What we know about smart ventilation

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SUMMARY

The buildings 'sector is facing multiple challenges due to the need to generalize a sober approach and to reduce its energy consumption, its CO_2 emissions and its impact on climate change, to reduce its environmental impact and its carbon footprint, to reduce the burden of disease due to exposure to unhealthy indoor environments and to adapt and be resilient in the face of climate change and environmental changes such as the increase in pandemics, the urban heat island and outdoor pollution.

Ventilation in buildings is at the heart of all these challenges and is sometimes misunderstood, contrasting the need to reduce air flow to save energy with the need to increase air flow to provide healthy air for humans. We know that reality is never simple, as it is in this field. Building ventilation represents an incredible and underestimated factor in reconciling all these challenges, part of the solution. Firstly, because to achieve all these objectives, including IAQ, summer comfort and energy savings from heating and air conditioning, you really have to control the air flows in buildings. This means limiting unintentional infiltration due to air leaks and controlling voluntary air flows using ventilation system components. Secondly, through the concept of smart ventilation, which can be a solution for both new and existing buildings.

Indeed, providing a constant ventilation airflow rate throughout a building, whatever the boundary conditions (climate, outdoor pollution, seasons, …), whatever the needs of the occupants, whatever the risks of damage to the buildings, seems totally unsuited to our challenging changing world and our need to adapt. Nevertheless, most buildings in developed countries are equipped with constant-airflow ventilation solutions, where ventilation exists.

Smart ventilation has been defined by 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).* (…)". Starting from this definition, demand-controlled ventilation (DCV) is considered as a specific subset of smart ventilation. This definition of smart ventilation includes a wide range of systems currently available in the literature and on the market depending on the type of sensing parameters (CO_2, humidity, occupancy, etc.), the type of sensing combinations, the type of installation (centralized/decentralized) and the types of control algorithms. A literature review on smart ventilation used in residential buildings, showed that with various smart ventilation systems based on CO2-, humidity-, combined CO2- and TVOC-, occupancy-, outdoor temperature-controlled ventilation, energy savings up to 60% could be obtained without compromising, and sometimes improving, IAQ (Guyot et al., 2018a).

While the terms "smart ventilation" were first used fairly recently by LBNL researchers (Walker et al., 2014; Less and Walker, 2016; Lubliner et al., 2016), and have been increasingly used since (Table 1), the concept of smart ventilation is older. Demand-controlled ventilation emerged after the oil crisis of the early 1980, with some research published at the time (Anon, 1983; Barthez and Soupault, 1984; Nicolas, 1985). More recently, a favourable context has been created to develop smart ventilation strategies, with DCV systems widely and easily available on the market in some countries, with more than 20-30 DCV systems approved and available in countries such as Belgium, France and the Netherlands (Guyot et al., 2018b).

The smart ventilation concept is also interesting because it demonstrates the **applicability of performance-based approaches** applied to ventilation. Even if the final report of the IEA EBC Annex 9 (1982-1986) already stated that in principle two approaches may be used to specify ventilation standards:

i. The prescriptive approach, in which an outdoor air flow rate is stated.

ii. The air quality approach, in which a limiting maximum pollutant concentration is defined and the building designer or user, is required to supply sufficient air to ensure that this is not exceeded.

To date, however, most national regulations and standards in this area still use the prescriptive approach.

In the field of smart ventilation, before being authorised or used in buildings, smart ventilation must undergo procedures/calculations in order to demonstrate that it is at least equivalent to traditional/reference ventilation, or

to demonstrated that the use of smart ventilation makes it possible to comply with IAQ requirements (Guyot et al., 2018b; Guyot, 2019; Guyot et al., 2019). To our knowledge, Spain is the only country in the world which generalized the performance-based approach for every type of ventilation in new residential buildings.

Smart ventilation is promising because such strategies can adjust the airflows in a changing world and changing outdoor conditions, like heat waves or outdoor pollution peaks. If balanced ventilation with heat recovery systems are often prioritized in strong winter climate conditions like in the European Scandinavian countries, smart ventilation could be very performing in several conditions (Laverge et al., 2013; Zukowska et al., 2020).

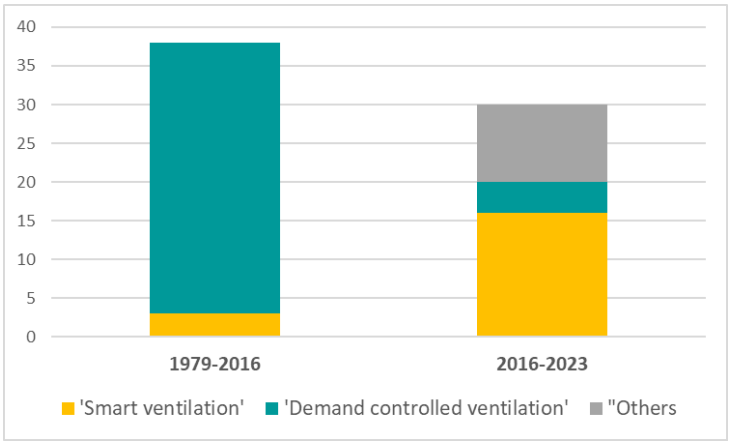
Several challenges can be addressed thanks to the use of smart ventilation: face to the lack of commissioning and the number of dysfunctions observed on ventilation systems, smart ventilation can offer online and continuing commissioning, and it can participate to the decrease of the carbon footprint of buildings. For all smart ventilation, robustness and resilience (to occupant, to life time, to other factors…) should also be taken into account. Indeed, durability of building performances is still a general crucial issue to be addressed. Nevertheless, with smart ventilation, we generally allow lower airflows at some times when needs are low (no occupancy, low emissions, etc…), but we have to secure even more than with other ventilation systems that expected ventilation airflows are still correctly provided, over the building life.

In the IEA-EBC Annex 86, and especially in the ST4-smart ventilation, we have been gathering and pushing and international effort about the promotion of smart ventilation strategies. ST4 includes a review work of existing knowledge about IAQ and energy performances of residential smart ventilation, their cost, and the choice of several smart ventilation strategies being highlighted as promising from the review analysis, and considered in the further work of the subtask as examples. This activity also includes a review of performance assessment methodologies, namely “performance-based” approaches used for smart ventilation, being used in the countries of the participants. At least, this activity is going to propose a performance-based rating approach for smart ventilation. The approach will be demonstrated by means of simulations, establishing a common exercise throughout the participating countries. We will propose quality managements schemes and inspection protocol for insuring the quality of implementation and address the issue of durability of smart ventilation systems and components. The keynote will give an overview of the recent knowledge on smart ventilation gathered through this Annex.

KEYWORDS

Ventilation, demand-controlled ventilation, performance, smart ventilation

Table 1. Number of studies dealing with smart ventilation



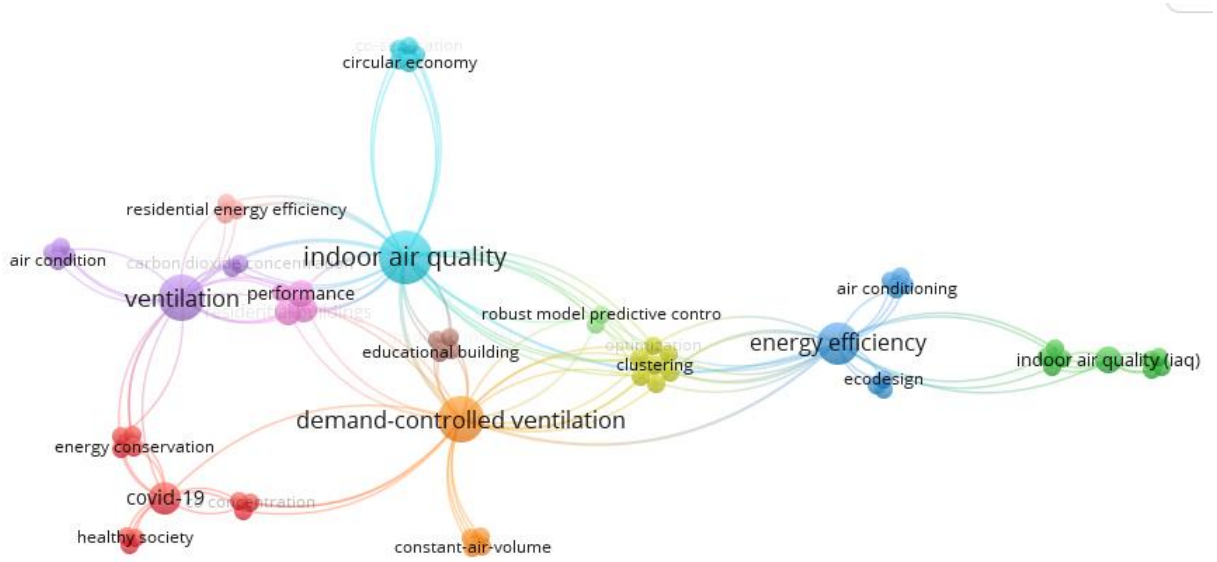


Figure 1: Keywords connection from the request “smart ventilation” and “demand-controlled ventilation” using Sciencedirect database, February 2023. Source:VOS viewer

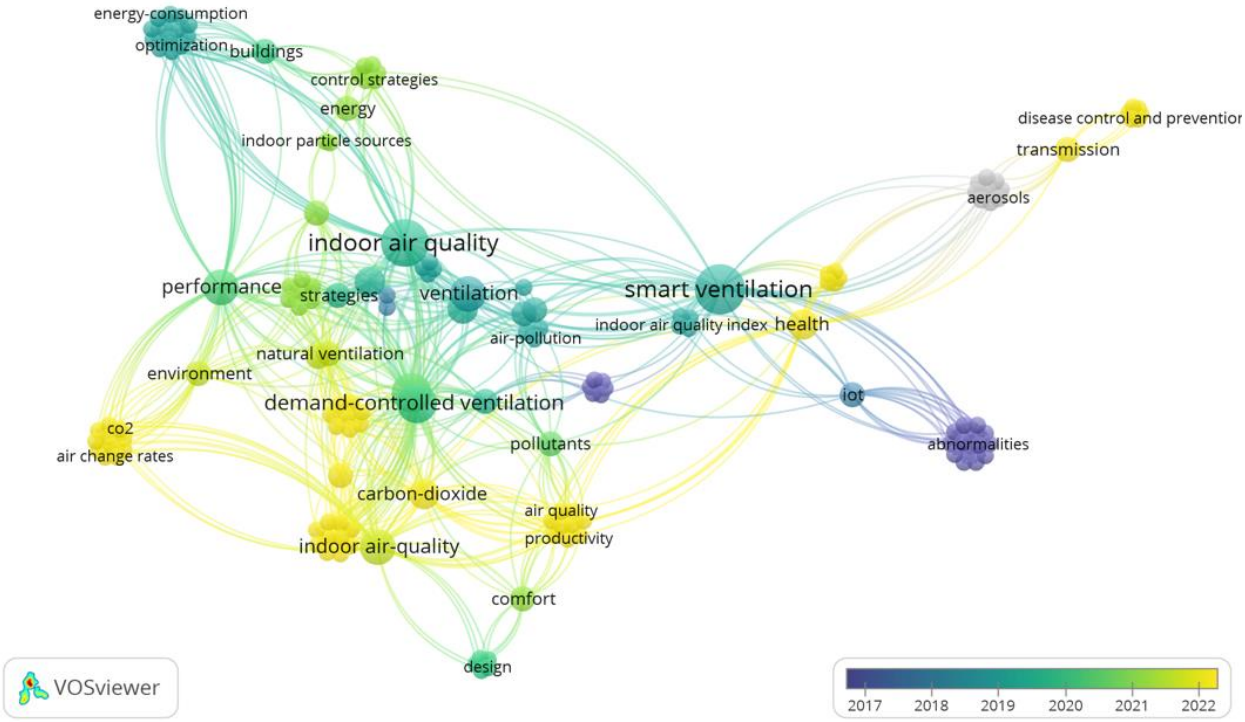


Figure 2: Keywords connection from the request “smart ventilation” using Sciencedirect database, February 2023. Source:VOS viewer

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