



Shaping Tomorrow's
Built Environment Today



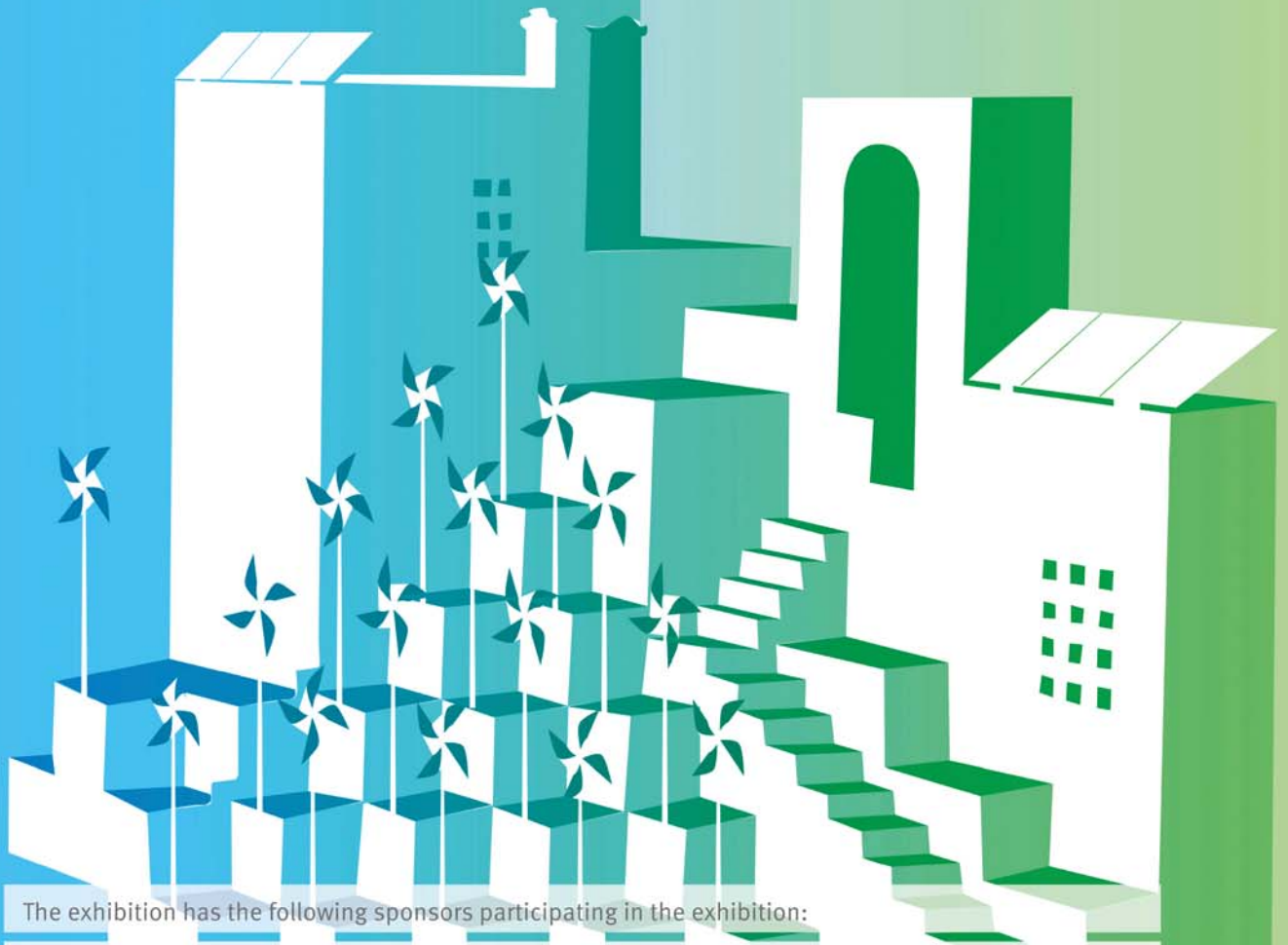
The Munib and Angela Masri Institute
of Energy and Natural Resources
The Department of Mechanical Engineering

THE FIRST INTERNATIONAL ASHRAE CONFERENCE & EXHIBITION ON

EFFICIENT BUILDING DESIGN

October 2–3, 2014
West Hall, American
University of Beirut

Materials & HVAC equipment
technologies



The exhibition has the following sponsors participating in the exhibition:

GOLDEN

AWAL Gulf Manufacturing Co.
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BRONZE

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Lebanese Center for Energy Conservation,
Lebanese Ministry of Energy.

General Schedule | Opening Ceremony

The First International ASHRAE Conference and Exhibition on Efficient Building Design on October 2 & 3, 2014 at the American University of Beirut

Date: Thursday October 2, 2014

Venue: American University of Beirut, Lebanon

West Hall, Bathish Auditorium & Malhas Common Room

ASHRAE, 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 its Opening Ceremony for the First International Conference and Exhibition on Efficient Building Design on October 2 & 3, 2014 at AUB.

Conference Opening Ceremony [West Hall, Bathish Auditorium]

8:45 - 8:50 Dr Nesreen Ghaddar, Conference Chair

8:50 - 8:55 Dr Kamel Ghali, Chair of the Department of Mechanical Engineering

8:55 - 9:00 Dr Makram Suidan, Dean of the Faculty of Engineering and Architecture, AUB

9:00 - 9:05 Dr Peter Dorman, President, AUB

9:05 - 9:10 Mr. Omar Masri, Masri Institute Advisory Council

9:10 - 9:15 Dr Walid Chakroun, ASHRAE Society Representative

9:15 - 9:25 HE Mr. Arthur Nazarian, Minister of Energy, Lebanon

Exhibition Opening Ceremony [West Hall, Common Room]

9:30 - 10:00 HE Minister of Energy and President Dorman Cutting of the Ribbon with a short tour of the exhibition.

10:00: 10:15 Coffee Break

Keynotes and their Biographies

Keynote Talk 1

Thursday October 2, 2014, 10:15 AM - 11:15 AM

Application of Simulations for the Development and Evaluation of ASHRAE Standard 90.1

Mr. Ron Jarnagin; ASHRAE

Moderator: Dr. Kamel Ghali, AUB

Room: Auditorium A



Mr. Ronald E. Jarnagin is currently the Principal owner of RLK Technical Consultants, LLC, a company focused on energy use in the built environment. Previously Ron served as a Staff Scientist at the Pacific Northwest National Laboratory where he lead a team of researchers focused on energy efficiency in buildings for 25 years. Prior to that Ron served as a faculty member in Mechanical Engineering at the University of Florida for 10 years.

Ron was the ASHRAE global Society President in 2011-2012 and previously served as the chair of Technology Council as a Vice President, Standards Project Committee 90.1, Sustainability Roadmap Committee, Sustainability Oversight Committee, Vision 2020 Committee and Building Energy Labelling Committee. He also served on the Headquarters Renovation Committee that delivered a LEED Platinum renovation project for the ASHRAE Headquarters in Atlanta, Georgia. Ron received an Exceptional Service Award from ASHRAE, an Engineer of the Year Award from the National Society of Professional Engineers, a Special Recognition award from the Association of Energy Engineers and a Presidential Award from the Illuminating Society of Engineers. In addition, he has been inducted into the University of Florida Hall of Fame. He is also a decorated U.S. Navy veteran of Vietnam, having served in the river patrol services there.

Keynote Talk 2

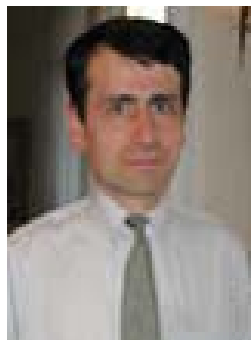
Thursday October 2, 2014, 2:00 PM - 3:00 PM

Phasing Out HCFCs without Increasing Greenhouse Gases Emissions: The Challenges

Mr. Didier Coulomb; Director of the International Institute of Refrigeration (IIR)

Moderator: Dr. Fadel Moukalled, AUB

Room: Auditorium A



Mr. Didier Coulomb has been elected as the director of the IIR since 2004. With the agreement of the stakeholders (61 member countries ...), he has tried to promote more environmental friendly technologies taking into account the impact of the ozone layer and the climate change particularly.

Through international conferences organized by the IIR: the series of conferences on natural refrigerants, every two years; a new series of conferences on ammonia. These refrigerants have no impact on the ozone layer and a low impact on the climate change; they can replace

CFCs and HCFCs in many applications.

Joined publications with the UNEP: Refrigeration drives sustainable development, a special issue of the IIR newsletter, special issues of industrial E formations. Statements during the various meetings of the parties to the Montreal protocol and a special event on ammonia and a refrigerant during the last one

Keynote Talk 3

Friday October 3, 2014, 9:00 AM -10:00 AM

UNEP-UNIDO High-Ambient Project (PRAHA)

Mr. Ayman Eltalouny, Programme Officer, United Nations Environment Programme, UNEP, Regional Office for West Asia

Mr. Bassam ELASSAAD, RTOC member; Consultant to UNEP/UNIDO High-Ambient Project

Dr. Walid Chakroun, Fellow ASHRAE, Kuwait University, Kuwait

Moderator: Dr. Michel Hayek, NDU

Room: Auditorium A



Mr. Eltalouny joined UNEP in 2003. He holds Mechanical Engineering Degree from Cairo University, and specialized in the field of Refrigeration and Air-conditioning. Before joining the UN he spent 10 years in the Refrigeration Industry and 4 years as Technical Advisor for the Egyptian Environmental Affairs Agency (EEAA) for the implementation of Montreal Protocol. Mr. Eltalouny is currently responsible for the implementation of phase-out plans of ODS in West Asia region and is closely working with West Asian governments to eliminate the use of ozone

depleting refrigerants in different refrigeration and air-conditioning industrial and servicing sectors as well as combating illegal trade in ODS and ODS-based products.

During more than 20 years of professional experience, he was involved in both technical and policy aspects in relation to the refrigeration and air-conditioning (RAC) industry starting by an extensive work in RAC systems designs and industry followed by technical and policy work in RAC environmental concerns, in particular in relation to the Montreal Protocol, at the national level (Egypt) and concluded, in the last 12 years, by working at the regional (West Asia) and international levels to assist countries in developing and implementing strategies for the RAC sectors in line with their obligations towards relevant Multilateral Environmental Agreements (MEAs) and in particular in relation to the refrigeration and air-conditioning including the development and update of technical/vocational curricula, development of relevant standards/codes, training programs on good practices and other several technical assistance programs to assist countries in complying with their environmental obligations and reduce emissions of refrigerants. And recently, he is managing the global UNEP-UNIDO project for low-GWP alternative refrigerants in high-ambient countries. Mr. Eltalouny is an active ASHRAE member since more than 15 years. He is founding member of ASHRAE Bahrain Chapter served President (2010-2011) and board member for many years. He also dynamically work with AHRI, through a joint AHRI-UNEP initiative to establish the first association for refrigeration and air-conditioning manufacturers in the Middle East and North Africa.

Keynote Talk 4

Friday October 3, 2014, 1:30 PM - 2:30 PM

Personalized and Localized Cooling and Ventilation Devices and Systems

Dr. Kamel Ghali, Chair of the Department of Mechanical Engineering, AUB.

Moderator: Dr. Walid Chakroun, Kuwait University

Room: Auditorium A



Dr. Kamel Ghali is currently the Chairman of the Mechanical Department at the American University of Beirut (AUB). He earned a BS in chemistry from AUB in 1983, and then joined Kansas State University (KSU) to complete his BS, MS, and PhD (1992) in Mechanical Engineering. Dr. Ghali was later awarded two postdoctoral fellowships, one at KSU in the field of air quality and indoor-air-velocity measurement and the other in the field of biomedical engineering at

Case Western Reserve University's School of Engineering where he worked on human airway system modeling.

In 1995 Dr. Ghali returned to Beirut and worked for two years on large-scale projects as senior mechanical engineer at Dar Al-Handasah. In 1997, he started his academic career as an assistant professor at Beirut Arab University and in 2009 he joined AUB as an associate professor. Dr. Ghali's research interests are in heat and moisture transport through clothed human beings, energy conservation in buildings, and renewable energy. He has conducted extensive experimental and numerical modeling in indoor air quality and on energy efficient air distribution systems capable of delivering fresh air directly to the occupant's breathing zone with minimal mixing with return air.

Organizing Committee

- Ghaddar, Nesreen, AUB (Chair)
- Al-Hindi, Mahmoud, AUB
- Chakroun, Walid, Kuwait University
- Elassaad, Bassam (ASHRAE sub-region Chair for Europe)
- El-Hayek, Michel, NDU
- Ghali, Kamel, AUB (Chair)
- Moukalled, Fadl AUB
- Traboulsi, Samir, AUB (FEA, Alumni Chapter)

Scientific Committee

- Chakroun, Walid | KU
- Dwyer, Tim | UCL
- El-Hayek, Michel | NDU
- Fardoun, Farouk | LU
- Ghali, Kamel | AUB
- Hosni, Mohammad | KSU
- Hosny, Ossama | AUC
- Houry, Ahmad | LAU
- Khoury, Khalil | LU
- Mohtar, Rabih | Purdue
- Mukalled, Fadl | AUB
- Olesen, Bjame | DTU
- Ouahrani, Djamel | QU
- Serag El-Din, Amr | AUC
- Sherif, Ahmed | AUC
- White, Stephen | CSIRO
-

Technical Sessions

Thursday, October 2

10:15 AM - 11:15 AM
KEYNOTE TALK 1
Room: Auditorium A

Application of Simulations for the Development and Evaluation of ASHRAE Standard 90.1

Mr. Ronald E. Jarnagin; ASHRAE

11:15 AM - 12:45 PM
TECHNICAL PAPER SESSION 1
Indoor Air Quality

*Room: Auditorium A, West Hall
Chair: Dr. Kamel Ghali, Chair of Mechanical Department, American University of Beirut*

1. Slashing Energy Use In Labs & Commercial Facilities While Still Providing Superior IEQ

Gordon Sharp, the Founder & Chairman of Aircuity, Newton, MA, USA

2. A Simplified Mathematical Model for predicting Cross-Contamination in Office Building air Conditioned by Displacement Ventilation

Carine Habshi₁, Kamel Ghali, PhD₂, and Nesreen Ghaddar, PhD₂, (1)Graduate Student at American University of Beirut, (2) Professors in the Department of Mechanical Engineering at American University of Beirut.

3. Facing the realities and Challenges of Sustaining Energy Performance and Improving Indoor Air Quality During Operations & Maintenance of Buildings

Om Taneja, PhD.PE, Associate Director, Public Building Service, GSA, Region2, New York City

11:15 AM - 12:45 PM
TECHNICAL PAPER SESSION 2
Modeling and Simulation I

*Room: Auditorium B, West Hall
Chair: Dr. Ron Jarnagin, Principal owner of RLK Technical Consultants, LLC*

1. Body Cooling Vest for Improving Endurance under Hot Environment
Haneen Hamdan₁, Nesreen Ghaddar, PhD₂, and Kamel Ghali, PhD₂, (1)Graduate Student at American University of Beirut, (2) Professors in the Department of Mechanical Engineering at American University of Beirut
2. Predicting Ventilation rates of Clothed human segment
Nagham Ismail₁, Nesreen Ghaddar, PhD₂, and Kamel Ghali, PhD₂, (1)Graduate Student at American University of Beirut, (2) Professors in the Department of Mechanical Engineering at American University of Beirut.
3. A New Full Scale Multi-Physics Model to Predict Hydrodynamics and Heat and Mass Transfer Performance of a Water Cooled Evaporator
Iyad Fayssal₁ and Fadl Moukalled, PhD₂, (1) PhD Mechanical Department at American University of Beirut, (2) Professor the Department of Mechanical Engineering at American University of Beirut

11:15 AM - 12:45 PM
PANEL SESSION
HPMP and the Building Sector: a Win-Win Relationship
Room: Collage Hall, B1

- UNEP experience in addressing the buildings Sector through HPMPs in the region
Ayman Eltalouny - Programme Officer, UNEP
1. HPMP application in Lebanon
Mazen Hussein - Head, National Ozone Unit Lebanon

2. HPMP Best practices from the region
Bassam Elassaad - Consultant, UNEP
3. Development of building codes and their effect on the HPMP
Samir Traboulsi - AUB & ASHRAE.

2:00 PM - 3:00 PM
KEYNOTE TALK 2

Room: Auditorium A

Phasing Out HCFCs without Increasing Greenhouse Gases Emissions: The Challenges

Mr. Didier Coulomb; Director of the International Institute of Refrigeration (IIR)

3:00 PM - 4:45 PM

TECHNICAL PAPER SESSION 3
Building Envelop

Room: Auditorium A, West Hall

Chair: *Dr. Walid Chakroun, Ph.D., Associate Provost at Kuwait University*

1. Efficacy of Using Phase Change Materials (PCMs) As Thermal Energy Storage for Building Applications in the Mediterranean Region

Alissar Yehya₁, Hassan Naji, PhD₂, and Laurent Zalewski, PhD₂, (1) PhD student in Université Lille Nord de France and Université d'Artois, (2) Professors in Professors in Université Lille Nord de France and Université d'Artois

2. Optimization of the Building Envelope in Hot and Humid Climates

Balsam A. Nehme₁ and Ghina R. Annan₂, (1) the head of the energy modeling, condensation and acoustics unit in the Department of Mechanical Engineering at Dar Al Handasah (Shair and partners), Beirut, Lebanon. (2) team member in the energy modeling, condensation and acoustics unit in the Department of Mechanical Engineering at Dar Al Handasah (Shair and partners), Beirut, Lebanon.

3. Use of Solar Regenerated Membrane-desiccant system to control humidity and decrease energy consumption in office buildings

Khoudor Keniar₁, Kamel Ghali, PhD₂, and Nesreen Ghaddar, PhD₂, (1) Graduate Student at American University of Beirut, (2) Professors in the Department of Mechanical Engineering at American University of Beirut, Presented by Bachir El Fil on the behalf of the author.

3:00 PM - 4:45 PM

TECHNICAL PAPER SESSION 4
Heat Recovery and Applications

Room: Auditorium B, West Hall

Chair: *Mr. Didier Coulomb, Director of the International Institute of Refrigeration (IIR)*

1. Heating Water Using the Recovered Waste Heat from Boilers in HVAC Applications - Thermal Modeling and Parametric Analysis
Mahmoud Khaled, PhD, Mohamad Ramadan, PhD, Charbel Habchi, PhD, Mehdi Chouman, PhD, Authors of this paper are faculty members in the Mechanical Department of the School of Engineering of the Lebanese International University.
2. A Review on HVAC Heat Recovery Systems
Mohamad Ramadan, PhD₁, Mostafa Gad EL-Rab, PhD₂, Mahmoud Khaled, PhD₃, Author (1), (2), and (3) are Assistant Professors at the Department of Mechanical Engineering of the Lebanese International University, Beirut, Lebanon. Author (2) is also an Assistant Professor in the Department of Mechanical and Power Engineering of Minoufyia University, Shebin El-Kom, Egypt
3. Fresh Air Cooling Plant in Hot and Humid Climate Comparative Study
Charbel Seif₁, Mazen Hassanieh₂, Rani Garzidin₃, (1) A senior mechanical

engineer at Dar Al Handassah, Shair and partners, Beirut, Lebanon. (2) A project mechanical engineer at Dar Al Handassah, Shair and partners, Beirut, Lebanon. (3) A design mechanical engineer at Dar Al Handassah, Shair and partners, Beirut, Lebanon.

3:00 PM - 4:45 PM

INDUSTRIAL SESSION 1

Room: Collage Hall, B1

Chair: Mr. Ayman Eltalouny, United Nations Environment Program

1. Dynamic Simulations for the Retrofit of an Office Building in a Mild Climate by means of a Reversible Heat Pump: Michele Decarli - CLIMAVENETA
2. Solar Energy: Houssam Chebaro DAR-AI-Handasah
3. Integrated Water-Cooled VRV System & Underfloor Heating: Mohamad Hajj Hassan, Khatib & Alami

Friday, October 3

9:00 AM - 10:00 AM

KEYNOTE TALK 3

Room: Auditorium A

UNEP-UNIDO High-Ambient Project (PRAHA)

Mr. Ayman Eltalouny, Programme Officer, United Nations Environment Programme, UNEP, Regional Office for West Asia
Mr. Bassam Elassaad, RTOC member; Consultant to UNEP/UNIDO High-Ambient Project
Dr. Walid Chakroun, Fellow ASHRAE, Kuwait University, Kuwait

10:15 AM - 12:15 PM

TECHNICAL PAPER SESSION 5

Alternative Energy Use in Buildings

Room: Auditorium A, West Hall

Chair: Dr. Samir Traboulsi, General Manager of Thermotrade SAL, Beirut, Lebanon

1. Ground source heat pump systems for residential buildings in warm climates: Energy, Environmental and Economic considerations

Apostolos Michopoulos¹, Dr. Ing. Katerina Tsikaloudaki², Dr. Ing. Vasiliki Voulgari³, M. Eng. Theodoros Zachariadis⁴, Dr. Ing. (1) A senior researcher in the Department of Environmental Science and Technology, Cyprus University of Technology, Limassol, Cyprus, (2) An Assistant Professor in the School of Civil Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece, (3) A researcher in the Department of Environmental Science and Technology, Cyprus University of Technology, Limassol, Cyprus, (4) An Assistant Professor in the Department of Environmental Science and Technology, Cyprus University of Technology, Limassol, Cyprus

2. Geothermal Cooling Application for Fresh Air Treatment Plant in Doha Qatar, Case Study
Charbel Seif¹ and Nicolas Ibrahim², (1) A senior mechanical engineer at Dar Al Handasah, Shair and partners, Beirut, Lebanon; (2) A design mechanical engineer at Dar Al Handasah, Shair and partners, Beirut, Lebanon.
3. Passive Solar Heating
Subhas Prasad, B.E. and Somjit Sahani, B.E., are the lead designer in Mechanical & Electrical Domain
4. Earthen HVAC System
Tanmay Jain¹, and Harish Mahadhasu¹, (1) Student in the Department of Mechanical Engineering, Indian Institute of Technology Roorkee, Roorkee, India.

10:15 AM - 12:15 PM
TECHNICAL PAPER SESSION 6
Energy Conservation Strategies
Room: Auditorium B, West Hall

Chair: Dr. Michel Hayek, Dean of Engineering at Notre Dame University

1. Performance of a Variable Speed Refrigeration System Using Smart Control Strategy
M. H. Salama₁, PhD N. A. Mohamed₂, PhD N. A. Mahmoud₃, Prof, (1) A head of refrigeration department, Carrier, 6th October, Egypt (2) A lecturer in mechanical power department, faculty of engineering, Ain Shams University, Cairo, Egypt (3) A professor in mechanical power department, faculty of engineering, Ain Shams University, Cairo, Egypt.
2. Impact and Feasibility Analysis of an Alternate Illumination Strategy to Cut-Down on Energy Loads
Gaurav Chaudhary and Tanmay Jain are B.Arch. in the Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India
3. HVAC System Optimization and energy savings at Hot Dry Climate Zones in Middle
Mohie Eldin M. Elsayed Badawi, Free-lance Mechanical Engineer, Mechanical Consultant and Chairman of CEC-Cairo Engineering Consultant office
4. Optimizing Energy Efficiency in PNU Campus
Toufic Itani₁, Suhail Shatila₂, and Sharbel El Haber₃. (1) M.E., LEED AP BD+C and O+M, is a project/lead mechanical and energy modeling engineer at Dar Al Handasah (Shair). (2) M.E., LEED AP BD+C is a mechanical and energy modeling engineer at Dar Al-Handasah (Shair). (3) M.E.M., M.A, LEED AP BD+C, is a senior mechanical engineer and previous associate at Dar Al Handasah (Shair)

1:30 PM - 2:30 PM
KEYNOTE TALK 4
Room: Auditorium A

Personalized and Localized Cooling and Ventilation Devices and Systems

Dr. Kamel Ghali, Chair of the Department of Mechanical Engineering, AUB.

2:30 PM - 4:45 PM
TECHNICAL PAPER SESSION 7

Solar Energy Integration with Building Systems
Room: Auditorium A, West Hall
Chair: Mahmoud Al-Hindi, Chemical Engineering Program, American University of Beirut

1. Efficient Method to Utilize Solar Energy in Buildings Via Combined Solar Thermal Technologies
Armen Gharibyan₁, PhD, Ken Touryan₂, PhD Arman Shvagir₃, Msc (1) State Engineering University of Armenia (2) American University of Armenia (3) CBS LLC
2. Hybrid PV Battery System for a Typical House in Lebanon Inland Region
Raghd Farhat₁, Ghaith Tibi₁, Nesreen Ghaddar₂, PhD Kamel Ghali₂, PhD; (1) Graduate Student at American University of Beirut, (2) Professors in the Department of Mechanical Engineering at American University of Beirut.
3. Princess Nora Bint Abdul Rahman University (PNU) Solar System
Houssam Chebaro₁, PhD, Wissam Jamrak₂ (1) Senior Associate at Dar Al Handasah Consultants (Shair and Partners); (2) Mechanical Engineer at Dar Al Handasah Consultants (Shair and Partners)
4. Cooling PV Arrays Using the Return Air Flow of Air Conditioning Systems
Wassim Salameh, PhD, Ali Assi, PhD, Charbel Habchi, PhD, Mahmoud Khaled, PhD, School of Engineering at the

*Lebanese International University LIU,
Beirut, Lebanon.*

2:30 PM - 4:45 PM

TECHNICAL PAPER SESSION 8

Modeling Simulations and Standards II

Room: Auditorium B, West Hall

*Chair: Dr. Fadl Moukalled, Associate
Dean in Faculty of Engineering and
Architecture, AUB*

1. **Application of ASHRAE 90.2 for Middle East Regions**
Mir Gayas Ali₁, Walid. M. Chakroun₂, PhD, PE Wayne Reedy₃; (1) A Senior Mechanical Engineer in SSH International Consultants, Kuwait (2) A Professor in Kuwait University, Kuwait (3) A Consultant in Monticello, IN.
2. **CFD Investigation of the Performance of Localized Air-Conditioning with Upper-Room Ultraviolet Germicidal Irradiation in Reducing Cross-Infection**
Mohamad Kanaan₁, Nesreen Ghaddar₂, PhD Kamel Ghali₂, PhD Georges Araj₃, MD (1) A PhD student (2) Professors in the Department of Mechanical Engineering, American University of Beirut (3) A professor and director of clinical microbiology in the department of pathology and laboratory medicine, AUBMC, Beirut, Lebanon.
3. **Fire Management of Underground Car Park Using Computational Fluid Dynamics**
Charbel Habchi₁, PhD, Mahmoud Khaled₁, PhD, Mohamad Ramadan₁, PhD, Georges Harika₂, Eng (1) Assistant Professors in the School of Engineering at the Lebanese International University LIU, Beirut, Lebanon (2) Mechanical Engineer at WTA - MEP, Sin El Fil, Lebanon
4. **Towards Sustainable Design with Cutting Edge CFD Simulation.**

*Adnan Akhdar₁ and Youssef Ghousoub₂;
(1) Leader of CFD unit in the Mechanical
Department at Dar Al Handasah (2)*

*Mechanical Engineer and member CFD
unit in Dar Al Handasah.*

2:30 PM - 4:45 PM

INDUSTRIAL SESSION 2

Room: Collage Hall, B1

*Chair: Bassam Elassaad, ASHRAE Sub
Region Chair*

1. **Managing Program Benefits: Attaining sustainability beyond project deliverables**
Saadi Adra, Collaboration, Management & Control Solutions (CMCS) - Lebanon
2. **R&D Opportunities for Non-Vapor Compression HVAC Technologies - Emphasis on Energy Saving.**
Mr. Omar Habib, AWAL.
3. **Dynamic Simulation: Merging the Field of Energy Modeling with the Science of Computational Fluid Dynamics.**
Karim Dadda₁ and Adnan Akhdar₂; (1) Dar Al Handasah and ASHRAE member. (2) Leader of CFD unit in the Mechanical Department at Dar Al Handasah.
4. **System Efficiency, Heat Recovery, and Energy Saving**
Mr. Walid Khonaysser, UNIC Co - Lebanon
5. **Indoor Air Quality, Indoor Environment Quality and Dedicated Outdoor Air Systems (DOAS):**
Mr. Vivek Thombre, DESICCANT ROTORS INTERNATIONAL PVT. LTD., Sharjah, UAE.

Abstracts

Keynote Lectures

PHASING OUT HCFCs WITHOUT INCREASING GREENHOUSE GASES EMISSIONS: THE CHALLENGES

Didier Coulomb, Director of the International Institute of Refrigeration (IIR)

Refrigeration, including air conditioning needs will increase in the future. HCFCs will be phased out in the near future because of the Montreal Protocol on the stratospheric ozone layer. We should avoid replacing them by high global warming potential HFCs because of the global trend to phase down these refrigerants. Current international negotiations are presented, as well as various possible solutions.

CHALLENGES IN IDENTIFYING LOW-GWP REFRIGERANTS FOR HIGH AMBIENT TEMPERATURE CLIMATES

Ayman Eltalouny, P. Eng, Programme Officer; UNEP; Bassam Elassaad, RTOC member; Consultant to UNEP/UNIDO High-Ambient Project; Walid Chakroun, Ph.D., Fellow ASHRAE, Kuwait University, Kuwait

Over the last two decades, the refrigeration and air-conditioning industry witnessed rapid changes and developments in response to the global environmental calls and conventions in particular those related to the preservation of the stratospheric ozone layer and combating climate change. In September of 2007, the Parties to the Montreal Protocol agreed to accelerate the phase-out schedule for HCFCs in developing countries. Parties agreed to reduce Hydrochlorofluorocarbon (HCFC) consumption in developing countries through an accelerated scheme that included freezing consumption levels, based on 2009-2010 averages, in the year 2013 followed by cuts, to the same level, of 10%, 35%, 67.5% & 97.5% for the years 2015, 2020, 2025 & 2030 respectively allowing 2.5% to continue during the period 2030-2040 as service tail which will be further assessed and modified in the year 2025.

On the other hand Hydrofluorocarbons (HFCs), the primary commercially available alternative to CFCs and HCFCs since the early 90s, are currently doubtful to continue playing the same role given their contribution to global warming. Most of high/higher GWP HFC refrigerants have started to be less welcomed or accepted over the last few years in several places in the world.

Countries with high-ambient temperature characteristics and high dependency on refrigeration and air-conditioning applications are mainly located in the Middle East and particularly in the Gulf region. Those countries have traditionally been recipients of globally proved refrigeration technologies. This trend is witnessing a change lately with movement of regional industry to enhance their research and selection capacities but it remains framed with what is commercially available worldwide in terms of the raw materials. The governments and respective industries in that region expressed, over the last few years, concerns and worries about their ability to continue doing so in order to meet the environmental commitments of freezing and reducing the use of HCFCs when long-term low-

GWP alternatives to HCFC-22, particularly for small/medium size air-conditioning applications, are not yet ready for their markets. Thus, meeting the Montreal Protocol phase-out targets will be a challenge as well as approaching the 35% reduction targets, by 2020, unless we move to high GWP options which obviously are not be a wise decision at this time.

Additionally, most of the governments in the region have started to apply new energy efficiency requirements for air-conditioning equipment. Known as MEPS (Minimum Energy Performance Standards), these standards will certainly have impact on the choice of refrigerant as well as design and operating characteristics of air-conditioning units. Meeting those conditions for high-ambient climates is another challenge for countries with air-conditioning consuming 50-60% of their domestic power supply. As a response to the above issues, UNEP & UNIDO designed and launched a regional project for assessing the feasibility of Low-GWP Alternatives for the air-conditioning industry in high-ambient countries which is globally known today as PRAHA. The project aims to practically assess next-generation low-GWP refrigerants taking into account energy efficiency, environmental impact, performance, safety, and cost. The project involves partnerships of 13 international/regional technology providers and equipment manufacturers, aiming to independently assess and evaluate the techno-economic feasibility of low-GWP refrigerants in comparison with existing commercially available refrigerants i.e. HCFCs and HFCs for different domestic and medium size commercial air-conditioning applications.

APPLICATION OF SIMULATIONS FOR THE DEVELOPMENT AND EVALUATION OF ASHRAE STANDARD 90.1

Ronald E. Jarnagin

This presentation will provide a background on the use of simulation modeling in the U.S. as well as describing what simulations can and cannot do effectively. Additionally the presentation will address how simulations are applied to energy standards development as well as how they are used in the evaluation of the impact of energy standards.

PERSONALIZED AND LOCALIZED COOLING AND VENTILATION DEVICES AND SYSTEMS

Kamel Ghali, Chair of the Department of Mechanical Engineering, AUB.

Personalized ventilators are the state of the art devices that aim towards providing individuals with thermal comfort and high quality breathable air. Unlike conventional air conditioning systems, personalized ventilators deliver the fresh air directly to the breathing zone of building's occupants reducing the ventilation load and the air-conditioning energy consumption. For the advantages of the personalized ventilators to be better realized, it should be installed in reachable places near the occupant to deliver effectively the individual fresh air needs. The personalized ventilation devices are grouped under four general types: 1) desktop-mounted task ventilation; 2) chair-based personalized ventilators; 3) wearable personalized ventilators; and 4) localized and partition-based ventilators. This talk presents the performance of the different personalized ventilators and the methodology used in assessing their effect on air quality and on the segmental and overall comfort of humans. The usefulness of the different PV types is assessed in relation to its impact on thermal comfort, air quality and particle dispersion in different adopted air conditioning systems.

Technical Sessions

:: Paper No.: ICEBD-MET - 2014 - 14706 ::

SLASHING ENERGY USE IN LABS & COMMERCIAL FACILITIES WHILE STILL PROVIDING SUPERIOR IEQ

G. Sharp

Laboratory facilities are energy intense building types due to the vast amounts of 100% outside air required. With today's concerns over high energy expenses, reducing carbon footprints, plus efforts to make facilities green and provide a better indoor environment, reducing both new and existing lab facility energy expenses has become a critical challenge particularly in hot and humid climates where the cost of conditioning this vast amount of outside air can be prohibitive. The primary reason behind many labs' high energy expenses is the minimum ventilation or air change requirements that often dominate the amount of outside air required by these facilities. This paper will present a proven Demand Based Control solution to this problem. In this approach that is referred to in the ASHRAE handbook, rather than use a fixed air change rate of 6 to 12 ACH (Air Changes Per Hour), real time measurements of the actual lab indoor environmental quality are used to vary the air change rates from as low as 2 to 4 ACH to upwards of 8 to 16 ACH based on the cleanliness of the lab room air. By safely cutting the lab air change rates often times by as much as 50% or more for about 98% of the time, this approach is often cited as the single largest energy conservation approach for many lab facility designs. Furthermore in new designs significant net reductions in first cost may also be achieved through reductions in the sizing of the HVAC systems. Finally by significantly increasing air change rates when contaminants are sensed, improved Indoor Environmental Quality (IEQ) can be achieved. This paper will describe this successful approach for labs and vivariums plus discuss the technology used to implement it cost effectively. Additionally, the results will be shown for the largest study ever done of lab IEQ conditions covering over 1.5 million hours of lab operation. Furthermore a variation of this concept is often applied to other types of facilities such as office buildings, educational facilities, public assembly buildings such libraries and student centers, as well as healthcare facilities. This approach has been used in over 400 buildings including well over 200 lab facilities and two case studies will be highlighted such as a full lab building retrofit of the 2006 R&D Lab of the year at Arizona State University which is saving over \$1 million a year in annual energy costs from this concept. Finally, a highly sustainable, "near zero carbon" lab project in the often hot and humid climate of Abu Dhabi, UAE will also be discussed.

:: Paper No.: ICEBD-MET - 2014 - 14737 ::

FACING THE REALITIES AND CHALLENGES OF SUSTAINING ENERGY PERFORMANCE AND IMPROVING INDOOR AIR QUALITY DURING OPERATIONS & MAINTENANCE OF BUILDINGS

O. Taneja,

Buildings are high users of energy and other resources. There are opportunities to make the building equipment, systems and operations more efficient. It is believed that improvements in efficiency of buildings can be achieved at a relatively lower cost, by including efficiency measures during renovations and reconstruction. The process of improving efficiency entails that an effective integrated design, construction and operations approach be used, engaging

architect, engineer, builder, tenants, information technology administrators and trained operating and maintenance staff. In addition, investment decisions need to focus on transforming existing buildings into "Smart and resilient Buildings". Behavioral changes, development of middle management and Buildings Managers to invoke operational excellence is valuable. This movement is driven not only from climate change concerns, but also due to legislative or business pressures of cutting waste, lowering costs, and adopting modern technology to bring greater transparency. . Concurrent with efficient operations, greater focus is also necessary on hardening the buildings and their infrastructure so as to be smarter and adaptive to inclement climatic conditions. However, without the staff developing competencies in energy management, technology, safety, and performance based leadership, such goals cannot be met. Structured training and development of Buildings Managers and Operators can help in immediate operational Improvements without significant capital needs. Building managers face many challenges in sustaining high performance of buildings. The purpose of this paper is to first address the causes of the problems and elements required for transformation to best in class operations. Benefits lie in integrating those elements to sustain high performance, over the life-cycle of a building. Missed opportunities of including efficiency measures can have adverse performance and cost consequences during the life time of the building. Embracing performance measurements and benchmarking, employing operational "best practices" and commitment to development of staff capacity can be a great asset. Energy use tracking and analytics can guide the operations and maintenance staff in performing their responsibilities and facilitate continuous commissioning. Facilities managers and IT system administrators need to collaborate to be able to dynamically manage the building operating parameters based on occupancy, time of day, and other human, environmental, and business and resilience considerations. Use of Green Procurement, recycling program, regular sensor and equipment calibration, and computerized maintenance management systems can further boost the performance.

:: Paper No.: ICEBD-MET - 2014 - 14753 ::

IMPROVING PERFORMANCE OF A VARIABLE SPEED REFRIGERATION SYSTEM USING SMART CONTROL STRATEGY

M. Salama, N. Mohamad, and N. Mahmoud

A refrigeration system was used in cooling and freezing applications controlled by a smart control strategy. This was done using an inverter driven scroll compressor, an inverter driven evaporator fan motors, an inverter driven condenser water pump and an electronic expansion valve. The smart control strategy depends on different controllers; it controls the compressor by artificial neural networks (ANN), the evaporator fan motors by proportional controller, the condenser water pump and the electronic expansion valve by proportional integral differential (PID) controller. Controlling the evaporator fan motors speed was done to maintain a constant supply air temperature, while controlling the condenser water pump speed was done to maintain a constant condensing pressure. The compressor speed was controlled using artificial neural networks (ANN) based on the analyzed data from a preceding experimental results. It was found that operating the refrigeration system using smart control strategy to control the motors speeds improved the performance of the refrigeration system compared to traditional on/off control strategy. Using smart control strategy showed a reduction in the starting operation time compared to the traditional on/off control strategy by 55% in order to achieve the desired room temperature set value. The reduction in operation time to achieve the desired room temperature set value results in total energy saving 60% by using smart control strategy compared to traditional on/off control strategy. The energy saving during system operation in the starting operation period is found to be 11.3%, while the energy saving during the steady state operation time is 11%.

:: Paper No.: ICEBD-MET - 2014 - 14766::

HYBRID PV BATTERY SYSTEM FOR A TYPICAL HOUSE IN LEBANON INLAND REGION

R. Farhat, G. Tibi, N. Ghaddar, and K. Ghali

Power shortages are forcing residential sector to rely on backup diesel generators (DG). Using photovoltaic (PV) technology can be one of the clean solutions to this problem; however its adoption is challenged by its relative high capital cost. To overcome this challenge, we propose reducing the initial construction cost through the use of local low-embodied energy construction materials and use the savings resulting from envelope replacement costs to offset the PV cost. A typical house in the dry desert climate of inland Lebanon is thermally modeled using commercial software for the base case and when using local low-embodied energy construction materials, mainly hemp and straw. The savings resulting from reduced electrical demand and from the initial cost change between the base case model and the local material model were found to be \$41/m². The savings are used to assess the investment in installing a hybrid PV battery system while reducing operating cost of the diesel generator. HOMER software is used in the assessment of hybrid PV battery system while considering two scenarios. In scenario 1, we used the savings from the initial cost of envelope material and downsized DG which resulted in net energy savings up to 47% with payback period of 3 years. In scenario two, the DG replacement by PV is based on life cycle assessment in which further investment in the PV system is evaluated and optimized. This resulted in a system able to operate without need for the DG, to decrease the electricity purchased from the grid, and to increase the electricity sold to the grid with net energy savings reaching 130% with a payback period of 6 years.

:: Paper No.: ICEBD-MET - 2014 - 14769 ::

HYBRID PV BATTERY SYSTEM FOR A TYPICAL HOUSE IN LEBANON INLAND REGION

H. Hamdan, N. Ghaddar, and K. Ghali

This work models a passive method of cooling the body to increase the work periods in hot environment. Cooling is performed by wearing a cooling vest containing packages of phase change materials (PCM) made of salt mixtures that melt at a fixed temperature to prevent increase in skin temperature thus maintaining comfort. A dynamic mathematical model of the heat and moisture transport in clothing layers with PCM material is developed. The fabric-PCM model is validated by experiment on clothed heated cylinder in wind tunnel under controlled environment. The internal air layers confined between the PCM and the heated cylinder (microclimate air) and between the PCM and the outer clothing (macroclimate air) are measured. Good agreement is found between experimental temperatures and predicted values by the fabric-PCM model with maximum errors of 4.5% and 2.5 % respectively.

:: Paper No.: ICEBD-MET - 2014 - 14782 ::

EFFICIENT METHOD TO UTILIZE SOLAR ENERGY IN BUILDINGS VIA COMBINED SOLAR THERMAL TECHNOLOGIES

A. Gharibyan, K. Touryan A. Shvagir

HVAC systems in buildings consume the largest amounts of energy. They also contribute to green house gases significantly, and are responsible for ozone depletion. It has been shown that the best economically viable active solution for reducing the energy consumption from HVAC systems is the utilization of solar energy in buildings. In this study a combined solar space heating, cooling, and solar hot water scheme and methodology is proposed which will allow maximal utilization of solar thermal energy generated from solar thermal collectors, in all the seasons of the year. All calculations and assumptions have been done for the continental climate zones. An optimization objective function has been set up for determination of the optimum area of solar thermal collectors that could yield maximum cost savings, based on monthly energy consumption patterns. It has been shown that the suggested methodology provides full utilization of the available solar thermal energy, year round.

:: Paper No.: ICEBD-MET - 2014 - 14784 ::

HVAC SYSTEM OPTIMIZATION AND ENERGY SAVINGS AT HOT DRY CLIMATE ZONES IN MIDDLE EAST

M. Badawi

In approach of optimization the HVAC system to make the system much more efficient and minimizing the initial and running cost, a lot of variables has to be considered during the system design, the building application, the project location and the end users specific requirements are the major concerns to be respected. This article focused in the large chilled water system application that might applicable in the mega projects such as the airports, the industrial hangers, the Holy Haram extensions, assembly areas and all the applications need the large amount of fresh air. The amount of fresh air should meet the minimum requirements of the IAQ specified in ASHRAE standard 62.1-2010 or the latest published version. The larger the amount of the fresh air the great cooling capacity and electrical power consumption shall be expected. In deed the fresh air load has the great impact in the thermal load and the cooling capacity of the HVAC system equipments. In such buildings applications, the power consumption of the HVAC system represents at least 60% of the total connecting power input, the percentage shall increased in the hot climate zones. The water cooled central chilled water system is normally the suitable system for such applications when considering the higher COP of the centrifugal chillers. In hot dry climate zone in US western cities, such as lass Vegas, los angelus, Albuquerque, Tocson, the indirect / direct water evaporation system integrated with the traditional cooling coil is the most energy efficient air cooling system. The engineering technical analysis performed for the cities located in the Middle East such as Riyadh, Madinah in KSA and Aswan in Upper Egypt gives significant energy savings in both of the capital cost and interested benefits in the running savings.

At least 20% saving of the initial cooling capacity and 60% annual savings in the electrical power consumption as resulting from the technical engineering analysis, when considering to provide indirect - direct evaporation sections to the traditional full fresh air handling units, moreover the saving of the makeup water needed for the cooling towers due to the 20% saving in the chillers capacity shall used to the indirect direct evaporation sections in the air handling units. The technical analysis performed based on the ASHRAE handbook, fundamentals, system and equipments and code of practice referenced to the brand name manufacturer's in this field.

:: Paper No.: ICEBD-MET - 2014 - 14790 ::

GROUND SOURCE HEAT PUMP SYSTEMS FOR RESIDENTIAL BUILDINGS IN WARM CLIMATES: ENERGY, ENVIRONMENTAL AND ECONOMIC CONSIDERATIONS

A. Michopoulos, K. Tsikaloudaki, V. Voulgari, and T. Zachariadis

In this paper the heating and cooling energy consumption of a typical single-family house is calculated for five selected locations in Cyprus. Hourly calculations are performed using the Energy Plus software. The results are translated in oil or LPG and electricity consumption, assuming that the typical building in Cyprus is equipped with an oil-fired or LPG-fired boiler for heating and local air-to-air split-type heat pumps for cooling. The same energy needs are assumed to be covered by an alternative system, i.e. a vertical closed loop ground heat exchanger combined with a water-to-water heat pump system for heating and cooling. The ground source heat pump system is dimensioned with the aid of the EED 3.0 software, analyzed using an in-house developed and validated simulation code, and as a result the electricity consumption of the system is calculated. Based on the resulting fuel consumption of the alternative system, the primary energy consumption and the corresponding emissions are determined, while a financial analysis is also performed. The results prove that significant energy, environmental and economic benefits can be achieved.

:: Paper No.: ICEBD-MET - 2014 - 14791 ::

PREDICTING VENTILATION RATES OF CLOTHED HUMAN SEGMENT

N. Ismail, N. Ghaddar, and K. Ghali

Most comfort indices for indoor environment are based on static ensemble clothing insulation and assumed sedentary activity level at low air velocities. However, to consume less energy, research has recently focused on increasing velocity to bring thermal comfort at elevated air temperatures by enhancing ventilation through clothing. This work aims to implement an integrated heat transport model of clothed human body subject to external wind. Each clothed segment of the human body is modeled as a vertical annulus of a heated cylinder surrounded by a permeable cylinder, subject to cross uniform wind with open or close end to the environment, depending on the aperture configuration, in the presence of natural convection. The flow and heat transport characteristics are obtained by solving the steady state mass and energy balance equations of body segments 'microclimate air annulus numerically. Experiments were performed in a low speed wind tunnel in which an isothermally heated vertical clothed cylinder with open bottom aperture was placed in uniform cross wind. Good agreement was found between the model predictions and experimental measurements of temperature at different angular and vertical location in the microclimate air layer. It is found that clothed segments opened from bottom increases ventilation rate by 40 % when compared to clothed segments opened from top. Furthermore, an increase of wind speed by 1 m/s (3.28 feet/s) leads to an increase of about 36 % of ventilation rate. Permeability also plays another role in enhancing ventilation and total heat loss from the clothed segment especially when natural convection is important. At wind velocity less than 2 m/s (6.56 feet/s), the increase in ventilation and heat loss by moving from semi permeable clothing to permeable clothing were around 20% and 19 % respectively.

:: Paper No.: ICEBD-MET - 2014 - 14794 ::

FRESH AIR COOLING PLANT IN HOT AND HUMID CLIMATE COMPARATIVE STUDY

C. Seif, M. Hassanieh, and R. Garzidin,

In the design of air conditioning systems, introducing outdoor air is essential in maintaining a good indoor environmental air quality that helps building occupants feel stimulated and comfortable. In hot and humid weathers the fresh air cooling load may reach up to 50% of the building cooling load. Since air-conditioning equipment are the major energy consumers in buildings, reducing the Fresh air cooling energy demand a major challenge for engineers designing green and energy efficient buildings. The aim of this paper is to provide a comparative study for the energy performance of four different central fresh air treatment plant arrangements. The first arrangement considers the widely used tradition system of using a cooling coil to cool and dehumidify outside air to a low temperature followed by a heating coil to maintain the required supply temperature at the plant outlet. In the second arrangement air is divided in two streams, one that passes through a cooling coil while the other bypasses the coil; the two streams are then mixed to achieve dehumidification requirements. Combined air stream passes through a heating coil to maintain a fixed supply temperature at the plant outlet. A horseshoe heat pipe configuration is used in the third arrangement as a mean for precooling air entering as well as reheating air leaving the plant; in this arrangement a cooling coil is used to dehumidify outside air. In the fourth arrangement similar to arrangement 2, air is divided into two streams the first passes through the cooling coil and the second through an enthalpy wheel, then the streams are mixed and reheat is achieved through a heating coil. Doha, Qatar, weather condition is considered the basis for this study since it is classified as having hot and humid summer weather. All plant arrangements are simulated to have a leaving condition of 18°C (64.4 °F) and 9.5g/kg (0.0095 lb/lb) of air moisture content. The moisture content level is selected to be equivalent to a comfort indoor condition of 24°C (75.2 °F), 55% relative humidity. The fourth arrangement showed the best result in terms of the Peak cooling load, Peak heating load and total cooling energy when compared to the other three arrangements. Utilizing arrangement four in designing fresh air treatment plant may reduce the plant cooling energy load by 22% and the reheating energy load by 80% compared to traditional systems.

:: Paper No.: ICEBD-MET - 2014 - 14795 ::

OPTIMIZING ENERGY EFFICIENCY IN PNU CAMPUS

T. Itani, S. Shatila, and S. El Haber

Princess Nora Bint Abdul-Rahman University (PNU) is currently the largest construction project in the Kingdom. Initiated in 2009 and opened in May 2011, the built-up area totalled 2.8 million m², with an ultimate population of 40,000 students and 12,000 staff. PNU represents almost one-quarter of current LEED registered projects in the Kingdom. With 38 separate buildings having a total BUA in excess of 1 million m², it is the largest higher education facility in the world to target LEED on such a scale. All its campus buildings aspire to be LEED NC v.2.2 Certified with the exception of: the Female Administration building and the Central Library, which aspire to be LEED Gold certified, the Academic Campus which has been awarded LEED Gold Certification, and the PNU Medical Center and Hospital that will be the world's largest LEED certified healthcare facilities. In optimizing sustainability and, specifically, energy efficiency, the design process integrated numerous energy conservation measures among all engineering disciplines. In addition to an air cooled district cooling plant with a 100,000 ton-hr thermal storage tank, a 36,341 m² solar panel

array comprising over 3,600 separate flat plate collectors provides about 10% of the campus's requirements for hot water. Following optimization of building orientation, the envelope is designed to demonstrate an energy efficient response to a harsh and challenging arid climate. The curtain wall system includes high performance vision glazing and insulated shadow-box construction at column and spandrel zones. The incorporation of shading strategies into the design of PNU's building facades consist of musharabiah-inspired glass fibre reinforced concrete panels and screens that shade the building from direct solar gain. Within the academic colleges, 80,000 m² of this shading has been deployed, contributing a 3.5% reduction in overall energy consumption and a 13% reduction in heat gain on the exterior envelope. Additional energy conservation measures (ECMs) include: decreased lighting power densities, occupancy and day-lighting controls, blow through fans for higher supply air temperature differential, demand control ventilation (DCV), variable frequency drives (VFDs) on all equipment, high equipment and motor efficiencies, dedicated outdoor air system (DOAS), under floor air distribution in auditoriums, evaporative cooling, heat recovery, pressure reset and dual-maximum-control sequence for VAV boxes, and last but not least supply air temperature reset during winter and unoccupied periods. A whole building simulation for the campus with over 30 energy models using Integrated Environmental Solutions IES VE indicated annual savings of 17.6 to 25.6% in energy and 16.3 to 22.8% in cost.

:: Paper No.: ICEBD-MET - 2014 - 14796 ::

GEOTHERMAL COOLING APPLICATION FOR FRESH AIR TREATMENT PLANT IN DOHA QATAR, CASE STUDY

C. Seif and N. Ibrahim

Geothermal energy is a cost effective, reliable, sustainable and environmentally friendly energy stored in the earth mass. Earth ground surface temperature is function of the ambient temperature. The soil temperature yearly fluctuations decrease as the soil is deeper. The deeper it is the more it converges to the mean yearly ambient temperature. Doha summer climate is considered to be hot and humid. Cooling humid fresh air contributes to around 50% of the building cooling load in that area. The purpose of this study is to investigate the effectiveness of using geothermal energy to pre-cool outside air in Doha Qatar. It evaluates two geothermal heat transfer systems to help reduce the overall building energy demand. The first geothermal system is based on closed loop principle. It consists of installing vertical loops that run perpendicular to the surface deep in the ground. The ground loop acts as a heat exchanger to cool the circulating water that will be used to precool building fresh air through air coils. In this study the optimal bore depth is considered to be 300 ft. (91m) with a heat exchange rate of 0.82 refrigeration tons per bore. The second geothermal system uses groundwater to pre-cool the outside air. This system consist on having a production well, an injection well and cooling air coils. Water extracted from the production well at ground temperature passes through air coils to pre-cool outside air. Heated water shall be injected into a second well called the injection well. In this system the minimum spacing between the production well and the injection well is estimated to be 170 ft. (51m). Maximum ground water temperature increase is limited to 8°C to avoid inducing thermal disturbance in the aquifer. Each refrigeration ton would require 0.108 l/s (0.228 cfm) of ground water. To conclude vertical loops compared to the ground water open loops have a higher initial cost since it involves extensive earth works where large number of drilled holes as well as water loops needs to be installed; however, vertical loops are considered more appropriate for Doha area application since it involves lower running cost as well as it preservation of the Doha deep aquifer.

:: Paper No.: ICEBD-MET - 2014 - 14800 ::

PRINCESS NORA BINT ABDUL RAHMAN UNIVERSITY (PNU) SOLAR SYSTEM

H. Chebaro and W. Jamrak

The Princess Nora Bint Abdul Rahman University (PNU) is designed with the goal of employing LEED strategies focusing on utilizing sustainable designs to reduce and improve the efficiencies, of energy consumptions, and reducing CO₂ emissions (Green design). One such measure towards achieving this goal is the use of solar energy as an obvious measure particularly in the KSA where solar energy is abundantly available over most of the year. Using the sun as a heating source for space heating and domestic hot water is a perfectly logical sustainable design solution. The principle of using a solar water heating is simple and the technology is both well-known and reliable. The PNU is designed with a central district water heating system that serves space heating and domestic hot water. At the heart of the central heating system is a boiler plant having a heating capacity to cover all the space heating and domestic water, i.e. to cater for 100% of the demand, especially for cloudy winter days and at winter night periods when the heating demand is at maximum and where there will not be any available solar energy. However, during winter non-cloudy days, and as well as the remaining days of the year, there will be abundant solar energy to harvest and use for heating, and for this reason, the PNU is provided with a central solar heating system. This solar heating system relies on highly reliable large flat plate collector technology installed on the roof of the logistic center located nearby the boiler plant. The system has a peak power yield of 17.3 MW (59,030 MBtu/h), and an annual yield of 26,011 MWH (88,753,216 MBtu). This paper will focus on the design of PNU solar system particulars (solar panels, circulating pumps, piping, buffer tanks, heat exchangers, control system, etc..) and the system engineering that took place and evolved in selecting the flat plate collector technology over other technologies such as compound parabolic collectors and parabolic trough collectors. Further, the paper will focus on the design and engineer measures that are implemented to protect the PNU solar system from overheating, damage or failure.

:: Paper No.: ICEBD-MET - 2014 - 14802 ::

PASSIVE SOLAR HEATING

S. Prasad and S. Sahani,

In any solar energy system for space heating there are three functions performed: collection of solar energy, storage, and distribution of that energy (heat) from storage to living space. The two basic categories of solar systems for space heating - active and passive - perform these three functions, but in different ways. Active solar heating systems incorporate mechanical devices to circulate air or fluids through collectors and into thermal storage units such as water tanks or rock beds. Additional fans or pumps are required to bring stored heat to areas where it is needed. Active systems can be quite complex and rely on external sources of energy to operate. The passive heating in cold climates through the thermal storage like Trombe wall can be available option. Solar heating and cooling (SHC) can play a significant role in providing an economically viable and environmentally sustainable long-term solution to these essential heating and cooling needs. SHC draws from an inexhaustible energy source while displacing fossil fuels and electricity otherwise needed for heating and cooling. The basic design of building involving right orientation, external obstructions to solar gain, right internal layout, optimum level of insulation, right window sizing, window type, right amount, placement & color of thermal mass & Trombe wall can lead us to a better sustainable building design.

:: Paper No.: ICEBD-MET - 2014 - 14803 ::

IMPACT AND FEASIBILITY ANALYSIS OF AN ALTERNATE ILLUMINATION STRATEGY TO CUT-DOWN ON ENERGY LOADS

G. Chaudhary and T. Jain

Recent studies have found that prolonged exposure to artificial lighting can be damaging to one's physical and psychological health. Whereas providing natural daylight can increase productivity up to 10%. These benefits are more noticeable in official, retail and educational buildings. This paper deals with improving illumination in our work spaces, specially targeting office and educational spaces where illumination lux is as high as 450 and reducing electricity consumption of the building through the use of central illumination in the roof cavity. The developed retrofit would be applicable only in 12-hr working building such as retail, offices, factories and educational spaces. In all these buildings recommended illumination lux is of range 300-450. Retrofit would be core right through the roof of the building and it would be like a hollow cuboid with its two sides made of a special translucent material and the other two sides concave mirrors facing inside the core. The translucent material opted is polycarbonate after considering all its properties like durability over a long period of time and that it is a natural ultraviolet filter. Experimental outcomes were taken from a miniature form of a scaled down actual building. The readings were taken using a well calibrated lux meter. The movement of sun was replicated using a Ring Heliodon. By doing the feasibility analysis of the device it was found that this device can work on par with other day lighting techniques. The payback period of this device was around 5 yrs.

:: Paper No.: ICEBD-MET - 2014 - 14808 ::

COOLING PV ARRAYS USING THE RETURN AIR FLOW OF AIR CONDITIONING SYSTEMS

W. Salameh, A. Assi, C. Habshi, and M. Khaled

Shading and increased temperature decrease the efficiency of photovoltaic (PV) systems. Dust accumulation is one type of shading that PV systems face during operation, while the increased temperature can be attributed to environmental conditions at places where the PV system is installed. Both issues affecting the efficiency of PV systems can be avoided by using a well-designed ventilation system that helps in reducing dust accumulation and the temperature of PV modules. The present work suggests the use of forced air flow of the return air of an air conditioning system to reduce the PV modules' temperature of operation in addition to reducing the dust accumulation on their surface. An analytical study is presented considering the problem as a forced convection between fluid flow and plane surface. The upstream effects on the Heating, Ventilating and Air Conditioning (HVAC) system are investigated and evaluated.

:: Paper No.: ICEBD-MET - 2014 - 14809 ::

OPTIMIZATION OF THE BUILDING ENVELOPE IN HOT AND HUMID CLIMATES

B. Nehme and G. Annan

This paper aims to promote building sustainable designs to reduce energy consumption by implementing optimized building envelope for high performance buildings. Several building envelope case studies for office, airport, retail and residential buildings, located in hot and

humid climates, are analyzed in WUFI, IES VE and CadnaA software in order to assess, simulate and optimize building envelope performance. A detailed building thermal energy performance simulation, assessing the impact of solar radiation and external shading devices, using IES VE, has been conducted to evaluate the effectiveness of the proposed building envelope designs and weigh the impact of sustainability measures on enhanced indoor environmental quality and building loads reduction. Also, a condensation analysis for external wall assemblies is conducted via WUFI software to study moisture influence on the thermal performance of the construction and long-term system behavior. Additionally, sound control software such as CadnaA assists in validating noise mitigation techniques from outdoor equipment to promote indoor occupant comfort. The simulation results also suggest building envelope composition optimized for hygrothermal and acoustic performance, window to wall ratios and appropriate shading strategies that promote reductions in building annual cooling energy for the different case studies to a range of savings varying from 5 % to 35% with respect to ASHRAE standard 90.1-2007 for hot and humid climates.

:: Paper No.: ICEBD-MET - 2014 - 14853 ::

EFFICACY OF USING PHASE CHANGE MATERIALS (PCMS) AS THERMAL ENERGY STORAGE FOR BUILDING APPLICATIONS IN THE MEDITERRANEAN REGION

Yehya. A and Naji. H

In the past decade, the economic situation started to change due to the raise in energy prices, hence researchers began to give more attention to phase change materials (PCM) applications for heating and cooling of buildings. PCM can be used for temperature regulation and their high storage capacity can reduce energy consumption in buildings. The development and testing are usually conducted for prototypes of PCM wallboard and PCM concrete systems to enhance their thermal energy storage capacity, with main concern in peak load shifting and solar energy utilization. However, for a more adequate integration, the industry needs to optimize the performance of PCM. In this work we present a review on the thermal energy storage with phase change materials (PCM) in buildings, and focus on the evaluation of its applications in the Mediterranean region. The efficacy here is related to the availability of PCM with suitable fusion temperatures for the studied climate and the period by which the savings in energy will compensate the relatively high prices of PCM. The studies undergone in Cyprus and other Mediterranean countries are promising and show the importance of using PCM in improving building energy performance and maintaining low heating and cooling loads. Furthermore, the increasing number of studies on PCM in many Mediterranean countries should therefore set the subject seriously into discussion in other neighboring countries like Lebanon, where energy saving is vital due to the increasing price of fuel. On the other hand, we highlight on the importance of the characterization of the thermo-physical properties of PCM through efficient experimental and numerical methods for their adequate integration in building applications. This study thus presents a short overview of basic material characteristics and necessary energy performance data based on available experiences to evaluate the efficacy of future applications of PCM in Mediterranean countries.

:: Paper No.: ICEBD-MET - 2014 - 14881 ::

EARTHEN HVAC SYSTEM

T. Jain and H. Mahadhasu

Cooling of air by evaporative cooling using earthen materials is proposed, the widespread use of water cooling using earthen pots is taken a step ahead by cooling air using the cold water. This cool air can be supplied directly into a space or into the intake of an air conditioner. The advantage over the existing desert coolers. No addition of moisture to the air. This system requires a part of the space to be conditioned to be made of a composite wall, which contains earthen material at one end facing the surroundings and the other surface to be made of metallic material, facing the conditioned space. The working of the setup initiates when air is supplied through the blower in the duct as shown in the figure below. The air first comes in contact with the metallic surface corresponding to a wall just ahead of the blower inlet. Then the air subsequently touches the other metallic surfaces before finally entering into the conditioned space from the recess. The metallic surface would absorb heat from the flowing air via two modes of heat transfer viz. Convection and conduction. The former mode can be greatly enhanced by increasing the surface area of the metallic surface area in contact with the air. If the amount of heat that is transferred to the water from the air is less than the heat lost due to evaporation at the outer surface. It can be said that the room will be cooled further. There can be several modifications to the metallic and evaporation surface, such increasing the surface area so as to improve heat transfer at both ends of the wall. The modifications are also mentioned. The system has various advantages in comparison to the existing systems. The electricity consumption will be minimal. Also no addition of moisture is present in the cooled air. The outlet air of the system can be fed to an air-conditioner as well.

:: Paper No.: ICEBD-MET - 2014 - 14935 ::

CFD INVESTIGATION OF THE PERFORMANCE OF LOCALIZED AIR-CONDITIONING WITH UPPER-ROOM ULTRAVIOLET GERMICIDAL IRRADIATION IN REDUCING CROSS-INFECTION

M. Kanaan, N .Ghaddar, K. Ghali, and G. Araj

*Localized airflow has been proven able to provide both temperature and pollutant concentration segregations with limited air mixing between adjacent occupied zones. However, it is not clear whether this type of air distribution can prevent cross-infection within the locally conditioned zone. The aim of this paper is to investigate using computational fluid dynamics (CFD) the transmission of *Staphylococcus aureus*, a common infectious type of airborne bacteria, and the applicability of upper-room ultraviolet germicidal irradiation (UR-UVGI) in minimizing cross-infection in spaces with localized air-conditioning systems. Lagrangian tracking model is used to predict the distribution of pathogens, and the microbiological air quality is assessed based on the pathogen concentration at the breathing level. Results reveal that UR-UVGI is needed to protect occupants in the localized environmental zone from airborne cross-infection in extreme cases of indoor bacteria generation, that delivering 54 W (184.25 BTU/h) UVC to the space may achieve 70% decrease in *S. aureus* concentration at the breathing level.*

:: Paper No.: ICEBD-MET - 2014 - 14937 ::

A SIMPLIFIED MATHEMATICAL MODEL FOR PREDICTING CROSS-CONTAMINATION IN OFFICE BUILDING AIR CONDITIONED BY DISPLACEMENT VENTILATION

C. Habshi, N. Ghaddar, and K. Ghali

In indoor environments, the occupants constitute one of the main sources of particles from the ultrafine to the coarse mode. As a result, diseases can be transmitted through exhaled droplets nuclei produced by the different respiratory activities. The behavior of the particles depends largely on their weight and the flow field determined by the air conditioning system adopted. To insure good indoor air quality (IAQ) it is advisable to design a ventilation system covering the inhalable range of particle diameters lower than $15\mu\text{m}$ ($4.92 \times 10^{-5}\text{ft}$). Recently, displacement ventilation system (DV) is widely used in offices and buildings for its effectiveness in providing high indoor air quality and its ability to carry contaminants from the lower occupied zone. The purpose of this work is to study cross-infection between occupants in typical internal offices by the development of a simplified model that simulates active particle behavior in spaces ventilated by displacement ventilation system. The developed model incorporates the deposition of particles on walls and the gravitational settling effect on particles distribution within the space. The model is able of capturing the physics of the problem with significant reduction of the computational time cost. The model results showed that as the particle diameter increases from the fine mode the effect of the gravitational settling increases reducing the stratification in concentration created by the DV system and thus increasing the particle concentration at the breathing level of the exposed person. This effect remains until reaching a diameter where deposition on the floor opposing the DV principle acts as a removal factor. Nevertheless, the removal effect occurs for relatively high diameters and thus doesn't cover the critical inhalable range (particles of diameter below $10\mu\text{m}$ ($3.28 \times 10^{-5}\text{ft}$)). To overwhelm the gravitational effect, higher ventilation air flow rates are needed to satisfy good indoor air quality but unfortunately at a higher energy cost. To overwhelm the gravitational effect, flow rates higher than 100L/s ($3.53\text{ft}^3/\text{s}$) with a recommended supply temperature of 22°C (71.6°F) are needed to satisfy good IAQ for the inhalable particle range and thermal comfort criteria.

:: Paper No.: ICEBD-MET - 2014 - 14940 ::

HEATING WATER USING THE RECOVERED WASTE HEAT FROM BOILERS IN HVAC APPLICATIONS - THERMAL MODELING AND PARAMETRIC ANALYSIS

M. Khaled, M. Ramadan, C. Habchi, M. Chouman, and F. Hachem.

The current tendency in the energy sector is to reduce fossil fuel-based energy investments in favor of an energy approach focusing on renewable energy concepts. On the other hand, Heating, Ventilating and Air Conditioning HVAC has changed from being luxury to essential need for people and comprises many energy components that require to be well managed. The present work concerns a coupling between these two energy domains and particularly aims to apply heat recovery concepts to HVAC applications. It particularly uses the energy waste from the exhaust gases of boilers to heat/preheat water. The heat exchanger considered is concentric tube heat exchanger. A thermal modeling of the heat recovery system applied to boilers as well as a corresponding iterative code are developed and presented. Calculations with the code are performed and give magnitude orders of energy saving and management in HVAC applications. A parametric analysis based on several geometrical configurations and boiler heating loads is carried out. It was shown that water can be heated from 20°C (68°F) to up to 100°C (212°F)

depending on the mass flow rate. The most efficient configuration is for water flowing in the inner tube with an inner to outer diameter ratio of 0.75.

:: Paper No.: ICEBD-MET - 2014 - 14941 ::

FIRE MANAGEMENT OF UNDERGROUND CAR PARK USING COMPUTATIONAL FLUID DYNAMICS

C. Habshi, M. Khaled, M. Ramadan, and G. Harika

Fire management consists on the design of adequate mechanical ventilation system to allow the smoke extraction within a short time in order to insure the safety of the personals. The zonal calculation method based on global estimations is widely applied to car parks. This method does not permit to test the fire extraction system and to see what happens locally. In this context, the present study report sample results obtained by computational fluid dynamics (CFD) for the ventilation and fire dynamics in a car park basement using the NFPA (National Fire Protection Association) standards. The tenability criteria are the temperature and soot visibility. The fire dynamic simulator (FDS) is used in the present study and which is based on the large eddy simulation (LES) method. Two cases are studied: car park with and without jet fans. It is shown that the jet fans enhance the smoke extraction by reducing the dead spots in the car park.

:: Paper No.: ICEBD-MET - 2014 - 14807 ::

TOWARDS SUSTAINABLE DESIGN WITH CUTTING EDGE CFD SIMULATION.

A. Akhdar and Y. Ghousoub

With the ever increasing demands for sustainable buildings, engineers are coming up with ever more complex and diversified designs to find ways to reduce loads, boost efficiency, and utilize renewable resources. CFD simulations have become an instrumental tool at Dar Al-Handasah, a multi-national EA consulting firm, to provide state-of-the-art designs for high performance buildings and meet the ongoing challenge of developing models that are energy efficient, sustainable, and LEED compliant. At an early phase in the design process, CFD simulations are extensively used as an optimization and validation tool in supporting the Company's design process through accurate prediction of thermal comfort conditions, design validation and optimization, and most importantly energy reduction for the HVAC building systems. Specifically, the simulations investigate insightful strategies for design and ingenious air conditioning systems and other energy saving measures that are geared towards decreasing the overall building energy cost, thus, qualifying the design for more points under LEED EA Credit 1, Optimize Energy Performance. Some of the innovative air-conditioning systems include radiant cooling coupled with DOAS in dry climates, under floor air distribution (UFAD) in high assembly spaces and optimized air flow distribution system for open stadia and high ceilinged spaces such as mosques.

:: Paper No.: ICEBD-MET - 2014 - 14953 ::

USE OF SOLAR REGENERATED MEMBRANE-DESICCANT SYSTEM TO CONTROL HUMIDITY AND DECREASE ENERGY CONSUMPTION IN OFFICE BUILDINGS

K. Keniar, N. Ghaddar, and K. Ghali

The proposed system is a hybrid air-conditioning system that uses a novel liquid desiccant cycle with porous membrane material. The cycle is integrated with a conventional HVAC system to allow for independent control of indoor humidity and temperature. Conventional liquid desiccant cycles dehumidify the air before supplying it to the indoor space, while the proposed cycle absorbs the humidity directly from indoor space using a permeable cylindrical membrane acting as a dehumidifier. The air leaving the indoor space is cooled using an evaporative cooler. The cooled air is then used to decrease the temperature of the desiccant entering the indoor space in order to reduce the sensible load that might be added to the space air and to increase the potential of the desiccant to absorb moisture. The size of the proposed cycle is significantly reduced as compared to the conventional cycles that rely on evaporative cooling towers or regenerators or even desiccant wheels. The regeneration of the desiccant is also done through the use of permeable membrane tubes with the aid of parabolic panels to collect solar energy. An integrated mathematical model of the permeable membrane with the space modal was developed to study the feasibility and efficiency of the proposed cycle. It was found that the system can achieve a 32-35 % reduction in electric energy consumption compared to conventional air conditioning systems operating on a typical office of size 4 m×5 m×6 m.

:: Paper No.: ICEBD-MET - 2014 - 14963 ::

APPLICATION OF ASHRAE 90.2 FOR MIDDLE EAST REGIONS

M.G. Ali, W. Chakroun, and W. Reedy

ASHRAE 90.2 is a standard for Energy-Efficient Design of Low-Rise Residential Buildings. It provides minimum design and construction requirements for low-rise residential buildings and their systems. In the Prescriptive Requirements by Component, ASHRAE 90.2-2010 provides values for building envelope components such as wall, roof, and glazing and energy efficiency for air conditioning systems for various climatic zones. It is often found that the values provided in the prescriptive requirements are not pertinent to the Middle Eastern regions because of its different geographical locations, climatic conditions, cultures, building practices and local regulations. Certain values are also often found to be less stringent than the local authority regulations and standard practices prevailing in the region. The objective of this Technical paper is to analyze and assess some of the prescriptive requirement values in ASHRAE 90.2 such as building envelope components wall, roof, glazing and energy efficiency of air-conditioning systems, using Building Energy Modeling Simulation techniques for different regions in the Middle East. It has been found that the building envelope forms a significant portion of the cooling or heating loads for low rise residential buildings and therefore a major percentage of energy consumption for the air-conditioning systems. Optimizing the building envelope values can provide substantial savings in energy. Similarly, the energy efficiency of the air-conditioning systems is a significant factor of energy consumption in the region. Optimizing the energy efficiency of air-conditioning systems can also provide substantial savings on energy. A comparative analysis is made for thermal conductivity (U) values of walls, roofs, and glazing, along with solar heat gain coefficient (SHGC) for glazing and energy efficiency of air-conditioning systems from the building energy modeling simulation results, to analyse the energy consumption

and potential energy savings and obtain optimized values for these parameters relevant to the Middle Eastern region. Comparative analysis is made using the ASHRAE 90.2 values against corresponding values in local regulations such as Ministry of Electricity & Water (MEW) Kuwait, Saudi Building Code (SBC), Dubai Municipality Regulations (DM) and Kharamaa, Qatar to form a wider spectrum of climatic regions. The optimised values of building envelope components and energy efficiency of systems can significantly improve and enhance the energy performance of the building and help in sustainable and efficient designs of buildings in the Middle Eastern region.

:: Paper No.: ICEBD-MET - 2014 - 14987 ::

A REVIEW ON HVAC HEAT RECOVERY SYSTEMS

M.Ramadan, M.El Rab, and M. Khaled

The energy crisis that has occurred during the last 15 years has pushed the researchers to study new sources of energy. The focus is generally concentrated on renewable energy, however another solution has recently been considered, that is energy recovery. Its main idea is to use the waste energy of any engineering system in another application. Energy recovery concept covers a wide range of domains among them heat recovery. The works existing in the literature concerning HVAC (heating, ventilation, and air-condition) heat recovery are few. However in this paper an investigation on heat recovery in HVAC applications is presented. The three main heat recovery strategies applied to HVAC applications are explained, "immersed condenser heat recovery system", "air to water heat recovery system" and "dual heat recovery system". Advantages and drawbacks are briefly discussed.

:: Paper No.: ICEBD-MET - 2014 - 16041 ::

A NEW FULL SCALE MULTI-PHYSICS MODEL TO PREDICT HYDRODYNAMICS AND HEAT AND MASS TRANSFER PERFORMANCE OF A WATER COOLED EVAPORATOR

I. Fayssal and F. Moukalled

In a recent article Moukalled et al. (2011) reported on the performance of a roof-top air conditioning unit by numerically predicting the thermal and hydrodynamic fields on the air flow side of the unit. This paper extends the work reported by Moukalled et al. (2011) and predicts the performance of the unit by analyzing the refrigerant flow side simultaneously with the air flow. The problem involves a turbulent multi-phase flow situation with condensation on the outer surface of the evaporator coil. Further, the heat transfer between the air flowing on the outer surface of the coil and the refrigerant flowing inside the pipes necessitates solving a conjugate heat transfer problem. Solutions are generated via a collocated unstructured finite volume method. . A conformal mesh was generated at the common interface regions separating fluid and solid zones to account for the continuity of heat fluxes at these interfaces. Two sets of results are presented in this manuscript simulating a wet and a dry coil. Detailed numerical predictions are compared with a developed lumped analytical model and with available experimental data for a similar coil model (Moukalled et al., 2011) and are found to be in good agreement. Complex turbulent flow fields were obtained in regions located upstream and downstream of the evaporator coil.

Abstracts of Industrial Sessions

HPMP AND THE BUILDING SECTOR: A WIN-WIN RELATIONSHIP

Mr. Yaqoub Almatouq - National Ozone Unit, Kuwait, Ayman Eltalouny - Programme Officer, UNEP; Bassam Elassaad - Consultant, UNEP; Samir Traboulsi - AUB & ASHRAE

In phasing out HCFC gases, The Multi-lateral Fund (MLF) has mandated that the replacement alternatives have low global warming potential in order to reduce the direct impact of refrigerant emissions on climate change. This action by the MLF comes at a time when the building industry is cooperating on reducing indirect emissions due to the use of inefficient heating and air conditioning systems that can contribute to more than half the energy consumption in the countries of the region. The HCFC phase-out management plans, known as HPMP, have elements that help countries design and execute projects and policy measures that can effectively contribute to reducing the impact on climate change. To date, the Montreal Protocol has contributed more than four times the effect on reducing emissions than the Kyoto Protocol did for the same period.

The special session that is co-organized by the United Nations Environment Programme (UNEP) and the National Ozone Unit at the Lebanese Ministry of Environment on the margins of the International Conference and Exhibition on Efficient Building Design (ICEBD) addresses the activities by the MLF and UNEP and the applications in Lebanon and the region of phasing out HCFCs while reducing emissions and their impact on climate change. The session will also discuss current practices and the need for specific codes and standards in order to support better practices in the region.

MANAGING PROGRAM BENEFITS

Attaining sustainability beyond project deliverables

Mr. Saadi Adra, Collaboration, Management & Control Solutions (CMCS) - Lebanon

Many individual projects succeed in producing the required deliverables within the chartered constraints of time, budget and quality, yet the clients or beneficiary fails to earn the needed business benefit and the deliverable is thrown away, hence requiring remake, rework or even clean start. The world loses Billions every year due to lack of proper management, therefore not only causing loss to the client/owner, but at the macro level, consuming our Earth's precious resources in vein.

In an attempt to optimize the utilization of resources, financial, human, capital assets and minerals, Program Management evolved focusing on understanding the strategy, environment, stakeholders and coming up with governance, infrastructure and plans to identify, analyze, plan, deliver, transition and sustain program, benefits, rather than mere project deliverables.

The paper is based on PMI's The Standard for Program Management, 3rd Revision, 2013 in addition to several other resources from IPMA, OGC, IJPM, PMJ and other books and peer-reviewed articles, combined with actual experience based on three case studies in the GCC and Africa, managing government and semi-government multi-billion dollar programs.

:: Paper No.: ICEBD-MET - 2014 - 14951 ::

DYNAMIC SIMULATION: MERGING THE FIELD OF ENERGY MODELING WITH THE SCIENCE OF COMPUTATIONAL FLUID DYNAMICS

K. Dada and A. Akhdar

Energy Modeling and Computational Fluid Dynamics (CFD) are two emerging engineering practices that have been put under persistent testing and validation in order to meet the ever increasing demand for sustainable and energy efficient designs. This push for efficiency and sustainability, in conjunction with the rapid acceleration of computer technology in recent decades, has resulted in computer hardware and software that are now capable of reliably predicting the behavior of engineering systems within known limits and in time frames that fit project schedules. These two cutting-edge engineering tools are now being extensively deployed in the building industry to accurately quantify the amount of energy lost or gained, reflected or absorbed, transferred or redirected in any given building. While energy modeling already considers some basic qualities of CFD in its energy balance calculations for convective and infiltration events, CFD provides the ability to practically visualize and quantify fluid flow in engineering systems. As such, there is significant potential to integrate both practices into one detailed and optimized model for the total building energy balance and behavior. The object of this paper is to expose the qualities of integrating energy modeling and CFD data into a single detailed model and illustrate how these two engineering practices can complement each other in the context of performance modeling and engineering building science. Two integration scenarios will be presented. In one hand, an initial energy model is done to derive the initial conditions for the CFD analysis, speeding up convergence and improving the accuracy of the boundary conditions of the CFD model. On another hand, the results from the CFD study are used to refine the energy model by providing critical data which due to the limitations of the energy model can only be accurately modelled using more detailed flow simulations

The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies.

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- *C. Seif, M. Hassanieh, R. Garzidin.* Fresh Air Cooling Plant in Hot and Humid Climate Comparative Study. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14794.
- *A. Michopoulos, K. Tsikaloudaki, V. Voulgari, T. Zachariadis.* Ground source heat pump systems for residential buildings in warm climates: Energy, Environmental and Economic considerations. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14790.
- *C. Seif, N. Ibrahim.* Geothermal Cooling Application for Fresh Air Treatment Plant in Doha Qatar, Case Study. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14796.
- *S. Prasad, S. Sahani.* Passive Solar Heating. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14802.
- *T. Jain and H. Mahadhasu.* Earthen HVAC System. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14881.
- *M. H. Salama, N.A. Mohamed, N. A. Mahmoud.* Improving Performance of a Variable Speed Refrigeration System Using Smart Control Strategy. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14753.
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- *T. Itani, S. Shatila, and S. El Haber.* Optimizing Energy Efficiency in PNU Campus. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14794.
- *A. Gharibyan, K. Touryan, A. Shvagir.* Efficient Method to Utilize Solar Energy in Buildings Via Combined Solar Thermal Technologies. The First International ASHRAE Conference on Efficient

- Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14782.
- R. Farhat, G. Tibi, N. Ghaddar, K. Ghali. Hybrid PV Battery System for a Typical House in Lebanon Inland Region. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14766.
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 - W. Salameh, A. Assi, C. Habchi. Cooling PV Arrays Using the Return Air Flow of Air Conditioning Systems. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14808.
 - M.G. Ali, W. M. Chakroun. Application of ASHRAE 90.2 for Middle East Regions. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14963.
 - C. Habchi, K. Ghali, N. Ghaddar. A Simplified Mathematical Model for predicting Cross-Contamination in Office Building air Conditioned by Displacement Ventilation. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14937.
 - O. Taneja. Facing the realities and Challenges of Sustaining Energy Performance and Improving Indoor Air Quality During Operations & Maintenance of Buildings. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14737.
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 - *I. Faysal, F. Moukalled*. A New Full Scale Multi-Physics Model to Predict Hydrodynamics and Heat and Mass Transfer Performance of a Water Cooled Evaporator. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:16041.
 - A. Yehya, H. Najji, L. *Zalowski*. Efficacy of Using Phase Change Materials (PCMs) As Thermal Energy Storage for Building Applications in the Mediterranean Region. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14853.
 - B. A. Nehme, G. Annan. Optimization of the Building Envelope in Hot and Humid Climates. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14809.
 - K. Keniar, K. Ghali, N. Ghaddar. Use of Solar Regenerated Membrane- desiccant system to control humidity and decrease energy consumption in office buildings. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No: 14953.

- M. Khaled, M. Ramadan, C. Habchi. Heating Water Using the Recovered Waste Heat from Boilers in HVAC Applications - Thermal Modeling and Parametric Analysis. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14940.
- *M. Ramadan, M.G. El-Rab, M. Khaled.* A Review on HVAC Heat Recovery Systems. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14987.
- Kanaan, N. Ghaddar, K. Ghali. CFD Investigation of the Performance of Localized Air-Conditioning with Upper-Room Ultraviolet Germicidal Irradiation in Reducing Cross-Infection. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14935.
- *C. Habchi, M. Khaled, M. Ramadan.* Fire Management of Underground Car Park Using Computational Fluid Dynamics. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14953.
- K. Dadda, A. Akhdar. Dynamic Simulation: Merging the Field of Energy Modeling with the Science of Computational Fluid Dynamics. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No:14951.
- A. Akhdar, Y. Ghossoub. Towards Sustainable Design with Cutting Edge CFD Simulation. The First International ASHRAE Conference on Efficient Building Design - Materials and HVAC Equipment Technologies. Beirut Lebanon, October 2-3, 2014. Paper No: 14807

List of Papers by Number

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Keynote 2	Phasing Out HCFCs without Increasing Greenhouse Gases Emissions: The Challenges	Thursday, October 02, 2014	2:00 - 3:00 PM	Auditorium A
Keynote 3	Application of Simulations for the Development and Evaluation of ASHRAE Standard 90.1	Friday, October 03, 2014	9:00 - 10:00 AM	Auditorium A
Keynote 4	Personalized and Localized Cooling and Ventilation Devices and Systems	Friday, October 03, 2014	1:30 - 2:30 PM	Auditorium A
14706	Slashing Energy Use in Labs & Commercial Facilities While still Providing Superior IEQ	Thursday, October 02, 2014	11:15 - 11:45 AM	Auditorium A
14737	Facing the realities and Challenges of Sustaining Energy Performance and Improving Indoor Air Quality During Operations & Maintenance of Buildings	Thursday, October 02, 2014	12:15 - 12:45 AM	Auditorium A
14753	Improving Performance of a Variable Speed Refrigeration System Using Smart Control Strategy	Friday, October 03, 2014	10:15 - 10:45 AM	Auditorium B
14766	Hybrid PV Battery System for a Typical House in Lebanon Inland Region	Friday, October 03, 2014	3:00 - 3:30 AM	Auditorium A
14769	Body Cooling Vest for Improving Endurance under Hot Environment	Thursday, October 02, 2014	11:15 - 11:45 AM	Auditorium B
14782	Efficient Method to Utilize Solar Energy in Buildings Via Combined Solar Thermal Technologies	Friday, October 03, 2014	2:30 - 3:00 PM	Auditorium A
14784	HVAC System Optimization and energy savings at Hot Dry Climate Zones in Middle East	Friday, October 03, 2014	11:15 - 11:45 AM	Auditorium B
14790	Ground source heat pump systems for residential buildings in warm climates: Energy, Environmental and Economic considerations	Friday, October 03, 2014	10:15 - 10:45 AM	Auditorium A
14791	Predicting Ventilation rates of Clothed human segment	Thursday, October 02, 2014	11:45 - 12:15 PM	Auditorium B
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14795	Optimizing Energy Efficiency in PNU Campus	Friday, October 03, 2014	11:45 - 12:15 PM	Auditorium B
14796	Geothermal Cooling Application for Fresh Air Treatment Plant in Doha Qatar, Case Study	Friday, October 03, 2014	10:45 - 11:15 AM	Auditorium A
14800	Princess Nora Bint Abdul Rahman University (PNU) Solar System	Friday, October 03, 2014	3:45 - 4:15 AM	Auditorium A
14802	Passive Solar Heating	Friday, October 03, 2014	11:15 - 11:45 AM	Auditorium A

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14807	Towards Sustainable Design with Cutting Edge CFD Simulation.	Friday, October 03, 2014	3:10 - 3:30 PM	Auditorium B
14808	Cooling PV Arrays Using the Return Air Flow of Air Conditioning Systems	Friday, October 03, 2014	4:15 - 4:45 PM	Auditorium A
14809	Optimization of the Building Envelope in Hot and Humid Climates	Thursday, October 02, 2014	3:45 - 4:15 PM	Auditorium A
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14951	Dynamic Simulation: Merging the Field of Energy Modeling with the Science of Computational Fluid Dynamics	Friday, October 03, 2014	4:15 - 4:45 PM	Auditorium B1 College Hall
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14963	Application of ASHRAE 90.2 for Middle East Regions	Friday, October 03, 2014	2:30 - 3:00 PM	Auditorium B
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