Session on: IEA EBC Annex 68 Project – Indoor Air Quality Design and Control in Low Energy Residential Buildings

Prof. Carsten Rode
Department of Civil Engineering
Technical University of Denmark
Building 402, DTU
Kgs. Lyngby, Denmark
E-mail: car@byg.dtu.dk

ABSTRACT

Introduction to IEA EBC Annex 68 and Discussion of the Project
The overall objective of the "Annex 68" Project, which belongs to the International Energy Agency's Energy in Buildings and Community program, is to develop the basis for optimal design and control strategies for good Indoor Air Quality (IAQ) in highly energy efficient residential buildings, and to disseminate this information in a practically applicable guide. Such strategies should facilitate the possibility to design and operate residential buildings with minimal energy use, while ensuring impeccable indoor climates. The project will gather existing data and provide new knowledge on pollution sources in buildings and their heat, airflow and moisture interactions. Contemporary models will be assembled to simulate the combined heat, air, moisture and pollution conditions of new NZEB's or energy refurbished existing buildings. The project will identify ways to optimize the provision of ventilation and air-conditioning.

The project is organized into five subtasks:
• Subtask 1 – "Defining the Metrics", will set up the metrics for the relevant performance parameters, which combine the aspiration for very high energy performance with good indoor air quality.
• Subtask 2 – "Pollutant loads in residential buildings", is to gather existing knowledge and provide new data on indoor air pollutants in as far as it has relation to thermal, airflow, and moisture conditions in buildings.
• Subtask 3 – "Modelling - review, gap analysis and categorization", will identify new couplings and use of modelling tools that can enhance our understanding of the combined thermal and mass flow effects under practical circumstances that can assist designers and operators of buildings.
• Subtask 4 – "Strategies for design and control of buildings", will build upon the previous subtasks to develop a guidebook on design and control strategies for energy efficient ventilation in residential buildings that will be optimized to provide also very good indoor air quality.
• Subtask 5 – "Field measurements and case studies", will identify and gather data from relevant case studies and field measurements where the above-mentioned strategies can be examined and optimized.

The first part of the seminar will be to present the project and its specific subtasks and activities therein, as well as to present the plan for deliverables. A subsequent part will be to discuss the content of the Annex project with the participants and gathering comments from the audience. The discussion shall focus on the expression of decisive metrics for IAQ with a view to implementation in policies, standards, and practice.

KEYWORDS
Indoor air quality, residential building, energy, ventilation, demand control, metrics

PRESENTERS, TITLES AND ABSTRACTS)

Carsten Rode, Ph.D., Member. Technical University of Denmark, Kgs. Lyngby, Denmark. car@byg.dtu.dk

Short bio: Professor in building physics with technical University of Denmark (DTU) since 2009. Associate professor, DTU 1996-2009. Senior researcher with Danish Building Research Institute 2002-2006. PhD 1990 on "Combined Heat and Moisture Transfer in Building Constructions". Chair, International Association of Building Physics, 2009-15.

"An International Project on Indoor Air Quality Design and Control in Low Energy Residential Buildings"
The overall objective of the "Annex 68" Project, which belongs to the International Energy Agency's Energy in Buildings and Community program, is to develop the basis for optimal design and control strategies for good Indoor Air Quality (IAQ) in highly energy efficient residential buildings, and to disseminate this information in a practically applicable guide. Such strategies should facilitate the possibility to design and operate residential buildings with minimal energy use, while ensuring impeccable indoor climates. The project will gather existing data and provide new knowledge on pollution sources in buildings and their heat, airflow and moisture interactions. Contemporary models will be assembled to simulate the combined heat, air, moisture and pollution conditions of new NZEB's or energy refurbished existing buildings. The project will identify ways to optimize the provision of ventilation and air-conditioning.

Marc Abadie. Université de La Rochelle, La Rochelle, France. mabadie@univ-lr.fr

Short Bio: Marc Abadie is associate professor since 2002 with University of la Rochelle. PhD in Building physics focusing on particle deposition in indoor environments (2000), followed by a PostDoc period with Lawrence Berkeley National Laboratory (USA). Research engineer at PUC-PR (Brazil), 2005-11. From 2011, he works at University of La Rochelle (France)

"Evaluating the Indoor Air Quality of Low-Energy Residential Buildings"
Subtask 1 aims at defining the metrics to enable a proper consideration of both energy and IAQ benefit in building design and operation. A first step consists in determining a list of target pollutants commonly found in residential buildings by identifying pollutants that are listed by cognizant authorities as harmful and verifying whether they are present in residential environments and at the concentrations, which can surpass the recommendations of the authorities. Benzene, carbon monoxide, formaldehyde, naphthalene, nitrogen dioxide, PM and PAH are clearly identified as high-priority target pollutants. Existing IAQ metrics will be reviewed to propose the best scientifically-sounded index (or set of indices) for the evaluation of indoor air pollution. The IAQ indices consider different pollutants, exposure limits and aggregations. A last part of the subtask will be dedicated to the inclusion of energy in the proposed evaluation. In particular, the index will also include additional energy use needed to improve IAQ in comparison with standard practice such as increased fan consumption induced by higher air change rates or additional particle/gas filters, or use of portable air cleaners.

Menghao Qin, Nanjing University, Nanjing, China. Email: mqin@nju.edu.cn

Short bio: Professor & Director of Center of Sustainable Building Research, Nanjing University.

"The combined effects of temperature and humidity on initial emittable formaldehyde concentration of fiberboard"
Individual effects of temperature and humidity on formaldehyde emissions from manufactured fiberboards have been studied previously, but their combined effects and possible correlation with initial emittable

concentration (C0) of building materials have not been reported yet. This project investigated their combined effects on C0 theoretically from microcosmic perspective. Total formaldehyde content related to humidity and formaldehyde molecular phases affected by temperature in the porous material were considered. A correlation between C0 and the combined effects of temperature and humidity was derived. Good agreement between the correlation and measurement data demonstrated the effectiveness of this correlation. The correlation could be helpful to simulate formaldehyde emissions and to estimate indoor formaldehyde exposure under varied temperature and humidity conditions in actual buildings. Influences of using different token parameters of humidity (absolute humidity vs. relative humidity) were also analyzed. The token parameter of humidity has significant effects on the quantitative conclusions on the influencing factors studies.

Jianshun Zhang, Ph.D., Fellow ASHRAE. Syracuse University, Syracuse, NY. jszhang@syr.edu

Short bio: Jensen Zhang is a Professor and Director of the Building Energy and Environmental Systems Laboratory at Syracuse University. His current research emphasis on integrated approach to indoor air quality and green building system design and intelligent controls.

"Predicting IAQ in low energy houses: the role of standard testing and benchmarking"
The objectives of Subtask 3 Modeling are to improve the understanding and develop prediction models on the impacts of outdoor pollutants, thermal environment, building materials and envelope, and indoor furnishing and occupant activities on the indoor air quality. The Subtask will also deal with the energy necessary to achieve the desired IAQ level in residential buildings, considering the IAQ metrics and pollution loads to be developed in Subtask 1 and 2, respectively. The approach of modeling the effects of combined heat, air, moisture and pollutant (CHAMPS) transport and their impact on energy and IEQ is needed. A whole building perspective is realized by integral consideration of indoor air and building envelope, building users and the building services systems. In this presentation, we will discuss an approach to defining a residential reference building and how the standard testing data could be applied to evaluate the VOC concentrations under various building ventilation conditions with the assistance of a system model.

Jakub Kolarik, Technical University of Denmark, jakol@byg.dtu.dk

Short bio: Associate Professor with Technical University of Denmark since 2013 working on development, design and application of sustainable climate conditioning systems. Researcher (2010-13); and Post-doc fellow with Technical University of Denmark, 2008-10. PhD, Silesian University of Technology, 2008.

”Design for “high Indoor Air Quality” in residences – current status and outlook for the future”
The objectives of Subtask 4 are to develop design and control strategies for energy efficient ventilation in residential buildings ensuring high indoor air quality. The strategies must go beyond the current common practice and actively utilize recent research findings regarding indoor air pollutants and combined heat, air and moisture transfer as well as take into account recent advances in sensor technology. Subtask 4 will utilize results of previous subtasks (metrics models, pollutant emission databases) together with existing knowledge to devise optimal and practically applicable design and control strategies. The presentation will focus on the first activity conducted in the subtask, which is mapping of current design strategies for high IAQ design in Europe, USA and China. Plans for the future work will be also presented.

Jelle Laverge. Ghent University, Gent, Belgium. Jelle.Laverge@UGent.be

Short bio: Tenured member of University staff with Ghent University. MSc in engineering with Ghent University in 2007. Since 2007, fulltime researcher and PhD-candidate with Ghent University. PhD 2013 on dissertation: ‘Design strategies for residential ventilation systems’.

“Field measurements and case studies”
Subtask 5 will identify and gather data from relevant case studies and field measurements where the strategies mentioned in conjunction with Subtask 4 can be examined and optimized. For instance, new ventilation patterns will be investigated in highly energy efficient residential buildings based on improved airtightness, increase insulation, use of materials, and possibly also new residential behavior. Several sites/climates will be proposed, and the field tests will include buildings declared as being energy efficient or recently refurbished to become so. The case studies will be validation experiments for the modelling work in Subtask 2 and Subtask 3.

Subsequent to the initial introduction presentation of the IEA Annex Project and presentation of each of the 5 subtasks (in 8+2 minute presentations), the session continues in a 30 minute discussion with the audience about the project. We will answer questions about the project, and we would very much like to have input in the form of comments and ideas from the audience.

LEARNING OBJECTIVES

After attending this session, the attendees will be able to

1. Explain some potential reasons why there may be conflict between residential buildings being highly energy efficient and providing good indoor air quality for occupants.
2. Explain which knowledge is available today and which knowledge gaps exist regarding data and models for emission of harmful compounds from materials in indoor environments.
3. Know what is written in guidebooks today about proper energy efficient management of buildings for high indoor air quality, and what new type of knowledge can be expected result from a project like IEA EBC Annex 68.
4. Know about test buildings that exist today where the combined performance in terms of energy efficiency and high IAQ is being investigated.

QUESTION AND ANSWERS

- **Question and Answers:**

  Q: q1.1 Among the pollutants listed below, what are the pollutants of highest priority regarding the Indoor Air Quality of residential buildings?

  - Particulate Matter (PM), Formaldehyde, Benzene, Radon
  - Particulate Matter (PM), Radon, Water vapor (i.e. relative humidity), CO_2
  - Formaldehyde, Benzene, Water vapor (i.e. relative humidity), CO_2
  - Water vapor (i.e. relative humidity), CO_2
  - Radon, Water vapor (i.e. relative humidity), CO_2
  - Particulate Matter (PM), Radon

  Q: q1.2 Are pollutant concentration levels higher in low-energy residential buildings than in older ones?

  - Yes
  - No
  - No straight answer

  Q: q2.1 Among the environmental parameters listed below, what is the most influential factor on formaldehyde emission from building materials?

  - Relative humidity
  - Temperature
  - Absolute humidity
  - Pressure

  Q: q2.2 Is the pollutant load in a residential building a constant value?

  - Yes
  - No

Q: q3.1 What is model-based testing and evaluation approach?

- It uses a mathematical model to represent the data collected from testing
- It uses test data to develop an empirical model
- **It uses test data to determine the parameters of a mechanistic model, which is then used to evaluate**

Q: q3.2 What is the advantage of the model based testing and evaluation approach over the traditional standard testing and evaluation method?

- **It can be used to evaluate how indoor pollutant concentrations are affected by many influencing factors such as ventilation rate, indoor material emission rates, outdoor pollution level, and environmental conditions beyond the testing conditions**
- It has a more complex and interesting mathematical model

Q: q4.1 Design of ventilation air-flows for residences is nowadays usually based on (choose one answer)

- **Minimum requirements specified in a particular building code or national/international standard**
- Analysis conducted in dynamic building energy simulation tool
- Pollution load for the designed dwelling estimated by means of emission models for high priority IAQ pollutants defined by WHO

Q: q4.2 What are the recommended total ventilation rates based on floor area for category I (best IAQ), II and III residential buildings according to European standard EN 15 251 (choose one answer)?

- 0.7 L/s m^2, 0.35 L/s m^2, 0.1 L/s m^2
- **0.49 L/s m^2, 0.42 L/s m^2, 0.35 L/s m^2**
- 0.3 L/s m^2, 0.6 L/s m^2, 0.8 L/s m^2

Q: q5.1 We can measure all indoor pollutants

- True
- **False**

Q: q5.2 We can use air purification technologies to remove all harmful pollutants indoors

- **False**
- True