Climate Change, Ventilation and Resilience

AIVC International Workshop

Madrid, Spain

21-22 April 2026

Energy in Buildings and Communities Programme
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES
CSIC CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
INIVE
venticool the platform for resilient ventilative cooling

Douaa Al Assaad
KU Leuven, Belgium

Bio:

Douaa Al-Assaad is an assistant professor at the M3-BIORES research group of KU Leuven, Belgium. Her primary research focus lies in evaluating the performance of personal environmental comfort systems and their short and long-term influence on human responses to environmental stressors. With a Ph.D. in Mechanical Engineering from the American University of Beirut, Lebanon, she has 9 years of expertise in indoor environmental quality research. Douaa has significantly contributed to various national projects, showcasing her proficiency in diverse modeling techniques and multi-scale experimental approaches. Her belief in sustainable building solutions earned her the prestigious FWO junior postdoctoral scholarship in 2023 where she investigated the performance of personalized environmental control systems and their combinations, particularly their impact on human resilience performance under disruptions such as extreme heat and pollution events. Drawing on collaborations in international projects such as IEA EBC Annex 80, 86, 87 & 95, Douaa brings a distinctive perspective to her research. Driven by a commitment to excellence, she aims to contribute with her research to improving human health and wellbeing, with a special focus on the challenges posed by climate change.

Presentation Title:

Thermal resilience performance of personalized environmental control systems (PECS) in a multi-occupied office

Abstract:

Across disciplines, resilience was defined as “a performance characteristic that describes the extent to which a system can absorb sudden disruptive events, withstand its effects within an acceptable degradation range, and recover from it back to its designed performance within a suitable time”. In the framework of indoor environmental quality (IEQ), this refers to the ability of a building and its systems to maintain the thermal, indoor air quality, acoustic and visual quality of the environment that will eventually determine the physiological and psychological resilience responses of occupants. When it comes to understanding and improving thermal resilience, current literature has focused on manipulating building system and envelope designs (window to wall ratio, thermal mass, shading, passive cooling) with the rough assumption that the impacts of such interventions will be uniform and instantaneous across the built environment. However, indoor flow fields are complex and highly non homogenous, and “total-volume” interventions can have a slower response time. This can overestimate the improvement in occupant-level resilience. Thus, resilience has strong temporal and spatial dependencies and would benefit from occupant-centric strategies that could create habitable personal zones regardless of the background environment. A potential solution lies in personalized environmental control systems (PECS) where the asymmetrical conditions created around the person could even shift the personal zone from habitable to even comfortable. The aim of this work is to assess through computational fluid dynamics (CFD) simulations pseudo-coupled to thermoregulation and comfort models, the thermal resilience performance of personalized environmental control systems (PECS), particularly personalized ventilation and chair fans, during an overheating event in a typical office environment caused by a failure of the cooling system. Compared to mixing ventilation, PECS contributed to a lower cumulative degree. hours and faster recovery rates and in turn reduced discomfort across the heat period. This shows their potential as a mitigating strategy during heat stress events in multi-occupied spaces.

Keywords:

Thermal resilience, personalized environmental control systems (PECS), computational fluid dynamics (CFD), cooling system failure

Carmen Alonso

Eduardo Torroja Institute for Construction Science (IETCC), Spain

Bio:

Carmen Alonso. Architect, PhD from the Polytechnic University of Madrid. She works at Eduardo Torroja Institute for Construction Science (IETCC), that forms part of the Spanish National Research Council (CSIC). Her research focuses on the improvement of comfort conditions, air quality, energy efficiency and sustainability in inhabited spaces.

Presentation Title:

Temperature and CO_2 in Madrid social housing through one year monitored data

Abstract:

Housing energy rehabilitation has become a key priority across Europe, particularly in the context of climate change and social vulnerability, and is aligned with the mechanisms for a just transition under the European Green Deal and the Renovation Wave. In disadvantaged neighbourhoods, improving energy efficiency and indoor comfort conditions has a significant impact on residents' quality of life and well-being, while reducing the risk of energy poverty. However, rehabilitation strategies are often designed based on standardized scenarios, without adequately considering variations related to user behaviour, household composition, or specific building typologies. Systematic monitoring of social housing provides essential data to identify the most effective strategies, grounded in an accurate diagnosis of actual performance rather than theoretical assumptions.

We present the analysis of one year of monitored data on energy consumption, hygrothermal comfort, and indoor CO_2 levels for 22 dwellings located in six vulnerable areas of Madrid. The monitoring campaign covers not only typical weather conditions but also periods of extreme heat and cold, as well as two exceptional events: the "Filomena" snowfall and the COVID-19 pandemic lockdown. These circumstances offer a unique opportunity to assess building performance under stress conditions.

The overall results reveal poor indoor environmental quality in these homes, both in living spaces and bedrooms, alongside evidence of deficient building envelopes. Recorded energy consumption is consistently lower than reference values established by standards or predictive models, achieved at the expense of indoor temperatures outside comfort ranges. Minimum temperatures during cold periods are lower, and maximum temperatures during warm periods are higher in single-person households and in dwellings located under the roof. Higher CO_2 concentrations are associated with higher relative humidity, a greater number of occupants, and longer periods of stay in the dwellings. Indoor conditions in bedrooms differ significantly from those in main living spaces: temperatures are generally lower, while CO_2 concentration and relative humidity are typically higher, with marked seasonal variations. The dataset discussed in this study is available through the following publication: https://doi.org/10.1016/j.buildenv.2024.111354.

Energy renovation strategies for homes rarely include approaches to indoor air management, as natural ventilation is assumed to occur depending on user behaviour. Conversely, improving the building envelope often increases airtightness, which can lead to a deterioration in indoor air quality. The analysis underscores the need for retrofit strategies that integrate household-specific factors—such as single-person households or families with children—the heightened vulnerability of dwellings with greater energy demand, the influence of subjective thermal perception and user behaviour, and the critical importance of improving indoor air renewal systems.

Keywords:

IAQ, naturally ventilated dwellings, indoor monitoring, retrofit strategies, social housing

Peihang An

KU Leuven, Belgium

Bio:

Peihang An is a PhD student in the Building Physics and Sustainable Design group at KU Leuven (Ghent Campus). His research focuses on the thermal and indoor air quality resilience of buildings, with particular emphasis on the performance of building systems during disruptive events such as heat waves and power outages, as well as the spatial variation of resilience within single building zones. Peihang holds a B.Eng in Architecture from Huazhong University of Science and Technology (China), an M.Sc in Engineering with Management from the University of Bristol, and an M.Sc in Smart Buildings and Digital Engineering from University College London. He used to work at a state-owned building design institute and at a technology company specializing in remote sensing. He also has long served as a part-time freelance translator and assistant editor for ArchDaily.

Presentation Title:

Power outage profiles generation to assess thermal and indoor air quality resilience

Abstract:

Climate change amplifies the frequency of extreme weather events, leading to increased risk of power outages. Power outage is a critical disturbance for buildings because it disrupts heating, ventilation, and air conditioning systems, simultaneously challenging the resilience of a building's thermal and indoor air quality performance. Resilience means the ability of a building or system to maintain acceptable indoor environmental quality during shocks such as a power outage and recover after it ends. Existing building resilience studies often rely on simplified and unrealistic assumptions, such as outages that last for multiple days or outages that occur during the worst weather conditions, without considering the actual probability of occurrences. Such subjective assumptions, lacking empirical data, can easily lead to misjudgements on the actual impact of power outages on thermal and indoor air quality resilience.

This work introduces a data-driven methodology combining geometrical probability with Monte Carlo sampling to generate power outage profiles from historical outage records. These profiles can be used as boundary conditions in building simulations and support more objective assessments on resilience. A lecture room at the KU Leuven campus in Ghent, Belgium, is used as the case study to demonstrate the methodology. The building and air handling unit system is modelled in Dymola and has been validated in previous work. Historical outage data from mid-June to mid-October 2024 is collected from a local electricity supplier. A total of 163 distinct profiles were generated to represent the local power outages. For each profile, one outage case and one paired benchmark case are simulated. In the outage cases, the air handling unit is interrupted according to the outage defined by the profile; in the benchmark cases, the system operates normally, enabling direct comparison of the performance changes. Resilience is quantified through cumulative exposure over a threshold, defined as the time-integrated portion of an indicator that exceeds a predefined limit. The results show that carbon dioxide concentration is the most sensitive to power outages in the case study building. The number of cases with exceedance rises by over 70 % under outages, with the strongest impacts when outages overlap with the occupancy schedule. Volatile organic compounds exhibit only a modest increase in cumulative exposure, as many benchmark cases are already close to saturated levels. Particulate matter concentrations remain almost unchanged because the increased indoor accumulation is offset by lower outdoor particle infiltration. Thermal resilience is barely affected, since the simulations use typical summer weather without heat waves. Overall, the responses of different thermal and indoor air quality resilience indicators vary markedly, underlining the need for probability-based power outage profiles to assess the resilience.

The proposed methodology offers a transparent and transferable framework that links power outage with resilience assessment based on building performance simulation. It avoids subjective assumptions on power outages and can be readily extended to other cases. Future works will focus on applying the methodology to combined heat wave and power outage conditions, where higher outdoor temperatures, increased cooling demand, and more severe grid disturbances are expected to challenge resilience more strongly.

Keywords:

Building modelling simulation, thermal resilience, indoor air quality resilience, power outages, Monte Carlo sampling

María del Mar Barbero Barrera

Technical University of Madrid (UPM), Spain

Bio:

María del Mar Barbero Barrera is a PhD Architect and Full Professor at the School of Architecture of the Technical University of Madrid (Universidad Politécnica de Madrid, UPM) (ORCID: 0000-0002-4605-3154). With an H-index of 16 according to Web of Science, her research activity focuses on sustainable construction, as well as on the characterisation and development of building materials and construction systems. She is the Principal Investigator of the Lime4Health research project (PID2021-123023OA-I00), which addresses indoor air quality in primary school buildings.

Presentation Title:

Consequences of climate change on indoor air quality at primary schools in Madrid

Abstract:

Indoor air quality (IAQ) in educational buildings is a critical public health issue, particularly for children, who are more vulnerable to pollutant exposure and spend prolonged periods indoors. While ventilation is widely promoted as a key mitigation strategy, its effectiveness for controlling volatile organic compounds (VOCs) remains insufficiently explored, especially in the context of climate change and evolving ventilation practices. This challenge is further amplified by current energy efficiency policies, which promote increased thermal insulation and more airtight building envelopes, often resulting in significantly reduced levels of uncontrolled ventilation.

This study focuses on VOC concentrations in primary school classrooms in the Madrid region, with particular attention to emissions associated with common educational materials and classroom activities. Two representative schools are analysed: one equipped with mechanical ventilation and one relying exclusively on natural ventilation. The analysis is based on in situ monitoring campaigns conducted across multiple periods, combining spatially distributed measurements of indoor air quality with detailed records of classroom activities, ventilation practices, and occupancy patterns.

Results indicate that VOC levels are primarily influenced by material-related emissions and usage patterns. Differences observed between the two schools suggest that ventilation performance for VOC removal depends not only on the type of system implemented, but also on operational conditions, maintenance practices, and user interaction. These findings highlight the need to assess ventilation strategies beyond nominal air change rates, incorporating source control and real operating conditions, particularly under climate-driven constraints affecting window opening.

This work contributes to the broader framework of the doctoral research "Energy efficiency and indoor air quality in schools in the city of Madrid and its periphery", providing evidence-based insights to support the development of robust and resilient ventilation strategies for healthy school environments.

Keywords:

Indoor air quality, Volatile organic compounds, School buildings, Ventilation strategies, Energy efficiency and airtightness

Wouter Borsboom

TNO, Netherlands

Bio:

Wouter Borsboom is a Business Consultant at TNO, working at the intersection of building physics, energy performance, and indoor environmental quality. He supports public and private stakeholders in translating scientific insights into practical strategies for sustainable and healthy buildings. His expertise includes thermal and energy modeling, ventilation and indoor air quality, and the integration of smart control concepts in residential and non-residential buildings.

Wouter has contributed to and coordinated numerous national and European projects related to the energy transition and climate adaptation of the built environment. His work addresses topics such as net-zero and low-carbon buildings, electrification of heating systems, mitigation of heat stress, and performance-based evaluation of building concepts. By combining analytical modeling with real-world constraints, he helps bridge the gap between research, policy, and market implementation, enabling robust decision-making for a resilient and future-proof built environment.

Presentation Title:

healthRiskADAPT: Advanced Ventilation and Filtration Strategies for Indoor Air Quality and Thermal Comfort

Abstract:

The TNO contribution in the EU healthRiskADAPT project focuses on developing and validating a multi-zone ventilation and thermal comfort model to quantify health risks associated with heatwaves, air pollution, wildfire emissions, and pollen exposure in residential and healthcare environments. The research integrates dynamic simulations with real-world monitoring to improve predictive accuracy for indoor air quality (IAQ) and thermal resilience under extreme climate conditions.

Four energy-efficient dwellings equipped with balanced ventilation systems with heat recovery were monitored for key IAQ parameters, including PM2.5, CO_2, relative humidity, and temperature. Advanced sensor networks tracked window status and occupant presence to capture behavioural influences on ventilation performance. Results demonstrate that indoor PM2.5 concentrations are strongly influenced by mechanical ventilation rates, infiltration dynamics, window operation, indoor emission sources, and filter efficiency.

Comparative analysis of coarse G3 filters versus fine F7 filters revealed that fine filtration significantly reduces indoor PM2.5 concentrations, achieving levels below WHO annual guidelines. Infiltration factors were markedly lower with fine filters, and the validated model accurately predicted ventilation and infiltration flows using CO_2-based algorithms.
Future work will extend the model to healthcare facilities, incorporating high-efficiency ASPRA filtration systems and advanced thermal modelling to address combined heat and pollutant stress. This integrated approach supports evidence-based design for resilient, low-energy buildings that safeguard occupant health under evolving environmental challenges.

Keywords:

Indoor Air Quality (IAQ), PM2.5 Filtration, Balanced Ventilation, Heat Recovery, Multi-Zone Modelling, Thermal Comfort, Infiltration Dynamics, CO_2-Based Ventilation Control, ASPRA Filters, Energy-Efficient Buildings, Health Risk Assessment, Climate Adaptation, Wildfire Emissions, Pollen Exposure, WHO Guidelines

Hilde Breesch

KU Leuven, Belgium

Bio:

Hilde Breesch graduated as a Master of Science in Civil Engineering at KU Leuven in 1999 and obtained her PhD in Engineering Science from Ghent University in 2006, with a dissertation on the performances of natural night ventilation in office buildings. Since 2021, she has been an associate professor at the Faculty of Engineering Technology, Ghent Campus, KU Leuven. She is assigned within the Building Physics and Sustainable Buildings section in the Department of Civil Engineering. She leads the research line on indoor climate and energy performance of buildings. Her research centers on building–system–control–user interactions, with two core themes: developing control strategies for ventilation systems, incorporating user interaction, and developing assessment frameworks for thermal and IAQ resilience of buildings.

Internationally, she is coordinator of venticool, the dissemination platform for resilient ventilative cooling, she represents Belgium on the board of the Air Infiltration and Ventilation Centre (AIVC) and she serves as an officer of the non-profit organization INIVE, the International Network for Information on Ventilation and Energy Performance.

Presentation Title:

Overheating assessment & ventilative cooling in national building codes regarding indoor environmental quality and energy performance

Abstract:

The world meteorological organization (WMO) reported that the past 11 years (2015-2025) are now the warmest on record. This accelerating warming trend highlights a shift in building practice: from focusing on heating needs (in cold and moderate climates) to addressing cooling demand, overheating risks, and thermal resilience. Within this context, ventilative cooling is recognized as a key strategy to meet cooling demand and to enhance resilience during heatwaves. Designers typically rely on national building codes on indoor environmental quality (IEQ) and energy performance when assessing overheating risks. Therefore, we aimed to assess how these codes address overheating and ventilative cooling in buildings. We conducted a cross-country survey in 2024-2025, targeting 19 countries/regions - Australia, Austria, Flanders (Belgium), Canada, Denmark, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands,

Norway, Portugal, South Korea, Spain, Sweden, Switzerland and England & Wales (GB). This survey gathered detailed information on assessment methods, performance requirements, and the integration of passive cooling concepts in both residential and non-residential buildings in current regulations. All information provided reflects the interpretation of national experts based on their understanding of applicable regulations.
The analysis of the survey responses shows that approximately half of the surveyed countries/regions include an assessment method and/or requirements for overheating in buildings. Both simplified and detailed assessment approaches are applied. Among these, 50% of the building codes specifies a separate performance-based indicator for overheating in residential buildings. Regarding ventilative cooling, fewer than 50% of the studied countries explicitly include ventilative cooling as a mitigating strategy. Where ventilative cooling is considered, building codes typically provide multiple options for design and control. A clear distinction exits between residential and non-residential buildings: overheating assessment methods as well as requirements are common in residential buildings. Finally, current building codes do not account for climate change impact. Future weather files are absent, with Germany being the only (known) country planning to incorporate mid-term future weather data in its upcoming standard update. Resilience to overheating is mentioned in only one-third of the reviewed buildings codes.

Keywords:

Overheating, ventilative cooling, thermal resilience, building codes

Teresa Cuerdo-Vilches
Eduardo Torroja Institute for Construction Science (IETCC), Spain

Bio:

PhD. Architect and researcher at the Eduardo Torroja Institute for Construction Sciences, belonging to the Spanish National Research Council (CSIC), she leads national and international projects on energy, habitability, and indoor environmental quality in buildings and urban environments, and their impact on public health and well-being, including energy vulnerability and poverty, urban and social adaptation to climate change, and the energy transition. She is co-chair of the European IWG5 Working Group on Building Efficiency for the implementation of the EU Strategic Energy Technology (SET) Plan, funded by the European Commission, focusing on clean heating and cooling technologies, thermal energy storage, just transition, and affordable and sustainable building renovation. Besides, she is professor, teaching Building Conditioning Techniques and other related subjects as part of the Architecture Fundamentals Degree and also Masters' Degree lectures.

Presentation Title 1:

IEQ in domestic workspaces: indicators and perceptions in Spanish homes

Abstract 1:

Teleworking is a flexible work modality whose analysis has mainly focused on organizational aspects, while a research gap remains regarding the indoor environmental quality of domestic spaces where it takes place. From an architectural and environmental health perspective, variables such as thermal, acoustic and visual comfort, as well as indoor air quality, are known to directly influence well-being and productivity. These conditions are more difficult to assess in the home environment due to its private and heterogeneous nature, which justifies the need for specific studies examining their relationship with the perceived adequacy of teleworking spaces.

A nationally representative study was conducted through an online survey of 65 questions, gathering at least 1,150 responses proportionally distributed across Spain. Quotas by sex and age were applied, with a ±3% margin of error and a 95% confidence level. The analysis focused on the variable "adequacy" of the teleworking space, relating it to sociodemographic factors, housing characteristics, workspace conditions, digital resources, ergonomics, and indoor environmental quality components. Binary logistic regression was used to identify significant predictors. Data were collected in May 2025 and analyzed using JASP and R.

Besides, an on-the-ground monitoring campaign in home-based workspaces was carried out during winter 2025-2026, which enriched the analysis, with supplementary info on how people interact with their work settings at home, and what indoor environmental parameters are more relevant for them, with implications on their perceived well-being.

The results show that adequate teleworking spaces are associated with higher education levels, higher income, adequate digital resources, positive prior teleworking experience, managerial positions, and intellectually demanding tasks performed from home on a regular basis. No significant differences were found by age or gender. At the residential level, adequacy was related to dwellings built after 1979, in good condition, larger in size, owner-occupied, and with good environmental conditions. Inadequacy was linked to physical deficiencies of the workspace and thermal discomfort, particularly in winter. Logistic regression highlighted indoor air quality as the most influential factor in perceiving the workspace as adequate, followed by overall lighting, artificial lighting satisfaction, and adequate natural light. An inadequate heating system showed a negative association.

In conclusion, the perceived adequacy of teleworking spaces depends on both sociodemographic and occupational factors as well as housing characteristics, with indoor air quality, lighting, and thermal comfort playing a decisive role.

Keywords:

Telework, Indoor Environmental Quality (IEQ), work setting, housing, Indoor Air Quality (IAQ)

Presentation Title 2:

On energy transitions, clean cooling, and societal needs and implications. A European overview

Abstract 2:

The European Union (EU) is pursuing ambitious goals to reduce greenhouse gas emissions, promote renewable energy, and improve energy efficiency. The built environment accounts for around 35% of greenhouse gas emissions, and with 85% of European buildings over 25 years old, decarbonising heating and cooling is a central European climate objective. Achieving fully renewable heating and cooling requires transforming existing systems, focusing on efficiency, flexibility, and large-scale integration of renewables.

European goals prioritise deploying clean and efficient heating and cooling systems, improving performance, reliability, and adaptability to various building types and climates. Ensuring thermal comfort while reducing energy demand is essential, particularly in renovations. Key challenges include increasing system efficiency, enabling higher operating temperatures, simplifying installation, and integrating smart control. Thermal energy storage is a strategic enabler, enhancing flexibility and better use of intermittent renewable energy. Objectives also include improving integration with the wider energy system, digitalising design, operation, and maintenance, and developing harmonised assessment and cost–benefit methods.

Achieving these goals requires inclusive strategies addressing social vulnerabilities, especially energy poverty. Renovating buildings is crucial for efficiency and reducing costs, but clean heating solutions—like heat pumps and renewable district heating—must be accessible and affordable. Electrification must avoid additional financial burdens on vulnerable consumers, and heavy biomass use in energy-poor homes raises air quality and health concerns.

European and national initiatives support a fair energy transition. Collective systems—district heating, positive energy districts, and renewable energy communities—strengthen local participation and energy autonomy. One-stop shops provide tailored advice, energy coaching, and renovation passports to help households make informed, cost-effective choices. Societal readiness encourages public engagement and addresses social and behavioural barriers. By combining social, economic, and technical strategies, these efforts aim to ensure a fair energy transition, particularly for vulnerable citizens, while promoting innovation in building and industry sectors in a safer, more stable way.

Keywords:

Energy Transition, SET Plan, European policy, HVAC, society

Sonia García Ortega

Eduardo Torroja Institute for Construction Science (IETCC), Spain

Bio:

Sonia García Ortega is a senior researcher at the Eduardo Torroja Institute for Construction Sciences (IETcc-CSIC), where she works in the field of pre-normative research related to building habitability and sustainability. She holds a PhD in Construction and Architectural Technology from the Technical University of Madrid, with a research focus on indoor air quality (IAQ) in naturally ventilated dwellings and the development of predictive models applicable at large scale.

Her work combines experimental research, data analysis and regulatory development, with a particular emphasis on ventilation requirements, CO_2-based performance approaches, and the interaction between energy efficiency measures and IAQ in existing residential buildings. She has extensive experience advising the Spanish Ministry of Housing and Urban Agenda on technical regulations related to IAQ, water supply and drainage systems, and radon protection in buildings.

She represents Spain in international expert groups such as the Air Infiltration and Ventilation Centre (AIVC) and actively contributes to European Union CPR Acquis expert groups, assisting the Commission in issues related to the Construction Products Regulation.

Presentation Title:

Data processing possibilities for large-scale IAQ prediction

Abstract:

Indoor air quality (IAQ) in residential buildings is a key determinant of occupants' health, yet its assessment in existing dwellings remains limited, particularly at large scale. In Spain, natural ventilation based on window opening, thermal draft and air infiltration through the building envelope is still predominant. Over recent decades, European Union energy policies—particularly those linked to energy efficiency and climate mitigation—have strongly promoted building renovation and envelope airtightness. While effective in reducing energy demand, these interventions have frequently led to unintended negative impacts on IAQ, especially in dwellings relying on natural ventilation where reduced infiltration is not compensated by mechanical systems.

Current EU policy frameworks, including the Energy Performance of Buildings Directive and the Renovation Wave, are progressively evolving towards a more holistic approach that integrates energy performance, health and indoor environmental quality. However, the incorporation of IAQ into building refurbishment and incentive schemes requires a robust understanding of the actual conditions of the existing housing stock, as well as scalable and cost-effective methods to assess IAQ at large scale and identify priority areas for improvement.

This communication investigates data processing strategies that enable large-scale IAQ prediction in naturally ventilated dwellings without relying on ventilation flow rate measurements. The research is based on the hypothesis that indoor CO_2 concentration, as an indicator of IAQ, can be predicted using a reduced set of easily obtainable parameters. The main objective was to develop a predictive model for IAQ in existing dwellings, supported by two subsidiary aims: to characterise IAQ conditions in naturally ventilated housing and to provide technical evidence to support regulatory adaptations facilitating the use of natural ventilation.

An experimental campaign was conducted in 12 single-storey dwellings located in multifamily residential buildings in Madrid, covering 42 rooms and 75 measurement cases. A generalised linear model was developed to estimate average indoor CO_2 concentration using five input variables: season, room use, dwelling floor area, regular occupancy and number of façades with openings. The model demonstrates high explanatory capacity and robust predictive performance, enabling IAQ estimation without continuous monitoring.

The results show that approximately half of the monitored dwellings do not comply with current IAQ requirements, with excessive CO_2 levels in bedrooms identified as the main cause of non-compliance, particularly during winter. Occupants' ventilation behaviour was found to be a critical influencing factor. By enabling IAQ assessment at scale using readily available data, the proposed approach supports evidence-based policymaking and provides a practical foundation for integrating IAQ considerations into future EU energy renovation strategies and building regulations.

Keywords:

Indoor air quality regulation, Building code, natural ventilation, CO_2-based performance criteria, Predictive modelling

Eduardo González Cruz

Eduardo Torroja Institute for Construction Science (IETCC), Spain

Bio:

Doctorate in Energy from the École des Mines de Paris and Architect from the University of Zulia, Maracaibo, Venezuela. Professor Emeritus and Researcher at the University of Zulia (1976 to 2013). National Housing Research Award (1997). Director of the Research Institute of the Faculty of Architecture and Design, LUZ (1998-01). Deputy Coordinator of the Doctorate Programme in Environmental Sciences, University of Zulia-Polytechnic University of Madrid (2005-2012). Guest lecturer at universities in Spain, Mexico, Panama, Colombia and Brazil. Visiting Professor, Postgraduate Programme in Civil Engineering, UTFPR, Curitiba, Brazil (2019-23). Researcher at the Eduardo Torroja Institute of Construction Sciences-CSIC (2023-24).

Presentation Title:

Full-scale facility for night and day-time passive radiative cooling system assessment

Abstract:

As part of the EURAMET research project "Metrological framework for passive radiative cooling technologies" (PaRaMetriC), the aim of the research is to implement a prototype cooling system to assess the potential of passive radiative cooling (PRC) materials and their applicability for achieving thermal comfort conditions in buildings. The experimental setup is based on a full-scale facility located in Arganda del Rey, community of Madrid, Spain. This study describes the characteristics of the radiative cooling system with its different components and the test facility. Previous experiments have demonstrated the applicability of a similar system, based only on nighttime radiative cooling, for less favorable climatic conditions in Curitiba, Brazil. The assessment of the system in full-scale is essential to showcase the contribution of PRC materials can have for ensuring indoor thermal comfort in extreme weather conditions.

Keywords:

Building comfort, Passive radiative cooling, Full-scale test cells, Performance assessment, Radiant-capacity cooling system

Jialiang Guo

KU Leuven, Belgium

Bio:

Jialiang Guo is a PhD researcher at KU Leuven (Belgium), a FWO PhD Strategic basic research fellowship holder funded by Research Foundation-Flanders. He works on the PhD project named 'Assessment framework of multi-scale low-energy cooling solutions', with particular focus on low-energy cooling solutions, building energy simulation, building-microclimate coupling simulations. He previously completed Master by research degree in Architecture at Guangzhou University (China), where he studied indoor heat mitigation and passive cooling strategy, and published related works on Building and Environment, Journal of Building Engineering journals. He is also contributing to the projects IEA EBC Annex 97 'Sustainable Cooling in Cites'. At this AIVC 2026 workshop, he will present results from a summer field measurement campaign in and around an elderly care facility in Ghent (Belgium), assessing outdoor microclimate variations and indoor heat stress, and linking the block-scale morphology parameters to observed heat stress differences.

Presentation Title:

Outdoor Microclimate Variations and Indoor Thermal Stress: Summer Field Measurements in an Elderly Care Facility

Abstract:

Cities are becoming warmer due to climate change, which worsens both indoor and outdoor thermal conditions. This challenge is particularly critical for vulnerable residents of elderly care facilities, where combined indoor and outdoor heat exposure can severely threaten health and wellbeing. This study reports a summer field campaign at an elderly care facility in Ghent, Belgium, designed to evaluate recent heat stress in and around the building. We simultaneously monitored indoor and outdoor thermal environments at 4 spots with typical urban microclimate settings (street canyon, inner courtyard, park area with semi-shaded, park area with exposure) and in 7 resident rooms with different orientations and surrounding microclimates. Rooftop and pedestrian-level weather stations, together with indoor HOBO data loggers, recorded air temperature, relative humidity, wind speed and solar radiation. Outdoor (pedestrian level) and indoor heat stress were quantified using two thermal comfort indices – Physiological Equivalent Temperature (PET) and Standard Effective Temperature (SET). Posthoc comparison tests were applied to identify significant differences in heat stress between sites and rooms, and an explainable machine-learning approach (SHapley Additive exPlanations) was used to identify the main driving factors. The exposed park spot experienced the highest outdoor heat stress, with total exceedance degree-hours between 600°Ch and 1,100°Ch above different heat stress thresholds (29°C, 35°C, 41°C). The semi-shaded park showed roughly half of this value, demonstrating that tree cover ratio could substantially reduce outdoor heat stress. The street canyon and courtyard showed similar outdoor heat stress levels, with intermediate exceedance degree-hours between those of the two park locations. The machine-learning analysis indicated that air temperature (during day and night) and solar radiation (during daytime) are the dominant drivers of outdoor heat stress at pedestrian level. Indoors, all top-floor resident rooms showed higher heat stress than ground-floor rooms. Top-floor rooms facing the street canyon and the courtyard on the top floor had the most severe conditions, with exceedance degree-hours based on 26°C threshold of 136°Ch and 75°Ch, respectively. In addition, two ground-floor rooms with similar orientation but different surrounding microclimates (facing semi-shaded park and courtyard), showed a difference in indoor heat stress. Their maximum difference in the indoor comfort index reaching about 1.42 °C. This indicates that, beyond room orientation, the neighbouring microclimate around the building may also impact indoor thermal stress. Overall, the findings highlight the need to consider outdoor morphology parameters, such as tree cover ratio and impervious cover ratio that help lower ambient temperature leading to outdoor microclimate variance, when considering indoor heat stress mitigation strategy. Further investigation should be conducted for assessing different factors for indoor thermal stress with building-microclimate coupling simulations.

Keywords:

Indoor thermal stress, Outdoor microclimate, Field measurement, Elderly care facility

Nolwenn Hurel
Cerema, France

Bio:

Nolwenn Hurel is a researcher in the High-Performance Buildings in Their Environment (BPE) team at Cerema, France. Her work focuses on airflows in buildings and their impact on indoor air quality, energy use, and thermal comfort. She studies in particular the multicriteria performance of ventilation systems and the overheating during heatwaves, especially in schools. Her research combines experiments, measurement campaigns, and modeling to develop strategies adapted to future climates and building typologies. She has contributed to the development of European building ventilation standards within CEN/TC 156, is co-author of 25 international publications, and co-leads the TAAC international network on building and ductwork airtightness and the inspection of ventilation systems.

Presentation Title:

Multi-Criteria Evaluation of Eight Ventilation Systems in Renovated Houses: Energy, Air Quality and Comfort Performance

Abstract:

In the renovation of single-family homes, ventilation is often overlooked: there is no regulatory obligation to upgrade it, and installing mechanical ventilation in existing buildings can be difficult or costly. Yet renovated homes often reach high airtightness, making indoor air quality (IAQ) strongly dependent on mechanical systems. This poses health and comfort risks and highlights the need for guidance. In France, the ongoing research project JUSTAIR addresses this by assessing the performance of ventilation systems for low-energy retrofitted dwellings. A multi-criteria approach compares systems not only for IAQ and energy use, but also thermal, acoustic, and olfactory comfort, and cost. Eight systems were evaluated, including very common ones and others less widespread but sometimes used in renovation due to installation and cost constraints: balanced ventilation with heat recovery (BV), thermodynamic BV, single-exhaust humidity-based systems (EV-rh a/b), supply-based (SV), decentralized mechanical balanced ventilation (DBV), BV without supply ducts (BV-nsd), and distributed mechanical ventilation (DEV).

The study relies on a coupled CONTAM–TRNSYS model representing airflow, pollutant transport, and thermal behaviour. Three of the less widespread systems (SV, BV-nsd, DBV) were first experimentally tested in the INCA experimental house. The experimental data were used to calibrate and improve the numerical models. A parametric analysis then explored variations in occupancy, emissions, outdoor pollution, insulation and airtightness, climate, and window-opening behaviour, enabling harmonised comparisons across indicators for CO_2, humidity, formaldehyde, PM2.5, NO_2, radon, airflow rates and directions, energy use, and summer and olfactory comfort.

Results show marked contrasts in winter. CO_2 performance depends more on window use and airtightness than on occupancy: BV achieves the best levels (ICONE <1.5, P95 <1500 ppm) due to higher airflow, while EV-rh and DEV systems show higher concentrations (ICONE >3, P95 ≈3000 ppm). SV is highly sensitive to openings, as supplied air tends to escape through nearby windows rather than circulate through rooms to outlets. Humidity is better controlled by EV-rh systems regarding time outside 40–60%, though periods >70% are similar across systems. Formaldehyde exposure roughly doubles for EV-rh and DEV, mainly driven by emissions and window management. PM2.5 decreases by about one third with BV, whereas DEV performs worst with periods without ventilation rates. NO_2 depends mainly on outdoor levels, with similar exposure across systems. Radon is best mitigated by SV and, to a lesser extent, BV.

In summer, IAQ improves overall, mainly because windows are opened more often: lower CO_2 peaks, reduced formaldehyde, and slight decreases in PM2.5, NO_2, and radon. Regarding fan consumption, EV-rh systems consume less due to lower fan flows on average. Summer discomfort depends more on window use, climate, and envelope performance than on ventilation. Odour removal is weakest for DEV (periods without airflow) and partly for SV (air outlets less efficient than exhausts), while acoustic comfort is acceptable except at high DBV speeds.

This multi-criteria evaluation highlights trade-offs between IAQ, comfort, and energy, providing valuable guidance for ventilation choices in renovation contexts.

Keywords:

Ventilation, IAQ, numerical model, experimental measurements, parametric study

Arnold Janssens

AIVC Operating Agent/INIVE/UGent, Belgium

Bio:

Arnold Janssens (°1967) is senior full professor of building physics and building construction applications at the Faculty of Engineering and Architecture at Ghent University in Belgium. After obtaining a doctorate in applied sciences at the Laboratory of Building Physics at KU Leuven in 1998, he started as assistant professor at the Department of Architecture and Urban planning of Ghent University in 1999 and was appointed full professor in 2012. In between 2014 and 2020, he was also head of the Department of Architecture and Urban Planning.

He has been teaching courses on "building physics", "building acoustics and lighting", "residential comfort systems", "building performance simulation" and "energy transition of buildings" within the architectural and civil engineering programmes.

He is chair of the research group Building Physics at Ghent University. He and his co-workers wrote over 350 research articles published in international journals, proceedings of international conferences and books.

He has been involved in several research projects within the EBC programme of the International Energy Agency (Energy in Buildings and Communities). One of those is the Air Infiltration and Ventilation Centre AIVC, for which he has been board member representing Belgium since 2012, and for which he acts as operating agent since 2022 together with dr. Peter Wouters. He is member of the editorial board of the International Journal of Building Physics, and the International Journal of Ventilation.

Presentation Title:

Overview of AIVC, TightVent & Venticool

Abstract:

This talk presents the Air Infiltration and Ventilation Centre AIVC, the Building and ductwork airtightness platform TightVent, and the platform for resilient ventilative cooling venticool. These organisations are knowledge and dissemination platforms which collect information and create knowledge by collaboration with international partners, and have a long history.

The AIVC (Air infiltration and Ventilation Centre) is the International Energy Agency's information centre on energy efficient ventilation, which was created in 1979. The AIVC's main goal is to provide reference information on ventilation and air infiltration in the built environment with respect to efficient energy use and good Indoor Environmental Quality (IEQ), in collaboration with other international organisations such as TightVent and venticool. Since 2011, AIVC activities have been structured around thematic projects, resulting in different dissemination outputs, for example webinars, conference sessions, information papers, and technical reports.

Keywords:

AIVC, TightVent, Venticool

Pilar Linares-Alemparte

Eduardo Torroja Institute for Construction Science (IETCC), Spain

Bio:

Pilar Linares Alemparte is a PhD architect and senior researcher at the Instituto de Ciencias de la Construcción Eduardo Torroja (IETcc CSIC), where she has worked since 2001. Her research focuses on indoor air quality, ventilation strategies, and radon protection in buildings, with a strong emphasis on integrating scientific evidence into regulatory development.

She coordinates the work related to Hygiene, health and environment protection within the Spanish Building Code (CTE), particularly in the areas of indoor air quality and protection against radon. Pilar has led the most recent revision of DB HS3, the section on IAQ regulations, introducing a more performance based approach to encourage efficient and innovative ventilation solutions. She is also the lead author of DB HS6, the new section dedicated to radon protection.

In addition, she authored the Radon Rehabilitation Guide, a national reference document that provides technical criteria and practical solutions for mitigating radon in existing buildings.

Presentation Title:

Spanish indoor air quality regulation reinvented: research as the pathway from prescriptive to performance-based regulations

Abstract:

This communication examines the crucial role of pre normative research in the development of effective regulatory frameworks for indoor air quality in buildings. Pre normative studies provide the scientific basis needed to understand pollutant dynamics, evaluate ventilation performance under realistic conditions, and determine how regulatory requirements can best protect occupants while supporting energy efficient building design. By grounding regulations in evidence rather than rigid prescriptions, policymakers can create standards that are both technically robust and capable of adapting to new technologies and building practices.

The article highlights the recent revision of Spain's Documento Básico HS3, which is part of the Spanish Building Code (Código Técnico de la Edificación, CTE), and governs national regulations relating to indoor air quality in residential buildings. The updated version reinforces a performance-based approach, shifting the focus from predefined solutions to the achievement of measurable outcomes related to air renewal and pollutant control. This shift encourages the adoption of more efficient ventilation strategies, including demand-controlled systems and advanced mechanical solutions that can better respond to real patterns of occupancy and use.

A significant consequence of this research driven revision was the possibility of reducing minimum ventilation flow rates. Earlier regulatory versions assumed continuous occupancy of all rooms, leading to conservative requirements that often resulted in oversized systems and unnecessary energy consumption. The new approach is grounded in simulation studies that incorporate realistic occupancy scenarios, acknowledging that dwellings are used dynamically and that not all spaces require constant ventilation at maximum rates. By integrating these findings, the regulation achieves a more balanced relationship between indoor air quality, energy performance, and practical building operation.

Overall, the article argues that pre normative research is essential for designing regulations that effectively protect public health while remaining aligned with contemporary building practices and sustainability goals. The evolution of DB HS3 demonstrates how evidence-based policymaking can lead to more flexible, efficient, and context appropriate standards for indoor air quality in residential environments.

Keywords:

Regulations, performance-based, research, IAQ

Jesus Lizana

University of Oxford, United Kingdom

Bio:

Jesus Lizana is Associate Professor in the Department of Engineering Science at the University of Oxford. He leads the research programme on zero-carbon heating and cooling at the ZERO Institute. His work encompasses sustainable heating and cooling solutions through innovative materials, advanced modelling, real-world testing, and strategic planning. He also teaches building services engineering across Oxford's MEng and MSc programmes. Lizana has held academic positions in Spain, Portugal, Germany, and the United Kingdom, contributing to over 20 research projects and authoring more than 40 scientific publications. His work has been recognised through several national and international programmes and awards, including the Marie Skłodowska-Curie Individual Fellowship, the 2025 CIBSE Award in Learning and Development, and the 2025 UK Emerging Talent Award. He also works internationally as a consultant, having delivered projects with more than 20 institutions, and advises organisations such as the UK Department of Energy, UNEP, and CIBSE on energy and climate policy.

Presentation Title:

Citizen science for multi-scale climate assessment: integrating distributed modelling and crowdsourced observations to inform urban heat adaptation

Abstract:

Cities require improved climate information to anticipate rising temperatures and increasingly variable local conditions. This study examines the contribution of citizen science to this objective through two complementary methodologies that together span global to neighbourhood scales.

The first methodology employs volunteered distributed computing to run the HadAM4 climate model via the climateprediction.net platform for high-resolution climate change projections. This approach leverages the unused computational capacity of thousands of personal computers to generate very large, high-resolution climate ensembles that would otherwise be prohibitively expensive to produce on conventional supercomputers. The second methodology uses crowd-sourced weather observations obtained from privately owned, low-cost weather stations connected to platforms such as Netatmo and Wunderground. Using London as a case study, time series from 1,823 citizen weather stations were quality-controlled and analysed to characterise urban climate dynamics at high resolution. The results

from both methodologies are compared using Cooling Degree Days (CDD), a widely used indicator of heat intensity and cooling demand.

The distributed computing experiments provide a global perspective on the impact of global climate change on cooling needs using CDD at approximately 60 km at mid-latitudes. The results identify areas where increases in CDD intensity are greatest under future warming and indicate regions likely to experience substantial absolute and relative changes. The analysis further shows that changes in CDD intensity are non-linear, with the most significant increases occurring early in the warming trajectory, particularly as global temperatures approach 1.5ºC, underscoring the urgency of near-term adaptation planning.

The crowdsourced weather observations complement these findings by providing high-resolution, city-scale evidence of heat exposure. They resolve spatial and temporal temperature variability at 1 km resolution, revealing micro-climatic patterns that exceed surrounding temperatures by more than 6°C and indicating areas where adaptation interventions should be prioritised. These results also enable the assessment of local interventions, supporting the identification of effective heat-mitigation strategies.

Together, the two techniques demonstrate how citizen participation can generate scientifically robust climate information across scales. The integration of distributed computing and dense observational networks highlights the potential of citizen science to enhance climate projections, refine local risk assessments, and inform targeted adaptation strategies for more climate-resilient citie.

Keywords:

Citizen science, Climate change, Urban overheating, Climate adaptation, Cooling Degree Days

Andrea Martínez Topete

Technical University of Madrid (UPM)/ Eduardo Torroja Institute of Construction Science (IETcc-CSIC), Spain

Bio:

Andrea Martínez Topete holds a degree in Chemistry from the Complutense University of Madrid (UCM) and is currently in the final phase of her PhD within the Environmental, Chemical, and Materials Engineering Program at the Technical University of Madrid (UPM), funded by an FPU fellowship from the Spanish Ministry of Universities. Her research is carried out in the ISCMA group (Sustainable Interaction of Construction Materials with the Environment) at the Eduardo Torroja Institute of Construction Science (IETcc-CSIC). Her work focuses on the study and development of photocatalytic materials for environmental remediation, with a particular emphasis on sustainable and innovative solutions that enhance the interaction of construction materials with the environment.

Presentation Title:

Multifunctional materials in indoor environments: air remediation and cooling properties

Abstract:

In this work, a series of bismuth oxyiodide materials were synthesized using a coprecipitation method characterized by low energy demand and high phase tunability. By carefully controlling the synthesis parameters, materials with tailored crystal phases and morphologies were obtained, allowing the optimization of their optical, chemical, and electrochemical properties. Comprehensive characterization was carried out to establish clear correlations between material structure, light absorption, charge transfer behavior, surface chemistry, and functional performance.

Photocatalytic activity was systematically evaluated under ultraviolet and visible light for key indoor air pollutants, including nitrogen oxides, VOCs and microorganisms. Selected materials exhibited enhanced visible-light photocatalytic efficiency compared to conventional photocatalysts, achieving effective pollutant degradation and bacterial inactivation without relying on ultraviolet irradiation. Mechanistic studies revealed that superoxide radicals, singlet oxygen, and direct charge carrier interactions dominate the photocatalytic processes, while hydroxyl radicals play a negligible role. In addition to their photocatalytic performance, the synthesized materials exhibited high near-infrared reflectance and suitable thermal emissivity, key properties for passive cooling applications. Their thermal behaviour was systematically evaluated, demonstrating a reduced heat absorption under solar irradiation and a clear potential to mitigate indoor heat gain. Construction materials using cement, lime and gypsum, functionalised with the bismuth oxyiodide materials were cast. The positive cooling results confirm the multifunctional nature of the materials and support their suitability for combined air remediation and thermal management in indoor environments.

Overall, this study highlights the potential of bismuth oxyiodide-based materials as multifunctional candidates for indoor applications, combining visible-light-driven indoor air purification with energy-efficient cooling. The results indicate that these materials could serve as a basis for the development of advanced building materials, although further validation is required. Future work is focused on pilot-scale studies and the incorporation of these materials into indoor paint coatings, aiming to evaluate their performance, durability, and safety under realistic indoor conditions.

Keywords:

Indoor air remediation, visible-light photocatalysis, multifunctional coatings, bismuth oxyiodides, passive cooling

Marta Sacristán-Uña
University of Valladolid, Spain

Bio:

PhD student at the University of Valladolid since November 2024, in the Department of Architectural Constructions at the E.T.S. Architecture of Universidad de Valladolid. My research work is focused on building envelope airtightness, air infiltration in buildings, indoor air quality (IAQ), and ventilation strategies.

Presentation Title:

Beyond conventional IAQ metrics: individual Volatile Organic Compounds in Spanish dwellings

Abstract:

Indoor air quality (IAQ) in residential buildings is critical for occupant health, particularly during the winter season, when reduced ventilation rates are common. Conventional IAQ assessments tend to focus on pollutants that can be measured by low-cost sensors, like CO2, HCHO, TVOC, PM's, CO, O3 and NO2. However, other contaminants, which are relevant to human health, have usually been omitted because their study requires less accessible technologies for accurate measurement. Previous initiatives developed by the INDEX and EBC ANNEX 68 projects have studied in depth this kind of compound, but there is still a lack of knowledge about their presence in Spanish dwellings.

A selection of Volatile Organic Compounds (VOCs), which are not usually monitored in residential environments, has been measured, since Spain has not participated in the aforementioned international projects. The selection of VOC compounds (Formaldehyde, Benzene, Naphthalene, Toluene, Xylene, Limonene and α-Pinene) was quantified using a combined technology of Solid-Phase Micro-Extraction coupled with Gas Chromatography and Flame Ionization Detection (SPME-GC-FID) and colorimetric tubes. Measurements were conducted in 29 occupied typical dwellings, considering the number of bedrooms and occupancy patterns.

Among the compounds analysed, Acetone was the most prevalent, detected in approximately 86% of the dwellings. Its concentration distribution was asymmetrical. These peaks were mainly associated with the extensive use of cleaning products and personal care cosmetics, highlighting the strong influence of occupant behaviour on indoor pollution levels. Limonene was also detected in a large proportion of dwellings (~79%) and showed a clear correlation with Acetone. The relatively high

concentrations observed are consistent with its widespread presence in air fresheners, household cleaning products, and detergents.

Overall, the results reveal substantial variability in indoor VOC concentrations. The findings underline the dominant role of domestic sources related to cleanliness and personal hygiene in shaping IAQ in Spanish dwellings. These sources are often overlooked in conventional IAQ assessments. The study therefore suggests that current risk assessment frameworks should place greater emphasis on further occupant-related emission sources, particularly under winter conditions characterised by limited ventilation, which are typical of cold and temperate climates.

Keywords:

Indoor air quality, Volatile organic compounds, Residential buildings, Domestic emission sources

Aurora Monge-Barrio

University of Navarra, Spain

Bio:

PhD Architect and Associate Professor at the School of Architecture at the University of Navarra. Her research interests focus on passive architectural strategies for de-carbonization of buildings, the re-naturalization of buildings and urban environments, and new concepts of thermal envelopes, particularly those, climate adaptive or incorporating transparent PV. Her approach considers the impacts and effects of climate and climate change on the well-being and health of people, especially the most vulnerable, such as the elderly, children, and people living in energy poverty. She has participated in more than 11 research projects at international, national, and regional levels and 4 research contracts with the regional administration. She is the co-author of a book, 25 peer-reviewed indexed articles (18 of them Q1), and more than 25 presentations at international conferences. She has participated in Annex 75 and 86, and in Action Cost TU 1403. Her teaching is related to the construction of building envelopes, and passive strategies for nearly zero-consumption buildings, both in the Architecture degree and in the MDGAE master's degree at the University of Navarra. Actually, she is co-directing the national research project CLIMAREADY+TPV, “Towards a decarbonized and climate-ready architecture. Evaluation of the potential of transparent photovoltaic glass for use in schools and housing” (2024-27), and she is coordinating the Interreg SUDOE project COL3NATUR “Re-naturalization of buildings, playgrounds and school paths for Climate Change Adaptation” (2025-28).

Presentation Title:

Relation of Overheating and IAQ during Heatwaves. Case Studies in two Southern European Locations

Abstract:

Heatwave events are one of the major impacts of Climate Change affecting directly wellbeing and health in the built environment. Natural ventilation remains one of the main strategies to both ensure IAQ and improve night temperatures in the residential stock of Southern Europe, although high temperatures during heatwaves can compromise its effectiveness. In addition, the occurrence of blackouts during these events could directly impact health in the most extreme climates.

This study is based in the monitoring of 23 dwellings in Pamplona and Seville in Spain, encompassing different climate classifications: Cfb and Csa according to Köppen-Geiger classification, and 4A and 3A, according to Ashrae climate classification respectively, being the latter, one of the hottest locations in the Southern Europe. Dwellings were monitored during summer 2022, which remains the year with more days of heatwaves in Spain (41 days during three events, one of them taking place very early in June).

Dwelling selection comprises multifamily buildings constructed under different Spanish Energy Codes, assessing dwellings located in intermediate and top floors, and with different ventilation and cooling strategies. In Pamplona, the coolest location, all dwellings were naturally ventilated although some of them had systems with heat recovery mechanical ventilation (MVHR). On the other hand, in Seville, the hottest location, dwellings were equipped with air conditioning systems (AC) although some of them were also naturally ventilated and others were mechanically ventilated. Main bedroom and living room of each dwelling were monitored (air temperature, relative humidity and CO2 concentration), and overheating was calculated according to UNE EN 16798 standard (IOH, Indoor overheating hours).

Results shown that during heatwaves, the milder location without AC, has the lowest indoor temperatures, but the highest overheating, and the hottest location equipped with AC, has however the highest indoor temperatures but the lowest overheating (due to the different thresholds according to the severity of the climate), and better IAQ. High variability exists among different dwellings even in the same location, due to thermal envelope characteristics, main orientations, shading systems and floor.

In a warming climate with the possibility of blackouts during extreme events as HW, better comprehension of architectonical design and passive strategies to improve resilience in the residential built environment is needed.

Keywords:

Heatwaves, monitoring, blackout, natural ventilation, passive strategies

Bjarne W. Olesen

Technical University of Denmark, Denmark

Bio:

Bjarne W. Olesen, Professor, Ph.D, Dr.H.C., R.1.

Master's degree in civil engineering, 1972. Ph.D., Laboratory of heating and Air Conditioning, Technical University of Denmark, 1975. In the period 1972-1990 Research scientist at the Laboratory of Heating and Air Conditioning. Part time affiliated as product manager at Brüel & Kjaer 1978-1992. Senior Research Scientist, College of Architecture, Virginia Tech. in the period 1992-1993. Since 1993 until January 2004 Head of Research & Development at UPONOR-VELTA GmbH KG & Co., Norderstedt, Germany. Since January 2004 full professor in Indoor Environment & Energy at the Technical University of Denmark and past director of the International Center for Indoor Environment and Energy, Technical University of Denmark. From 2023 Professor Emeritus.

Awarded the Ralph Nevins Award (1982), Distinguish Service Award (1997), Fellow Award (2001) and Exceptional Service Award (2006), Andrew T. Boggs Award (2020), Donald Bahnfleth Environmental Health Award. (2021) from ASHRAE. ASHRAE president 2017/18. Honorary member of AICARR (Italy), SHASE (Japan) and VDI-TGA (Germany). Chivalric Order of Dannebrog, from the Danish Queen (2012) and order of 1. Degree (2023). Doctor Honoris Causa, Slovak University of Technology

Is active in several CEN-ISO. standard committees regarding indoor environment and energy performance of buildings and HVAC systems. Has published more than 600 papers including more than 200 in peer reviewed journals.

Presentation Title 1:

Indoor Environmental Quality-
Revision of standard EN16798-1 in relation to the EPBD guideline

Abstract 1:

EN16798-1/2 specifies the relevant parameters for determining the indoor environmental quality (thermal comfort, air quality, lighting, and acoustic) in buildings and how these parameters are used for building systems, design, assessment, operation, and energy performance calculations. The standard is applicable where the criteria for indoor environmental quality are set for human occupancy and where the production or process does not have a major impact on indoor environmental quality.

Recently, a guideline "Technical building systems, indoor environmental quality and inspections (Articles 13, 23 and 24)" to the recast Energy Performance of Buildings Directive was issued. Related to indoor environmental quality, the guideline focuses on and refers to EN16798-1/2. It is therefore important that the revision makes sure that what is referred to in the existing standard can be found in the revised version. It is also important that the revision of the standard looks at additional requirements for the indoor environment will be included.
According to the directive, 'technical building system' means technical equipment of a building or building unit for space heating, space cooling, ventilation, domestic hot water, built-in lighting, building automation and control, on-site renewable energy generation and energy storage. The standard is system-neutral and deals with input values for the calculation of energy use for heating-cooling, operation of buildings and design of heating, cooling, ventilation, air cleaning, and lighting systems
The standards do not specify design methods but give the relevant input parameters for the design and assessment of buildings, heating, cooling, and ventilation systems, together with building automation and control systems. In addition, it proposes methods for determining the indoor environmental quality and classes for different limit values.
The talk will focus on thermal comfort and indoor air quality, which are also the two minimum topics required according to the EPBD guideline. In the revision, the part of the standard dealing with lighting and acoustics will be extended and developed by the appropriate CEN technical committees.
Topics to be included or extended in the standards are yearly key performance indicators (KPI's) for indoor environmental quality, use of air cleaning to partly substitute for ventilation, use of CO2 as an indicator for ventilation/air quality, ventilation during a pandemic and cross-contamination.

Keywords:

Standards, indoor environmental quality, energy performance directive, technical building systems

Presentation Title 2:

Sustainable cooling in cities- Assessment of human exposure to the outside environment

Abstract 2:

One of the objectives of IEA-EBC Annexe 97 is to establish a comprehensive set of key performance indicators (KPIs) to evaluate the comfort, health, productivity, and safety of people during exposure in cities to the outside environment.
Even if we spend on average about 90% of the time indoors, the outdoor environment is also important for people's health and well-being. Trends like "Tiny-Houses" will increase the need for outdoor areas providing acceptable environments. Most people would like to sit outside at restaurants, cafés, sports events, etc. during the summertime.
Many types of people during different activities are exposed to the outdoor environment. People are exposed during transportation (train, bus, waiting area, platforms), during sports activities (spectators, athletes, leisure exercise), and outside work. (building and road construction, others).
The focus of Annexe 97 is the exposure of people in cities. Here, the cooling of buildings may create a heat island. Buildings may reflect sunshine that may cause glare and increase radiant heat. Building

ventilation and particular emissions from industrial buildings may create unacceptable outdoor conditions regarding smells or particles. Especially under extreme weather conditions, the exposures can be harmful (heat waves, forest fires).

This talk will focus on how to. Evaluate the exposure to people. Other activities of the annexe are dealing with methods to improve the outdoor conditions for people using different methods for cooling, like evaporative cooling at outdoor spaces in dry locations, and shading trees. Or roofing in semi-outdoor spaces.

In literature, most of the KPI's deal with exposure to the thermal environment. There is a need to look at KPI's for other factors like air quality, noise, light, etc. Over 120 years of study of thermal indices exist in the literature. It involves the perspectives of human thermal comfort and stress in both indoor and outdoor environments. The KPIs can be categorised into 3 types of indices: Rational index, Empirical index, and Direct index. The rational indices are based on the human physiological model of heat exchange between the human and the surrounding environment. Empirical indices used a multiple regression model to reflect human responses in each environment and behavioural activity. Direct indices emerge from the previous two types of indices, which are suitable for practical use through instrumental measurements.

The effect of the transient conditions going from inside the conditioned space to outside and vice versa needs evaluation methods. Therefore, multiple KPI's and different threshold values will be needed

Keywords:

Outdoor environment, heat stress, human exposure, shading, evaporative cooling,

Nicholas Paradza
La Rochelle University, France

Bio:

Nicholas Paradza is a Structural/Building Engineer with over five years of experience in structural engineering, sustainable urban development, and infrastructure risk management. His work spans Southern Africa, where he led multidisciplinary teams on residential, commercial, and climate-resilient infrastructure projects.

He earned his B.Sc. in Civil Engineering from Cyprus International University in 2019. He later completed his M.Sc. in Built Environment: Environmental Design and Engineering at University College London in 2024, focusing on building energy modelling, HVAC design, net-zero buildings, smart infrastructure, and sustainable urban planning. In 2024, he joined the ERASMUS+ EU NORISK programme, pursuing dual European Master's degrees at the University of Minho (Portugal) and the University of La Rochelle (France). The programme was centred on risk assessment, digital twins, BIM, non-destructive testing, and the use of AI and machine learning to support climate-resilient infrastructure.

He is currently doing his PhD with La Rochelle University in France focusing on building resiliency and risk assessment methods development for heatwave and climate change in France. His professional interests include building energy performance, climate adaptation, climate risk assessment, and developing sustainable, resilient infrastructure systems.

Presentation Title:

Linking Indoor Overheating and Mortality: A Risk-Based Assessment of Heatwave Impacts on Buildings and Occupants

Abstract:

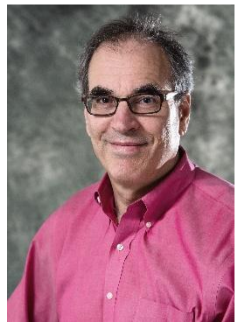
Climate change is driving an unprecedented increase in the frequency, duration, and intensity of heatwaves across Europe, transforming indoor overheating from a matter of thermal discomfort into a critical public health emergency. In Metropolitan France, recent summers have shown that the built environment is a primary modifier of heat exposure. Yet, current adaptation strategies often prioritise winter energy efficiency over summer health resilience. This research bridges the disciplinary gap between building physics and epidemiology to propose a novel, quantitative risk assessment framework. The study defines heatwave risk through the integration of three probabilistic components:

hazard (climate exposure), vulnerability (building performance), and impact (mortality outcomes). This study utilises a comprehensive dataset covering Metropolitan France, combining daily average temperature with daily mortality data (2019–2024). The hazard component is determined by calculating the probability that outdoor temperatures exceed the Minimum Mortality Temperature (MMT). To quantify impact, the study employs Distributed Lag Non-Linear Models (DLNM) with a quasi-Poisson regression. This epidemiological approach captures the complex, delayed health effects of heat, revealing that mortality risks persist for up to 21 days post-exposure. For the vulnerability assessment, dynamic thermal simulations (EnergyPlus) were conducted on five representative residential archetypes classified by construction period (i.e., 1950, 1982, 2005, 2012, and 2020), under free-floating conditions. Logistic regression was applied to these simulation outputs to generate fragility curves, representing the probability of indoor temperatures exceeding health-critical thresholds (26 °C night/28 °C Day) for three consecutive days. The results showed that older, uninsulated masonry buildings (1950) are often considered thermally poor, but they perform comparatively better during heatwaves due to higher thermal mass and envelope permeability. In contrast, modern, highly insulated, and airtight buildings (RT2012 and RE2020 standards) exhibit a "heat-trapping" effect. The study found that occupants in RE2020-compliant dwellings face a heat-attributable mortality risk of 0.9%, nearly double the 0.53% risk observed for 1950s typologies, highlighting a severe trade-off between energy conservation and summer health safety. Furthermore, the risk matrix analysis identifies that the highest cumulative mortality burden is not driven by rare, extreme peaks (> 32 °C), but by frequent, moderate heat events (28 -30 °C). These temperatures occur often enough to generate substantial cumulative physiological stress yet are frequently overlooked in emergency planning. This research provides a scalable, risk-based metric, Attributable Risk (AR), that empowers policymakers to move beyond simple temperature thresholds. The findings advocate for an urgent revision of building codes to include mandatory summer performance certificates and passive cooling requirements. By quantifying the lethal potential of indoor overheating in energy-efficient housing, this framework offers a vital decision-making tool for urban planners seeking to align decarbonization goals with the preservation of human health in a warming climate.

Keywords:

Indoor Overheating, Heatwave Mortality Risk, Building Vulnerability, Attributable Fraction, Fragility Curves

Andrew Persily
NIST, USA



Bio:

Dr. Andrew Persily is retired from the U.S. National Institute of Standards and Technology (NIST), where he held the position of Fellow and previously served as Chief of the Energy and Environment Division. He worked at NIST for more than four decades after earning a Ph.D. in Mechanical and Aerospace Engineering from Princeton University. His research focused on indoor air quality and ventilation in commercial and residential buildings, including the development and application of measurement techniques to evaluate airflow and indoor air quality performance and of multi-zone airflow and contaminant dispersal models. He has published more than 300 journal articles, conference papers and NIST reports. Dr. Persily was a vice-president of ASHRAE from 2007 to 2009, and is past chair of ASHRAE Standard 62.1 (Ventilation for Acceptable Indoor Air Quality) and Standard 189.1 (Design of High-Performance Green Buildings). He is a Fellow of ASHRAE, ASTM and ISIAQ, and recipient of the NIST Bronze, Silver and Gold medals

Presentation Title:

A Review and Discussion of Indoor Environmental Resilience: An Update since 2015

Abstract:

In 2015, under a NIST effort to develop planning guidance to increase community-based resilience in the face of a broad range of natural disasters and other extreme events, we conducted a review of the potential indoor environmental quality (IEQ) impacts of such events. These impacts included primarily increases in indoor airborne contaminant levels and health risks as well as challenges in maintaining acceptable indoor environmental conditions during the event and afterwards in the recovery phase. At that time, it was noted that the elements of what we then referred to as indoor environmental resilience had not been identified and discussed in a systematic fashion. That 2015 effort, organized by type of event, reviewed existing information, standards, programs and other technical resources related to events that are likely to impact IEQ, focusing on the potential impacts, current activities to address these impacts, important gaps requiring research, and needs for standards and guidance.

The 2015 review included the following types of events: heat waves, storms causing power failures, floods and mold exposure, wildfires, and airborne releases of chemical, biological or radiological agents. The review also addressed pandemics, but only in terms of the role of healthcare facilities, as well as indoor environmental conditions in safe rooms and shelter-in-place facilities. In both cases, these two additional topics were only covered to a limited degree. Since 2015, the need to address pandemic response and impacts increased greatly as a result of the COVID-19 pandemic. The need to address wildfires also increased significantly due to their increased frequency and the widespread impact of wildfire smoke in the past decade.

This presentation will summarize the earlier effort and describe key updates since 2015 in the status of the technical resources, standards, research needs, and needs for new standards and guidance for the events covered previously. There will be expanded information related to airborne infectious disease and wildfires based on the events, trends and lessons learned over the past 10 years.

Keywords:

extreme events, hazards, indoor environmental quality, resilience, risk

Anna Laura Pisello
University of Perugia, Italy

Bio:

Anna Laura Pisello is a Professor of Building Physics and Energy Systems at the University of Perugia, Italy, and the founder of the EAPLAB (Environmental Applied Physics Lab), and concurrently holds the position of Visiting Research Associate at Princeton University (NJ, USA) since 2018.

Dr. Pisello earned her Bachelor's degree with honors in Building Engineering from the Polytechnic University of Milan in 2009 and went on to achieve her Ph.D. in Energy Engineering from the University of Perugia in 2013 with a visiting scholar at Columbia University, Virginia Tech, and City University of New York.

Dr. Pisello's academic contributions are shown through her authorship of over 250 international refereed journal papers and the receipt of 10 prestigious international academic awards, including the title of Best Editor of the Year 2023 of Solar Energy (Elsevier). She actively engages with prominent academic journals, holding editorial roles in Solar Energy (Elsevier), Energy and Buildings (Elsevier), Energy Research and Social Science (Elsevier), and Nature Scientific Reports, among others.

As an educator, Dr. Pisello coordinates the teaching board of the Doctorate School of Energy and Sustainable Development, where she guides numerous Ph.D. students. She gives lectures on Building Physics, Energy Systems, and Renewables at the University of Perugia, and has played a pivotal role as a co-advisor for more than 50 master's theses in Building/Civil and Mechanical Engineering in this same university, among others in Italy and abroad.

Dr. Pisello leads several Horizon 2020 grants, two Marie Curie Doctoral Network projects, and is the Principal Investigator of the ERC Starting Grant HELIOS, focusing on radiative cooling to combat urban overheating.

Dr. Pisello's research interests revolve around two key areas that complement each other through a human-centric multidisciplinary vision and approach. First, she explores innovative smart materials to optimize multifunctionality and conduct thermo-physics characterization of building-to-urban envelopes. Second, she delves into the study of indoor-outdoor microclimates, focusing on environmental comfort and energy conservation, particularly in dense urban areas and for enhancing city resilience to climate change.

Presentation Title:

Multisensory Outdoor Environmental Study for Enhancing Urban Population Resilience to Climate

Abstract:

Climate adaptation requires a fundamental shift from single-domain thermal interventions to integrated multisensory approaches that reflect the actual complexity of human-environment interactions. While indoor laboratory studies have provided valuable insights into multisensory integration, their controlled conditions often lack the ecological validity needed for outdoor urban applications, where dynamic environmental fluctuations, circadian rhythms, safety perception, and contextual factors fundamentally shape human responses. This workshop introduces a research framework advancing urban resilience through multiscale integration—from materials and inter-building microclimates to neighborhood and city-regional configurations—multidomain environmental assessment across thermal, acoustic, air quality, and visual conditions, and multisensory human-centered solutions validated in authentic urban environments. The framework establishes how environmental stimuli activate both material responses and human physiological adaptation across scales. Photoluminescent compounds demonstrate domain-specific activation patterns under varied lighting spectra, while synchronized physiological-environmental monitoring reveals that multidomain models substantially outperform single-domain approaches in predicting human stress. Integrated monitoring strategies combining fixed stations, mobile and wearable sensing, and crowdsourced data capture spatiotemporal environmental variations and authentic human perceptions. Critically, individuals exhibit heterogeneous resilience to identical conditions, operationalized through quantifiable adaptation metrics that challenge demographic vulnerability assumptions. Temporal investigations further reveal that safety perception and circadian rhythms produce distinct urban chronotypes—contexts where specific environmental domains dominate response patterns and interventions achieve maximum effectiveness. These insights converge in the Multisensory Urban Climate Zones framework, extending traditional morphology-based classification by overlaying dynamic anthropogenic indicators with static urban form. The framework identifies adaptation zones through spatial analysis of domain-specific sensitivities and temporal dynamics, demonstrating that human activity patterns—more adaptable than fixed urban form—offer practical intervention pathways validated through actual physiological responses rather than theoretical assumptions. By bridging individual sensing to neighbourhood-scale resilience planning across the full spectrum of environmental exposures, this approach provides actionable intelligence for climate-responsive urban design that enhances population wellbeing in our changing climate.

Keywords:

multisensory urban design, climate adaptation, multidomain environmental assessment, human resilience, urban climate zones

Manuel Ruiz de Adana

University of Cordoba, Spain

Bio:

Full Professor with +30 years of experience in thermal engineering, advanced HVAC systems and Indoor Air Quality. Specialist in hybrid and evaporative cooling technologies, experimental performance assessment and technology transfer to the HVACR industry.

Presentation Title 1:

Personal exposure to exhaled contaminants using a personalised exhaust system integrated in a hospital bed

Abstract 1:

The control of airborne contaminants in hospital rooms is a critical requirement for ventilation engineering, particularly when exhaled aerosols interact with complex indoor flow structures. This study evaluated the effectiveness of two general ventilation strategies combined with a personalised extraction system (PES) integrated into a hospital bed.

Experiments were carried out in a mechanically ventilated full-scale chamber using two breathing thermal manikins configured as a contaminant source (patient) and a receiver (healthcare worker). Both operated under controlled respiratory boundary conditions, enabling quantification of particle concentration in the macroenvironment and in the microenvironment corresponding to the healthcare worker's breathing zone. Two ventilation configurations -upper–upper (UG–UG) and upper–lower (UG–LG)- were tested. The PES was installed either at the head or at the foot of the bed, enabling assessment of positional effects on personal exposure reduction.

Without PES assistance, UG–UG produced the highest exposure due to persistent recirculation cells that favoured re-entrainment of the exhaled plume, whereas UG–LG achieved lower background concentrations through a more efficient supply-to-exhaust flow path. Activation of the PES generated substantial exposure reductions in both ventilation regimes. In UG–UG, the PES decreased macroenvironment concentrations by 32–36% and microenvironment levels by 31–33%, demonstrating its capacity to disrupt the coupling between the buoyant exhaled jet and the coherent recirculation structures that dominate the room flow field. In UG–LG, where baseline exposure was lower, the PES

achieved additional reductions of 8–13% in the macroenvironment and 8–17% in the microenvironment.
PES positioning exhibited a dominant influence on personal exposure. Locating the extraction at the foot of the bed consistently yielded the highest performance, with microenvironment reductions reaching up to 33%, compared with 17% when installed at the head. This behaviour is attributed to the earlier and more stable interception of the exhaled jet enabled by the foot end configuration, allowing its capture before dispersion and subsequent entrainment into the healthcare worker's inhalation flow.
These findings confirm that hospital bed-integrated local exhaust constitutes an effective personalised environmental control measure capable of reducing near-field exposure beyond what is achievable with general ventilation alone, supporting its integration into resilient ventilation strategies for airborne infection control.

Keywords:

Personalised exhaust system, hospital airborne exposure, breathing thermal manikins, contaminant dispersion control, ventilation effectiveness

Presentation Title 2:

Climate-resilient ventilative cooling: experimental performance of a renewable hybrid air-cooling technology under heatwave conditions

Abstract 2:

Building cooling demand is rapidly intensifying across Southern Europe due to the increasing frequency, duration and severity of heatwaves associated with climate change scenario. This trend is placing unprecedented pressure on conventional mechanical-compression systems, which typically experience reduced efficiency and capacity under high outdoor air temperatures and humidity, while relying heavily on synthetic refrigerants with high global warming potential. In this context, energy-efficient, low-emission and climate-resilient cooling alternatives are urgently needed to support thermal comfort and public health in future urban environments.
This study presents an experimental investigation of a renewable ventilative cooling technology based exclusively on 100% outdoor air and a hybrid desiccant–dew-point cooling process, enabling independent control of supply air temperature and humidity without refrigerants. This hybrid system comprises a desiccant wheel for moisture removal control and a dew-point indirect evaporative cooler for high-efficiency sensible cooling. An 11-week experimental campaign was carried out during summer 2022 in Córdoba, Southern Spain, including 30 representative "summer" and "heatwave" days identified from historical climate percentiles. Instantaneous behaviour and seasonal performance were evaluated in terms of thermal and electrical energy balances, supply air conditions and water consumption.
Results demonstrate stable supply air temperatures of 16–20°C even when outdoor air exceeded 40°C. Under severe heatwave conditions, total cooling capacities reached 421.6 MJ/day, with peak sensible and latent cooling energies of 314.4 MJ/day and 134.6 MJ/day, respectively. The system achieved daily coefficient of performance values up to 15.6 due to low electricity demand, while water consumption

remained moderate, with water-to-cooling ratios up to 1.85 MJ/l. Unlike conventional air-conditioning, its performance improved precisely under the most extreme climatic stress. These findings highlight the potential of hybrid desiccant–evaporative ventilative cooling as a robust, scalable and climate-adaptive strategy for sustainable building climate control in Mediterranean and arid regions. The results provide valuable insight for engineers and policymakers working towards low-carbon resilient cooling strategies aligned with EU climate targets.

Keywords:

ventilative cooling, desiccant-based air conditioning, dew-point evaporative cooling, heatwave resilience, renewable cooling

Julie Soriano
CETIAT, France

Bio:

Julie Soriano works in CETIAT in Lyon (France) in topics related to CO2 sensors testing and ventilation since September 2024.

Between 2020 and 2024, she has been working in the field of urban climate modelisation, with a PhD at CETHIL and LMFA in Lyon, followed by a post-doctoral study at CETHIL. Her work consisted in the development of a physics-based model in python named MATHIS for Microscale Atmospheric Temperature Heat Island Simulation.

Between 2018 and 2020, she worked at Cylergie Engie Lab as research engineer on an experimental bench designed to test wood ashes as air pollutant filters.

In 2018, she was graduated from the INSA of Lyon in the field of energy and environment engineer.

Presentation Title:

Assessment of low-cost CO2 sensors performance for smart ventilation

Abstract:

To minimize the energy consumption of buildings while maintaining good Indoor Air Quality (IAQ), smart ventilation is an area of growing interest, enhanced in Europe by the directive EPBD (EU) 2024/1275 and the Ecodesign regulation 1253/2014. In this context, the use of low-cost CO2 sensors to control ventilation systems is increasing, which makes it necessary on one hand to understand better the strengths and weaknesses of these sensors and on the other hand to dispose of an adequate and reproduceable method to assess the performance of these sensors.

Several scientific research studies already evaluate CO2 sensors. However, they often either compare a small number of CO2 sensors or use test methods that are not thought to be reproduceable.

This contribution presents a study that performs laboratory tests on six models of low-cost air quality CO2 sensors, pursuing two objectives:

- Propose a test method suitable for routine assessment, which could support the standardisation processes currently ongoing in Europe on this matter (CEN\TC 247).
- Identify some strengths and weaknesses of these sensors for ventilation control.

First, a test bench for CO2 sensors was developed allowing to control the reference CO2 concentration, humidity and air temperature in a test chamber. To control CO2 concentration and humidity, thermal mass flowmeters are used to regulate the flow in multiple lines that mix before the test chamber. The control of temperature is achieved through thermal conditioning of the test chamber. Before going further, a validation of the test bench was conducted.

Then, six different models of CO2 low-cost sensors were selected, with a sample of three sensors for each model, resulting of a total of 18 sensors tested. Among the sensors, a wide range of prices were chosen from 8 euros to 60 euros and three different technologies are represented: Non-Dispersive Infrared Radiation (NDIR) single channel, NDIR dual channel and Photoacoustic Spectroscopy (PAS).

The testing protocol is conceived in two phases: first conducting broad testing and secondly proposing a routine test method. In the first phase of the testing, the influence of air humidity and air temperature is evaluated. Moreover, the drift in time should also be evaluated with long-term tests. In the second phase, the analysis of the results will be exploited to choose the appropriate tests for a routine assessment.

As a perspective, this study could be extended in the future to VOCs sensors, which are also used occasionally for ventilation control.

Keywords:

CO2, low-cost sensors, laboratory test, NDIR, photoacoustic spectroscopy, smart ventilation

Lula Timmerman

Federal Public Service Health, Belgium

Bio:

Lula Timmerman holds a master's in science in Bioengineering (Ir, Msc) and began her professional career in an operational enforcement role within chemical inspection, where she gained hands-on experience with regulatory compliance, risk assessment, and implementation in the field.

She later transitioned into a policy advisory role within the Federal Public Service (FPS) Health, Food Chain Safety and Environment of Belgium. She is currently the lead technical expert, working on the development and implementation of indoor air quality (IAQ) policies aimed at protecting public health. Her work focuses on translating scientific evidence into effective regulatory and operational frameworks, with particular attention to ventilation strategies, IAQ monitoring, and indoor air quality management in enclosed and publicly accessible environments.

In addition to her national policy role, she is a member of the Board of the Air Infiltration and Ventilation Centre (AIVC) since 2025.

Presentation Title:

From Law to Public Health Impact: Implementing the Belgian Framework for Improving Indoor Air Quality in Public Places

Abstract:

Indoor air quality is recognised as a key determinant of public health, given that people spend the majority of their time in indoor environments. In response to growing scientific evidence on the adverse health effects of indoor air pollution, and informed by insights gained during the coronavirus pandemic, Belgium adopted the Law of 6 November 2022 aimed at improving indoor air quality in public places. This legislation establishes a preventive public health framework designed to reduce exposure to indoor air pollutants and to protect the population's health.

The law introduces a structured and progressive approach to indoor air quality management in publicly accessible spaces. It is based on risk assessment, monitoring, transparency, and continuous improvement. Operators of public places are required to assess indoor air quality, implement appropriate mitigation measures when necessary, and inform users about the air quality status of their

premises. Reference indicators are used to support these assessments and to guide corrective actions, ensuring a consistent and comparable approach across different types of public spaces.

A central element of the legislation is the development of a health-based norm for indoor air quality. This norm is being established on the basis of the best available scientific evidence and aims to translate complex health data into clear, actionable criteria for policy implementation, inspection, and enforcement. By grounding regulatory requirements in health protection objectives, the law explicitly links indoor air quality management to broader public health and prevention strategies.

The implementation of the law has highlighted several challenges. At the political level, coordination between different authorities and stakeholders is required due to the distribution of competences. From a scientific perspective, difficulties arise in converting evolving and sometimes uncertain evidence into stable regulatory thresholds. In addition, public understanding and acceptance of indoor air quality measures require clear communication and awareness-raising, as indoor air pollution is often less visible than other environmental health risks.

The legislation provides for ongoing evaluation and future development. Planned actions include further refinement of the health-based norm, strengthening data collection and monitoring, building capacity among operators and inspectors, and enhancing public communication. Overall, the Law of 6 November 2022 establishes a comprehensive and preventive framework that integrates indoor air quality into public health policy, with the long-term objective of improving indoor environments and safeguarding population health

Keywords:

Indoor air quality, Public health policy, Health-based standards, Indoor air regulation, Certification of indoor air

Borja Frutos Vázquez

Eduardo Torroja Institute for Construction Science (IETCC), Spain

Bio:

Borja Frutos Vázquez is Head of the Research Group Building Systems and Habitability at the Eduardo Torroja Institute (IETcc-CSIC). His research addresses building habitability, energy efficiency, and indoor environmental quality—particularly radon contamination—within a sustainability framework. He initiated radon research in the architectural field in Spain in 2002, consolidating this line through his PhD, and has since contributed to studies published in journals and books, as well as presentations at international conferences.

His work has fostered collaborations with leading institutions such as the University of Galway, CSTB-France, and ENBRI networks. He co-founded the European Radon Association (ERA) and launched RadonArt S.L., a spin-off dedicated to radon mitigation. Borja has also led projects on radon in heritage buildings, including the Santiago de Compostela Cathedral and the Tower of Hercules.

Beyond research, he has held leadership roles as Technical Deputy Director of the Institute (2014–2018) and currently serves as Advisor to the Directorate. He is an evaluator, editorial board member, and active participant in scientific committees, contributing to the advancement of sustainable and healthy building practices.

Presentation Title:

Radon Exhalation from Structural Walls in Heritage Buildings: Health Risks and Innovative Monitoring Approaches

Abstract:

The presence of radon in historic buildings represents an emerging challenge for both public health and heritage preservation. Recent studies have shown that, in these constructions, the main source of radon is not only the ground but also the building materials that make up their walls, typically granite with high structural mass. This condition leads to high radon exhalation rates, resulting in elevated indoor concentrations and posing a significant risk to occupants such as faculty, students, administrative staff, museum guides, and tourists. Furthermore, the architectural nature and heritage protection of these buildings complicate the application of conventional mitigation techniques.

The authors have documented this issue in emblematic cases such as the Tower of Hercules (A Coruña), the Cathedral and several university buildings in Santiago de Compostela, as well as historic constructions located in the Sierra de Madrid. Recorded radon exhalation rates range between 150–250 Bq/m²·h, values that are two orders of magnitude higher than those observed in conventional building materials and comparable to soils with high natural radon concentrations.

To address this challenge, the RADIANT project (Radon Assessment and monitoring using robotics, Digitization, and Artificial Intelligence techNologies in heriTage buildings, PID2024-159276OB-C41), funded under the Spanish Research Plan, is being developed. In its initial phase, the project investigates experimental methodologies for measuring wall exhalation using specific chambers and associated gamma radiation detection. Complementarily, simulation models are being implemented in COMSOL Multiphysics to analyze radon behavior in different construction configurations. Once calibrated with experimental data obtained from demonstrator buildings, these models will be used to evaluate mitigation strategies tailored to the identified source and compatible with the high level of architectural protection of these structures.

Preliminary results lay the groundwork for developing non-invasive measurement protocols and the future integration of digital, robotic, and artificial intelligence technologies in radon monitoring within heritage buildings, contributing to both health protection and the conservation of architectural heritage.

Keywords:

Radon exhalation, Heritage buildings, Health risk, Simulation

Jensen Zhang
Syracuse University, USA

Bio:

Dr. Jianshun “Jensen” Zhang is Professor and Interim Department Chair of Mechanical and Aerospace Engineering and Executive Director of SyracuseCoE at Syracuse University (SU), New York, USA. He received his BS and MS from China University of Agriculture in 1982 and 1985, respectively, and his Ph.D. from University of Illinois at Urbana-Champaign (UIUC) in 1991. Prior to his Ph.D. study at UIUC, he spent a year as a visiting scholar at University of Minnesota, Minneapolis-St. Paul. After his Ph.D. study, he had worked as a researcher at National Research Council of Canada for 8 years before joining SU in November 1999. Dr. Zhang is an expert in room air and contaminant distribution, material emissions, air purification, building enclosure performance, and combined heat, air, moisture, and pollutant simulations (CHAMPS) for integrative design and intelligent controls of buildings. He has authored/co-authored over 200 technical papers, 3 American national standards and 3 book chapters. He is Editor in Chief of the International Journal of Ventilation, Associate Editor of Science and Technology for the Built Environment, and a Member of the Editorial Boards of Building Simulations—an international Journal. He served as the US Expert to IEA EBC Annex 20, 68, 78, 86 and 92, and was co-founder of the CHAMPS Collaborative. He was conference Chairman for IAQVEC 2010—7th International Conference on Indoor Air Quality, Ventilation and Energy Conservation in Buildings and IBPC 2018—7th International Building Physics Conference. He served as President of the International Association of Building Physics from 2018 to 2021 and is a Vice President of IAQVEC Association. He also chaired ASHRAE TC 4.10 Indoor Environmental Modeling (1997-1999) and the ASHRAE Environmental Health Committee (2011-2012). He is Fellow of ASHRAE and ISIAQ.

Presentation Title:

Personal Environmental Control Systems: Occupant-system interactions and impact on cognitive performance

Abstract:

Personal environmental control systems (PECS) allow office occupants to regulate their immediate environment, yet there remains a limited understanding of how users interact with such systems under changing thermal conditions. This study aimed to investigate how occupants respond to different room temperatures and a gradual decrease in temperature during winter months. The experiments were conducted in a full-scale office laboratory consisting of 12 workstations, each equipped with a PECS that provided desk cooling, desk heating, floor heating, and adjustable fan speeds. Before the test day, participants received comprehensive training on how to operate the PECS. During the experiment, participants were allowed to freely adjust the PECS settings, thereby simulating realistic office conditions. The tests' temperatures ranged from 74°F to 78°F. Each test consisted of two sessions. During the first session, room temperature was maintained at 74°F for 40 minutes. It was followed by a 30-minute transition to 78°F room temperature when the second session began and lasted 40 minutes at 78°F. Data on PECS settings and environmental conditions were continuously recorded. During each session, participants completed a series of cognitive tasks assessing learning, memory, attention, perception, mathematical reasoning, and divergent thinking. When the room ambient temperature was 74°F, 78.5% of participants chose to use the PECS, with an average usage time of 31.4 minutes. This proportion increased to 93.9% at 78°F, with the average usage time extending to 37.6 minutes. Most participants preferred the desk cooling function, and average fan speed selections showed little variation between the two ambient temperature conditions. The results reveal how occupants adapt to temperature changes through different control strategies, indicate preferences for specific functions in warmer environments, and demonstrate the impact of these adaptations on cognitive performance. Furthermore, the cognitive performance data enable the identification of optimal temperature ranges for maximizing occupant productivity. These findings provide new insights into the interaction between occupants and PECS, which can inform the design of systems that are more practical, energy-efficient, and responsive to user comfort while improving work performance.

Keywords:

Personalized environmental control systems (PECS), Floor Heating, Desk Heating/Cooling, Cognitive Performance

Michele Zinzi

ENEA, Italy

Bio:

Michele Zinzi received his degree in Civil Engineering and his PhD in Energetics from La Sapienza University of Rome, Italy. He is senior researcher at ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, since 2020, and he holds the national scientific qualification as full professor in Applied Physics. Interests and research activities regard: high-performance energy buildings, materials and components for the building envelope, innovative solutions for the indoor environmental quality, analysis and mitigation of urban heat island. He was scientific responsible for ENEA in many national and EU Projects. He has authored or co-authored more than 150 publications in technical and scientific journals and conference proceedings, he was also co-guest editor in several special issues for scientific journals. He is the Executive Committee member of the IEA-Energy in Building ad Communities Programme for Italy and board member of the Air Infiltration and Ventilation Centre of IEA-EBC. He serves as associate editor in the Energy and Buildings Journal (Elsevier) and is part of the Editorial board of the Building and Environment (Elsevier) and Climate (MDPI) Journals.

Presentation Title:

On the energy and environmental assessment of PECS in office buildings. Findings from Italian Living Labs experience

Abstract:

Personalized environmental comfort systems (PECS) represent a promising solution to simultaneously enhance occupants' comfort conditions and reduce the building energy consumption. Despite the concept dates to several decades, interest in PECS has increased significantly in recent years, particularly following the activities carried out within the Annex 87 - Energy and Indoor Environmental Quality Performance of PECS framework, an international project developed within the IEA Energy in Buildings and Communities Programme.

PECS can address multiple indoor environmental domains; however, this study focuses on convective PECS for thermal comfort enhancement and energy-saving strategies during heating and cooling seasons. The experimentation was conducted in two Living Labs in central Italy, namely in Perugia (LL1) and Rome (LL2) during January and July 2025, through the energy and environmental monitoring. The main objective was to assess whether, and to what extent, PECS may reduce or replace conventional

heating and cooling systems. Three distinct operational scenarios were identified: (i) cooling/heating systems operating under standard conditions, (ii) PECS operating as replacement for conventional systems, (iii) PECS integrated with conventional systems operated under relaxed set-points (28°C instead of 26° and 20°C instead of 22°C in summer and winter, respectively). The winter PECS consisted of a 370W constant power fan heater, with adjustable set-point through a knob by the user; while the summer PECS was an evaporative fan cooler (40W peak power), also operable as a standard fan if no water was used.
Indoor environmental quality and user acceptance were assessed through surveys completed by more than 22 participants, designed in accordance with validate questionnaire to evaluate sensation, satisfaction and preference. Beside the environmental quality, participants also provided qualitative feedback on their experience with the PECS technology. PECS energy consumption was monitored using smart metering plugs connected to the building grid, while the energy use of conventional systems was directly measured in LL2 and estimated in LL1 based on set-point changes and associated calculations. Results indicate that PECS cannot realistically replace conventional heating and cooling systems, at least in the tested environments. However, PECS proved effective when integrated with conventional room systems operating at relaxed set-points, as confirmed by users' feedback. In this configuration, PECS demonstrated potential energy savings during the cooling season due to their low power demand. Conversely, winter results were mixed, reflecting the low energy demand of both Living Labs and the relatively high-power absorption of fan heaters. Overall, the results highlight the energy-saving potential of PECS, while emphasizing the need for further development of low-energy PECS technologies to maximize their effectiveness.

Keywords:

Personalized environmental comfort systems (PECS), Living Lab, energy monitoring, indoor environmental quality, users' acceptance