Feedback from the 44th AIVC-12th TightVent & 10th venticool Conference: Summary of the resilient ventilative cooling track

On 9-10 October 2024, the AIVC – TightVent - venticool 2024 joint Conference "Retrofitting the Building Stock: Challenges and Opportunities for Indoor Environmental Quality", 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) and the international platform for ventilative cooling (venticool). The University of Galway, the Maynooth University and the Sustainable Energy Authority Of Ireland (SEAI) were also key organisers. This successful event brought together over 180 participants, including researchers, engineers, architects, policymakers, manufacturers, stakeholders, and international organizations from 26 countries.

The conference programme featured three parallel tracks with approximately 150 presentations across the key themes of Smart Ventilation, Indoor Air Quality (IAQ) and Health, Building & Ductwork Airtightness, and Ventilative and Resilient Cooling. A special session of "90-Second Industry Presentations", was organised to disseminate exclusive information from the event's sponsors to the conference participants, in addition to the conference exhibition.

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

1. Topical Session: Ventilative Cooling – latest and greatest. Importance of early design in the world of overheating mitigation using ventilative cooling
2. Climate change resilience
3. Topical Session: Resilient Indoor Thermal Environments: Findings & Future Policy from an Irish National Study on Non-Residential Buildings
4. Natural ventilation & cooling
5. Topical Session: ReCOver++: Improving resilience of buildings to overheating
6. Topical Session: State of the art of Personalized Environmental Control Systems (PECS)
7. Natural Ventilation analysis

This article offers an overview of the main trends, ideas, and insights shared over the two-day conference, focusing particularly on resilient ventilative cooling. The article is structured into four main themes:

1. Ventilative cooling & resilient cooling design
2. Thermal resilience assessment
3. Natural ventilation
4. Personal Environmental Control Systems

Ventilative cooling & resilient cooling design

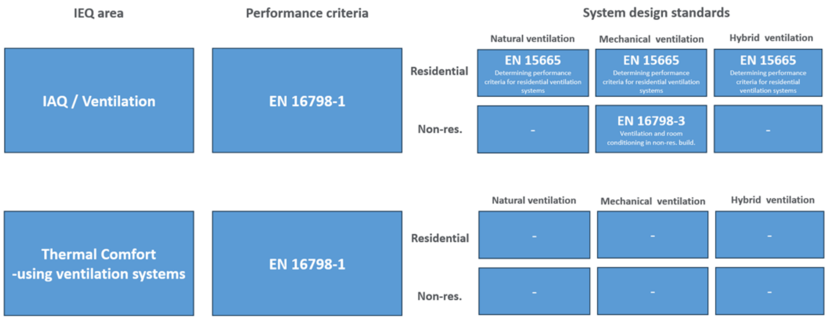
During the topical session "Ventilative cooling – latest and greatest. Importance of early design in the world of overheating mitigation using ventilative cooling" Pleasner & Roth (2024) presented the latest content of the upcoming European Technical Specification (CEN/TS) called "Ventilative cooling systems – Design". O'Sullivan (2024) and Frei (2024) contributed to the session by sharing insights on a ventilative cooling design process and "the cooling ladder".

This CEN/TS sets the framework for designing ventilative cooling systems able to cope with the set criteria, from the early feasibility phase to the actual design phase for both residential and non-residential buildings (Figure 1, Figure 2). Furthermore, the document is a "system design" document much like prEN15665 (under revision) and EN 16798-3 referencing existing EPBD standards e.g. thermal comfort criteria from EN 16798-1 or national regulations. The document serves as an important reference for prEN 16798-1-2 (thermal comfort) providing guidance on designing buildings without mechanical cooling while aligning with the chosen IEQ requirements; it is currently the only available document in Europe explaining how to design ventilative cooling systems. The core features of the document are:

8 design steps - to follow when designing free cooling systems

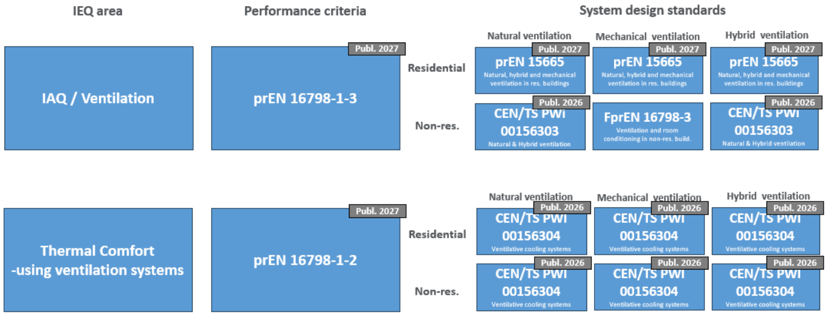
- ✓ Cooling ladder ethos – prioritising passive cooling solutions before moving to active cooling measures (Figure 3)
- ✓ Ventilative cooling potential method – that assesses outdoor air-cooling potential in the early design phase
- ✓ Flow diagram – enabling a simplified overview of the design steps and cooling ladder ethos including which choices to make
- ✓ Resilience checks – enabling checks to enhance readiness for future extreme weather events (probably the first standard to include this)
- ✓ Renewable energy for cooling calculations using ventilative cooling – as found in Renewable Energy Directive (RED II).

During the discussion part of the session, important conclusions were drawn such as the importance of correct formulas to quantify thermal mass, the significance of micro-climate considerations at different design stages, the significance of climate data to assess ventilative cooling properly etc.



IEQ area	Performance criteria		System design standards		
			Natural ventilation	Mechanical ventilation	Hybrid ventilation
IAQ / Ventilation	EN 16798-1	Residential	EN 15665 Determining performance criteria for residential ventilation systems	EN 15665 Determining performance criteria for residential ventilation systems	EN 15665 Determining performance criteria for residential ventilation systems
		Non-res.	-	EN 16798-3 Ventilation and room conditioning in non-res. build.	-
			Natural ventilation	Mechanical ventilation	Hybrid ventilation
Thermal Comfort -using ventilation systems	EN 16798-1	Residential	-	-	-
		Non-res.	-	-	-

Figure 1: Lack of standards for system design of ventilative cooling (Plesner & Roth, 2024)



IEQ area	Performance criteria		System design standards		
			Natural ventilation	Mechanical ventilation	Hybrid ventilation
IAQ / Ventilation	Publ. 2027 prEN 16798-1-3	Residential	Publ. 2027 prEN 15665 Natural, hybrid and mechanical ventilation in res. buildings	Publ. 2027 prEN 15665 Natural, hybrid and mechanical ventilation in res. buildings	Publ. 2027 prEN 15665 Natural, hybrid and mechanical ventilation in res. buildings
		Non-res.	Publ. 2026 CEN/TS PWI 00156303 Natural & Hybrid ventilation	FprEN 16798-3 Ventilation and room conditioning in non-res. build.	Publ. 2026 CEN/TS PWI 00156303 Natural & Hybrid ventilation
			Natural ventilation	Mechanical ventilation	Hybrid ventilation
Thermal Comfort -using ventilation systems	Publ. 2027 prEN 16798-1-2	Residential	Publ. 2026 CEN/TS PWI 00156304 Ventilative cooling systems	Publ. 2026 CEN/TS PWI 00156304 Ventilative cooling systems	Publ. 2026 CEN/TS PWI 00156304 Ventilative cooling systems
		Non-res.	Publ. 2026 CEN/TS PWI 00156304 Ventilative cooling systems	Publ. 2026 CEN/TS PWI 00156304 Ventilative cooling systems	Publ. 2026 CEN/TS PWI 00156304 Ventilative cooling systems

Figure 2: Upcoming standards for ventilative cooling (Plesner & Roth, 2024)

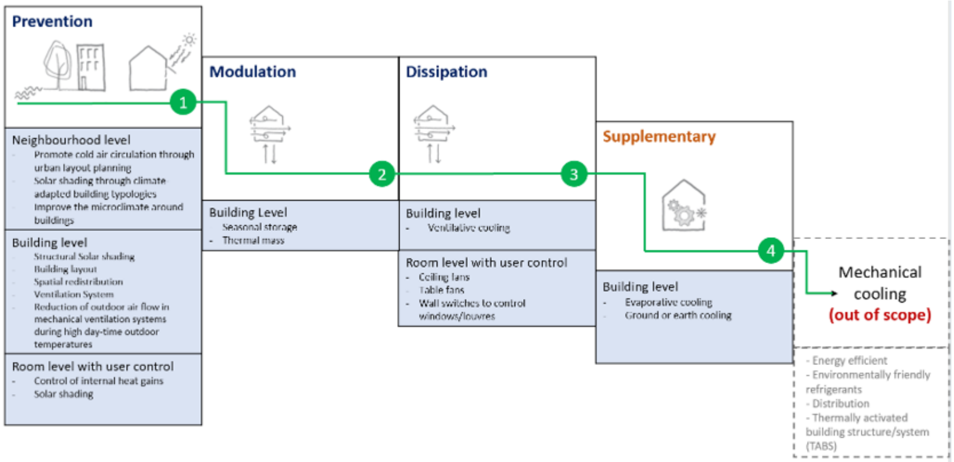


Figure 3: The Cooling Ladder: A design ethos for VC designers (O’Sullivan, 2024)

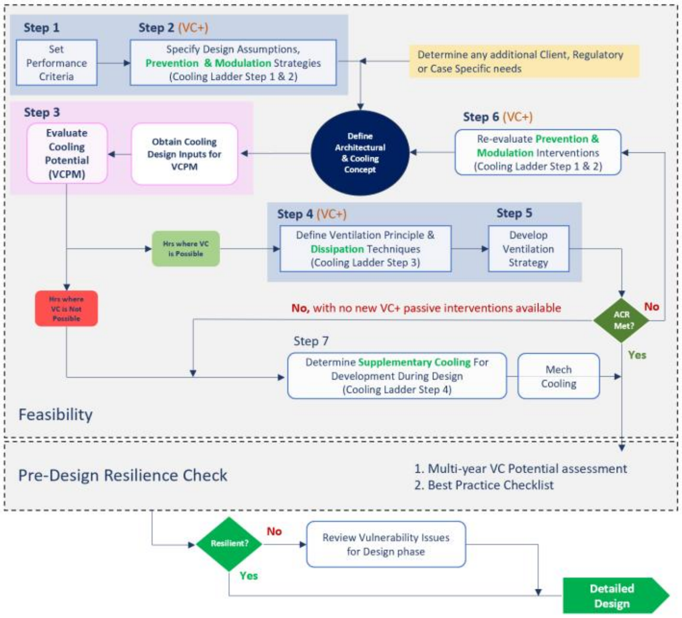
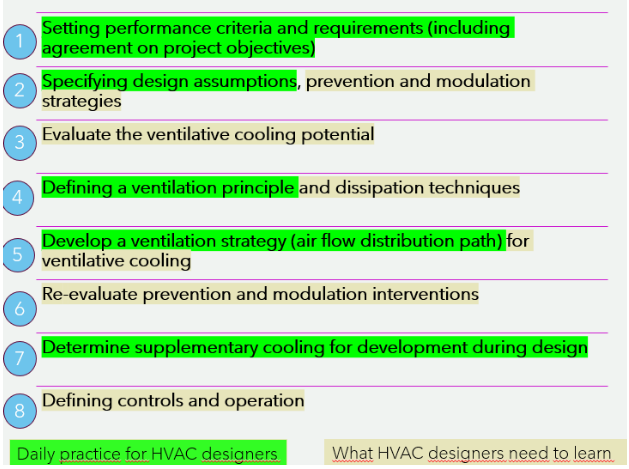


Figure 4: Early-stage design process for evaluation of ventilative cooling potential (O’Sullivan, 2024)



1 Setting performance criteria and requirements (including agreement on project objectives)

2 Specifying design assumptions, prevention and modulation strategies

3 Evaluate the ventilative cooling potential

4 Defining a ventilation principle and dissipation techniques

5 Develop a ventilation strategy (air flow distribution path) for ventilative cooling

6 Re-evaluate prevention and modulation interventions

7 Determine supplementary cooling for development during design

8 Defining controls and operation

Daily practice for HVAC designers   What HVAC designers need to learn

Figure 5: The eight-steps design process of ventilative cooling systems – Daily practice for HVAC designers/What HVAC designers need to learn (Frei, 2024)

The topical session “Resilient Indoor Thermal Environments: Findings & Future Policy from an Irish National Study on Non-Residential Buildings” discussed results from the three-year Project RESILIENCE, which investigated indoor thermal resilience and overheating risks in 33 high performance low-energy non-residential buildings in Ireland (schools, offices, and healthcare buildings) (Sullivan, 2024). The session explored policy implications, building vulnerabilities, and the need for improved regulatory measures to enhance thermal resilience. Session discussions also focused on how thermal failure for indoor environments could be defined in practice as well as the role and responsibilities of the designer in mitigating future heat stress events in buildings as part of their designs. Initial findings from the project showed that while Irish schools appear resilient to future ambient warming, there are some warning signs that healthcare and offices are more vulnerable (O' Donovan, 2024).

Declercq & Holvoet (2024) investigated thermal resilience to overheating through climate-responsive architectural design, focusing on two real-life non-residential case studies modelled and simulated under future weather conditions, including shocks. They evaluated the impact of several architectural building features such as thermal mass, natural ventilative cooling strategies and different mechanical cooling strategies influencing the resilience to overheating under extreme conditions. Their findings, identified glazing ratio, shading, thermal mass, and ventilative cooling as key architectural factors, with shading and ventilative cooling proving highly effective, while thermal mass had a lesser impact during prolonged heatwaves. Overall, climate-responsive strategies, such as reducing glazing ratios, adding shading, and employing ventilative cooling, effectively reduce cooling energy demands and enhance resilience to heatwaves.

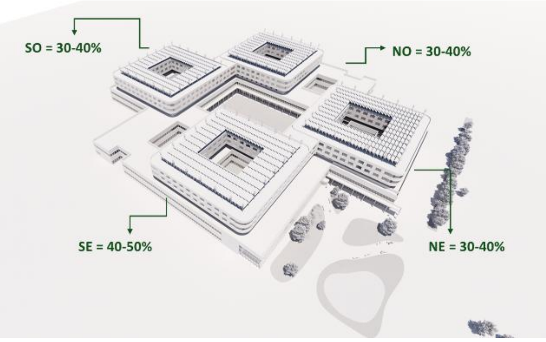


Figure 6: Solarloads on the facade (Declercq, 2024)

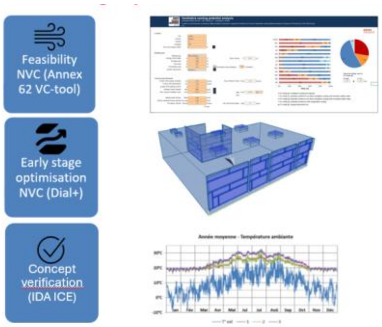


Figure 7: The design process (Declercq, 2024)

Thermal resilience assessment

Roccamena, et al. (2024) presented a method for assessing the resilience of social housing in Paris to current and future heat waves, considering the impact of climate change. Applied to 60,000 dwellings managed by RIVP (Régie Immobilière de la Ville de Paris), it quantifies the risk of heat-related health impacts for the tenants based on temperature thresholds (27°C at night, 30°C during the day) and projects their recurrence across different timelines (present, near future-2040, distant-future 2080). Dwellings are categorised into three groups based on how frequently the climatic conditions that deteriorate their thermal performance are exceeded within a given timeframe (Table 1): those where such conditions occur once every ten years or less, less than once annually, and more than once annually. The study underscores the significant advantages of window solar protection while highlighting the crucial role of nighttime ventilation in lowering indoor temperatures. However, despite the effectiveness of employing passive solutions, the findings reveal that maintaining nighttime temperature thresholds is still challenging due to heat evacuation difficulties, which are further intensified by increasing outdoor temperatures driven by global warming.

Table 1: Number of times each type of dwelling exceeds its outside limit required conditions in the present, near future, and distant future (Roccamena, et al., 2024)

	Outside limit required conditions				
	2006 - 1	**2017 - 1**	**2015 - 1**	**1983 - 2**	**2017 - 2**
Type and period of construction of the dwellings becoming faulty	"Vulnerable" dwellings before refurbishment: – before 1918 – 1918-1955 – 1960-1974 – 1975-1999 "Vulnerable" dwellings after refurbishment: - 1918-1955	"Typical" dwellings before refurbishment: – 1918-1955 – 1960-1974 – 1975-1999 "Vulnerable" dwellings after refurbishment: - 1960-1974 "Vulnerable" dwelling built after 2000	"Typical" dwellings after refurbishment: – before 1918 – 1918-1955 – 1960-1974 – 1975-1999 "Typical" dwelling built after 2000	"Typical" dwelling before refurbishment: – Before 1918	"Vulnerable" dwellings after refurbishment: – before 1918 – 1975-1999
Number of times the climatic sequences are exceeded in the present	**More than once a year**	**Once every 3 years**	**Once every 10 years**	**Once every 2 years**	**More than once every 2 years**
Number of times the climatic sequences are exceeded in the near future	**More than twice a year**	**More than 4 times every 7 years**	**More than 4 times every 10 years**	**More than once a year**	**More than once a year**
Number of times the climatic sequences are exceeded in the distant future	**More than three times a year**	**Twice a year or more**	**Once a year or more**	**More than twice a year**	**More than twice a year**

A study by Sengupta, et al. (2024) introduced a novel thermal resilience indicator providing architects and HVAC engineers with a practical tool to evaluate and enhance buildings' resilience to overheating. They assessed resilience across different building types (mid-sized offices, schools, apartments) and heatwave intensities (severe, intense and long) using simulations and global sensitivity analysis to identify the most influential design parameters affecting shock impact on heat stress of occupants. Key factors influencing thermal resilience, such as window-to-wall ratio, cooling capacity, solar shading, and natural night ventilation, were identified as twice as impactful as other design parameters (i.e. building orientation, envelope and glazing properties, occupancy pattern, airtightness, and cooling set-point). The study developed regression models/thermal resilience indicators based on the results of the sensitivity analysis to predict Standard Effective Temperature Degree hours (SET-Dh) for each type of building during 3 increasing shocks. The indicator incorporates the most influential design parameters and the health impacts of overheating during heatwaves, tested on office and residential buildings in two heatwave scenarios. This approach aims to guide architects, engineers, and policymakers in designing more resilient buildings under future climate scenarios.

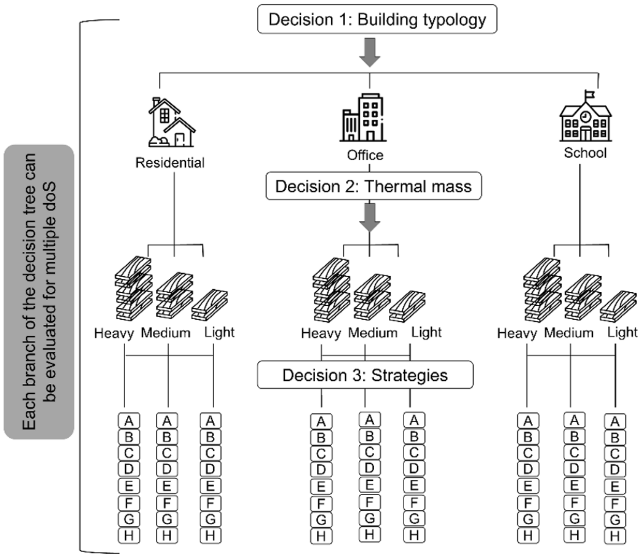


Figure 8: Decision tree for the development of thermal resilience indicators for different building types, thermal mass and operation of resilient cooling strategies (Sengupta, Al Assaad, Breesch, & Steeman, 2024)

Natural ventilation

Kolokotroni, et al. (2024) conducted an intervention study using a climate correlation model to guide occupants of low-technology, naturally ventilated buildings in optimizing thermal comfort and indoor air quality (IAQ), to open the windows. The model, developed in the framework of the PRELUDE H2020 project, uses simplified linear correlations between external climatic variables and internal environmental variables derived from EnergyPlus simulations. Tested in three European buildings (in Greece, Switzerland, and Poland), the model provided occupants with daily guidance on window operation and shading via email or text. The results demonstrate the feasibility of using a single thermal study and associated correlation equations to inform occupants on the best way to control their internal environment based on prevailing external conditions in low-tech buildings without advanced sensors or actuators.

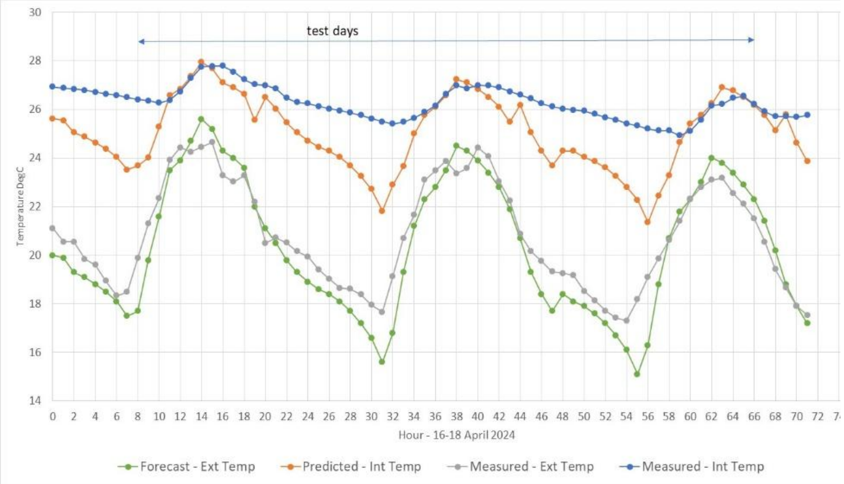
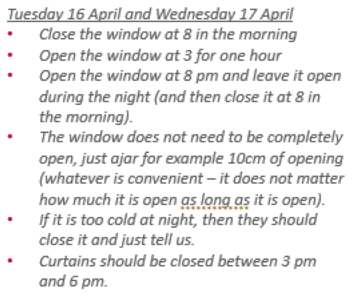


Figure 9: Athens: Thermal comfort predictions and measurements during the test period (Kolokotroni, et al., 2024)


Tuesday 16 April and Wednesday 17 April

- *Close the window at 8 in the morning*
- *Open the window at 3 for one hour*
- *Open the window at 8 pm and leave it open during the night (and then close it at 8 in the morning).*
- *The window does not need to be completely open, just ajar for example 10cm of opening (whatever is convenient – it does not matter how much it is open as long as it is open).*
- *If it is too cold at night, then they should close it and just tell us.*
- *Curtains should be closed between 3 pm and 6 pm.*

Figure 10: Instructions on window operation (Kolokotroni, et al., 2024)

The impact of night ventilation through motorized windows on the energy and thermal performance of office buildings was investigated by Zinzi, et al. (2024) using a living lab in Rome, Italy, as the test site. Their study explored various motorized windows to optimize ventilative cooling and reduce cooling energy demand. These windows (Figure 11), measuring 200 cm by 160 cm, feature two sashes: a manually operated one (130 cm wide) and a motorized sash (67.5 cm wide) controlled by a 30 cm developing chain, allowing a maximum opening angle of 30°. Using a TRNSYS calibrated model of the living lab based on field measurements, the research demonstrated that increasing the aperture size significantly enhances airflow and cooling performance, achieving up to 70% energy savings during the cooling season (Table 2).

Figure 11: Front view of the new window, left, with the push-button indicated on the right sash; detail of the motorized chain to open/close the sash on the right. (Zinzi, Botticelli, Romano, & Agnoli, 2024)

Table 2: Window aperture geometry and energy performance for the identified configurations (Zinzi, Botticelli, Romano, & Agnoli, 2024)

Chain length [m]	**Aperture area [m²]**	**Aperture to floor area ratio [%]**	**Energy [kWh]**	**Energy intensity [kWh/m²]**
0.00	0.00	0.0	4558	37.4
0.26	0.35	2.1	1983	16.3
0.31	0.43	2.5	1762	14.5
0.36	0.51	3.0	1613	13.2
0.41	0.59	3.5	1510	12.4
0.46	0.66	3.9	1445	11.9
0.51	0.74	4.4	1386	11.4

A study, by Kubota, et al. (2024) evaluated a novel design for a double apartment building incorporating a closed vertical void to enhance natural cross ventilation, particularly for leeward units (Figure 12). Using a full-scale experimental house in Tegal, Indonesia, the research examined wind velocity and volumetric flow rates (VFR) through field measurements and a tracer gas decay method. The proposed design includes a pilot at the ground floor and a closed-vertical void with a slit-shaped wind fin on the leeward side to create a positive pressure region by leveraging the venturi effect. While the venturi effect was clearly observed at the pilot, increased wind did not sufficiently reach the upper floors of leeward units, even with larger fins. Window and door opening conditions significantly influenced wind velocity distribution in and around the void. Sufficient levels of VFR were achieved even in the upper floor of leeward units due to the increased static pressure inside the closed void (Figure 13). The study concluded that this system could provide effective cross-ventilation for double apartment buildings, even mid-rise structures, by increased static pressure.

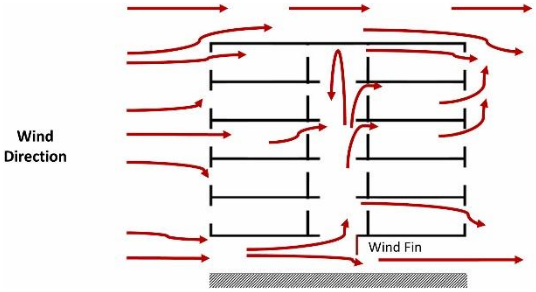


Figure 12: Natural ventilation concept of the proposed apartment building with a closed-vertical void (Kubota, et al., 2024)

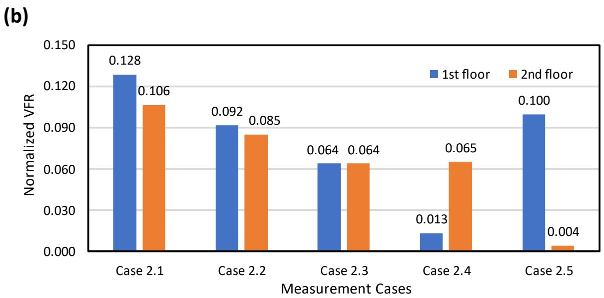


Figure 13: Normalized volumetric flow rates in leeward loft units (Kubota, et al., 2024)

Wang, et al. (2024) explored the energy-saving potential of a dynamic façade system integrating natural ventilation and shading in an office building (Figure 14). Using a validated simulation model, the researchers optimized façade operation strategies based on local solar radiation indexes and seasonal variations, achieving a 14.9% reduction in energy demand compared to a model without natural ventilation. The study revealed that natural ventilation contributed significantly to energy savings. Furthermore, a wider range of heating and cooling setpoints had a significant energy saving effect. Additionally, since occupants in naturally ventilated spaces can adapt to a wider range of indoor temperatures, the researchers recommend a wider thermal comfort adaptive temperature range for building operations to save energy. Overall, the study confirms the substantial energy-saving potential of dynamic façade systems that combine natural ventilation and shading strategies.

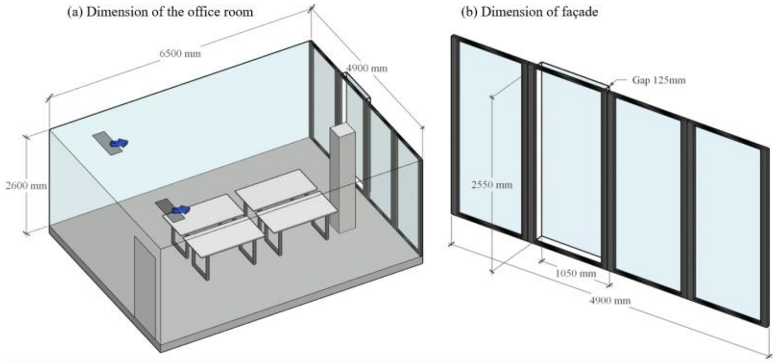


Figure 14: Geometry of the office room and façade system (Wang, Hajdukiewicz, Hoes, & Loomans, 2024)

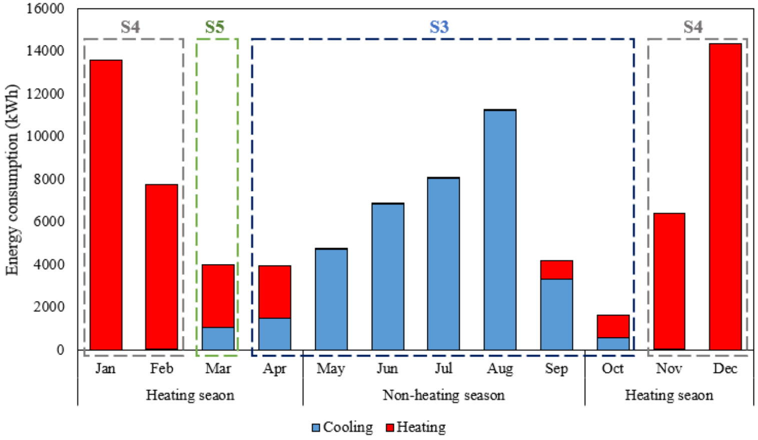


Figure 15: Combined strategy with monthly minimized energy demand (Wang, Hajdukiewicz, Hoes, & Loomans, 2024)

Personal Environmental Control Systems

The IEA-EBC Annex 87, "Energy and Indoor Environmental Quality Performance of Personalized Environmental Control Systems," hosted a topical session focused on an extensive literature review. After a brief introduction to Annex 87, four presentations were delivered, each covering findings from four of its five subtasks (Bivolarova, Khovalyg, & Olesen, 2024), (Rewitz, Kim, Nabilou, Bayode, & Müller, 2024), (Al Assaad & Pigliautile, 2024), (Rawal, Olesen, Berk Kazanci, & Melikov, 2024). Comprehensive literature reviews were conducted for each subtask and presented during the session (Olesen, 2024), (Bivolarova & Shinoda, 2024), (Rewitz & Al Assad, 2024). The session concluded with a discussion on the work and insights of Annex 87.

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