The Fifth International ASHRAE Conference on Efficient Building Design in Beirut will be presented in a hybrid format, offering both in-person and virtual options for participation for attendees, ensuring convenience, flexibility, and a greater audience engagement with experts and professionals delivering timely and useful industry content.

The conference features six sessions with more than 25 presentations by local and international speakers over two days, as well as four live keynote presentations from experts and professionals in the field. The conference presents advanced research targeting human wellbeing and energy through design of safe, healthy, thermally comfortable, and resilient buildings at minimal energy costs. Moreover, papers will be presented on topics that encompass sustainable HVAC solutions that can combat global warming in arid and semi-arid regions and the influence of adoption of sustainable practices by various stakeholders on the investment in decarbonization of buildings.

The technical program is organized around the following topics:

1. Modeling, Thermal Storage, and Standards
2. Sustainable Ventilation and Climates
3. Building Façade
4. Indoor Air Quality and Thermal Comfort
5. Energy Conservation Strategies
6. Renewable Energy and Applications in Buildings

The focus of the Fifth ASHRAE Beirut Conference is on better building design and state-of-the-art technologies in building materials and systems that will greatly reduce the energy consumption and, hence, reduce the emission in carbon dioxide. The conference will present the latest developments, designs, systems, and control strategies of low-energy and near zero-energy buildings and prospects of next-generation sustainable HVAC systems that are dependent on renewable energy sources.

Two interactive online courses from the Global Training Center will be offered in conjunction with ASHRAE’s topical conference on October 18-19, 2022 (prior to the conference) for participants.

The conference will also feature a special panel on decarbonization titled Decarbonization of the Building Sector: Challenges/Opportunities and the Climate with the participation of scientists, policy makers, and industrialists who will exchange the most recent approaches and focus on integrating aspects of transition towards zero net carbon buildings.
ASHRAE founded in 1894, is a global society advancing human wellbeing through sustainable technology for the built environment. The society and its members focus on building systems, energy efficiency, indoor air quality, refrigeration, and sustainability within the industry. Through research, standards writing, publishing, and continuing education, ASHRAE shapes tomorrow’s built environment today. ASHRAE was formed as the American Society of Heating, Refrigerating and Air-Conditioning Engineers by the merger in 1959 of the American Society of Heating and Air-Conditioning Engineers (ASHAE) founded in 1894 and The American Society of Refrigerating Engineers (ASRE) founded in 1904.

Munib and Angela Masri Institute of Energy and Natural Resources (MI) at AUB
MI provides a vehicle for promoting research and advanced study in the petroleum, water, and energy disciplines, as well as a focal point for collaborative research among scientists, engineers, and professionals in Lebanon and in the region at large. The institute serves as an interfaculty-coordinating unit in AUB and a catalyst for advanced research in the sciences and engineering for the management and conservation of natural resources and energy.

The Lebanese ASHRAE Chapter
The Lebanese ASHRAE Chapter is representing ASHRAE in Lebanon and serves the local industries in all matters related to heating, refrigerating, air-conditioning, as well as associated activities. The Lebanese ASHRAE Chapter holds lectures and seminars on a regular basis on different HVAC topics and topics relevant to Lebanon and the region in order to contribute to the continuous training and education of the local engineers, in addition to keeping the country up to international standards.

Organizing Committee
- Ayah Said, Manager, ASHRAE GTC
- Bassam Elassaad, ASHRAE Life Member and Past Regional Chair for Europe
- Ghina Annan, Senior Sustainability Specialist, Stantec, Ottawa
- Hassan Sultan, ASHRAE RAL Regional Lecturer and Advisory Committee Chair
- Kamel Ghali, American University of Beirut
- Michel Abi Saab, Manager, Energy Services, Masdar
- Nesreen Ghaddar, Conference Chair, American University of Beirut
- Nohad Boudani, ASHRAE Conference & Exposition Committee
- Samir Traboulsi, American University of Beirut / ASHRAE Global Training Center
- Tony Giometti, Senior Manager of Conference Programs, ASHRAE
- Walid Chakroun, Kuwait University
- William Bahnfleth, Pennsylvania State University

Scientific Committee
- Fadl Moukalled, American University of Beirut
- Kamel Ghali, American University of Beirut
- Samir Traboulsi, American University of Beirut / ASHRAE Global Training Center
- Walid Chakroun, Kuwait University
- William Bahnfleth, Pennsylvania State University

Support Staff
- Christopher Preyor, ASHRAE
- Haley Booker-Lauridsen, ASHRAE
- Lizzy Seymour, ASHRAE
- Staci Loeffler, ASHRAE
- Sandrine Assaad, American University of Beirut

The Fifth International Conference on Efficient Building Design will take place on October 20-21, 2022, at the American University of Beirut.

The technical sessions will be held in the Munib and Angela Masri Building, M207 on the 2nd floor and the Jassim Al-Qatami Engineering Lecture Hall on the 1st floor.
The conference location is in the Munib and Angela Masri Building marked in blue.
The closest entrances to the conference would be from lower campus at the OSB Gate on Paris Avenue while Main Gate on Bliss Street is the closest from upper campus marked in orange.
Hotel Venue
Gefinor Rotana will be hosting the speakers for the Fifth International Conference on Efficient Building Design. Located in the famous Hamra area, Gefinor Rotana has set the trend with its location “truly in the heart of the city”, being close to all city attractions; a 10-minute walk away from the Corniche and Zaitouna Bay and a five-minute walk away from the vibrant Hamra street where you can find a wide choice of restaurants, pubs, and shops.

Gefinor Rotana is a 7-minute walk to AUB. Below is a map for additional information.

Speakers’ Lounge
Speakers and chairs of technical sessions can meet at the speakers’ lounge in the Munib and Angela Masri Building (M501) and in Bechtel 537. If a presentation has not been submitted online, the speaker is asked to drop by the speakers’ lounge to upload the presentation and have it checked for commercialization.

Hybrid Conference Registration and Features
The hybrid conference on Efficient Building Design will take place on October 20-21, 2022, offering both in-person and virtual options for participation for attendees. Register to join in-person or virtually, it’s up to you! Registration includes access to all technical content, live sessions, and networking hours.

In-person attendance
Paid in-person attendance (Deadline: September 20)

| ASHRAE members: $100 | Non-ASHRAE members: $125 |

Paid registration includes the following:
- Access to all conference sessions
- Three nights’ stay at a 5-star hotel (international speakers only)
- Transportation to and from Beirut airport (international speakers only)
- Conference proceedings
- Lunches on October 20 and 21
- Coffee breaks
- Gala Dinner
- Certificate of attendance

Free in-person attendance: available to students and faculty
Free registration includes the following:
- Access to all conference sessions
- Certificate of attendance

Virtual attendance
 Paid virtual attendance: $30
- Access to all conference sessions
- Conference proceedings
- Certificate of attendance

Free virtual attendance:
- Access to all conference sessions
- Certificate of attendance
### Social Program for in-person attendees

#### Gala Dinner

*Venue TBC* | *Thursday, October 20, 2022* | *8:00 pm*

#### Lunch

*Rooftop Terrace - The Munib and Angela Masri Building* | *Thursday, October 20 and Friday, October 21*

#### Lab Tours

*IOEC Lab* | *Thursday, October 20, 2022* | *1:15 pm*

An optional lab tour can be arranged on the first day of the conference. Interested participants are requested to inform our staff at the registration booth by Thursday, October 20, 2022, at 9:30 am at the latest.

#### Cultural Tour

*Jeita and Byblos* | *Saturday, October 22, 2022* | *7:45 am – 1:00 pm*

Pick-up Point: Gefinor Rotana Hotel, Hamra

You can register for a one-day tour at a special rate of $88 per person. The minimum number of passengers needed per tour is two. Please don’t hesitate to contact our registration desk before Friday, October 21, 2022, at noon to reserve a seat in the guided tour.

### Registration for in-person attendees

- Registration for paid in-person attendees should be completed online by September 20 at the latest, so that a name tag and registration package is ready to be picked up on the first day of the conference at the lower entrance (level 1) of the Munib and Angela Masri building from 8:00 am until 2:00 pm and on the second day from 8:00 am till 12:00 pm.
- Onsite registration for free in-person attendees (students and faculty) outside the Masri Building is also possible at the Registration Desk.

Internet access will be available for free in the hotel venue and on campus at the American University of Beirut.

Photo-release photographs will be taken at the International Conference for Efficient Building Design.

By attending this conference in-person, you agree to allow ASHRAE to use your photo in any publications or website.

### General Schedule

ASHRAE, the Lebanese ASHRAE Chapter, the Munib and Angela Masri Institute of Energy and Natural Resources, and the Department of Mechanical Engineering at AUB are honored to invite you to join their Opening Ceremony on October 20, 2022, at Jassim Al-Qatami Engineering Lecture Hall, AUB.

#### CONFERENCE OPENING CEREMONY | 8:45 – 9:30 am

- **Dr. Fadlo Khuri**, president, American University of Beirut
- **Mr. Omar Masri**, representing Trustee Munib Masri
- **Dr. Ahmad Alaa Eldin Mohammed**, representing ASHRAE president
- **Mr. Zaki Zaatari**, president, Lebanese ASHRAE Chapter
- **Dr. Alan Shihadeh**, dean of the Maroun Semaan Faculty of Engineering and Architecture, American University of Beirut

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**Keynotes: Biographies and Abstracts**

**Keynote Talk 1:**
**Thursday, October 20, 2022 | 10:15–11:15 am (Beirut time)**

**BIO-BASED MATERIALS FOR HYGRIC AND THERMAL CONTROL IN BUILDINGS**

Moderated by Dr. Fadl Moukalled, Department of Mechanical Engineering, Maroun Semaan Faculty of Engineering and Architecture–American University of Beirut, Lebanon

Dr. Sylvie Lorente, associate dean for research and innovation, College of Engineering, Villanova University

**Biography:** Dr. Sylvie Lorente is the associate dean for research and innovation in the College of Engineering at Villanova University, PA, USA. She is the College of Engineering chair professor in mechanical engineering at Villanova, and professor (exceptional class) at the National Institute of Applied Sciences (INSA), University of Toulouse, France. She is also Hung Hing-Ying Distinguished Visiting Professorship in Science and Technology at Hong Kong University (Hong Kong), extraordinary professor at the University of Pretoria (South Africa), and adjunct professor at Duke University (USA). She is a member of the Academy of Europe. Lorente has a passion for flow architectures, and works on thermal design, energy storage, vascularized structures, porous media, biological flow networks, and urban design and organizations, among other things. She is the author of seven books, 10 book chapters and 200+ peer-reviewed international journal papers. She is listed among the two percent most cited scientists worldwide.

**Abstract:** In the context of the energy transition, new construction materials are being developed, with the concern of being more eco-friendly all along their life cycle. This includes bio-based materials like hemp concrete. Using such materials in the building envelope corresponds not only to the objective of leaving a lower carbon footprint, but also to the purpose of using less air-conditioning by taking advantage of the hygric and thermal properties that these material possess inherently.

Here, we review our recent work on a hemp-based hygroscopic material under various temperature and moisture dynamic conditions. The wall was made of precast hemp concrete (HC) blocks with air cavities. It was tested within a bi-climatic chamber and monitored thanks to hygrothermal sensors in the wall and in the chambers. A numerical model predicting heat and moisture transfer through hemp concrete was developed. Based on scale analysis, it allows to go further into the description by identifying the dominant driving forces both for moisture and heat transfer, for different classes of relative humidity. The results indicate how the heat and moisture transport phenomena within the wall are coupled, particularly how a temperature difference can be a sufficient driving force for the release of moisture. The work points out the impact of moisture adsorption on heat release and on the temperature changes within the wall.

**Keynote Talk 2:**
**Thursday, October 20, 2022 | 3:00–4:00 pm (Beirut time)**

**OVERVIEW OF SMART ENERGY SYSTEMS FOR THE BUILT ENVIRONMENT**

Moderated by Dr. Walid Chakroun, Ph.D., P.E., fellow ASHRAE, professor, Department of Mechanical Engineering, Kuwait University

Dr. Moncef Krarti, Ph.D., PE, LEED®AP, professor and coordinator, Building Systems Program, University of Colorado

**Biography:** Dr. Moncef Krarti, professor and coordinator, Building Systems Program, Civil, Environmental, and Architectural Engineering Department at the University of Colorado. He is also the director for the Building Energy Smart Technologies (BEST) center that fosters research collaborations between industry representatives and university researchers to advance the knowledge in smart buildings, cities, and grids. He is the co-founder and the editor of Journal of Engineering for Sustainable Buildings and Cities (JESBC). Krarti has a vast experience in designing, testing, and assessing innovative energy efficiency and renewable energy technologies applied to buildings. Krarti has published over 300 technical journals and handbook chapters in various fields related to energy efficiency, distribution generation, and demand side management for the built environment. Moreover, he has published several books on building energy efficient systems. Due to his dedication to disseminate knowledge, Krarti is a fellow member of the American Society for Mechanical Engineers (ASME), the largest international professional society. Krarti has an extensive experience in promoting building energy technologies and policies overseas, including the establishment of energy research centers, the development of building energy codes, and the delivery of energy training programs in several countries.

**Abstract:** The presentation overviews new concepts and specific technologies suitable to design and operate buildings to be adaptive to the outdoor environment as well as response to the electrical grid. Concepts of grid-interactive efficient buildings are introduced with several examples of technologies suitable for designing, retrofitting, and operating the built environment to be energy efficient, resilient, and sustainable. In particular, the energy performance of a wide range of smart and automated controlled technologies are presented including dynamic building envelope, electrified heating and cooling equipment, on-site power generation systems, and smart controls. The applications of these smart technologies to individual buildings, communities, and urban centers are outlined throughout the presentation with some guidelines on their energy and non-energy benefits for various climates and countries.
**Keynote Talk 3:**

**Friday October 21, 2022 | 9:00–10:00 am (Beirut time)**

**SAFE OR SAVE? CITIES SMART RESILIENCY TO AIRBORNE EPIDEMIC AND ITS ENVIRONMENTAL COSTS**

Moderated by Dr. Kamel Ghali, Department of Mechanical Engineering, Maroun Semaan Faculty of Engineering and Architecture–American University of Beirut, Lebanon, and ASHRAE member

**Dr. Marco Simonetti**, associate professor of Building Physics and Thermodynamics, Politecnico di Torino

### Biography:
Dr. Marco Simonetti is a Ph.D. engineer, associate professor of Building Physics and Thermodynamics at the Politecnico di Torino (Italy), with more than 20 years of experience as an academic and as a HVAC project engineer and construction supervisor. His research and teaching activities have been focused on innovative and sustainable design of buildings, through the study of human comfort, the application of low-exergy technologies, and the exploitation of renewable energy sources. Simonetti co-authored more than 50 publications in peer-reviewed journals and conferences, and co-invented six patents (four granted and two pending). He is the co-founder of three start-ups and academic spin-off companies.

In the framework of a collaboration agreement between Politecnico di Torino and WHO (World Health Organization)-Technè, Simonetti’s team is studying, testing, and delivering innovative design of natural/hybrid ventilation of building, optimized for the control of air vector of COVID-19 and other airborne diseases in hospitals, tertiary and residential buildings. He visits regularly and collaborates with colleagues at the Andlinger Center for Energy and Environment at Princeton University, US.

### Abstract:
Buildings in our cities are connected to roughly one third of the global CO2 emissions. Cities are also where the epidemics mostly spread. COVID-19 outbreaks and “super-spreading” events have been reported in poorly ventilated buildings. Even in buildings where ventilation has been correctly implemented, we understood that current international ventilation standards are insufficient to mitigate airborne contagion in long-occupancy area. A 2x, up to 6x, increase is necessary. This requirement implies enormous consequences on the current standards, in terms of design, construction, and management costs. Moreover, it puts into risks what the motto “keep it tight, ventilate right” summarizes, the tradeoff between energy savings and in-door air quality we have been following since the “sick building syndrome” and “energy crises” (the original) era, and we are nowadays pushing further to reduce emissions and mitigate global warming.

In this presentation, we will recall some fundamental knowledge about airborne infection and new findings from the pandemics, we will share some experiences taken from building projects’ reviewing for UN agencies related to COVID-19, and we will try to highlight possible paths to solve the conundrum of pursuing infection control and reduction of global emissions.

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**Keynote Talk 4:**

**Friday October 21, 2022 | 3:00–4:00 pm (Beirut time)**

**ASHRAE’S EFFORTS IN DECARBONIZING THE BUILT ENVIRONMENT**

Moderated by Dr. Samir Traboulsi, senior lecturer, American University of Beirut, Lebanon, and ASHRAE Global Training Center

**Ms. Ginger Scoggins, P.E., CEM, CxA, fellow ASHRAE, 2022-23 ASHRAE President-Elect**

### Biography:
Prior to her 2022-23 term as President-Elect, Ms. Scoggins served two terms on ASHRAE’s board of directors as vice president. She also served as chair of the Building Headquarters Ad Hoc Committee, chair of the AIA Liaison Committee, vice chair of the technology council and Region IV director and regional chair. In addition to her contributions to ASHRAE, she is the president of Engineered Designs, Inc. in Cary, N.C., a full-service consulting engineering firm providing mechanical, electrical, plumbing and fire protection engineering services, commissioning, and construction administration. Scoggins co-founded Engineered Designs in 1997.

Scoggins has focused her career on providing state-of-the-art mechanical system designs that focus on pushing the envelope on energy conservation, addressing and exceeding the requirements of the current energy standards. For her dedication to ASHRAE, Scoggins is a recipient of the Exceptional Service Award and Distinguished Service Award.

Scoggins earned her bachelor of science in mechanical engineering in 1986 from Tennessee Technological University.

### Abstract:
The focus of this keynote presentation will be to inform attendees about the importance of decarbonizing the built environment in order to address the effects of climate change across the globe, the role our industry plays in this effort, and the steps that ASHRAE is taking to provide resources to our members to understand how to design, build, and operate energy-efficient and low-to-zero carbon facilities. An example of the low-carbon, net-zero design project for the new ASHRAE headquarters will be given.
Decarbonization or net-zero CO2 emissions from the building sector is a challenging topic, given the building HVAC and power systems energy consumption and their impact on global warming. How can this sector be on track to carbon neutrality, given that it emits around 50 percent of total greenhouse gas emissions globally? Of those total emissions, building operations are responsible for 27 percent annually, while embodied carbon in building materials and construction presents an additional 20 percent annually. The panel will discuss a broad range of these pressing issues and how key decarbonization actors in various sectors have tackled them.

Most solutions and breakthrough innovations for decarbonization of the sector and implementation of sustainable air-conditioning require cooperation and partnership among building industry stakeholders, universities, professional organizations, policy makers, and society. An integrated strategy where all sectors are willing to pay and invest in climate neutral products and processes along with support to technology innovations that accelerate the change.

The panel aims at exploring the transition towards net-zero carbon buildings and exchanging the most recent approaches and outcomes towards reaching this goal.

Moderated by Dr. Nesreen Ghaddar, professor of mechanical engineering and director of the Munib and Angela Masri Institute of Energy and Natural Resources.
Online Training Sessions

VARIABLE REFRIGERANT FLOW SYSTEMS: DESIGN AND APPLICATIONS (MENA)

Part 1: Tuesday, October 18, 2022 | 3:00–6:00 pm (Beirut time)
Part 2: Wednesday, October 19, 2022 | 3:00–6:00 pm (Beirut time)

The VRF training offered by the ASHRAE Global Training Center provides in-depth training of VRF technology, including equipment and system types, heating/cooling operation, heat recovery, and the benefits of variable refrigerant flow (VRF) systems customized for the Middle East & Northern Africa practitioners. The training focuses on the VRF design process, including load profile, analysis, and ventilation air strategy. Among other course features is a review of refrigerant piping design, unit sizing, and system monitoring/controls.

The training covers a review of ASHRAE Standard 15 “Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants,” the industry reference to ensure the safe design, construction, installation and operation of refrigeration and air conditioning systems by establishing specific safety requirements. Applying Standard 15 to VRF systems is accomplished by reviewing three basic sorting classification: occupancy, system, and refrigerant.

The training explains the step-by-step approach to ensure that the VRF system design follows the safety requirements of Standard 15. The course concludes with a focus on human comfort and sustainable design featuring example buildings, ventilation systems, and VRF system lay-outs.

Course Topics:
- Background of Variable Refrigerant Flow
- VRF Technology Benefits
- VRF System Types and Applications
- Water-Source VRF Systems
- Air-Source VRF Systems
- Design Considerations
- VRF System Design Example
- Dedicated Outdoor Air System
- VRF Ventilation System Design
- VRF Design Workshop Residential Application
- Safety Considerations for VRF Systems
- Refrigerant Piping Design

Course Objectives:
- Provide overview of variable refrigerant flow (VRF) system technology, theory, and operation
- Discuss consideration for design and application of VRF systems in buildings
- Describe applicability of ASHRAE Standard 15, Safety Standard for Refrigeration Systems, requirements to VRF systems
- Review application of VRF systems in different building types

DESIGNING TOWARD NET-ZERO ENERGY COMMERCIAL BUILDINGS

October 19, 2022 | 11:00 am–2:00 pm (Beirut time)

Net-zero energy buildings (NZEBs) are those which, on an annual basis, use no more energy from the utility grid than is provided by on-site renewable energy sources. These buildings use 50 percent to 70 percent less energy than comparable traditional buildings. The remaining energy use comes from renewable sources, like solar panels or wind turbines incorporated into the facility itself. The three-hour course provides application knowledge of the design and operating principles for energy-efficient buildings and available technologies and systems to achieve NZEBs design. Building design strategies; review of current policy and regulation, energy, environmental and economic assessment of building's performance; energy efficiency in HVAC, lighting, and appliances; and on-site renewable energy sources are topics covered.

Course Topics:
- Defining NZEBs
- Why Net Zero
- Background on CO2 and Global Warming
- Targets for Net-Zero
- Examples and Case Studies
- Energy Consumption
- Design Standards and Calculations
- NZEB Design

Course Objectives:
- Discuss Design Strategies to achieve NZEB
- Discuss Design Principles of Energy Efficient Buildings
- Describe Operating Principles of Energy Efficient Buildings
- Describe Energy, Environmental, and Economic Assessment of Building’s Performance
- VRF System Design Example
- Dedicated Outdoor Air System
- VRF Ventilation System Design
- VRF Design Workshop Residential Application
- Safety Considerations for VRF Systems
- Refrigerant Piping Design

Examples and Case Studies
- Energy Consumption
- Design Standards and Calculations
- NZEB Design
| Abstracts of Papers by Technical Session |

SESSION 1: MODELING, THERMAL STORAGE, AND STANDARDS

Paper No.: ICEBD-MET: 2022-2132

Utilization Of Mobilized Thermal Energy Storage (M-TES) System For Heating/Cooling Of Leb-anese University Campus: Simulation, Economic and Environmental Analysis
Rana Hassan Hamza; Mazen Ghandour; Hussein Ibrahim

The mobilized thermal energy storage system M-TES has been investigated for decades. The system proves that it is competitive with the different heat generation systems (oil/gas/pellets/water boilers). To study the system on large scale, a Lebanese case study was taken where a typical Lebanese powerplant waste heat was valorized in M-TES to cover both space heating and cooling load in addition to water heating in Lebanese university cam-pus. The different heat exchangers of the system were modeled, Erythritol was chosen as phase change material for latent heat storage. The charge phase was simulated, and the effects of HTF flow and the waste heat potential were studied, the simulation show that the in-crease of heat transfer medium causes the decrease of charging time and the increase in charging efficiency, while the increase of waste heat potential causes the decrease of charging efficiency and a little decrease in charging time. After the charge phase, the M-TES undergoes a self-discharging phase during transportation or waiting time before discharge, this phase is simulated also. Furthermore, the discharging phase was simulated for the different discharge loads. In addition, the number of cycles and the effect of M-TES on the increase of powerplant efficiency were calculated. Moreover, the economic evaluation was conducted and was com-pared to previous studies, the results show that the cost of heating decreased because the area is larger and the number of containers is higher, and the cost of energy decreased when using M-TES for both space heating and cooling loads than when using M-TES to cover heating de-mand only.

Paper No.: ICEBD-MET: 2022-2131

Energy Requirements & Benchmarking for Aerobic Wastewater Treatment Plants – Case Study in Lebanon
Adel Mourtada; Remi Daou; Mazen Ghandour; Firas Fayssal

Until very recently power management has not been much of a concern to those people man-aging wastewater treatment facilities. Latterly, however, much has been written in the media and elsewhere about “the end of cheap energy”. This project is to define the preliminary, primary, secondary and tertiary energy benchmark of energy use per unit of m3 per month (based on raw influent loads). No renewable energy, pre-dominantly co-generation from biogas or any other alternative are used. The definition of benchmarking values as a monitoring tool for continuous improvement is the main aim of this project. A number of areas for future improvement can be identified from this study including data collection, data handling and sharing, data validation, etc. Energy benchmarking is a powerful tool in the optimization of wastewater treatment plants (WWTPs) in helping to reduce costs and greenhouse gas emissions. Traditionally, energy benchmarking methods focused solely on reporting electricity consumption, In this study, one full-scale WWTP were benchmarked, both incorporated preliminary, secondary (Aerobic Acti- vat-ed sludge) and tertiary treatment processes and sludge treatment. The results indicated that Site Tebnin required 1.95 kWh/m3 against 1.66 kWh/m3 for Batroun Site, against 1.46 kWh/m3 for Chekka Site, against 0.5 kWh/m3 for Zahle Site . Aeration presented the highest energy consumption for all site.

:: Paper No.: ICEBD-MET: 2022-2102

Thermal Energy Storage Technologies and Their Global Application Examples
Zafer Ure

Thermal Energy Storage (TES) is the temporary storage of high or low temperature energy for later use. It bridges the time gap between energy requirement and energy use. For HVAC and refrigeration application purposes, water and the water ice constitute the principal storage media.

Water has the advantage of universal availability, low cost and transport ability through other system components. However, water ice as latent heat energy storage can only be produced using inefficient low temperature chillers for cooling applications and if it is applied for heating using purely sensible heat storage capacity designers’ have to use large storage tanks.

However, Phase Change Materials (PCM) between +4˚C and +90˚C range offer us new horizons and practical application options. One can provide a latent heat Coolth energy storage utilising conventional water chillers for new and retrofit applications without the need for any modifications as well as having the pos-sibility of free cooling.

By storing day-time warm energy for evening periods and night-time cool energy for day-time cooling requirements, a PCM system can simply bridge the gap between energy availability and energy use and therefore has the potential to achieve considerable environmental as well as economical benef-its for many heating and cooling applications.

This paper aims to cover the commercially available PCM solutions and associated products together with their practical application examples around the World.

Practical application guide together with the real application examples around the World will be presented in a format that will aid practising engineers or consultants to develop an effec-tive and low energy design based on PCM based thermal energy storage cooling / heating and heat recovery systems.

:: Paper No.: ICEBD-MET: 2022-2130

Development and Validation of ASHRAE Indoor Environmental Quality Standard
Sunil Kumar Sansaniwal; Jyotirmay Mathur

This paper represents the journey of India’s first-ever IEQ standard (i.e., ISHRAE IEQ Standard: 10001-2019). This standard provides the threshold limits of IEQ parameters by classifying them into three classes covering international and local benchmarking. It also specifies the method-ology, including field measurement protocol and specification of monitoring devices for IEQ assessment. The first version of the IEQ standard was reviewed and implemented in the actual buildings. The findings thus obtained from the case study were used to validate the standard. Most of the IEQ parameters showed compliance with the standard except for some of the IAQ parameters, probably due to increased pollution and dust storms in the study location. Also, the unavailability of monitoring instruments recommended in the standard was the major bottle-neck in performing the field measurements. The experience gained through the case study and feedback from various stakeholders and global practitioners was utilized to revise the standard.

This paper discusses all the improvements made so far in the prevailing version of the stand-ard. These improvements are envisaged to increase the standard’s efficacy and applicability in the Indian context. This standard helps evolve the IEQ rating of buildings in India, where most building stocks are yet to be built.
We aim to induce airflow by natural convection in an open-ended, isothermally heated building shaft whose length, width, and height are 3 m x 3 m x 32 m (9.84 ft x 9.84 ft x 104.9 ft), respectively. The building in which we intend to install our shaft is an open-ground story building, and the shaft is an open space at the center of the building. We want to perform a parametric study in which we vary the temperature difference between the walls and the ambient. The six cases of temperature difference covered are 0°C (32°F), 5°C (41°F), 10°C (50°F), 15°C (59°F), 20°C (68°F), 25°C (77°F), and 30°C (86°F). The key variables of interest, which we will investigate in our parametric study, are the wall heat flux and the mass flow rate in the shaft. Our ultimate aim is to improve the ventilation conditions and increase the mass flow rate in the shaft by modifying our design parameters. This study is a numerical one, and we use ANSYS-Fluent to run our numerical simulations.

Paper No.: ICEBD-MET: 2022-2145

Modeling of Solar Thermal Cooling System for a Hostel Building in Tropical Climate

Arun Kumar Shukla; Ashwini Kumar Yadav; Ravi Prakash

Energy consumption by buildings is rising rapidly due to an increase in population and living standards. Approximately 71 percent of global energy consumption is due to infrastructure, commercial and residential buildings. In order to provide thermal comfort in a tropical country like India, the use of conventional window air-conditioners is very electricity-intensive, which may lead to a further increase in greenhouse gas (GHG) emissions. This study considers a hostel building on the campus of an engineering institute located in the tropical city of Prayagraj, UP, India. The cooling load estimation is done considering location, orientation, size, capacity (occupants), and design of the rooms of the building. An energy balance model is developed to calculate the heat gain through walls, roofs, and windows. Internal heat gain and infiltration load are calculated by using a standard table and handbook. Monthly averaged solar radiation received by the roof, walls, and windows of the building is also considered in the cooling load calculation. The maximum and the minimum cooling load of respectively 320 ton and 89 tons were estimated during May and march month.

Paper No.: ICEBD-MET: 2022-2151

Applying the New Effective Strategies of HVAC System Design with the Focus on Sustainable Development in Public Buildings in Humid Subtropical Climates

Ali Reza Haddadi; Esmaeil Jalali Lavasani

It is essential to control the humidity of indoor spaces in humid subtropical climates for public areas because it needs high energy demand, mainly to provide fresh air for people. Since the latent load is remarkable in the fresh air, the use of full fresh air systems (by DOAS units) is facing a severe challenge to dehumidify air in these areas.

This paper presents a new method to curb the dependence of HVAC systems on electricity us-age in public buildings. In this approach, an ice storage system, which runs in non-peak load time, supplies the chilled water for dehumidification coils. Hence, the dehumidification coils are applied plus conventional coils to every terminal to control the humidity of every zone. In other words, all air handling units take advantage of 6-pipe coils (2-pipe for cooling coil, 2-pipe for heating coil, and 2-pipe for dehumidification coil), and every fan coil unit is similarly equipped with 4-pipe connections of coils by adding the dehumidification coil to the convective terminal. All cooling coils are supplied with central chillers, whereas the dehumidification coils are fed using an ice storage system to mitigate electricity usage in peak loads. A pas-senger terminal has been selected to study in an area with high dry bulb temperature and high relative humidity simultaneously (JASK harbor in Iran) to prove the effectiveness of this method. In this case, because of the high ceiling of the terminal hall, the displacement ventilation alongside the air to air energy heat recovery exchanger could handle the waste of energy. In addition, using 3-way control valves on each dehumidification coil, humidistats at indoor spaces, and a DDC controller for central systems could provide thermal comfort for people. Finally, the results are reported by eQuest 3.65.

Paper No.: ICEBD-MET: 2022-2112

Simultaneous Cooling And Fresh Water Production For Classrooms In Hot And Humid Climate

Jean Paul Harrouz; Kamel Ghali; Nesreen Ghaddar

Providing acceptable thermal comfort and breathable indoor air quality (IAQ) in university classrooms is crucial to maintain the students’ well-being and decision-making abilities. These are achieved by maintaining indoor temperature, relative humidity (RH) and CO2 concentra-tions within acceptable ranges. For this reason, ventilation and air conditioning (VAC) systems are used to supply large amounts of dry cool ambient air.

Conventionally, these VAC systems use vapor compression systems in order to dehumidify the ambient air by cooling it below its dew-point temperature. The air must then be heated to the required supply temperature to avoid causing draught discomfort, leading thus to energy intensive cooling systems. However, this cooling system’s size can be reduced by separating the latent and sensible loads. This is achieved through the use of solid desiccant that adsorbs excess water vapor from the ambient air, while the vapor compression handles the sensible cooling load. Moreover, commercial desiccants such as silica gel showed good adsorption capacity with low regeneration energy and temperature that enables the use of low-grade thermal energy. Additionally, the desiccant re-generation airflow carrying the desorbed water provides a potential free source of fresh water. By cooling the regeneration airflow that is typically discharged to the environment, water vapor can be condensed. Therefore, the hybrid desiccant – vapor compression system have the ability to provide the cooling needs of a classroom and produce potable water for students’ consumption. Validated mathematical models were used to assess the integrated system’s ability in maintaining acceptable thermal comfort and IAQ levels while producing water at minimal en-ergy consumption. The simulations were carried out for the peak load month for a case study of an occupied classroom located in the hot and humid climate of Beirut, Lebanese.

Paper No.: ICEBD-MET: 2022-2142

Natural Convection Airflow In an Open-ended Isothermally Heated Building Shaft

Maram Ammar; Aram Yeretzian; Fadl Mokalled; Issam Lakki

In this study, our objective is to assess the feasibility of ventilating urban street canyons using building shafts having the external surface of their walls maintained at a temperature higher than the ambient temperature.
The estimated load of the selected hostel building is validated with the eQUEST software model. Further, a solar parabolic trough collector (PTC) is modeled to heat the heat transfer fluid (HTF), water is considered as HTF. Hot water from the PTC outlet is stored in the storage tank and used as a heat source for the generator of the absorption cooling system (ACS) during summer and Hot Water Demand during winter. Monthly averaged solar radiation data of the given location is considered to power the PTC. And maximum and minimum temperature of water 90-115˚C were found. The maximum COP of Libr-H2O was calculated corresponding generator temperature and mass flow rate of the refrigerant.

Paper No.: ICEBD-MET: 2022-2122

A New Passive Design Analysis Methodology and Correlation To Occupant Perception

Mahendra Gooroochurn

Passive design is a fundamental consideration in the making of energy efficient and thermally comfortable interiors. However passive design requires customisation to the specific building context in terms of the land plot geometry, building fabric and glazing types and proportions, building orientation and layout. This in itself makes analysis of the efficacy of passive measures and prescription of appropriate ones a complex task, solvable by carrying building simulations, but inappropriate for the residential sector. An innovative 3 x 3 array model is proposed which when rotated through suitable angle increments allow to generate scenarios of space configurations that will be encountered in real building scenarios, and hence better understand the influence of the design parameters and influence on thermal comfort and active cooling energy. The 3 x 3 array model proposed further allows the assessment of the efficacy of passive measures with respect to the complex design parameters, and to take a prescriptive approach for the low and middle-sized residential developments. The simulation results obtained from the simulation model are compared to thermal perception results obtained from an occupant survey where information on the actual setup was gathered. Furthermore, the proposed methodology sets the basis for generating the needed data set to develop AI algorithms for predictive analysis of thermal comfort and hence control of building systems in an optimum way with respect to recent, current and anticipated weather profiles.

SESSION 3: BUILDING FACADE

Paper No.: ICEBD-MET: 2022-2114

Near Zero Cooling Residential Building Using Hot and Cold Phase Change Material Thermal Storages - Lebanon Case Study

Mohamed Nizar Hmad; Mazen Ghandour; Adel Mourtada; Remi Daou

The present paper investigates the performance of a solar cooling system using hot and cold phase change material as thermal storage to reach near-zero cooling energy building. The system consists of evacuated tube solar collectors, hot water Lithium Bromide absorption chiller, hot and cold phase change material storage tanks. A residential building (3000m2 (32291.73 ft2) total occupied area) in Lebanon was taken as a case study. A baseline conventional cooling system was modeled using the “Design Builder” simulation program and the hourly cooling load year-round was calculated (the annual chilled water load is 200.96 MWh, (685.7 MBtu)). Since chillers work the best at their full load capacity, two operating strategies were compared. Load Shifting and Load Leveling. In the “Load Shifting” strategy, the absorption chiller will work only when solar irradiances are available. While in the “Load Leveling” strategy, the absorption chiller will work 24 hours per day. Both hot and cold phase change materials were introduced to meet the hourly fluctuations in solar irradiance and needed cooling load. A mathematical model for the solar cooling system was coded using “Visual Basic” for the different components in the two strategies was found. Finally, the life cycle assessment performed shows that adopting the load-leveling strategy was capable of providing the cooling energy year-round without the use of any auxiliary source of energy. The optimal combination was as follows: 454.65 m2 (4893.1 ft2) evacuated tube solar collectors, 124.425 kW (424.538 kBtu/h) absorption-chiller, 124m3 (32757.33 gals) cold phase change material thermal storage, and 98m3 (25888.86 gals) hot phase change material thermal storage. The energy consumption reduction percentage reached up to 92.6 percent and the feasibility study shows that the payback period is around nine years.

Paper No.: ICEBD-MET: 2022-2127

Digitized Insulation System for Energy-Efficient Facade in Warm Countries

Ayman Bishara

The trend towards the application of external thermal insulation composite systems (ETICS) on energy efficient façades under hot climatic conditions, is becoming increasingly important for energy saving in summer (summer heat protection). However, both the construction and the performance of the system should be investigated to ensure the functionality and the avoid-ance of damage. In this paper, the development and the functionality of ETICS as well as the analysis of mass-urement data for solving building-climatology challenging planning tasks in warm countries is presented. Related to the measurement data collected in a real case study, the results of a hy-drothermal simulation tool are validated. Based on this, the use of thermal insulation under hot climatic conditions, for energy saving in summer, has been verified and the implementa-tion into a simulation model is shown. For the verification of results, a case study in the cam-pus of the American University in Ras al Khaimah (RAKRIC), in United Arab Emirates (UAE) was chosen, in which interior and exterior temperature and relative humidity values were measured. Even with the peculiarity of an irregular user behavior of the building, good accordance between measured and calculated value can be achieved. The optimized building design, facilitating a damage-free operation and a low building energy consumption, is presented in detail and essential optimization steps are discussed. Based on the analysis and evaluation of measurement data as well as the implementation of hygrothermal simulations, the presented study provides a guideline for planning of ETICS with respect to southern climate conditions.

Paper No.: ICEBD-MET: 2022-2106

Biodome Homesteading: A Community Based Open-Source Subsistence Homesteading Plat-form

Stephen Charles Welty

In the face of increasing political refugee and climate migrant numbers, it is time for the World to embark on an “open source” subsistence homesteading project for humanity on a global scale like the projects created by the United States Department of Agriculture during the Great Depression. A key missing element for that project is the infrastructure to make efficient use of the scarce energy, water and food. The presented study provides a guideline for planning of ETICS with respect to southern climate conditions.

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David Goldstein

The HVAC industry will play a critical role in the transformation of the built environment to eliminate harmful emissions, improve indoor environmental quality, and increase housing affordability. Retrofitting existing buildings to achieve these goals has proven to be too expensive and too invasive to be implemented at the large scale necessary using current technologies. This paper introduces the concept and engineering principles behind a new category of HVAC system called Façade-Integrated Mechanical Systems (FIMS) which can be installed over the facade of an existing building with minimal disturbance to the tenants inside. FIMS offer im-proved overall performance compared to existing retrofit technologies while applying the principles of industrialized construction and modular assembly to reduce costs and shorten project schedules. By simplifying retrofit logistics and offering an attractive return on investment, FIMS enable the widespread implementation of deep energy retrofits at the scale necessary to meet global emissions targets while improving indoor air quality and increasing the affordability of high-performance housing. This paper describes FIMS as applied to multifamily retrofits, though the concept is applicable to a broad range of building typologies and offers similar ben-efits when applied to new construction.

SESSION 4: INDOOR AIR QUALITY AND THERMAL COMFORT

Investigating The Effect Of Individual Control Of Personalized Ventilation Temperature On Cross-Contamination In An Office Space

Elvire Katramiz; Nesreen Ghaddar; Kamel Ghali

The transmission of respiratory diseases in indoor spaces is largely affected by room ventila-tion, especially localized ventilation near the infection source. Thus, source control strategies emerge as a vital technique that controls the microclimate of the occupants. One renowned strategy is personalized ventilation (PV). By delivering conditioned clean air towards the breathing zone, PV provides the user with protection and acceptable thermal comfort levels: PV users can individually control their microclimate by varying the operating conditions of the PV jet. Literature studies investigated the effect of varying the PV flow rate. However, when used by an infected person, this control strategy was proven to induce the transport of the expiratory droplets into the space, increasing the risk of airborne cross-contamination in some cases. Fixing the PV flow rate and varying the jet's temperature can be a promising strategy to mitigate cross-infection while meeting the personal preferences of occupants; the effect of such a con-trol strategy on airborne diseases dispersion has not been assessed in literature to the authors' knowledge.

Therefore, this study investigates the impact of individually controlling the temperature of a PV-delivered jet on cross-contamination between occupants in an office. An infected person conducting breathing is seated in a tandem (i.e. back-to-face) position with respect to a healthy person, located at a distance of 1.5 m. The PV system is set to deliver a flow at a con-stant rate of 10 l/s, and users can vary the jet's temperature between 23°C and 26°C to satisfy their thermal preferences. A validated computational fluid dynamics model of an office equipped with PV and background mixing ventilation is used to assess the cross-contamination. The aim is to highlight the influence of PV jet temperature control on contaminants' dispersion in the room and the resulting exposure level of the healthy occupant.
Ventilation is a key component to maintaining healthy, safe indoor air quality. Especially important in laboratories, ventilation is the first line of defense against airborne hazards pro-dured during research activities. Though a vital component, laboratory ventilation systems are often victim to ineffective operation, posing a risk to the most important asset—the researchers. Furthermore, system inefficiencies can lead to up to 50 percent wasted energy. To improve both energy efficiency and safety in laboratories, we present the Smart Labs Toolkit—a re-source developed by the U.S. Department of Energy Federal Energy Management Program and the International Institute for Sustainable Laboratories that guides laboratory stakeholders through a straight-forward, holistic approach to achieve dynamic, high-performance laborato-ries. Smart Labs enable safe and efficient world class science to occur in laboratories through high-performance methods. A Smart Labs program employs a combination of physical, admin-istrative, and management techniques to assess, optimize, and manage high performance la-boratories.

We will focus on a central component of the Smart Labs approach—the Laboratory Ventilation Risk Assessment, a systematic process for identifying risk due to airborne hazards to inform the operation of dynamic ventilation that optimizes safety and efficiency. Case studies of or-ganizations that have successfully implemented Smart Labs ventilation management programs will also be shared. In learning ventilation strategies successful in critical laboratory environ-ments, learn the tools and resources needed to successfully manage energy in any building through smarter, safer ventilation.

**SESSION 5: ENERGY CONSERVATION STRATEGIES**

**Paper No.: ICEBD-MET: 2022-2121**

**Dual Core Hot Well Approach For High Rise Buildings**

Ibrahim Kronfol

A Hot Well concept is developed to manage heat rejected from refrigeration and air-conditioning systems within high rise buildings. The working principle is to capture and collect condensing-units heat rejection that produces a passive ventilation in an efficient manner to optimize the overall efficiency of the building HVAC Systems.

The Hot well approach is an alternative to the classical heat rejection practice in most of the high-rise Buildings using DX-units (VRF, split-units, and refrigeration) that suffers from air-conditioning system performance concerns specifically at the higher floors. High-rise buildings have outdoor condensing-units commonly stacked on a strip of the building facade and covered with louvers to fit the purpose for air circulation.

What happens is that hot air extracted from condensing-units will mix with the makeup air in-take from almost the same location causing the ambient air to heat-up as it rises (and sur-rounding the outdoor condensing-units), reaching a very high temperatures at the upper floors. The ambient air temperature will get higher and as such, the condensing-units’ performance will decrease.

Alternatively, The Hot Well approach is an integrated dual core concept within the building: First core is an equipment shaft connected with floor gratings and an adjacent second hot well core dedicated for heat rejection.

The dual core hot well application is an integrated design approach in which can be used in ad-dition to DX condensing-units as a passive basement/parking ventilation. This will be accom-plished via the stack effect and from condensing-units’ fans operation. CFD analysis is carried to support the design in three aspects:

- Ensuring equipment performance during operation, with complete separation between makeup air and hot air rejected.
- Generating a passive parking ventilation, i.e. reduction/elimination of the parking ventilation fans and corresponding energy consumption.
- Enhancing the building facade from aesthetical and day-lighting aspects.
- Enhancing equipment operating conditions and extending its lifetime.

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**Paper No.: ICEBD-MET: 2022-2110**

**Techno-Economic Assessment Of Photovoltaic Glazing System for an Office Building in Saudi Arabia**

Noman Ashraf; Faris Al-Maziad

The energy consumption of the glazed office buildings is extremely high owing to the heavy cooling loads in summer. Therefore, building designers resort to the solutions to reduce solar heat gain and save energy. The glazing systems are responsible for 60 percent of total energy consumption in buildings. Unfortunately, conventional window glazing systems are not able to meet such high thermal standard and daylight performance. The objective of this research is to assess the various glazing options on overall energy performance, daylight performance, and economic viability for an office building under the hot and humid climate of Saudi Arabia. The building was modelled and simulated in DesignBuilder V6 software while the Berkeley Lab WINDOW 7 software was utilized to evaluate the thermal and optical properties of the glazing systems. The PV glazing systems were found to be energy efficient owing to saving up to 13.8 percent of the overall energy consumption. The spatial daylight autonomy (sDA) reached more than 40 percent of the space area for the single glazing whereas PV glazing options showed limited daylight performance. The results advanced the understanding of the applicability and limitation of the PV glazing. The techno-economic analysis found the Double low-e argon 6/12/6 as the best glazing option with the payback period of 2.8 years and additional investment of about 700,920.4 SAR.

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**Paper No.: ICEBD-MET: 2022-2118**

**Analysis of Zero Energy Building through Grid Code Operation of PV Solar and Squall Energy Systems in Oman**

Ninzo Thomas; Ch. Venkateswara Rao

Major share of the energy generated in Oman is still mainly dependent on non-renewable energy sources, such as fossil fuel. As per the estimations made, the fossil fuel resources will be depleted by 2060, if it is used at the current rate. At this juncture, it is inevitable that every building, globally, generates its own renewable energy that they require and, if possible, feed the excess electrical energy produced to the grid. Here comes the importance of Zero Energy Buildings (ZEBs) and Near Zero Energy Buildings (NZEBS). Oman, being a warmer country with an average global solar irradiation of 5.56kWh/m2/day and an average wind speed of 6.58 knots, solar and wind are the primary resources that can be tapped. Solar & wind power plants are started and they are following the Grid Code Operations from 2020. Poor performance of building’s external enclosure, usage of traditional building materials for construction and little or no focus on sustainability has led to thermally inefficient building envelopes in Oman. This contributes to high energy consumption and adds to the global warming. The average global surface temperature is escalated due to extensive use of fossil fuel.

The main aim of this paper is to analyze the design and development of ZEB/NZEB technology to be used in an educational institute in Oman, incorporating feasible renewable energy sources with battery storage system, energy efficient building construction/modification and orientation, smart and energy efficient systems and appliances, HVAC approaches and conservation practices. These techniques will involve cost effective control and conversion of energy and analysis using IoT and simulations.
Reducing HVAC Energy Consumption Through Optimal Sub-Zoning Considering Occupant-Centric Control (OCC)

Jesu Celine Jacob; Debapratim Pandit; Joy Sen

Improving thermal zoning is a significant means to reduce HVAC energy consumption and to improve thermal comfort. Virtual division of super-zones (space bound by physical partitions), into zones (area catered by each air handling unit (AHU)) and sub-zones (regions catered by each diffuser), are gaining popularity for commercial buildings such as open-plan offices with occupant-centric control (OCC). Since thermal coupling from adjacent sub-zones are prominent in such virtual divisions, unplanned sub-zones can lead to energy wastage. Architects and HVAC designers sometimes use their domain knowledge to delineate these zones based on their thermal and functional requirements, occupancy schedule, and system capabilities. Current literature, however, does not address a systematic method of sub-zoning or its optimal size. Our work addresses this gap by exploring a method of parameterized sub-zoning. The effect of spatial parameters such as (1) spatial design (2) location of diffusers and (3) thermostats; dynamic parameters such as (4) ambient conditions, (5) occupancy; and HVAC parameters such as (6) type of diffusers and (7) air supply conditions are analyzed using layouts of existing open-plan offices in India. Transient state parametric analysis of sub-zonal conditioning is performed on a typical open-plan office through CFD simulations using ANSYS Fluent after validating the numerical model using experimental results. Results indicate that (1) planned sub-zonal conditioning can reduce total energy consumption up to 40 percent despite an increase in return air temperature; (2) Use of setback conditions in unoccupied sub-zones improve cooling time and helps in reducing sharp vertical thermal gradi-ents; (3) Relative location of diffusers and air supply velocity are two parameters that influence the spread of jets and tuning them is critical in sub-zonal OCC. Our findings enhance literature on thermal zoning highlighting the possibilities and limitations of sub-zonal conditioning and highlights the need for integrated architectural and HVAC design.

Effect of Thermal Superheating on the Performance of an Air-Conditioning System

Anil Kumar; Rana Veer Pratap; Jyotirmay Mathur

A novel superheating assisted cooling system is introduced and analysed from the thermodynamic standpoint. The contribution of the study towards the subject field lies in the quantified assessment of the effect of different degrees of superheating of the refrigerant on air condition-tioner performance. This can help system designers and installers to decide the size of the solar hybrid air conditioner. In the proposed system, the vapour compression-based cooling sys-tem is integrated with an external shell and tube heat exchanger. Refrigerant after compres-sion in the compressor is further superheated to the different degrees of super heat in the ex-ternal heat exchanger. Based on the energy balance and log mean temperature difference (LMTD) method, the theoretical coefficient of performance of the system is calculated. It is found that because of the high rate of heat transfer, COP of the system is increasing with a higher degree of superheat. To validate the theoretical findings an experimental facility was developed at Malaviya National Institute of Technology Jaipur, India. The hypothesis was validated by conducting the experiment in a similar environment with the similar thermodynamic characteristics that have been assumed during the theoretical assessment. The per-formance of the system at 5, 10, and 15 degrees of post-compression superheat was investigated experimentally. Results reveal that due to the high rate of heat transfer, for 15 degrees of superheating the refrigerant temperature at the condenser outlet decreased from 40.10°C in the base case to 36.81°C. Also, the refrigerating effect enhanced from 282.29 W to 432.73 W from base case to 15 degrees of superheat respectively which corresponds to the enhancement of COP from 1.13 to 1.70.

Modification of Clay Plaster Properties Using Sol-gel Coatings

Pooja Anil Kumar Nair; Juliana Calabria-Holley; Daniel Maskell; Pete Walker

For the first time, a bottom-up approach will be used to improve the indoor air quality (IAQ) in buildings using natural earth-based plasters coupled with nanotechnology. In an effort to reduce the operational energy consumption of buildings, there has been an increase in airtight-ness, leading to an unintentional reduction in IAQ, impacting occupant wellbeing. Earthen based construction materials not only are low embodied impact but can help improve the IAQ passively due to their unique physicochemical properties. However, there is an opportunity to enhance and engineer these properties. This study presents the use of TiO2 based sol-gel coatings for the modification of clay plaster. TiO2 based sol-gel formulations will be dip-coated on the plaster samples to tailor the pore structure of the plaster and remove the volatile organic compounds (VOCs) from the atmosphere. This was achieved by combining photocatalytic effect and pore structure manipulation. The pore structure of the novel sol-gel coatings was manipulated by controlling the amount of surfactant, Triton X-100. The tailored TiO2 sol-gel coated plaster had improved breathability and IAQ regulation. In addition, the coatings were able to regulate the Relative Humidity (RH) and at the same time eliminate indoor VOCs. The use of sol-gel technology enabled the engineering of the plaster’s structure at the nano-level, produc-ing breathable protective coatings against VOCs and enhancing the plaster’s performance at the macro-level.
Both new and retrofit applications.

This paper aims to cover application examples around the World and further design guide in order to help practicing engineers or consultants developing a simple energy saving adiabatic air inlet cooling system for both new and retrofit applications.

Using this new adiabatic cooling kit installation around the World has demonstrated 20-35 per-cent peak power reduction. As the concept can be considering as a simple DIY kit for both New and Retrofit applications, it offers significant energy saving and Carbon Emission reduction opportunities.

Energy Saving By Using Mains Water Adiabatic Cooling Retrofit Kit For Dry Heat Rejection Equipments

Zafer Ure

Air cooled heat rejection systems such as condensers, chillers and dry coolers rely on ambient dry bulb which is 5-15°C , higher than wet bulb temperatures. Traditionally, large heat rejection systems use a cooling tower in order to reduce the energy consumption. However, the water based corrosion, maintenance and legionella risks have moved the industry towards less efficient dry systems.

Adiabatic air inlet cooling can be provided by fitting a mesh in front of the dry air heat rejection coil and intermittently spraying tap water directly over the mesh surface thereby introduce wa-ter into the incoming air stream while keeping the coil dry. Water evaporates on the surface of the mesh providing 10-25°C lower than the incoming air and effectively saves as much as 30-40 percent of the peak power consumption.

The majority of the time the water presence remains with the sealed main water pipe and is based on Total Waste principle. Hence, health risks associated with standing water and atom-ised spray are completely eliminated.

Using this new adiabatic cooling kit installation around the World has demonstrated 20-35 per-cent peak power reduction. As the concept can be considering as a simple DIY kit for both New and Retrofit applications, it offers significant energy saving and Carbon Emission reduction opportunities.

This paper aims to cover application examples around the World and further design guide in order to help practicing engineers or consultants developing a simple energy saving adiabatic air inlet cooling system for both new and retrofit applications.
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