Energy Efficient IAQ Management in residential buildings

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ABSTRACT

In this extended abstract, we introduce the new IEA EBC Annex on 'Energy Efficient IAQ Management in residential buildings'. In this Annex, we address a number of challenges in implementing smart IAQ management strategies.

Annex 68 provided us with a general framework for integrated simulation and assessment of Energy Efficiency (EE) and chemical indoor air pollution. This framework can now be further extended to develop and assess a series of smart Indoor Air Quality (IAQ) management strategies.

By mapping the existing work on the pollution sources in residential context, we develop a consistent set of metrics for assessing the performance of the various technologies in terms of energy efficiency, comfort and health for the occupants. This includes extending the framework developed in Annex 68 with specific metrics for energy efficiency and particulate matter, explicitly including moisture control and HVAC component modeling as well as creating a common methodology for IAQ data sharing among smart devices. By pooling and analyzing the data, the range of conditions in dwellings can be better understood and the most appropriate energy efficient IAQ management strategies can be identified. The application of the metrics over time also allows continuous commissioning and conveying the achieved performance to the occupants.

In this Annex, we therefore optimize the energy efficiency of IAQ management by addressing these issues. For the IAQ management we mainly focus on the use of smart materials (materials that have an ability to actively influence IAQ situation in the space) and smart ventilation (as defined by AIVC VIP paper nr. 38), since these are the strategies that have a high EE potential (air cleaning is already studied in a separate Annex 78).

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INTRODUCTION

The IEA EBC program has had a series of Annexes, a type of international coördination projects similar to eg. EU Cost Actions, related to energy efficient ventilation. From the remaining questions from the last of these ventilation related Annexes, Annex 68, a proposal for a new Annex starting in the autumn of 2020 has recently been submitted to the IEA EBC Executive Committee. This extended abstract introduces the goals of this new Annex project and invites interested partners to participate.

GOALS OF THE ANNEX

The energy performance of new and existing residential buildings needs to be radically improved to meet ambitious climate change goals and residential buildings are by far the largest component in the total building stock. A central boundary condition in constructing energy efficient buildings is doing so while maintaining a healthy, acceptable and desirable indoor environment. In its mission statement, the IEQ-Global Alliance (IEQ_GA) states that Indoor Environmental Quality includes the thermal environment, the indoor air quality, lighting and the acoustic environment that occupants experience in buildings. While ventilation is the main strategy that is adopted for IAQ management, other technologies influencing IAQ (e.g. air filtration) are available as well and a large number of ventilation strategies exist. There is, however, no coherent assessment framework to rate and compare the performance of IAQ management strategies. This annex will therefore focus on assessing the performance trade-off between and identifying the optimal solutions for maximizing energy savings while guaranteeing a high level of indoor air quality in new, renovated and existing residential buildings.

Within this context, The Annex has the following specific key objectives:

- To select metrics to assess energy performance and indoor environmental quality of an IAQ management strategy and study their aggregation
- To improve the acceptability, control, installation quality and long-term reliability of IAQ management strategies by proposing specific metrics for these quality issues
- To set up a coherent rating method for IAQ management strategy that takes into account the selected metrics
- To identify or further develop the tools that will be needed to assist designers and managers of buildings in assessing the performance of an IAQ management strategy using the rating method
- To gather existing or provide new standardized input data for the rating method
- To study the potential use of smart materials as (an integral part of) an IAQ management strategy
- To develop specific energy efficient IAQ management solutions for retrofitting existing buildings
- To benefit from recent advances in sensor technology and cloud-based data storage to systematically improve the quality of the implemented IAQ management strategies, ensure their operation and improve the quality of the rating method as well as the input data
- To improve the availability of these data sources by exploring use cases for their providers
- To disseminate about each of the above findings.

WORKPLAN

By mapping the existing work on the pollution sources in residential context (including occupant activities and the penetration of outdoor pollution), we want to develop a consistent set of metrics that allows us to assess the performance of the various technologies in terms of energy efficiency, comfort and health for the occupants. This includes extending the framework developed in Annex 68 with specific metrics for energy efficiency and particulate matter, explicitly including moisture control and HVAC component modeling as well as creating a common

methodology for IAQ data sharing among smart devices. By pooling and analyzing the data, the range of conditions in dwellings can be better understood and the most appropriate energy efficient IAQ management strategies can be identified. The application of the metrics over time will also allow continuous commissioning to ensure that the predicted energy efficiency is actually maintained over the lifetime of the system. Another advantage is the possibility of conveying the information towards building occupants, building operators and facility managers in a coherent way. Ensuring performance over the lifetime of the system, however, requires continuous commissioning of the technical components of the system as well to prevent deterioration of the performance.

These activities will be structured in 6 subtasks as described below. A range of methods will be used to accomplish the work in this annex, ranging from literature review to experimental lab work. There will be face to face consent workshops, for the development of the rating method. There will also be a considerable amount of numerical modeling to compare system options in a set of identical conditions.

Subtask 1 Metrics and development of an IAQ management strategy rating method

This subtask is devoted to the development of a general rating method for the benchmarking of the performance of IAQ management systems. It will propose relevant metrics, a set of appropriate tools, consistent modeling assumptions, and monitoring protocols.

Subtask 2 Source characterization and typical exposure in residential buildings

This Subtask creates consistent input values for the assessment method developed in ST 1 and control strategies in ST 4. It starts from information available in literature, adding new experimental results where needed and reviewing and developing models (empirical, semi-empirical or physical models) for characterizing relevant residential sources. Areas of particular interest are: sources from building materials and pieces of furniture (review and consolidation of models and parameters), indoor sources from occupants and occupant activities (cooking, cosmetics, cleaning…) and occupancy patterns (partly drawing on the outputs of Annex 79), heating and cooking appliances (wood and gas stoves, fireplaces…), outdoor sources (from air and from ground), biological activity (fungal growth), secondary emissions due to indoor chemistry (e.g., O3-initiated reactions), bedroom environments, epidemiology aspects (airborne transmission paths).

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Subtask 3 Smart materials as an IAQ management strategy

This subtask identifies opportunities to use the building structure and (bio-based) building materials (e.g. hemp concrete) and the novel functional materials (e.g. Metal-Organic Frameworks (MOFs), precise humidity control material (PHCM) etc.) inside it to autonomously manage the IAQ, for example, through active paint, wallboards, textiles coated with advanced sorbents or hemp concrete, and quantifies their potential based on the assessment framework developed in ST 1.

Subtask 4 Ensuring performance of smart ventilation

This subtask focuses on practical conditions that assure reliable, cost effective and robust implementation of smart ventilation. This includes both installation and operation. A poor performance of smart ventilation systems can not only lead to waste of energy and aggravated IAQ. It can also create a bad reputation of smart ventilation among relevant stakeholders - designers, installers as well as occupants. This, in the end, can lead to adoption of more primitive, less efficient (in terms of energy use) and less effective (in terms of IAQ) forms of IAQ management.

The subtask defines a smart ventilation according to the AIVC: “Smart ventilation is a process to continually

adjust the ventilation system in time, and optionally by location, to provide the desired IAQ benefits while minimizing energy consumption, utility bills and other non-IAQ costs (such as thermal discomfort or noise). (…)". This definition includes a wide range of systems currently available in the literature and on the market depending on the type of sensing parameters (CO2, humidity, occupancy, …) and their combinations, the type of installation (centralized/decentralized) and the types of control algorithms. The subtask will propose a rating of smart ventilation strategies, here the results from subtask 1 and to are going to be directly applied. The second activity will focus on quality control of implementation of smart ventilation. The activity aims to produce a protocol that the practitioners will be able to apply to ensure proper installation, commissioning and well as long term monitoring and maintenance. Furthermore the subtask will include also activities focused on durability of smart ventilation systems and their component and an activity focused on occupant interaction with the systems.

Subtask 5 Energy savings and IAQ: improvements and validation through cloud data and IoT connected devices

This subtask is exploring the potential of the new generation of IoT connected devices (both standalone and embedded in eg. AHU's) for smart IAQ management. What can we learn from big data? Can we benchmark system energy and IAQ performance based on this data? How can we make sure that the data is available and can be accessed? Can we update what we think we know about what happens in dwellings based on what we see in big data rollouts? What are the best protocols and ontologies? How to create viable services out of the data/business plans? How can we integrate data with smart grids?

These issues will be addressed by reporting experiences from a series of implementation case studies and overview of available (types of) datasets.

Subtask 6 Dissemination, management and interaction

The final subtask assures the close alignment of the activities within the annex and the interaction with the AIVC. This subtask includes the outreach of the annex, eg. by managing the dedicated section of the IEA EBC webpage. It uses the different platforms that the AIVC provides to interact with the broader target audience. This task will also ensure the continuation of the link with (the results from) other ongoing and ended Annexes, especially Annex 68.

EXPECTED OUTCOMES/DELIVERABLES

The project work towards 4 deliverables:

- A literature list for energy efficient energy management that will provide a comprehensive overview of all the literature that was used and highlighted during the annex.
- An open database with source data for the rating of IAQ management strategies that brings together all the (references to) data collected to support the work in the annex.
- An overview report on methods and tools for the rating of IAQ management strategies that will provide researchers, professionals and practitioners with a collection of methods and tools for IAQ management strategy rating.
- A collection of case studies and demonstrations of energy efficient IAQ management strategies that will provide practitioners with an overview of current practises and use cases of IAQ management strategies.

PARTICIPATION IN THE ANNEX

The consortium of partner in the Annex includes engineers, building physicists, experts in ventilation and controls technology, indoor air specialists, material scientists and experts in atmospheric chemistry and businesses in the smart ventilation space. Currently it includes institutions from 11 countries, however, we welcome participation of all further interested parties, who can join the activities during the first preparation year of the Annex.

Each participant works in at least one of the sutasks. All participants are also required to deliver information and written material to the final reports. Each participant individually bears their own costs incurred in the Annex activities. Funding is expected to cover labour costs, consumables and investments (including overhead costs where applicable) associated with the execution of contributed research activities and to cover traveling costs for participating in at least two expert meetings per year during the 5-year duration of the Annex. The working meetings will be hosted by one of the participants.

ACKNOWLEDGMENTS

The authors would like to thank all Annex participants, with a special thank you for those that contributed to the Annex proposal