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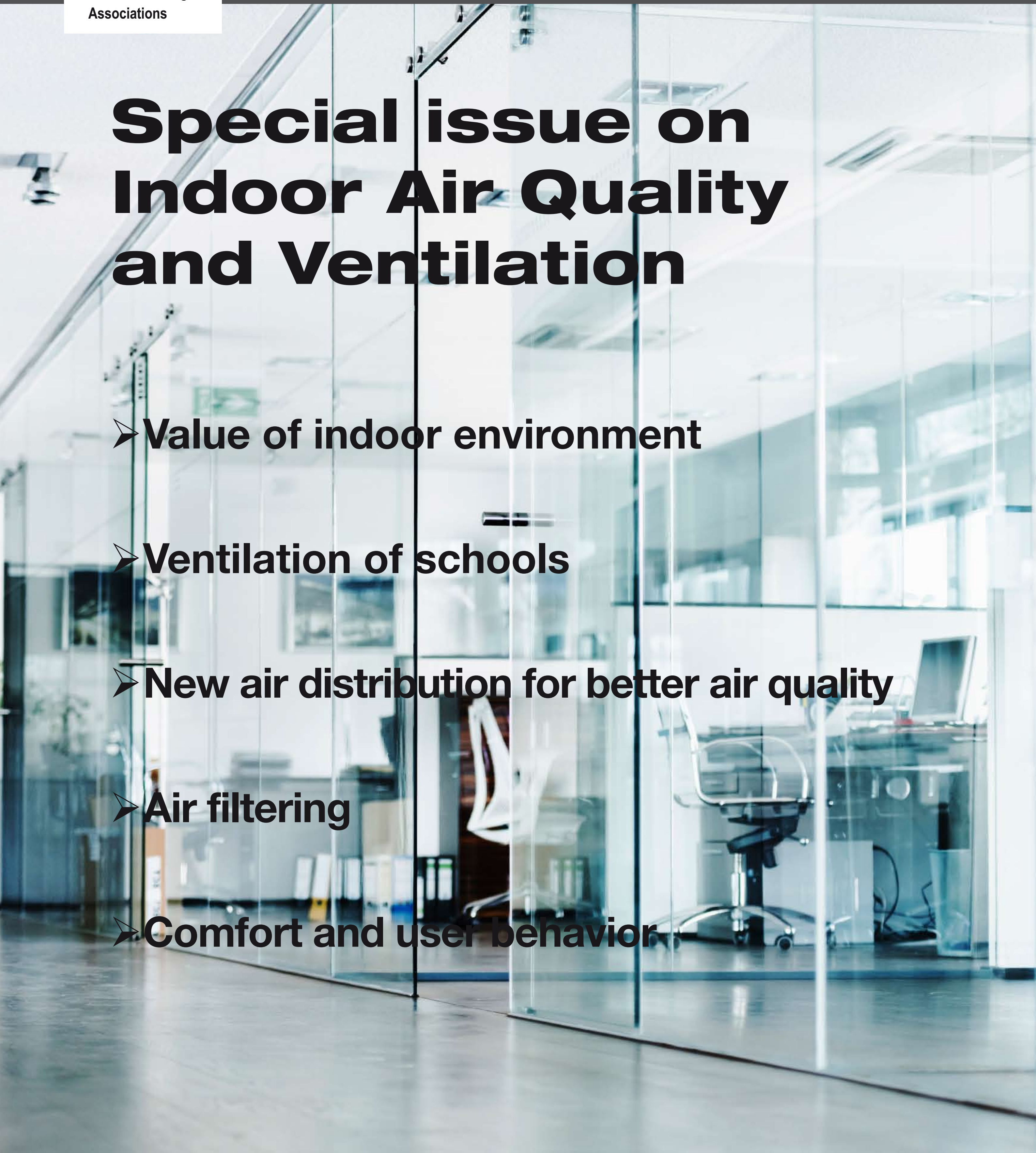

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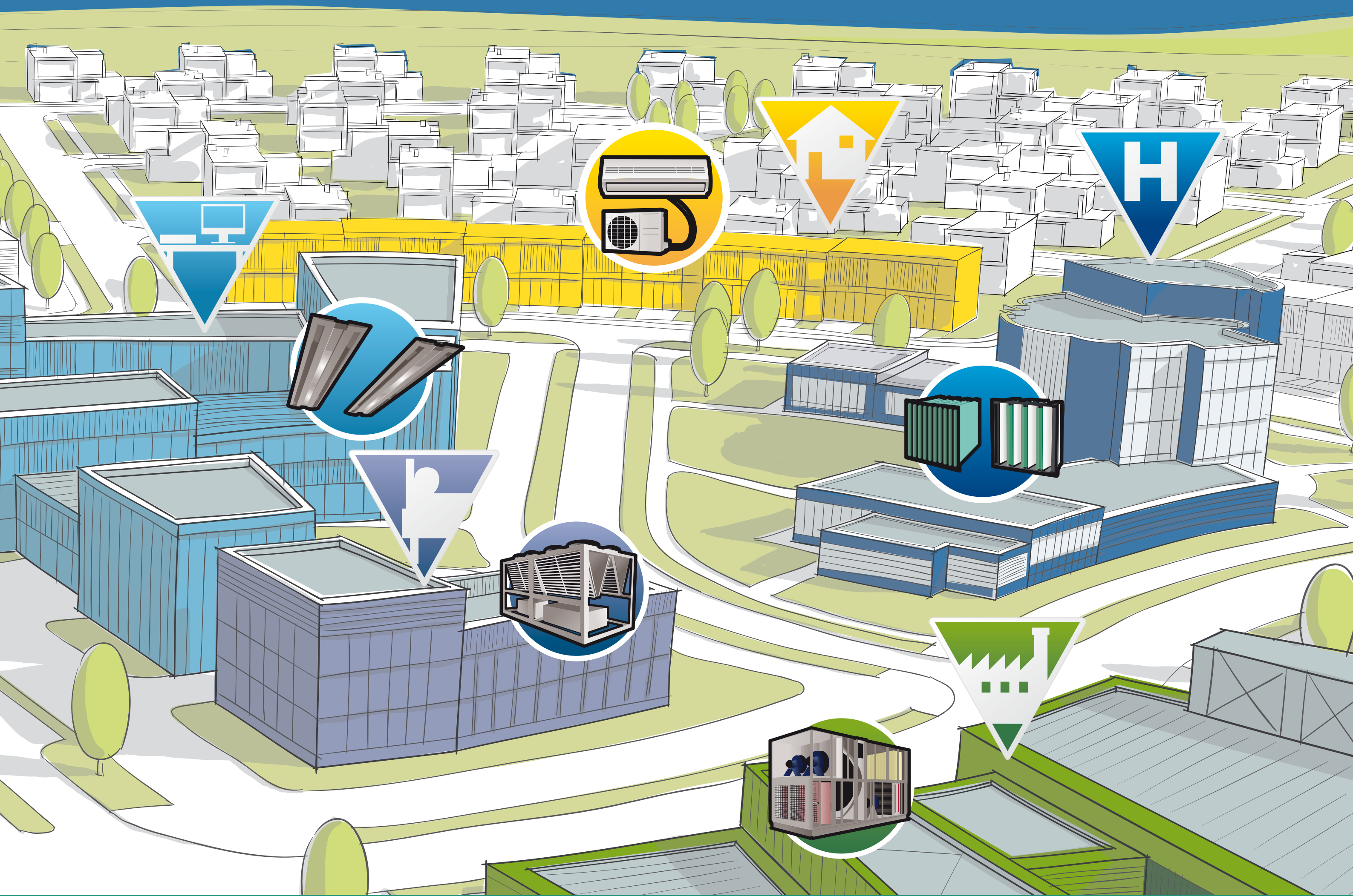

Good indoor environment should not be sacrificed for low energy use

OLLI SEPPÄNEN
Professor
Editor-in-chief

The indoor environment in buildings affects energy use and health, productivity and comfort of the occupants. Both energy use and effects on occupants are cost items. But the costs of the poor indoor environment for the society, employer and building owner are often higher than the cost of energy used in the same buildings.

Health and comfort of occupants shall not be sacrificed for lower energy use. Therefore, there is a need to specify criteria for the indoor environment for design, energy calculations and performance evaluation. Already in 2009, the EnVIE project, funded by DG Sanco, reported that EU-27 loses about 2 million disability adjusted life years annually (DALYs) due to the exposure to various pollutants indoors. The conclusions of this project underlined the need for an integrated approach to tackle effectively poor IAQ. The indoor environment is not only a health and comfort issue. It also affects work performance and learning of the occupants. Even a small increase in performance leads to a significant increase in productivity. This was summarised already in a REHVA Guidebook no 6, published in 2006.

Building owners appreciate both low energy use and good indoor environment, which enhances the value of the building. Also many certification systems of buildings include both energy use and the quality of the indoor environment, in the evaluation criteria. Thus, it is desirable to develop systems and solutions which lead to high quality indoor environment with low energy use.

The performance of a building depends how it is designed, built and operated. It is important to let a building owner know the consequences of the decisions related to indoor environmental quality in the design phase. The building with better design and higher investment cost usually also performs better. The owner cannot expect high quality with low investment cost. However, some building owners and occupants do not expect the building to meet the most stringent criteria of indoor air quality, and may still be satisfied with the quality of the building as they do not expect the perfectly controlled indoor environment. In all cases the designer shall always document design criteria for the indoor environment, these criteria shall be available with the energy use data when renting or selling the building space. It is also recommended that design values for the indoor environment and indicators for the environmental comfort are included in the energy certificate and displayed with actual values for the energy consumption. During the life time of a building the use of rooms may change significantly. Unfortunately, the changes in HVAC system are not always made accordingly, and as consequence occupants suffer from poor indoor environment.

One of the most important factors affecting indoor environment of building is the ventilation. Increased ventilation rates usually mean higher energy use. However, the scientific evidence shows that ventilation is essential for good indoor environmental quality. Ventilation strategies are also important for the energy efficiency of buildings. The requirements for good indoor air quality and energy efficiency have often been considered to conflict with each other but they do not have to be. Many strategies and technologies are available which improve indoor air quality while at the same time maintain or even lower the level of energy use.

On European level significant efforts are taken to this direction when two important ventilation related standards are being revised: EN 15251 "Indoor environmental input parameters for the design and assessment of energy performance of building" and EN 13779 "Ventilation for non-residential buildings". Both belong to the mandate from the European Commission to CEN for revising EPBD related standards. These draft standards are almost completed and are scheduled for be sent for national enquiry in September. Several technologies are described in these standards and accompanying technical reports. These include heat recovery, air tightness, demand controlled ventilation, specific fan power, filtering, localised control of indoor environment, revised target values of indoor environment etc. Hopefully these standards will be used when revising the national building regulations. ■


HALTON

Good indoor environment and energy efficiency increase monetary value of buildings

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Investments to good and energy efficient indoor environment are very profitable, according to the latest research findings. Excellent and energy efficient indoor environmental conditions has a significant impact on real estate asset value, occupancy rate and rental yield.

Keywords: indoor environment, value, real options, real estate asset, yield.

Energy efficient indoor environment is a common goal for all building project stakeholders. Together with reducing of operation cost, high quality environment increase value for investor and building owner. At the moment, there is a lack of understanding on how good indoor environment can improve business based on earning logics of owners, investors and tenants. Currently a good indoor environment is often fostered by regulations not business interests. Thus, only few investor and owners have realized the potential of sustainable indoor environments for their business. This article aims to provide new insights on the economic value of excellent indoor environment based on recent research results. The results are presented according the following themes and sections: improved asset value, occupancy rate and rental yield. The state of the art of research indicate that excellent indoor environment is hard currency for investors. In fact, based on the findings it could be estimated that asset value of buildings with excellent indoor environment is 10% higher that with the standard buildings and the price premium is likely to significantly increase in the next 5 years. Moreover, in buildings with high quality indoor environment the occupancy rate is approximately 10% higher and the rent is 5% higher that with standard building.

Improved asset value

Building owners and tenants can financially benefit from sustainability and improved indoor environmental quality. For owners, these improvements can result in increased property value such as (Virta et al 2012):

- Reduced life-cycle costs
- Extended building and equipment life span
- Longer tenant occupancy and lease renewals
- Reduced churn costs
- Reduced insurance costs
- Reduced liability risks
- Brand value

Excellent indoor environment quality increases well-being and performance of workers. The effect of room air temperature and indoor air quality is presented in REHVA's design guide (Wargocki and Seppänen 2006). It should be noted that the largest cost of organizations are usually the personnel, which consists of salary, healthcare and social costs. This can be more than ten times greater than workplace related costs. Moreover, according to a recent review of literature by an international expert panel (Sundell et al., 2011) there is strong evidence that higher ventilation rates in offices reduce the prevalence of sick building syndrome (SBS) symptoms of workers. In contrast, low ventilation rates increase short-term sick leaves, inflammation, respiratory infections and asthma symptoms.

Excellent conditions have a significant effect of monetary value of building. Based on the latest research findings,

good indoor environment and energy efficient building proofed by LEED Platinum certificate can increase property value by over 8% (Vimpari & Junnila 2014). In the study, it is argued that green certificates can be valued as real options by identifying the option characteristics. The results are in line with previous research results as summarized in **Table 1**. The range of the sustainability in the literature review is between 3 – 35%. All this indicates that the effect of sustainability on asset value is significant.

The study emphasizes that a clear correlation exists between sustainability and asset value premium. The results have been identified by real estate researchers and practitioners to be the "future of industry". First time, sustainability has been recognized to influence the real estate and construction (REC) cluster profoundly and also to offer an unprecedented opportunity. In practice, we are already seeing that sustainable buildings liquidity and transaction price upside are growing as increasing number of real estate investors and funds are investing in high performance sustainable buildings.

Investments on sustainability seem to be delayed partly because the justification of the investments with the traditional investment analysis methods, such as discounted cash flow (DCF). Most traditional methods focus on risk assessment and do not account for life-cycle uncertainty of the investment and value of flexibility brought about by good indoor environment design and systems. In fact, indoor environment investment valuation practices are not typically linked with the level of indoor conditions and the respective monetary life-cycle benefits e.g., cost savings and asset value premium. The option pricing theory, specifically real options analysis (ROA) is a potential valuation approach to establish this link and to appropriately value sustainability investments. The approach is less recognized by public but has big potential for REC sector decision-makers. The benefit of ROA is that it accounts for the quality of indoor environment investment through uncertainty and upside potential for the investment life-cycle.

Higher occupancy

Good indoor environment improves the occupancy of the buildings. Investors can improve the occupancy of buildings by improving user satisfaction of indoor environment and analysing and developing flexibility of the facilities. The effect of renovation on perceived thermal comfort and air quality in four case study office buildings have been studied (Koskela et al. 2013). The perceived conditions were notably better after the renovation. The highest effect was achieved with air quality where the percentage of dissatisfied decreased in three offices from 70% level to 30% level on average. The research indicates that the quality of the indoor air is a significant factor for user satisfaction in facilities.

Moving people is expensive. The cost of a move depends on the extent to which the facility must be modified to accommodate the changes. Often new walls, new or additional wiring, new telecommunications systems, or other construction are needed to complete the move.

In today's work environment, churn is a major issue.

As teams are continuously changing, workplaces need to be flexible and adaptable. Therefore, the focus on systems' and work places' adaptability and flexibility is very important in the design phase. Depending on the selected systems, the cost of modifying a space (50–250 Eur per m²) and the time the space cannot be used (1 hour … 3 months) varies a lot. These costs can be minimised if adaptability is focused on in systems design and system selection.

The economical feasibility of facilities' flexibility was studied in renovated buildings (Vimpari et al. 2014). The main finding of that study is that real option analysis can be used for assessing the monetary value of service flexibility over the investment life-cycle. In the empirical case, value of service flexibility for the investor and tenants was analyzed and the results were utilized building briefing stage by setting the cost and profit target values for room programme and building design. Service flexibility was very profitable in certain sections of the case building, which was a 12 000 sqm office building built in the 1970s. The present value of the pay-off from flexibility ranged from negative 58 €/sqm to positive 130 €/sqm depending on the tenant. The results demonstrate that real option analysis is a

Table 1. Asset value results from literature (adopted from: Sayce & Lorenz 2011).

Study / authors	Country	Property Type	Credentials	+/– Magnitude	Impact on
Brounen and Kok. 2010	The Netherlands	Residential Homes	Energy Performance Certificate (Class A. B. C)	+2.8%	Selling price
Eichholtz. Kok and Quigley. 2010	USA	Office Buildings	LEED	+11.1%	Selling price
Fuerst and McAllister. 2008	USA	Office Buildings	LEED	+31% – 35%	Selling price
Salvi et. al. 2008	Switzerland	Residential Homes	MINERGIE Label	+7%	Selling price

Table 2. Occupancy and energy efficient buildings; results from literature (adopted from: Sayce & Lorenz 2011).

Study / authors	Country	Property Type	Credentials	+/– Magnitude	Impact on
Fuerst and McAllister, 2010	USA	Office Buildings	LEED	+8%	Occupancy Rates
Pivo and Fischer, 2010	USA	Office Buildings	Energy Star, close distance to transit, location in redevelopment areas	+0.2% – 1.3%	Occupancy Rates
Wiley, Benefield and Johnson, 2008	USA	Office Buildings	LEED, Energy Star	+10 – 18%	Occupancy Rates
MIT, 2012	USA	Office Buildings	Design flexibility	30%	Occupancy Rates

Table 3. Rental yield and energy efficiency (adopted from: Sayce & Lorenz 2011).

Study / authors	Country	Property Type	Credentials	+/– Magnitude	Impact on
City of Darmstadt, Rental Index, 2010	Germany (Darmstadt)	Residential multi-family houses	Primary energy value below 175 kWh/m²a	+0,50 €/m²	Rental Price
Pivo and Fischer, 2010	USA	Office Buildings	Energy Star, close distance to transit, location in redevelopment areas	+4.8% – 5.2%	Occupancy Rates
Salvi et. al, 2010	Switzerland	Residential Flats	MINERGIE Label	+6%	Rental Price
Wiley, Benefield and Johnson, 2008	USA	Office Buildings	LEED	+7% – 17%	Rental Price

useful tool for investors to deal with the major uncertainties related to user function changes and shorter lease lengths. It can be used to for example increase office building occupancy through sensible flexibility investments in a retrofit project.

In general, the occupancy in flexible facilities is higher. The costs of flexibility can be justified and the value of the flexibility is 1–8% (**Table 2**). In general, if it is plausible that the tenant will change in facilities near future, it is highly profitable to invest in flexibility.

Rental yield

In the facility management, the main concern of the net operation income is to reduce running costs. Beside the improved occupancy and asset value, excellent indoor environment affects rental yield. According the research results, better building rent ability and lower maintenance costs can be achieved through good and energy efficient indoor environment. Good indoor environment and energy efficiency attract tenants.

A study of the preferences of corporate occupiers in relation to their occupied offices indicates high impact on rent (Karhu et al. 2012). The results show that location achieved the highest importance, even though it was asked only in terms of environmental sense. The energy efficiency of a building was ranked second. The indicative results suggest that the line of industry and the position of respondent seem to effect to the importance of the preferences as well.

Facility management services may decrease annual maintenance costs over 15% (Aaltonen et al. 2013). A study shows that high quality facility management (FM) services that improves indoor environment and energy efficiency has an affect on rental yield. The results indicate that FM service processes have both direct and indirect influence on the building environmental performance metrics. The case building was a 16,300 square meter office building that hosts a staff of 800. The results show that by relatively light changes and modifications to the FM service processes, quite extensive environmental benefits can be achieved. Monetary savings from electricity reduction were approximately 32,000 € and from heating energy reduction 35,500 € during one year.

The results are in line with the literature review results (**Table 3**). The review depicts that with the high performance building is possible to get 5–10% higher rent.

This article provides new insights on the economic value of excellent indoor environment based on recent research results. The state of the art of research indicate that excellent indoor environment is hard currency for investors. In fact, based on the findings it could be estimated that asset value of buildings with excellent indoor environment is 10% higher that with the standard buildings and the price premium is likely to significantly increase in the next 5 years. Moreover, in buildings with high quality indoor environment the occupancy rate is approximately 10% higher and the rent is 5% higher that with standard building. ■

Acknowledgement

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For more information: indoorenvironment.org and rym.fi

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Indoor Air Quality and Thermal Environment in Classrooms with Different Ventilation Systems

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This article presents the measurements of indoor climate in classrooms in the same school in Denmark. The classrooms had different ventilation systems: Ventilation was achieved either by manually operable windows, or by automatically operable windows with and without an exhaust fan in operation, or by a balanced mechanical ventilation system. Indoor air temperature and carbon dioxide (CO_2) concentration, as well as opening of windows were continuously monitored for one month in the non-heating and heating seasons; measured CO_2 concentration was used to estimate average classroom ventilation rates. The results show that mechanical ventilation and natural ventilation with automatically operable windows with exhaust fan performed notably better than the other systems. They indicate also that opening of windows was largely affected by customs and habits. Present results can be used as the basis for rational selection of systems that ensure adequate classroom ventilation.

Keywords: school, classroom, ventilation system type, indoor temperature, carbon dioxide.

Introduction

The main purpose of classroom ventilation is to create indoor environmental conditions that reduce the risk of health problems among pupils and minimise their discomfort to avoid negative effects on learning [1-5].

Classroom ventilation is still provided in many schools in Europe by expecting that teachers and pupils will open the windows [6-7]. An increasing number of school classrooms are being now fitted with other methods for achieving classroom ventilation. These include among others automatically operable windows, extract ventilation using exhaust fans or mechanical ventilation systems with balanced supply and exhaust from a central or local air-handling unit. There are yet no systematic data on the performance of these various types of ventilation in schools, especially as regards their impact on the indoor climate in classrooms, on the health of pupils and teachers or on learning; some data exist on their energy performance [8-9]. Interestingly, there are also very little data on the window opening behaviour of pupils and its effect on classroom ventilation and indoor climate; some data on window opening behaviour is available for other types of buildings especially dwellings [10].

The main objective of the present work was to provide data on long-term performance of different methods for achieving classroom ventilation and their influence on the indoor climate in classrooms [11].

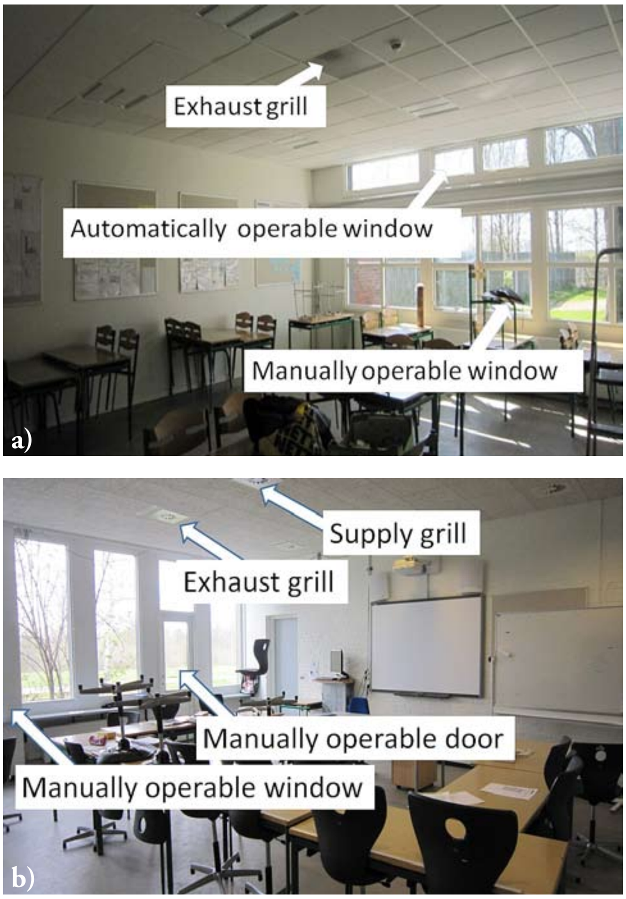

Figure 1. Classrooms, where the measurements took place: (a) classroom with automatically operable windows and exhaust fan; (b) mechanically ventilated classroom.

Methodology

The study was performed in an elementary school in Denmark located in rural area north of Copenhagen. Three classrooms were selected where ventilation is normally achieved by automatically operated windows and exhaust fan (**Figure 1a**). Two of these classrooms were adapted for the purpose of the present experiments to create two different modes of ventilation with either manually or automatically operable windows; the control in the third classroom remained unchanged. Additionally one classroom was selected where ventilation is achieved by a balanced mechanical ventilation system at a rate of 120 L/s per class (**Figure 1b**). All classrooms could be additionally ventilated (aired) by windows/garden doors that could be opened manually by pupils and/or teachers. None of the classrooms had mechanical cooling installed. The typology of all classrooms is presented in **Table 1**.

The measurements were performed for one month both in the non-heating season (May) and the heating season (November-December). They included the measurements of CO_2 concentration using a VAISALA GM20D sensor (accuracy: ±30 ppm +2% of the

Table 1. Typology of classrooms, in which the measurements were performed.

Classroom	Acronym	Description of ventilation systems	Average occupancy		Space volume	Floor area
			Non-heating season	Heating season	(m^3)	(m^2)
1	MW	Classroom ventilated (aired) by manually operable windows	22	19	123.5	49.4
2	AW	Classroom ventilated primarily by automatically operable windows	24	22	123.5	49.4
3	AW/EF	Classroom ventilated primarily by automatically operable windows and exhaust fan	25	24	123.5	49.4
4	MV	Classroom ventilated primarily by the mechanical ventilation system	20	16	180	72

reading) connected to a HOBO U12 logger. The logger recorded additionally the classroom temperature (accuracy: ±0.7°C) and relative humidity (RH) (accuracy: ±5% RH). Opening of windows (both manually and automatically operable) and garden doors was registered using HOBO State loggers, which were attached to the frame of each window/door in every classroom where the measurements took place. Mass balance model was used to estimate ventilation rates assuming the CO_2 generation rate per pupil to be 0.004 L/s and per teacher 0.0054 L/s; average peak CO_2 concentration was used to approximate the minimum outdoor air supply rates [12]. The outdoor CO_2 was assumed to be 350 ppm.

Results and discussion

Measured classroom temperatures in the non-heating season were systematically higher than those in the heating season (**Figure 2**). Measured temperatures in different classrooms in the non-heating season were between 22°C and 26°C and were not alike: The highest temperature was measured in the classroom, where ventilation could only be achieved by opening the manually operable windows/garden door, and the lowest temperature was measured in the mechanically ventilated classroom. Still, the classrooms can be generally classified as spaces, where high expectations of thermal conditions are met independently of the type of ventilation system installed [13]. In the heating season, the mean weighted classroom temperatures were between 19°C to 25°C the temperatures. The temperatures in classrooms without mechanical ventilation were similar; in classroom with mechanical ventilation, the temperatures in the morning were slightly lower. Consequently, the classrooms, which did not have mechanical ventilation system, could be classified as spaces fulfilling a high level of expectation, while the classroom with the mechanical ventilation system met only a moderate level of expectation [13]. The classrooms were heated by water-filled radiators placed under the windows. The radiators were equipped with thermostatic valves but their set points were not recorded during the measurements. The difference in temperatures in the classrooms could therefore have occurred due to different set points of these valves, which could be operated by the teachers and pupils according to their needs.

Measured CO_2 concentrations in the classrooms were systematically lower in the non-heating season than in the heating season (**Figure 3**). Average CO_2 concentration was below 1,000 ppm in the non-heating season in all classrooms and only in the classroom where windows had to be opened manually to achieve ventilation was the peak concentration higher than 1,000 ppm. There were clear differences in the average CO_2 concentration in classrooms during the heating season: CO_2 concentrations were close to or higher than 1,000 ppm in all classrooms and the highest concentration was measured in the classroom where windows had to be opened manually to achieve proper ventilation (airing), while the second highest CO_2 concentration was observed in the classroom with automatically operable windows where no exhaust fan was in operation.

Danish Building Regulations stipulate that the ventilation rates in classrooms should be about 6 L/s per person [14]. The estimated outdoor air supply rates met the requirements of the Danish Building Regulations only in the classroom with a mechanical ventilation system and were close to these requirements in the classroom with automatically operated windows with an exhaust fan. During the heating season, the estimated ventilation rates were lower than in the non-heating season and only the classroom with the mechanical system fulfilled the requirements of the Danish Building Regulation (**Table 2**). The lower ventilation rates are most likely the consequence of the less frequently opened windows, both manually and automatically (**Figure 4**). Especially lower outdoor temperature cause cold drafts indoors and reduce window opening. Consequently, there is a need for installing an alternate system that can provide the ventilation when windows have to remain closed due to unfavourable weather conditions, or to inform the pupils and teachers when they ned to be opened [15].

Table 2. Peak CO_2 concentration and the estimated ventilation rates in classrooms with different ventilation systems [mean (s.d.)] (for acronyms see ***Table 1***).

	Non-heating season				Heating season			
	MW	AW	AW/EF	MV	MW	AW	AW/EF	MV
Peak CO_2 concentration (ppm)	1463 (273)	1319 (154)	1093 (147)	887 (149)	2200 (436)	1447 (248)	1303 (185)	954 (147)
Estimated ventilation rates (L/s per person)	3.8 (0.9)	4.3 (0.8)	5.6 (1.0)	7.8 (1.2)	2.3 (0.6)	4.2 (0.9)	4.5 (1.3)	7.3 (1.8)

Based on the number of opened windows and the duration of the windows opening registered by the loggers, the average time during which windows were open per day in different classrooms was calculated separately for the non-heating and heating season (**Figure 4**). The results show that manually operable windows/garden doors were opened less often in the heating season, and generally much longer in the classroom where the windows/garden door had to be open manually to achieve ventilation (airing) of the classroom.

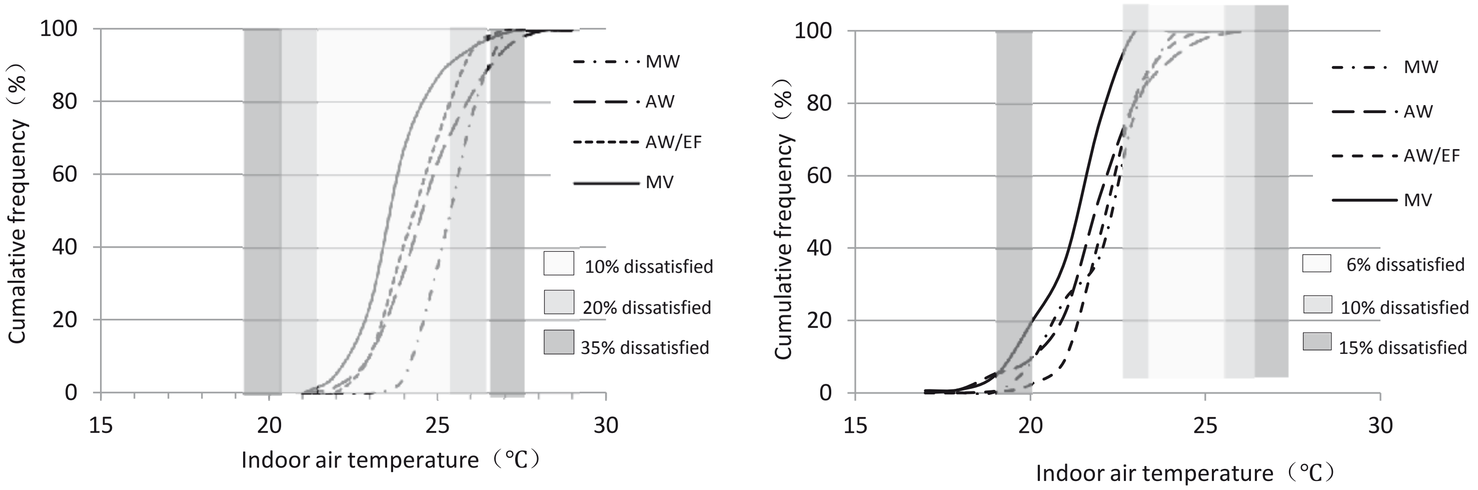

Figure 2. Temperatures during school hours in classrooms with different ventilation systems in the non-heating season (left) and the heating season (right); bands indicate ranges of indoor temperatures with different level of expectation concerning thermal environment according to EN15251 [13] (for acronyms, see ***Table 1***).

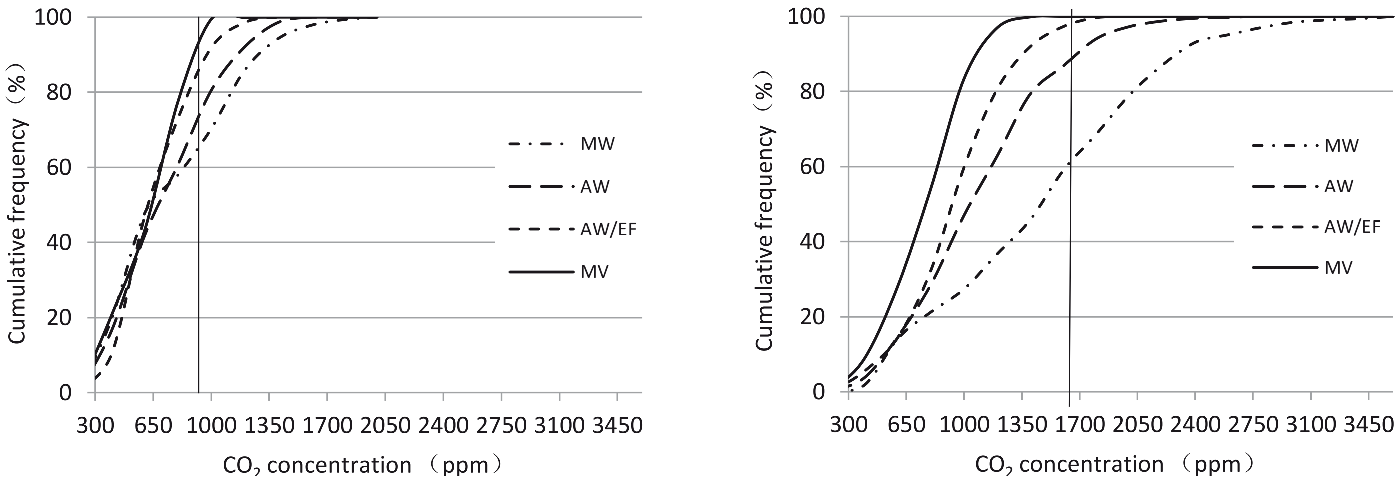

Figure 3. CO_2 concentration during school hours in classrooms with different ventilation systems in the non-heating season (left) and the heating season (right); the line shows CO_2 at concentration of 1,000 ppm, the level which should not be exceeded in classrooms [14](for acronyms see ***Table 1***).

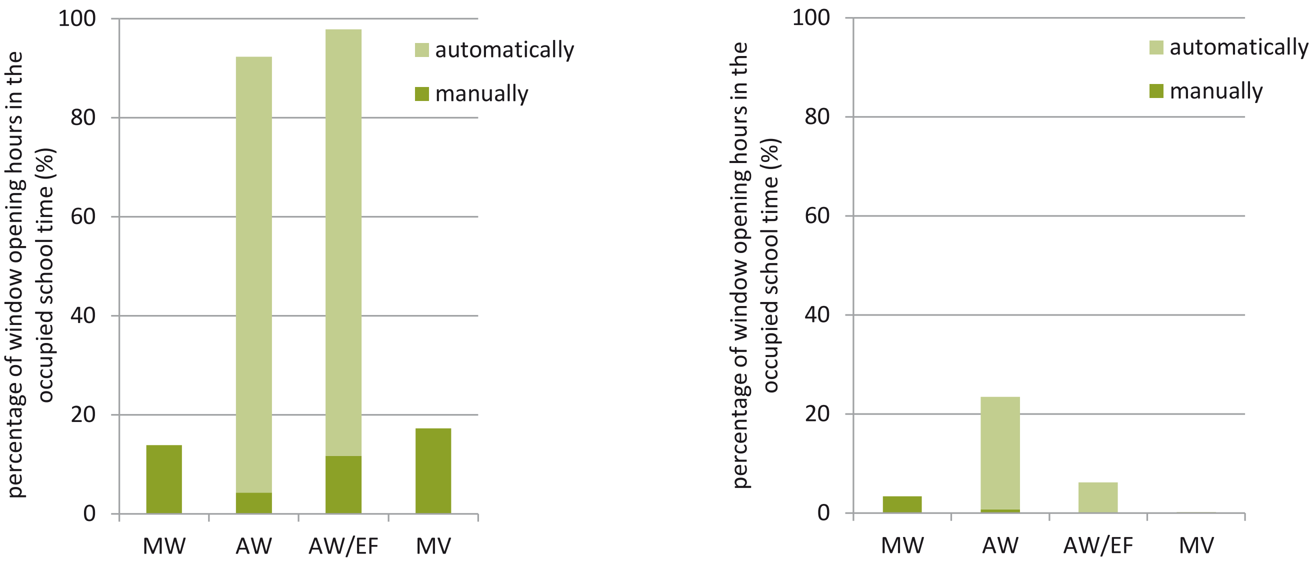

Figure 4. Proportion of time with windows open during school hours in classrooms with different ventilation systems in the non-heating season (left) and the heating season (right) (for acronyms see ***Table 1***).

The total period, during which all windows/garden doors (manually and automatically operable) were opened in different classrooms was much longer in the classrooms with automatically operable windows. This was especially the case in the non-heating season, when they were opened nearly for the entire school day, i.e. on average 6 to 7 hours per day. The windows were opened even in the classroom with a mechanical ventilation system, which suggests that window opening is largely affected by the habits and customs of the occupants.

Conclusions and implications

The measurements show that the performance of mechanical ventilation and natural ventilation with automatically operable windows in which adequate ventilation is assured was notably better than in the classrooms where windows had to be opened manually for achieving ventilation or where windows were opened automatically but with no means of ensuring that this would provide adequate ventilation (exhaust fan idled). The present results have not clearly determined which of the two preferred systems is better. The two most important selection criteria are energy use and the need for conditions that do not have a negative effect on learning. Neither of them was determined. School location and climate conditions are also among factors that can be considered when selecting the ventilation system. In the present case, the ambient pollution levels did not place any restriction on the use of natural ventilation systems with manually or automatically operated windows: The school was located in suburban area. In places where the ambient pollution does not meet the levels recommended by the WHO [16], some means of filtration and air cleaning must be applied before the air can be admitted indoors.

The strength of the present measurements is that they were performed for a relatively long time (1 month) in two different seasons, so the results are applicable to the entire school year. The limitation is that the classroom where exhaust fan was idled was not especially designed for one-sided natural ventilation to promote cross-ventilation. Furthermore, the teachers and pupils were accustomed to having automatically operable windows even in the classroom where they were idled. This could to some extent influence and reduce the number of windows that were opened manually. Despite these limitations, present results represent the approach and basis for a rational selection of systems that ensure adequate classroom ventilation and acceptable indoor environmental quality throughout the entire school year. ■

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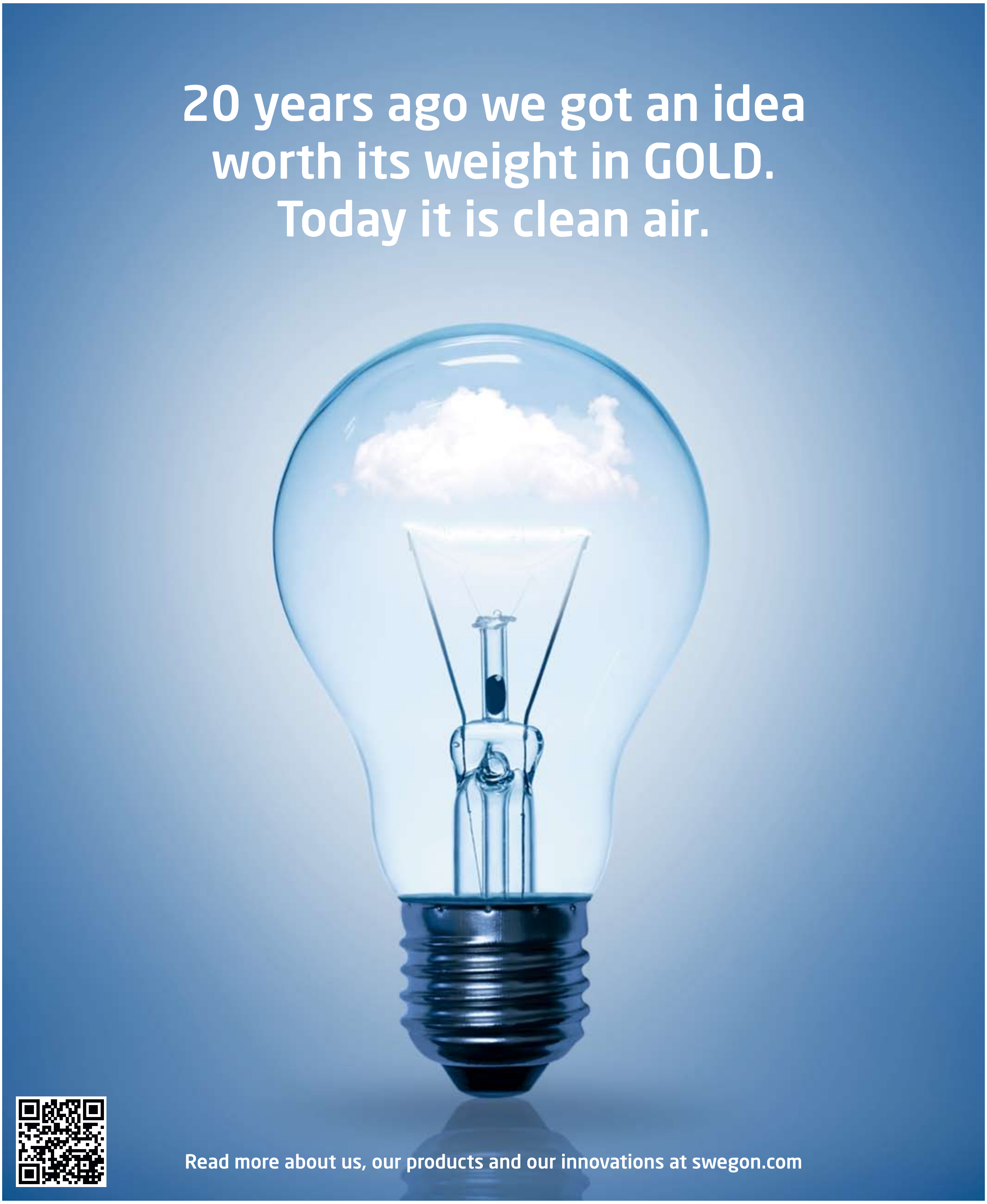

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Energy upgrading measures improve also indoor climate

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A new survey shows that the economy is what motivates Danish owners of single-family houses the most to start energy upgrading, and that improved indoor climate is also an important factor. After the upgrading, homeowners experience both improved economy and indoor climate. Measurements in a number of new low-energy houses show that it is possible to obtain good thermal comfort and air quality in well-insulated houses even with large window areas. This experience is useful in the upgrading of existing homes.

Keywords: energy retroits, indoor climate, occupant satisfaction, questionnaire, homeowner.

In a questionnaire survey on energy upgrading among owners of single-family houses and rowhouses, mainly from 1960 to 1979, in a municipality north of Copenhagen, it appears that altogether at least 60% of the homeowners would like more knowledge about how to save on their energy bill. (Photo: Karl Grau Sørensen).

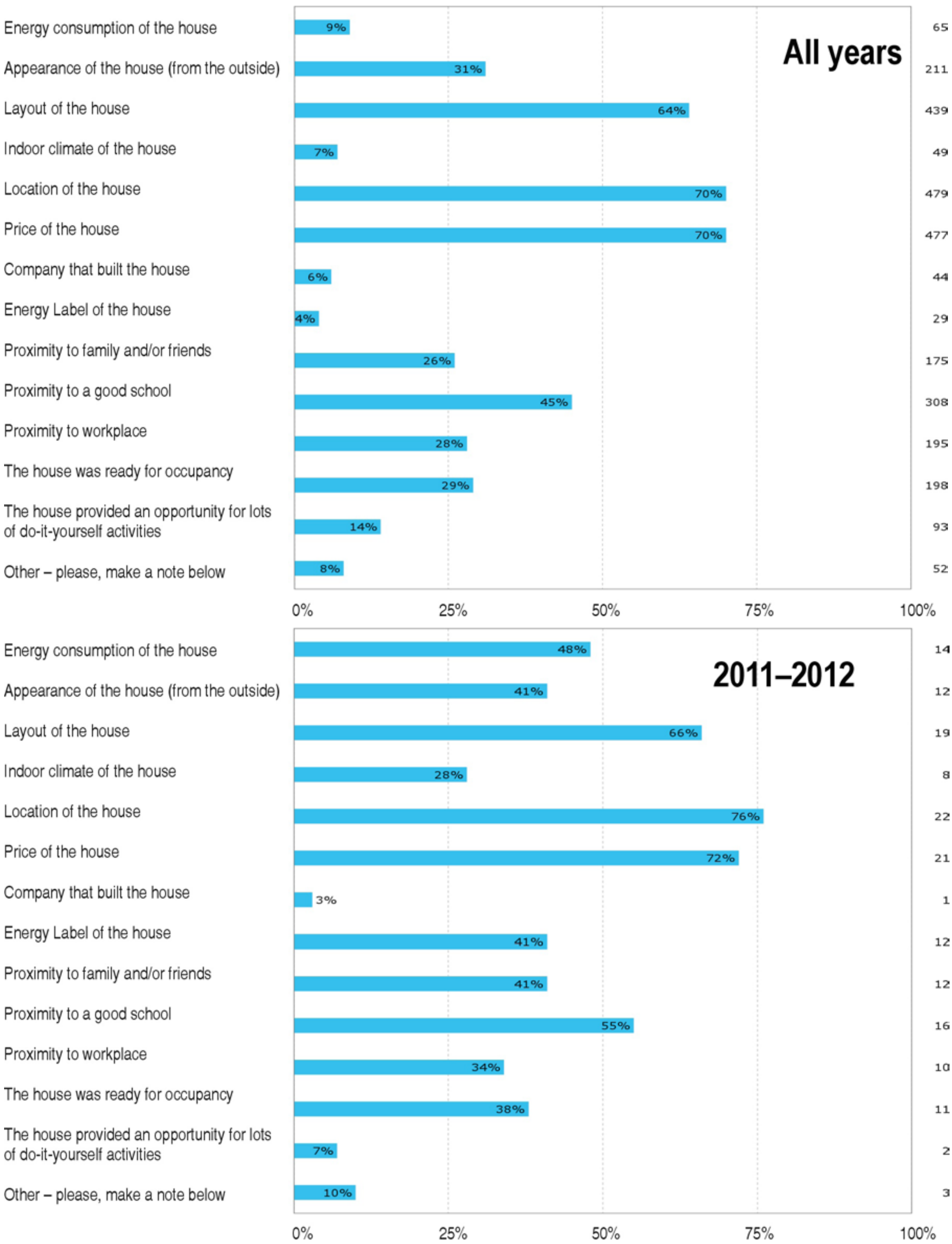
As part of the Danish 2012 Energy Agreement, it was decided that the Government should prepare a comprehensive strategy for energy upgrading of the Danish building stock. As part of the implementation of the strategy, the Minister for Climate, Energy and Building established a network for energy upgrading in 2012, which submitted a calatogue of initiatives to the Minister in May 2013. Among other things, the network identified an urgent need for renovation of Danish homes, not least the many single-family houses built in the 1960s and 1970s. The catalogue also points out that focus should centre not only on energy savings, but also on possible positive side effects like an improved indoor climate.

This article describes a survey carried out among homeowners with the purpose of clarifying incentives, barriers and experiences when making energy upgradings. The accompaning article describes the experience of thermal comfort and air quality in newly built low-energy houses, which can be of relevance for renovations.

Homeowners' motivation and experiences of energy upgrading

Even though the possible benefits are many, it is only a few homeowners who venture into major energy upgrading projects. This is the background for a questionnaire survey among 1,990 randomly selected homeowners in the municipality of Furesø, north of Copenhagen. The survey focused on the incentives and barriers that they might experience in relation to venturing into energy upgrading of their home and the possible benefits they experienced after having upgraded their home, e.g. in relation to the indoor climate. A total of 683 households participated in the survey resulting in a response rate of 34%. It included responses from homeowners who had already carried out energy upgradings (22%) and

Question 1. When you bought your house, what was most important for your choice?

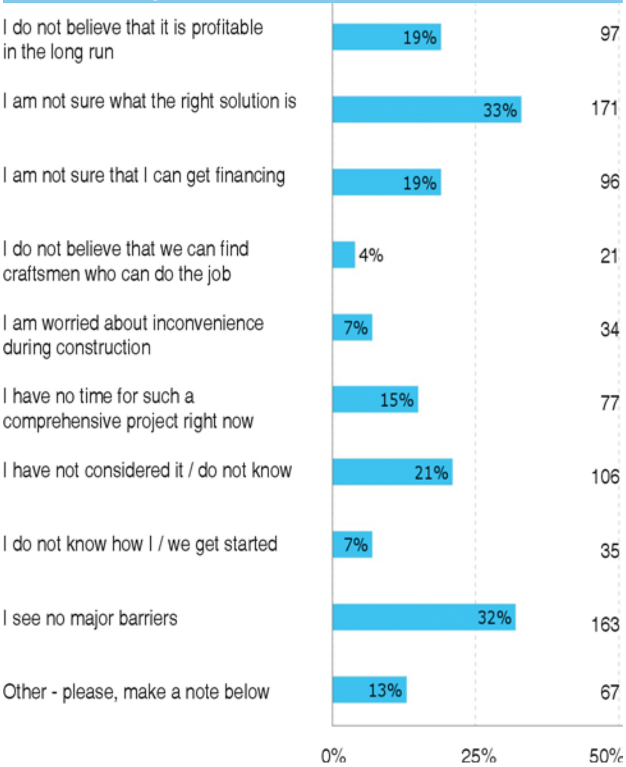


homeowners who were already making some kind of energy upgrading (19%).

More focus on energy and indoor climate

Among the homeowners who had bought their house within the last couple of years (2011–2012), there is a tendency that energy consumption and indoor climate have become more important than earlier, **Question 1**. What was most important for the homeowners, when they chose the house they own today, was location, price and interior layout. Energy consumption and energy label used to be of little importance as only 4–9% refers to it.

Question 2. From your knowledge of energy upgrading, what do you consider the largest barriers for you?



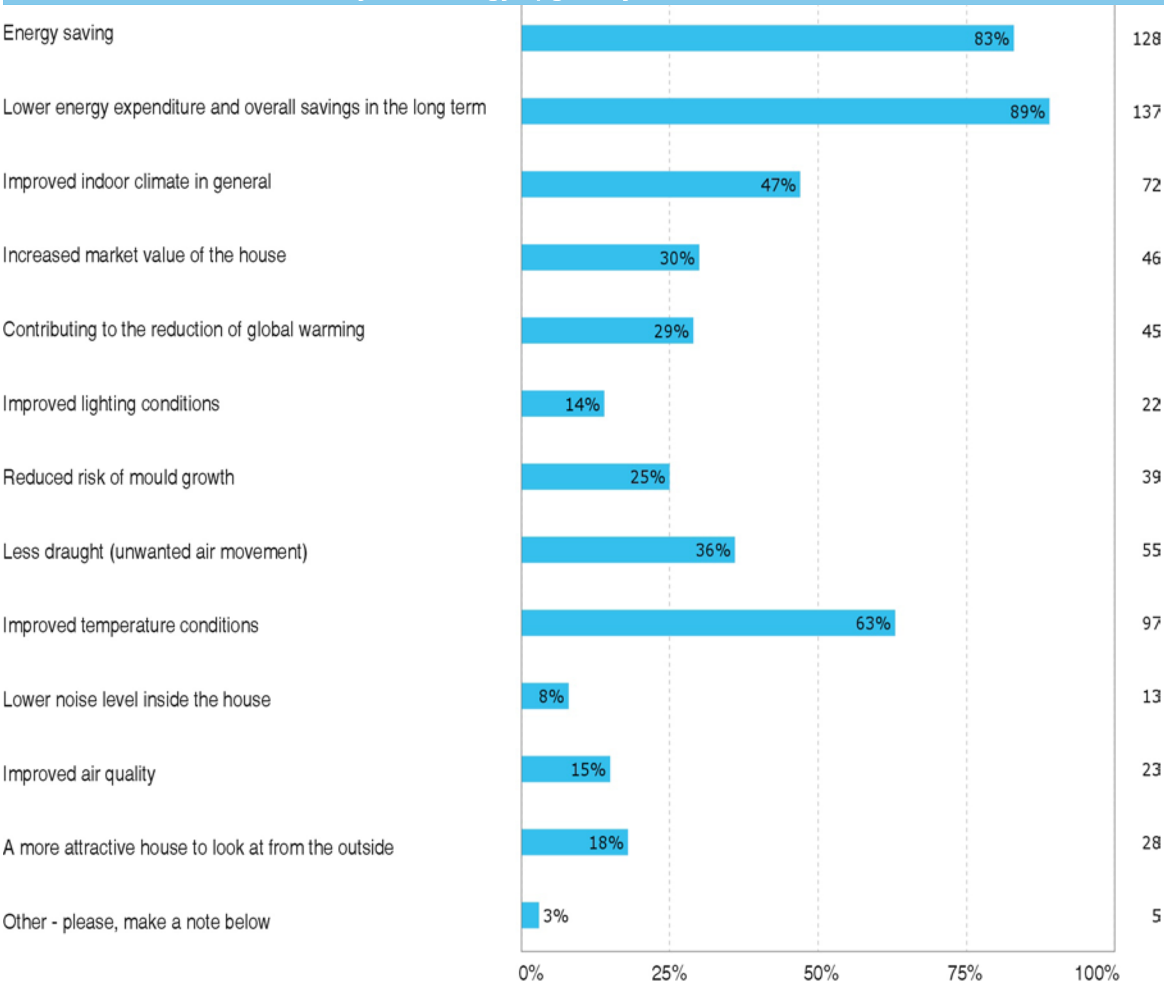
It should be noted, however, that the energy label was not introduced until 1979 and was not really known among house buyers until the mid 1980s. Moreover, only 7% found the indoor climate important. Considering only the relatively few homeowners (29), who bought their house in 2011 or 2012, there is a development that the energy consumption/energy label and indoor climate of the house is becoming more important (48/41% and 28%).

Homeowners unsure of what is the best solution

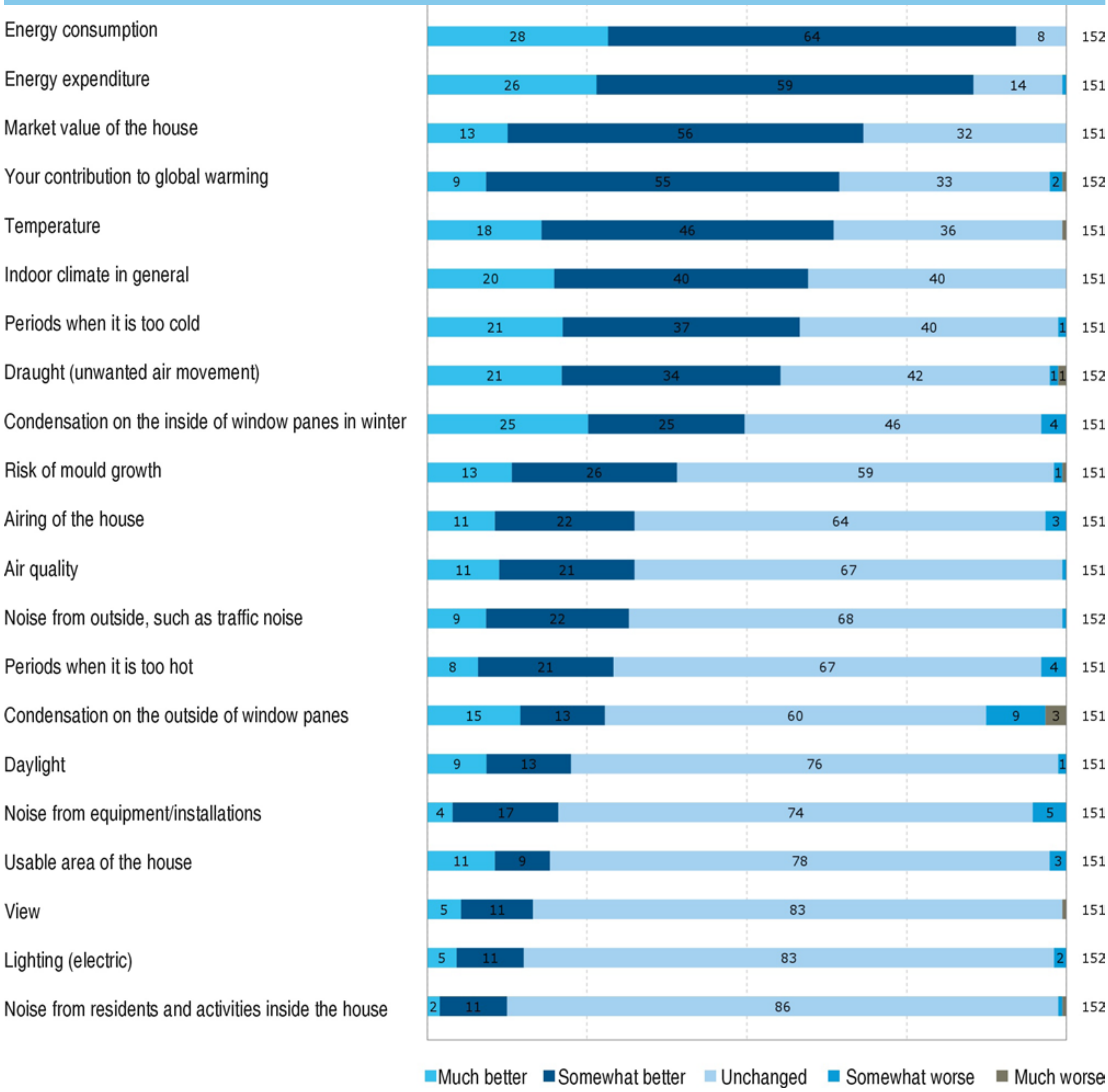
Energy upgrading is complicated and this is also how it is perceived by many homeowners, **Question 2**. When it comes to barriers to energy upgrading, one third of the homeowners state that they are unsure of what is the right solution. As regards economy, one fifth doubt that they can get financing and another fifth do not believe that energy upgrading is profitable in the long run.

Consequently, there is a need to assist homeowners by showing the potential of their houses, the relevant solutions and clarification of how renovation is financially viable. The better the economy of an energy ugrading, the faster the homeowner will reach the decision to go ahead.

Question 3. What motivated you to energy upgrade your home?



Question 4. After you have energy upgraded your house, to what degree have the following conditions improved or worsened?



Economy is the most important factor, next comes the indoor climate

Significant savings on the energy bill is the greatest motivation for homeowners to start energy upgrading of their house, **Question 3**. Next follows a wish for better temperature conditions, better indoor climate in general and less draught. Only then follows increased market value of the house and the wish to reduce global warming. The availability of investment grants, tax deduction and a reasonable payback time can help motivate homeowners.

Homeowners pleased with the energy upgrading

The homeowners who carried out energy upgradings, have an overall positive experience of the energy upgrading of their house. This appears from the fact that 87% of the homeowners would recommend others to energy upgrade their house and 93% are satisfied with the way the energy upgrading was carried out.

Add to this that the homeowners experience that a lot of conditions have improved after the upgrading, **Question 4**.

The large majority experience improvement of the energy consumption, cost of energy, market value of the house and contribution to global warming. Then they experience improvements of the temperature (64%), indoor climate in general (60%), periods when it is too cold (58%), draught (55%) and condensation on the inside of the panes in winter (50%). So, it is possible to choose renovation measures that not only reduce the energy consumption, but also added value in form of i.a. an improved indoor climate. These measures include improved insulation, change of windows, improved tightness and ventilation.

Conclusion

In a strategy to increase the number of homeowners who venture into a major energy upgrading of their house, the demonstrated positive side effects, more than energy savings, should be included in the communication to motivate homeowners. The barriers should be reduced by "taking the homeowners by the hand" and helping them to choose relevant energy-saving solutions as well as clarifying the financial consequences and opportunities.

The survey among homeowners clearly shows that economy is a decisive factor for initiating an upgrading project, but also that improved indoor climate is a marked added value that the homeowners want and which they would also experience after energy upgrading of their home. ■

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Cumberland Lodge, the venue of the Conference, close to Royal Windsor Castle (in the end of the boulevard).

The Windsor conference focused on the cost of comfort indoors

Summary by
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Cumberland Lodge is situated in the heart of the Great Park of Windsor Castle just west of London. The Queen has granted the use of this beautiful seventeenth-century house as a conference centre for 'discussions aimed at the betterment of society'. It is here that the biennial Windsor conferences have been held over the last 20 years to provide a forum for the discussion and development of the science of thermal comfort and its impacts in terms of energy use in buildings.

Because the venue is located in the middle of the Great Park, and the conference is residential delegates have plenty of opportunity to socialise and exchange ideas and views in this congenial rural setting. These conversations have in turn led both expert and novice researchers to explore and expand new approaches and ideas, and innovative experiences and research findings in the atmosphere created by a unique location and the knowledgeable 'Windsor' audience. The conference has witnessed and informed many major developments in the field over the last two decades - particularly in the field of adaptive thermal comfort.

In the late 20th century, Standards such as ISO7730 were used to suggest limits for the indoor thermal environment based on the Predicted Mean Vote (PMV) index based on a simple steady-state physiological model. The model worked quite well in buildings with mechanical heating or cooling but the thinking that a 'right' temperature actually exists meant that the recommended thermal comfort limits tended to shrink at a time when narrower limits were assumed to be better.

A constant indoor temperature was one way to provide comfort – but was it the only way? Other researchers, using field studies, had found that the conditions people find comfortable change from season to season or climate to climate. This realisation led to the approach called adaptive comfort (Nicol et al 2013). A major contribution of the early Windsor conferences was to encourage and help guide the development of 'adaptive' standards for indoor temperature.

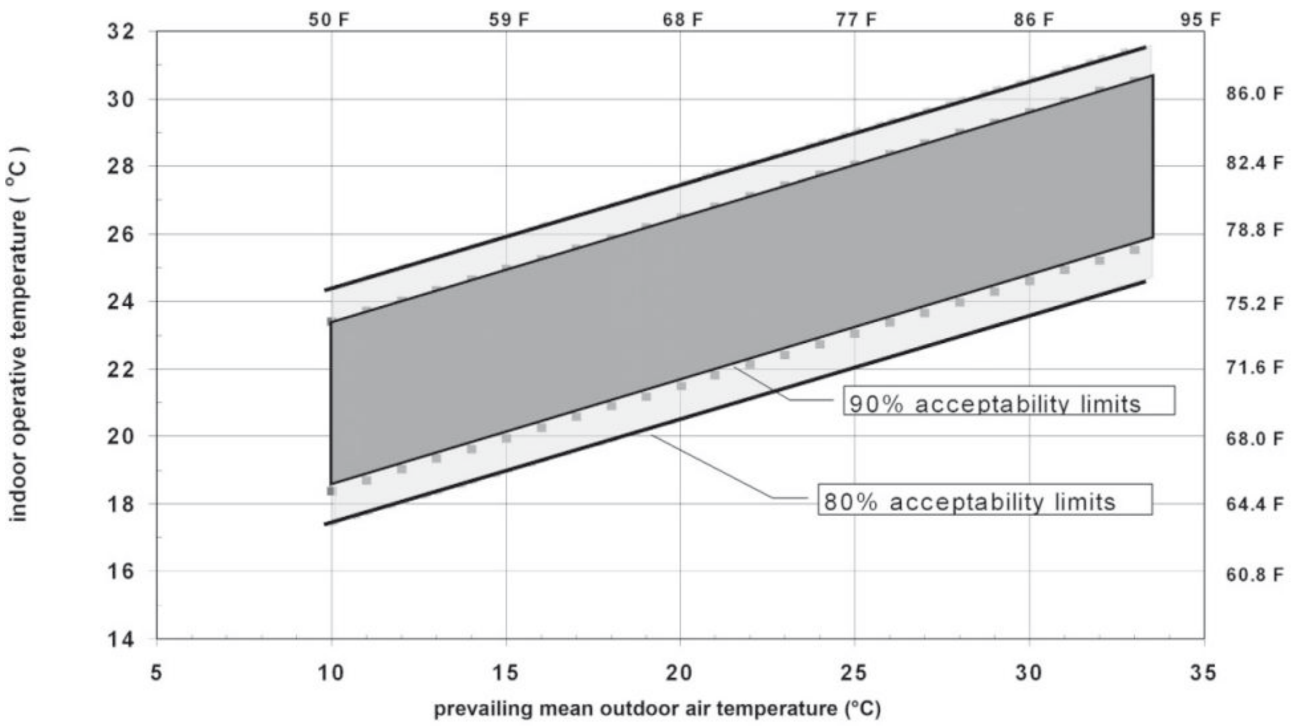

Figure 1. Acceptable operative temperature ranges for naturally conditioned spaces. Source: ASHRAE 55 (2013).

The science for these standards is based on analyses often first aired at Windsor. Their significance was that they recognised that indoor temperatures which might be unacceptable in buildings with mechanical cooling or heating could often be found comfortable in the more variable conditions found in naturally ventilated buildings. The standards (ASHRAE 55 and CEN 15251) have now been in place for some years.

Windsor 2014

The theme of Windsor 2014 was *Counting the cost of comfort in a changing world*. The theme was not strictly adhered to as Scientific research tends to follow the interests of the researcher and of the funding bodies, but it did lend some direction to the deliberations at the conference.

Several problems of and challenges for adaptive standards were addressed with some papers dealing directly with weaknesses in the current standards and in particular with the ranges of acceptable environment they allow. Others investigated the applicability of standards based studies done largely in offices with adult populations.

Papers reported comfort studies using different occupants and occupancy patterns in homes where people may have different motivations and access to adaptive opportunities, and also in laboratories or mosques where occupancy may be very different from day to day and variable within any day. Evidence was given that schools may need to be considered differently as the sensitivity of children appears to vary from that of adults. Extreme climates such as the high Himalayas and the Arabian Desert can suggest comfort limits which may seem strange to people from more temperate climes.

A paper from Australia explored the effect of the motivation - two groups of Australians characterised as 'thermal mavericks'[1] one in Melbourne and one in Darwin show a keen interest in environmental concerns. Preliminary results show how motivation can stretch the 'comfort zone'. The Melbourne cohort were comfortable at lower temperatures than the ASHRAE adaptive model predicts as acceptable, while the Darwin cohort are comfortable at higher temperatures.

[1] The term 'thermal maverick' refers to those occupants who choose to live in a-typical dwellings that do not necessarily have extensive heating or cooling. In Australia, 17.4% of households do not have heating and 26.9% do not have cooling. In the study of these households, specifically dwellings incorporating earth construction components in a cold temperate climate and naturally ventilated houses in a hot humid climate, occupants reported to be comfortable at, or even preferred, conditions outside of the ASHRAE adaptive comfort standard. It has been suggested that the study of 'thermal mavericks' may "*make the strongest case against the further spread of ambient temperature standards*". Thanks are due to Lyrian Daniel and her co-workers at the School of Architecture and Built Environment, The University of Adelaide, Australia for their permission to use **Figure 2** and for these notes on thermal mavericks

Controls and the re-emergence of physiology

The control of indoor conditions in buildings is an enduring Windsor theme. How best can we use windows, fans and shading, for instance to change indoor conditions? Should they be controlled according to an automated algorithm or left to the control of building occupants? How can appropriate simulation algorithms be developed to represent these stochastic factors in a realistic way?

In the early conferences on thermal comfort, a major concern centred on the physiological model of comfort and the definition of its constituents (clothing insulation, metabolic heat and so on). One notable development at Windsor 2014 is the re-emergence of the physiologists. Their concerns are more with the dynamic relationship between occupants in their buildings, reflecting again the emerging 'whole system thinking' within comfort theory. Change is increasingly recognised as natural in our relationship with our environment, stasis is not only expensive to achieve, but often runs counter to our best interests. Even for older people an unvarying environment is not just psychologically boring but may also be reducing the ability of the individual to physiologically cope with change.

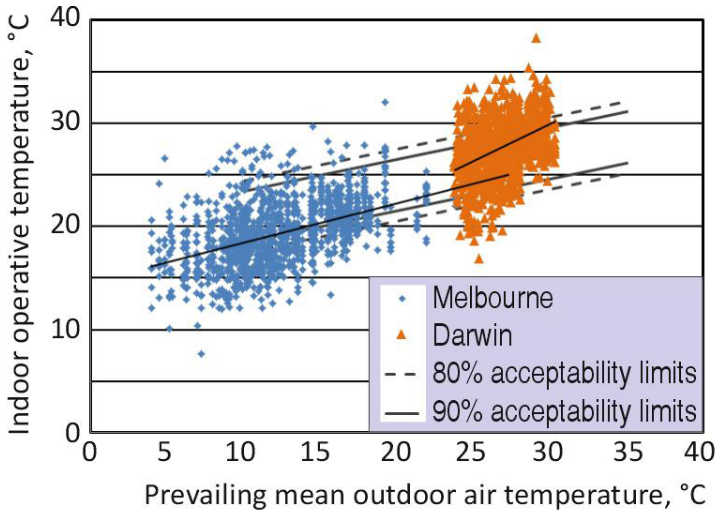

Figure 2. showing the range of temperatures found comfortable by the 'mavericks' in Melbourne (blue) and Darwin (brown) compared to the ASHRAE 55 adaptive comfort zones. The 'best fit' lines for each group are also shown (Source: Daniel et al).

Avoiding Overheating

Much is said about avoiding overheating in buildings especially in the light of global warming, but the exact meaning of the term and the ways to characterise it are still ill-defined. CIBSE has produced a technical memorandum which presents an approach based on sound adaptive principles linked to the European standard EN15251. Evidence from simulations predicts that well designed buildings can stay comfortable as people adapt to new conditions.

The Australian Mavericks will have a different definition of overheating from European office workers, school children or Tibetan householders. This leads to the question "Is temperature the best measure of thermal comfort?" and if not how to best account for climate, culture, ventilation strategy, and, yes, the cost of comfort (or should that be discomfort)? There is still much to discuss at the next Windsor conference scheduled for 7–10th April 2016 at Cumberland Lodge. ■

References

A range of papers developed from papers presented at Windsor 2014 will appear in forthcoming issues of both Building Research Information and Architectural Science Review and will, with the whole gamut of presented papers and ideas from the conference, now available on the NCEUB website, provide a rich and evolving feedstock for the discussions at the next Windsor conference to be held on the 7th – 10th April 2016 at Cumberland Lodge.

A short history and overview of the Windsor conference can be found at http://windsorconference.com.

Conference papers mentioned and the full conference proceedings can be downloaded from http://nceub.org.uk//W2014/webpage/W2014_index.html.

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Comfort, user behavior and energy efficiency – Summary of a workshop at Windsor Conference 2014

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It is widely accepted that the adaptive approach to thermal comfort may be applied to passively cooled buildings and the static approach to air-conditioned buildings.

Though the standards (e.g. EN 15251 or ASHRAE 55) give precise definition that the adaptive approach should only applied to buildings without any kind of mechanical cooling, there is an on-going discussion on the application of the adaptive or a hybrid approach to mixed-mode buildings or low energy buildings with limited cooling capacity (e.g. mechanical night ventilation or thermo-active building systems), respectively. Workshop explored aspects of thermal comfort and user behavior especially for buildings with low-energy cooling concepts.

During the workshop several statements were presented. Workshop participants were invited to indicate (hands up) whether they agreed (YES) or disagreed (NO) with the statements. After which a few YES-voters and a few NO-voters were invited to further clarify their opinions (votes).

A total of 11 statements were discussed. Below the workshop results are presented, one statement at a time.

Statement #1: Users' expectations strongly influence the satisfaction with their thermal environment

Voting result: YES/NO: 95/5%

Arguments of the YES-voters:
- Thermal comfort is very much about the interaction between physiology and psychology, so you have to include psychological aspects like expectations and past experiences
- Adaptation can only occur when people have an idea what to expect / when people have conscious or unconscious expectations
- It's all very much about normative and mental expectations

Arguments of the NO-voters:
- The thermofysiological models, that by definition do not address the expectations aspect, (e.g. as described in ISO 7730) are still very useful

Statement #2: We know how building occupants use controls

Voting results: YES/NO: 15/85%

Arguments of the YES-voters:
- We know already some things have an influence on the use the control, like cultural background, building type and workplace culture
- Also we know that training about the use of controls helps
- And we have a pretty good understanding about how controls are used if the controls are simple and used in a relative simple context e.g. at home

Arguments of the NO-voters:
- A lot of aspects are involved in control use, in general it is a complex issue which we have limited knowledge about
- Building service systems and their interfaces are still often designed with an unclear understanding of what the end user wants and needs in terms of control over their indoor climate
- Man-environment interactions in the built environment should be studied further before we can truly say that we understand the problems and challenges involved

Statement #3: We know how overheating affects behaviour of people at home

Voting result: YES/NO: 20/ 80%

Arguments of the YES-voters:
- See above (YES answers,)
- There have been a few field studies focusing on this (overheating & behaviour)

Arguments of the NO-voters:
- See above (NO answers, second statement)
- There is limited experience with overheating and its impact on behaviour in moderate climates

Other remark:
- Preventing overheating is more difficult then preventing cold stress and due to climate changes overheating is on the rise; an extra reason to study the relation between overheating and behaviour further

Statement #5: We should add 3 extra parameters to the standard 6 'Fanger parameters': i. expectation, ii. imposed variation, iii. available/ perceived control

Voting result: YES/NO: 60/40%

Arguments of the YES-voters:
- It would be a good idea to evolve further the standard physiological models with psychological aspects like expectation, variation and control
- This would be a good idea, but we first need to agree on the purpose and objectives of that new model

Arguments of the NO-voters:
- The standard Fanger model / ISO 7730 should stay as is and should be used for what it's intended for
- If we change the present model we first and for all should start talking in terms of 'predicted percentage of delighted' instead of 'predicted percentage of

Statement #7: HVAC engineers want control over building occupants at all times

Voting result: YES/NO: 30/70%

Arguments of the YES-voters:
- Engineers are trained to be deterministic; the standard engineering approach is to think in terms of cause and effect but that does not really work in systems that include building occupants
- Heating, cooling and ventilation systems are becoming more and more complex, so it is tempting for engineers to keep (often irrational) occupant behaviour out of the calculation

Arguments of the NO-voters:
- Good system design by definition is only possible if one also designs for people-environment interactions
- In recent years, engineers have become more aware of building occupants' wishes and needs

Statement #4: Allowing for occupant control leads to higher energy use

Voting result: YES/NO: 20/40% | 40% neither/nor

Arguments of the YES-voters:
- Occupant control often leads to extra energy use, think e.g. of opening windows during winter

Arguments of the NO-voters:
- If buildings and building systems are designed smart, occupant use of controls does not have to lead to higher energy use
- When you allow for occupant control set points (e.g. for winter heating temperature and summer cooling temperature) can be relaxed which results in energy savings

Arguments of the neither/nor voters:
- It depends very much of the circumstances how offering or not offering occupant control affects energy use, there are just too many parameters

Statement #6: Building occupants want control over their indoor climate at all times

Voting result: YES/NO: 20/80%

Arguments of the YES-voters:
- Generally people like to be in control over their thermal environment, local air quality etc.
- Many people want to know that they are in control even though in practice they might not really use their controls
- Building occupants normally do not like automated control of their indoor climate, people just want to be able to override central control

Arguments of the NO-voters:
- In many situations (e.g. in corridors or in hospital environments) people in fact do not have a need to control their indoor climate
- It depends very much from person to person; quite a few people prefer the indoor climate to be just right without them having to (re)adjust it all the time
- The advantage of a centrally controlled environment is that people can focus on their work and just be productive

Statement #8: Operable windows should be mandatory

Voting result: YES: 100% for dwellings, 80% for schools, 60% for offices | NO: rest

Arguments of the YES-voters:
- From a public health point of view it is important that building occupants have access to operable windows, especially at home
- Operable buildings in dwellings should be obligatory; people should not be totally dependent upon the functioning of mechanical systems
- Both from a physiological and a psychological point of view it is important that building occupants have control over their fresh air supply and room temperature

Arguments of the NO-voters:
- Sometimes (e.g. in offices) it is quite difficult to use operable windows for example in relatively high buildings or with open floor plans
- Allowing for operable window use might lead to higher energy use

Other remark:
- Too much focus on energy efficient buildings could lead to situations where building occupant will be deprived of their operable windows (or where occupants are told that the use of operable windows is prohibited); this should be avoided, buildings should be designed for health and comfort, adequate options for end user control are an essential part of that

Statement #9: Adaptivity and usability in buildings needs to be safeguarded in building codes

Voting result: YES/NO: 95/5%

Arguments of the YES-voters:
- Adaptivity and usability are essential qualities from the end users perspectives so these should be safeguarded in building codes
- Already in the UK proposals have been made to add "usability" in terms of performance criteria in British standards (see e.g. also some of the BREEAM requirements)

Arguments of the NO-voters:
- In general it is difficult nowadays to include extra demands in building codes; partly because most governments in and outside the EU are about less central rules

Statement #10: New building designs should be tested beforehand for adaptivity and usability

Voting result: YES/NO: 90/10%

Arguments of the YES-voters:
- There are six standard criteria for evaluation of usability (according to Fionn Stevenson) that can easily be tested for during the design and construction phase, so why not test it for those 6 criteria?
- Adaptivity and usability should get more attention during the design process; contractors should be forced to also deal with end user's expectations and perspectives
- "Soft qualities" of building designs get in general to little attention and any initiative that tries to change this is welcome

Arguments of the NO-voters:
- An alternative approach could work too; specifically a performance based approach where adaptivity and usability is tested upon delivery and not during the construction phase

Other remark:
- It would be better in this context to talk in terms of "to evaluate" than in terms of "to test"

Statement #11: We should have way more interaction with environmental psychologists

Voting result: YES/NO: 95/5%

Arguments of the YES-voters:
- Building scientists, architects and building system engineers lack quite a bit of knowledge on man-environment interactions and therefore should interact more with environmental psychologists
- Human factors and 'soft qualities' of buildings need to be defined further at conferences like the Windsor conferences and therefore more input from social scientists would be beneficial

Arguments of the NO-voters:
- There are already many studies that deal with people effects of buildings available; we should just start to apply them in practice

A new concept to reduce indoor air particle concentration

The existing techniques used in air conditioning systems allow only limited possibilities to control the particle concentration in indoor air. The air purification concept developed by VTT makes it possible to significantly reduce the indoor particle concentration without increasing the ventilation rate, the size of air conditioning system, and without major increase in energy consumption. The expected reduction of the indoor particle concentration is at least 90% compared with the level achieved with conventional techniques.

Keywords: air conditioning, indoor air quality, air filtration, supply air diffusors, electret filters, particle concentration.






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Indoor air purification concept

A significant reduction of the particle concentration of the indoor air requires that 1) the particle concentration of the supply air can be essentially reduced and 2) considerably more clean air can be supplied into the indoor environment. Considering the techno-economic limitations (investment and operation costs), the prerequisite is that the improvement should be achieved without adding the ventilation rate and the size of the air conditioning system.

Air handling unit solution

In an air handling unit (AHU), the increase in filtration efficiency of the supply air can be achieved by electrically charging the particles and utilizing electret filters for the particle filtration (**Figure 1**). This solution can be usually implemented without major changes in the air handling unit. The electric power consumption due to the charging of the particles is in the range of 1 W/m³/s which is practically insignificant. Because the pressure drop of the charger-filter combination is in the same range as with traditional filters, the energy consumption of fans is not increased.

Air diffuser solution

In an indoor environment, the influence of the filtered supply air can be significantly increased by removing particles also from the secondary air flow induced by the supply air entering room from the diffuser. (**Figure 2**) [1][2]. It must be emphasized that the flow resistance of the particle removal system must be very low. Although the use of mechanical filters with pressure drop below 5 Pa has been reported [3], efficient utilization of secondary air filtration requires much lower pressure drop. The prototype device developed at VTT is equipped with a special electrostatic air cleaning system which provides an effective particle removal at extremely low pressure drop level (<1 Pa).

Applications of the concepts

Some of persons who have been exposed to harmful pollutants (e.g. moulds) of the indoor air have become sensitive to such an extent that they are not able to stay even in renovated indoor air premises [4]. It is reasonable to assume that significant improvement of indoor air quality, achievable without costly modifications of the ventilation systems, could make it possible for these people to continue working, e.g. in office and school buildings.

The new particle filtration solutions enable to produce distinctly cleaner indoor environments only by applying the solutions into existing air conditioning systems. To achieve the best result, both the air handling units and the air diffusers should be equipped with the new solutions.

An example of clean indoor air premise where the concept has been applied is illustrated in **Figure 3**.

Results

The effect of the air purification concept to particle concentration of the indoor air has been measured in VTT´s office building in Tampere, Finland. The supply air filtration solution (**Figure 1**) was installed to an air handling unit that provided the supply air to a small office wing consisting of three rooms. Four air diffusers provided with the particle filtration (**Figure 2**) were installed to the wing.

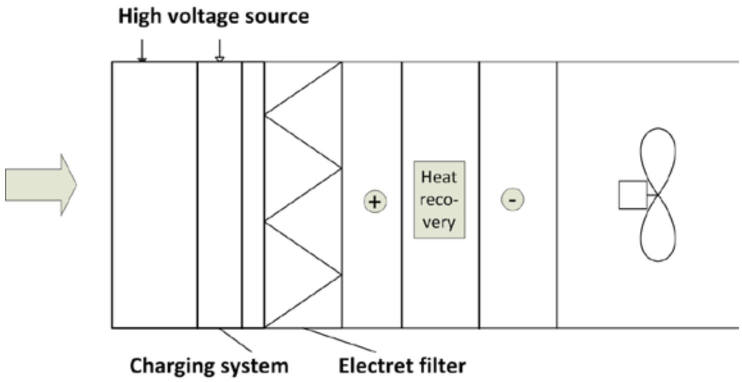

Figure 1. An electric charging system and an electret filter installed in an air handling unit.

Before the installations, the particle removal efficiency of the air diffuser was measured in a 233 m³ laboratory test room. According to the experimental results, it was assessed that with the air diffuser (modified Swegon Parasol) it is possible to achieve ca. 65–67% reduction of the particle concentration in the selected office rooms. It is worth mentioning that the available pressure in the supply air duct was slightly too low for optimal operation of the air diffuser.

After the installations, the particle concentration was monitored from three locations:

- the supply air from the air handling unit into the air diffuser,
- the supply air into the room from the air diffuser, and
- the indoor air.

The particle concentrations were measured in three different conditions:

- neither of the filtration solutions were in use (reference situation with F7 class filtration in the air handling unit)
- the air diffuser solution was in use, and
- both the air handling unit solution and the air diffuser solution were in use.

The measurements were performed with a MetOne 3313 particle counter equipped with a multi-valve sampling system controlled by a computer.

The measurement results are presented in **Figure 4.** The particle concentrations have been normalised based on the particle concentration of the supply air from the air handling unit. When both solutions are off, the relative particle concentration in the room was 92% compared to the supply air from the AHU. The corresponding value was 36% when the air diffuser solution was in operation, and 12% when both the AHU and the air diffuser solutions were in operation.

Discussion and conclusions

According to the results, the ability of air conditioning systems to control the particle concentration of the indoor air can be considerably improved without increasing the ventilation rate or without major increase in the energy consumption. A minor increase of energy consumption

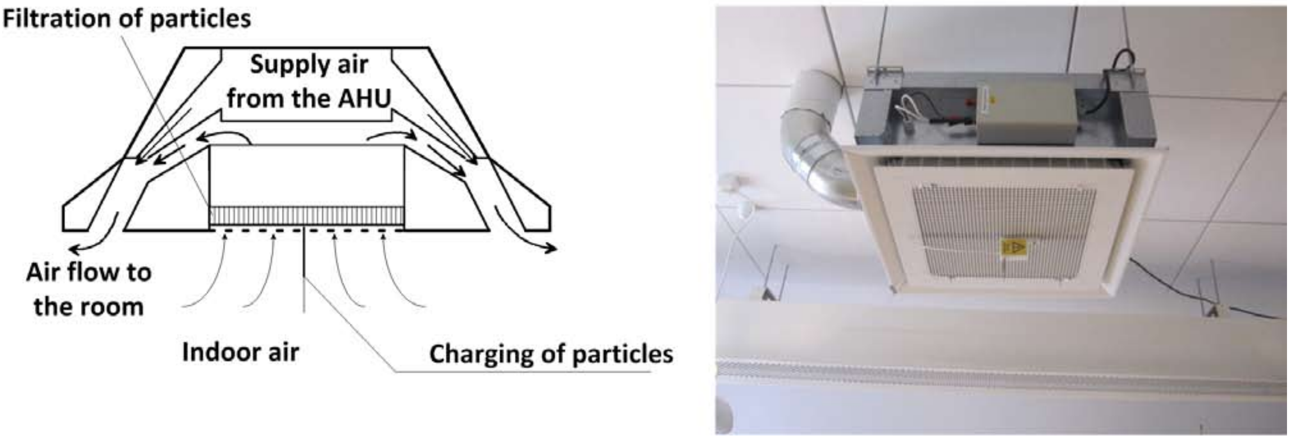

Figure 2. Operating principle (left) and a prototype (right, modified Swegon Parasol) of the air diffuser equipped with particle filtration.

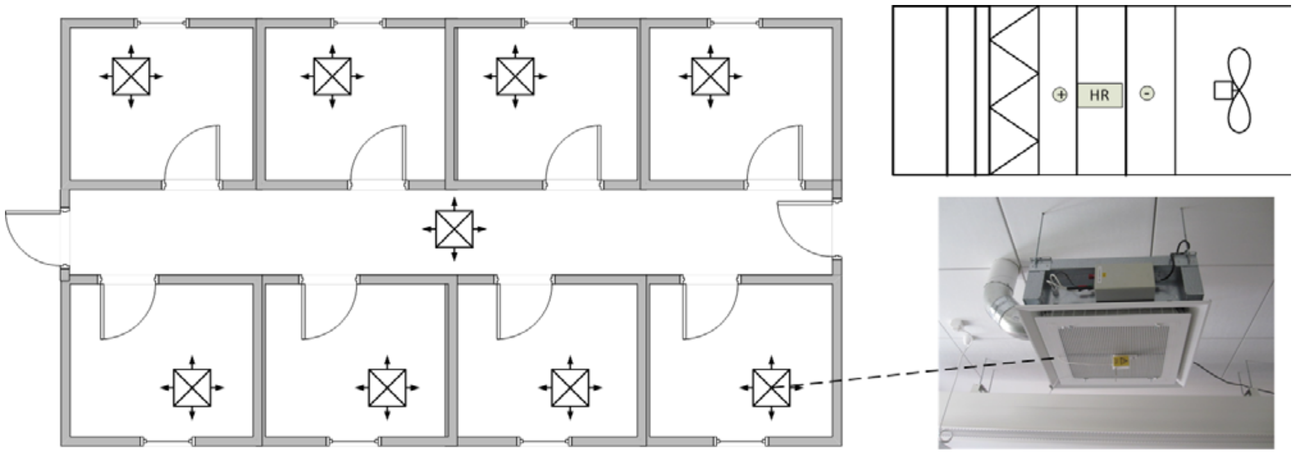

Figure 3. Application of the concept in an office unit: the air handling unit is equipped with the charger/electret filter combination and the air diffusers with the particle filtration.

is possible if the pressure in the supply air duct must be raised in order to generate adequate secondary air flow through the air cleaning system.

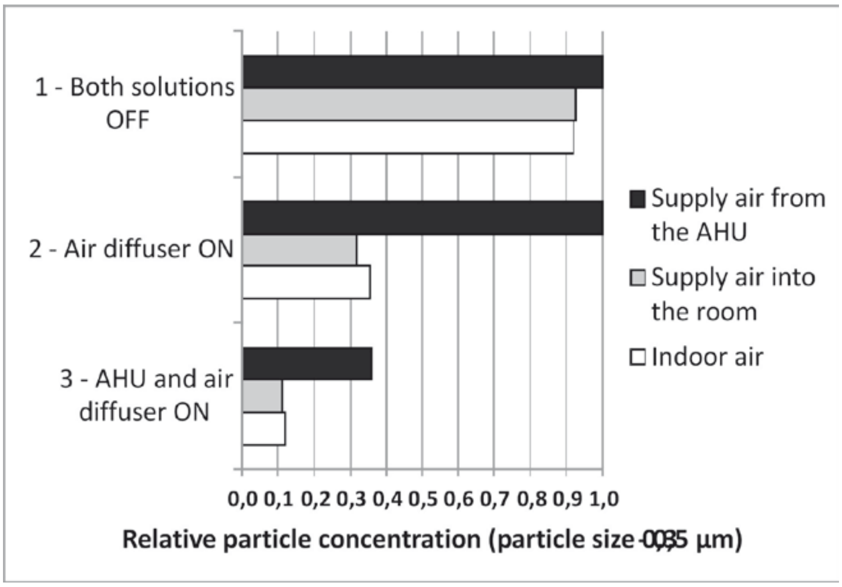

Figure 4. Effect of the air purification solutions to particle concentration in an office room.

In the laboratory studies, it was assessed that with the used air diffuser solution it was possible to achieve ca. 65–67% reduction of the particle concentration. In practice, the particle reduction in an office room was slightly lower, 63%. This is probably due to the air infiltration, i.e. uncontrolled air flows through the air leaks in the building. It has been estimated that the achieved reduction percentage can be regarded as typical value for the new air cleaning system. However, it must be emphasized that the prototype system was constructed from an existing supply air device. It is possible that the operation of the air cleaning technique can be improved by careful optimization of the structure of supply air diffuser.

The subsystems of the modular concept can be used together or separately depending on the application and the target level of the particle concentration. To achieve the best result (90% reduction), both the air handling units and the air diffusers should be equipped with the novel filtration solutions. The air purification solutions presented in this paper can be used to create building sections with enhanced indoor air quality e.g. in office or school buildings, hotels, hospitals or in premises used for demanding industrial production. ■

Acknowledgement

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The electric filtration technique of the air handling unit has been studied in 2012-2013 funded by VTT.

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Modifications to the Eurovent Energy Efficiency Classification for Air Filters

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EN779:2012 CLASSIFIES, EUROVENT VERIFIES
The classification of an air filter has no value if it is not verified by an independent party. Eurovent therefore carries out an annual, independent assessment to verify the promised performance of air filters, in accordance with EN779:2012. As a result, Eurovent certifies the filtration efficiency, pressure drop and energy efficiency. Manufacturers that participate in Eurovent, including AAF, are entitled to display the Eurovent logo: proof that their air filters live up to the promise based on the EN779:2012 classification.

For 2014, the Eurovent Energy Efficiency Classification has undergone several modifications. The modifications comprise the energy efficiency classification itself and the design of the energy label. Air filters that were A rated in 2013 remain A rated in 2014, but as from now on in bright blue instead of dark green.

Keywords: Eurovent certification, Eurovent Guideline 4/11, energy efficiency, energy label, energy use, air filters, filter class, EN 779.

Eurovent, certification of air filters

Eurovent Certification is the European association for certifying performance of air-conditioning and refrigeration products according to European and international standards. One certification programme is geared towards air filters, which are classified and sold as medium and fine filters M5, M6 and F7 up to and including F9, as defined in the EN779:2012 standard. Thanks to certification, customers have the assurance that installed air filters actually provide the performance claimed by the manufacturers.

Energy Efficiency Classification of air filters

Eurovent conducts independent tests not only to measure the performance in terms of filtration efficiency and pressure drop, but also the energy efficiency. For this purpose, Eurovent introduced a new method in 2011 under the name Guideline 4/11: the Energy Efficiency Classification of Air Filters for General Ventilation Purposes. This method helps customers select the most energy-efficient air filters. Eurovent bases its calculation on a test airflow rate of 3400 m³/h, a fan efficiency of 50% and an annual operating time of 6000 hours. The annual energy consumption measured is compared to the limits set for each filter class.

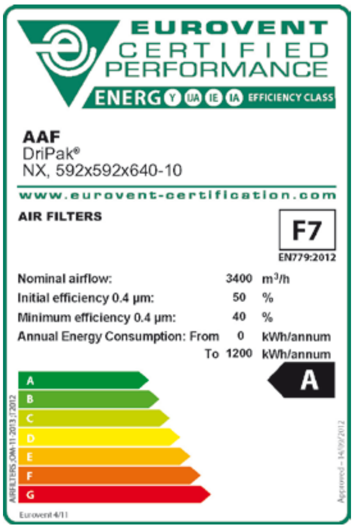
DriPak® NX synthetic pocket filter with A label.

With this method Eurovent can validate the claims of manufacturers concerning annual energy consumption of air filters. The findings are awarded energy labels showing the Eurovent energy logo.

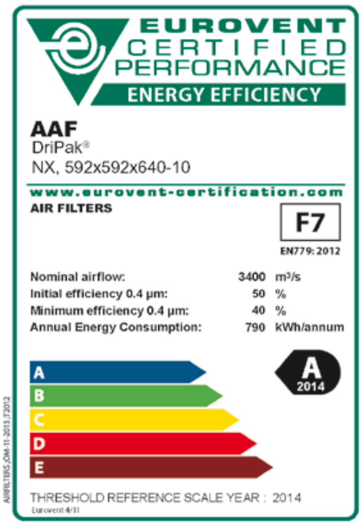
Table 1. Eurovent energy classes of filters based of the new filter classification in EN 779.

Filter class EN779:2012		M5	M6	F7	F8	F9
ME		-	-	ME ≥ 35%	ME ≥ 55%	ME ≥ 70%
		M_m = 250 g ASHRAE		M_F = 100 g ASHRAE		
2014	2013					
A	= A	0 - 650 kWh	0 - 800 kWh	0 - 1200 kWh	0 - 1600 kWh	0 - 2000 kWh
B	≈ B + C	> 650 - 950 kWh	> 800 - 1100 kWh	> 1200 - 1700 kWh	> 1600 - 2300 kWh	> 2000 - 3000 kWh
C	≈ D + E	> 950 - 1250 kWh	> 1100 - 1400 kWh	> 1700 - 2200 kWh	> 2300 - 3000 kWh	> 3000 - 4000 kWh
D	≈ F + G	> 1250 - 1550 kWh	> 1400 - 1700 kWh	> 2200 - 2700 kWh	> 3000 - 3700 kWh	> 4000 - 5000 kWh
E	= G	> 1550 kWh	> 1700 kWh	> 2700 kWh	> 3700 kWh	> 5000 kWh

Modified classification of energy efficiency with class limits for the annual energy consumption. Including comparison between energy label in 2014 and 2013.
Source: Eurovent Guideline 4/11 2014. ME = Minimum Efficiency according to EN779:2012.



Energy label 2013



Energy label 2014

MAIN CHANGES SUMMARIZED:

- 5 Energy classes instead of 7
- Class A remains best, class E is worst
- New color coding of energy classes
- Mentioning of exact kWh values
- Introduction year now included

Important guideline changes for 2014

For 2014, the Eurovent Energy Efficiency Classification has undergone several modifications, comprising the energy classification itself as well as the design of the energy label. The most notable changes are summarized below.

The number of energy classes has gone down from 7 to 5 classes. Class A remains the best level and class E has become the worst level; energy classes F and G have been removed. Also the limits between the energy efficiency classes have been modified with the exception of energy class A.

New design of the energy label

The new 2014 energy label will show a different color coding of the energy classes. Class A is from now on displayed in blue instead of green and the worst class, now being E, is in brown instead of in red. In contrast to the 2013 energy label, which showed energy consumption ranges (e.g. 0 - 1200 kWh for an A rated class F7 filter), the 2014 energy label includes the exact energy consumption of the air filter. This makes it easier for customers to distinguish between an average A rated filter and an excellent A rated filter. The differences in annual energy costs between various A-label air filters could run as high as several tens of euros per filter per year. A bright blue filter pays for itself quickly simply as a result of its energy savings.

Only for Eurovent certified manufacturers

Not all manufacturers of air filters are allowed to display the new Eurovent energy label; it is restricted to air filter manufacturers officially certified by Eurovent. This means that only the new energy labels including the original Eurovent logo give the assurance that the performance in dependently validated. A summary of the modifications to Eurovent Guideline 4/11 for 2014 can be found on: http://www.slideshare.net/aafeurope/eurovent-guidelines-411-2014. ■

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Protected zone ventilation reduces personal exposure to indoor pollution

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The objective of this study is to exam the performance of protected zone ventilation (PZV), which is known as protected occupied zone ventilation (POV) as well, regarding protection of occupants from exposure to various indoor pollutants. Both gaseous and particulate pollutants were used to test the capacity of PZV to reduce the personal exposure to various indoor pollutant sources. Two breathing thermal manikins and a cough generator were used in this study to produce exhaled airflow and cough jets, which simulated different indoor pollutant source. PZV is able to separate an indoor space into a source zone and a target zone with different pollutant concentration. The direct exposure of target manikin to breathing airflow and a cough is significantly reduced by using PZV with higher supply air velocity. The results may be used to make a guideline to design an efficient PZV system for different industry and engineering applications.

Keywords: ventilation, protected zone ventilation, air jets, cross contamination, protective ventilation, air curtain

Introduction

Airflow distribution plays an important role in the indoor environment, where people spend over 90% of their time. Nowadays global epidemic respiratory diseases break out more often than ever, for example tuberculosis (TB) (1990), SARS (2003) and H1N1 (2009), which took place in many countries (WHO website and the CDC website). In some special application, the indoor air change rate can be as high as 12–42 ACH. However, recent studies show that mixing ventilation alone is not able to reduce substantially the exposure to indoor pollutant (Melikov et al. 2011, Mazumdar and Chen, 2009). Regarding the exposure to exhaled airflow, the exposure risk can be as high as 20 times by using MV than other ventilation method (Olmedo, 2012; Nielsen, 2014). However, it is very challenge for these methods to deal with both gaseous and particulate pollutants. Amongst some commonly used ventilation systems, the protected occupied zone ventilation (POV) was developed to reduce the personal exposure to indoor pollutant (Cao et al. 2011). POV has similar form as an 'air curtain', which may be used to prevent the transfer of heat from indoor to outdoor via door way (Sirén, 2003). Pollutants source will be located in the source zone, and even a sick person can be a pollutant source while breathing and coughing. By using CO_2 as indoor pollutant source, the protection efficiency of POV varies from 8% to 50% depending on the exhaust location, supply air velocity and the usage of partitions (Cao et al. 2013). A push-pull ventilation system was proved to be an efficient way to control contaminant and protect occupants. The term of protected zone ventilation (PZV) is similar to POV using downward plane jets to separate an indoor space into a source zone and a target zone, but can be used in some specific conditions.

However, little studies have discovered how different airflow distribution will affect indoor air quality with regards to the transport of gaseous and aerosols particles from the source zone and the target zone. The objective of study is to find out the performance of PZV/POV regarding protection of occupants from exposure to indoor pollutants.

Performance of POV to reduce the concentration of indoor gaseous pollutant in the target zone

Experimental setup and measurement conditions

All measurements were conducted in a full-scale test room for two office workers at Aalto University, Finland. The room has dimensions of (width × length × height) 2.0 m × 4.0 m × 2.65 m. The room was ventilated by a laminar airflow diffuser, as can be seen in **Figure 1**. Measurement were done with room temperature and supply air of 20°C other conditions are shown in **Table 1**.

Results and discussion

Figure 2 shows the average values of measured CO_2 concentration in 6 cases. Results show that the supply air velocity of the plane jet affects the performance of POV. When supply air velocity is 1.75 and 1.5 m/s, the plane jet can separate the protected zone from the polluted zone at 800 ppm. With a lower supply air velocity, at 1.00 m/s, the plane jet does not prevent the transmission of pollutants from the polluted zone to the protected zone. There is almost no difference between the two zones in Case 3, 6 and 9. Which means the pollutant was mixed up in the entire room, which is similar to the performance of mixing ventilation.

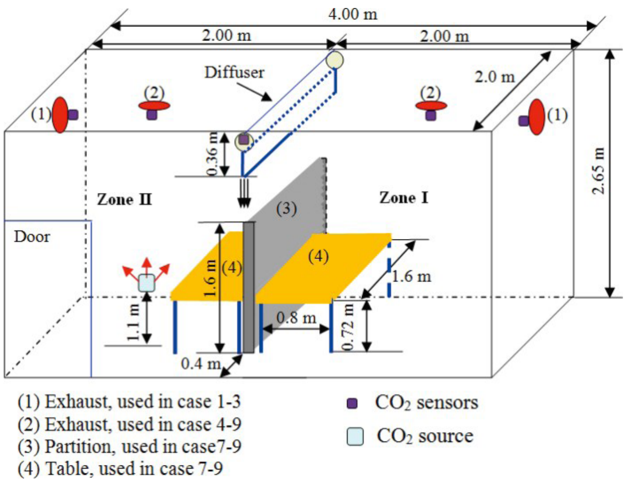


Figure 1. Sketch of measurement set-up of POV with the location of exhaust and diffuser (Cao et al. 2013).

Performance of PZV to reduce personal exposure to breathing airflow

Experimental setup

The climate chamber used in this study is an experimental room with surfaces that can change thermal conditions according to the ambient conditions in Aalborg University, Denmark. The test room was inside the chamber has a size of height, width, length equal to 5.20 m (length) x 2.00 m (width) x 2.50 m (height) (as shown in **Figure 3**). **Figure 3** shows the sketch of the

Table 1. Measurement conditions. (Cao et al. 2013)

	Q_{supply} (l/s)	Average velocity at slot (m/s)	Re at slot	Air change rate of the room	$Q_{e\text{-}left} = Q_{e\text{-}right}$ (l/s)	CO_2 release (L/min)
Case 1	35 ±1.0	1.75 ±0.05	1167	5.9	17.5 ±0.5	4.3 ±0.1
Case 2	30 ±1.0	1.50 ±0.05	1000	5.1	15.0 ±0.5	4.3 ±0.1
Case 3	20 ±1.0	1.00 ±0.05	667	3.4	10.0 ±0.5	4.0 ±0.1
Case 4	35 ±1.0	1.75 ±0.05	1167	5.9	17.5 ±0.5	4.3 ±0.1
Case 5	30 ±1.0	1.50 ±0.05	1000	5.1	15.0 ±0.5	4.3 ±0.1
Case 6	20 ±1.0	1.00 ±0.05	667	3.4	10.0 ±0.5	4.2 ±0.1
Case 7	35 ±1.0	1.75 ±0.05	1167	5.9	17.5 ±0.5	4.3 ±0.1
Case 8	30 ±1.0	1.50 ±0.05	1000	5.1	15.0 ±0.5	4.2 ±0.1
Case 9	20 ±1.0	1.00 ±0.05	667	3.4	10.0 ±0.5	4.0 ±0.1

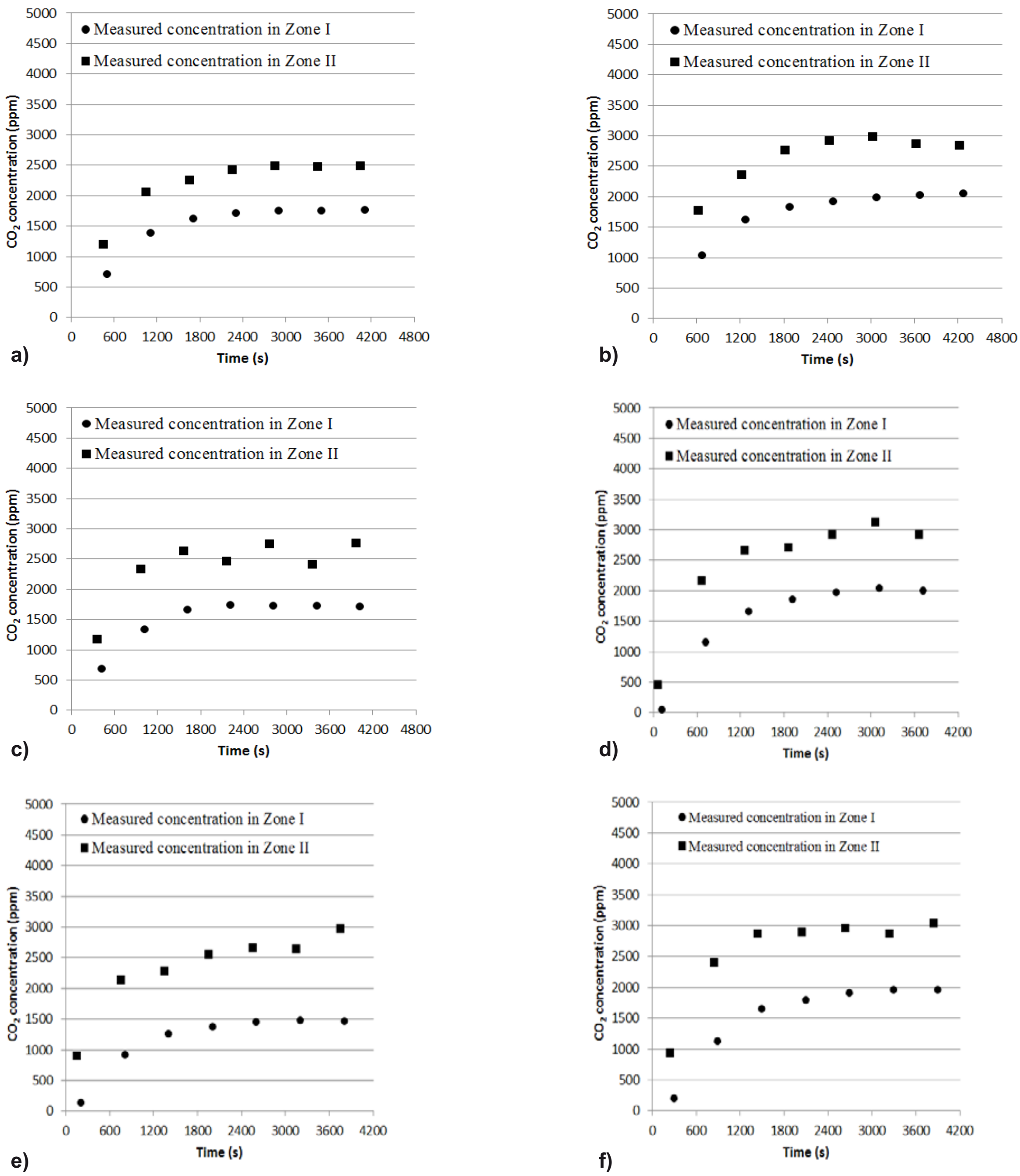


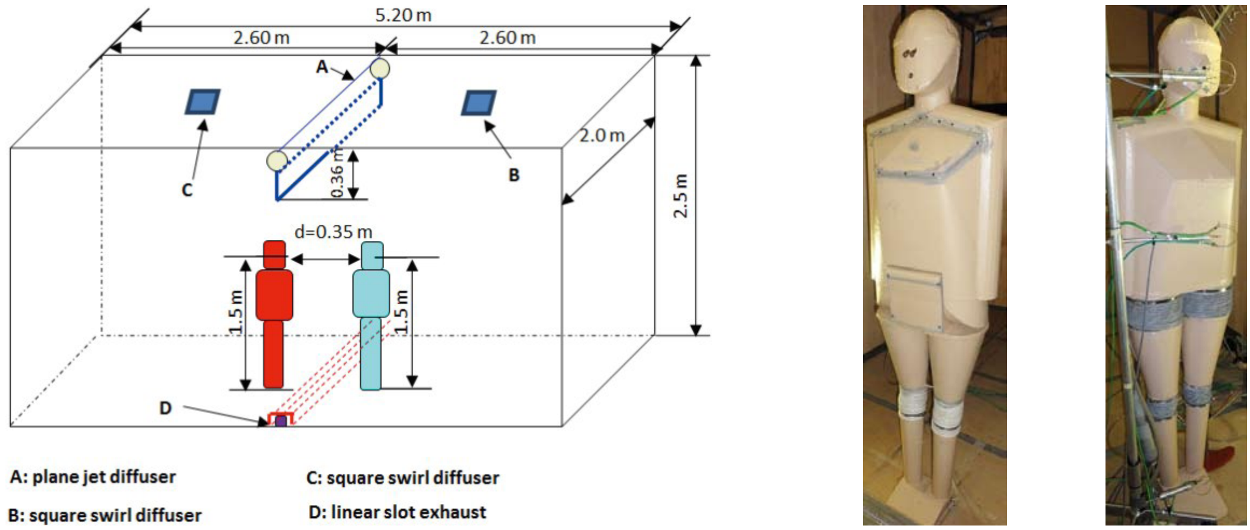
Figure 2. Calculated and measured CO_2 concentration: a) Case 1, b) Case 2, c) Case 4, d) Case 5, e) Case 7, f) Case 8 (Cao et al. 2013).

test room and the locations of the breathing thermal manikin (BTM) and air diffusers.

Mechanical lungs are connected to the manikin to simulate breathing functions. The breathing frequency of the two manikins in the experiments is kept at 16 times/minutes. The manikin simulates a standing person, which has a metabolic rate of 1.2 met. The volume of breathing air is kept at 8.8 L/minutes for each manikin.

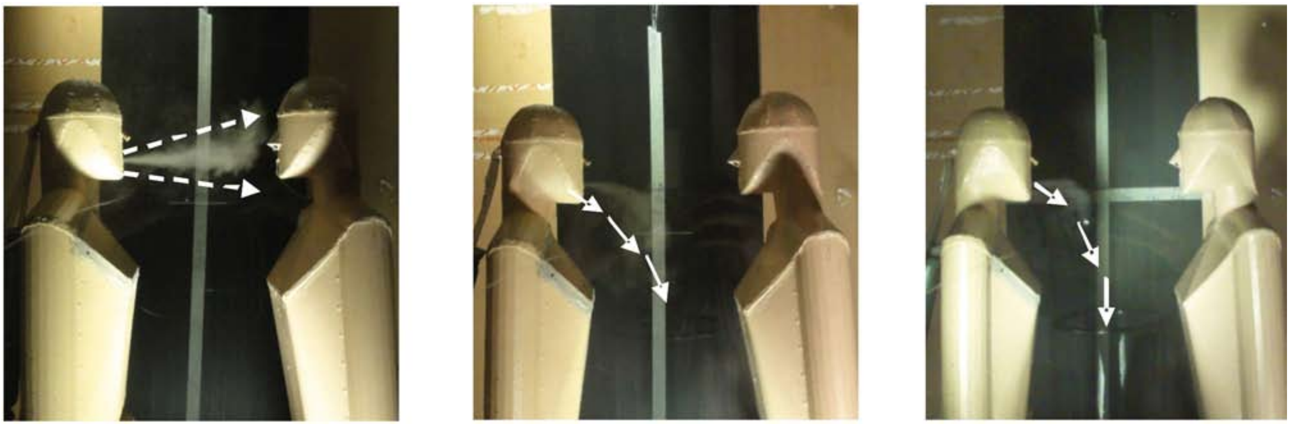
Visualization of the cross-infection risk between two persons

As the cross-infection risk will be very high when the distance between two manikins gets as close as 0.35 m, this section presents the visualization results of the cross-infection risk between two persons with PZV. At a distance of 0.35 m between two manikins, the exposure, c_{exp}/c_R, could be as high as 13 by using downward flow ventilation (c_{exp} is the inhaled concentration of the target person and c_R is the concentration in the return of the



a) b) c)

Figure 3. Sketch of measurement set-up of PZV and photos of BTMs, a) Sketch of measurement set-up, b) source BTM c) target BTM .



a) b) c)

Figure 4. Photos of smoke visualization between two BTM with and without downward plane jet, a) without downward plane jet, b) jet velocity 2.2 m/s, c) jet velocity 3.0 m/s.

room). **Figure 4** shows that when there is no downward plane jet between the two breathing thermal manikins, the exhaled air from the source manikin can easily approach the breathing zone of the target manikin. The exhaled airflow bends to the lower part of the target manikin, which lowers the risk of the cross infection between source manikin and target manikin. When the supply velocity is increased up to 3.0 m/s, the exhaled airflow cannot penetrate the download plane jet anymore.

Performance of POV to reduce personal exposure to a cough jet

Experimental setup

The experiments were performed in a chamber, which is located in the University of Texas at Austin, with dimensions of 2.3 m (length) × 1.94 m (height) × 2.1 m (width) (see **Figure 5**). POV was used to separate a space into a source zone and a protected zone. Total particle concentration was used to calculate the personal exposure value, which means all particle sizes will be summed together by using Aerodynamic Particle Sizer Spectrometer (APS) Model 3321 and AeroTrak particle counter Model 8220.

Results and discussion

The dimensionless exposure index is used to express the risk of personal exposure (PE) to a cough jet (Cao et al. 2013). **Figure 6** shows that the average peak normalized concentration in the breathing zone for MV is 5 times and 20 times higher than by two-slot POV and one-slot POV respectively. The one-slot POV has great potential to reduce the peak concentration than a traditional MV.

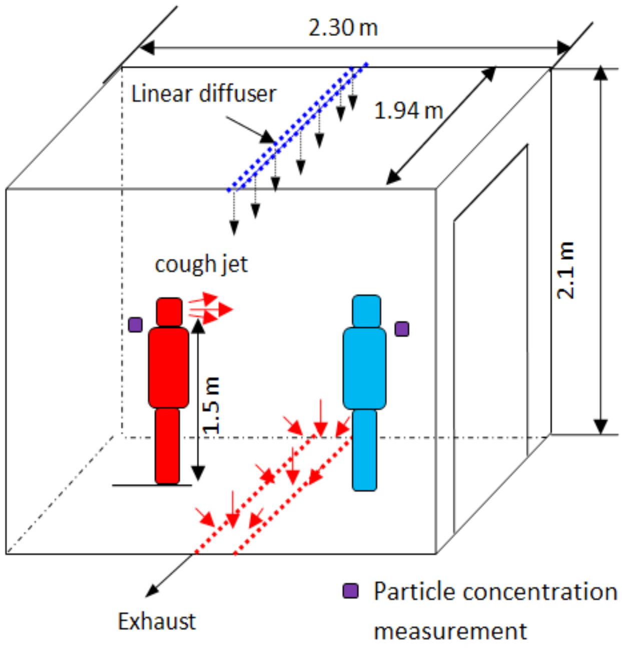


Figure 5. Sketch of measurement set-up of POV and photos of the setup.

Conclusions

The PZV/POV systems using a plane jet is able to separate the room into two zones with a different concentration level of contaminant. This indicates the PZV may protect people from the cross-contaminant in a room with an unknown indoor pollutant source. By using partitions and upper exhaust in PZV, the protected zone can be kept at a lower contaminant concentration in the same room. The personal exposure to the respiratory activities may be very high when the distance between two people becomes very close. The downward airflow in PZV system may bend the exhaled airflow downward and reduce the direct exposure of the target manikin to the source manikin. The direct exposure of target manikin to breathing airflow and a cough is significantly reduced by using PZV with higher supply air velocity. The results may be used to guide the design of an efficient PZV system for different industry and engineering applications. More detailed studies are needed to get a better understanding of the performance of the PZV under different conditions. ■

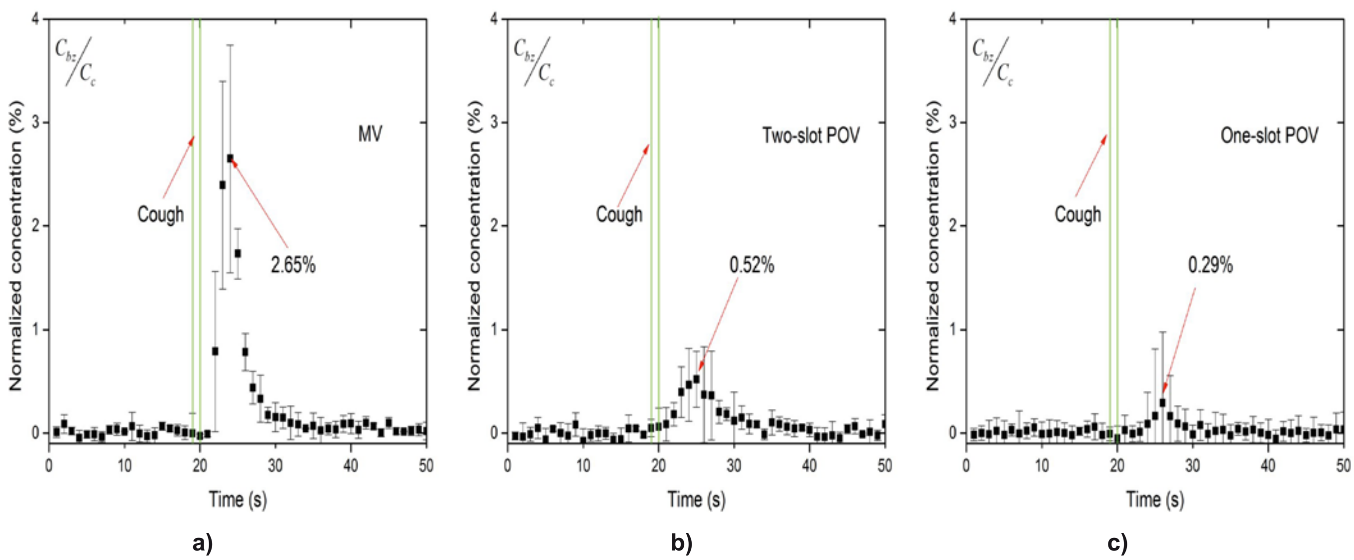


Figure 6. Normalized concentration of coughed particles (0.77 µm) in the breathing zone, a) with MV, b) with POV (two-slot), c) POV (one-slot) (Liu et al. 2014)

Acknowledgement

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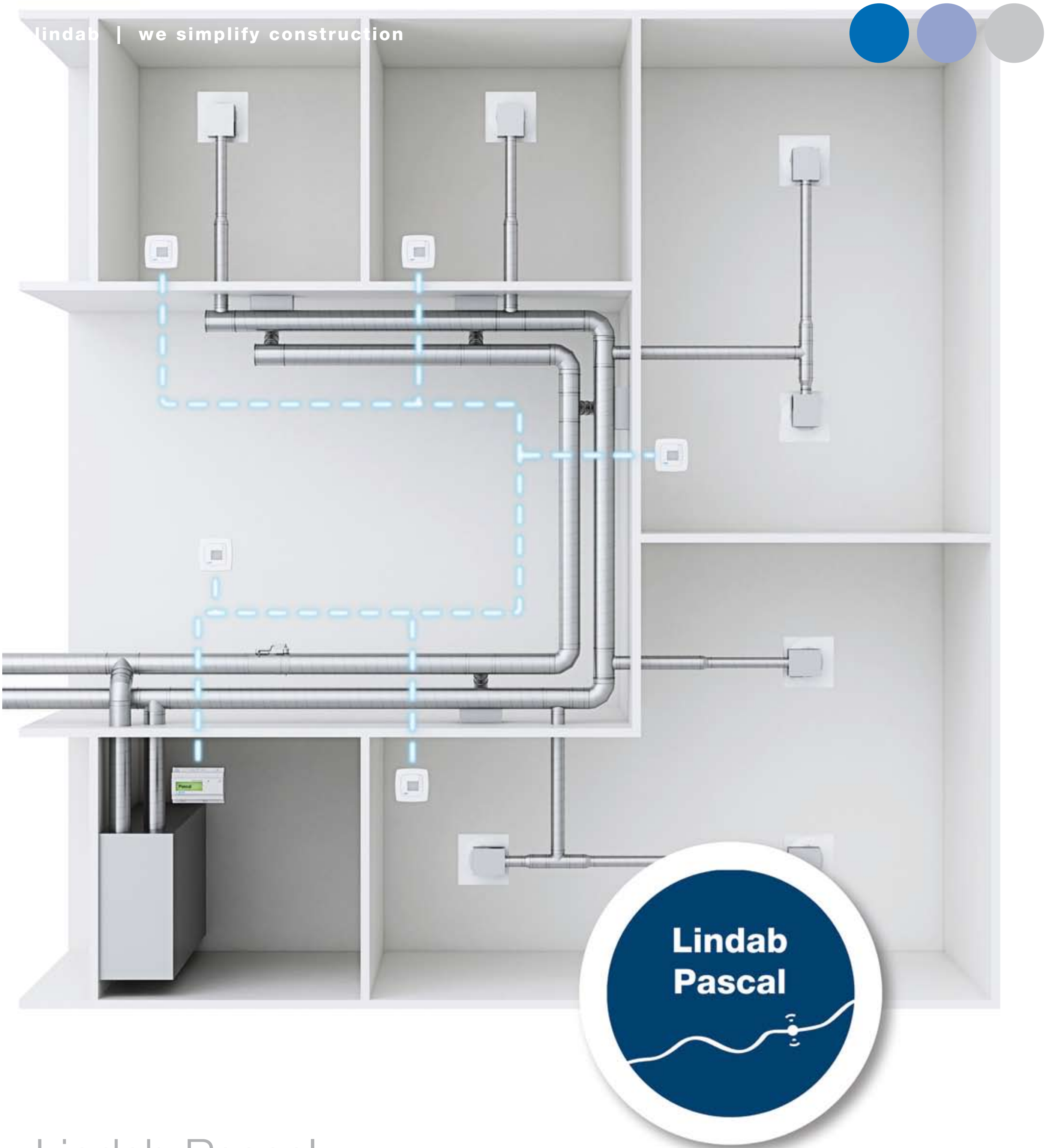

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Stratum Ventilation – A Solution to Meet Challenges to Contemporary Air Distribution

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The goal of decreasing carbon emission and increasing energy conservation is a continuous process. There is no single method for achieving this goal. Should we aim to increase the amount of equipment in order to offset the negative byproducts of our existing systems? In contrast, we can try to decrease the amount of equipment we use. As long as we satisfy the performance requirements, the result will be a decrease in economic and environmental costs. Only with ongoing research and development are we able to make progress towards the correct path. This paper looks at the field of HVAC with regards to the increasing pressure from climate change. It proposes the use of a new type of air distribution system: stratum ventilation, which takes advantage of the allowance for higher indoor air velocities to offset the elevated temperatures.

Keywords: ventilation, air distribution, air jets, stratum ventilation, thermal comfort.

Current Situation

With the looming presence of worldwide climate change (Pachauri 2007), there is constant pressure to make changes to improve the situation. As a result of numerous global conferences and discussions, there is an international consensus to reduce CO_2 emission. The EU has established policies to achieve nearly zero energy buildings by 2020 (Directive 2010/31/EU 2010). A byproduct of these types of buildings, however, is the extreme insulation and airtightness they are constructed with in order to withstand the harsh climates. The result is reduced indoor air quality and thermal comfort in the summer due to the restricted evacuation of heat gains. Therefore, the role of mechanical ventilation is increased in these buildings to compensate for the increase in sanitary and cooling requirements. Alternatively, minimizing the energy consumption used by air-conditioning systems would decrease the amount of CO_2 emission. With this in mind, while revising EN ISO 7730 (Olesen n.d.), Fountain and Aren's theory was used. The theory stated that higher air speed was required to offset increased indoor temperature (Fountain and Arens 1993).

In East Asia, the governments of the various judiciaries have recently issued guidelines and made changes in setting the indoor air temperature during the summer:

- The Hong Kong Electrical and Mechanical Services Department (EMSD) established guidelines to set the room temperature of an air-conditioned space to 25.5°C in the summer months (Electrical and Mechanical Services Department (EMSD), Government of Hong Kong S.A.R. n.d.).
- The National Development and Reform Commission of the Chinese State Council established guidelines to set the indoor temperature to 26°C in the cooling season (National Development and Reform Commission (NDRC), The State Council of China n.d.).

- Room temperature in the "Presidential Office" in Taipei has been set to 27°C after Dr. Ma Ying-jeou's inauguration in May 2008 (NOW news 2008).
- The Ministry of Knowledge and Economy of Korea recommends room temperatures ranging from 26°C to 28°C in summer (Ministry of Knowledge and Economy 2008).
- The Ministry of Environment (MoE) of the Japanese Cabinet has encouraged its citizens to set the temperature of offices to 28°C in summer months (Ministry of the Environment (MoE) 2005).

Although these guidelines are correct from a political and environmental point of view, they are not widely implemented for two reasons. Firstly, the setting of indoor temperature is guided by the thermal comfort of the occupants and not by government regulations. Secondly, even if the room temperature is set to 26°C, only a small percentage of energy savings is obtained using conventional air distribution with a non-reheat air treatment. If a reheat air treatment is applied, even more energy would be consumed. With this in mind, it would be ideal if thermal comfort was obtainable at elevated temperatures while also achieving notable energy savings.

Allowance for increased air velocity

Air velocity is one of the major factors influencing thermal comfort along with air temperature, relative humidity, mean radiant temperature, metabolic rate, and clothing insulation. One of the implications of ASHRAE 55-2004 was that the air velocity should not be perceived by the occupants ($v < 0.35$ m/s). The introduction of ASHRAE 55-2010 allowed for elevated air movement to broadly offset the need to cool the air in warm conditions (ASHRAE 2010). This recent change allows for new opportunities to manage increased room temperatures.

Identifying suitable air distribution systems for elevated temperatures

In order to take advantage of a higher air velocity allowance, a criterion must be established to identify suitable air distribution systems for elevated temperatures. These systems should operate with temperatures and air movements comparably higher but within the range defined by ASHRAE 55-2010. There should be horizontal airflow targeting the head, neck, and chest of the occupants from the frontal or lateral directions. This criterion was based on studies that for light activities, to remove metabolic heat from the brain, cooling should be focused upon an area superficial to the carotid arteries and jugular vein (Williams and Chambers 1971, Brown and Williams 1982, Nunneley et al. 1982, Cohen et al. 1989, Nakamura et al. 2008). Studies also showed that occupants were less sensitive to air movement from the front (Mayer 1992) and sides (Toftum, Zhou and Melikov 1997). Using this criterion, an assessment was made to determine how conventional air distribution systems match up.

Mixing ventilation is the most common air distribution system. With its ceiling-mounted air inlets and outlets, horizontal air movement is not available. Mixing ventilation would have high fan energy consumption if the required air movement in the occupied zone is realized because of the distances between the diffusers and the occupants. It is also not applicable for heating due to the short circuiting of the warm airflows.

Displacement ventilation is thermally driven with air movement flowing upwards from the floor level. It generally provides higher air quality and better ventilation efficiency than mixing ventilation with the same airflow (Awbi 1991). Using horizontal air movement would be contradictory to the concept of displacement ventilation as it would disrupt the thermal plume around the occupants. Displacement ventilation also tends to cause overcooling of the lower zone, causing discomfort at the leg area of occupants (Wyon and Sandberg 1990). Similar to mixing ventilation, using displacement ventilation for heating would cause short circuiting of the airflow because the warm supply air is buoyant.

Using personalized/task ventilation would satisfy the established criterion. This type of air distribution supplies occupants with air from nozzles located nearby plus a background general air distribution. It uses nozzles near the occupants to distribute fresh air, providing horizontal air flow. It is very effective at providing adequate indoor air quality with good energy efficiency. However, it is often difficult and expensive to connect ducts and equip nozzles to various indoor spaces. It would also be difficult to manage in cases where the occupants require any sort of mobility and repositioning.

Stratum ventilation for small-medium rooms

The rationale behind stratum ventilation is that the indoor air quality and thermal comfort are unimportant beyond the occupied zone. In addition, the indoor air quality below the breathing zone is not important.

Stratum ventilation uses air inlets and outlets mounted on the wall(s) as shown in **Figures 1 and 2**. The air is supplied directly into the breathing zone, forming a young air layer as shown in **Figure 3**.

The occupants get the benefit of good IAQ by staying within the air supply streams and gaining more exposure to the fresh air. The age of air is younger and the CO_2 concentration is lower compared with conventional air distributions (Lin et al. 2012, Tian et al. 2010 and 2011). Unlike with mixing ventilation and displacement ventilation, the return air inlets mounted in the occupied zone allow for the possibility of heating, where the stratum effect is maintained.

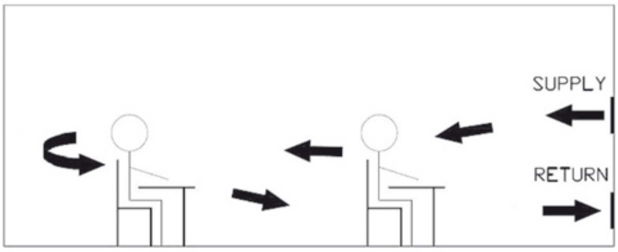

Fig 1. Conceptual design of stratum ventilation.

Fig 2. Application of stratum ventilation in a classroom.

Fig 3. Demonstration of the air supply stratum with smoke.

This setup creates a modest, reverse temperature gradient (**Figure 4**) in the occupied zone, preventing the lower zone from being over-cooled. The thermal sensation of stratum ventilation was explored alongside mixing ventilation and displacement ventilation with an experimental study involving human subjects. The same subjects were subjected to varying room temperatures in a thermal sensation analysis. Using the thermal sensation votes, it was determined that mixing ventilation, displacement ventilation, and stratum ventilation had a neutral temperature of 24.6°C, 25.1°C, and 27.1°C respectively as shown in **Figure 5** (Fong et al. 2011).

This shows that stratum ventilation is more suitable at operating in elevated temperatures than conventional ventilation systems. A larger database comprising of the aforementioned data and data also for varying supply airflow rates and air diffuser types reveals that stratum ventilation can provide a uniform thermal environment (Cheng et al. 2014).

Energy savings with stratum ventilation

There are eight factors which contribute to the energy savings of stratum ventilation in comparison to conventional systems.

1. The neutral temperature of 27°C yields a higher humidity ratio for same relative humidity, lowering the latent load.
2. The higher neutral temperature means there is a smaller temperature difference between the indoor and outdoor space, resulting in smaller transmission loads.
3. The smaller enthalpy difference between the indoor air and outdoor air means there is a lower ventilation load.
4. There is a longer free cooling period because of the higher enthalpy of the indoor air.
5. The higher ventilation effectiveness means a lower ventilation load.
6. The reverse temperature gradient in the occupied zone means there is no over-cooling of the lower zone.
7. The elevated supply air temperature allows the associate chiller to have a higher evaporative temperature.
8. The lower cooling capacity permits the use of smaller pumps and fans.

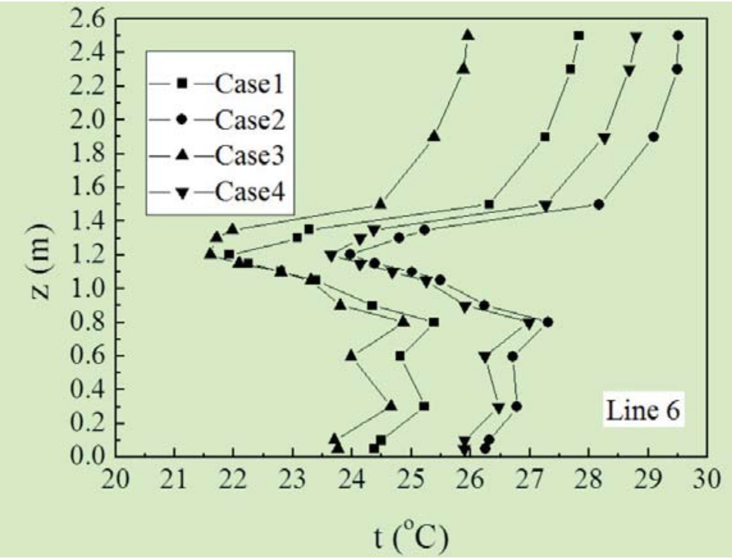

Fig 4. Vertical temperature profile of stratum ventilation.

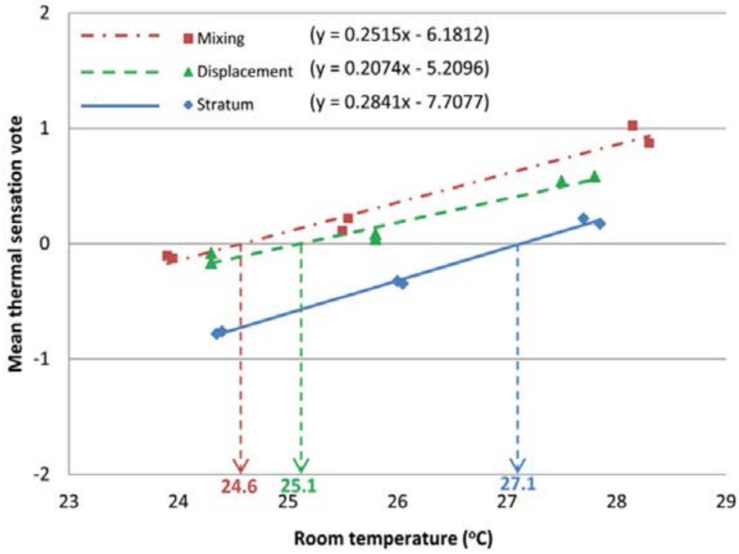

Fig 5. Thermal sensation votes of subjects.

A simulation of the year-round electric energy consumption of a typical office, a typical retail shop and a typical classroom in Hong Kong shows that stratum ventilation provides a significant amount of energy savings as seen in **Table 1** (Lin et al. 2011, Lee et al. 2013). The electrical energy consumption includes the entire air conditioning system, namely chiller and AHU (fans are inclusive), but excludes lighting, appliances in the rooms and other non-air-conditioning equipment in the rooms.

Overall, stratum ventilation is novel in that it is an innovative air distribution design concept while being old technology that requires only existing components, minimizing the risk of failure. The smaller capacity of stratum ventilation leads to smaller mechanical plants and ductwork, smaller air conditioning systems that take up less space, and substantially lower year-round energy consumption. These aspects yield lower initial costs, operational costs, and a smaller life-cycle carbon footprint.

Table 1. Comparison of the year-round energy consumption between different ventilation systems.

Air distribution system	Electric energy consumption (kWh/netto-m²)
Mixing	794
Displacement	592
Stratum	472
	Energy savings
Mixing to Displacement	25.40%
Displacement to Stratum	20.15%
Mixing to Stratum	40.43%

Conclusion

With the presence of worldwide climate change and the corresponding governmental responses, improvements must be made upon conventional air distribution systems. With the introduction of ASHRAE 55-2010, there are new provisions for changes to conventional systems to meet the demands of elevated temperatures. Stratum ventilation has shown the potential to be a significant improvement upon conventional systems. Its use of increased air velocity allows for thermal comfort at temperatures 2.5°C higher while providing yearly energy savings of at least 20% over conventional systems. ■

Acknowledgement

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Please see the complete list of references of the article in the html-version at **www.rehva.eu**
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Automatic volume flow balancing in ventilation units

Keywords: ventilation, air balance, pressure difference, ventilation unit, control, 3ENCULT.

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Controlled ventilation with heat recovery plays an increasingly important role not only in new buildings, but also in energy efficient refurbishments due to the high savings potential and better indoor air quality. Basic information on the need for ventilation (indoor air quality, health and comfort) as well as on energy efficient ventilation systems with heat recovery can be found in passipedia.passiv.de *

In practice however, as a result of incorrectly or inadequately balanced systems, the potential for reducing heat losses frequently cannot be fully exploited, a fact that has often been proved through measurements and subsequent examination of new systems. Within the European Project 3ENCULT about energy efficient retrofit different concepts to achieve long term air flow balance have been investigated.

Significance of volume flow balancing

If a ventilation system is operated in unbalanced state (e.g. due to filter clogging) the ventilation heat losses will increase accordingly since some of the air volume (due to the resulting over- or under pressure in the building) enters the building through leaks in the building envelope (thus bypassing the heat recovery system) rather than via the heat recovery system.

A ventilation system with heat recovery should always be operated in a balanced way. This is the only way to ensure long-term heat recovery efficiency of the ventilation unit and thus achieve energy savings compared with exhaust-only systems. Devices with automatically balanced volume flow rates can secure balanced operation on a permanent basis.

Besides reducing the ventilation heat losses, automatic balancing of volume flow rates also has another essential purpose, namely the prevention of structural damage, which plays an especially important role in relation to historical buildings. If warm, humid indoor air penetrates the thermal building envelope towards the outside through leaks, condensation occurs at materials with temperatures below the dew-point temperature and may lead to structural damage.

In terms of building physics, the risk of damage due to moisture in historical buildings is much higher than in the case of new constructions; in historical buildings, it may be difficult to achieve a consistently airtight building envelope which is equally effective all over, on account of problems due to existing structures such as wooden beam ceilings. In order to compensate for these weak points, balanced operation of the ventilation system becomes even more important.

Available practicable methods and accuracies

Large ventilation systems with ventilation performance > 600 m³/h are usually equipped with a system which ascertains the volume flow rate by means of a measurement of the effective pressure at the fan's inlet. With this method, a high rate of accuracy could be achieved; laboratory measurements of ventilation units with air flow rates > 600 m³/h (within the framework of Passive House component certification of ventilation units with ventilation performance > 600 m³/h, see www.passiv.de) prove that at upper and middle air flow rates deviations (between device measurement and laboratory measurement) of less than 3 % are possible (**Figure 1**).

Today smaller ventilation units for single dwellings (< 600 m³/h) frequently also have systems for automatic volume flow balancing. Constant volume flow fans utilise the relationship between the rotational frequency (rpm) and power consumption of the fans and the volume flow rate. In the case of fans that have forward-curved blades, the volume flow rate can be clearly determined from their

*http://passipedia.passiv.de/passipedia_en/planning/building_services/ventilation.

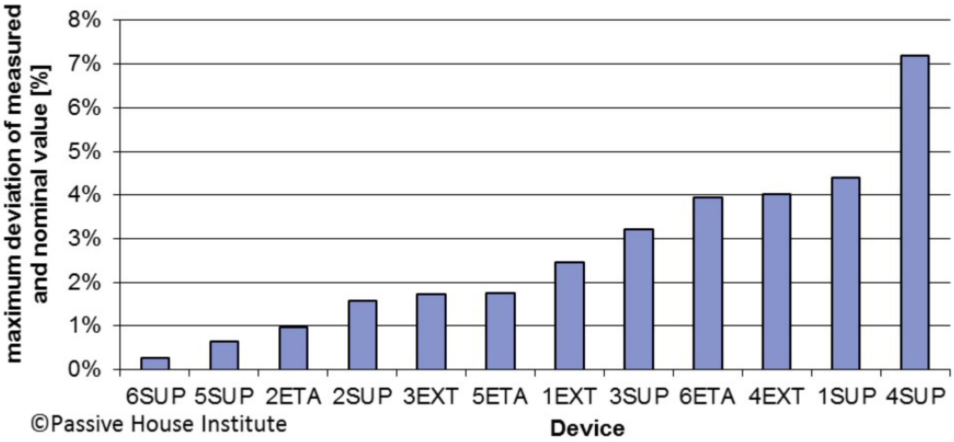

Figure 1. Measured results of volume flow balance with ventilation units > 600 m³/h within the scope of certification as Passive House Component: Maximum deviation of the displayed value (set point) from the measured volume flow rate based on the set point value in the middle operating range.

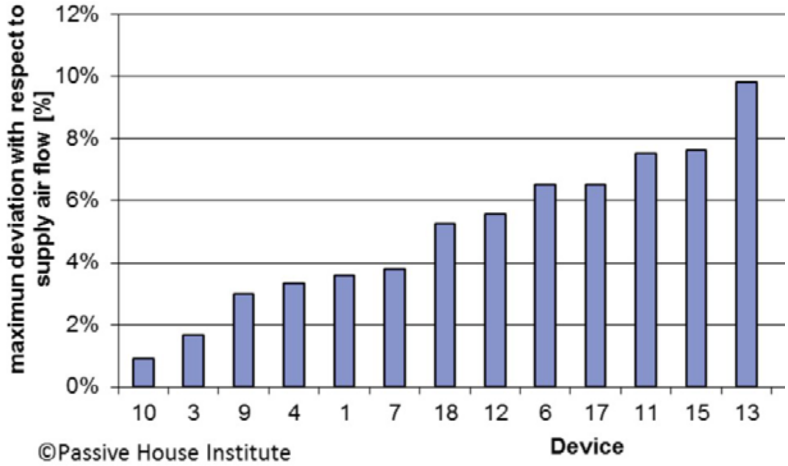

Figure 2. Measured results of volume flow balance with ventilation units < 600 m³/h: Maximum deviation in the supply air and extract air volume flows based on the supply air volume flow in the middle operating range.

characteristic curve only based on the rotational frequency and the power consumption. By comparing the actual and set values and the corresponding readjustment by the fan control, the volume flow rate can be kept constant regardless of the changing pressure drop in the duct work. However, there are still large differences relating to maintenance of the balance (**Figure 2**). Calibration of the flow rate measuring system of the fan to the respective ventilation device in the installed state can lead to significantly improved accuracy of the built-in flow rate measuring system as well as the air flow balance.

Automatic volume flow balancing – practical recommendations

When installing new ventilation systems, it should be ensured that they are equipped with a system for automatic balancing of volume flow rates. In this case, the additional investment provides the following benefits for the user:

- Prevention of structural damage: balanced operation of the ventilation system minimises leakage flows through the building envelope. The potential for structural damage is reduced since lower leakage flow rates also lead to a lower risk of condensation forming inside the building structure.
- Reduction of ventilation heat losses and thus lower running costs for energy: balanced operation of the ventilation system ensures long-term heat recovery efficiency.
- Reduction in maintenance costs: due to a ventilation system which automatically ensures constant volume flow rates. Costs for readjustment of the system (which should be carried out at least every 5 years in the case of a ventilation system without automatic volume flow balance) will not incur.
- Simplified adjustment of the volume flow rates during commissioning

The higher the heat recovery efficiency of the ventilation system and the better the air tightness of the building are, the higher the savings will be with a system with automatic balancing of volume flow rates. Under consideration of the investment costs (manufacturers' estimate of extra costs for end-users: €150 – 200 for separate ventilation units per apartment), in principle this measure will be cost-effective if the air tightness level of the building is 1.0 h^{-1} or better (**Figure 3**). With air tightness values worse than 1.0 h^{-1} advantage in terms of cost can only be achieved with very high heat recovery rates.

In particular for historical buildings, automatic volume flow balancing should still be considered in spite of the mostly rather moderate levels of air tightness. In this regard, priority should be give.n to preservation of the building substance and thus preservation of the cultural heritage.

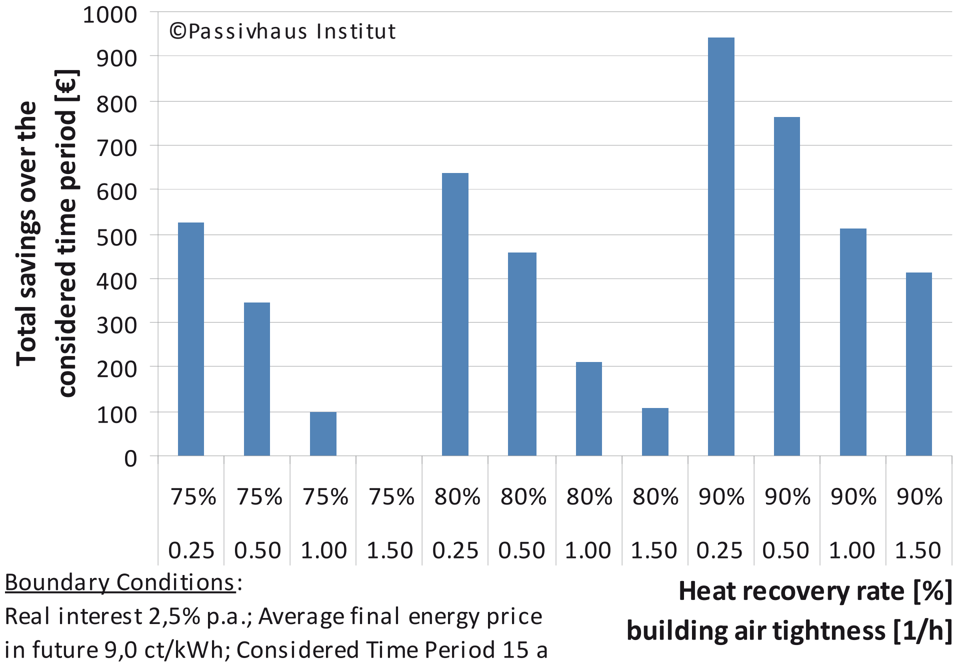

Figure 3. Overall savings achievable with automatic volume flow balancing throughout the period under consideration in comparison with non-balanced systems (assumptions: degree of balance of the non-balanced system = 65%, degree of balance with automatic volume flow balancing = 100%). Boundary conditions: ventilation device for one dwelling 120 m³/h; air change rate 0.35 h^{-1}.

The following points should be kept in mind when choosing the system:

- As far as possible, devices with built-in systems should be used, as these do not depend on oncoming flow conditions in the duct and require no extra effort for installation. In addition, one source of error is avoided due to the fact that the volume flow measurement device is usually integrated into the fan system.
- Ventilation systems with ventilation rate over 600 m³/h are usually equipped with a system for automatic balance adjustment in any case. A high quality is essential; this can easily be checked by means of a test stand measurement by comparing the test measurement result with that of the built-in volume flow rate measuring device.
- Today smaller ventilation units (< 600 m³/h) frequently also have systems for automatic volume flow balancing. However, there are still large differences relating to maintenance of the balance. Calibration of the flow rate measuring system of the fan to the respective ventilation device in the installed state can lead to significantly improved accuracy of the built-in flow rate measuring system as well as the air flow balance.

Attention should be given to the following points when adjusting the balance:

- The balance between the outdoor air flow and exhaust air flow should always be adjusted as accurately as possible.
- **In the case of historical buildings:** If it is not possible to improve air tightness to a high standard during the retrofit, a small amount of extract air surplus (maximum of 10%) can be set when adjusting the ventilation system in order to protect the building structures, as the risk of structural damage due to supply air surplus is much higher than it is in new constructions.

However, in order to maintain the extract air surplus, here also it should be ensured that the ventilation system provides a system for automatically keeping the adjusted air flow rates constant. Control of the extract air surplus in dependence on the pressure difference between critical rooms and the outside by means of suitable sensors is desirable. Due to the thermal lift, critical areas are mainly the upper floors. Therefore measuring the pressure difference towards outside at least there in order to keep a slightly lower pressure inside is recommended. ■

Source

Analysis of the cost-effectiveness of automatic volume flow balancing in ventilation units with heat recovery; report within 3ENCULT project, Passive House Institute, Darmstadt 2014

Thermal comfort with radiant and convective cooling systems

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The difference in thermal conditions between convective and radiant systems is not significant. Contrary to common awareness air temperature and operative temperature are almost similar in room occupied zone with radiant ceiling and chilled beam systems. Experiments with human subjects indicate similar performance of systems with respect to the whole body thermal sensation and acceptability of thermal conditions.

Keywords: radiant cooling, convective cooling, thermal comfort, operative temperature, radiant panels.

To describe human body heat transfer, the concept of operative temperature has been introduced. The combined influence of room air temperature and mean radiant temperatures is expressed as the operative temperature. In normal conditions, air temperature and mean radiant temperature in spaces are equally important for thermal comfort. Compared to a convective cooling system a radiant surface cooling system can achieve the same level of operative temperature at a higher room air temperature. Thus, it is desirable to generate indoor conditions where operative temperature is lower than room air temperature and realise savings in energy consumption.

Providing high convective cooling capacity can result in increased draft risk. In offices where heat loads are often at the level of 60 – 100 W per floor-m^2, it becomes challenging for the designers to provide thermally comfortable conditions as recommended in the present standards (ISO 7730 2005 and EN 15251 2007). Water is much more efficient to transport energy than air: density and specific heat capacity of water is much higher than that of air making it 4 000 times more efficient for the same volume of fluid used. Therefore combined air-water cooling systems are well-accepted solution, i.e. chilled ceiling combined with mixing ventilation, chilled beam, chilled beam with incorporated radiant panels, etc. are nowadays commonly use in commercial buildings. Inlet water temperature of combined air-water systems is typically 14–19°C in cooling mode and 35–40°C in heating mode. Hence, these systems can utilize high temperature level of water for cooling and low temperature level of water for heating allowing to increase the total efficiency. In air-water cooling systems, heat/cold is transferred to room space based on radiation, convection or combination of both. In radiant ceiling panel, the convection and radiant are almost equal (radiation 50%

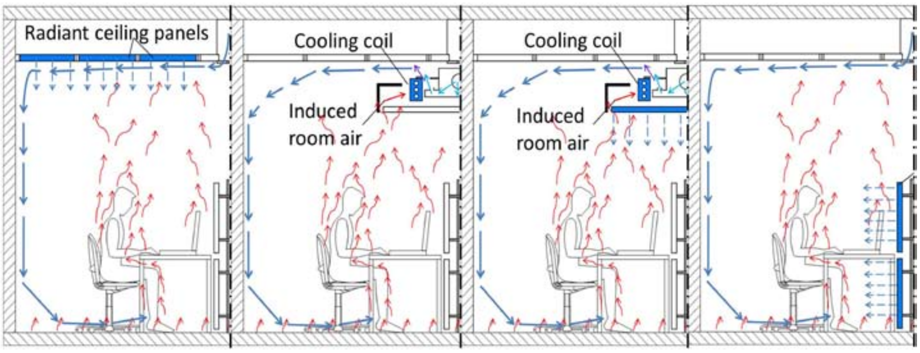

Figure 1. Operating principle of the four cooling systems (from left): radiant ceiling (CCMV), chilled beam (CB), chilled beam with radiant panel (CBR) and mounted local radiant cooling panels with mixing ventilation MVRC. Note: Only half of the room is shown with symmetry line on right side.

versus convection 50%). With chilled beam as with all-air systems, heat transfer is only based on convection.

It is commonly assumed that radiant cooling system has a significant influence on operative temperature. Some companies claim that operative temperature with radiant cooling is even 2 K lower than the room air temperature. However physical measurements performed in the occupied zone of a room showed no significant differences in thermal environment between radiant and convective cooling systems (Mustakallio et al. 2013). The difference in the operative temperatures was only 0.2 K between the two systems. Human perception of a room thermal environment obtained with radiant and convective cooling systems was also studied (Bolashikov et al. 2013). Whole body thermal sensation (TS) and whole body TS acceptability were at about the same level for the convective and radiant systems. Thus, there was not found any significant difference between the systems with regard to human response.

Comparison of radiant and convective cooling systems

The physical environment and human response to four air conditioning systems was studied. The systems comprised: chilled beam (CB), chilled beam with radiant panel (CBR), chilled ceiling with overhead mixing ventilation (CCMV) and four desk partition mounted local radiant cooling panels with overhead mixing ventilation (MVRC), **Figure 1**. Radiant ceiling was Uponor Comfort panel system integrated into the false ceiling tiles. Radiant ceiling covered maximum 77% of the total ceiling surface. The top surface of the tiles was not insulated. Supply air was discharged by two Halton SLN-472 linear diffusers. Halton CBR-2700-2100 chilled beam was used in both CBR case and CB case. For the CB case study there was no water circulation in the face panels of the chilled beam. Radiant panel surface area in chilled beam was 3.6 m². Chilled beam was removed from the ceiling when chilled ceiling cases were measured. The local radiant cooling (MVRC) was used

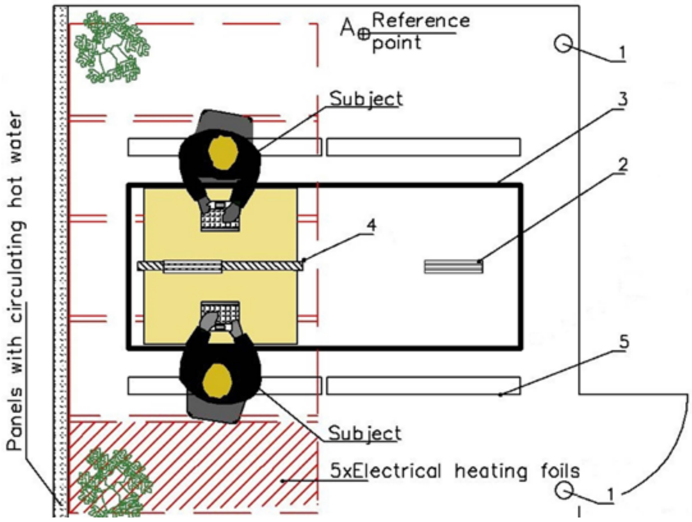

Figure 2. A) Top view of the test room with measurement pole locations: 1) ventilation exhaust, 2) ventilation supply, 3) chilled beam (CB), 4) desk partition mounted radiant cooling panels, 5) light fixtures, B) photograph of the measurement setup in CB, CBR and CCMV cases and C) photograph of the measurement setup in MVRC case (thermal mannequins above were used in actual measurements).

during the experiments with people. Rettig panel radiators, PURMO Hygiene H10, were used to provide local radiant cooling. Supply air volume flow was increased under the MVRC cases in order to compensate for the reduced cooling power from the panel radiators.

Steady state conditions at 26°C air temperature were maintained in a test room (4.12 x 4.20 x 2.89 m, L x W x H) used to simulate the two persons office. Measurements at two heat loads, 64 W/m² (design conditions) and 38 W/m² (usual conditions) were performed. The heat load was generated from two occupants, computers, lighting units, and solar heat gains from windows and sun-lit floor just below the windows (**Figure 2**). Supply air temperature in all cases was kept at 16°C and water inlet temperature at 15°C with return water 2–3 K warmer.

Physical environment

Room air temperature, operative temperature, velocity and turbulent intensity were measured and draft rate levels calculated at 8 heights in the room for a grid of 25 points positioned within the occupied zone of the room. Surface temperatures and radiant temperature asymmetry were measured as well.

Average values of indoor climate parameters from the physical measurements are presented in **Table 1**. Average room air velocities were similar under all four systems. Top five highest velocities were within the range of 0.20–0.25 m/s. Those air velocity values are still in the acceptable range level.

Average room air temperature and operative temperatures were nearly the same with all four tested cooling systems. Average operative temperature was only 0.2 K cooler for the chilled ceiling (CCMV) than for the chilled beam (CB). This difference was close to the accuracy of the sensors. It should be noted that in all cases the average operative temperature was slightly higher than the room air temperature.

The reasons for small difference among the four systems are: 1) the temperature level of radiant surface is relatively high and 2) air distribution and convection flows of heat gains churn the room space. Specially, the effect of convection flow is remarkable with all systems. This is seen in the horizontal room air temperature gradient: there was quite significant temperature difference between window side and door side of the room (in design conditions 1.0–1.2 K and in usual case up to 0.7 K). However, the vertical temperature gradient was small with all system.

Human perception on thermal conditions

The response of twenty-four subjects, 12 males and 12 females all healthy and non-smokers to the thermal environment generated by the four cooling systems was collected during one hour exposure. The exposures to the four systems were randomized. The subjects were not informed which of the systems was in operation. The subjects reported on the whole body and local thermal sensation using ASHRAE's 7-point thermal sensation scale: cold, cool, slightly cool, neutral, slightly warm, warm and hot ASHRAE 55 (2010). EN 15251-2007. The acceptability of the thermal sensation experienced was reported on acceptability scale, from "clearly unacceptable" to "just unacceptable" and from "just acceptable" to "clearly acceptable" (EN 15251-2007).

Under the studied conditions, all four systems showed similar performance with respect to the whole body TS: occupants felt between "neutral" to "slightly warm" on the TS scale in EN 15251-2007. Female felt the whole body TS closer to "neutral" compared to male, whose votes were closer to the "slightly warm" thermal sensation. The whole body TS acceptability was rated closer to ''clearly acceptable" (EN 15251-2007) and was independent of the subject's gender for all tested systems.

Figure 3a compares the medians for each of the four experiments with CB, CBR, CCMV and MVRC systems. As can be seen no major difference were docu-

Table 1. Average values of measurement results.

OFFICE ROOM IN DESIGN (WITH BOLD FONT) AND USUAL CONDITIONS (WITH NORMAL FONT)

Measurement results in occupied zone at heights 0.1 m - 1.7 m	Chilled ceiling with mixing vent.	Chilled beam	Chilled beam with radiant panels
Average air velocity [m/s]	**0.13**	**0.13**	**0.12**
	0.11	0.12	0.11
Average of 5 highest velocities	**0.22**	**0.25**	**0.23**
	0.20	0.25	0.25
Average air temperature [°C]	**26.1**	**25.8**	**26.1**
	26.0	25.8	25.9
Average temperature of window side	**26.8**	**26.4**	**26.9**
	26.4	26.2	26.4
Average temperature of door side	**25.7**	**25.4**	**25.7**
	25.7	25.6	25.7
Average horizontal temperature diff.	**1.1**	**1.0**	**1.2**
	0.7	0.7	0.7
Average vertical temperature diff.	**0.0**	**0.3**	**0.2**
	0.3	0.4	0.2
Horizontal operative temperature diff.	**1.6**	**1.4**	**1.5**
	0.8	0.9	0.9
Vertical operative temperature diff.	**-0.1**	**0.5**	**0.2**
	0.3	0.5	n.a.
Average operative-air temperature	**0.13**	**0.29**	**0.19**
	0.12	0.13	0.10
Average draft rate [%]	**7.9**	**9.5**	**8.1**
	5.7	7.8	6.9
Average of 5 highest draft rates	**14.3**	**18.9**	**17.1**
	11.7	17.4	16.2

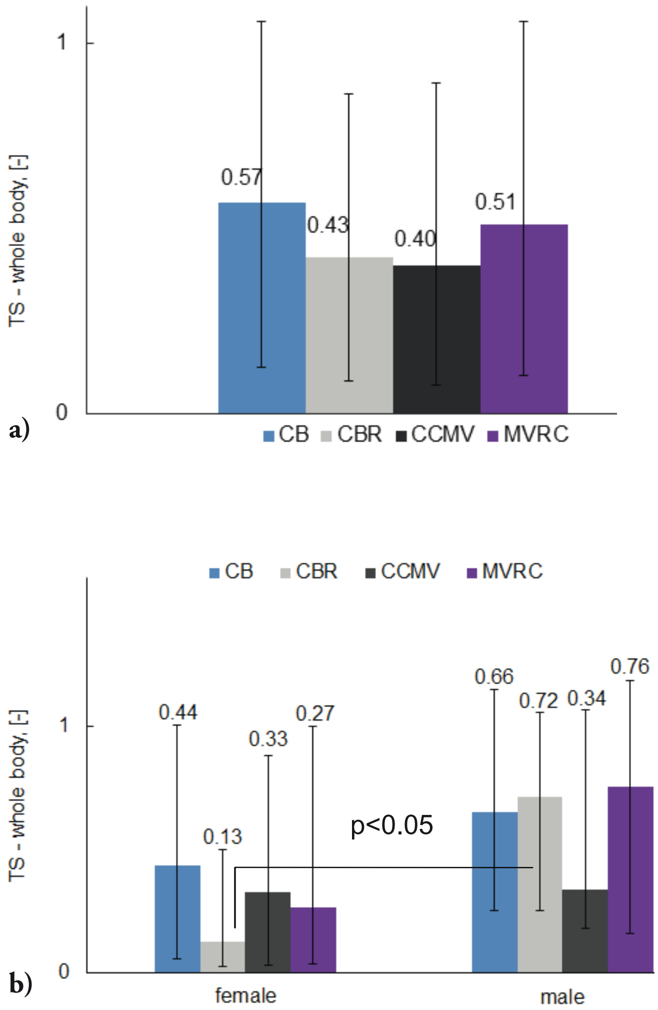

Figure 3. Whole body thermal sensation with the studied systems, CB, CBR, CCMV and MVRC; a) median of the whole body TS over the whole exposure, b) median of the whole body TS over the whole exposure divided by gender.

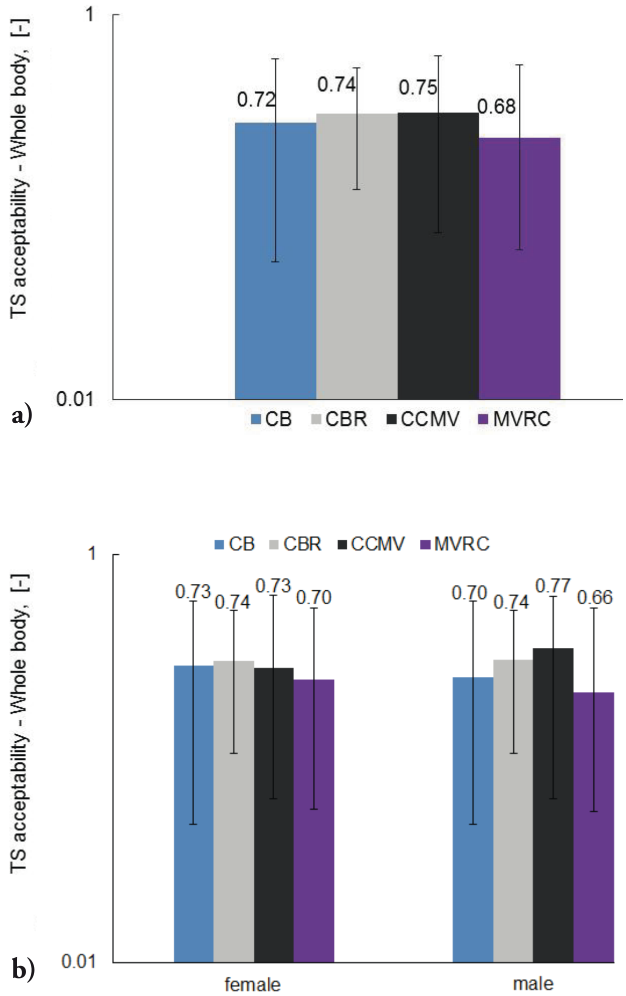

Figure 4. Acceptability of whole body thermal sensation with the studied systems, CB, CBR, CCMV and MVRC; a) median of whole body TS acceptability over the whole exposure, b) median of the whole body TS acceptability over the whole exposure divided by gender.

mented among the four systems tested. All of them managed to keep the thermal sensation of the subjects between "neutral" = 0 and "slightly warm" = 1.

Figure 3b is similar to **Figure 3a**, but here the median vote for the whole body thermal sensation are plotted as a function of the occupants' gender. In general females felt the thermal conditions with all four cooling systems cooler than males, i.e. closer to the "neutral" = 0 sensation. No significant differences were found among three of the four systems. Female subjects were significantly more sensitive to the whole body cooling with CBR than males.

The acceptability of the whole body thermal sensation experienced by the 24 participants with all four cooling systems was evaluated as being close to "clearly acceptable" = 1, **Figure 4**. No clear difference could be observed among the systems based on the acceptability of the whole body thermal sensation felt.

Both females and males rated highly the acceptability of their whole body thermal sensation: the median vote was close to "clearly acceptable" = 1for all four systems. No clear trend in rating the systems based on whole body TS acceptability was documented for the female participants.

Conclusions

- The results revealed that the differences in thermal conditions between the convective and radiant systems were not big.
- An important finding was that air temperature and operative temperature were similar with convective or combined convective and radiant systems. This result was contrary to the expectation that operative temperature would be lower with radiant ceiling and local radiant cooling panel system
- Whole body thermal sensation acceptability was close to "clearly acceptable" with all tested systems.
- Female subjects were more sensitive to the provided cooling than male subjects. ■

Acknowledgement

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This article is based on a presentation at World Sustainable Energy Days conference in Wels, Austria, February 2014

Assessing renovation measures by the effectiveness

Designing a renovation is a big European challenge knowing that about 80% of the current building stock will stay in place beyond 2050. The effectiveness of the entire renovation is strongly influenced by the measures taken in the early-design-phase. This article explains the effectiveness of individual renovation measures for typical houses in Serbia. The results from dynamical simulations were delivered in a form of a toolbox, which could be used as a support instrument for the design. Understanding the potential of the measures could provide an upgrade for the house renovation design process.

Keywords: energy savings, effectiveness, house, thermal insulation, renovation measures, toolbox.

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Developing the approach

Residential buildings build in 1970's and 1980's are identified by the First Serbian National Energy Efficiency Action Plan as the biggest problem regarding energy efficiency in the country [4]. In Serbia, about 70% of the population lives in houses. Moreover, the similar situation is in the neighboring countries [5].

This article summarizes the previous scientific work [1-2]. Developed methodology assessed the effectiveness of individual renovation measures for houses in the South-East European (SEE) climate conditions. Analyzed locations were two Serbian cities: Belgrade with 2520 heating degree days and Nis with 2613 heating degree days. Three typical detached houses were extracted from the catalogue of typical housing designs from 70's and 80's (**Figure 1**) [6]. This was done with the purpose to identify the average saving potential for these three houses regarding their heating demands. Three buildings had typical concrete-structure with brick-block walls, semi-fabricated ceiling construction, plaster finishing and no thermal insulation. Dynamic simulations were performed in Euro Waebed (EW) and Geba simulation software. The main focus was on energy conservation measures. In addition, economic and social implications were discussed.

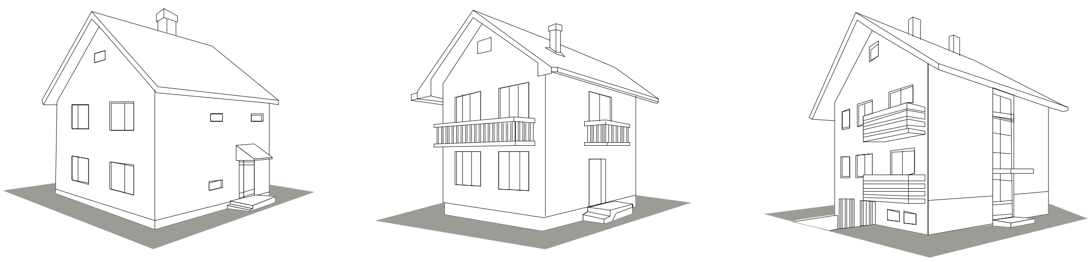

Figure 1. Analyzed houses positioned in two cities marked by codes from the catalogue. [6]

Simulating settings were changing only one building component in the reference model. This approach enabled evaluating the individual contribution of each measure. The external walls, ceilings and roofs were insulated with an expanded polystyrene (EPS); the internal insulation was performed with a capillary thermal insulation system; the ground-floors were insulated with an extruded polystyrene foam (XPS). Windows replacement considered both double and triple glazing. For the ventilation, heat recovery (HR) device with 95% efficiency was used. All renovation options were systematically arranged in a form of a "toolbox" (**Table I**).

Table I. Overview of assessed energy-conservation measures.

External wall	Floor	Roof	Windows	Air-control
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Windows ventilation
Outdated insulation	Floor on ground – no ins.	Roof ceiling – insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Floor on ground – insulated	Pitched roof – no ins.	Upgrade existing windows	Airtight envelope
ETICS – additional thickness	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated below	Green roof	Replace: 3x glazing	
Ventilated facade			External shading	

Energy saving potential

Although reference houses differed by the initial heating demands, the applied measures showed the similar effectiveness in each case. The average saving potential of the measures is shown in the **Figure 2**.

The external walls demonstrated greater potential than any other building element. Savings by insulating the walls were up to 39%. This supported that the external walls should be the basic element for the refurbishment. The ground-floor upgrade indicated 11% of savings

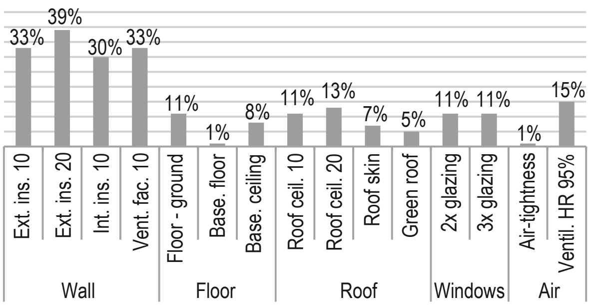

Figure 2. Calculated savings in heating energy for renovation measures when implemented individually.

comparable to 8% of savings by insulating the basement ceiling construction. The roof ceiling renovation demonstrated 13% of savings.

Interestingly, double-glazed and triple-glazed windows showed equal energy saving potential. The windows replacement considered double glazed option (4-12-4 mm) and triple glazed option (4-8-4-8-4 mm), both with the krypton gas filling. Regarding these circumstances, the high quality double-glazed windows were the optimal solution. Improving the air-tightness showed low savings, due to the separated evaluation of the measures. In EW simulations, the length of windows joints was set to 3 m per square meter of glazed area, while the value for the air flow through the joints was modified from 2.5 to 0.5 m^2h^{-1}. When applied individually on the basic non-insulated models, window sealing showed low savings. The settings regarded changing the air leakage of windows from 2.5 to 0.5 m^2h^{-1}. However, the sealing was obligatory measure for achieving the comprehensive passive house refurbishment (**Table IV**). Taking these settings into account, the window sealing would have greater contribution only if combined with other renovation measures. The ventilation system with heat recovery demonstrated reducing the initial consumption for 15% on average.

"When applied individually on the basic non-insulated models, window sealing showed low savings. The settings regarded changing the air leakage of windows from 2.5 $m^3/h/m$ to 0.5 $m^3/h/m$. However, the sealing was obligatory measure for achieving the comprehensive passive house refurbishment (**Table IV**)*."*

Economical issues

Regarding local socio-economic conditions the effective measures were insulating the walls and ceilings, windows replacement as well as improvements on air tightness. Insulating the floor on the ground was the most expensive option, followed by the installation of the HR ventilation system. A period of the investment-return was relatively long due to the relation of the investments to the local energy prices. For more information see the reference [2].

Summer conditions

Overheating requires a special attention in designing the renovation in the SEE region. GEBA simulations showed that almost all options improved thermal comfort during summer by reducing the temperatures in critical south-oriented rooms. This created more comfortable and healthier living environment. Nevertheless, insulating the floor on the ground induced an increase of the inner temperatures. This should not be neglected since the well-being is one of the important reasons for tenants to invest in renovation.

Applicability

Having an overview of the effectiveness, a combination of the measures was evaluated in one case study. The model was previously introduced "HP+1-116" house (**Figure 1**). The toolbox was employed to diagnose the basic case and to develop two renovations by choosing set of measures. In the initial case, the house had brick-block walls without insulation, low performance windows and non-airtight envelope. In the first renovation scenario (R1), the intention was to achieve over 50% of the savings. Therefore, following measures were applied: an addition of 10 cm of EPS insulation on the external walls and the roof ceiling as well as an installation of double glazed windows. In the second scenario (R2), the aim was to achieve the national passive house standard. For that purpose, the walls and the roof ceiling were insulated with 20 cm of EPS, the basement slab with 10 cm of EPS as well as the roof skin. An airtight envelope was made; the double glazed windows with external shutters were installed as well as the HR ventilation system with 95% efficiency. The renovation-boxes for these scenarios are marked in the **Tables II-IV**.

In the R1 scenario, the reduction of the heating demands was up to 58%. In the R2 scenario, the "factor-10" renovation with 90% of savings was achieved which indicated reaching the passive house standard. The case study highlighted how the systematic knowledge can facilitate designers to develop suitable renovations.

Table II. Initial case diagnosis.

WALL	FLOOR	ROOF	WINDOW	AIR
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Window ventilation
Outdated insulation	Ground-floor – no ins.	Roof ceiling-insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Ground-floor – insulated	Pitched roof – no ins.	Upgrade of existing windows	Airtight envelope
ETICS 20 cm	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated	Green roof	Replace: 3x glazing	
Ventil. Facade			Shading	

Table III. Scenario R1.

WALL	FLOOR	ROOF	WINDOW	AIR
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Window ventilation
Outdated insulation	Ground-floor – no ins.	Roof ceiling – insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Ground-floor – insulated	Pitched roof – no ins.	Upgrade of existing windows	Airtight envelope
ETICS 20 cm	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated	Green roof	Replace: 3x glazing	
Ventil. Facade			Shading	

Table IV. Scenario R2.

WALL	FLOOR	ROOF	WINDOW	AIR
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Window ventilation
Outdated insulation	Ground-floor – no ins.	Roof ceiling – insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Ground-floor – insulated	Pitched roof – no ins.	Upgrade of existing windows	Airtight envelope
ETICS 20 cm	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated	Green roof	Replace: 3x glazing	
Ventil. Facade			Shading	

Conclusion

The toolbox provided data on energy saving potential (**Figure 2**). The intention was to describe to designers and investors the impact of their possible choice of renovation. Significant savings of heating energy, up to 90%, were achieved by employing the proposed renovation procedure (**Table IV**). Since a triple-glazing did not show significant difference in reducing energy demands, double-glazed windows seem to be a sufficient solution for the analyzed models in SEE climate conditions.

Due to the sampling procedure, the data could be helpful for retrofitting the homes from 1970's and 1980's in the most suitable manner. A bigger sample could lead to a higher generalization of the theory. The recommendation is that house owners and planners should perform environmental, economic and social assessment and develop the most appropriate renovation for a specific case.

The output information could be integrated into planning procedure in the very early-design-phase, thus enhance the conventional renovation process.

Acknowledgments

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References

Please see the complete list of references of the article in the html-version at **www.rehva.eu**
-> REHVA Journal

Maison air et lumière a case from model home 2020 project

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Keywords: nearly zero energy building, thermal comfort, indoor air quality, ventilation, daylight.

Good thermal comfort in new low-energy houses with large window areas

When energy upgrading existing houses, it is important to avoid pitfalls like e.g. overheating by involving experience gained from energy efficient new buildings. Maison Air et Lumière (**Figure 1**) is one of five European houses built as part of the Model Home 2020 project (see link below). The house was completed in 2011 and a family lived in it for a year. During that year of occupancy, detailed measurements of energy consumption and indoor climate were undertaken.

The house follows the Active House principles (see link below). This means that energy consumption, indoor climate and connection to the outdoor environment must be balanced. The calculated heating requirement for the house is 14.2 kWh/m². Special focus is on good daylight conditions and fresh air through natural ventilation. Most rooms have a daylight factor of above 5%. This in itself means a higher risk of overheating in summer than for older houses with less daylight and less insulation. The results shown here are from Maison Air et Lumière, but are also representative of the other houses of the Model Home 2020 project. In Maison Air et Lumière, ventilation is a hybrid solution. Mechanical ventilation with heat recovery is used during cold periods and natural ventilation in periods when the outdoor temperature is high enough to make heat recovery unnecessary – which is about 25-30% of the year. The ventilation is demand-controlled based on temperatures and CO_2 all year round.

To avoid overheating, the house has overhangs, automatically controlled external solar shading and controlled

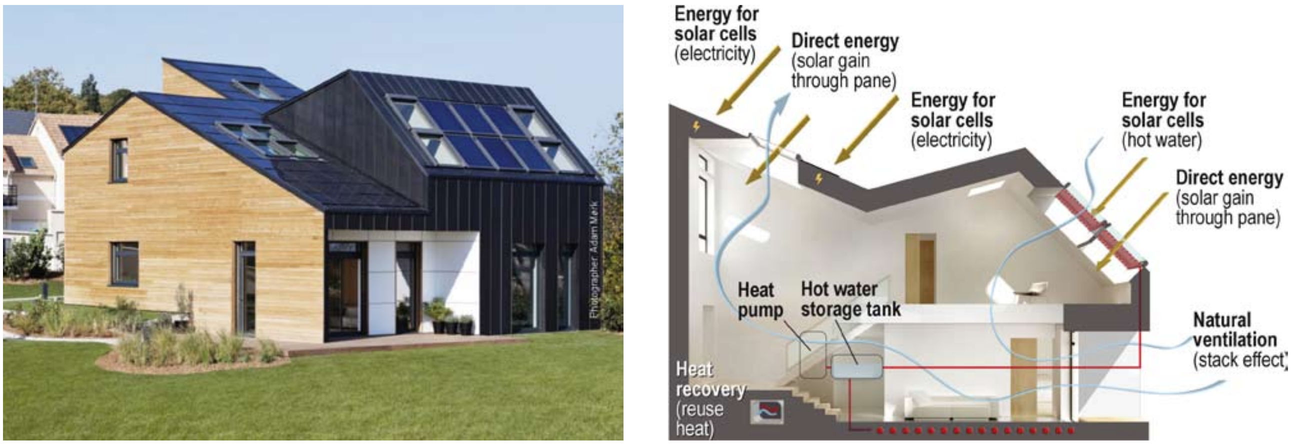

Figure 1. Maison Air et Lumière and its daylight, ventilation and energy concept. Architects: Nomade Architectes.

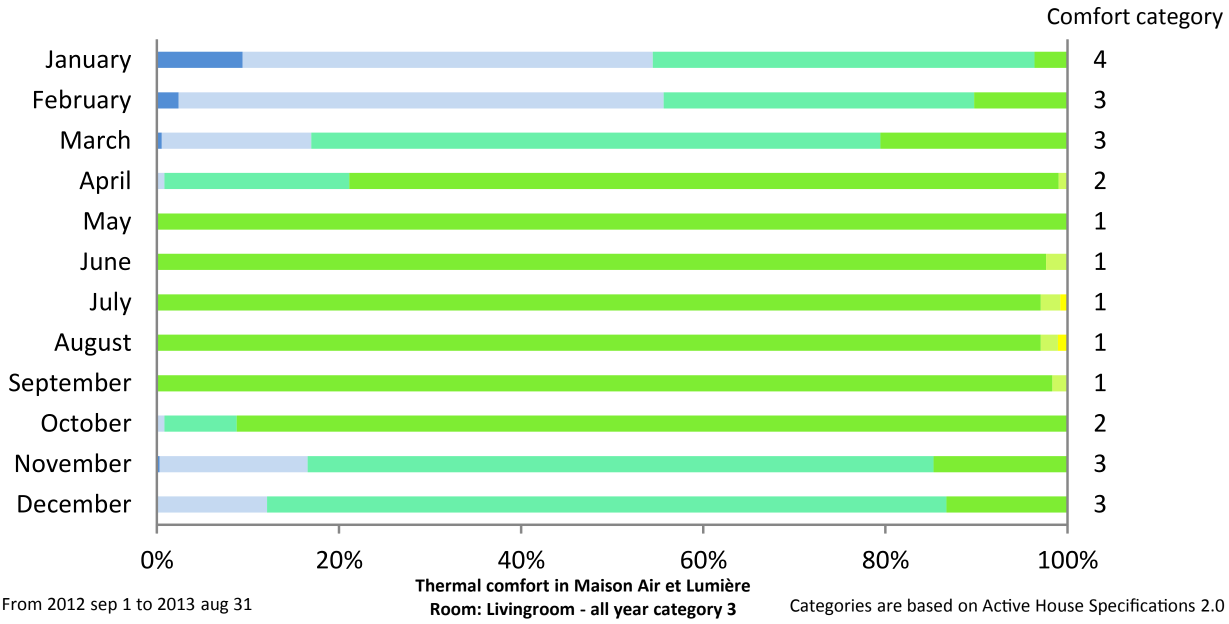

Figure 2. Thermal comfort categories for kitchen-dining room on a monthly basis. The categories refer to the Active House Specification. For the summer situation, category 1 allows a variation of +/- 2°C of the temperature around the optimal temperature, while category 4 allows a variation of +/-5°C. The figures at the right side of the diagram state a total category for each individual month. To obtain e.g. category 2, at least 95% of the hours in the period must be in category 2.

natural ventilation (ventilative cooling). The results are very positive. The Active House Specification, 2nd edition, is used for the evaluation; see REHVA Journal May 2013 pp 10 – 14 for a description of the criteria.

Figure 2 shows the monthly spread of thermal comfort in the room with the strongest inflow of light, i.e. the living room. During the summer months, the room was in category 1 with only a few hours in categories 2 and 3. In winter, the room is in categories 2 to 4. To obtain category 1 in winter, the indoor temperature must be above 21°C. The occupants themselves chose to have a temperature below 21°C.

Active use of natural ventilation (ventilative cooling) and solar shading played an important part in maintaining good thermal comfort in summer. Windows and solar shading were automatically controlled, but allowed the occupants to overrule it. **Figure 6** is a carpet plot showing every hour during the year as a coloured rectangle with date by the x-axis and time of day by the y-axis. The figure shows two things: 1) when the windows in the living room were open and 2) the category of thermal comfort.

The diagram shows to what degree natural ventilation has helped maintain an acceptable thermal comfort. As seen from **Figure 2**, there were some hours with temperatures below category 1, particularly in January, but also in February and March. **Figure 3** shows that windows were

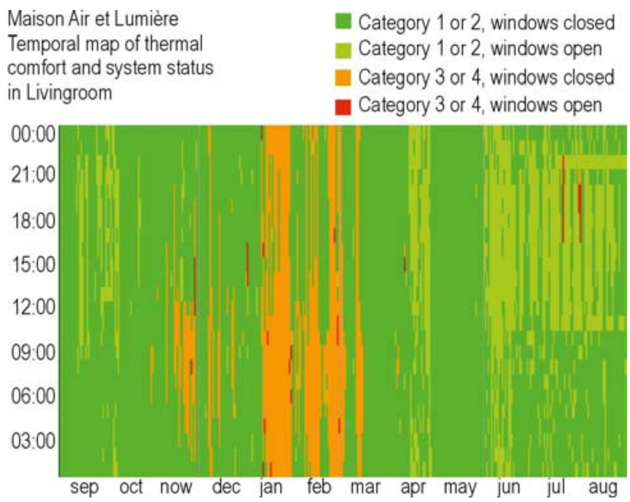

Figure 3. Carpet plot for living room showing comfort category in combination with window position (open or closed).

closed during these periods, so the reduced temperature was not caused by draught.

During daytime, the windows were open for a large part of the time from June to August. In this period, the windows were also open during the night in order to utilise night cooling; the windows were used 2–3 days per week, with an average use of four hours per night. In summer, there is a coincidence between periods with good thermal comfort and open windows. This indicates

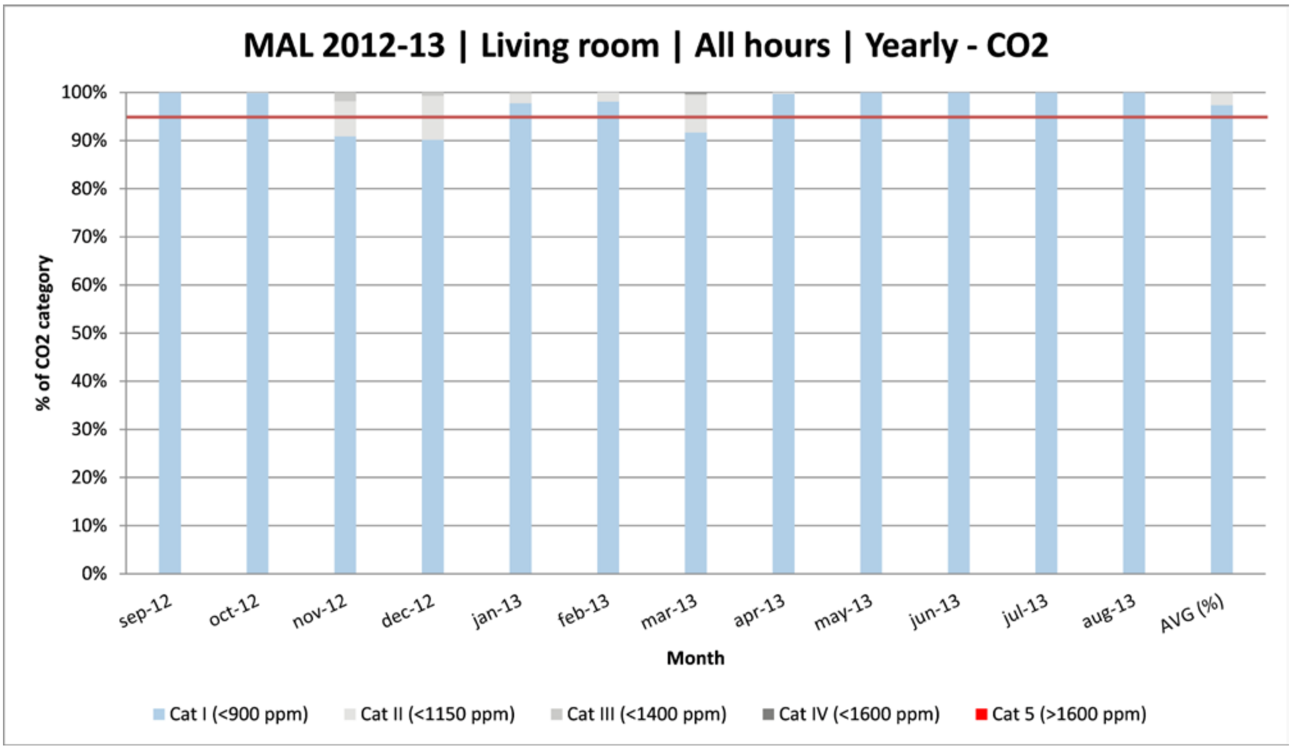

Figure 4. CO_2 levels in living room divided into categories as defined in Active House Specification. Values are the absolute, measured values.

that it is generally possible to prevent overheating in houses with high daylight levels, despite the particular risk of overheating in this type of house. The results from the other rooms in the house show the same tendency as the kitchen-dining room.

The results also show good air quality, expressed by a low CO_2 level in the living room, **Figure 4**. The air quality is best in summer when natural ventilation is used to prevent superheating and the air change rates are higher than in winter. In winter, the CO_2 levels increase to above 900 ppm for approx. 10% of the time, which is considered satisfactory. Similar results were found in the other rooms of the house, however, with the exception of bedrooms. In these rooms, the CO_2 level increased to category 2 during winter.

Even though Maison Air et Lumière is a new building, the experience gained is relevant for the energy upgrading of existing houses. Good air quality can be obtained through energy efficiency by combining mechanical and natural ventilation. It is possible to combine good daylight conditions with good thermal comfort by applying a suitable control strategy for dynamic solar shading and natural ventilation.

Conclusion

In a strategy to increase the number of homeowners who venture into a major energy upgrading of their house, the demonstrated positive side effects, more than energy savings, should be included in the communication to motivate homeowners. The barriers should be reduced by "taking the homeowners by the hand" and helping them to choose relevant energy-saving solutions as well as clarifying the financial consequences and opportunities.

Experience gained from new low-energy houses shows that low energy consumption can be obtained simultaneously with good thermal comfort, good daylight conditions and good air quality by means of a combination of controlled external sun screening and natural ventilation. ■

More information

Maison Air et Lumière: http://www.velux.com/sustainable_living/demonstration_buildings/Maison_Air_et_Lumiere

Active House Specification: http://activehouse.info/about-active-house/specification

Integration, energy efficiency and internationalism

– Themes of the 39th Mostra Convegno Expocomfort, 18-21 March 2014, Fiera Milano

The International exhibition dedicated to residential and industrial installations, air-conditioning and renewable energy was organized by Reed Exhibitions Italia, at Fiera Milano. Leading companies, cutting-edge products and solutions for heating, air-conditioning, refrigeration, valves, hardware, sanitary technology, water treatment, and renewable energy will be the undisputed protagonists of MCE 2014. The strength of MCE is in its consolidated international outlook: 2,042 exhibitors, of whom 43% from abroad representing 59 countries, with a rise in the number of participants coming from Turkey, Poland, all the countries in Eastern Europe, and Spain also in line with the previous edition, confirming the trend of the show of trust by foreign companies in a leading specialized trade fair.

Excellent numbers for MCE 2014 that reaffirms its leading position within an industry segment providing ground-breaking solutions in terms of innovation technology, increasingly strategic in the current global economic scenario and that has been able to continue reinventing itself over the years to fulfil the overall needs of businesses, market and international trade professionals.

The concept behind MCE 2014 is Global Comfort Technology: designing buildings today means not only

optimizing energy performance by reducing energy consumption, but also using plant engineering technologies with innovative integrated control and management tools to improve home comfort, quality and high performance in the real estate industry.

Energy efficiency, and high grade integration between building envelope and installation-technology, and buildings and cities, are the focus of this edition. More particularly, European and domestic regulatory scenarios impose mandatory minimum efficiency standards for a new urban planning where building and territory are tightly connected while plant infrastructure is fundamental to the development of smart networks or smart grids.

Many REHVA supporters presented their new, high quality products at Mostra Convegno in Milan.

1600 participants in the Finnish Seminar on indoor environmental quality

Finnish Society of Indoor Air Quality and Climate (FiSIAQ) organized in March 29th annual seminar on indoor air quality and climate. The number of participants in the seminar has increased every year reaching this year the all-time record of 1 600 participants. This seminar series was started by Prof. Seppänen as joint project between Helsinki University of Technology and FiSIAQ 1985. In 30 years it has grown to the biggest annual event in Europe on the indoor environmental quality attracting scientist, academics, designers, authorities, building inspectors, building owners etc. This annual events offers a great platform for participants to present and test new ideas with a large audience.

Finnish Society of Indoor Air Quality and Climate (FiSIAQ) was established in 1990 to organize the 6th International Conference on Indoor Air Quality and Climate, two years after the International Society of Indoor Air Quality and Climate (ISIAQ) was founded. FiSIAQ is also a member of FINVAC (Finnish Association of HAVC Societies). Members of FISIAQ are invited after being active in working in the area of indoor environmental issues.

Finnish Annual Seminar on Indoor Air Quality and Climate attracted 1 600 participants in 2014.
The seminar was opened by the Minister of Housing.

Light+building

This year during the exhibition, REHVA organised in collaboration with VDI a seminar on 'Greater energy efficiency with automated buildings' on Monday March 31st in Messe Frankfurt.

Jan Aufderheijde (REHVA Secretary General) welcomed all the seminar participants. Professor Achim Heidemann from the Hochschule Albstadt-Sigmaringen in Germany presented the Benefits of BACS – the Big Picture. Professor Dr. Martin Becker from the Hochschule Biberach, in Germany explained the Energy efficiency thanks to building automation. He also did an overview of the VDI standard 3813 Room Automation. Some technical and implementations and solutions were presented by Jan Spelsberg from Spelsberg Gebäudeautomation GmbH in Moers, Germany. Prof. Micheala Lambertz from DS-Plan Düsseldorf/FH Köln explained how building automation contributes to building sustainability. Christian Welsch from Osram GmbH presented the Energy efficent lighting and control. The Benefits of building automation for energy efficient were presented by Jan Kerdèl from Priva BV from the Netherlands. The seminar ended with a dynamic panel discussion. The lectures were translated simultaneously into German / English.

All the presentations are available for download at
www.rehva.eu

REHVA 2014 Annual Meeting –
2014 REHVA General Assembly participants in Dusseldorf

The 58th REHVA General Assembly was held on Tuesday 29 April 2014 in Düsseldorf, Germany. It gathered nearly 110 delegates from 25 European member countries. After a welcoming address by the host, VDI Director, **Ralph Appel** from Germany, Prof **Karel Kabele** opened the General Assembly.

In the later afternoon, Prof. Karel Kabele presented the 2013 annual report. At the end of the Assembly was the election of two REHVA board Members. Two seats were available this year. The treasurer, **Zoltan Magyar** came at the end of his terms. Prof. Kabele and the Assembly warmly thanked Prof. Magyar for his contribution to REHVA's development during the past nine years. Prof. **Stefano Corgnati** was unanimously re-elected. **Egils Dzelzitis** from Latvia was also unanimously elected. The meeting ended with the introduction of the new REHVA Member, the Moldavian Association of Heating, Ventilation and Air-conditioning engineers, AIIRM.

Prof Egisl Dzelzitis from Latvia was elected to the REHVA Board for 2014-17

There was not only a change within the board, also **Maija Virta** who served as the chair of REHVA's Publishing & Marketing Committee since 2008 stepped aside and was honoured with very warm words of REHVA President. **Frank Hovorka** was chosen in the PMC meeting as the new chair of the Committee.

Karel Kabele thanked Maija Virta for her services as chair of the REHVA Publishing & Marketing Committee.

Olli Seppänen, the editor-in-chief of REHVA Journal, announced his retirement from August 2014

The REHVA Board members and their main responsibilities:

Karel Kabele, president, (STP, Czech Republic), Awards committee
Stefano P. Corgnati (AiCARR, Italy), Treasurer
Ioan Silviu Dobosi (AIIR, Romania), Supporters Committee
Manuel Gameiro da Silva (Ordem dos Engenheiros, Portugal), Education and Training Committee
Frank Hovorka (AICVF, France), Publishing and Marketing Committee
Jarek Kurnitski (EKVU, Estonia), Technical and Research Committee
Egils Dzelzitis (AHGWTEL/LATVAC, Latvia), Membership Committee
Jan Aufderheijde continues as Secretary General of REHVA.

In the General Assembly the editor-of-chief the REHVA journal announced his retirement in August 2014. Karel Kabele thanked **Olli Seppänen** for all the work he has done as Editor-in-Chief of the REHVA journal. During the six year term of prof Seppänen the journal had gained significant international reputation, its number of pages per volume and circulation was tripled. The journal is now established its position as a reliable information source of European HVAC technology. Karel Kabele underlined his feelings by handing over a small sculpture with title 'Passion', what expresses the way Olli did his work for REHVA in general and for REHVA journal in particular.

REHVA Awards 2014

On the occasion of the Annual Meeting 2014, the following members of REHVA national associations received a REHVA Award:

Prof. Wim Zeiler (TVVL – The Netherlands) was recognized for his outstanding achievements in science and for his contributions to improve energy efficiency and the indoor environment of buildings.

Derrick Braham (CIBSE – United Kingdom) was recognized for his outstanding achievements in technology and for his contributions to improve energy efficiency and the indoor environment of buildings.

Michal Krajčík (SSTP – Slovakia) and **Angela Simone** (DANVAK – Denmark) received a REHVA Young Scientist Award.

Prof. Karel Kabele and Prof. Wim Zeiler

Derrick Braham

Michal Krajčík

Angela Simone

Certification Programme for Residential Air Handling Units (RAHU)

After nearly 3 years of preparation by the Eurovent Certita Certification has launched a certification programme for Residential Air Handling units (RAHU). The Operational Manual and Rating Standards for RAHU have been finalized by the end of 2013.

The scope of the programme includes all residential supply and exhaust ventilation units equipped with heat recovery systems including air-to-air heat-pumps. The certification programme is based on random testing of units according to the European standard EN 13141:2011. All tests will be performed by independent testing laboratories.

The following performances will be certified:

- Leakage class
- Airflow/pressure curves
- Specific Power Input
- Heat recovery efficiency
- Sound power levels
- Specific Energy Consumption (SEC)
- Energy efficiency class
- Performances at cold climate conditions

The following schedule is being foreseen:

- **April 2014:** Signing of agreement by manufacturers for RAHU programme (contact apply@eurovent-certification.com). There is no deadline as this is a voluntary registration.
- **December 2014:** Publication of certified data on Eurovent Certification website by 31 December 2014 for all manufacturers signing the agreement before 30 May 2014.

Per product certificate will be available using Certiflash application (www.certiflash.com) as for any other ECC certified products. Data will also be updated in the EDIBATEC (Clé@ - www.catalogue-clea.fr) database for the benefit of optimum validity of building thermal load or design software output.

EUROVENT CERTITA CERTIFICATION is a major European certification body in the field of HVAC-R, operating 35 certification programs and generating about € 10 million in turnover. It focuses on certifying products' performances as well as data needed to implement regulations. The main quality marks currently proposed are the marks "Eurovent certified performance", NF, CSTBat, and the European Keymark.

HEE Version of POWERCIAT2 from CIAT

CIAT's eco-designed POWERCIAT2 water chiller, for cooling capacities ranging from 610 to 1350 kW, is now available in a High Energy Efficiency (HEE) version. Thanks to its latest-generation components, and in particular the integration of a micro-channel coil and CIAT's new high efficiency evaporator, POWERCIAT2 HEE is on average 10% more energy efficient than the standard model. It achieves the highest possible energy rating, Class A, with an average EER of 3.15 and exceptional seasonal efficiency levels, proven by an average ESEER of 4.1. Versatile, POWERCIAT2 HEE is specially designed for the air conditioning of large buildings such as hotels, offices, shopping centres and industrial facilities.

POWERCIAT2 HEE is a range of 10 new water chiller models that broaden the standard range and offer cooling capacities of 600 to 1 160 kW.

To improve its energy efficiency, CIAT's teams leveraged the standard version of POWERCIAT2, optimized the heat transfer area of its coils and evaporator, and added the latest generation of very low energy screw compressors. The result is a unit with an improved ratio of cooling capacity to power input that gives it a particularly high level of energy efficiency. In addition to its low power consumption, POWERCIAT2 HEE features the same innovations and performance levels as the standard version, offering the best ratio of power to refrigerant charge on the market (7 kW of cooling/kg of R134a).

POWERCIAT2 HEE is currently the only water chiller that combines both micro-channel coil and shell-and-tube dry expansion evaporator technologies. It has been engineered using eco-design principles to minimise its environmental impact throughout its entire life cycle. Compared to the previous generation of water chillers, the major technical innovation of POWERCIAT2 HEE is its all-aluminium micro-channel coil and the many advantages this offers: 45% less refrigerant, 20% lighter machines (making them easier to handle, transport and install on site) and a 20% smaller footprint. It is also easy to maintain. The coil's rigid external surface is compatible with high-pressure cleaning and its all-aluminium design eliminates galvanic currents between different metals and offers greater resistance to corrosion.

TANGRA introduces the floor convectors TANGRA FFCU

The floor convectors are modern esthetic element in the heating and cooling systems. Designed for incorporation into the floor and used for heating and air conditioning of large spaces in commercial buildings, stores, showrooms, apartments, houses or other premises. They are particularly suitable for rooms with large windows displays where the units have both functional and decorative value.

The floor convectors can be used as a main or additional element for air conditioning in combination with another type of heating or cooling.

The floor convectors TANGRA FFCU are available in two different lengths (1 250 mm and 2 000 mm) and three models:

*** FFCU-Silent** – low-noise version, suitable for residential buildings, living and sleeping rooms.

*** FFCU-Power** – high efficient version – for public buildings.

*** FFCU-H** – floor convector suitable only for heating, without condensation tray.

More information: www.tangra.bg

Magazines and journals published by REHVA members

Collected and edited by Olli Seppänen

REHVA is a Federation of 27 associations in heating, ventilation and air conditioning. All the associations publish journals on the practical application of HVAC&R technology. These journals publish articles from a range of contributors, including journalists, experts in the field, building services professionals, academics, consultants and product makers.

These journals provides news, analysis, comments, special features, interviews, technical articles, regulatory advice and learning tools needed by the wide range of professionals working in the modern building services world. These journals are circulated to all their members. The introduction of HVAC&R journals will continue in the next issues of the REHVA Journal.

Belgium

Belgium HVAC Society - publication

Name of HVAC publications: ATIC NEWS
Number of issues per year: 50 issues per year

The publication has information on ATIC activities and training in Belgium. It has also some news on our sister associations in French and Netherlands.

Contact information
email: info@atic.be

Czech Republic

Czech Republic Society of Environmental Engineering (STP). - journal

Name of HVAC Journal: VVI Journal - Journal of Heating, Ventilation and Sanitary Installation
Number of issues per year: 5 issues per year
Number of copies per issue: 3 000

VVI Journal is a national technical journal published by Society of Environmental Engineering (STP). The journal is oriented to professionals dealing with Environmental Engineering. It provides information for designers, investors, producers, assembly and installation engineers, manufacturers, process technicians, workers, professional in schools and universities, and government authorities. It is also targeted for those who want to be informed about the possibilities, methods and ways to improve indoor air quality.

VVI Journal brings information:

- about the latest trends in heating, ventilation, air conditioning, cooling, humidification, dehumidification, hygiene, sanitary installations, measurement and control, lighting, noise, air quality, energy conservation, traditional and alternative energy sources at home and abroad;
- about new products, techniques and domestic or foreign technology for accurate and efficient operation of buildings with examples of practical use;
- about testing and measures improving quality of domestic production and enhancing sales of domestic products at foreign markets;

- about theoretical works dealing with new knowledge characteristics of new products, new computational methods and application of computer technology in the field of environmental engineering;
- about interesting issues regarding environmental engineering;
- about news in legal enactments and technical standards;
- about innovation in building design from the environmental engineering point of view including interesting technical solutions providing a wide range of inspirations for designers;
- in newsletter annex where are published upcoming activities of the Society for Environmental Engineering: seminars, conferences, workshops, training, corporate events, offers of publications, activities of expert agencies, exhibitions etc.

Articles are published in Czech or Slovak language, with abstracts and keywords both in Czech and English language. English papers are translated into Czech language by publisher.

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website: http://www.stpcr.cz/?page=en,vvi

Finland

FINVAC
The Finnish Association of HVAC Societies

The society members of FINVAC, the Finnish Associations of HVAC Societies publishes 3 journals:

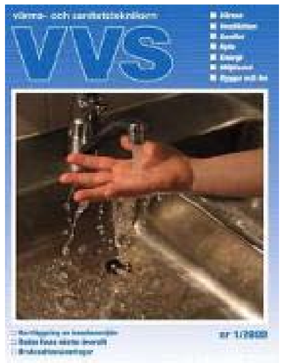
Name of the HVAC Journal:Talotekniikka (HVAC Journal in Finnish)
Number of issues/ year: 8
Number of copies per issue: 7 500

Talotekniikka is the leading Finnish media in the HVAC branch supported and own by top Finnish HVAC organisations. It provides up-to-date information for professionals dealing with design, construction and contracting, computerized modelling tools, material and product manufacturing, wholesale and retail, technical facility management, public services and many more.

Contact information

Website: www.talotekniikka-lehti.fi

Name of the HVAC Journal: VVS värme- och sanitetsteknikern (HVAC Journal in Swedish)
Number of issues/ year: 5
Number of copies per issue: 2300



The magazine "VVS Värme- och Sanitetsteknikern" (Heat- and Sanitary Technician) is published by VVS Föreningen i Finland. It is well-known for its high-class technical articles and for penetrating actual questions in the field. Detailed examinations of new buildings and sufficient space where new products and new technique are presented form a part of this review's profile.

Contact information

Website: www.vvsfinland.fi

Sisäilmauutiset (Indoor Air News in Finnish)
Number of issues/ year: 2 (in Finnish)
Number of copies per issue: 6.000

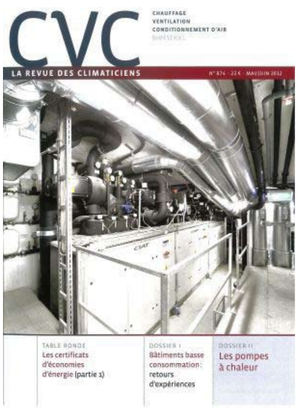
Finnish Society of Indoor Air Quality and Climate (FiSIAQ) and publishes this newsletter which is focused on IEQ issues.

Contact information

Website: www.sisailmauutiset.fi

France

Association des Ingénieurs en Climatique, Ventilation et Froid, France - journal



Name of the HVAC Journal: CVC - La revue des climaticiens
Number of issues per year: 5 issues per year
Number of copies per issue: 3000

The main purpose of the journal is to provide information for a broad range of specialists on the activities of heating, ventilation and air conditioning; development of energy efficient construction technologies in France and abroad.

Contact information

Director of publication: Bertrand Montmoreau
Editor in Chief: Michel Laval
Publisher: Atelier Chévara
email: secretariat@aicvf.net
website: www.aicvf.org/la-revue-cvc/

Germany

VDI-Gesellschaft Bauen und Gebäudetechnik

The Association of German Engineers - Division Building Services of VDI-Society for Civil Engineering and Building Services (VDI-TGA) - journal

Name of HVAC Journal: HLH
Number of issues per year – 12
Number of copies per issue: 12 000

HLH covers in a practical, but scientifically based manner all aspects of building services. This embraces individual product reports, short features on current developments, news from commerce and industry as well as background contributions from authors of repute and specialist journalists.

Contact information

Editor in Chief: Dipl-Ing. Hermann Bliesener
email: hlh@springer-vdi-verlag.de
website: http://www.hlh.de/hlh/
Publisher: Springer-VDI-Verlag GmbH & Co. KG

Hungary

ETE - Scientific Society for Building - journal

Name of the HVAC Journal: Magyar Épületgépészet
Number of issues per year: 12
Number of copies per issue: 1 500

The journal is a theoretical and practical periodical in the field of HVAC. The editorial teams believe their task is to inform their subscribers about important theoretic or practical issues, novelties, news and traditions in our field. The target audience is comprised of building service engineers, especially building service system designers and operators. The aim is to promote the further education of HVAC engineers and students. The periodical is distributed to subscribers, members of the Hungarian Scientific Society for Building Service Engineering, as well as the HVAC departments of universities in Hungary.

Contact information

Managing director: Dr. Zoltán Magyar
Editor in Chief: Lajos Barna
Email: info@epgeplap.hu
Website: www.epgeponline.hu

Italy

Italian Association on Air Conditioning, Heating and Refrigeration - journal

Name of the HVAC Journal: AiCARR Journal
Number of issues per year: 6 in 2014
Number of copies per issue: 10 000 copies

AiCARR's house organ, is a monographic magazine that explores new directions in science and cutting-edge technology systems, in the area of energy optimization in civil, industrial and commercial sectors.

Each issue presents the latest developments in the regulatory field and describes applications and case histories related to the monographic topic. The authors are the most eminent and expert professors, researchers and plants designers. The magazine, published by Quine Business Publisher, has six issues in 2014 and it is distributed free of charge to AiCARR's members.

Contact information

Director of publication: Marco Zani
Email: casaclima@quine.it
Website: http://www.casaeclima.com/ct_21_Rivista%252DAiCARR%252Djournal.html

Norway

Norwegian HVAC Association NORVAC - journal

Name of the HVAC Journal: NORSK VVS
Number of issues per year - 12
Number of copies per issue: 5 000

NORSK VVS is a magazine owned by the Norwegian HVAC Association NORVAC. NORSK VVS will help to promote socially sensible use of our energy resources, good hygiene and extensive protection of the internal and external environment.

NORSK VVS is an industry tools to stay informed about news in areas such as climate, energy, climate engineering, sanitation and nearby areas.

Contact information

Editor in Chief: Bjorn Gronlien
Email: bjorn.gronlien@skarland.no
Website: www.norskvvs.no
Publisher: Skarland Press as

Portugal

Portuguese Association of Engineers (ODE) - journal

Name of HVAC Journal: Edificios e Energia
Number of issues per year: 6
Number of copies per issue: 5 000

Edificios e Energia (Buildings and Energy, in English) is a bimonthly publication that exists for more than 14 years in the Portuguese market. It is a rebranding of the Climarização magazine, which was at first dedicated to HVAC market and industry, IAQ, etc. As the market evolved, so did the contents of the magazine. Today **Edificios e Energia** gives a wider approach of energy use in buildings, with special regards to heating and cooling, HVAC, IAQ renewable energy technologies (photovoltaics, solar thermal systems, heat pumps...), engineering and architecture, energy efficiency, energy services, etc. **Edificios e Energia** follows closely national and European regulations, new technologies and innovation and other important developments on these topics. The magazine also has a website (www.edificioseenergia.pt) with daily news.

Contact information

Director of publication: Rita Ascenso
email: edificioseenergia@medialine.pt
website: www.medialine.pt
Publisher: Media Line

Russia

Association of Engineers in Heating, Ventilation, Air-conditioning, Heat Supply & Building Thermal Physics - journals

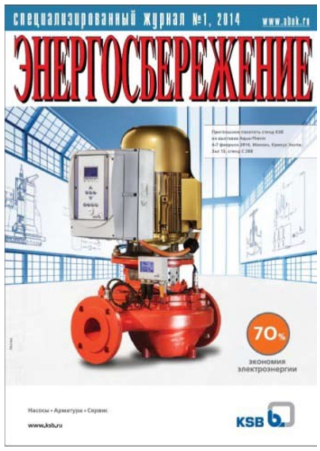
Name of the HVAC Journal: ABOK Journal: Ventilation, Heating, Air Conditioning, Heat Supply and Building Thermal Physics
Number of issues per year: 8 issues per year
Number of copies per issue: 12 000 copies per issue

ABOK Journal is a full-color periodical of the Russian Association of Heating, Ventilation, Air Conditioning, Heat Supply, and Building Thermal Physics Engineers.

ABOK Journal has been published since 1990. The main purpose of the journal is to provide information for a broad range of specialists on the activities of the Association; development of energy efficient construction technologies in Russia and abroad; engineering, regulatory, and social problems in energy conservation; new equipment and materials; modern heating, ventilation, air conditioning, cooling, refrigeration systems and engineering; large Russian and international manufacturers of such equipment; new normative documents and standards; development of self-contained or district heating systems for buildings; building thermal physics parameters and thermal protection properties of enclosing structures of buildings and facilities.

ABOK Journal is distributed in 720 large centers in Russia, as well as in Austria, Azerbaijan, Belarus, Canada, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Hungary, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Norway, Slovakia, Sweden, Switzerland, Turkey, UK, Ukraine, and USA.

ABOK Journal is also distributed at large exhibitions and conferences held in Moscow, St.-Petersburg, Nizhni Novgorod, Kazan, Tyumen, Novosibirsk, Volgograd, Rostov-on-Don, Omsk.



Name of the HVAC Journal: Energy Conservation journal - "Energosberezheniye"
Number of issues per year: 8 issues per year
Number of copies per issue: 13 000 copies per issue

This is a full-color analytical journal aiming to reach a wide range of specialists in the area of construction, housing and utility services, and power engineering. The journal has been published since 1995 by the Fuel and Energy Administration of the Moscow City Government and the Russian Association of Heating, Ventilating, Air Conditioning, Heat Supply and Building Thermal Physics Engineers (ABOK).

Energosberezheniye journal now is a best forum in Russia to discuss the following topics:

- New engineering, technological, economic, regulatory and legal developments in the area of energy and resource conservation in construction, housing and utility services, and energy sector;
- Reviews, analytical and reference information on the status of the Russian market for goods and services in the construction, housing and utility services, and energy sectors, as well as reference information on manufacturers and suppliers of such goods and services;
- Information on the upcoming exhibitions, seminars, workshops and conferences to consider energy and resource conservation issues and demonstrate energy and resource conservation products for various branches of the economy;

Other subject–matters of interest and use to a wide range of readers, including issues relating to product certification, power tariffs in various locales in Russia, regulations on holding show competitions and tenders to implement specific energy conservation projects in Moscow, etc.

Name of the HVAC Journal: SANTECHNIKA journal (water supply, pipes, fittings)
Number of issues per year: 6 issues per year
Number of copies per issue: 10 000 copies per issue

The target audience of specialized scientific, technical, review and analytical SANTECHNIKA journal (water supply, pipes, fittings) is specialists and managers of construction, erecting and trade organizations, the staff of design institutes and architectural studios. The main topics of the magazine are water supply and disposal, pump equipment, pipeline systems, plumbing fittings and equipment, specific tools, and heating equipment.

SANTECHNIKA journal provides specialists with a full range of information in the area of water supply and removal, covers specialized exhibitions, forums, conferences and seminars that take place in Russia and other countries all around the World.

The journal is issued from the year of 1997. It is distributed in Russia, CIS and other foreign countries among construction, design, subcontractor, trade and erecting companies, educational establishments, commercial and government organizations which are specialized in the area of water supply and disposal, pipeline systems, pump equipment and engineering plumbing.

Name of the HVAC Journal: Sustainable Building Technologies e-journal
Number of issues per year: 4 issues per year
Number of copies per issue: E-journal and a website: 70 000 subscribers.

Sustainable Building Technologies is a new media-project which is issued as an e-journal and a website. Its mission is to inform and update all industry decision-makers including investors, developers, architects, and engineers of the benefits of sustainable technologies and green construction:

- green building standards in implementation
- energy and resource efficient technologies
- innovations and legal framework
- feasibility studies
- the audience covered: 400 cities in Russia and the CIS
- 90 to 120 pages in each issue
- free subscription (through the website, Apple Store and Play Market)
- technical and economic calculations
- clear infographics, colourful images
- up to 30 projects presented in each issue
- an English-language section providing a review of the situation in Russia
- representation in the social media

Contact information

Editor in chief: Marianna Brodach, vice-president ABOK
email: zvt.abok.ru, abok.ru, brodatch@abok.ru
Website: www.abok.ru/

Serbia

Serbian HVAC&R Society - journal
Name of HVAC Journal: KGH National Journal HVAC&R
Number of issues per year: 4
Number of copies per issue: 500

There are 4 to 6 scientific or practical papers in Serbian. There are always abstract in English. The publication has information on HVAC national and international regulations. There are also news in English on UNEP (United Nation Environment Protection) and news about the society activities.

Contact information

Editor in chief: Branislav Todorovic
email: todorob@eunet.rs

Slovakia

Slovak Society for Environmental Technology - journal

Name of the HVAC Journal: TZB HAUSTECHNIK
Number of issues/ year: 5
Number of copies per issue: 3 500

The typical reader is a university or secondary-school educated man in the productive age of between 23 and 55. To the reader group belong, although to a lesser extent, women. A prevailing section of readers operate in design and realisation companies, who use in their professions the information gained from TZB HAUSTECHNIK magazine. This is also reflected in the growing interest in information from the world of practice and in non-commercial information on current products and trends in the Slovak market

Contact information

Editor in Chief: Silvia Friedlová
Email: silvia.friedlova@jaga.sk
Publisher: JAGA GROUP, s.r.o.
Website: www.casopistzb.sk

Sweden

Swedish HVAC Society - Society of Energy and Environmental Technology
Name of the HVAC Journal: Energi & Miljö (Energi & Environment)
Number of issues per year: 11
Number of copies per issue: 10 600

Energy & Environment has been around since 1929 and its Energy and Environmental Technology Association members are the foundation of our readership. Energy & Environment talks about current projects will help you keep track of changes in regulations and tips on including energy and construction law. Energy & Environment is published by EMTF Publishers AB.

Contact information

Director of publication: Ingar Lindholm
Email: medlemsservice@emtf.se.

Switzerland

Swiss society of engineering in Building Services - publications

Name of the HVAC Journal(s)
SWKI-Bulletin – Haustech-Magazin
Number of issues per year: SWKI-Bulletin: 2-time/year
Haustech-Magazin: Published 10 times/year
Number of copies per issue
SWKI-Bulletin: 610
Haustech-Magazin: more than 3200

SWKI-Bulletin is a magazine for the members with reviews and outlooks of SWKI-events, technical training and educational events and interesting topics of the organization and its members. www.swki.ch

Haustech-Magazin includes technical articles, information to standard/guidelines projects and its publication, marketing for acquisition of new members and team members for technical groups, technical training and educational events and SWKI agenda. www.haustech-magazin.ch

United Kingdom

Chartered Institution of Building Services Engineers - journal

Name of the HVAC Journal: CIBSE Journal
Number of issues per year: 12
Number of copies per issue: 18 558

The official journal of the Chartered Institution of Building Services Engineers has been transformed over recent years and is read by a wide variety of building professionals and academics. Covering the broad area that represents CIBSE activity it has developed some novel (and free to access) electronic versions of the journal that provide all members of the building community simple, and rich dynamic interactive access to the material at cibsejournal.com including specifically designed apps.

Contact information
Editor: Alex Smith
Email: asmith@cibsejournal.com
Website: www.cibsejournal.com

OCTOBER, 19th-22nd, 2014. São Paulo, Brazil
ROOMVENT 2014

Nearly 200 ABSTRACTS submitted to ROOMVENT 2014

The 13th SCANVAC international conference on air distribution in rooms will be held in Sao Paulo, Brazil, on 19-22 October 2014.

Until 15th of April, 190 abstracts have been submitted. The deadline for abstracts has been extended, so now the new and final deadline is **10 May 2014**.

Approximately one third of all abstracts submitted by mid-April deal with the "Indoor Air Quality and Human Comfort" theme. Other popular themes are "Innovative Strategies and components for ventilation and air conditioning" with approximately 20% of the abstracts submitted, and "Ventilation and Air Conditioning in green buildings".

Registration of the participants will open on 1st of June 2014. Practical information about registration, conference fees, hotel accommodation etc. can be found on the ROOMVENT website at http://www.roomvent2014.com.br/

14-16 October 2014, Nuremberg, Germany

International Trade Fair Chillventa is the gathering for Refrigeration - Air Conditioning - Ventilation - Heat Pumps experts.

Chillventa shows trends, innovations, products and services for refrigeration, insulation, C&I/automation, air conditioning, ventilation and heat pumps all in one place.

www.chillventa.de/en/

FinnBuild 2014

1-3 October 2014, Helsinki, Finland

- a showcase for the Finnish construction industry

The Finland's largest building and building services trade fair, FinnBuild 2014, will be held at Messukeskus Helsinki, Expo & Convention Centre, on 1-3 October 2014. FinnBuild presents the best expertise, products, services and solutions for construction.

FinnBUILD
1-3 Oct 2014
Messukeskus Helsinki

This year's event is the 21st as the first FinnBuild was organised already in 1974. The largest and the most prominent event in the construction industry in Finland attracts visitors who want to keep themselves at the forefront professionally.

Four other professional events are held at the same time with FinnBuild: **InfraExpo** - fair for technical infrastructure, **Arena** - fair for constructing sporting arenas, **ParkTec** focusing on the design, construction and management of green areas, and **EnviroExpo** with the focus on environmental technology.

Last time, two years ago, the fairs gathered 32,000 professional visitors of the building and building services industry, including students of the construction branch.

This year for the fourth time an impartial jury will choose the FinnBuild Highlights. The Highlights exhibition will showcase a selection of the most interesting innovations at the fair.

REHVA will organize with FINVAC a seminar on Thursday Oct 2nd **"HVAC equipment and systems in nearly zero energy buildings"**.

The seminar is free to all vistors. The speakers are prominent European anmd Finnish experts.

The similar seminar in 2012 attracted more than 200 participants.

FinnBuild, Arena, InfraExpo, ParkTec and EnviroExpo will be held at Messukeskus Helsinki on 1 – 3 October 2014.

www.finnbuild.fi

Cold Climate 2015

20–23 October 2015 | Dalian, China

About cold climate conference

International Conference on HVAC in Cold Climate has been successfully hosted seven times since 1994. The 8th International Cold Climate HVAC Conference will take place in Dalian, China during October 20-23, 2015. The conference will be organized by Dalian University of Technology and co-organized by Tsinghua University and VTT Technical Research Centre of Finland.

Topics of Cold Climate 2015

Conference theme: Sustainable buildings and energy utilization in cold climate zone

Topics include:

- Sustainable buildings and energy efficiency and savings
- Zero energy buildings
- Heating technology and policy
- Usage of renewable energy
- Ventilation and heat recovery
- Heat pump technology
- Building simulation
- Building energy efficiency and savings in rural areas

Abstract submission deadline: Jan. 15, 2015

Contact E-mail:
hvac@dlut.edu.cn

More information:
www.coldclimate2015.org

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Ventilation 2015

26-28 October 2015 | Shanghai, China

Just a few days after the Cold Climate 2015 in Dalian, the **11th International Conference of Industrial Ventilation** will be held in Shanghai, China. The conference is organized by Tongji University, VTT (Technical Research Center of Finland) and Tsinghua University.

As in earlier "Ventilation" conferences, the main focus will be in technologies, processes and applications in industrial indoor environment, from "heavy" industries to hospitals, clean rooms and commercial kitchens. The aims of industrial ventilation are to protect health, to prevent environmental pollution and to guarantee high product quality. These aims should be achieved with constant concern for energy efficiency and for sustainable development. The "Ventilation" conferences have played an important role in indoor environment research and have always been well attended by researchers and academics from worldwide.

The four main themes of the conference are:

1. Occupational health
2. Ventilation and sustainable development
3. Specialized applications
4. Clean air technology, design and control.

Deadline for Abstracts: 20 December 2014.

Contact E-mail:
ventilation2015@tongji.edu.cn

More information:
http://www.ventilation2015.org/

Endorsed by
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Federation of European Heating, Ventilation and Air Conditioning Associations

Ventilation and airtightness in transforming the building stock to high performance

35th AIVC Conference
4th TightVent Conference
2nd venticool Conference

Poznań, Poland, 24–25 September 2014

Conference concept

- The conference will consist of 2 or 3 parallel tracks:
- One track will to a large extent be devoted to ventilative cooling;
- One track will to a large extent be devoted to airtightness issues.

The conference will consist of a mixture of:

- Well-prepared structured workshops focused on the conference topics;
- Presentations on invitation;
- Presentations from call for papers.

Topics of the conference

Contributions are invited in the areas of research, development, application and market and legislative implementation of ventilation and infiltration. Preference will be given to abstracts focusing on one of the following topics:

For ventilative cooling aspects:

- Potential for ventilative cooling strategies
- Ventilative cooling in energy performance regulations
- Design approaches for ventilative cooling and case studies – Integrated design
- Thermal comfort and ventilation
- Active facades

For airtightness related aspects:

- Building and ductwork airtightness in existing buildings
- Infiltration measurement techniques and IR thermography
- Quality schemes for airtightness testers
- Durability of building and ductwork airtightness
- Energy and IAQ impact of envelope and ductwork leakage

For ventilation in relation to IAQ and health aspects:

- IAQ impacts from outdoor sources
- Demand-controlled ventilation
- Humidity control and moisture damage
- Ventilation in renovated buildings
- Characterization of air cleaning technologies
- Other aspects relevant to the conference include:
- Multi-family buildings
- Quality of ventilation systems
- Fan energy use
- Innovative ventilation concepts and combined systems
- Controls and user interaction

Deadline for abstracts: March 15, 2014

More information: www.aivc.org

This conference is at present supported by the following organizations:

Send information of your event to Ms Cynthia Despradel cd@rehva.eu

Events in 2014 - 2015

Conferences and seminars 2014

June 5–6	International Conference "Energy Performance of Buildings"	Bucharest, Romania	www.rcepb.ro
June 17–19	BREEAM International New Construction 2013 Assessor Training Course	Bucharest, Romania	www.aiiro.ro
June 23–24	Building Simulation and Optimization BSO14	London, United Kingdom	www.bso14.org
June 23–27	"Sustainable Energy Week EU Sustainable Energy Week"	Brussels, Belgium	www.eusew.eu
June 28–July 2	ASHRAE 2014 Annual Conference	Seattle, WA, USA	http://ashraem.confex.com/ashraem/s14/cfp.cgi
July 1–3	Alternative energy Sources	Kromeriz, Czech Republic	www.azecr.cz
July 7–12	Indoor Air 2014	University of Hong Kong, Hong Kong	www.indoorair2014.org
August 31–Sep 2	11th IIR-Gustav Lorentzen Conference on Natural Refrigerants - GL2014	Hangzhou, China	
September 7–9	14th International Symposium on District Heating and Cooling	Stockholm, Sweden	http://svenskfjarrvarme.se/dhc14
September 10–12	ASHRAE/IBPSA-USA Building Simulation Conference	Atlanta, GA, USA	http://ashraem.confex.com/ashraem/emc14/cfp.cgi
September 10–12	Building Services Summer School	Cesky Sternberk, Czech Republic	tzb.fsv.cvut.cz
September 21–24	Licht 2014 - Den Haag Holland	Den Haag, The Netherlands	www.licht2014.nl
September 24–25	35th AIVC Conference - 4th TightVent Conference - 2nd venticool Conference	Poznań, Poland	www.aivc.org
October 15–17	The 49th National Conference on Building Services	Sinaia, Romania	www.aiiro.ro
October 19–22	Roomvent 2014	Sao Paulo, Brazil	www.roomvent2014.com.br
October 28–29	9th International ENERGY FORUM on Advanced Building Skins	Bressanone, Italy	www.energy-forum.com/fr.html
October 29–31	XXXI ABOK conference and exhibition "Moscow - Energy Efficient City"	Moscow, Russia	http://events.abok.ru/meeg
October 29–31	CCHVAC 2014 conference	Tianjin, China	
December 3–5	45 HVAC&R International Congress	Belgrade, Serbia	www.kgh-kongres.org
December 10–12	9th International Conference on System Simulation in Buildings - SSB2014	Liege, Belgium	www.ssb2014.ulg.ac.be

Exhibitions 2014

October 1–3	Finnbuild 2014	Helsinki, Finland	www.finnbuild.fi
October 14–16	Chillventa 2014	Nuremberg, Germany	www.chillventa.de/en/

Conferences and seminars 2015

February 25–27	World Sustainable Energy Days 2015	Wels, Austria	www.wsed.at
April 16–18	International Conference Ammonia and CO2 Refrigeration Technologies	Ohrid, Republic of Macedonia	
May 7–8	Advanced HVAC and Natural Gas Technologies	Riga, Latvia	www.hvacriga2015.eu
May 6–7	REHVA Annual Meeting	Riga, Latvia	www.lsgutis.lv/
June 14–17	International Building Physics Conference	Torino, Italy	
August 16–22	IIR International Congress of Refrigeration	Yokohama, Japan	www.icr2015.org
September 10–11	CLIMAMED	Juan Les Pins, France	
October 20–23	Cold Climate HVAC	Dalian, China	www.coldclimate2015.org
October 26–28	11th International Conference on Industrial Ventilation	Shanghai, China	www.ventilation2015.org

Exhibitions 2015

January 26–28	2015 AHR Expo	Chicago, Illinois, USA	www.ahrexpo.com
February 26–28	ACREX India	Biec, Bangalore, India	www.acrex.in
March 10–14	ISH	Frankfurt, Germany	http://ish.messefrankfurt.com

Conferences and seminars 2016

May 22–25	12th REHVA World Conference - CLIMA 2016	Aalborg, Denmark	www.clima2016.org

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