Feedback from the 42^{nd} AIVC-10^{th} TightVent & 8^{th} venticool Conference: Summary of the "Resilient Ventilative Cooling" track

The AIVC – TightVent - venticool 2022 joint Conference "Ventilation Challenges in a Changing World", organized 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 resilient ventilative cooling (venticool) & the Dutch Organization for Applied Scientific Research (TNO), was held on 5-6 October in Rotterdam, Netherlands. The event drew just over 140 participants - researchers, engineers & architects, policy makers or regulatory bodies, manufacturers & stakeholders and international organizations from 22 countries.

The programme included 3 parallel tracks of structured sessions with around 130 presentations covering the main conference topics namely: Smart Ventilation, Indoor Air Quality (IAQ) and Health; Building & Ductwork Airtightness; Ventilative cooling – Resilient cooling. A special session i.e. "90 seconds industry presentations" was also organized and devoted to the sponsors of the event.

The event has also been a major discussion place for on-going international projects such as, the IEA EBC annex 87 "Energy and Indoor Environmental Quality Performance of Personalized Environmental Control Systems", and the IEA EBC Annex 80 "Resilient Cooling of Buildings").

The "Resilient Ventilative Cooling" track at the AIVC 2022 conference consisted of 30 presentations organized in 5 sessions, 3 of which were topical sessions with a number of invited presentations:

1. Ventilative cooling & climate change
2. Resilient cooling in a changing climate
3. Ventilative & resilient cooling
4. New IEA EBC Annex 87 on Personalized Environmental Control Systems (PECS)
5. Ventilative cooling to reduce overheating in buildings in ventilation related standards and legislation in the context of well-being, sustainability and energy

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 resilience (future weather data development, assessment, design), over new technologies & control to legislation & standardization.

Resilience: future weather data development

Research outcomes from the EBC Annex 80 as well as findings from related research work were presented. Annex 80 sought to provide a sound basis for the assessment of cooling technologies by creating concise sets of future weather data and heat waves.

(Toesca, David, Johannes, & Lussault, 2022) developed a 4-step methodology for the constitution of a restricted set of heatwaves, derived from climate projections, that can be used for building performance simulations. The first two steps consisted of collecting climate projection data, and detecting heatwaves contained in these data, while the last two steps consisted of characterizing the heatwaves and selecting a set of distinct heatwaves, representative of the meteorological diversity of a given location. The methodology allows to study the capacity of buildings to maintain acceptable comfort conditions during future heatwaves and in particular, to study the effectiveness of cooling by natural ventilation and thus decide whether passive techniques are effective enough or the use of air conditioning is essential.

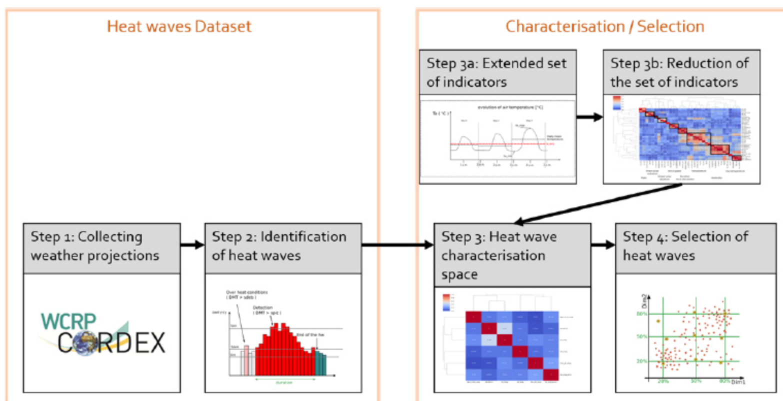

Figure 1: Scheme of the methodology (Toesca, David, Johannes, & Lussault, 2022)

(Salvati & Kolokotroni, 2022) assessed the impact of urban microclimate on ventilation and thermal performance of multi-family residential buildings. They developed a method to consider microclimatic conditions (see figure 4), especially the effect of wind variations around the building in urban context, which impacts natural ventilation rates. They found that ventilation rates are significantly reduced in comparison to a standard approach using the meteorological weather files data and this reduction impacts negatively on internal operative temperatures in summer. A thermal comfort analysis carried out indicated that the selection of a suitable (future) weather file and microclimatic conditions is essential for more accurate predictions of internal thermal comfort and will assist in the sizing of passive and active systems to avoid overheating.

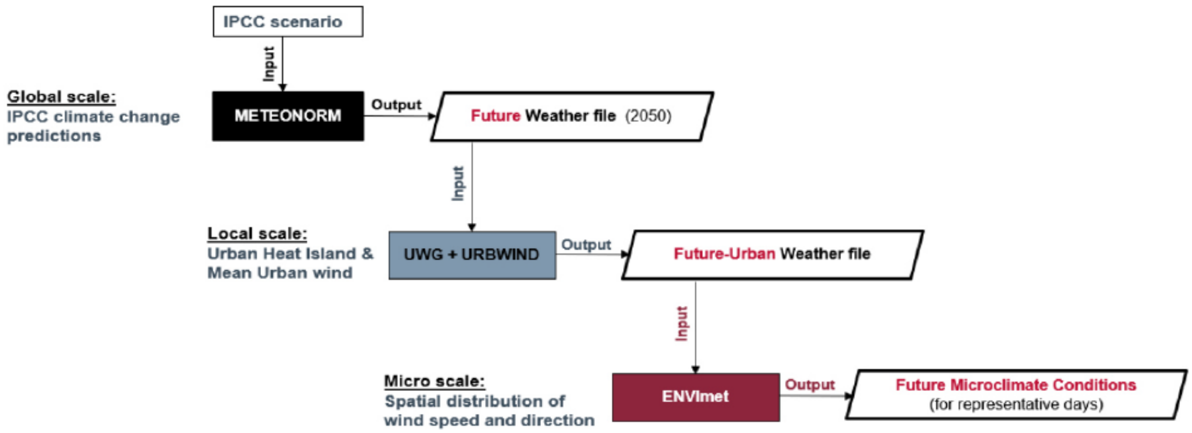

Figure 2: Method to generate future urban microclimate conditions to perform dynamic thermal simulations (Salvati & Kolokotroni, 2022)

Resilience: assessment

A transition from overheating to resilience and from thermal comfort to heat stress was observed.

(Avanzini, et al., 2022) analyzed the thermal resilience of a reference building in Barcelona against extreme temperature events and assessed its ability to maintain a comfortable and safe indoor environment through passive strategies. They compared two passive overheating mitigation strategies, which adopt natural ventilation and solar shading, under historic and future extreme climate conditions. What is important to note here is that their analysis made use of the Indoor Overheating Degree (IOD), introduced by Hamdy et al. in 2017, to account for different comfort limits for separate dwelling zones, reflecting the particular occupant's behaviour and the adaptation capacity of each identified zone as well as the Overheating Escalation Factor, a metric that represents the deviation of the intensity of indoor OH (IOD) from the severity of the outdoor warmness (AWD) which is causing it.

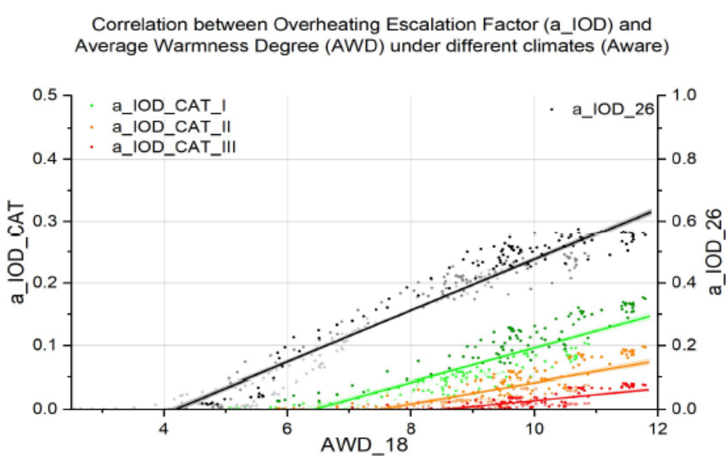

Figure 3: Correlation between Average Warmness Degree (AWD) and Overheating Escalation Factor (α_IOD), calculated using fixed (right – a_IOD_26) and adaptive comfort temperature thresholds (left – a_IOD_CAT), with aware ventilation control; dots are two weeks period around every summer day of 2019, 2030 and 2050 (Avanzini, et al., 2022)

(O'Donovan, Psomas, & O' Sullivan, 2022) and (Sengupta, Breesch, Al Assaad, & Steeman, 2022) presented two papers where these definitions were applied in the evaluation of case study buildings in Ireland and Belgium. (Sengupta, Breesch, Al Assaad, & Steeman, 2022) evaluated the thermal resilience of two test lecture rooms equipped with low-energy cooling strategies during heatwave and power outage scenarios, through dynamic building energy simulations. The authors found that there is an increased overheating risk and low thermal resilience to overheating and that a 24h power outage decreases thermal performance. Moreover, in the case of heavy thermal mass, absorptive capacity increases while the recovery capacity decreases. The authors highlighted that shocks and thermal resilience quantification is crucial and pointed out the gap in the existing indicators to assess the resilience.

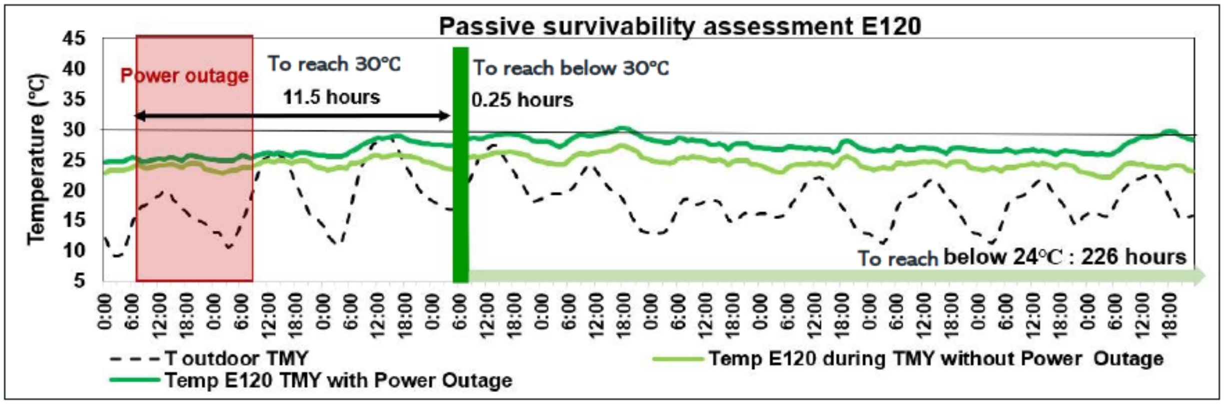

Figure 4: 24-hour power outage (No operation of the AHU, natural night ventilation and shading) imposed on the hottest day for each weather scenario (Sengupta, Breesch, Al Assaad, & Steeman, 2022)

(O'Donovan, Psomas, & O' Sullivan, 2022) presented an overheating assessment of two A-rated homes in Ireland using a data-driven approach and compared this to an ambient warming resilience assessment using the same data. They showed that this assessment is feasible, however, further work is needed to provide additional diagnostics, different categorical or continuous variables, comparative assessments of the accuracy of existing low cost systems over time (reliability). The use of ambient warming resilience metrics was found to aid in diagnosing the current suppressibility of the buildings passive systems; it was found that both buildings, having zones that overheat, can supress this heat and if additional measures are used to reduce solar loads both may be resistant to ambient warmness in current conditions.

An evaluation of the impact of climate change on the overheating risk and its impact on students' academic performance in low energy primary schools in Ireland was performed by (Tavakoli, O' Donovan, & O'Sullivan, 2022). Findings showed that while according to typical overheating standards, the classrooms were not vulnerable to overheating in future extreme weather conditions, evaluations based on the overheating escalation factor and recommended threshold for students' productivity showed the classrooms were vulnerable to overheating risk and could not resist it.

(Vanwynsberghe, Sengupta, Breesch, & Steeman, 2022) evaluated the impact of existing building designs and passive strategies on the overheating risks in buildings. The thermal resilience to overheating of the building and passive and active cooling strategies (night cooling and air conditioning) were tested in a parametric study varying building parameters (solar shading and window-to-wall ratio) during shocks such as heatwaves (varying intensity, duration and severity) and power outages (varying duration and time of occurrence). Results showed that the recovery time of the studied apartment building was shortened from more than 2 weeks to 28 hours during an intense heatwave. Implementing solar shading managed to improve the thermal comfort during an intense heatwave by approximately 30% of the occupied hours. When changing the window-to-wall ratio in combination with night cooling, a balance between window opening and solar heat gains was considered important.

Resilience: design

A presentation by (O'Sullivan, 2022) showed that there is a resilient ventilative cooling design framework needed in the early conceptual design phase to include decission makers. The greater the investment in information gathering, analysis and decission making during pre-design and conceptual design phases, the fewer expensive changes later in the project. Therefore, attention is needed to translate the expert knowledge about resilience to non experts.

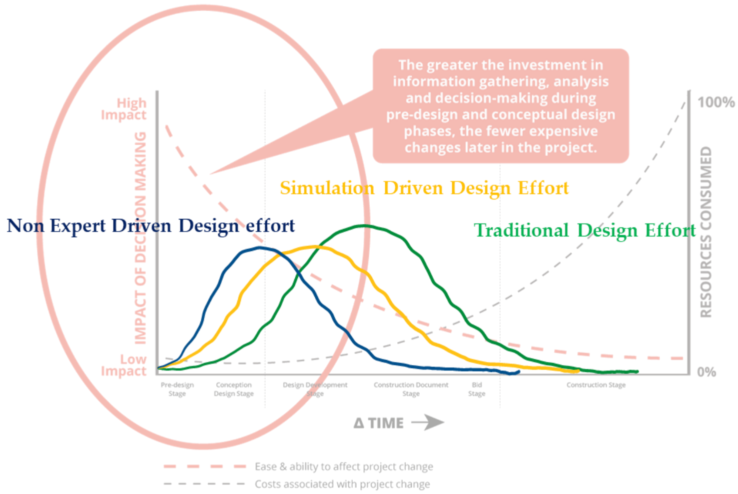

Figure 5: Conceptual stage design frameworks that non experts (architects etc.) can use to evaluate resilience (MacLeamy Curve: Influence of Early Effective Decision-making on Project Outcomes) (O'Sullivan, 2022)

New technologies

Annex 80 has been investigating four resilient cooling-strategy categories based on their approaches to cooling people or the indoor environment. One of these technologies refers to "Enhancing personal comfort apart from cooling whole spaces" and specifically personal comfort system (PCS) which is also the focus of the new IEA EBC annex 87 **on Personalized Environmental Control Systems (PECS)**. The topical session organized by annex 87 introduced this new Annex and discussed several annex related aspects to gather input from the conference audience.

Following an introduction (Olesen, Shinoda, & Kazanci, 2022) by the annex's operating agents, (Kazanci, 2022) presented the advantages and limitations of PECS. According to the speaker, the main advantages of PECS include: improved occupant comfort, health, and productivity; higher occupant satisfaction with the indoor environment; potential energy and cost savings; possibility of addressing the individual demands and preferences towards the indoor environment; resilience to extreme outdoor events; and pandemic-proofing of indoor environments, such as providing clean and fresh air directly to the occupants and minimizing cross-contamination. The main limitations of PECS mentioned by the speaker were: lack of design guide or operation manual; lack of guide about PECS' integration in buildings; lack of standards and building codes readiness to accommodate PECS; need for several practical issues to be addressed; PECS not being at the level of a "common" solution in buildings; very limited application examples from real buildings; and the availability of very few commercial products.

(Shinoda, Bogatu, Olesen, & Kazanci, 2022) did a qualitative evaluation of the resilience of PECS, using and expanding the principles and Key Performance Indicators (KPIs) developed by IEA EBC Annex 80. Preliminary assessments in this study showed that PECS has the potential to be a resilient solution as they have a high adaptive and restorative capacity lity in the case of extreme events such as heatwaves, power outages, and outdoor and indoor air pollution (e.g. wildfires, sandstorms, volcanic eruptions, pandemics) (see Table 1).The results serve as the first step towards the quantification and guidance on the applicability and potential of PECS under future heatwaves, power outages, and indoor and outdoor air pollution.

Table 1: Assessment of PECS in terms of resilience (Excerpted and modified based on Zhang et al., 2021) (Shinoda, Bogatu, Olesen, & Kazanci, 2022)

Extreme event	Absorptive capacity	Adaptive capacity	Restorative capacity	Recovery speed
Heatwave	N/A	High	High	High
Power outage	N/A	N/A or low	High	High
Air pollution	N/A	High	High	High

(Najafi Ziarani, Cook, & O'Sullivan, 2022) looked into the effect of airflow guiding components on effective ventilation rates in single-sided ventilation applications. Results of CFD simulations showed louvers can play a crucial role in controlling the secondary air circulation inside the room and they could either improve or worsen the performance of single-sided ventilation in terms of air-exchange efficiency. It was shown that in most cases if louvers were the cause of incremental changes in turbulent intensity within the indoor space, then they are effective as an air-exchange efficiency improvement strategy.

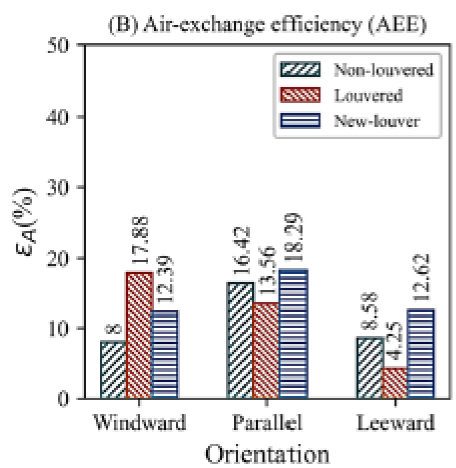

Figure 6: Air-exchange efficiency bar charts (Najafi Ziarani, Cook, & O'Sullivan, 2022)

Ventilative cooling in standards, legislation

Energy performance regulations are key market drivers due to their increasing impact on building design options, energy etc. Proper building design strategies can overcome the risk of overheating with little or even no use of active cooling. Ventilative cooling has proven to be effective to address this overheating risk and it is of great importance to integrate it in standards and legislation and account for its positive influence. Relevant activities have already started in CEN & ISO while the European Comission now considers ventilative cooling a type of renewable energy.

During the topical session "**Ventilative cooling to reduce overheating in buildings in ventilation related standards and legislation in the context of well-being, sustainability and energy**" the organizers (Plesner & Roth, 2022) informed the audience of new ventilative cooling projects in CEN & ISO such as the CEN European technical specification (CEN/TS) on "Ventilative cooling systems - Design" which is under development in CEN/TC 156/WG21, as well as the ISO standard on "Design process of ventilative cooling systems Part 1-natural and hybrid Natural and hybrid ventilative cooling systems in non-residential buildings" in ISO/TC 205/WG2.

(Pollet, 2022) highlighted that ventilative cooling is a type of renewable energy, and this is now officially supported by the entry into force of the Commission Delegated Regulation (EU) 2022/759 of 14 December 2021 amending Annex VII to Directive (EU) 2018/2001 of the European Parliament and of the Council regarding a methodology for calculating the amount of renewable energy used for cooling and district cooling. As shown on Figure 7, ventilative cooling is, contrary to common renewable energy sources like photo-voltaic etc., a direct renewable energy source.

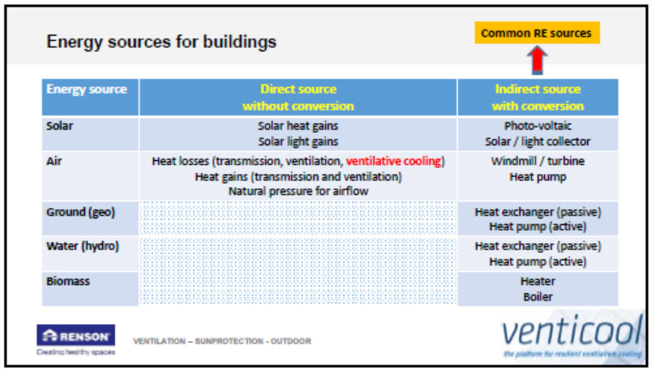

Figure 7: Energy Sources for buildings (Pollet, 2022)

(Leprince, Hurel, & Plesner, 2022) developed a more precise calculation method adapted to roof windows to take into account cross-ventilation that may occur through them (even when there are no facade windows in the zone) and compared results obtained using this “adapted” method and the existing single-sided method from EN 16798-7. Their study showed that, for a building with low buildings surrounding it, the simplified single-sided method from EN 16798-7 underestimates the airflow rate by up to 77%.

On another topic as to window airing, (Rojas, Greml, Pfluger, & Tappler, 2022) developed a Monte Carlo based spreadsheet calculation to estimate airing intervals and mould risk in window ventilated buildings and assess if natural in-/exfiltration and window airing can provide sufficient ventilation to comply with given CO2 concentration limits and ensure low mould risk. This “simple-to-use” stochastic approach based on simplified physical models, accounts for uncertainty and variability of the input parameters providing uncertainty information in the outputs. The implementation is geared towards Austrian buildings and circumstances, however, an adaption or amendment for other countries or regions is easily possible. According to the results, for current Austrian construction practices, it is not reasonable to rely solely on window airing by the occupants to provide sufficient ventilation in multifamily housing in terms of CO2 concentration and mould risk.

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