
# Feedback from the 43rd AIVC-11th TightVent & 9th venticool Conference: Summary of the resilient ventilative cooling track

On 4-5 October 2023, the AIVC – TightVent - venticool 2023 joint Conference "Ventilation, IEQ, and Health in Sustainable Buildings", was organised by the International Network on Ventilation and Energy Performance (INIVE) on behalf of the Air Infiltration and Ventilation Centre (AIVC), the Building and Ductwork Airtightness Platform (TightVent Europe), the international platform for ventilative cooling (venticool), and Aalborg University. It was a successful event, which drew just over 200 participants - researchers, engineers & architects, policy makers or regulatory bodies, manufacturers & stakeholders and international organisations from 33 countries.

The conference programme featured three parallel tracks of structured sessions, with around 150 presentations that exploring the main conference themes: Smart Ventilation, Indoor Air Quality (IAQ) and Health, Building & Ductwork Airtightness, and Ventilative Cooling – Resilient Cooling. A special session known as: “90 seconds industry presentations” was specifically organised for the event's sponsors.

Furthermore, the conference served as a major discussion place for ongoing projects, such as the IEA EBC Annex 78 "Supplementing Ventilation with Gas-phase Air Cleaning, Implementation, and Energy Implications", the IEA EBC Annex 80 "Resilient Cooling of Buildings", the IEA EBC Annex 86 "Energy Efficient IAQ Management in Residential Buildings" and the IEA EBC Annex 87 "Energy and Indoor Environmental Quality Performance of Personalized Environmental Control Systems".

The “Resilient Ventilative Cooling” track at the AIVC 2023 conference was organised in 7 sessions, 4 of which were topical sessions with a number of invited presentations:

1. Topical Session: Summer comfort and energy efficiency in hot periods: interest of mixed mode cooling and need of occupant feedback
2. Climate change & Resilient cooling
3. Topical Session: Resilient Cooling of Buildings meets Resilient Cooling in Cities
4. Ventilation strategies & thermal comfort
5. Topical Session: Importance of good resilient building design and standards to ensure good ventilative cooling performance to reduce overheating and environmental impact
6. Ventilative cooling & Natural Ventilation
7. Topical Session: Personalized Environmental Control Systems (PECS) operation and evaluation

The article available here presents main trends, ideas, considerations and conclusions that emerged from the two days of the conference on this topic. The main topics covered by the speakers varied from window opening behaviour, over the use of future weather data to design of resilient cooling/ventilative cooling.

## Window opening behaviour

Hostein et al. examined the thermal environment and indoor air quality during the summer period of 2022 in four French dwellings (Hostein, Moujalled, Musy, & El Mankibi, 2023). They studied window use to identify the physical and contextual factors influencing the occupants’ behaviour using a feature selection algorithm. Their results showed that the four households had different window user behaviours and the analysis of the data revealed that the variables influencing occupants' window behaviour were indoor and outdoor air temperatures, indoor $CO_2$ and VOC concentrations, global horizontal irradiation and time of day.

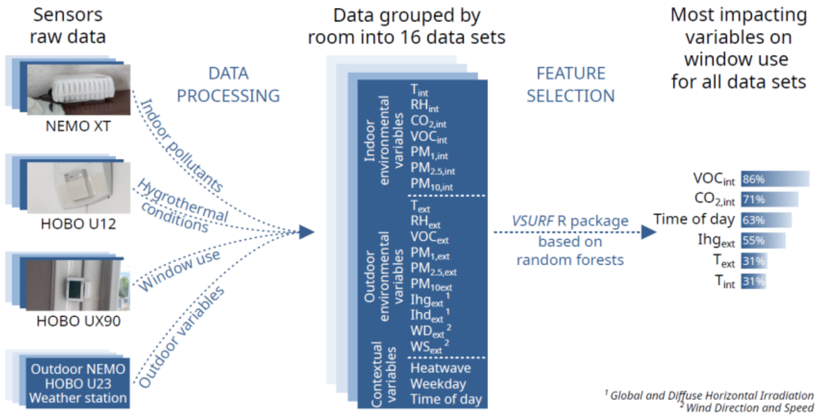

Figure 1: Feature selection analysis (Hostein, Moujalled, Musy, & El Mankibi, 2023)

Tookey et al. performed a pilot study on window opening behaviour in a primary school in Auckland, New Zealand, during non-heating seasons to provide evidence of natural ventilation practices and their potential impact on classroom air quality (Tookey, et al., 2023). Based on their results, the main reasons for window operations by the teachers are: (1) upon teacher's arrival and (2) for Indoor Environmental Quality (IEQ) reasons.

Berger & Mahdavi reflected on alternative modelling approach regarding occupants' operation of windows. They concluded that utility of purely data-driven black-box models could be improved if model derivation process is preceded by specific hypotheses influencing frequency and timing of window opening actions (Berger & Mahdavi, 2023).

Payet et al. presented a novel approach to integrate previously developed behaviour models with dynamic thermal simulation software, coupling Python and EnergyPlus (Payet, Boulinguez, David, Lauret, & Garde, 2023). The method of coupling the building model with behavioural models (decision tree model, random forest model) allowed for more accurate replication of user actions regarding window opening and ceiling fans behaviour compared to conventional practices employed by engineering and design firms.

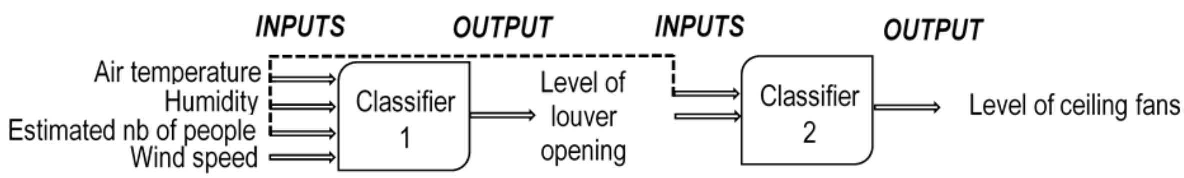

Figure 2: Random forest model (Payet, Boulinguez, David, Lauret, & Garde, 2023)

Jay et al. presented the first results of a coaching tool developed to help occupants to know whether it is a good option to open or close their windows (Jay, Bernaud, & Alessi, 2023). The prototype of this coach considered thermal comfort, indoor air quality (IAQ) and energy consumption and was based on environmental data i.e., indoor and outdoor air temperature and indoor $CO_2$ concentration.

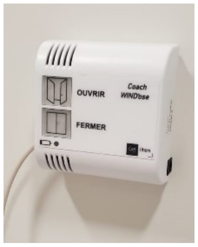


*Figure 3: Indoor Air temperature & CO2 concentration sensors*

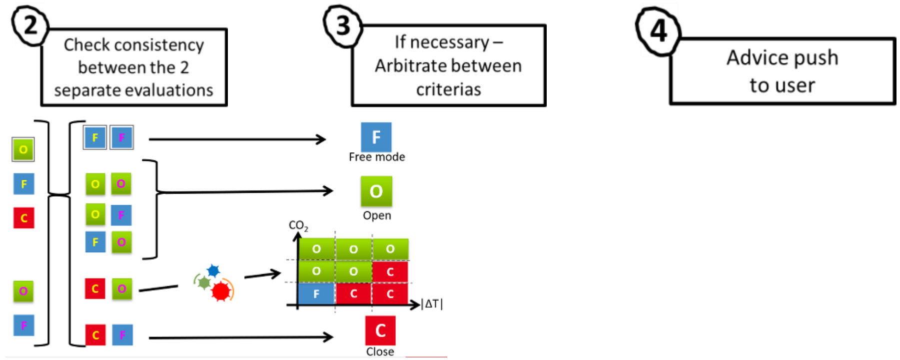


*Figure 4: Wind'ose Algorithm (Jay, Bernaud, & Alessi, 2023)*

## Assessment: use of future weather data

Many presenters focussed on the **use of future weather data** to assess **resilience** (Sengupta, Kerckaert, Steeman, & Breesch, 2023) (Khosravi, Declercq, Sengupta, & Breesch, 2023), **thermal comfort** (Sengupta, Kerckaert, Steeman, & Breesch, 2023) (Kolokotroni, Zune, Tun, Christantoni, & Tsakanika, 2023) (Khosravi, Declercq, & Ramon, 2023) and **energy demand** (Kolokotroni, Zune, Tun, Christantoni, & Tsakanika, 2023) (Khosravi, Declercq, Sengupta, & Breesch, 2023) (Romero-Lara, Comino, & de Adana, 2023) (O' Donovan, Psomas, & O' Sullivan, 2023).

Sengupta et al. performed a study to determine the most influential building and system design parameters that impact the thermal resilience to overheating (Sengupta, Kerckaert, Steeman, & Breesch, 2023). According to their findings, overheating is most likely to occur in current buildings with high window to wall ratio (WWR), no solar shading and with lighter thermal mass; WWR has highest impact on the thermal resilience followed by thermal mass. However, in buildings with higher WWR and lighter thermal mass, thermal resilience can be improved with implementation of solar shading and passive cooling strategies such as natural night ventilation (NNV); NNV is not effective during a heatwave period as the diurnal variations of temperature are limited.

Khosravi et al. evaluated and compared the effectiveness of natural ventilation in current and future climate scenarios, particularly during extreme warm years (Khosravi, Declercq, & Ramon, 2023) and concluded that natural ventilation can substantially reduce overheating risks and cooling demand during a typical year both in current and future climate scenarios. They noted however, that during heatwaves natural ventilation becomes less efficient and cannot guarantee full thermal comfort to all occupants.

Kolokotroni et al. investigated the changes in energy demand in residential buildings considering the overlapping effect of climate change and urban heat island intensity in Athens (hot European climate, dense urban setting) (Kolokotroni, Zune, Tun, Christantoni, & Tsakanika, 2023). They underlined that the confounding effects of urban density, urban textures and exposure to the wind, building design and human activities, alter weather characteristics over and around urban areas. They also stressed that it is essential to use a suitable weather file to include urban external conditions in thermal simulations for more accurate predictions of energy demand and internal avoidance of overheating in free-floating buildings.

In the framework of the work performed by IEA EBC Annex 80: Resilient Cooling of Buildings, Khosravi et al. looked into a case study of an office building in Belgium, applying a step-by-step design process to reach a resilient building with focus on passive design strategies and in particular the combination of solar shading, natural ventilative cooling (NVC) and exposed thermal mass. They highlighted the need for a resilience indicator, communicable to stakeholders, explaining how buildings react to shocks (Khosravi, Declercq, Sengupta, & Breesch, 2023).

(Romero-Lara, Comino, & de Adana, 2023) evaluated the seasonal energy behaviour of a Dew-point Indirect Evaporative Cooler (DIEC) for three different climatic zones under a hostile climate change scenario. They noted that the DIEC could be an interesting solution in terms of energy efficiency as it showed a more efficient seasonal energy behaviour for hot-dry climatic conditions.

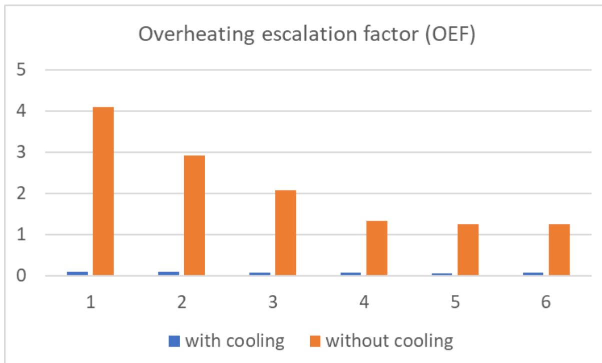


*Figure 5: Resilience assessment - Heat wave (future long-term – 44d) (Khosravi, Declercq, Sengupta, & Breesch, 2023)*

The aim of the work by O' Donovan et al. was to determine the potential renewable energy contribution that natural ventilative cooling systems (NVCs) or mechanical ventilative cooling systems (MVCs) can have under favourable conditions in a temperate climate (O' Donovan, Psomas, & O' Sullivan, 2023). They performed a 3-stage evaluation including: a cooling demand using cooling degree hour (CDH) analysis in current and future conditions; a simplified design stage evaluation of the potential of single-sided NVC and MVC; and a calculation of the seasonal performance factor (SPF) for NVC and MVC systems. Based on their results, the cooling energy supplied by ventilative cooling outstrips estimated demand levels (on an annualised basis). In addition, NVC and MVC systems are likely to be a renewable source with a high SPF, that is currently not officially accounted for.

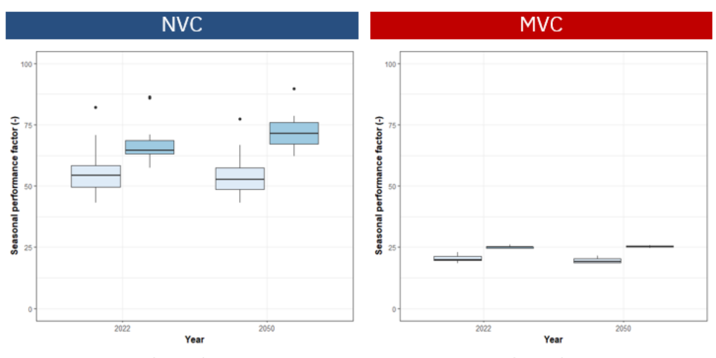


*Figure 6: Boxplots of Seasonal Performance Factor (SPF) with respect to year (Left: SPF values for NVC, Right: SPF values for MVC, colour indicates SPF for day or night-time) (O' Donovan, Psomas, & O' Sullivan, 2023)*

## Design resilient cooling/ventilative cooling

### Resilient cooling design exercise

During the interactive topical session: "Resilient Cooling of Buildings meets Resilient Cooling in Cities" the organisers addressed the challenges of resilient cooling of buildings and their relation to their urban surroundings. Following two presentations on the upcoming publication of the Technology profiles of resilient cooling strategies of EBC Annex 80 Resilient Cooling of Buildings by Patryk Czarnecki (Czarnecki, 2023) and the Resilient Cooling Guidelines upcoming publication by (Corrado, Psomas, & Stern, 2023), the audience worked in small groups on a prepared set of built environments. The participants were asked to define the measures they would implement to make the case buildings (in São Paulo, Abu Dhabi and Los Angeles) more resilient against heat waves and power outages as regards the building envelope, the building interior & operation, the surrounding building exterior or other measures (technical, political, societal, etc.).

## Life cycle assessment

A Danish office building designed with a hybrid ventilation system was compared with a full mechanical ventilation system in the same building (Roth, 2023). The comparison included a life cycle analysis (LCA) focussing on $CO_2$ equivalents ($CO_2$-eq) and life cycle cost (LCC) of these two ventilation solutions. The results showed that by adding embodied carbon from natural ventilative cooling of 0.033 kg $CO_2$- eq/$m^2$/year one can reduce the $CO_2$-eq: embodied by more than 40%; electricity by more than 50%; in total by more than 30%.

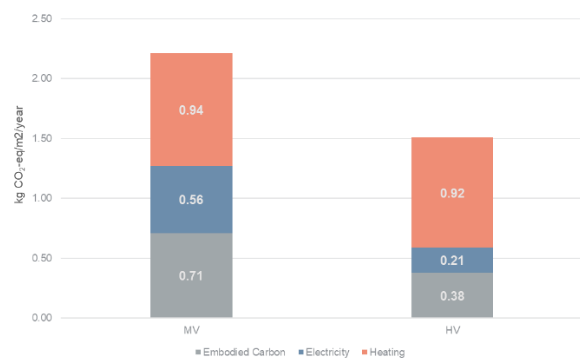


*Figure 7: Environmental calculation focusing on $CO_2$- eq (Roth, 2023)*

## Design practice

Sohail et al. & O'Sullivan presented initial findings from a survey targeted at Building Design Practitioners, in the United Kingdom and Ireland, about their design practices and experienced based approaches to designing ventilative cooling in low energy buildings at the concept design stages (Sohail, O'Donovan, Plesner, & O'Sullivan, 2023) (O'Sullivan, et al., 2023). From these first results, it is evident that around 50% of the building design practitioners are familiar with the term "ventilative cooling" but they admit the lack of decision-making frameworks and tools in promoting the uptake of VC solutions in their building designs to make buildings resilient against threats of heat waves.

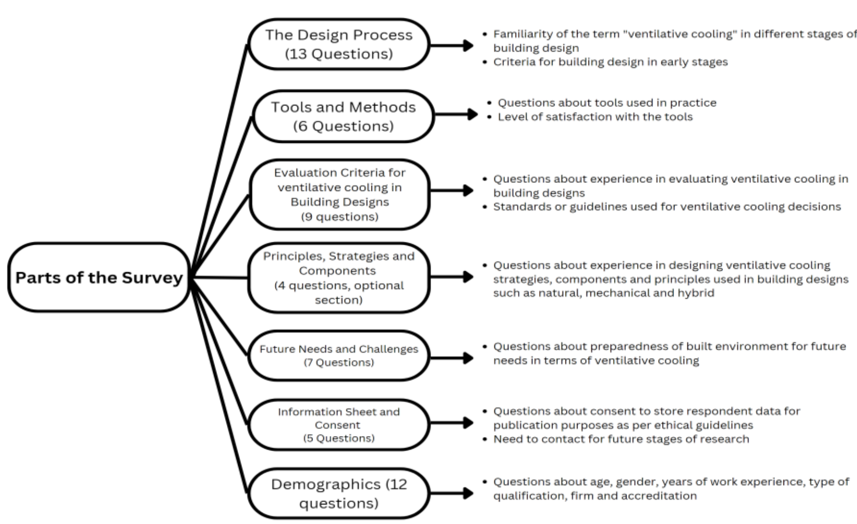


*Figure 8: Summary of 57 questions used in the survey (Sohail, O'Donovan, Plesner, & O'Sullivan, 2023)*

## Early-stage building design VC tool

Fossati et al. presented an update of the ventilative cooling (VC) potential tool assessing the VC potential at early design stages & its validation process (Radice, Belleri, & van Dijk, 2023). The tool was first developed within IEA-EBC Annex 62 Ventilative Cooling and then further developed within CEN/TC 156/WG21 TG on "Ventilative cooling systems - Design". The main development regards the application of thermal balance calculation method from EN ISO 52016-1:2017 to calculate free-floating temperature, heating and cooling loads with and without ventilative cooling contribution, which considers also lumped thermal capacity. Among the results, they found the VC potential evaluation method useful to compare the VC capacity in different climates for different building typologies and thermal capacities. In addition, the tool enables to analyse the effect of other energy efficiency measures, like internal gains reduction, solar gains control and envelope performance, on VC effectiveness.

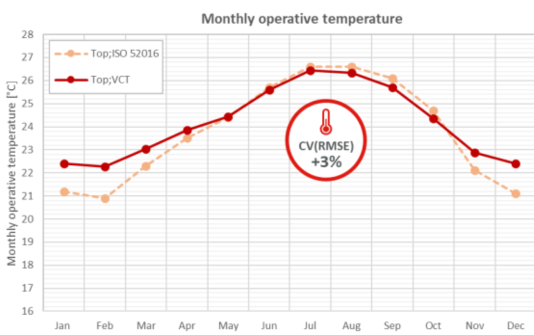


*Figure 9: Validation results of BESTEST 940 (single thermal zone with heavyweight envelope for climate in Denver, USA) (Radice, Belleri, & van Dijk, 2023)*

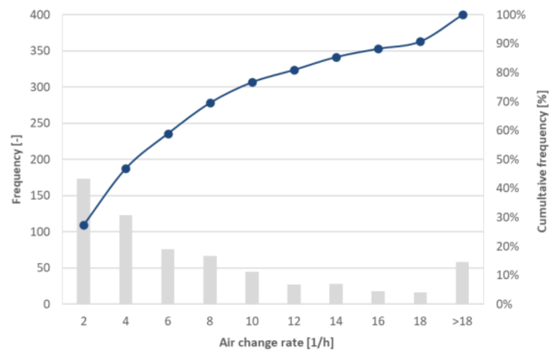


*Figure 10: Output: frequency of ACH required to provide potential comfort (Radice, Belleri, & van Dijk, 2023)*

## New CEN Ventilative Cooling Technical Specification

Plesner & O'Sullivan both focused on the new European Technical specification (CEN/TS) "Ventilative cooling systems – Design" which will provide a framework for (reasonably) easy assessment of the feasibility of ventilative cooling design (O'Sullivan, et al., 2023). Plesner highlighted that resilience indicators and checks are necessary in the early design process to ensure future proof buildings, and this is being incorporated into the European technical specification (Plesner, 2023).

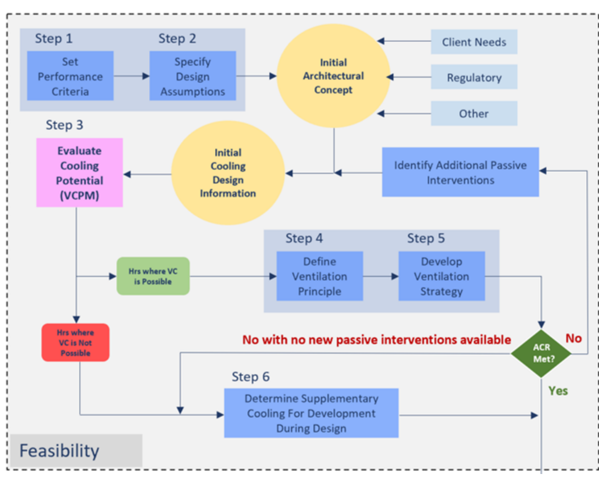


*Figure 11: 6 stages in ventilative cooling design (O'Sullivan, et al., 2023)*

## References


Berger, C., & Mahdavi, A. (2023). Reflections on alternative modelling approaches regarding occupants' window operation behaviour. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 408-415). AIVC.

Corrado, V. (2023). Resilient Cooling Design Guidelines. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 429-433). AIVC.

Corrado, V., Psomas, T., & Stern, P. (2023). Resilient Cooling Guidelines from the IEA EBC Annex 80. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 284-285). AIVC.

Czarnecki, P. (2023). IEA EBC Annex 80 - Resilient Cooling - Resilient Cooling Technology Profiles from the EBC Annex 80. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 412-428). AIVC.

Czarnecki, P. (2023). IEA EBC Annex 80 - Resilient Cooling - Update on Resilient cooling and indicators from the IEA EBC Annex 80. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 636-642). AIVC.

Hostein, M., Moujalled, B., Musy, M., & El Mankibi, M. (2023). A study of indoor environment and window use in French dwellings monitored during a summer with heatwaves. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 222-231). AIVC.

Hostein, M., Moujalled, B., Musy, M., & El Mankibi, M. (2023). A study of indoor environment and window use in French dwellings monitored during a summer with heatwaves. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 314-319). AIVC.

Jay, A., Bernaud, P., & Alessi, F. (2023). An IAQ and thermal comfort coach prototype to improve comfort and energy consumption thanks to adequate management of natural ventilation: development and first feedback results. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 122-123). AIVC.

Jay, A., Bernaud, P., & Alessi, F. (2023). An IAQ and thermal comfort coach prototype to improve comfort and energy consumption thanks to adequate management of natural ventilation: development and first feedback results. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 198-203). AIVC.

Khosravi, S., Declercq, J., & Ramon, D. (2023). Analyzing natural ventilation and cooling potential in a communal space building in Belgium under future climate conditions. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 214-221). AIVC.

Khosravi, S., Declercq, J., Sengupta, A., & Breesch, H. (2023). Resilient cooling in office buildings: case study in Belgium. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 672-676). AIVC.

Kolokotroni, M., Zune, M., Tun, T. P., Christantoni, I., & Tsakanika, D. (2023). Urban context and climate change impact on the thermal performance and ventilation of residential buildings: a case-study in Athens. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 194-203). AIVC.

O' Donovan, A., Psomas, T., & O' Sullivan, P. D. (2023). Renewable ventilative cooling? Insights from an Irish perspective. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 183-193). AIVC.

O' Donovan, A., Tavakoli, E., & O'Sullivan, P. D. (2023). Lessons Learned from Irish Schools: Early-stage Insights on overheating. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 643-655). AIVC.

O' Donovan, A., Tavakoli, E., & O'Sullivan, P. D. (2023). Lessons Learned from Irish Schools: Early-stage Insights on Overheating. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 625-627). AIVC.

O'Sullivan, P. D., O' Donovan, A., Sohail, M., Plesner, C., Roth, J. K., Frei, B., . . . Radice, V. (2023). Ventilative Cooling Design in Practice: Where Next? *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 661-671). AIVC.

Payet, M., Boulinguez, M., David, M., Lauret, P., & Garde, F. (2023). Windows and ceiling fan occupant behaviour model coupling methodology with building energy models, a tropical case study. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 103-111). AIVC.

Payet, M., Boulinguez, M., David, M., Lauret, P., & Garde, F. (2023). Windows and ceiling fan occupant behaviour model coupling methodology with building energy models, a tropical case study. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 183-190). AIVC.

Plesner, C. (2023). Design procedures for ventilative cooling integrated in new standards. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 677-680). AIVC.

Radice, V. F., Belleri, A., & van Dijk, D. (2023). A methodology for evaluating the ventilative cooling. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 715-724). AIVC.

Romero-Lara, M., Comino, F., & de Adana, M. R. (2023). Long-term energy performance of dew-point indirect evaporative cooler under the climate change world scenario. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 478-486). AIVC.

Roth, J. K. (2023). Life cycle assessment: A design element for ventilation system selection. *Presentations of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 656-660). AIVC.

Sengupta, A., Kerckaert, J., Steeman, M., & Breesch, H. (2023). Which design parameters impact the resilience to overheating in a typical apartment building? *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 173-182). AIVC.

Sohail, M., O'Donovan, A., Plesner, C., & O'Sullivan, P. D. (2023). A survey of building design practitioner perceptions of ventilative cooling in their building design processes. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 743-752). AIVC.

Tookey, L., Boulic, M., McDonald, B., Page, W., Wargocki, P., & van Heerden, H. (2023). Ventilation reliability: A pilot study on window opening behaviour in a primary school. *Proceedings of the 43nd AIVC Conference "Ventilation, IEQ and health in sustainable buildings" Copenhagen, Denmark, 4-5 October 2023* (pp. 727-742). AIVC.

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