Over 160 persons attended the joint '33rd AIVC Conference' and '2nd TightVent Conference' in Copenhagen, on 10-11 October, 2012.

Summary of the AIVC-TightVent Conference 2012

Optimising Ventilative Cooling and Airtightness for Nearly Zero-Energy Buildings, IAQ and Comfort

The conference focused on ventilation and infiltration in nearly zero-energy buildings and more particularly on challenges and perspectives for ventilative cooling (the use of ventilation systems to cool indoor spaces), on the rationale and solutions for better building and ductwork airtightness, as well as on developments of ventilation requirements based on health. The programme included presentations of invited world-renowned and key experts as well as 75 papers selected from the call for abstracts for long- and short-oral presentations.

The conference was organized by the International Network on Ventilation and Energy Performance (INIVE) on behalf of the Air Infiltration and Ventilation Centre (AIVC) and TightVent Europe (the Building and Ductwork Airtightness Platform) with support from the VELUX group.

Per Heiselberg, **Willem de Gids**, and **Arnold Janssens** give here below a summary of the three tracks.

Visit www.aivc.org or www.tightvent.eu for additional information.

Next AIVC conference will be in Athens, Greece, 25–26 September 2013. It will be organised in conjunction with the 1st Venticool conference and the 3rd TightVent conference. More information will be soon available at www.aivc.org

Ventilation and Health track

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The ventilation and health related presentations and papers on the 33rd AIVC conference were very interesting. We could learn a lot from these papers. Many were presented results of international projects/initiatives such as:

- HealthVent "Health-Based Ventilation Guidelines for Europe"
- IAIAQ "Promoting actions for healthy indoor air"
- EnVie "Co-ordination Action on Indoor Air Quality and Health Effects"
- "Health and comfort in highly energy efficient buildings" Clear Up "Clear and resource efficient buildings for real life"

This summary synthesizes the papers and describes what we can learn from them. It is not a classic overview of papers but more a vision paper for future developments.

Why we ventilate?

Ventilation is often seen as the ultimate solution to all kind of indoor air quality problems. However ventilation is not a panacea for all indoor air quality problems: "just a little bit more ventilation and all problems are gone" does not always work. It is very clear that ventilation plays an important role in the control of a healthy environment in buildings. But to understand when, where and how much ventilation is a necessity is a question which is not easy to answer.

Let's first of all look to the functions and effects of ventilation:

- Supply of oxygen for breathing to survive in buildings
- Minimize exposure to hazardous contaminants to reduce health risks
- Minimize the nuisance of odors due to bio effluents to control comfort
- Dilution and transport of moisture to prevent from damp problems
- Creation of an environment in which people can perform in a optimal way
- Creation of an environment in which people feel thermally comfortable

The supply of oxygen, although an absolute necessity, is not an issue in buildings with the normally realized ventilation levels. On the other hand, ventilation can significantly affect comfort, health risks, damp problems and performance of people in buildings.

Health, comfort and performance are the key aspects for ventilation.

In the built environment the existence of ventilation is in most cases based on dilution and mixing processes. However, removing the unavoidable pollutant by local extraction is of course more effective. Displacement ventilation is the most effective mechanism to control ventilation flow and prevent from spreading of pollutants. Engineers often try to apply this so called "piston flow" mechanism, because of its effectiveness. But in practice due to disturbances, for instance, moving people and buoyancy driven flows, it is difficult to maintain and realize the flow patterns we had in mind during the design process.

In the Ventilation and Health track, there were sessions organized around Health and Demand Controlled Ventilation (DCV). Sometimes the results of the studies presented seem to conflict with each other. But analyzing the results more carefully, the conclusion appeared to be that the results of the studies were more complementary than conflicting. The main reason for this is the time frame which was considered in the studies, for instance short term exposure (a few hours) versus long term exposure (a few years)

Most important pollutants indoors

From the most leading international studies, it looks like that the main important pollutants which effect our health indoors are:

1. tobacco smoke (ETS)
2. ultra fine particles (UFP)
3. acrolein (unsaturated aldehyde)
4. formaldehyde
5. benzene
6. naphthalene
7. carbon tetra chloride
8. NOx
9. ozone
10. radon

For all these pollutants the general rule is: control the source therefore minimize their presence in the indoor environment. Only for that part of these pollutants which can be considered as unavoidable the exposure can be minimized with ventilation means.

ETS can be seen as an avoidable source in some buildings, while for instance radon should be minimized in most cases by special measures and not specifically and only by ventilation.

Carbon dioxide (CO_2) is not mentioned as an important pollutant at all, because it is a marker for bio-effluents of people. The level of CO_2 can be related to nuisance of odor. This was established since Pettenkofer in 1860 the basis for almost all ventilation requirements in buildings. Later Yaglou, Cain and Fanger were underlying this "odor nuisance driven" ventilation approach. Odor nuisance has not much to do with health, it is comfort driven.

There are also recent studies indicating that CO_2 itself might of influence to the cognitive performance of people. In case the performance of people is the most important parameter in rooms such as classrooms, lecture-rooms and even in some cases offices, CO_2 levels should determine more the ventilation level than nuisance and/or comfort.

When is ventilation needed and at what level?

This question is most important when discussing demand controlled ventilation. The only answer can be: It depends on the specific effect you are ventilating for on the place of consideration. The important question is:

"What determines the ventilation flow at a certain moment on a certain or specific place?"

For short term health effects for instance due to exposure of formaldehyde, which cause eye and throat irritations an immediate level of ventilation is required. For long term health effects (exposure during years) such as long term exposure to formaldehyde at very low concentration a yearly average ventilation of a certain ventilation level may the answer. Looking at moisture behavior in buildings, the processes of condensation, absorption, desorption and evaporation in relation to building fabric and furniture are typically processes of a number of hours so that diurnal average ventilation might be sufficient.

Looking into the performance of people in most cases again an immediate level of ventilation is required to perform well.

The time frame, the moment, the reason why one will ventilate gives the answer to the question what is the dominant pollutant at a certain moment on a certain place. Demand controlled ventilation in future should develop its control algorithms and control sensors in line with this view. In the field of CO_2 and VOC sensor control, some papers indicate that much progress has been made over the last years on sensor technology and sensor development.

Disability Adjusted Life Years

Many studies in this 33rd AIVC conference have tried to find a single expression of the effect ventilation might have on health. More and more common becomes the expression DALY, Disability Adjusted Life-Years. The DALY is more and more used as an indicator for health. It combines in fact three aspects:

- life expectancy
- quality of life
- number of people effected

With the aid of the metric DALY, all kind of decision can be made more objectively also in combination with cost on the basis of cost effectiveness.

Several speakers reported that, only for Europe, around 2.2 million DALYs/year are related to the indoor air quality in buildings. We can make progress in minimizing this problem by controlling the indoor air quality. Ventilation may contribute to that in a significant way in case we find effective solutions.

Ventilative Cooling track

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The current development in building energy efficiency towards nearly-zero energy buildings represents a number of new challenges to design and construction of buildings. One of the major new challenges is the increased need for cooling present in these highly insulated and airtight buildings, which is not only present in the summer period but also in the shoulder seasons and in offices even during occupied hours in winter. In most post-occupancy studies of high performance buildings in European countries elevated temperature levels is the most reported problem, especially in residences.

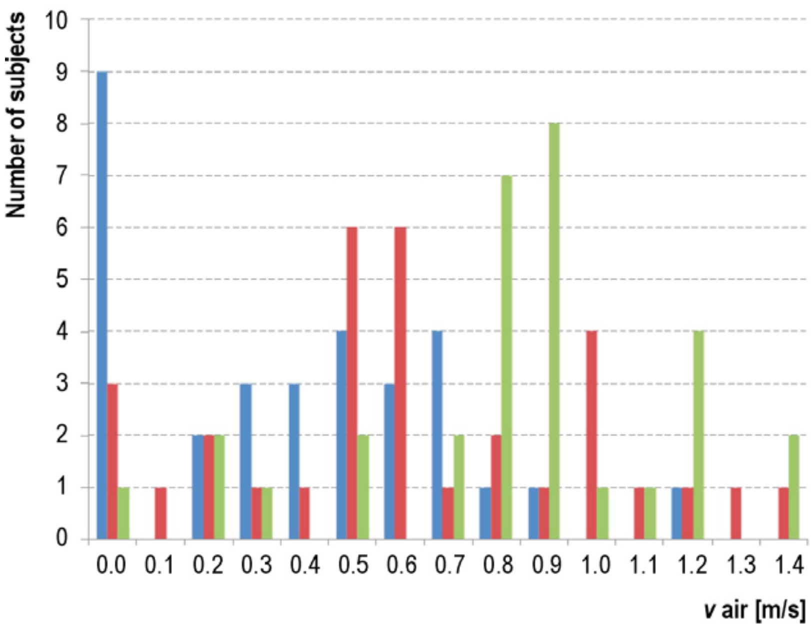
These new challenges were strongly reflected in the programme of the 33rd AIVC conference where about 30 papers and presentations in 6 sessions dealt with different issues related to ventilative cooling.

Performance Criteria

The first question to ask in the design of ventilative cooling systems is what are the performance criteria? What is considered as overheating and how can ventilative cooling be a solution? Research on different strategies to offset of warm sensation in high temperature conditions showed that increased air velocities can compensate and ensure comfortable conditions at higher temperature levels and that air fluctuations and turbulence intensity play an important role. But, the research results also showed significant individual differences in the preferred air velocity, which indicate that personal control is very important.

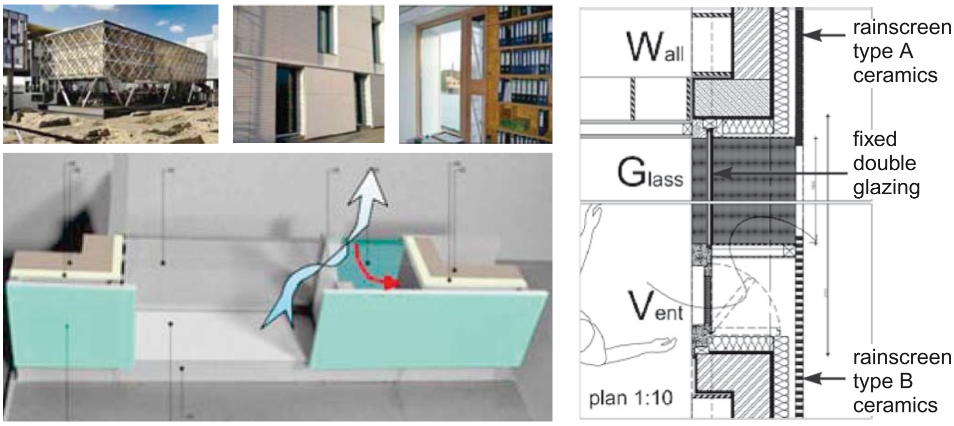
Prediction Methods

Prediction of energy use in residential buildings is often based on simplified monthly methods and is estimated for the residence as a whole. Averaging the need for cooling in both time and space underestimates the need for cooling. Excess heat in spaces exposed to solar radiation is considered to be distributed fully to other



Condition	t_o[°C]	RH %
A	26	50
B	28	45
C	30	40

Number of subjects choosing a certain velocity.
[Giulio Cattarin et al.
AIVC Conference proceedings,
pp. 8-12, 2012].



The Nicosia Townhall where special façade vents were developed to realise ventilative cooling in the building. [Flourentzou et al. AIVC Conference proceedings, pp. 233-237, 2012]

spaces and excess solar radiation during daytime is partly distributed to night time. Therefore, the need for cooling to ensure acceptable temperature levels in all spaces will be higher in reality. The analysis of the risk of overheating is often based on the calculated cooling need. Unfortunately, there is no correlation between the calculated cooling need with these simplified methods and the number of hours with elevated temperature levels. So, even if no cooling need is predicted and designers do not expect overheating problems, the number of hours with elevated temperature levels can be considerable. Several presentations dealt with these issues both from a more theoretical approach analyzing the energy balance and heat transfer processes within spaces in buildings but also different methods to predict Ventilative Cooling performance and the risk of overheating was presented.

Case Studies

A number of case studies on the application of ventilative cooling were presented. The case studies demonstrated ventilative cooling solutions both in residences, schools and shopping malls and in many situations considerable energy savings was obtained.

Several of the case studies highlighted the need for development of new technical solutions. One example was in the new Nicosia Townhall, where it was concluded that free cooling by night ventilation was the simplest strategy to keep comfortable temperatures, but using standard openings was not the best solution. In order to ensure better opening possibilities as well as protection from insects, dust and vandalism special façade vents were developed.

Conclusion

Ventilative cooling can be an attractive and energy efficient solution to avoid overheating of both new and renovated buildings. Ventilation is already present in most buildings through mechanical and/or natural systems and it can both remove excess heat gains as well as increase air velocities and thereby widen the thermal comfort range. As cooling becomes a need also outside the summer period the possibilities of utilizing the cooling potential of low temperature outdoor air increases considerably. The outcome of the Ventilative Cooling track was that especially for residences there is a need to improve both the way we estimate the need and the performance of ventilative cooling as well as for development of new, off-the-shelf and competitive technical solutions.

Airtightness track

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The airtightness track at the AIVC conference consisted of 29 presentations organized in 7 sessions. In 3 sessions research work was presented dealing with various airtightness related aspects as requested in the call for papers. In 4 sessions invited presentations and structured discussions were offered to give an overview of some specific conference topics:

- Ductwork airtightness
- Quality and building airtightness
- Quality of domestic ventilation systems
- Philosophy and approaches for building airtightness requirements

In the following paragraphs a bird's eye view is given of trends and conclusions that appeared in the presentations and discussions in the airtightness track.

From airtightness requirements to quality assurance

A number of presentations showed experimental evidence of the fact that new buildings become increasingly more airtight, compared to buildings built in previous decades. This evolution is attributed to the strengthening of energy performance requirements, typically in European countries, and to innovations in construction practice. According to the European Energy Performance of Buildings Directive (EPBD) the influence of air infiltration on the energy use of a building is taken into account when assessing the energy performance. As a result, building designers pay more attention to airtightness in order to meet more severe energy performance requirements for new buildings. However, in some countries also explicit airtightness requirements are set in order to prepare the market for a change towards 'nearly zero energy buildings'. An example of this approach is the French RT2012 legislation, which requires the airtightness of all new residential buildings to be tested in order to show compliance to legal limits.

Several presentations showed that the specification of airtightness requirements alone is not enough to achieve good building airtightness in reality. When no quality framework is adopted, design intents for airtightness are not systematically met because of flaws and variations in workmanship. This was shown in a project in Greenland where a large number of identical flats in a building was tested and a standard deviation of 47% was reported. Creating airtight building envelopes entails profound changes in design and construction practice and requires careful planning of the overall building process. Therefore a number of quality management and training schemes were presented in order to master this process. Sweden has a long experience with the implementation of quality ductwork systems and has included quality requirements in the AMA specification guidelines, based on subsequent partial testing. In France regulatory quality management processes are operational for building airtightness compliance by constructors, based on self-declared testing of a sample of the housing production. Control tests have shown that these schemes are very effective in achieving good airtightness in practice (**Figure 1**). Good examples of

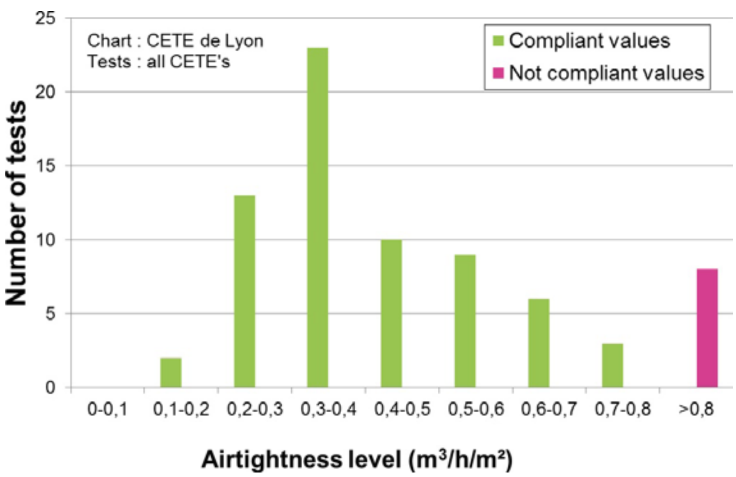

Figure 1. Results of control tests showing effectiveness of French quality framework for building airtightness compliance (85% compliance demanded, 89% compliance achieved). [Juricic et al.]

certification schemes for craftsmen were given by FLiB in Germany (Fachverband Luftdichtheit im Bauwesen), with guidelines for selection and installation of air barrier systems.

Air leakage testing and infiltration modelling

When airtightness requirements become more severe, also fan pressurization equipment and testing procedures to show compliance should allow to obtain reliable and repeatable test results. Several presentations were dealing with these issues. For testing single apartments in multifamily buildings different experimental procedures exist, and it is not always clear what one is measuring. A number of test results were presented quantifying the leakage distribution in apartments for different purposes: eg to assess the transfer of pollution between individual flats, or to assess the air leakage distribution ratio between internal and external partitions of apartments. A large-scale measuring campaign in high rise residential buildings in South Korea revealed that internal walls between flats often show the highest leakage (30-60% of total leakage).

A better knowledge of the air leakage distribution over the building envelope is also important to come to a more reliable extrapolation of fan pressurization test results at 50 Pa to air infiltration rates under natural driving forces (and related heat losses). While this extrapolation is typically based on rules of thumbs (the 'rule-of-20') or simplified steady-state models (Normalized Leakage), advanced simulation studies were presented to analyse the influence of uneven leakage distribution and unsteady wind conditions on air infiltration rates. Ultimately these studies should allow to develop more refined and accurate leakage models for infiltration heat loss assessment in high performance buildings.

IAQ and ventilation in airtight buildings

The fact that new buildings become more airtight is good news for the energy performance of buildings, but is also a reason for concern when indoor air quality and health issues are considered. In countries where residential ventilation traditionally relied on air leakage and on occasional opening of windows, such as in New Zealand, it is now found necessary to introduce reliable ventilation solutions to achieve acceptable IAQ and moisture control in new airtight houses. Even in countries where the installation of residential ventilation systems is part of the building code requirements, such as in most European countries, acceptable indoor air quality is not necessarily achieved. A number of multizone simulation studies were presented addressing IAQ performance in airtight houses. Although simulations showed that IAQ may improve with enhanced building airtightness, specifically for exhaust ventilation systems where designed air transfer is reinforced, the IAQ and indoor humidity achieved in airtight houses is sensitive to ventilation system design, sizing and installation errors.

However, some presentations discussed results of large-scale field studies showing striking evidence that installation quality of residential ventilation systems is typically insufficient. This was the case for studies performed in the Netherlands, Belgium and Estonia. Common shortcomings were insufficient supply ventilation capacity compared to design standards (in more than half of the investigated houses, **Figure 2**), increased noise levels in case of mechanical ventilation systems, and poor operation and maintenance. An overall conclusion was that together with increased building airtightness, more attention should be paid to ventilation system performance and installation quality, in order to guarantee healthy indoor environments. This requires a change of mind set, not only with building practitioners, but also with builders who should be more willing to pay the price for good quality ventilation systems.

Air Infiltration and Ventilation Centre

In recognition of the significant impact of ventilation on energy use, combined with concerns over indoor air quality, the International Energy Agency (IEA) inaugurated the Air Infiltration and Ventilation Centre in 1979. The AIVC is one of the annexes running under the ECBCS, Energy Conservation in Buildings and Community Systems, which is one of the Implementing Agreements of the IEA. The AIVC offers industry and research organisations technical support aimed at optimising ventilation technology. It offers a range of services and facilities, including comprehensive database on literature standards, and ventilation data. AIVC also produce a series of guides and technical notes. The Centre holds annual conferences and workshops. The operating agent of the AIVC is INIVE eeig (www.inive.org)

Figure 2. Air supply rates (average, P10 and P90) in the living room, master bedroom and other bedrooms in dwellings with balanced mechanical ventilation, at different control settings. The horizontal line gives the reference (minimum) level according to the Dutch Building Code (0.7 l/s/m2), (Boerstra et al.).

References

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Boerstra A., J. Balvers, R. Bogers, R. Jongeneel, F. van Dijken. 2012. Residential ventilation system performance: outcomes of a field study in the Netherlands. Proceedings of the 33rd AIVC Conference and 2nd TightVent Conference, Copenhagen, INIVE, 170-175.