Personalized environmental control systems (PECS): Overview of applications, technology classification and KPIs

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SUMMARY

Personal Environmental Control Systems (PECS) enable to individually control the environment in the immediate surroundings of an occupant regarding the thermal, air quality, acoustic, and/or luminous domain without directly influencing the entire space and other occupants' environment. Although many studies on the influence on the respective comfort and acceptance in relation to the different domains already exist and estimates of energy savings have already been made, PECS have not yet established themselves on the market across the board. In this session we will propose how to classify PECS for the built environment and which KPIs can be used to evaluate different types of them. This is a first step towards a standardised qualitative and quantitative assessment of the benefits that PECS can provide.

KEYWORDS

Indoor Environment, Personalized Environmental Control Systems (PECS), Thermal Comfort, Air Quality, KPI

1 INTRODUCTION

The application of PECS in buildings primarily enables an increase in comfort and user acceptance which is often also combined with healthier environments and increased productivity (Rawal et al. 2020; Luo et al. 2022; Song et al. 2022). These systems can be used for heating, cooling, ventilation, and air filtration as well as for adjusting the lighting and acoustic environment. PECS can also cover a combination of these application areas. In addition, studies of PECS often estimating a reduction in overall building energy demand as well as an economic advantage (Zhang et al. 2015; Hoyt et al. 2015).
However, PECS are not yet widespread and are used even less frequently in an overall building concept. The possibility of retrofitting often depends on the energy and media connection. For example, an electrically heated office chair is easier to retrofit than a personal ventilation system that has to be connected to a fresh air supply. Energy savings furthermore depend on the possibility of integrating PECS into the building automation system or taking it into account there. Planners and building operators therefore need an overview of the different types of PECS, their capabilities, and limitations to be able to use them in a more targeted way and answer the following questions, for example:

- Which PECS help to improve user satisfaction and comfort in certain domains?
- Which PECS help to decrease overall energy demand?

- Which PECS can be used for a certain building and can costs be saved when refurbishing with PECS compared to conventional approaches?
- How can PECS are integrated into the planning process for new buildings, e.g., through a smaller design or by avoiding conventional air handling units?

To help to answer these questions, this session will provide classification proposals and KPI of PECS for the different domains.

2 METHODOLOGY

Based on an extensive literature search within the framework of IEA-EBC Annex 87, in which the databases of Scopus, Web of Science, PubMed, Research Gate, Google Scholar, and Taylor and Francis were searched, classification proposals for different PECS are first developed. In addition to the already known categorizations regarding the thermal, air quality, acoustic and luminous domains, further relevant properties need to be identified to provide a better overview of the areas of application, implementation options and operation. For the implementation, a differentiation can be made regarding the general design as to whether the PECS are integrated into the building structure ("building attached", e.g., a locally heated or cooled wall), can be used independently from the building structure ("building detached", e.g., furniture-integrated device) or can be considered as building semi-detached (e.g., personalized ventilation with the supply duct connected to the central HVAC). Regarding implementation, a distinction can also be made between the media or energy supply (e.g., electricity, water or air-based) and the data connection (none, cable, wireless) as well as the communication protocol used. For operation, for example regarding the thermal domain, a difference can be made between the heat transport mechanisms (radiation, conduction, convection, evaporation), which have an influence on PECS efficiency. A distinction can also be made as to whether the PECS are operated in a stationary or transient mode.

In collaboration with the working group from Subtask-D of IEA-EBC ANNEX-87, relevant KPIs were analyzed based on the literature review. Firstly, the evaluation metrics for the individual domains were analyzed. For the thermal domain, for example, this includes the corrective power in the case of a change in the average room temperature, which represents the compensatory capacity of the PECS, which can be expressed either in K or in a shift in thermal sensation (Zhang et al. 2015). In addition, the degree of coverage of the PECS in relation to the body segments reached and the (specific) energy requirement are considered. Further KPIs are proposed with regard to the implementation effort for an evaluation of retrofitting in existing buildings and in terms of higher-level building automation with regard to the data and communication interfaces. Finally, economical KPI as well as indirect and overarching effects on productivity, well-being and health are summarized.

3 RESULTS AND DISCUSSION

During the workshop on PECS during the 44th AIVC – 12th TightVent & 10th venticool Conference, this session will propose the following:

- Extended classification approach for PECS regarding application, implementation, and operation in the built environment
- Summary of relevant KPI from literature and discussion of new KPI proposals
- Discussion of the results and new approaches

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