Performance assessment framework for smart ventilation systems

Hilde Breesch[1], Jelle Laverge[2], Ivan Verhaert[3], Twan van Hooff[4], Lieven De Geetere[5] and Romy Van Gaever[5]

[1]*KU Leuven, Department of Civil Engineering, Building Physics and Sustainable Design*
Gebroeders De Smetstraat 1
Ghent, Belgium
[2]*Ghent University, Faculty of Engineering and Architecture, Building Physics Research Group*
Campus UFO T4, St-Pietersnieuwstraat 41
Ghent, Belgium
[3]*University of Antwerp, Department of Electromechanics, Energy and Materials in Infrastructure in Buildings*
Groenenborgerlaan 171
Antwerp, Belgium
[4]*TU Eindhoven, Department of Built Environment, Building Physics and Services*
Groene Loper 6
Eindhoven, The Netherlands
[5]*Buildwise, HVAC laboratory & Acoustics laboratory*
Avenue P. Holoffe 21
Limelette, Belgium

ABSTRACT

A smart ventilation system is able to continually adjust itself to provide the desired indoor air quality (IAQ) while minimizing energy use, utility bills, thermal discomfort and noise. A smart ventilation system is also responsive to e.g. occupancy, outdoor conditions, direct sensing of contaminants and can provide information about e.g. IAQ, energy use and the need for maintenance or repair. Technically, all components for such systems are available in the market. For midsized buildings, where the system complexity exceeds the typical 'all-in-one-box' solutions that are available for single-family dwellings, the design of ventilation systems is very conservative and inefficient. No method exists today to select the most optimal system and room layout in a specific building based on a coherent set of indicators for design optimisation (i.e. indoor environmental quality (IEQ), energy use, life cycle costs, comfort, maintenance, resilience).

This study aims to address the knowledge gap by presenting a performance assessment framework consisting of a general economic indicator. The indicator can be integrated as an objective function in the design optimization of air distribution networks. The indicator is tailored for different room types, and IEQ parameters (acoustics, resilience, occupant behaviour, sleep). The use of a global economic indicator is an improvement on the current ventilation design methods, which are driven by minimum requirements for IAQ, energy consumption and/or investment costs.

As all these factors impact at different levels, it is important to select a common metric for evaluation. Assessment of financial costs induced by the various categories will be used in that purpose. The major complexity relies on the identification and objective evaluation of each separate cost at building or individual scale. Identified impacts are divided into two categories: hard costs and soft costs. Hard costs include material, maintenance, operation and installation costs while soft costs gathers medical costs, productivity lost, learning disturbance and willingness to pay. For each concerned category, a generalization of medical cost calculated by Disability Adjusted Life Years (DALY) approach; and productivity lost function. Costs related to user satisfaction are assessed by a correlation between thermal comfort, energy consumption and productivity. This assessment framework is applied on a case study, i.e. one floor of an educational building at University of Antwerp, including classrooms, offices and labs.

KEYWORDS

Indoor Environmental Quality, Smart Ventilation, Economic costs, Assessment framework