmental consequences that are manifested in higher than normal temperature around the world which cascade down to affect a multitude of global effects including the loss of ice-caps in the Arctic Circle, rising sea levels and changes in natural ecosystems. Carbon dioxide emissions from industrial and commercial industries increase global warming levels. Buildings account for 38.9% of primary source energy and produce 38% of CO₂ emissions in the US. In residential buildings, most of this energy - 75% is used in heating, cooling, ventilation and domestic hot water production. In particular, 17% of electricity generated for commercial and residential buildings is used for space cooling. Cooling requirements are especially prevalent in developing countries which are experiencing significant economic growth, motivating the need for more efficient space cooling technologies. Prior studies involving CO₂ as a refrigerant are solely for DHW (Domestic Hot Water) or space heating applications. Heat pumps that use ground source exchange (GSE) systems take advantage of lower ground temperatures as compared to ambient air temperatures. This lower heat sink temperature increases heat pump efficiency. Combining transcritical operation of CO₂ with ground-source exchange increases overall refrigerating efficiency. If waste heat is also utilized, the system can simultaneously provide heat for DHW and reduce required bore-hole length. Designing a CO₂ based cooling system with GSE introduces challenges and advantages that will be explored in the design of a cooling system for a 7,000 square foot office building located in Pittsburg, PA. The first motivation of this study is to utilize a refrigerant with reduced GWP (Global Warming Potential) and ODP (Ozone Depletion Potential) compared to conventional refrigerants used for commercial refrigeration. CO₂ provides a solution to this challenge by having no ODP and a GWP of 1. The second motivation is to provide a cooling system that reduces the indirect environmental impact of refrigeration by providing adequate cooling with reduced electricity input. This enhancement will be achieved by transcritical operation at optimum gas cooler discharge pressure and a GSE (Ground Source Exchange) system which provides relatively constant heat rejection source, increasing the cooling system ability to remove heat with lower energy consumption measured by system Coefficient of Performance (COP).

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Conference Paper Session 14



Net-Zero Energy Houses in North America. Can They Be Comfortable and Affordable?

Track: Net Zero Buildings

Room: Mont Royal

Chair: Michel Tardif, Member, CanmetENERGY, Ottawa, ON, Canada

To be competitive and attractive a net-zero energy house should also be affordable and comfortable. This session, through some interesting case studies, is addressing the comfort and cost issues prevailing in moderate and cold climate regions in North America. The papers provide findings that will be of guidance for the design of future net zero homes.

1. New England Net Zero Production Houses (ML-11-C036)

Kohta Ueno, Associate Member¹ and Daniel M. Bergey¹, (1)Building Science Corporation, Somerville, MA

A homebuilder working in the New England area has been building net zero energy single family homes since circa 2008, and is currently continuing with multiple small-scale subdivisions of 20 or more homes. This builder specializes in net zero affordable homes and sustainable net zero communities, while retaining houses with a familiar local vernacular appearance. Some of the key features of these houses include solar orientation, superinsulated double-stud above-grade walls (R-45+ nominal), triple glazed low emissivity krypton-filled windows, and exceptional airtightness. The mechanical design takes advantage of the reduction in enclosure-based heating loads by using single-point (or one point per floor) heating, in the form of mini-split air source heat pumps. This modification substantially reduces installed HVAC system costs relative to a conventional ducted system. The effects of this single-point distribution in superinsulated housing are a matter of further measurement in this study. In addition, the ability of an air source heat pump to meet heating loads in a cold climate is a matter of concern; the ability to maintain setpoint (and dependence on backup heat) is another matter of study. The renewable energy component is a roof-mounted photovoltaic system, sized to meet the modeled loads; a PVT system (combined photovoltaic-solar thermal) was also used in some cases. Controlled mechanical ventilation options have included heat recovery ventilators and simplified supply-only systems. When combining the factors of the installed cost of HRVs, the ventilation rates used, and the increased electrical (fan) energy of HRVs, the cost-benefit relationship of heat recovery appear to be not as advantageous as originally thought. The builder also has been concentrating on cost control for these houses, given the shift into full-scale production, and has been actively involved in monitoring of the effectiveness of various measures. Energy modeling and analysis have also been used to examine the cost-effectiveness of various options. Avenues examined have included various solar domestic hot water systems, building-integrated photovoltaics, modifications to the wall construction, and modified foundations.

2. Energy Consumption and User Comfort in Cold Climate NZEHs (ML-11-C037)

Peter Engelmann¹ and Kurt Roth, Ph.D., Member¹, (1)Fraunhofer Center for Sustainable Energy Systems, Cambridge, MA

We will present results from in-depth monitoring of two single-family “Net Zero Energy Homes” (NZEH) in Massachusetts. With insulation levels of R-47 in the walls and up to R-67 in the attic, triple-glazed windows and a ventilation system with heat recovery, it has an estimated heating energy demand of 4.2 kBtu/ ft²-yr. One house is all- electric with ductless mini-splits for heating and cooling and DHW from an air-to-water heat pump. The other one is also equipped with a ductless mini-split, and uses an instantaneous gas heater for water heating. Both homes have a PV system, resulting in HERS indices of less than 5. Our study will evaluate – and we will present at the Conference – the performance of both NZEHs from two key perspectives: (1) Energy Consumption: We are measuring the electricity consumption of both homes at the individual circuit level, with a one-minute time resolution. Using this detailed information in combination with the homes’ design parameters and weather data, we will provide a very detailed picture of energy consumption patterns and user behavior - including the challenges that arise in achieving a net-zero energy balance. (2) Indoor Comfort: We are measuring parameters including indoor air temperatures, relative humidity, and CO₂ concentrations to evaluate indoor comfort and indoor air quality (IAQ) performance throughout the year. This will provide very valuable feedback on the effectiveness of the ventilation / air distribution systems deployed. The initial data we have collected so far indicate that, consistent with earlier studies of very low-energy homes in (normally) space heating-dominated climates, other loads become the main loads. Notably, the energy demand for domestic hot water and miscellaneous and electronic loads become the largest loads in the home. In addition, the energy consumption of energy supply and distributions systems can become a significant portion of the total energy consumption. Finally, we expect that our analysis of the actual operating data will reveal opportunities to further improve operations and other efficiency measures. For example, the crankcase heater for one ductless mini-split unit has a “standby” power draw of approximately 50W, substantially increasing HVAC energy consumption in a very-low energy home.

3. Net-Zero Energy Homes: Solar Photovoltaic Electricity Scenario Analysis Based on Current and Future Costs (ML-11-C038)

Veronique Delisle, CanmetENERGY, Varennes, QC, Canada

The Net-Zero Energy Home (NZEH) Coalition has a vision that all new home constructions are to meet a Net-Zero Energy Home standard by 2030. During this time, the price of building envelope components, renewable energy technologies, electricity and fuel will likely fluctuate, ultimately influencing the affordability and cost-effectiveness of NZEH. To evaluate the potential impact of the price fluctuation on NZEH construction costs, this study compares various energy efficiency measure and renewable energy technology combinations integrated into a newly constructed typical Quebec residence such that the annual energy production is equal to the home's annual energy consumption. For each scenario, the study evaluates the cost-benefit of building a net-zero energy house today based on actual costs to that if the house were to be built in 2030. The effect of a potential photovoltaic technology cost reduction due to increase market penetration was also examined.

4. San Francisco Bay Area Net Zero Urban Infill (ML-11-C039)

Kohta Ueno, Associate Member¹ and John Straube, Member², (1)Building Science Corp., Somerville, MA, (2)Building Science Corp., Boston, MA

A startup builder in the San Francisco Bay Area has a goal of producing factory built/modular houses with net zero energy performance. Their first prototype was a two-story, two bedroom, urban infill townhouse design. It has been in operation for roughly a year, and has been extensively monitored, providing information about its net zero performance, and the contribution of its various sub-systems. Some technologies incorporated into this prototype include higher R value walls than typically used in this mild climate (R-25 nominal), high performance (triple glazed) windows, excellent airtightness, a heat pump water heater, drainwater heat recovery, and a residential-scale economizer. The house also has a control system that is intended to make use of semi-active control of the thermal mass located in the conditioned crawl space. The data collected to date indicate that the building is roughly on track to achieve net zero performance, given the current occupancy. Several obstacles arose during the construction and commissioning of the building, which provided some useful lessons on the integrating more advanced technologies with the existing construction trades. Another design constraint is that the builder wished to have an all-electric house: both for 'perceived net zero performance' (all measured in electricity), as well as the California net metering laws then in effect (no credit for overproduction of photovoltaics). In addition, the builder asked for an analysis judging the relative cost-effectiveness of various building enclosure and mechanical measures used; this information is included here. The monitored data is providing a wealth of information: it includes submetered energy consumption for various end uses, photovoltaic system output, efficiency of the heat pump water heater (which can be used to calculate in-service energy factor), and the effectiveness of the drainwater heat recovery system. It has already been used to remotely diagnose malfunctioning or improperly operated equipment.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Seminar 44 (Intermediate)



DOE's New Buildings Energy Efficiency HUB Focusing on Virtually Integrated Retrofit Solutions

Track: Engineering Tools

Room: Lachine

Chair: Richard Sweetser, Member, Exergy Partners Corp., Herndon, VA

According to U.S. President Obama, "Making our buildings more energy-efficient is one of the fastest, easiest and cheapest ways to save money, combat pollution and create jobs right here in the United States of America." These remarks were made on February 3, 2011 when the President announced creation of the Building Energy Efficiency HUB. The new Energy HUB will focus its attention on transforming the commercial/institutional retrofit industry by developing transformation assessment tools; creating new retrofit components; systems and integrated systems; developing innovative public policy initiatives; providing education and workforce transformation programs; and delivering business models and commercialization. This seminar describes DOE's Building's Energy HUB and its specific relationship with ASHRAE.

1. Buildings Energy Efficiency HUB Vision, Mission and Strategic Plan

James Freihaut, Ph.D., Member, The Pennsylvania State University, State College, PA

The DOE HUB is located at the Philadelphia Navy Yard and is charged with transforming the existing building stock in the eleven counties surrounding and including the City of Philadelphia. The specific focus of this HUB is on commercial and institutional buildings 100,000 square feet and below. The EEB HUB is working closely with DOE Headquarters, Oak Ridge, Lawrence Berkley, Pacific Northwest and the National Renewable Energy Laboratories in this effort to reduce energy use in existing building by 50%. The HUB is also working closely with ASHRAE to achieve these daunting goals. This presentation will cover the underpinnings of the effort.

2. Transformative Retrofit Energy Assessments

John Messner, Ph.D., The Pennsylvania State University, State College, PA

Incorporating full spectrum energy efficiency retrofits into mainstream building remodels and upgrades requires significant change in assessment and modeling tools specifically to reduce assessment cost, reduce assessment time, improve ease of use and increase verified results aimed at reducing risk. One EEB HUB Task Group is focusing on delivering decision level tools into the market place in the next few years that will provide practitioners with energy retrofit tools upgrading and integrating existing independent tool sets, creating easy to use interfaces, increasing verified performance and cost data and incorporating them in the cloud. This presentation will document details of the EEB HUB approach to this difficult challenge.

3. The Future of Retrofit Focused Controls, Components, Integrated Systems, Operations and Maintenance

Timothy Wagner, Ph.D., Member, Energy Systems Program Office at United Technologies Research Center, Hartford, CT

Visualizing a building as an integrated system and design problem like a car is easy for most engineers – at least in theory. In practice, this is one of the most challenging efforts which has not yet been achieved in new buildings, much less in retrofit buildings. Developing the right sensors, controls, components, systems and building level integrated systems focused on full spectrum energy retrofits is a new area of research. Integrating envelopes with new materials and variable characteristics, with HVAC systems and air cleaning technologies that save energy, enhance lighting and improve or at least do no harm to Indoor Environmental Quality (IEQ) is the focus of one Task Group working to deliver near-term cost effective solutions to the market.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Seminar 45 (Intermediate)



Getting to 50: First Look at the 50% Advanced Energy Design Guide for Small and Medium Office Buildings

Track: HVAC Applications

Room: Lasalle

Sponsor: ASHRAE Special Project 133, AEDG Steering Committee

Chair: Donald Colliver, Ph.D., P.E., Presidential Fellow Life Member, University of Kentucky, Lexington, KY

The award-winning 30% Advanced Energy Design Guide series is now concluded, having produced six volumes that have been well received by the building design and construction professions. The next group of publications will provide guidance as to how to achieve a 50% savings compared with ASHRAE/IESNA Standard 90.1-2004. The first of these volumes, the 50% AEDG for Small and Medium Office Buildings has now been printed. This seminar provides an overview of the work of ASHRAE SP-133 which produced, in conjunction with AIA, IESNA, USGBC and DOE, the first in a series of 50% AEDG — Advanced Energy Design Guide for Small to Medium Office Buildings.

1. Overview of the 50% AEDG Series and What's New in the 50% AEDG Office Guide

Bing Liu, P.E., Member, Pacific Northwest National Laboratory, Richland, WA

This session will provide the overview of the ASHRAE's 50% Advanced Energy Design Guide series, including the scope, energy target, and building type planned to cover in this series publication. Specifically, this session gives an overview of this newly published book, Advanced Energy Design Guide for Small to Medium Office

Building, the first in a series of 50% AEDGs. The topic will include the goal of this guide, scope, methodologies and how to use this guide. It will also provide the extensive energy saving analysis results by implementing the energy efficiency recommendations from this Guide.

2. Building Envelope Strategies for the 50% AEDG SMO

Merle F. McBride, Ph.D., Member, Owens Corning Center of Science and Technology, Granville, OH

Upgrading the thermal efficiency of the envelope through reduced thermal transmittance and solar loads is the first and most obvious goal but this needs to be complemented with fundamental changes in the building basic structure and form. New features include orientation sensitive window-to wall ratios, limited use of flat roof skylights, incorporation of daylighting and view glazing, vestibules and mitigation of thermal bridges at roof/wall intersections, foundations and windows. Rounding out the envelop measures include continuous air barriers, exterior shading of south facing windows and the use of thermal mass to reduce loads.

3. Lighting and Daylighting Issues for the 50% AEDG SMO

Michael D. Lane, Lighting Design Lab, Seattle, WA

The lighting section of the AEDG pushes three main areas of energy savings to help meet the 50% goal; daylighting, lower lighting power densities, and controls (daylighting and occupancy). Locating open office areas on the North and South sides of the building and using daylight as the primary light source. Lower lighting power densities are possible by using high-performance lensed fluorescent fixtures as the general light source and using spill light from the general lighting to light the corridors when possible. Occupancy sensors are used as the primary control mechanism throughout the spaces to ensure that light are turned off when the spaces are unoccupied.

4. Mechanical Systems and Systems Integration Issues for the 50% AEDG SMO

Daniel Nall, P.E., Member, WSP Flack + Kurtz, New York, NY

Optimization of mechanical systems was critical to achieving the 50% energy savings goal required by the guideline. Successful strategies were fully evaluated using comprehensive building energy simulation and were vetted for functionality and operability by the project committee. Systems were evaluated for both electrical and fossil fuel heating source. Successful strategies maximized part load energy savings, eliminated simultaneous heating and cooling, recovered energy from exhaust air and decoupled outside air delivery from sensible temperature control.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Seminar 46 (Intermediate)



New High Quality Solar Data Sources and Analysis Methods for High Resolution Weather Applications, Part 2

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 04.02 Climatic Information

Chair: Norman J. Bourassa, Associate Member, Lawrence Berkeley National Lab, Berkeley, CA
Steve Cornick, P.Eng., National Research Council Canada, Ottawa, ON, Canada

The quality and amount of data available from meteorological satellites has opened up multiple opportunities to improve the development of new solar radiation model methodologies. These new methodologies have created advances in weather data engineering applications for the modeling and design of energy efficient buildings. In this second part, we will learn about the analysis methods and availability of solar data derived from reanalysis models (NARR) and we will close with a look at NASA's work on providing meteorological satellite data for renewable energy systems.

1. Reliability and Quality of NARR Data

Didier Thevenard, Ph.D., P.E., Member, Numerical Logics Inc., Waterloo, ON, Canada

Numerical weather prediction models that include solar radiation data at the surface is increasingly available at higher time and spatial resolutions. One of these models is the North American Regional Analysis (NARR) data set available from the National Oceanic and Atmospheric Administration (NOAA). The NARR model provides spatial

coverage of the North American continent at 32 km resolution and covers the period from 1979 to 2009. Among other outputs, this model provides estimates of solar radiation on a 3-hour, daily and monthly basis. The model was tested against measured data from a number of Canadian stations. The analysis revealed that raw solar radiation estimates provided by the model are unusable as they suffer from a significant bias (20 to 30% depending on the season). A simple technique (based on a linear fit) was tested to remove the bias. The modified NARR model performs acceptably with a positive bias of only 1.4%, and with daily and monthly RMSEs on the order of 29% and 9%, respectively, without a marked seasonal bias. However, the fact that the NARR bias needs to be removed casts a doubt on the confidence one can have in the model.

2. NASA's Support of Integrated Renewable Energy Systems Through Provision of Solar and Meteorological Resource Information

Paul W. Stackhouse Jr., Ph.D., NASA Langley Research Center, Hampton, VA

NASA's Earth Science research program has long supported satellite systems and research providing data important to the study of climate and climate processes. These data include long-term estimates of meteorological quantities and surface solar energy fluxes. This presentation gives an overview of the NASA Langley Research Center Applied Science projects related to the development of parameters for the solar power and other renewable energy industries. First, the current status and accuracy of the Surface Meteorology and Solar Energy (SSE) dataset are reviewed. Secondly, we present the plans and current status of a project in collaboration with the National Renewable Energy Laboratory (NREL) and with the NOAA National Climatic Data Center (NCDC) to provide a production system capable of reproducing the entire data set and continue production into the future.

3. Solar and Photovoltaic Forecasting through Post-processing of the Global Environmental Multiscale Numerical Weather Prediction Model

Sophie Pelland, Ph.D., Natural Resources Canada, Varennes, QC, Canada

Hourly solar and photovoltaic (PV) forecasts for horizons between 0 and 48 hours ahead were developed using Environment Canada's Global Environmental Multiscale (GEM) model. The motivation for this research was to explore PV forecasting in Ontario, Canada where feed-in tariffs are driving rapid growth in installed PV capacity. The solar and PV forecasts were compared to irradiance data from 10 North American ground stations and to AC power data from 3 Canadian PV systems. A one year period was used to train the forecasts and the following year was used for testing. Two post-processing methods were applied to the solar forecasts: spatial averaging and bias removal using a Kalman filter. On average, these two methods lead to a 43% reduction in RMSE over a persistence forecast (skill score = 0.67) and to a 15% reduction in RMSE over the GEM forecasts without post-processing (skill score = 0.28). Bias removal was primarily useful when considering a « regional » forecast for the average irradiance of the 10 ground stations, since bias was a more significant fraction of RMSE in this case. PV forecast accuracy was influenced mainly by the underlying (horizontal) solar forecast accuracy, with RMSE ranging from 6.4 to 9.2% of rated power for the individual PV systems. About 76% of the PV forecast errors were within +/-5% of the rated power for the individual systems, but the largest errors reached up to 44 to 57% of rated power.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Seminar 47 (Intermediate)



Radiant Cooling Systems for Energy Efficiency and IEQ

Track: Alternative Technologies

Room: Hampstead

Sponsor: 06.05 Radiant Heating and Cooling, 06.01 Hydronic and Steam Equipment and Systems

Chair: Robert Bean R.E.T. P.L(Eng.), Member, Healthy Heating, Calgary, AB, Canada

This seminar provides an overview of strategies used to incorporate radiant cooling in medium to large buildings in Canada and abroad. These projects demonstrate the viability of radiant cooling as an alternative system solution to dramatically reduce building energy usage and improve IEQ.

1. Geo-Exchange and Radiant Cooling for Big Box Retail Development

David Clark, P.E., Member, Stantec Engineering, Toronto, ON, Canada

This presentation and paper will review a eco-friendly and sustainable big box retail store constructed in 2008 that has been in operation since January 2009. The sustainable design features the following systems: First-of-its-kind demonstration of geothermal heating and cooling technology in a large-scale Canadian retail operation – facilitated by 15 km of piping buried under parking lot; Daylight harvesting system using skylights to refract daylight throughout the store; light sensors monitor the amount of natural light available and rise, dim or turn off lighting as needed; Store is powered 100% by renewable power sources like wind and low-impact water power through Bullfrog Power; In-floor radiant heating and cooling system circulates water to transfer heat and cold instead of air vents, requiring less electricity; Heat from refrigeration system captured and reused to heat store; Energy-saving motion-activated LED lights in refrigerator and freezer cases reduces energy use; Low-wattage parking lot lights as well as LED external signs reduce energy use; and White roof membrane deflects sunlight by an estimated 85 per cent to reduce heat gain in summer and demand on the electrical grid. The presentation will focus on the details of the geothermal loop field construction, the synergies between the radiant floor heating and cooling system and the ground source heat pumps, and the installation parameters of the radiant floor system. Integration of the radiant system with the ventilation and de-humidification systems will also be discussed. Energy savings are being monitored in the store and this store design is using 60% less energy than the traditional supercentre store design. Overall system payback and installation costs will be discussed and presented.

2. Manitoba Hydro Place: Alternative Technologies in Tall Buildings at -40 F and C

John Munroe, P.Eng.¹ and Mark Pauls B.Sc.², (1)AECOM, Calgary, AB, Canada, (2)Manitoba Hydro, Winnipeg, MB, Canada

The 22 story Manitoba Hydro Place was designed to optimize passive free energy year round in a city where [temperatures fluctuate](#) from -35 degrees Celsius (-31 degrees Fahrenheit) to +34 degrees Celsius (95 degrees Fahrenheit) with peaks down to -40 degrees F & C; and without compromising design quality and human comfort. The building was commissioned in 2009 and is achieving over 60% better than the MNECB. It is exceeding its performance targets with an integrated system comprising of a geothermal heat pump system, thermal mass with in-slab radiant heating and cooling, solar chimney with 100% fresh air displacement ventilation and heat recovery, natural day lighting, and a double façade with operable windows. Presentation will discuss what was learned, what is working and what can be done differently to further enhance the use of alternative technologies in tall buildings.

3. Modeling Occupant Comfort Control in Larger Non-Traditional Spaces

Peter Simmonds, Ph.D., Fellow ASHRAE, IBE Consulting Engineers, Sherman Oaks, CA

Comfort control of spaces is a traditional HVAC engineering process; however we tend to look at these processes in a steady state environment. When dynamics are introduced into the equation the response and performance of a conditioning system become critical. This presentation will address the conditioning concepts including radiant floors for the Louis Vuitton museum and other large spaces that contains traditional galleries and nontraditional spaces all designed to provide different levels of flexibility, yet at the same time provide a system that performs in response to the performance required. The system performance described in this presentation will address occupant comfort control under different operating modes.

4. Radiant Heating and Cooling Options for School Buildings

Timothy J. McGinn, P.Eng., Member, DIALOG, Calgary, AB, Canada

There are a variety of approaches to conditioning school buildings with radiant heating and cooling technology. The speaker will a number of successful approaches and will use case studies to outlines the differences, advantages and challenges of various systems as they relate to energy use and their contribution to indoor environmental quality of the spaces served.

Tuesday, June 28, 2011, 11:00 AM-12:30 PM

Seminar 48 (Intermediate)



Ventilation Rates and Health

Track: HVAC Applications

Room: Outremont

Sponsor: Environmental Health Committee

Chair: Steven Emmerich, Member, National Institute of Standards and Technology, Gaithersburg, MD

For ASHRAE URP 1443, a multidisciplinary group of IAQ scientists reviewed the scientific literature on the effects of ventilation rates on health in non-industrial indoor environments (offices, schools, homes, etc.). The findings of this study are presented and have important implications for ASHRAE ventilation and green building standards (62.1, 62.2 and 189.1). This seminar discusses improvements needed in measuring ventilation rates and related health effects in different types of buildings and different climates and cultures.

1. Ventilation Rates and Health: What We Know

Jan Sundell, Ph.D., Member, Tsinghua University, Beijing, China

For ASHRAE URP 1443, a multidisciplinary group of IAQ scientists reviewed the scientific literature on the effects of ventilation rates on health in non-industrial indoor environments (offices, schools, homes, etc.). This talk will provide an overview of this research project and present the key findings of the study. Important implications for ASHRAE ventilation and green building Standards (62.1, 62.2 and 189.1) will also be presented.

2. Ventilation Measurement Methods in Selected IAQ Studies

Andrew Persily, Ph.D., Member, National Institute of Standards and Technology, Gaithersburg, MD

For ASHRAE URP 1443, a multidisciplinary group of IAQ scientists reviewed the scientific literature on the effects of ventilation rates on health in non-industrial indoor environments (offices, schools, homes, etc.). This talk will discuss improvements needed in measuring ventilation rates in IAQ studies in order to produce reliable results. The advantages and shortcomings of various ventilation measurement methods will be explained.

3. Ventilation Rates and Health: What We Still Need to Learn

Hal Levin, Fellow ASHRAE, Building Ecology Research Group, Santa Cruz, CA

For ASHRAE URP 1443, a multidisciplinary group of IAQ scientists reviewed the scientific literature on the effects of ventilation rates on health in non-industrial indoor environments (offices, schools, homes, etc.). This talk will discuss what we still need to learn about ventilation rates and related health effects in different types of buildings and different climates and cultures. The limitations of the research study will be described and the needs for further studies will be presented.

Tuesday, June 28, 2011, 11:00 AM-1:00 PM

Poster Paper 1

ASHRAE Poster Session

Track: Alternative Technologies

Room: Le Portage

Chair: Tiffany D. Cox, ASHRAE Staff, Atl, GA

Presentation of 15 ASHRAE Technical Papers by poster.

1. A New Air Distribution System Inside Hospital Railway Coaches (ML-11-018)

Andrea Vallati, Ph.D.¹ and Roberto de lieto Vollaro, Ph.D.², (1)Department of Technical Phisic, Rome, Italy, (2)University of Roma 3, Rome, Italy

Using a correct air distribution system is very important for ensuring a cleaner indoor air as the railway coaches are not only “closed” but also host ill people. The air distribution system studied, envisages the use of high induction created by means of emissions from overhead micro nuzzles, in such a way as to maintain the air velocity in the

occupied areas, within the preset limits. Adjustable micro nozzles allow, wherever necessary, the customization of the air jets. Simulation tests' results are well in line with the values obtained from experimental measures on the prototype. Checks have been made on the main parameters, representative of the comfort, measured at horizontal planes 0.3 meters above each stretcher and at planes transversal to the coach.

2. Application of a Run-Around Membrane Energy Exchanger in an Office Building HVAC System (ML-11-019)

Carey Simonson, Ph.D., P.E., Member¹, Mohammad Rasouli, Student Member¹, Soheil Akbari, Student Member¹, Howard Hemingson, Student Member¹ and Robert W. Besant, Fellow Life Member¹, (1)University of Saskatchewan, Saskatoon, SK, Canada

A Run-Around Membrane Energy Exchanger (RAMEE) has been introduced in the literature as a novel energy recovery system that transfers heat and moisture between the ventilation and exhaust air. The RAMEE consists of two separate (supply and exhaust) flat-plate exchangers made of water vapor permeable membranes, and coupled with an aqueous salt solution. In this paper, the application of a RAMEE in an HVAC system is investigated. The paper discusses the dependency of RAMEE performance on ventilation air and salt solution flow rates and indoor and outdoor air conditions and describes how to control the RAMEE in different operating conditions (summer, winter and part-load). An Artificial Neural Network (ANN) that is able to predict the optimal system performance was developed in previous research. The ANN results are used for TRNSYS computer simulation of the RAMEE system when operating in an office building in four different climates. The results show up to 43% heating energy saving in cold climates, and up to 15% cooling energy saving in hot climates. Cost analysis proves the important role of pressure drop across the exchangers in life cycle cost, and predicts payback period ranging from 2 to 5 years for the RAMEE.

3. Considerations for Incorporating Standby Power Measurement Requirements into the DOE Test Procedures (ML-11-020)

Mike Galler, Member¹, Natascha Milesi Ferretti, P.E., Member¹ and Farhad Omar, Member¹, (1)National Institute of Science and Technology, Gaithersburg, MD

This paper discusses the issue of standby power in the Department of Energy's (DOE) residential appliance test procedures. Section 1 introduces DOE's legislative mandate, briefly discusses the increase in standby power in residential appliances, and describes the global scale of this energy use. Section 2 describes the differences in the definition for standby power and measurement methodologies between industrial, national and international organizations. Section 3 presents a more detailed, component-level discussion of the sources of standby power use. Section 4 presents broader changes that can reduce energy use on the U.S. building stock, including appliance design, changes in user behavior, and policy measures that may serve as good examples to follow. In Section 5, the paper lists recommendations for the ongoing revisions of the DOE test procedures for three residential appliances (dishwashers, clothes dryers and clothes washers). Section 6 presents conclusions.

4. Convective Heat Transfer in Hemispherical Cavities with Planar Inner Surfaces (1415-RP) (ML-11-021)

Hamed H. Saber, Ph.D.¹ and Abdelaziz Laouadi, Ph.D., Member¹, (1)National Research Council Canada, Ottawa, ON, Canada

Domed cavities are found in many applications in buildings, particularly in conventional skylights and tubular daylighting devices. Heat transfer through domed cavities is thus an important factor in evaluating the energy performance rating of such skylight systems, and in calculating the heating and cooling loads of buildings. Although there have been many studies on the convective heat transfer in related geometries, there is very limited information on natural convective heat transfer in domed cavities with planar inner surfaces. In this paper, a numerical study is conducted on natural laminar convective heat transfer in horizontal domed cavities with planar inner surfaces. The bounding surfaces are subject to uniform temperature conditions. The numerical model is based on the finite element method. The model predictions are successfully compared with published data in literature for concentric spheres and hemispherical cavities. The results show that for different boundary temperature conditions, the airflow in the cavities is mono-cellular and reaches steady state conditions for both cold and hot weather conditions. The numerical results are used to develop practical correlations for the Nusselt number.

5. Development and Evaluation of Copper Tube and Fittings Suitable for R-410A Applications (ML-11-022)

Tommy L. Jamison, P.E., Associate Member¹ and Charles Stout², (1)Jamison Engineering, Memphis, TN, (2)Mueller Industries, Memphis, TN

Why do some end customers experience gas leaks in air conditioning and refrigeration units before ten years of usage? Always, context is required before an attempt should be made to answer such a question. Consensus standards (ASME B31.5, ASTM B280, ASME B16.22) governing the production and use of copper tube and fittings deem most of these products not sufficient to meet the higher operating temperature and pressure requirements of R-410A and other refrigerants. Though these standards appear to err to the very conservative side, data taken from refrigeration and air conditioning OEM products seem to err to a very liberal position. For example, according to ASME B16.22 a 3/8" copper fitting with a minimum wall thickness of .026" is rated at 660 PSI at 150 degrees F. However, data taken from OEM (R-410A) products has shown internal wall thicknesses as low as .009" in some failed units. The standard calculation for a wall of .009" would result in an allowable operating pressure of less than 300 PSI. So where is the discrepancy? The purpose of this paper is four fold: 1. Baseline the critical material properties necessary to meet the higher pressure and temperature requirements. (It is not just wall thickness and burst pressure. 2. Confirm the manufacturing process parameters that ensure the best material properties. 3. Provide an accurate performance based (empirical) method to calculate maximum operating pressures for annealed copper tube and fittings. 4. Validate the improved material properties through accelerated life test equivalent to 30 years in an R-410A system.

6. Empirical Modeling of a Rolling-Piston Compressor Heat Pump for Predictive Control in Low-Lift Cooling (ML-11-023)

Nick Gayeski, Ph.D., Associate Member¹, Tea Zakula, Student Member¹, Leslie K. Norford, Ph.D., Member¹ and Peter Armstrong, Ph.D., Member², (1)Massachusetts Institute of Technology, Cambridge, MA, (2)Masdar Institute of Science and Technology, Abu Dhabi, United Arab Emirates

This paper describes the measurement and empirical modeling of the performance of an inverter-driven variable capacity rolling-piston compressor heat pump for use in a predictive control algorithm to achieve energy-efficient low-lift heat pump operation. A 0.75 refrigeration ton heat pump was tested at 131 steady-state operating conditions spanning pressure ratios from 1.2 to 4.8. Compressor speed, condenser fan speed, condenser air inlet temperature and evaporator air inlet temperature were varied to map the performance of the heat pump over a broad range of conditions including low pressure ratios. Empirical, regression-based curve-fit models of the heat pump power consumption, cooling capacity, and coefficient of performance were identified that accurately represent heat pump performance over the full range of test conditions. This model can be incorporated into model-based predictive chiller control algorithms where compressor speed and condenser fan speed can be tuned to achieve energy efficient low-lift chiller performance.

7. Literature Review of the Effect of Temperature and Humidity on Viruses (ML-11-024)

Farhad Memarzadeh, Ph.D., P.E., National Institutes of Health, Bethesda, MD

An extensive literature review of over 120 papers was conducted on the effect of humidity and temperature on the transmission of infectious viruses. This review targets infectious viruses known to be transmitted via the airborne route and by direct and indirect contact. Evidence is cited from both direct and indirect study results examining environmental conditions that affect infectious disease aerosol transmission in enclosed environments. These results will have a major influence on the choice of infection control measures in indoor environments as well as an associated cost for equipment and renovations to the ventilation system or room design.

8. Numerical Analysis and Measures for the Evaluation of Comfort Inside Buses Used for Public Transportation (ML-11-025)

Roberto De lieto vollaro, Ph.D., University of Roma 3, Rome, Italy

This work analyses the thermo hygrometric conditions inside buses used for public transportation. The technical solutions found through the analysis of the thermo-hygrometric conditions inside trains, were also set out and extended to buses. This was in order to maximize the conditioning system and the installation of the air distribution terminals. A pattern for the simulation of the thermo fluid dynamics has been researched, in order to evaluate

possible improvements in the conditioning system or in the distribution system. One of the most difficulties is due to the frequent opening of doors which makes the internal temperature to be non uniform throughout the whole bus, due to the strong air leakage in winter and in summer. It is also important to assess the heating and cooling transition which can often be long and unbearable for passengers inside. The simulation pattern produced with Airpack 2.1 (Fluent) software was then validated with a series of measures performed during the summer season, with which we used to calibrate the model. The simulation model was then used for the analysis of the main issues concerning discomfort. This assessment addresses the fundamental problem that takes place at a bus stop when passengers exit and enter. It has been compared to the solution studied for installing doors equipped with air screens (or air screened doors). The thermo fluid dynamic results guarantee a significant improvement in thermo hygrometric comfort.

9. Parameter Estimation of Dynamic Vapor Compression System Models Using Limited Sensor Information (ML-11-026)

Bryan Rasmussen, Ph.D., Member¹ and Natarajkumar Hariharan, Student Member², (1)Texas A&M University, College Station, TX, (2)Microstaq Inc., Austin, TX

This paper presents a novel approach for identifying critical parameters in dynamic vapor compression system models using limited sensor information. Because the system dynamics are extremely sensitive to changes in refrigerant mass flow rate, accurate expansion valve and compressor models are essential to creating effective dynamic models. However, mass flow rate information is not commonly available for installed systems. This work presents models for electronic and thermostatic expansion valves, evaporators and compressors. An integrated approach is used to identify model parameters using only temperature and pressure sensors. Two numerical search algorithms, nonlinear least squares and simplex search, are used to estimate the parameters, and the approach is validated on three distinct experimental systems. These techniques are enabling tools for creating effective models for dynamic analysis, control design and fault detection. An additional contribution of this work is the quantitative validation of a simple model of a Thermostatic Expansion Valve controlled system, which has been lacking in the literature.

10. Pollutant Removal Effectiveness with UFAD: Field Study of a Ducted Variable Flow System in a LEED Platinum Building (ML-11-027)

James A. Love, Ph.D., P.E., Member¹ and Eduard Cubi Montanya, Student Member¹, (1)University of Calgary, Calgary, AB, Canada

Underfloor air distribution (UFAD) systems have been more widely used over the past decade. UFAD systems are believed to provide better CO₂ extraction, reduced energy use, improved occupant satisfaction with thermal comfort, and easier reconfiguration relative to conventional overhead mixing ventilation (MV) systems, but relatively few field evaluations have been reported. One metric used in evaluating ventilation performance is pollutant removal effectiveness using CO₂ as the tracer gas. A field study found in the refereed literature determined that pollutant removal effectiveness was poorer than expected for a constant flow system in a LEED 1.0 commercial new construction pilot office building. This paper reports a field study of pollutant removal effectiveness and CO₂ concentration at breathing level with a ducted variable air volume UFAD system in a LEED platinum building. A variety of occupancy densities, diffuser locations, and room types were evaluated. Overall, the performance of the UFAD was better than reported for the previously reported constant flow system. The characteristics of the spaces and conditions during measurement are compared with those in the previous study. Factors affecting differences in performance for the two systems are discussed.

11. Potential Flow Model for Predicting Perforated Tile Airflow in Data Centers (ML-11-028)

James VanGilder, P.E., Member¹, Zachary R. Sheffer, Student Member¹, Xuanhang (Simon) Zhang, Member¹ and Christopher M. Healey, Ph.D.¹, (1)APC by Schneider Electric, Billerica, MA

In a typical data center, cooling airflow is distributed to Information Technology (IT) equipment through a raised-floor plenum utilizing perforated tiles. While the most important parameter affecting cooling performance is the perforated tile airflow rate, this quantity varies greatly across the facility and many design factors influence the amount of air that can be delivered through any given tile. This paper proposes a method for predicting tile airflow that is substantially simpler, faster, and cheaper than traditional Computational Fluid Dynamics (CFD) while

providing sufficient accuracy for data center design and management applications. The method is based on a numerical finite difference solution of the potential flow problem. Novel aspects of the potential flow solution include an iterative flow-pressure coupling technique to determine tile airflows, an efficient unstructured Cartesian grid system, and problem-specific solution control parameters. Tools have been developed with both two and three-dimensional algorithms; the two-dimensional implementation provides the best compromise between speed and accuracy. These advances combine to produce an algorithm which predicts perforated tile airflow in “real time” for practical applications utilizing common computing hardware. Results have been validated against CFD and measured data.

12. Rethinking Percent Savings- The Problem with Percent Savings and ZEPI: The New Scale for a Zero Net-Energy Future (ML-11-029)

Charles Eley, P.E., Member¹, Kimberly Goodrich¹, John Arent, P.E.¹, Randall Higa, P.E., Member² and Devin Rauss, P.E., Member², (1)Architectural Energy Corporation, San Francisco, CA, (2)Southern California Edison, Irwindale, CA

This paper proposes a stable metric for comparing the energy efficiency of buildings. The paper examines the problem of using “percent savings better than a given energy code” to appraise a building’s energy performance. The baseline for this metric, “a given energy code,” can vary greatly in its inherent efficiency. As an alternative, the paper recommends a new scale – the Zero Energy Performance Index (zEPI) – that can be used to evaluate buildings in a stable, elegant manner. A zEPI score of “0” would be a zero net-energy building, while a score of “100” represents a building with average energy consumption as of the year 2000. The score for a given building will be higher or lower in linear relationship to the year 2000 benchmark. Finally, the benefits of zEPI are examined including those for energy codes, building rating programs, incentive programs, and addressing non-regulated energy loads.

13. Steam Heating System Upgrade to Vapor Heating System with Naturally Induced Vacuum (ML-11-030)

Igor Zhadanovsky, Ph.D., Applied Engineering Consulting, Newton, MA

Building retrofits is one of the largest energy saving opportunities today. In many old buildings steam systems are being converted into hot water heating systems at high cost. Anticipated fuel savings of around twenty to twenty seven percent is attributed not to improved system performance but mostly to the replacement or modification of old boilers. Meanwhile, the steam system performance can be normally improved by conversion into vapor/vacuum (negative pressure) system; fuel savings documented in old days were nearly 35%. Compared to conversion into hot water, changes are limited to adding vacuum pump into two pipe reasonably leak tight system. A new improved technology has been re-introduced - vapor heating with naturally induced vacuum - VHSNIV. It can be utilized in two- and single-pipe steam systems. VHSNIV employs no vacuum pump, simplifies operation and maintenance. Steam systems can be converted into vapor heating systems with significantly less cost and risk than into hot water. Possible applications include, but are not limited to, new residential and commercial buildings, existing steam system retrofits, steam district heating systems, high rise buildings, and Co-generation Heat and Power. Copper tubing and lightweight panel radiators are implemented instead of heavy cast iron radiators and piping in order to reduce VHSNIV new installations time, cost, and heat losses.

14. Updated Experimental Results for Heat Gain from Office Equipment in Buildings (1482-RP) (ML-11-031)

Mohammed H. Hosni, Ph.D., Fellow ASHRAE¹ and B. Terry Beck, Ph.D., Member¹, (1)Kansas State University, Manhattan, KS

Measurement of the heat loss from equipment in buildings is necessary in order to make accurate assessments of its impact on cooling loads. Advances in the design of buildings and improvement of the thermal characteristics of insulation materials and building envelope systems have significantly reduced the cooling load from external sources; however, the addition of various types of office equipment to buildings has become a major source of internal cooling load. Some equipment includes a nameplate rating showing total power consumption, while other equipment does not have this. Some manufacturers measure maximum electric power consumption by the

equipment and list that as power ratings on the nameplate or in the equipment literature, while others list the maximum power capacity of the system. Since the manufacturers' power ratings, if reported, are usually based on instantaneous measurement while equipment is working at maximum capacity, use of equipment nameplate values for cooling load calculations may lead to over sizing of air-conditioning equipment, resulting in extra initial cost as well as higher operating costs. On the other hand, underestimating the cooling load may result in insufficient cooling capacity. Another factor affecting calculation of cooling load is the split between the radiant and convective heat load from the equipment. The convection portion of the heat transferred from the equipment to the surroundings is an instantaneous load, since it is added to room air by natural or forced convection without time delay, whereas the radiation portion is absorbed by the surfaces of the room and then dissipated over time. Accurate determination of cooling load is important in proper sizing of air-conditioning equipment. This article presents experimental results for the total heat gain and radiant/convective split from a sampling of the different types of equipment used in offices. The nameplate vs. measured values, operational vs. idle values, and radiant vs. convective values are compared and discussed.

15. Zero Energy Buildings in France: Overview and Feedback (ML-11-032)

Aurélie Lenoir, Student Member¹, Francois Garde, Ph.D., P.E., Member¹ and Etienne Wurtz, Ph.D.², (1)University of Reunion Island, Le Tampon, Reunion, (2)University of Savoie, Chambéry, France

This paper presents an overview of the first positive/near Zero Energy Buildings in France -NZEB. The aim is to study the design methods and to identify the innovative solution sets. Nineteen French zero energy buildings and projects have been identified so far. Innovative solutions sets in terms of design and conception that emerge from this state of the art have been highlighted and are presented in the first part of the paper. For instance, a general trend concerns the shape of NZEB that are narrower in terms of width. This allows to use passive solutions such as cross natural ventilation and natural lighting on both sides of the building. Then, as few Net ZEBs around the world are already built so far, the three first French NZEBs will be presented in a second part in order to give a feedback on their construction, utilization and energy consumptions. The comparison of the energy consumptions during design phase and occupancy given in the last part shows that it is always complicated to forecast the consumption of a building. One of the major problems to specify the energy consumption during the design stage is the definition of a timetable to evaluate the occupancy of the future building. This work is part of a joint international program supported by the International Energy Agency "Towards Net Zero Solar Buildings".

Wednesday, 06/29
8:00 AM-9:30 AM

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Technical Paper Session 8 (Advanced)



Improving VAV System Controls

Track: Engineering Tools

Room: Cote St Luc

Chair: Dunstan Macauley, Encon Group, Inc., Kensington, MD

The papers in this session reviews existing control technologies and discusses technology gaps for incorporating plug and play and self-configuring concepts into HVAC control systems. The session also examines a variable air volume control technology to improve occupant comfort.

1. Impact of Decentralized Controllers for Temperature Control on Control Performance (ML-11-033)

Yuji Yamakawa¹, Takanori Yamazaki, Ph.D.², Kazuyuki Kamimura, Ph.D., Member³ and Shigeru Kurosu, Ph.D.⁴, (1)University of Tokyo, Tokyo, Japan, (2)Oyama National College of Technology, Oyama, Japan, (3)Yamatake Co., Ltd, Tokyo, Japan, (4)Research Institute "Crotech", Chikusei, Japan

Air-conditioning system is generally nonlinear and the parameters such as the gain constant, the time constant and the deadtime in a linearized plant model are strongly affected by the supply airflow rates (or a control input).

Unstable control characteristics may occur if the parameters are excessively large in the region of too small supply airflow rates. When the parameters vary due to changes in the operating points (that is an equilibrium point given by a function of control input and disturbance inputs), one of the main issues in tuning proportional-integral-derivative (PID) controllers is stability. To avoid such instabilities, decentralized controllers (two single loop controllers) for temperature control in variable air volume (VAV) system will be presented. A decentralized controller is designed to bring the supply airflow rates back to some desired amounts. When the supply airflow rates become smaller than the necessary amounts, the decentralized controllers are shut down except the centralized (primary) controller. The temperature control mode can be changed from the decentralized controller to the centralized one. Typical daily simulation results showing the control performance of the decentralized controllers will be presented.

2. A Plug and Play Framework for an HVAC Air Handling Unit and Temperature Sensor Auto Recognition Technique-Part 1: Review of Critical Analysis (ML-11-034)

Xiaohui Zhou, Ph.D., Member¹ and Ron M. Nelson, Ph.D., P.E., Member², (1)Iowa Energy Center, Energy Resource Station, Ankeny, IA, (2)Iowa State University, Ames, IA

A huge barrier to wider adoption of building automation systems (BAS) in commercial buildings is their complex, time-consuming, and often proprietary installation, configuration, and commissioning process. A framework for plug and play HVAC air handling unit (AHU) control systems is proposed in this study. This is the foundation and the first step towards a plug and play HVAC control system that will eventually lead to self-configuring HVAC control systems for automatic BAS set-up, configuration, commissioning, and possible automatic detection and repair of potential controls problems. This framework is built on commercially available smart transducers that are compatible with the IEEE 1451 family of standards. To solve the critical issue of resolving system ambiguity, a structural pattern recognition algorithm is developed to automatically recognize temperature sensor locations in an AHU. The algorithm can be a critical part of a plug and play or self-configuring HVAC control system in establishing a binding list of control system input/output and automated assignment and verification of the binding list.

This paper consists of two parts. Part I reviews existing technologies and discusses technology gaps for incorporating plug and play and self-configuring concepts into HVAC control systems. A plug and play framework for an AHU is then proposed. In Part II, a structural pattern recognition algorithm to automatically identify AHU temperature sensor locations and a scheme to resolve AHU system ambiguity are developed. A prototype of the plug and play framework for an AHU was built and tested in an experimental facility. Tests are conducted at various initial conditions, environmental temperatures, and chilled water system configurations, to demonstrate the feasibility of the framework and the robustness of the pattern recognition algorithm.

3. A Plug and Play Framework for an HVAC Air Handling Unit and Temperature Sensor Auto Recognition Technique- Part 2: Pattern Recognition and Test Cases (ML-11-035)

Xiaohui Zhou, Ph.D., Member¹ and Ron M. Nelson, Ph.D., P.E., Member², (1)Iowa Energy Center, Energy Resource Station, Ankeny, IA, (2)Iowa State University, Ames, IA

A plug and play framework for an HVAC air handling unit (AHU) control system is proposed in Part I of this paper. In Part II, a structural pattern recognition algorithm to automatically recognize temperature sensors is developed. A prototype of the framework was built and used in experiments designed to test the validity of the method for automatically recognizing the locations of temperature sensors in an AHU. The experiments demonstrated the ability of the prototype to successfully identify the location of each of eleven temperature sensors located at various positions in two air handling units running under diverse conditions.

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Conference Paper Session 15



Building Integrated Photovoltaic (BIPV) System

Track: Alternative Technologies

Room: Verdun

Chair: Michael Deru, Ph.D., Member, National Renewable Energy Laboratory, Golden, CO Shanti Pless, Member, National Renewable Energy Laboratory, Golden, CO

This session is dedicated to presentations related to the building integrated photovoltaic (BIPV) system as part of the Net Zero Energy Building Track.

1. The Redesign of An Italian Building to Reach Net Zero Energy Performances: A Case Study of the SHC Task 40 - ECBCS Annex 52 (ML-11-C040)

Maurizio Cellura, Ph.D.¹, Lucia Campanella¹, Giuseppina Ciulla¹, Valerio Lo Brano¹, Orioli Aldo¹ and Davide Nardi Cesarini², (1)Universita degli Studi di Palermo, Palermo, Italy, (2)Loccioni Group, Ancona, Italy

In the framework of international actions to reduce the energy requirements and greenhouse gases emissions due to buildings, a new International Energy Agency task has been recently established in order to study Net Zero Energy Buildings (NZEBs). The commonly shared concept of NZEB, is a building whose annual balance of energy consumptions and greenhouse gases emissions tends to zero. This concept is still too imprecise and the authors of this paper participate to the activities of SubTask B of IEA Task40 with the aim of establishing an internationally agreed understanding on NZEBs. The task is based on a common methodology and identifying and refining design approaches and tools to support industry adoption of innovative demand/supply technologies for NZEBs. This goal is pursued through detailed modeling and analysis of specific NZEB case studies. Among the specific objectives of the Sub Task B it is possible to include the analysis of redesigned studies. Redesigned studies should describe better alternative solutions for plants, building envelope or impact on the environment that significantly modify the building. To provide high quality information about the design process of a NZEB, it was decided to examine in detail the specific case study of the Leaf House located in Ancona, Italy. In the Leaf House are used the most advanced available technologies for the distribution of heat, the production of electricity from renewable sources to minimize environmental impact and to optimize the energy use. The purpose of this paper is to present some options able to improve the performance of the selected building, identified by using the collected data and analyzing a detailed TRNSYS model of plant-building complex. The model has allowed to evaluate in detail the effects of some changes in the design that can improve the behaviour of the Leaf House in the point of view of consumptions of energy resources and environmental impact of the building. The performed analysis show that the building envelope is already very effective in terms of thermal performances while the redesign of the thermal plants should permit to reach a nearly net zero energy performance. Furthermore, the adoption of a more effective strategy of monitoring and a better building automation system would significantly improve the energy and environmental behavior of the building. This case study allows the designer to explore design decisions and to stress the capability and the limits of the TRNSYS model.

2. Net-Zero in Vermont: The Putney School Field House (ML-11-C041)

Andy M. Shapiro, Member¹, Daniel C. Lewis, Member² and William Maclay³, (1)Energy Balance, Montpelier, VT, (2)Kohler & Lewis, Keene, NH, (3)Maclay Architects, Waitsfield, VT

The net-zero, 18,000 square foot Putney School Field House, first occupied November 2009, includes a gym and spaces for other recreation, health and socializing. The Field House is located at the Putney School, in Putney, VT, a rural area with approximately 6,700 heating degree-F days. This building incorporates micro-load enclosure design, daylighting, passive solar gain, and demand controlled ventilation to minimize loads. Heating is provided by VRV air-source heat pumps without back-up. Ventilation is variable volume from a central enthalpy wheel energy recovery ventilator serving CO₂-controlled VAV terminals in each space. The building is not air-conditioned but both automatic and manual natural ventilation for passive cooling are incorporated. A 37 kW tracking PV array is expected to provide as much electricity in a year as the building consumes for all services. The building is on track for a LEED 3.0 Platinum rating. Building statistics and first year energy data, including sub-

metered heat, ventilation, lighting and hot water, measured parasitic loads and why air-source heat pumps were chosen will be used to present this case study of a net-zero building in a cold climate. Lessons learned during commissioning and first year operation will be discussed including challenges relating to building net-zero in terms of cost, marketplace availability of components and first year operation issues. While the Putney School Field House is the largest and most successful net-zero building produced by this team, all members of the team have experience with multiple other net-zero projects. The presentation will be supplemented with lessons from other net-zero and renewably powered projects including residences, offices, institutional buildings, and manufacturing facilities to discuss other approaches to net-zero building in a northern climate

3. From High Performance Toward Net-Zero Buildings in Canada: Overview and Long-Term Perspective (ML-11-C042)

Mike Lubun¹, Michel Tardif, Member² and Stephen Pope³, (1)Natural Resources Canada, Ottawa, ON, Canada, (2)CanmetENERGY, Ottawa, ON, Canada, (3)CanmetENERGY Natural Resources Canada, Ottawa, ON, Canada

On average, Commercial Buildings in Canada have shown little improvement in their energy balance over the last decade. A recent study assessing the progress made in designing high performance buildings in Canada i.e. consuming less than 60% of the Energy Code Base line showed a pleasant significant number of these buildings. The same study identified however only few buildings being close to net-zero and no existing net-zero commercial building. This paper wants to identify what progress have been made and what are the gaps to reach the net-zero energy target.

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Seminar 49 (Intermediate)



Building Simulation 103: Inverse Modeling Tools

Track: Engineering Tools

Room: Lachine

Sponsor: 04.07 Energy Calculations, GPC 14

Chair: Chris Balbach, P.E., Member, Performance Systems Development of NY, LLC, Ithaca, NY

This seminar is intended to introduce participants to the means and methods of 'Inverse Modeling' techniques. Speakers present how to understand 'savings uncertainty,' how to physically interpret coefficients of inverse models and how to practically apply inverse models to estimate energy savings associated with building or system retrofits.

1. Understanding Savings Uncertainty

John Shonder, Member, Oak Ridge National Laboratory, Oak Ridge, TN

Determining the uncertainty in energy, water and demand savings from retrofit projects requires techniques from statistics, measurement theory, sample survey theory, and other fields. Due to the perceived difficulty of the calculations involved, reported project savings do not always include an analysis of uncertainty. ASHRAE's Guideline 14 – presently under revision – includes a brief overview of uncertainty analysis, and presents simplified equations for calculating the uncertainty associated with several types of sampling-based and regression-based savings models. The purpose of this seminar is to review the basics of uncertainty analysis, and to show how to calculate savings uncertainty to ensure compliance with Guideline 14. Several informative examples will be provided.

2. Common and Uncommon Applications of Inverse Models

William E. Koran, Member, QuEST, West Linn, OR

Many engineers working with existing buildings use inverse models more than they realize. Inverse, or more generally, data-driven models can be as simple as an ordinary linear regression to characterize natural gas use as a function of ambient temperature. More complex multi-parameter change point models can characterize whole building electricity use as a function of ambient temperature, and polynomial models can characterize variable-

speed fan or pump power as a function of flow. Data-driven models have a broad range of applications. They can support M&V, be used for diagnostics, and are sometimes used as inputs to a forward (physics-based) model. A most common example of the latter is the use of historical weather data for energy calculations. There are many other ways in which inverse models could, and should be used to support energy calculations, and such models are also under-utilized for diagnostics. This presentation will demonstrate a variety of examples of how inverse models can be useful to energy engineers and others involved with the energy performance of buildings.

3. Initial Findings in RP-1404 - Measurement, Modeling, Analysis and Reporting Protocols for Short-term M&V of Whole Building Energy Performance

Bass Abushakra, Ph.D., Milwaukee School of Engineering, Milwaukee, WI

This seminar reports on initial findings in RP-1404, which primary objective is to develop analysis methodologies by which the time period for field monitoring of energy use in buildings can be reduced to less than a whole year while satisfying preset accuracy levels of annual energy performance verification. Such methodologies would be of great benefit to the ongoing efforts to spur the diffusion of high performance buildings by actual monitoring, and to Energy Service Companies (ESCOs) and energy professionals who need a more cost-effective and acceptable alternative to year-long monitoring. Three application areas for this type of situation exist: (1) when detailed audit for investment grade energy conservation measures (ECM) are required; (2) when savings from already installed ECMs are to be verified against pre-retrofit claims using pre-post monitored data of pre-stipulated length; and (3) when claims made by newly constructed “green” or high performance building owners or designers are to be ascertained by actual monitoring as required for performance based certification.

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Seminar 50 (Basic)



Modeling the Past to Maintain the Future: Sustaining Historic Buildings through Computer Tools

Track: Engineering Tools

Room: Lasalle

Sponsor: 01.05 Computer Applications, Historical Committee

Chair: Tim Dwyer, Fellow ASHRAE, University College London, London, United Kingdom

The global challenge for maintaining and developing a sustainable built environment in the coming decades is from the 95%+ of buildings that are already here. This session provides real experiences of applying modern modeling techniques to historic buildings as a means of developing designs that preserve the past as well as ensuring a viable future.

1. Applying Computational CFD to Design Air Flow in Archeological Church of Christ in Cairo, Egypt

Essam Khalil, Ph.D., Fellow ASHRAE, Cairo University, Cairo, Egypt

This presentation shows how 3D Computational Fluid Dynamics (CFD) model was used to assess the airflow characteristics in the archaeological Church of Christ (hanging Church) in Cairo, Egypt. The objective was to optimise the air movement and relative humidity by properly locating the supply diffusers and extract ports to not only maintain comfort conditions but to ensure that the wall paintings were not degraded by the airflows. The outcome from the study and how the use of CFD studies enable sympathetic and sustainable design of ventilation systems is presented.

2. Revealing Design and Construction Challenges of Historical Buildings During BIM Creation

David Branson, P.E., Member, Compliance Services Group, Inc., Lubbock, TX

Significant building elements can become hidden over time, only to be rediscovered during building information model (BIM) development as part of a renovation project. Documentation of these findings can be critical, and often are quite time consuming. Several of the speaker’s experiences with BIM development on projects that involve buildings of historical significance will be examined, and some considerations will be offered to aid in successful project completion.

3. The Actual Reality of Predicted Energy Modeling for Historic Toronto Building

David Clark, Member, Stantec, Toronto, ON, Canada

Wychwood Barns was built in Toronto in 1913 as a streetcar service garage, and is an important example of local, historical, industrial architecture. Abandoned until 2008, a local community partnership was formed to re-develop the site to provide affordable live/work studios for artists and community spaces for the arts. Key aims included community engagement, heritage preservation, and sustainable recognition (including aiming to become the first historic building in Canada to attain LEED® Gold Certification). The building's energy use was modeled as part of the MEP design and David will present the lessons learned from actual performance following a year of occupancy.

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Seminar 51 (Intermediate)

New and Improved Lubricants to Accommodate Low Global Warming Potential Refrigerants

Track: HVAC Applications

Room: Westmount

Sponsor: 03.04 Lubrication, 03.02 Refrigerant System Chemistry

Chair: Scott R. Gustafson, Member, Shrieve Chemical Products, Inc., The Woodlands, TX

The transition to low global warming potential (LGWP) refrigerants is critical to developing environmentally sustainable energy efficient refrigeration technologies suitable for net-zero energy applications. Lubricants optimized for HFC refrigerants are no longer suitable for use with many of the LGWP refrigerants being considered today. Significant energy savings can be achieved through proper optimization of lubricant/refrigerant solution properties to provide the best balance of lubrication in the compressor while maintaining excellent heat transfer in the refrigeration cycle. This seminar discusses fundamentals of lubrication, the important criteria for refrigeration lubricants and the development of lubricants designed specifically for LGWP refrigerants.

1. Fundamentals of Lubrication and the Development of Lubricants Optimized for Use in LGWP Refrigerant-Based Applications

Edward Hessell, Ph.D., Member, Chemtura Corporation, Middlebury, CT

The optimization of lubricant properties for use with a particular refrigerant is important to achieve the best overall balance of low energy consumption and reliability in the compressor, with good heat transfer properties and oil return in the refrigeration cycle. This paper will describe some lubrication fundamentals and explain some of the special lubrication issues associated with various LWGP refrigerants. One example will be presented on the development of a lubricant with properties optimized for trans-critical carbon dioxide applications.

2. Comparative Review of Synthetic Lubricants Applicability for LGWP Refrigerants

Elizabeth Dixon, Ph.D., Member, Shrieve Chemical Products, Inc., The Woodlands, TX

This paper presents a review of the primary lubricant choices available for application with LGWP refrigerants such as HFO and CO₂, and presents a comparison of key lubricant performance indicators. The technical considerations to be made when designing and selecting lubricants for use with low GWP refrigerants are reviewed. Data for traditional POEs and PAGs is compared with refrigerant specific adaptations of the POE and PAG technology, and includes the viscometrics of refrigerant/lubricant mixtures, load carrying capabilities and chemical / thermal / oxidative / hydrolytic stability of these mixtures.

3. Energy Efficiency Gains: Power of the Lubricant

Joseph Karnaz, Member, CPI Engineering/Lubrizol, Midland, MI

Sustainability has become a major force in development of products for refrigeration and air conditioning. Not only do designers need to be concerned with environmental aspect of products, like the use of LGWP refrigerants, but also energy consumption required to operate equipment. Regulations are being implemented to assure that equipment meets mandated requirements for energy efficiency. One way to provide energy efficiency gains with

LGWP refrigerants is to make changes to the lubricant used in compressor systems. This simple yet impacting change can be accomplished with no change to the system.

4. Lubricants for LGWP Refrigerants HFO-1234yf and HFO-1234ze

Christopher Seeton, Ph.D., Member, Honeywell, Buffalo, NY

HFO-1234yf has been chosen by the automotive industry to replace R-134a as the refrigerant in vehicle air conditioning systems. As regulations start to take place reducing the environmental footprint of stationary equipment, new alternatives are being sought to replace R134a in those applications. HFO-1234yf and HFO-1234ze are two new alternative refrigerants with GWP < 6 to replace R-134a with a GWP of 1430. A study has been undertaken to determine suitable lubricants for use with these new fluids in a variety of application scenarios (refrigerators and AC) with different compressor requirements. The results of this study are presented here.

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Seminar 52 (Intermediate)



Solar Cooling in the U.S. and Abroad

Track: Alternative Technologies

Room: Outremont

Sponsor: 08.12 Desiccant Dehumidification Equipment and Components, 06.07 Solar Energy Utilization

Chair: Andrew Lowenstein, Ph.D., Member, AIL Research, Inc., Princeton, NJ

Meeting a building's heating and cooling loads is one of the greatest challenges to designing a net zero energy building. Solar thermal collectors are commonly used to provide space and water heating in NZE buildings, but these solar systems often have excess capacity in the summer when solar insolation is greatest. Thermally driven cooling technologies are now meeting this need for year-round solar thermal loads. The seminar focuses on the experience with operating solar cooling systems that use desiccant, absorption and adsorption technologies.

1. A Survey of Solar Cooling Technologies in North America

Lucio Mesquita, Ph.D., Associate Member, Thermosol Consulting, Toronto, ON, Canada

In recent years more than 150 solar cooling systems have been installed worldwide, most with cooling capacity above 30 tons. The presentation includes a survey of 22 North American solar cooling installations that describes the number of systems, collector area and technology, and heat rejection technology. The survey draws a parallel with European systems installed in the last few years. A brief analysis of the challenges and opportunities for solar cooling in North America is discussed.

2. Design and Installation of the Solar Cooling Pilot Project at Shouldice Hospital in Toronto

Darren Cooper, P.Eng., Member, Glenbarra Energy Management Corp., Mississauga, ON, Canada

The design and installation of a solar cooling system at the Shouldice Hospital in Toronto is described. The core components of the system include 10 solar cooling machines that use an innovative triple-state absorption technology and 131 high performance evacuated tube solar collectors. Based on preliminary energy modeling, the Heating/Cooling System is targeted to offset 36% Heating, 44% Cooling and 91% Domestic Hot Water loads and reduce CO₂ emissions annually by an estimated 150 tonnes. This is Canada's first ever "Triple-State" absorption, thermally driven, Heating/Cooling system designed to address the cooling, heating and domestic hot water needs of the hospital using energy from the sun.

3. Canada's Largest Solar Thermal Cooling Project

Suni Ball, Proterra Solar, Woodstock, ON, Canada

The presentation covers the construction and operation of the Oxford Gardens Solar Cooling project. Topics will cover delays, over budget, cost saving ideas and "lessons learned" in the construction and operation of the project. We will review performance to date and any changes planned to improve this performance.

4. Operating Experience on a 3,000-CFM Solar Dedicated Outdoor Air System

Jesse Dean, Member, National Renewable Energy Laboratory, Golden, CO

In 2010, a 3,000-cfm liquid desiccant air conditioner (LDAC) was started up at the Tyndall Air Force Base in Panama City, FL under sponsorship of the Department of Defense's ESTCP program for new energy technology. A 1,000 square foot evacuated-tube solar array provides 100% of the thermal requirements to run the LDAC. Performance data for the solar LDAC will be discussed as will lessons learned during the commissioning and initial operation of the system.

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Seminar 53 (Intermediate)



Standard 62.1 Current Pressures and Challenges

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: SSPC 62.1

Chair: Eli Howard III, Member, SMACNA, Chantilly, VA

The session explores the pressures and challenges faced by designers, owners and facility operators of dealing with net zero energy buildings when faced with meeting IAQ requirements and the real and perceived economic impacts of these decisions.

1. How Do We Deal with the Challenges of Net Zero Buildings

Michael Apte, Ph.D., Member, Lawrence Berkeley National Laboratory, Berkeley, CA

2. How Do We Deal with the Real and Perceived Economic Impact

Roger Hedrick, Member, Architectural Energy Corp., Boulder, CO

3. Dealing with Ozone and Outdoor Air Requirements

Hal Levin, Fellow ASHRAE, Building Ecology Research Group, Santa Cruz, CA

Wednesday, June 29, 2011, 8:00 AM-9:30 AM

Seminar 54 (Intermediate)

The Four Cornerstones of High Performance Teams

Track: Professional Skills

Room: Hampstead

Chair: David Zimmerman, P.E., Member, Rollie Johnson, Inc., St. Lois, MO

In today's global marketplace, the demands on human resources are great. People are expected to be more productive with less time. How does this affect the quality of your product or service, absenteeism, performance and profit? We all know that the right environment creates a platform where people and productivity thrive. The challenge is how to tap into the potential of the company's greatest resource, its people, to create alignment with the corporate mission and objectives. This seminar introduces four core skills that will help leaders and teams create a culture of motivation, creativity, productivity and profit.

1. The Four Cornerstones of High Performance Teams

Godfrey H.J. Nash, P.Eng., Member, Keystone Marketing Inc, Vancouver, BC, Canada

In today's global marketplace, the demands on human resources are great. People are expected to be more productive with less time. How does this affect the quality of your product or service, absenteeism, performance and profit? We all know that the right environment creates a platform where people and productivity thrive. The challenge is how to tap into the potential of the company's greatest resource, its people, to create alignment with the corporate objectives and mission. This seminar will introduce four core skills that will help leaders and teams create a culture of motivation, creativity, productivity and profit.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Conference Paper Session 16



Building Energy Modeling to Improve Energy Efficiency

Track: HVAC Systems and Equipment

Room: Lasalle

Chair: Gary Debes, Member, SNC-Lavalin Project Services, Exton, PA

The papers present modeling and calibration processes for building energy models and how the process can maximize energy conservation with commissioning of building systems and measurement and verification (M&V).

1. Modeling and Calibration of Energy Models for a DoD Building (ML-11-C043)

Zheng O'Neill, Ph.D., P.E., Member¹, Shui Yuan¹, Trevor Bailey¹, Satish Narayanan¹, Vladimir Fonoberov, Ph.D.² and Bryan Eisenhower, Ph.D., Member³, (1)United Technologies Research Center, East Hartford, CT, (2)Aimdyn, Inc., Santa Barbara, CA, (3)UCSB-Center for Energy Efficient Design, Santa Barbara, CA

Calibrated energy models are useful for commissioning of building systems, measurement and verification (M&V) of retrofit projects, and predictions of savings from energy conservation measures (ECMS). This paper presents the modeling and calibration process for building energy models of a DoD building. The models are developed using the EnergyPlus and TRNSYS simulation programs with measured data from an enhanced building management system (BMS) including an on-site weather station. The building under study is the Naval Station Atlantic Drill Hall located at Great Lakes, IL. This LEED Gold certified building with a total floor area of 69,218 ft² (6,431 m²) mainly consists of a drill deck and administration offices. Static data from as-built drawings and dynamic data from building operations are collected and analyzed to create energy models with EnergyPlus and TRNSYS. An extensive sensitivity study by systematically perturbing more than a thousand parameters is employed for model calibration. Those parameters that most affect the building's energy end-use are selected and refined to calibrate the models. The calibration results, as well as problems encountered throughout the process from the user's perspective, are discussed. The total facility and individual equipment electricity consumption predictions from the models closely match the actual measured data.

2. Modeling the Commercial Buildings Sector: An Agent-Based Approach (ML-11-C044)

Ignacio J. Martinez-Moyano, Ph.D.¹, Eric R. Tatara, Ph.D.¹, Fei Zhao¹, Diane J. Graziano, Ph.D.¹ and Guenter Conzelmann¹, (1)Argonne National Laboratory, Argonne, IL

During the simulations, the decision makers interact and decide on courses of action relevant to the buildings stock (adopting energy efficiency measures, building new buildings, changing existing buildings, and demolishing buildings that no longer fit the needs or priorities of the owners). As the different actions of decision makers occur, the existing buildings stock is modified, sending crucial information cues back to the decision makers that influence their future courses of action. Different actors process information in different ways and with different degrees of accuracy; the model offers realism to the results by capturing different levels of variability in decision-making approaches of all decision-maker types. By using deductive capabilities to aid in the identification of the dynamic implications of interacting actors and policies in the commercial buildings sector, the agent-based model of the commercial buildings sector then becomes fully coherent, with a high level of correspondence to the reality of the sector. The prototype model and initial simulation results are presented. Achieving commercial building energy-efficiency targets strongly depends on the dynamics between the various market participants and how those dynamics are impacted by different physical and institutional constraints. Modeling can improve our understanding of how the diverse set of players within this market interact and choose to adopt (or not adopt) energy-efficient technologies and/or operations. Agent-based methods facilitate the representation of decision-maker diversity, are naturally amenable to geographic modeling, and are suited to represent highly complex and changing markets. We develop a Commercial Buildings Sector Agent-based Model (CoBAM) prototype that considers five general types of decision makers: owners, users, developers, building and energy professionals, capital providers, and community and regulatory interests. In the prototype, the commercial buildings sector is represented by nine types of buildings—or subsectors: education, food sales and service, healthcare, lodging, retail sales and services, office, assembly, warehouse, and other. For the simulations, we use data and characteristics of reference buildings

developed by DOE to populate an ecology of buildings that change over time as a function of investment decisions in maintenance levels and technology adoption.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Conference Paper Session 17



How Can Implementing Building Energy Audits Improve Energy Efficiency

Track: Engineering Tools

Room: Lachine

Chair: Steve Baumgartner, Associate Member, Buro Happold, New York, NY

The papers discuss updates to the publication and energy auditing methods that professionals can apply to their professional practice as well as implementation and verification studies to confirm the results of energy audits.

1. Updated Procedures for Commercial Building Energy Audits (ML-11-C045)

Jim Kelsey, P.E., Member¹ and Richard J. Pearson, Member², (1)kW Engineering, Oakland, CA, (2)Pearson Engineering, Madison, WI

In recent years ASHRAE and our nation have directed increasing attention towards the energy use of existing buildings. We've been reminded by former president Gordon Holness that "86% of building construction expenditures relate to renovation of existing buildings." If we are to guide our society towards a sustainable future, reduce our dependence on imported energy, and reduce our carbon footprint, we will need to reduce the energy use of our aging building stock. One important way to do that is through identifying energy efficiency opportunities through assessments in commercial buildings – commonly referred to as energy audits. While energy audits are a commonly-used component of our industry, there is great diversity in the services delivered to customers, and little industry standardization. ASHRAE seeks to promote best practices and fill a void in available information through publishing a new version of the special publication "Procedures for Commercial Building Energy Audits." The goals of the publication will be to provide a reference guide for building owners, government entities as to what to expect from an audit, establish guidelines for level of audit effort (i.e. I, II, III), and to introduce good audit procedures for energy auditors. The paper will discuss updates to the publication and energy auditing methods that professionals can apply to their professional practice. Topics will include definitions of energy audit levels of effort (currently referenced by LEED EB), how to build a successful team, successful approaches to site visits, incorporating onsite measurements, economic evaluation of measures, and how to organize an energy audit report that promotes action on the part of building owners and their staff.

2. Analysis of Measurement and Verification Methods for Energy Retrofits Applied to Residential Buildings (ML-11-046)

Tim Guiterman, Associate Member¹ and Moncef Krarti¹, (1)University of Colorado, Boulder, Boulder, CO

Thirty low-income housing units located in the high altitude San Luis Valley of Colorado received various energy conservation measures (ECM) in the summer of 2007. Measures included new furnaces, new tankless water heaters, programmable thermostats, addition/repair of roof insulation, existing furnace tune-up (where applicable), CFL bulbs and minor air sealing. Measurement and verification of the energy savings consisted of pre- and post-retrofit walk-through audits, blower door testing and temperature monitoring of select units.

Verification methods consist of two whole building approach methods in addition to the calibrated simulation approach, following the ASHRAE Guideline 14-2002 protocols. All three methods are shown to produce remarkably similar savings estimates, with whole building approach methods being the simplest and least costly (time-intensive) to utilize for savings verification. The analysis provides insight into the effectiveness of the various methods as well as the impacts of the ECMs on residential energy consumption.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Conference Paper Session 18



Unique Applications of Photovoltaic Systems

Track: Alternative Technologies

Room: Hampstead

Sponsor: 06.07 Solar Energy Utilization

Chair: Bryan R. Becker, Ph.D., P.E., Fellow ASHRAE, University of Missouri-Kansas City, Kansas City, MO

This session focuses on unique applications of photovoltaic systems. The applications include both a full scale building integrated photovoltaic/thermal system utilizing a transpired collector as well as a feasibility study of installing photovoltaic systems on several landfills that are targeted for closure.

1. Photovoltaics on Landfills in Puerto Rico (ML-11-C047)

James Salasovich¹, Gail Mosey¹ and Lars J. Lisell¹, (1)National Renewable Energy Laboratory, Golden, CO
The U.S. Environmental Protection Agency (EPA), in accordance with the RE-Powering America's Land initiative, selected the Commonwealth of Puerto Rico for a feasibility study of renewables on several brownfield sites. The EPA defines a brownfield as "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant." All of the brownfields in this study are landfill sites. Citizens of Puerto Rico, city planners, and site managers are interested in redevelopment uses for landfills in Puerto Rico, which are particularly well suited for solar photovoltaic (PV) installation. The purpose of this report is to assess the landfills with the highest potential for possible solar PV installation and estimate cost, performance, and site impacts of three different PV options: crystalline silicon (fixed-tilt), crystalline silicon (single-axis tracking), and thin film (fixed-tilt). Each option represents a standalone system that can be sized to use an entire available site area. In addition, the report outlines financing options that could assist in the implementation of a system. The feasibility of PV systems installed on landfills is highly impacted by the available area for an array, solar resource, operating status, landfill cap status, distance to transmission lines, and distance to major roads. All of the landfills in Puerto Rico were screened according to these criteria in order to determine the sites with the greatest potential. Eight landfills were chosen for site visits based on the screening criteria and location. Because of time constraints and the fact that Puerto Rico is a relatively large island, the eight landfills for this visit were all located in the eastern half of the island. The findings from this report can be applied to landfills in the western half of the island. The economics of a potential PV system on landfills in Puerto Rico depend greatly on the cost of electricity. Currently, PREPA has an average electric rate of \$0.119/kWh. Based on past electric rate increases in Puerto Rico and other islands in the Caribbean, this rate could increase to \$0.15/kWh or higher in a relatively short amount of time. In the coming years, increasing electrical rates and increased necessity for clean power will continue to improve the feasibility of implementing solar PV systems at these sites.

2. Design and Performance of a Photovoltaic/Thermal System Integrated with Transpired Collector (ML-11-C048)

James Bambara¹, Andreas Athienitis, Ph.D., P.E., Member¹ and Brendan O'Neill¹, (1)Concordia University, Montreal, QC, Canada

Building-integrated photovoltaic/thermal (BIPV/T) systems may be utilized to produce useful heat while simultaneously generating electricity from the same building envelope surface. A well known highly efficient collector is the open-loop unglazed transpired collector (UTC) which consists of dark porous cladding through which outdoor air is drawn and heated by absorbed solar radiation. Commercially available photovoltaic systems typically produce electricity with efficiencies up to about 18%. Thus, it is beneficial to obtain much of the normally wasted heat from the systems, possibly by combining UTC with photovoltaics (PV). The airflow behind the PV modules not only recovers thermal energy but also increases the electrical efficiency of the modules due to lower operating temperatures. Combination of BIPV/T and UTC systems for building facades is considered in this paper - specifically, the design of a prototype façade-integrated photovoltaic/thermal system with transpired collector (BIPV/T). A full scale prototype is constructed with 70% of UTC area covered with PV modules

specially designed to maximize heat recovery and tested under outdoor sunny conditions with low wind. Preliminary experimental results indicate that the combined thermal/electrical efficiency for the BIPV/T prototype varies from about 24% to 36% at the low and high flow rates, respectively. The ideas and results of the experimental design concept were used as major input for the design of a full scale BIPV/T system for a new office building – that of the John Molson School of Business (JMSB) at Concordia University located in Montreal. This active BIPV/T system replaces the building envelope of the near south-facing façade of the mechanical room, where its proximity to the fresh air intake reduces the need to build long ducts from the façade to the HVAC system. This 288 m² installation utilizes 384 building-integrated PV modules (the same modules used in the prototype) connected to five inverters. The system has a peak power output of 24.5 kW, while also preheating up to about 7.5 m³/s of fresh air for the building occupants. Detailed design and performance considerations of this project and similar full scale systems will be presented in this paper along with the various parameters that need to be considered for such a system; these include instantaneous price/value of heat and electricity, need for fresh air preheating, potential use of heated air outside the heating season and comprehensive optimization considerations.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Seminar 56 (Intermediate)



Are Net Zero Laboratories Even Possible, and if So How?

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 09.10 Laboratory Systems

Chair: Gordon P. Sharp, Member, Aircuity, Inc., Newton, MA

Laboratories with their intense use of outside air and safety concerns are one of the most challenging building types to achieve net zero. In fact, some might say it can't be done at least for many climates. However, a path does exist to achieve net zero using multiple technologies such as VAV lab and exhaust fan control, demand based control of ACH's, chilled beam or hydronic cooling, and possibly heat recovery. This seminar explores this topic from a holistic viewpoint and provides an actual case study of a large near net zero lab project in the UAE.

1. A Holistic Overview of Technologies and Strategies to Achieve Net Zero Labs

Gordon P. Sharp, Member, Aircuity, Inc., Newton, MA

As we strive to build more and more energy efficient laboratories whether to achieve net zero buildings, campuses, or only to significantly reduce energy expenses, the most impactful approach for many laboratories is to significantly reduce the volume of airflow moving through the building. The challenge is how to do this safely and cost effectively in the face of multiple lab building requirements related to the fume hoods, thermal loads and dilution ventilation. In the last few years there have been new design approaches that have been used to reduce lab airflows and reduce energy consumption including demand based control of air changes and hydronic cooling approaches such as chilled beams. Furthermore, in the last year, the major lab standards of NFPA 45 and ANSI/AHIA Z9.5 have also changed, and now provide for significantly reduced fume hood minimum flow rates down to about 40% of what was previously recommended. Although these and other concepts have been discussed individually, what has been lacking is a unified or holistic discussion of how these changes to the traditional lab design paradigm can be used together as well as combined with other energy saving technologies such as heat recovery to create a whole that is greater than the sum of the parts. This presentation will discuss the pros and cons of these technologies and approaches and how they can be combined to safely attain as low as 2 ACH of lab room airflow. The success of these approaches and the impact of combining them to save the most energy will be analyzed for many different climate conditions using new lab energy analysis software that contains a specialized lab HVAC model. Finally, a couple case studies of lab designs using these technologies will be provided including use in a near net zero lab building.

2. Case Study of a Large near Net Zero Lab Project in the UAE

Paul Lemestre, P.E., Member, Research Facilities Design, San Diego, CA

The Masdar City project in Abu Dhabi, UAE is one of the largest and most aggressive sustainable building projects in the world. The Abu Dhabi government is attempting to build an entire 6 square kilometer community including a new university as a near net zero carbon community. A variety of new technologies are being used including even waste to energy systems and replacing cars in some areas with automated personal electric vehicles. The first part of the project is the Masdar Institute of Science and technology (MIST) that is a new university focused on renewable energy and energy efficiency research that is in cooperation with MIT. Approximately 500,000 square ft. of mixed use space is currently occupied or being commissioned including about 75,000 sq. ft. of net lab space and a small cleanroom. Another 1,000,000 sq. ft. of facilities is currently under construction with another 150,000 sq. ft. of lab space. The design of the lab facilities will be described as well as the challenges faced and solutions employed to create a near net zero site in an extremely harsh climate with some of the worst temperature and humidity design conditions in the world.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Seminar 57 (Intermediate)



Helping Smart Grid Make the Grade with Energy Storage

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 06.09 Thermal Storage, 07.05 Smart Building Systems

Chair: Geoffrey C. Bares, Associate Member, CB&I, Plainfield,, IL

Smart grid technology is predicted to transform energy usage and optimize energy delivery, but it will require demand response capability to reach its full potential. Thermal energy storage (TES) is a proven technology that can meet this need by reducing power consumption during times of peak cooling load. This seminar explores how energy storage and the smart grid will be interlinked and why thermal energy storage should play a prominent role in the power grid of the future.

1. Energy Storage: An Integral Part of the Smart Grid

Mark MacCracken, P.E., Member, CALMAC Manufacturing Corp, Fair Lawn, NJ

The electric grid is now based on what was once thought of an endless supply of stored energy, mainly fossil fuels. The world's need to reduce its carbon emissions by, in part, reducing dependence on fossil fuel, will completely change the makeup of our electric delivery system. Renewable sources of energy like wind or solar are being added to a grid that has almost no ability to store that energy. As we move towards a higher percentage of renewables (or nuclear) on the grid enormous amounts of energy storage are going to be needed in order to make that energy dispatchable when we need it. The Smart Grid should be able to optimize this new dimension of the grid.

2. Unitary Thermal Storage Systems: An Intelligent Distributed Energy Resource

Brian Parsonnet¹ and Robert Willis, Member¹, (1)Ice Energy, Fort Collins, CO

Unitary Thermal Storage Systems (UTSS) can be deployed as a facility or utility asset. As a utility asset, it provides a scalable and dispatchable distributed energy resource. This presentation explores the design and capabilities of UTSS as they are applied for utility grid-scale deployments. An overview of the system and its design are provided followed by a description of the system's smart grid capabilities. Reporting, control and scheduling strategies are presented that allow utilities to create an aggregated energy storage resource capable of responding to changing system conditions and shaping peak demand.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Forum 9 (Intermediate)

Incorporating Acoustics into BIM

Track: Engineering Tools

Room: Verdun

Sponsor: 02.06 Sound and Vibration Control, 01.05 Computer Applications

Chair: Andrew Mitchell, Member, Acoustic Dimensions Inc., Dallas, TX

With the advent and progressive adoption of BIM in the building systems design community, there are opportunities to incorporate good design practices related to noise control in BIM models. The session discusses current known practices related to acoustics and noise control and to explore future possibilities and how ASHRAE may be able to help.

Wednesday, June 29, 2011, 9:45 AM-10:45 AM

Forum 10 (Advanced)

Should ASHRAE Have a Standard on Building Envelopes

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 01.12 Moisture Management in Buildings, 04.04 Building Materials and Building Envelope Performance

Chair: Raymond Patenaude, P.E., Member, The Holmes Agency, Inc., Tierra Verde, FL William B. Rose, Member, University of Illinois Building Research Council, Champaign, IL Anton Ten Wolde, Member, University of Wisconsin, Madison, WI

HVAC designers rely on the building envelope to control thermal and hygro-thermal loads from the outdoor environment. Yet, there are very little requirements regarding these issues and no organization has taken ownership of the parameters. If ASHRAE and its members are to achieve net zero energy design for buildings, the building envelope must control and reduce to a minimum, thermal transport, vapor diffusion, air exfiltration and infiltration.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Technical Paper Session 9 (Intermediate)

Modeling and Comparison of ECM and PSC Motors in Series and Parallel Fan Powered VAV Terminal Units

Track: HVAC Systems and Equipment

Room: Outremont

Sponsor: 05.03 Room Air Distribution

Chair: Gus Faris, Member, Nailor Industries Inc., Houston, TX

Electronically commutated motors (ECMs) have begun to be used on the fan motors in fan powered terminal units (FPTUs). This session provides performance data on ECM series and parallel terminal units with 8 in. (203 mm) and 12 in. (304 mm) primary inlets from three terminal unit manufacturers and two motor manufacturers. Semi-empirical models were developed for fan airflow output, fan power consumption, and primary airflow for parallel fan powered variable air volume terminal units with electronically commutated motors. The papers in this session are an extension to the prior work on FPTUs with SCR controllers in 1292-RP.

1. Performance of Series Fan Powered Terminal Units with Electronically Commutated Motors (ML-11-036)

Dennis L. O'Neal, Ph.D., P.E., Fellow ASHRAE¹, Jacob L. Edmondson², John Bryant, Ph.D., P.E., Member³ and Michael Davis, Ph.D., Associate Member⁴, (1)Texas A & M University, College Station, TX, (2)Goetting and

Associates, San Antonio, TX, (3)Texas A&M University at Qatar, Dohar, Qatar, (4)New York University, Abu Dhabi, United Arab Emirates

Semi-empirical models were developed for fan airflow output, fan power consumption, and primary airflow for series fan powered variable air volume terminal units with electronically commutated motors. Eight series terminal units with either 8 in. (203 mm) or 12 in. (304 mm) primary inlets from three terminal unit manufacturers and two motor manufacturers were evaluated. Fan power and airflow data were collected at a downstream static pressure of 0.25 in. w.g. (62.3 Pa). Upstream static (primary air) pressures were varied from 0.0 in. w.g. to 2.0 in. w.g. (0 Pa to 498 Pa). Data were collected at four primary inlet damper positions and at four fan motor settings. Model variables included primary air inlet damper position, fan motor input setting, the air inlet differential sensor pressure, and the upstream (primary air) and downstream (supply air) static pressures. All of the resulting fan power and airflow models had R^2 values greater than 0.895. The models for the fan airflow output and fan power had R^2 values greater than 0.968. The models developed in this paper can be used in HVAC simulation programs to estimate the energy use and potential savings of series fan powered terminal units with electronically commutated motors.

2. Performance of Parallel Fan Powered Terminal Units with Electronically Commutated Motors (ML-11-037)

Dennis L. O'Neal, Ph.D., P.E., Fellow ASHRAE¹, Jacob L. Edmondson², Michael Davis, Ph.D., Associate Member³ and John Bryant, Ph.D., P.E., Member⁴, (1)Texas A & M University, College Station, TX, (2)Goetting and Associates, San Antonio, TX, (3)New York University, Abu Dhabi, United Arab Emirates, (4)Texas A&M University at Qatar, Dohar, Qatar

Measurements were made on eight fan powered terminal units that utilized electronically commuted fan motors. Semi-empirical models were developed for fan airflow output, fan power consumption, and primary airflow for parallel fan powered variable air volume terminal units with electronically commutated motors. Units with both 8 in. (203 mm) and 12 in. (304 mm) primary inlets from three different manufacturers were tested. Fan power and airflow data were collected at downstream static pressures ranging from 0.1 in. w.g. to 0.5 in. w.g. (25 Pa to 125 Pa). Upstream static pressures were varied from 0.0 in. w.g. to 2.0 in. w.g. (0 Pa to 498 Pa). Data were collected at four different primary inlet damper positions and at four different control input voltage settings to the electronically commuted motors. Model variables included primary air inlet damper position, input voltage setting, the air inlet differential sensor pressure, and the upstream (primary air) and downstream (supply air) static pressures. Each terminal unit was also tested with the fan off to characterize any leakage from the unit. Most of the resulting fan power and airflow models, except leakage, had R^2 values greater than 0.90. The models for terminal unit leakage had R^2 values that ranged from 0.826 to 0.972. These models could be used in HVAC simulation programs to estimate the performance of parallel fan powered terminal units with electronically commutated motors. In addition, the potential savings of using EMC versus SCR controlled motors could be explored.

3. Inlet Installation Effects on Forward Curved Centrifugal Fans, Air Performance and Sound (ML-11-038)

Mark Stevens, AMCA International, Arlington Heights, IL

It has been known to the air moving industry for some time that duct fittings installed close to a fan's inlet or outlet can have adverse effects on the fan's performance. The magnitude of these adverse effects is generally determined through laboratory testing, and the body of knowledge is relatively small compared to the possible number of combinations of fan types, duct and inlet configurations, and duct fittings.

The purpose of the research project described in this paper was to determine the effect of a limited number of various inlet installations and product configurations on the air performance and sound of a typical forward curved centrifugal fan. Forward curved fans are common in heating, ventilating, and air conditioning systems.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Conference Paper Session 19



Data Center Sustainability of Systems; Design Techniques to Improve Water, Air and Equipment

Management

Track: HVAC Applications

Room: Westmount

Sponsor: 09.09 Mission Critical Facilities, Technology Spaces and Electronic Equipment

Chair: Wade Conlan, P.E., Member, exp, Maitland, FL

The design of data centers can drastically influence the energy performance of the facility and its PUE. Learn how to utilize rain and other water sources to increase the efficiencies. Also, learn an approach for embedding operations and maintenance (O&M) best practices considerations into the design increasing the chance of sustaining its performance. Finally, through the proper selection of floor tiles, assist in optimizing the important operational and maintenance issues for cooling the data center – delivering cold air to the servers, minimizing bypass and recirculation airflows and adjusting the quantity and placement of the tiles as the facility loads change over time.

1. Sustainable and Energy Efficient Uses of Rain and other Water Sources for Data Centers (ML-11-C049)

Gregory R. Jeffers, P.E., Member, McKenney's, Inc., Atlanta, GA

A recent report by the U.S. Environmental Protection Agency indicates that data centers now account for approximately 1.5% of energy consumption in the United States, with energy consumption expected to double by 2013. In addition, newer energy codes such as ASHRAE 90.1, 2010 dictate standardized efficiency requirements, now placing data centers under this code for the first time in history and requiring many data centers to have some sort of economizer. As the latest focus for data centers have been primarily on energy efficiency, the building industry as a whole has been moving towards additional sustainable practices for overall improvement of the environment. There is currently under development LEED (Leadership in Energy and Environmental Design developed by the US Green Building Council) criteria for Data Centers. One part of that rating is water conservation and the collection of rainwater and cooling coil condensate. Water is increasingly becoming more of a sustainable concern for all facilities and is expected to rival power use in the future for cost and availability. The purpose of this paper is to identify how water conservation, primarily the use of rain water and condensate can increase the efficiency of the data center, lower the PUE, improve reliability, increase capacity, reduce the water required at the facility and reduce the amount of water utilized at the regional power plant. This process lowers the water required for the entire region and reduces energy, a win-win situation. This paper will also describe how these systems can be utilized in lieu of some of the newer code required economizers where standard air and waterside economizers are impractical for various reasons and includes information from various case studies and actual installations, which will be used to summarize various application, installation, operation and maintenance requirements.

2. A Holistic Approach to Embed Operations & Maintenance Best Practices in the Design of Critical Facilities (ML-11-C050)

Terry Rodgers, Member, Syska Hennessy Group, Concord, NC

This paper discusses Operations and Maintenance (O&M) Best Practices including implementation strategies as applied to Critical Facilities. The discussion begins with a high-level discussion of the overall goals, objectives, and strategies associated with best-in-class operations and maintenance. The paper then discusses in detail how to design and implement O&M practices and is broken down into four main sub-topics of designing for maintainability, construction, startup, and commissioning, O&M staffing and organization, and O&M processes. The overall message is that O&M considerations should be embedded throughout the programming, design, construction, and commissioning phases to ensure qualified, trained staff and quality O&M processes are in place when the facility “goes live”. O&M requirements should be included in the project Owner’s Project Requirements

document and the engineer's Basis-Of-Design document. These requirements should be reflected in the formal Commissioning Plan and delivered during construction as part of the commissioning process and consistent with ASHRAE Guideline 0-2005. The facility's Operations and Maintenance organization and staff should be carefully selected to match the O&M strategies, duties, roles & responsibilities, and budget constraints. Considerations include deciding where the facilities related O&M staff fit within the overall corporate organization, what aspects will be staffed and performed in-house vs out-sourced, and how to define job descriptions, position descriptions, and Service Level Agreements. The discussion ends with a detailed review of various operations & maintenance processes including computerized maintenance management systems (CMMS), asset management systems (AMS), configuration management systems (CMS), and building information modeling systems (BIMS), and the challenges of integrating these into a comprehensive process. Also included is a discussion about the differences between O&M processes vs procedures, the recommended sequence to design and develop these processes and procedures, and what content and information should be included in each. The paper concludes with a final review and summary and some objective resources for additional information.

3. The Oft-Forgotten Component of Air Flow Management in Data Center Applications (ML-11-C051)

Vali Sorrell, P.E., Member, Syska Hennessy, Charlotte, NC

Most existing data centers use raised floor air distribution. And of those data centers that use underfloor air distribution, most use uncontained hot and cold aisles. Cooling capacity to the raised floor plenum for these data centers is typically provided with constant volume computer room air conditioning (CRAC) units for most older facilities; newer data centers typically use variable volume CRAC units. Various strategies have been devised to utilize either underfloor pressure or cold aisle temperature as the controlled variable to determine either the amount of CRAC units to operate or the speed of the CRAC unit fans. Often, these strategies are implemented through the Building Automation System. Unfortunately, more often than not, these strategies don't work effectively because the user of the facility is not adequately prepared to understand that despite the fact that an automation system has been provided for the data hall air flow, the placement and the quantity of perforated tiles is not automated. This paper will address how to select appropriate perforated tiles for various data center densities. In addition, it will provide guidelines for how to manage the quantity and placement of the tiles. These guidelines will assist in optimizing the important operational and maintenance issues for cooling the data center – delivering cold air to the servers, minimizing bypass and recirculation air flows, and adjusting the quantity and placement of the tiles as the facility loads change over time.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Conference Paper Session 20



Designing Integrated Building Systems

Track: Engineering Tools

Room: Lachine

Sponsor: 07.01 Integrated Building Design

Chair: Dennis Knight, P.E., Member, Whole Building Systems, LLC, Charleston, SC

This session provides information to the design professional on how to create, manage and work within an integrated design process and how to use manually gathered data, sensors and automated data collection to help make informed design and operation decisions regarding building performance in both modern facilities and historic structures.

1. Integrated Design Processes: Planning and Team Engagement (ML-11-C052)

Stephen Pope¹ and Michel Tardif, P.Eng., Member¹, (1)CanmetENERGY Natural Resources Canada, Ottawa, ON, Canada

Within an Integrated Design Process (IDP) structure the various design disciplines retain their conventional responsibilities within a collaborative framework. It is therefore instructive to explore the planning of an IDP with regard to scope of work and level of effort. This paper describes an approach to planning IDP design sessions appropriate for preliminary schedule and production budget purposes. A co-benefit for prospective building owners

is that statements of work for competitive project calls can also be produced. The outline is based on successful IDP projects from a variety of commercial, utility, and governmental client groups.

2. SenseCube: Sensor-Enabled Cubicles for Occupant-Centric Capture of Building Performance Data (ML-11-C053)

Ebenezer Hailemariam¹, Ramtin Attar¹, Azam Khan¹ and Gord Kurtenbach¹, (1)Autodesk Research, Toronto, ON, Canada

Building performance discourse has traditionally focused on the evaluation of a specific design. However, to increase the accuracy and ongoing validity of performance analysis, the building science community has come to understand the value of extending the focus beyond design to include the full building life-cycle. In the context of commercial office buildings, building performance analysis has been centered on the heating and air-conditioning system resulting in building instrumentation primarily serving large zones defined at design time. While this coarse level of metering and control may serve the needs of the building, a finer level of detail will be needed to better serve occupants with improved comfort levels. To move toward a more occupant-centric system, we propose the instrumentation of office furniture in the form of sensor-enabled cubicles. By considering a cubicle to be at the occupant scale, we suggest a level of data sampling sufficient to support detailed building performance visualization and analysis with the intention of minimizing energy consumption and maximizing occupant comfort.

3. A Dynamic Machine Learning-Based Technique for Automated Fault Detection In HVAC Systems (ML-11-C054)

Josh Wall, Ph.D., Member¹, Ying Guo, Ph.D.², Jiaming Li³ and Sam West³, (1)CSIRO Energy Technology, Newcastle, Australia, (2)CSIRO ICT Centre, Sydney, Australia, (3)CSIRO, Newcastle, Australia

With automated commissioning and fault detection and diagnostics tools poised to address many of the main barriers to good commissioning and maintenance practice and consequential energy savings, techniques from scientific disciplines such as artificial intelligent and machine learning (Peitsman and Bakker 1996; Lee et al. 1996; Morisot and Marchio 1999) are emerging as viable approaches where rules-based techniques can be disadvantaged. First generation rules-based and statistical fault detection techniques generally have several disadvantages; they focus on a small number of very specific faults; they use simplistic detection methods; and usually require expert assistance to install and commission (Friedman and Piette 2001). To address these shortcomings, the *Commonwealth Science & Industrial Research Organisation (CSIRO)* is developing a novel dynamic, machine-learning based technique for AFDD in HVAC systems, having already successfully applied similar techniques to detection in gas monitoring sensor networks (Wang et. al. 2008). The methodology consists of using a graphical model that encodes probabilistic relationships among variables of interest. When used in conjunction with statistical techniques, the graphical model has several advantages for data analysis: i. because the model encodes dependencies among all variables, it readily handles situations where some data entries are missing; ii. the model is able to learn causal relationships, and hence can be used to gain understanding about the problem domain and to predict the consequences of intervention; iii. because the model has both causal and probabilistic semantics, it is an ideal representation for combining prior knowledge (which often comes in causal form) and data; and iv. the use a probabilistic model in conjunction with statistical methods offers an efficient and principled approach for avoiding the over-fitting of data. The dynamic model is constructed via a learning process from historical training data. When new observations are made, inference is used on the model to find the correlation between the probability distributions of the training data and the new observations (the likelihood of the model given the new observations). A fault is identified if the likelihood value is low. This paper will present preliminary results showing the performance of the dynamic, machine learning-based technique in detecting common AHU faults based on fault data obtained from ASHRAE Project 1312-RP - Tools for Evaluating Fault Detection and Diagnostic Methods for Air-Handling Units (ASHRAE, 2008). Current research activities including adaptive techniques to dynamically determine fault alarm thresholds and perform proactive commissioning (Katipamula and Brambley 2007) will also be discussed.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Seminar 58 (Intermediate)



Design and Analysis Tools for Underfloor Air Distribution (UFAD) Systems

Track: HVAC Applications

Room: Cote St Luc

Sponsor: 05.03 Room Air Distribution

Chair: Fred Bauman, P.E., Member, Center for the Built Environment (CBE), University of California, Berkeley, Berkeley, CA

For the past 15 years, design engineers for UFAD systems have had to develop their designs, perform load calculations, and conduct energy simulations without the benefits of accurate and systematic design, analysis, and energy modeling tools. This seminar presents three currently available engineering tools that have been developed through research and design applications. Unlike previous methods, these new tools are capable of accounting for two key distinguishing characteristics of UFAD systems: room air stratification and thermal performance of underfloor air supply plenums. The tools covered include: whole-building energy simulation, simplified design sizing methods and computational fluid dynamics (CFD).

1. Whole-Building Energy Simulation of UFAD Systems

Tom Webster, P.E., Member, Center for the Built Environment (CBE), University of California, Berkeley, CA

The talk will cover the latest information on using EnergyPlus to simulate UFAD systems including underlying modeling approach, an overview of input specifications, and caveats on using current versions of EnergyPlus and anticipated future UFAD modeling improvements. Also covered will be examples of energy performance comparisons to conventional overhead VAV systems.

2. A Simple Design Method for Indoor Spaces with UFAD Systems (RP-1522)

Qingyan Chen, Ph.D., Fellow ASHRAE, Purdue University, West Lafayette, IN

This presentation introduces a simple design method to calculate supply airflow rate, number of diffusers and supply air temperature for Underfloor Air Distribution (UFAD) systems. This design method was developed based on a database of UFAD performances under various thermal and airflow conditions in six types of indoor spaces such as offices, classrooms, conference rooms, restaurants, workshops and retail shops. In order to evaluate the performance of the design method, this study compared the predicted temperatures with those from the database.

3. Computational Fluid Dynamics (CFD) Analysis of UFAD Systems

Kishor Khankari, Ph.D., Member¹, Tony Saracino¹ and Robert Bolin, P.E., Member¹, (1)Syska Hennessy Group, Ann Arbor, MI

During recent years under floor air distribution system for HVAC applications has become popular due its perceived improvement of thermal comfort, ventilation effectiveness and energy performance. For plenum-based distribution systems, the airflow and pressure distribution under the access floor play an important role in determining the supply airflow rates and temperatures into the occupied space above the access floor. The airflow patterns under the access floor also determine the rate of heat gain (thermal decay) to the supply air from the adjacent level's warm ceiling return air plenum. This paper will demonstrate a computational fluid dynamics (CFD) approach to show the effect of supply airflow rates, under floor physical obstructions, and the effect of rate of heat transfer from the adjacent warm ceiling return air plenum on the distribution of air pressure and airflow patterns as well as the extent of the thermal decay and air temperature distribution in the plenum space. The resulting variations in the supply airflow rate and supply air temperature from various diffusers will also be presented.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Seminar 59 (Intermediate)



Electric Vehicles and Net Zero Energy Buildings: A Perfect Match or an Odd Couple?

Track: Net Zero Buildings

Room: Mont Royal

Sponsor: 01.09 Electrical Systems

Chair: Steven Faulkner, Member, Georgia Power, Marietta, GA

This session provides an overview of electric transportation in the United States, market share and market penetration, different technologies being used for light duty and medium/heavy duty applications and an overview of electric vehicle service equipment. Addresses how electric vehicle charging could affect building operations and utility bills. Describes ASHRAE's building and other code issues associated with electric transportation.

1. Information on the Technology and Market Development (and policies that are having an influence)

Steve Rosenstock, Member, Edison Electric Institute, Washington, DC

Automobile manufacturer's are building more and more hybrid and full electric vehicles. Policies and technologies that support these vehicles are coming from all directions, auto manufacturers, battery manufacturer's and government.

2. Technical or Economic Issues Associated with Charging and Vehicles at a Building

Karen Sikes, SRA International, Knoxville, TN

Effects of penetrations of PHEVs & EVs (in numbers large enough to be a sustainable market) on the utility grid – changes in dispatch (not much) or region-specific carbon emissions. Expected type of vehicle to building (V2B) interaction for commercial office buildings.

3. Electric Vehicles and Net Zero Energy Buildings: A Perfect Match or an Odd Couple?

Steven Faulkner, Member, Georgia Power, Marietta, GA

Codes and Standards for the electric vehicles, what is in place, what needs to be added? In certain green building codes, there are mandates for charging stations in new buildings. The NEC has section 625 that deals with electric vehicle service equipment (EVSE).

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Seminar 60 (Advanced)

Is there a Better Way to Play, eh? (Comparisons in Green Building Project Execution in Canada and the US.)

Track: Net Zero Buildings

Room: Hampstead

Sponsor: 01.07 Business, Management & General Legal Education, 02.08 Building Environmental Impacts and Sustainability

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

There has been much hue and cry in the US about an impending wave of “green building” litigation arising out of everything from poor performance to late building certifications. Canada has had possibly an even more aggressive push on green or sustainable buildings but seems to be far less concerned or pressured on the litigation front of the green building wave. What’s up with that? Is there a “process?”

1. The Canadian Project Context

Dan Leduc, J.D., Ogilvy Renault LLP/S.E.N.C.R.L., s.r.l., Ottawa, ON, Canada

There has been much hue and cry in the US about an impending wave of “green building” litigation arising out of everything from poor performance to late building certifications. Canada has had possibly an even more aggressive push on green or sustainable buildings but seems to be far less concerned or pressured on the litigation front of the

green building wave. What's up with that? Is there a "process" difference between Canada and the US? Is there a philosophical difference? Or are Canadians just "nicer"? This program will present and juxtapose the execution strategies, processes and mindsets of Canadian and US practitioners to see what we can each learn from the other.

2. Great Expectations/Great Intentions

Sam Oboh, Public Works and Government Services Canada - Western Region, Edmonton, AB, Canada

There has been much hue and cry in the US about an impending wave of "green building" litigation arising out of everything from poor performance to late building certifications. Canada has had possibly an even more aggressive push on green or sustainable buildings but seems to be far less concerned or pressured on the litigation front of the green building wave. What's up with that? Is there a "process" difference between Canada and the US? Is there a philosophical difference? Or are Canadians just "nicer"? This program will present and juxtapose the execution strategies, processes and mindsets of Canadian and US practitioners to see what we can each learn from the other.

3. The US Project Context

Stephen Del Percio, J.D., Arent Fox LLP, New York, NY

There has been much hue and cry in the US about an impending wave of "green building" litigation arising out of everything from poor performance to late building certifications. Canada has had possibly an even more aggressive push on green or sustainable buildings but seems to be far less concerned or pressured on the litigation front of the green building wave. What's up with that? Is there a "process" difference between Canada and the US? Is there a philosophical difference? Or are Canadians just "nicer"? This program will present and juxtapose the execution strategies, processes and mindsets of Canadian and US practitioners to see what we can each learn from the other.

4. Stand and Deliver: Meeting Expectations in a Highly Expectant World

Malcolm Lewis, P.E., Member, CTG Energetics, Irvine, CA

There has been much hue and cry in the US about an impending wave of "green building" litigation arising out of everything from poor performance to late building certifications. Canada has had possibly an even more aggressive push on green or sustainable buildings but seems to be far less concerned or pressured on the litigation front of the green building wave. What's up with that? Is there a "process" difference between Canada and the US? Is there a philosophical difference? Or are Canadians just "nicer"? This program will present and juxtapose the execution strategies, processes and mindsets of Canadian and US practitioners to see what we can each learn from the other.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Seminar 61 (Intermediate)



Modeling Large Public Spaces

Track: Engineering Tools

Room: Lasalle

Sponsor: 04.10 Indoor Environmental Modeling

Chair: Ray Sinclair, Ph.D., RWDI, Guelph, ON, Canada

As we look to reduce energy consumption in buildings while still ensuring occupant comfort and health, CFD is becoming an ever more important design tool. Such spaces often pose unique modeling challenges due to their sheer size, architectural complexity, and design purpose. This seminar explores aspects unique to the modeling of large public spaces ranging from atria to grocery stores to auditoriums.

1. CFD for Grocery Store HVAC Design: Thermal Performance of Display Cases and Thermal Comfort of Occupants

James McNeill, Student Member¹ and John Zhai, Ph.D., Member¹, (1)University of Colorado, Boulder, CO

Thermal performance of vertical display cases and thermal comfort of customers in grocery stores must be balanced for optimum energy efficiency and sales. This presentation illustrates how CFD can be used to optimize HVAC design in grocery stores. The study explores the fundamental impacts of three HVAC designs: conventional mixing ventilation (from ceiling), displacement ventilation #1 (under the vertical display) and displacement ventilation #2 (in the aisle area) in a typical store. Results reveal that displacement ventilation may enhance the thermal comfort with improved performance.

2. Modeling Large Public Spaces Using Computational Fluid Dynamics (CFD)

Mikhail Koupriyanov, Price, Winnipeg, MB, Canada

CFD is quickly becoming a widely used analysis tool. Guidelines for its application to the analysis of large public spaces are discussed with emphasis on obtaining reliable results. Since the constraint of available computing requirements is even more stringent in this unique application, this will be the main focus of the seminar. The seminar will present strategies on how to translate a large and complex built environment with many occupants into a CFD model that fits within these computational constraints while still providing a meaningful representation of the space and yielding results that are useful to the designer.

3. Numerical Modeling of Public Concert Buildings

Andy Manning, Ph.D., Mentor Graphics, Marlborough, MA

Presentation will cover the use of Computational Fluid Dynamics (CFD) in the modeling of public concert buildings. In terms of thermal comfort, while there are no glazing issues to overcome in such buildings, cooling mode designs are difficult due to the irregular building spaces, disruptive internal structures and variation in the locations of occupants, lighting and performers. Examples of the use of CFD in these buildings include The Palladium, a theater at the Regional Performing Arts Center in Carmel, IN, and the Perth Concert Hall in Scotland, UK

4. Smoke Conditions in Atria: Comparison Between NFPA 92B Algebraic Equations and CFD

J. Greg Sanchez, P.E., Member, MTA-New York Transit, New York, NY

This presentation examines the use of NFPA 92B algebraic equations and compares results to CFD. This presentation uses an actual atrium layout, rather than an experimental box shape and considers two cases: axisymmetric and balcony spill. The discussion will present how important turbulence is to properly account for the mixing and will consider the boundary conditions and limitations of the NFPA92B algebraic equations. CFD modeling is found to be more robust and is recommended as the preferred tool to analyze smoke in atria and that algebraic equations should not be used as boundary conditions for the CFD analysis.

Wednesday, June 29, 2011, 11:00 AM-12:30 PM

Seminar 62 (Intermediate)



Simulation Quality Assurance

Track: Engineering Tools

Room: Verdun

Sponsor: 04.07 Energy Calculations

Chair: Carol M. Gardner, P.E., Associate Member, Gardner Resource Management Services, Vancouver, BC, Canada

Building modeling is used as an accounting tool to qualify projects for monetary incentives (Energy Star label, LEED points, tax breaks, etc.) Some of these programs base rewards on achieved percentage improvement over the baseline, with either a sliding incentive scale or contingent on the project meeting or exceeding an established target. Others base incentive on the difference in energy consumption between the baseline and proposed models. The end result of energy modeling in a given program is the key factor in establishing model review process. In any large-scale program involving energy modeling, many companies/individuals are involved in submittal review. To ensure consistency, the key review steps and decision factors in determining pass/resubmit/fail outcome must be documented.

1. Quality Control of ASHRAE 90.1 Appendix G Models

Maria Karpman, Member, Karpman Consulting, Glastonbury, CT

Administrative entities that adopt ASHRAE Standard 90.1 modeling protocol for use in incentive programs, to document tax breaks, or as local Code, must take on the responsibility of formulating requirements that the Standard leaves to the 'rating authority' to define, and establish the process for submittal review to ensure

compliance. The presentation will discuss lessons learned from implementing several large scale modeling-based incentive programs in the North East, including a list of the top five program implementation mistakes and the top ten mistakes uncovered in the modeling reports. It will also cover submittal review optimization strategies to help minimize the administrative overhead of running such programs.

2. The Building Energy Simulation Test for Existing Homes (BESTEST-EX)

Ron Judkoff, Ph.D., Member¹ and Joel Neymark, P.E., Member², (1)National Renewable Energy Laboratory, Golden, CO, (2)J. Neymark and Associates, Golden, CO

The test suite represents a set of cases applying the new Building Energy Simulation Test for Existing Homes (BESTEST-EX) Methodology developed by the National Renewable Energy Laboratory (NREL). The test cases were developed in consultation with home retrofit industry participants. BESTEST-EX includes two kinds of test cases: (1) Building physics test cases with fully known inputs: A given audit model is tested using specified inputs; resulting outputs are compared with reference results from three detailed simulation programs (EnergyPlus, DOE-2.1E, and SUNREL). Tested program results may also be compared with accompanying example acceptance criteria, or with other results generated using the test procedure. (2) Calibrated energy savings test cases with specified base-case monthly utility bill data and uncertainty ranges for selected inputs: A given audit model (and associated calibration method) is tested by comparing utility-bill-calibrated energy savings predictions to results from the reference programs listed above. Reference results for the calibrated energy-savings tests are not published with the test procedure so that both automated and manual calibration methods are tested blind, without access to the reference results (answers). Practical application of this procedure requires that tested-program results are compared to reference results by a third-party. The calibrated energy savings tests represent a new methodological development. The cases test the ability to model space heating loads in a representative heating climate and space cooling loads in a representative cooling climate. The building physics and calibrated energy savings cases include the following retrofit cases: infiltration air sealing, attic insulation, wall insulation, programmable thermostat, low-e windows, low exterior solar-absorptance roof (cool roof), and external solar shading. Combined retrofit cases are also included as appropriate to heating and cooling climates, respectively.

3. Developing Simulation Guidelines and Model Review Processes for Modeling

Nicholas Long, Member, National Renewable Energy Laboratory, Golden, CO

Building simulation and modeling is an excellent way of estimating the impacts are various efficiency measures throughout the design process, but how can one be sure that the simulations results are correct? First, one needs to ensure that the input files are versioned, organized, and structured similarly to allow for quick comparison of the inputs and outputs. Second, it is important to look at specific metadata on both the inputs and outputs to ensure that the relative differences of the simulations appear to be correct. There are many tools available to help diagnose problems and issues in the models, and common views of the data that help users to quickly assess the quality of the simulation.