Checking and assuring real IAQ and energy performances through demand control and cloud connectivity

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EXTENDED ABSTRACT

Since 2018, Renson has introduced a range of cloud-connected residential ventilation systems, including central and decentral mechanical extract ventilation (MEV), as well as fully mechanical systems with heat recovery (MVHR) (see Fig. 1). These systems incorporate smart control mechanisms that utilize different IAQ sensors (CO_2, VOC, RH), to adjust the airflow rate(s) locally or centrally to the detected needs. The IAQ sensors are located at the control valves or at the central unit, but not within the rooms. In that way, the full control system is integrated within the ventilation unit itself. The central MEV system also allows to extract air directly from the bedrooms, in addition to the wet rooms, to improve the sleeping environment.

Figure 1: Central MEV system (left), central MVHR system (middle), decentral MEV (right)

Cloud connectivity of smart devices offers a dual aspect. It presents several challenges that need to be addressed, including:

- Adoption of big data technology in construction industry is slow and difficult
- Accessing relevant insights from massive amounts of data is difficult
- Exploiting data requires significant investments to be made
- Security and privacy rights need to be maintained.

Despite these challenges, wired/wireless IoT devices offer valuable opportunities by creating added value for the different stakeholders, including manufacturers, installers, service companies, building owners, and end users. This is achieved by monitoring big data, which serves two key purposes:

- Providing services through interaction with the person of interest
- Gathering insights into real-time operation to optimize/improve system performances.

The range of services facilitated through digital interactions is numerous and includes the following:

- Digital communication:
  - Communication with residents/installers: Via resident/set-up app & web portals
    - Project preparation & planning: The set-up app supports the installer throughout the installation process by retrieving project parameters prepared in web portal, assisting in system calibration, displaying the installation parameters, and inserting measurement results for the automatic preparation and creation of the measurement ventilation report in the web portal.
    - Push notifications on smartphone for filter warnings and error detection: These notifications serve as alerts for potential faults, such as defective valves or fans, or to the installation of a wrong valve type for a given room. For instance, a bathroom valve can be switched with the one for a bedroom and vice versa.
    - Visual representation of real time/historic air quality and ventilation levels: The user app provides a visual display of air quality and ventilation levels in the home, down to room level. Colors indicate the air quality per home/room.
    - Service management and follow-up: remote inspection of correct functioning and maintenance of the devices to save time and money.
  - Communication with smart home/home automation: via API and/or via switching module
- Sending automatic software updates

To obtain valuable insights into real-time performance of connected systems, especially the central MEV system data was anonymously analyzed in recent years on several characteristics: energy consumption, IAQ, maximum ventilation rate, pressure losses, user interaction with the system, etc.

De Mare *et al*. (2019) presented a large-scale analysis of the performance of the smart MEV system based on field data. Half of the units were installed as a smartzone system which involved additional mechanical extraction from habitable rooms like bedrooms. Indoor climate and IAQ were analysed with respect to design criteria set out in standards as well as fan characteristics and energy consumptions. The finding revealed that, on average, the CO_2 level in bedrooms were below 950 ppm for at least 90% of the nighttime. For the MEV system with smartzone, the ctrl-factor of 0.26 was substantially lower than the default values (0.43-0.50) currently used in regulations. Additionally, the auxiliary energy consumption of the MEV with smartzone was found to be less than 50% of the literature values reported on similar systems. The average total yearly energy cost related to the operation of the ventilation system (heating and auxiliary energy) was found to be limited to €100 (in 2023 half that high due to price increases), and at least comparable to the operating cost of a MVHR system. Since rooms are often unoccupied or occupied at a low level, advanced demand control technology proves to have a high potential to limit total energy consumption, while assuring a good IAQ.

Another performance study was carried out by Pollet *et al*. (2022) to analyse the maximal used extract ventilation capacity of dwellings equipped with local air flow control during the heating season. The study examined how ventilation control options can have an impact on the maximal simultaneous ventilation losses. The central MEV system was again investigated with respect to the maximal occurring total extract rate during the heating period, based on big field and simulated data of the smart connected ventilation system. A maximal used fraction of the nominal installed ventilation capacity down to 50% was found, impacting in that way the required heat generation power (kW).

A third study was performed by Verniers *et al*. (2022), in which the significant impact of critical versus non-critical path control on the mean operating pressure and auxiliary fan consumption for residential DC-MEV systems was examined by means of multizone simulations during the heating season. Due to critical path control relative to non-critical path control, reductions of the fan power consumption in the range of 33 to 44% were obtained.

In today's context, residents have increasing expectations for simple and user-friendly solutions that minimize the need for complex manual adjustments. Besides, the ability to quickly react and adapt to indoor and outdoor changes (weather, occupancy, usage) is often expected. As a result, alongside smart ventilation systems, the integration of solar shading and ventilative cooling products as IoT devices into home automation has become common. These integrated systems work in harmony to enhance overall comfort and efficiency.

Furthermore, the use of model predictive control (MPC) is gaining recognition as a promising approach to improve occupant thermal comfort while reducing energy consumption. Instead of relying solely on rule-based control strategies, MPC leverages building design information, historical sensor data (e.g. indoor temperature), and weather forecasts to optimize building control. By considering predictive modelling, MPC allows for more proactive and efficient management of indoor conditions, resulting in enhanced occupant comfort and reduced energy usage.

The integration of smart ventilation systems, solar shading, ventilative cooling products, and the adoption of model predictive control represents a forward-thinking approach to building automation. These technologies work together to create responsive, comfortable, and energy-efficient living environments that align with residents' expectations for simplicity and adaptability.

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