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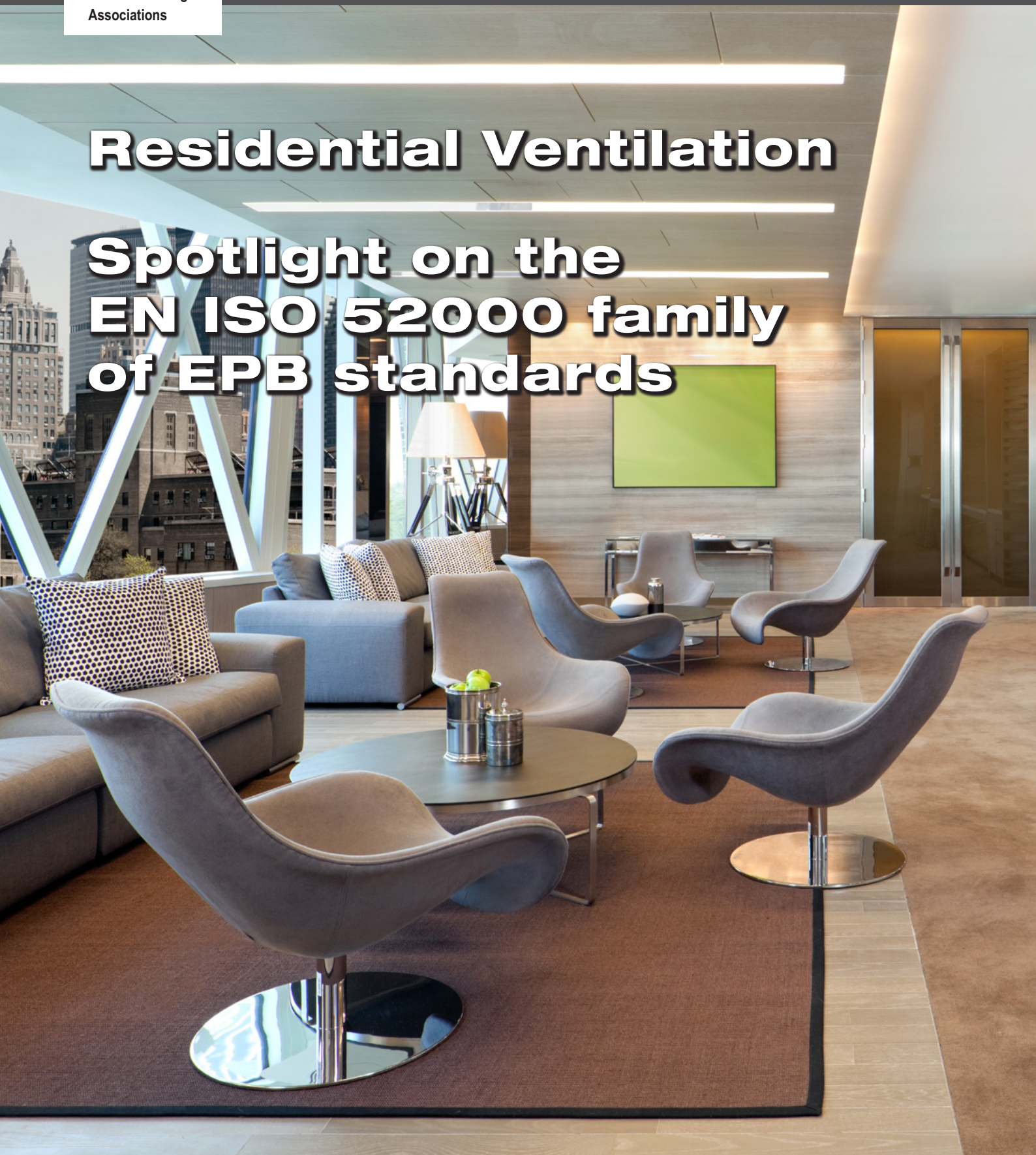

Residential Ventilation

Spotlight on the EN ISO 52000 family of EPB standards

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EPBD: *still ongoing discussion in Brussels**

eceee believes that energy efficiency first means that energy demand should be reduced as far as possible before the remaining energy needs are supplied by renewables. This principle is necessary to secure long-term sustainable building and to save more energy, resources and money. eceee has produced an update technical note on the EPBD Annex I, where these issues are defined.

In spite of much technical work, including work funded by the Commission, and of the extreme urgency of addressing the Climate crisis, the proposals currently on the table for the revision of Annex I of the EPBD are going to produce a regression compared to the 2010 version, by removing the double indicator of performance of buildings and reducing it only to one, primary energy (not better specified in the texts). This is in patent contradiction with the Standard ISO EN 52000-1 produced under Mandate 480 by the EU Commission. In fact, the Standard states: *"the use of only one requirement, e.g. the numeric indicator of primary energy use, can be misleading".*

The single indicator choice is also conflicting with the current interests of the major construction sector stakeholders, who are more and more interested in the environmental performance of buildings. Not by chance, the health performance of energy efficient buildings was a core issue of the REHVA Brussels Summit Conference and many articles in this Journal issue focus on ventilation systems and IEQ requirements.

Hartley supporting this quoted statement of eceee, referring to the EN ISO52000 family, it is our European Commission who reminds us that half of the EU's total energy consumption comes from heating buildings – whether in private homes, commercial or industrial facilities.

However, at political level this Commissions' statement seems forgotten every time the national ministers of the EU's 28 Member States meet. Last time EU Council met, the EU Commissioner in charge of climate action, Miguel Arias Cañete, lamented EU Member States' lack of ambition on energy efficiency.

Cañete's presence at the talks, the trialogue meeting, held December 5th, is a sign of the growing realisation among policymakers that buildings are the central piece of the puzzle when it comes to decarbonising the energy sector and offer multiple benefits beyond energy savings.

The challenge ahead is colossal. At the current rate of renovation of 1% per year, it would take a century to renovate Europe's entire building stock, the Commission stresses – well short of what is required to significantly reduce emissions from the sector.

The European Parliament rose up the occasion when it adopted its position on the EPBD, backing the report by Danish MEP Bendt Bendtsen by a large majority. The political debate focusses on long-term renovation plans and inspections for heating and cooling systems; e-mobility and decarbonised building stock by 2025; and transposition and review deadlines.

The European Parliament would like to have clear milestones for 2030, 40 and 50 to decarbonise the building stock. The Council seems to want just indicative milestones to ensure there are no binding commitments. The Council appears reluctant to close a loophole in the draft EPBD which would allow buildings powered by renewable energy sources to be labelled as more energy efficient than others, even when they are poorly insulated and waste huge amounts of heat.

The Parliament closed the loophole by tightening the definition of "near-zero emission buildings" in the annex of the directive, but the Council prefers keeping a vague wording, which makes the Member States less accountable to deliver.

On building automation and control systems (BACs) the EU Parliament wants binding measures introduced

* The discussion may not be closed yet. This editorial reflects my information dated 11-12-2017.

for large commercial buildings as of 2023 but EU countries don't want, claiming it's too technical. Which is a non-sense excuse if you combine this with reliable commission requirements to be reported regularly.

It seems the Council prefers vague terms like 'alternative measures', which doesn't offer the level playing field needed by industry to be able to invest in innovative solutions.

Moreover, by referring to alternative measures do nothing stay's an option. Perhaps an obligation could be acceptable for large commercial buildings, but be aware that their energy use is relative marginal considering the total existing building stock.

As things stand, the positions of the Parliament and Council are so far apart that a compromise seems out of reach. If the remaining month of December 2017 for the current Estonian Presidency will be used wisely, an acceptable compromise should be possible. Closing this discussion too quickly will have very negative consequences for the building and installation business in the coming 5–10 years. It will also not reflect the European Leadership to deliver on the Paris Agreement.

Quoting Monica Frassoni, President of the European Alliance to Save Energy (EU-ASE) "Investments in energy efficiency create essential multiple benefits for our economies, creating local jobs, increasing energy productivity and competitiveness. Energy savings achieved through energy efficiency investments are a chief enabler of sustainable growth and the energy transition". ■

JAAP HOGELING
Editor-in-Chief

Residential heat recovery ventilation – European guidebook under preparation

Nearly Zero Energy Buildings together with minimum ventilation requirements are already or are expected soon to be established because of new EPBD. These requirements are leading to general use of mechanical heat recovery ventilation systems. While there is almost no other option for heat recovery in heating dominated climates, this solution is also highly suitable for South European climates, because of effective filtering of carcinogenic particulate matter, whose concentrations are especially high in dense city areas.

Keywords: Heat Recovery, Residential Ventilation, Centralized Ventilation Systems, Decentralized Ventilation Systems, nZEB

JAREK KURNITSKI
Chair of Residential Ventilation Task Force

As with all dedicated systems, good technical knowledge and installation skills are needed in order to avoid problems caused by design and installation mistakes, which could easily destroy the reputation of any good system. REHVA set up Residential Ventilation Task Force in 2016 to develop an European guidebook including all information and calculation bases needed to design, size, install, commission and maintain Heat Recovery (HR) ventilation properly. If followed by practitioners, a challenge of silent, clean, draft-free and energy efficient ventilation can be solved European wide. The guidebook is expected to be published in March 2018 as REHVA-EUROVENT joint guidebook.

The guidebook includes major topics as selection of ventilation units, pressure drop and noise calculations, ventilation system layouts and installation in new and renovated buildings. It is mainly focused on centralized (one ventilation unit per staircase or building) and decentralized (one ventilation unit in every apartment) ventilation systems of Facade ventilation units were not seen suitable for nearly zero energy buildings because of many problems in operation and were excluded from the guidebook. When it is easy to install HR ventilation to new buildings, there are much more challenges and special solutions in renovation. To tackle this highly important market, best practice solutions were collected from North and Central Europe countries.

Airtight and highly energy efficient buildings create some new challenges for ventilation. There is no consensus in national regulation and guidelines about ventilation need, but latest standards FprEN 16798-1:2016 (replacing EN 15251:2007) and ISO 17772-1 include new section for airflow rate selection in residences. This is further developed by REHVA to be suitable for practical design, mostly with room-based supply and extract airflow rates, (see **Table 1**).

Noise calculation is perhaps the most "overkill" ventilation system calculation for most of practitioners. This has led to the situation where ventilation units are just installed without sound power and pressure calculation and this has resulted in many noise problems, because of undersized units or poor sound attenuation. For this reason, in addition to presenting noise calculations, the guidebook introduces noise prediction method which does not need any calculation. An example is shown in **Figure 1**.

Nearly Zero Energy Buildings are expected to be very airtight, with building leakage rate below 1 air change at 50 Pa. This provides new challenges for ventilation system balancing, especially in the case of cooker hood,

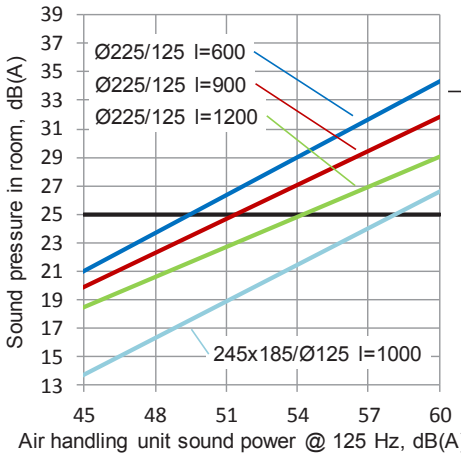
Table 1. Highlight from the new guidebook – an easy and straightforward room by room airflow rate selection procedure in residences. The values are to be multiplied by 3.6 to recalculate to m^3/h units.

	Supply airflowrate L/s	Extract airflowrate L/s	Air velocity[1] m/s
Living rooms[2] >15 m^2	8+0.27 L/(s m^2)		0.10
Bedrooms >15 m^2	14		0.10
Living rooms and bedrooms 11-15 m^2	12		0.10
Bedrooms <11 m^2, 3rd and the following bedrooms in large apartments	8		0.10
WC		10	
Bathroom		15	
Bathroom in one room apartment		10	
Utility room		8	
Wardrobe and storage room		6	
Kitchen[3]		8	
Kitchen[3], one room apartment		6	
Kitchen, cooker hood in operation		25	
Average airflowrate of a whole residence	0.42 L/(s m^2)		
Staircase of an apartment building	0.5 ACH		

[1] Maximum air velocity values apply at design airflow rate and supply air temperature in heating season conditions, in boost mode higher velocities may be accepted, see section 2.2.

[2] Transfer air from bedrooms may be reduced, 12 L/s is the minimum value

[3] Airflow rate in the kitchen when cooker hood is not in operation



	Attenuation, dB	
Attenuator	125 Hz	250 Hz
Ø225/125 l=600	6	13
Ø225/125 l=900	6	15
Ø225/125 l=1200	6	20
245x185/Ø125 l=1000	14	19

Figure 1. Selection of sound attenuator based on the sound power of the ventilation unit at frequency 125 Hz at design airflow rate. For example, if the sound power of the unit to supply duct is 54 dB, "green" silencer is required (1200 mm) to achieve 25 dB(A) sound pressure in bedrooms.

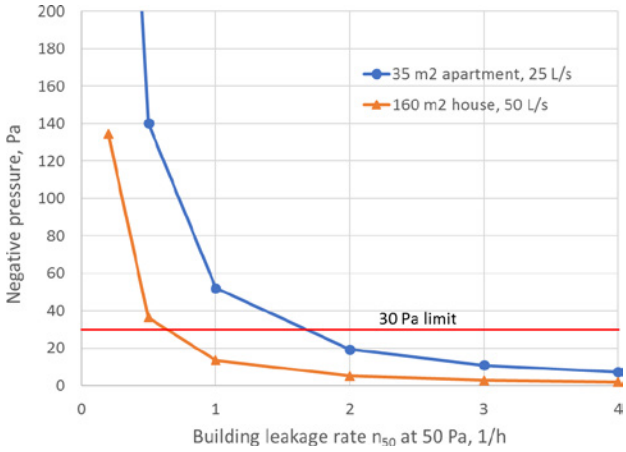


Figure 2. Conventional cooker hood in airtight nearly zero energy building leads easily to more than 100 Pa negative pressure.

fireplace or central vacuum cleaner operation. In airtight dwelling, a conventional cooker hood with 25 or 50 L/s exhaust, as considered in **Figure 2** example, can easily result in 100 Pa and more negative pressure. This occurrence becomes a safety issue, because doors cannot be opened by children if pressure difference is more than 30 Pa. Therefore, in all new buildings, cooker hoods are to compensated with supply air.

To achieve balanced operation, cooker hoods are recommended to be connected to ventilation units. In the case of units with plate heat exchanger, cooker

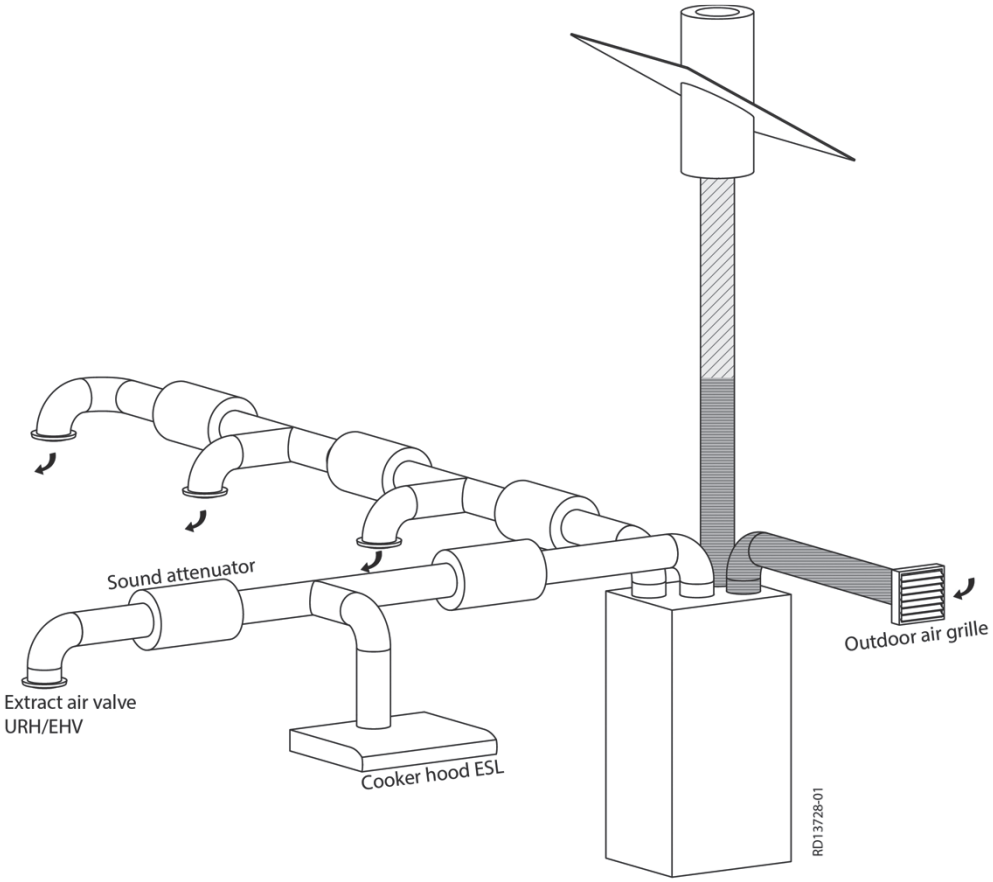


Figure 3. Cooker hood connected to ventilation unit with plate heat exchanger.

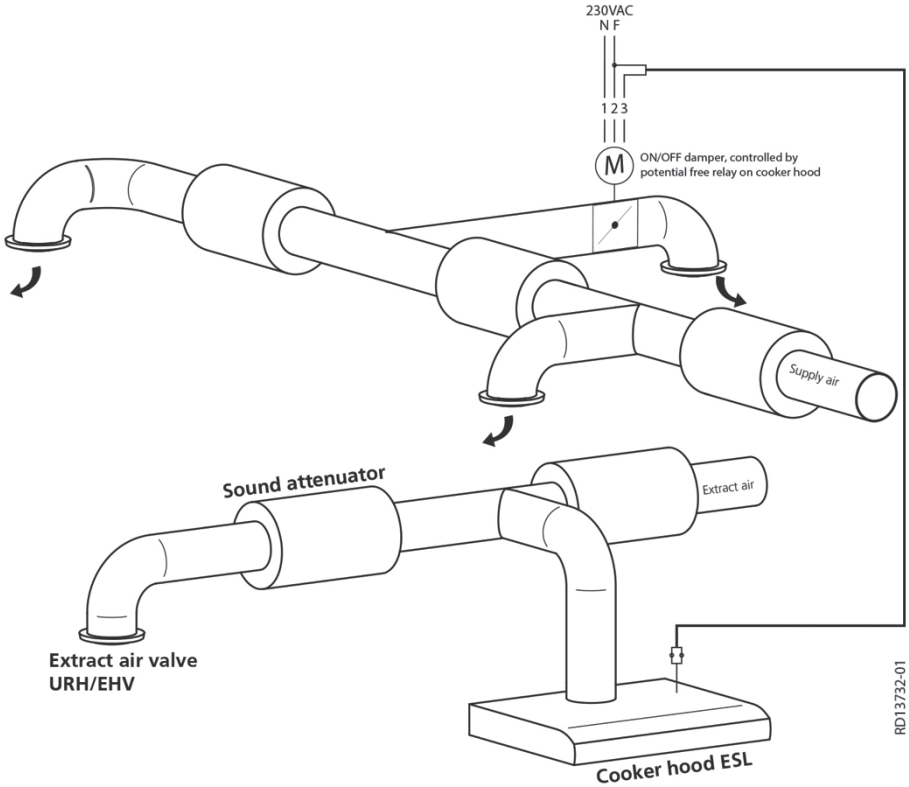
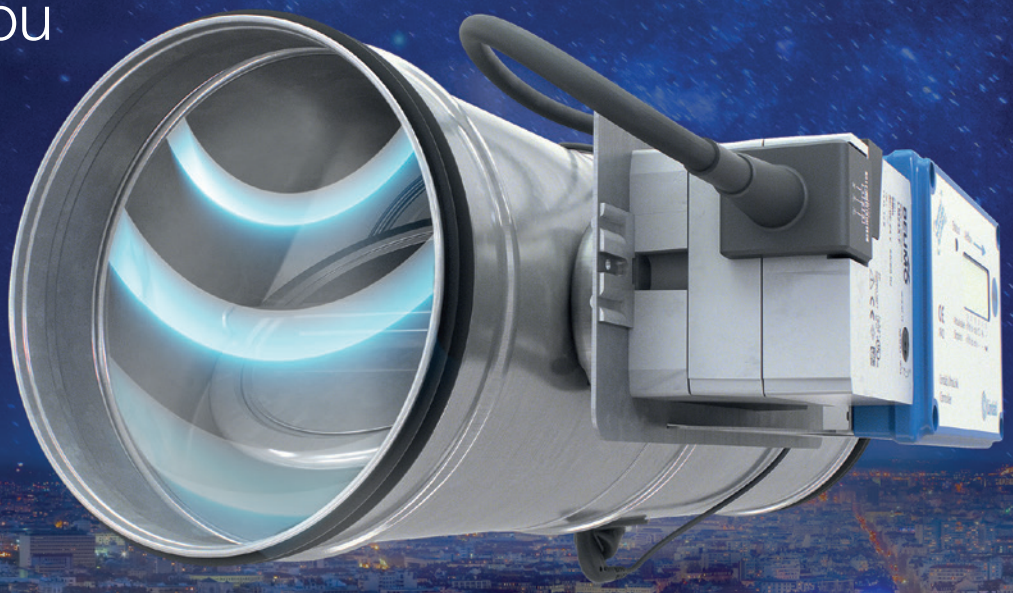


Figure 4. Cooker hood compensation in centralized ventilation system. During the operation, an additional supply air diffuser is opened.

hoods can be directly connected so that the extract air goes through the heat exchanger (see **Figure 3**). Units with rotary heat exchanger have special inlet for cooker hoods bypassing heat recovery.

In the case of centralized ventilation system, cooker hoods are similarly connected to extract air ductwork and central ventilation units must have plate heat exchangers. Opening the cooker hood will boost the ventilation. To compensate this, a voltage signal is used to open one additional supply air diffuser (see **Figure 4**). In such system, pressure sensor keeping constant pressure in risers will increase the fan speed, which means that the system still can be kept relatively simple ensuring reliable operation and low maintenance need. ■

The only thing you cannot measure is its potential



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Residential Ventilation – Needs, Trends and Expectations

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The increasing airtightness of our homes places new demands on residential ventilation: on the one hand ensuring occupants a good indoor climate, on the other hand protecting the building from damage caused by excessive air humidity. Legislation requiring ever lower energy consumption, combined with the expectations of adequate ventilation, presents a challenge for the ventilation market.

Keywords: Indoor Air Quality, Ventilation System, EPBD, EVIA

The new requirements for a residential building and its ventilation can be summarised in:

- energy efficiency and use of renewable energy,
- protection from any inside and outside harmful impact,
- good and healthy indoor environment,
- automatically operated and in a user friendly (smart) manner.

Buildings account for approximately 40% of overall energy consumption in the EU and for 36% of greenhouse gas emissions. Alongside non-residential and industrial buildings, residential buildings constitute a major source of emissions and energy consumption.

The Energy Performance in Buildings Directive (EPBD) aims to encourage EU Member States to facilitate the market transition to Nearly Zero Energy Buildings (NZEBs) with a very high energy performance. Whilst the drive to secure energy efficiency improvements is a laudable objective, the demands for energy savings is seeing our homes become increasingly airtight.

In turn, this places new demands on residential ventilation: on the one hand ensuring occupants a good indoor climate, on the other hand protecting the building from damage caused by excessive air humidity, e.g. mould growth.

Legislation requiring ever lower energy consumption, combined with an expectation of adequate ventilation, presents a challenge for the ventilation market.

It is therefore important to choose the right solution, rather than focusing on the cheapest options.

Indoor Environment Quality and Indoor Air Quality

Currently the main political and economic targets of the EPBD are energy savings, environmental impact and the cost of that. We forget that buildings are not built to save energy, money or emit low levels of CO_2. Buildings are fundamentally designed to protect humans by providing shelter from the cold, heat, rain, sun, dust, wind etc. Furthermore, buildings should not only provide protection from the elements, but should also ensure a high level of Indoor Environment Quality (IEQ) including:

- Indoor Air Quality (IAQ),
- thermal comfort
- lighting and acoustic environment

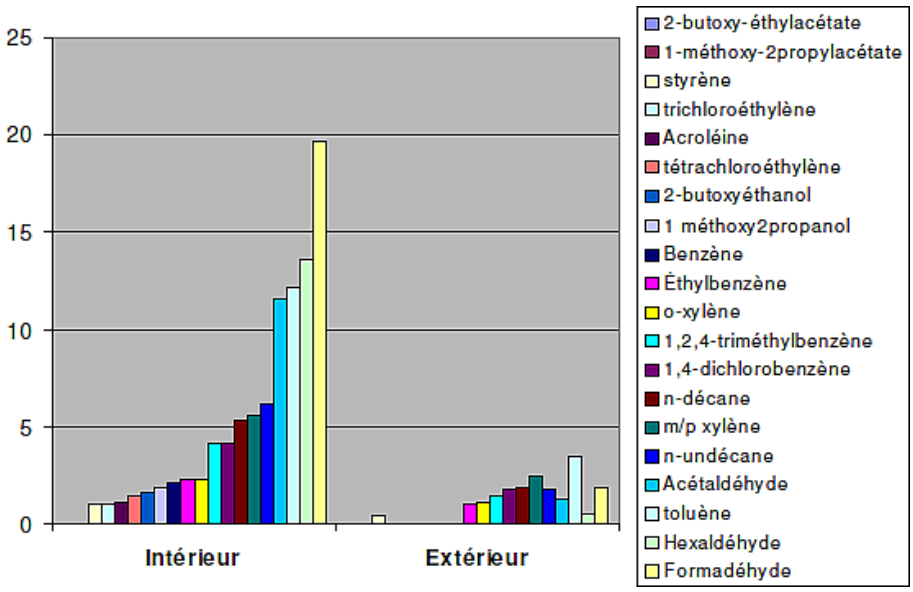


Figure 1. French National IAQ Survey, CSTB.

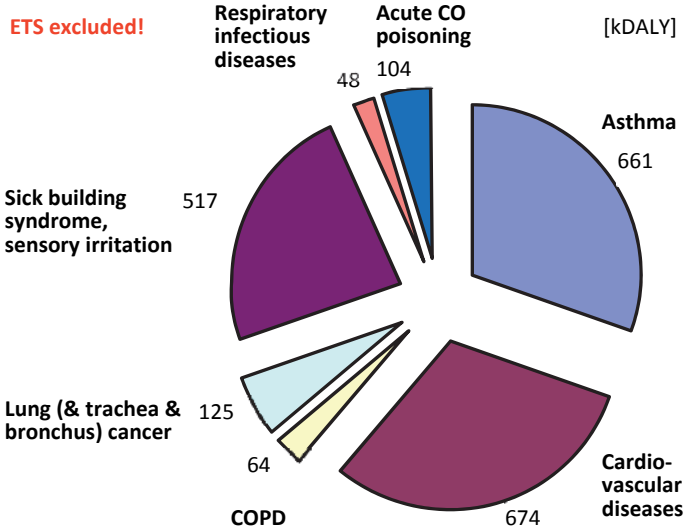


Figure 2. Health Effects of indoor air quality. [1]

Modern European citizens spend on average over 90% of their time indoors. Indoor air originates from outdoors, carrying outdoor air contaminants indoors with varying degrees of penetration: some are effectively transferred indoors (e.g. for PM2.5 penetration ranges from 50–90%), others are adsorbed on indoor surfaces or readily react with indoor air co-pollutants (e.g. ozone). In addition, indoor environments themselves contain sources of contaminants, which, due to the rate of air exchange in comparison to outdoor environments, can contribute considerably to high pollutant levels. Indoor environments have been widely studied for a range of chemicals and biological contaminants; in the presence of indoor sources, indoor concentrations of contaminants are higher, sometimes 10 or 20 times higher (e.g. formaldehyde), than those recorded in outdoor environments.

In combination, the generally higher indoor concentrations of contaminants and the overwhelming fraction of time spent by individuals indoors, mean that indoor air pollution is the dominant source of air pollution exposure regardless of whether the sources are indoors or outdoors. Indoor Air Quality is a complex result of occupant's activities, human responses, source emission, and contaminant removal.

Most indoor air pollutants arise from chemicals, through the use of cleaning products, air freshener and pesticides, and via emissions from furniture and construction materials, as well as from heating and cooking. Cooking emissions, for instance, have long been seen primarily as an odour problem. However,

recent field studies showed that Particulate Matter (PM) is a significant health risk of indoor air (Logue, 2013) and cooking can be a major source of PM2.5 [2].

In addition, outdoor sources can contribute considerably to indoor air pollution. Microbiological contaminants which may induce allergies and asthma also require consideration as indoor air pollutants. Examples of potential serious effects include respiratory disorders, including asthma and cancer.

Whilst CO_2 is considered as non-toxic, very high levels (typically not in residential buildings) have been shown to cause health problems for occupants.

However, from an indoor air quality standpoint, CO_2 is a surrogate measure for indoor pollutants emitted by humans as it is correlated with human metabolic activity and humans are the main indoor source of CO_2. Unusually, high indoor levels of CO_2 can cause occupants to grow drowsy, develop headaches and suffer from impaired activity levels [3] (**Figure 3**). Indoor CO_2 levels are an indicator of the adequacy of outdoor air ventilation relative to indoor occupant density and metabolic activity; with the highest levels of CO_2 typically recorded in bedrooms. Therefore, interior CO_2 levels are used as a scientifically accepted method of measuring how efficient a ventilation system is at maintaining the ventilation rate required to refresh the air.

Humans are the main indoor source of CO_2. Indoor levels are an indicator of the adequacy of outdoor air ventilation relative to indoor occupant density and metabolic activity. Typically, the highest CO_2 levels are measured in bedrooms. Thus, interior CO_2 levels are a useful way to measure how efficient the ventilation system is at maintaining the ventilation rate required to refresh the airflow.

Considering the aspects stated above, we can summarise the requirements for a residential building and its ventilation. The Building is

- energy efficient and uses renewable energy,
- gives protection from any inside and outside harmful impact,
- provides a good and healthy indoor environment,
- and operates automatically and in a user friendly (smart) manner.

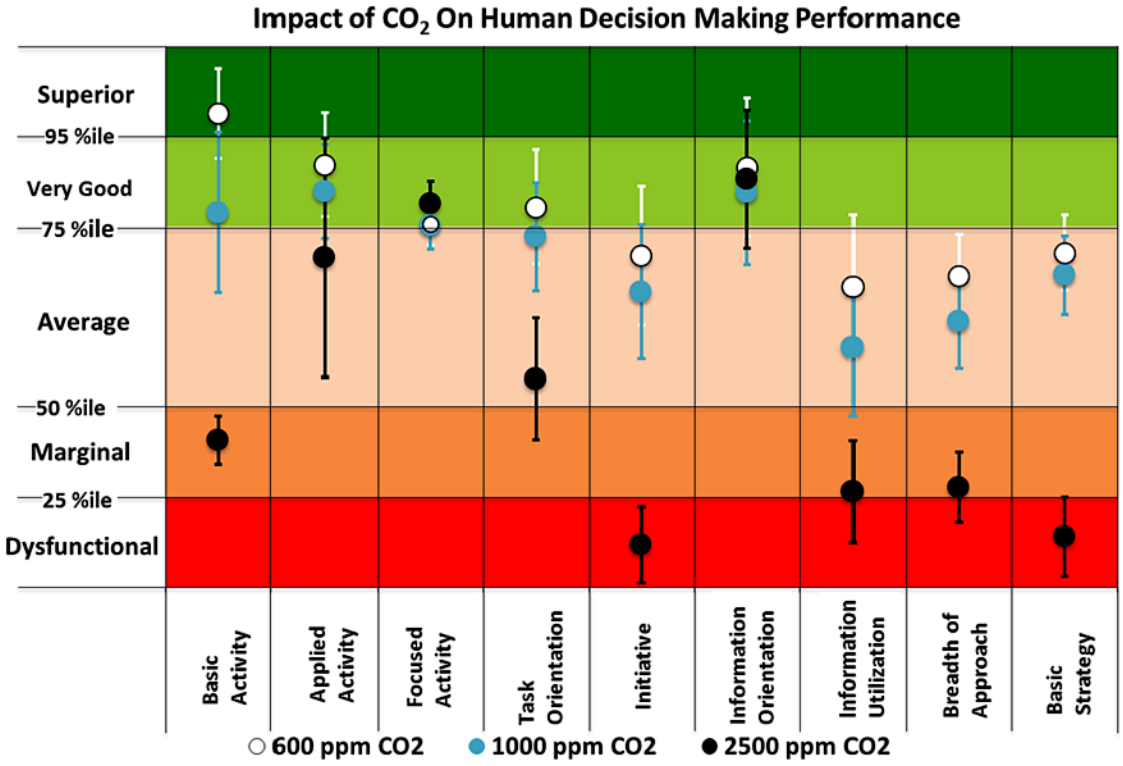


Figure 3. Impact of CO_2 on Human Decision-Making Performance. Error bars indicate one standard deviation. [3].

Residential Ventilation Systems

Europe has a wide range of climate zones and a big variety of building and construction traditions. This leads in parallel to a wide range of ventilation solutions for different applications. This is an advantage, because the building owner may select his preferred solution.

We distinguish the following different ventilation systems and strategies:

- Single technology systems
  - All natural
  - All mechanical (either centralized or local)
    - extraction only (MEU)
    - positive input ventilation
    - bidirectional ventilation with heat recovery (HRU)
- Multiple or hybrid technology systems

These systems may be equipped with:
- Demand control (CO_2, humidity, VOC, presence)
- Heat recovery (Air/Air or Air/Water with a heat pump)
- Smart feedback options
- Filtration (depending on the system options)

The energy impact of ventilation systems is covered in European and national EPB calculation rules, as lead down in the EPB standards. The energy rating of the ventilation products is declared according the Ecodesign and Energy Labelling Directives.

However, there is a distinct lack of information on IAQ performance. To correct for this discrepancy, EVIA is supporting the development of an IAQ calculation procedure [5] with the ambition of providing better information on the performance of residential ventilation systems and units in relation to IAQ.

Residential Ventilation Market

Modern residential ventilation systems provide high levels of IAQ at a low energy consumption. Therefore, it is surprising that up to now approximately 60% of the building stock in the EU has **no dedicated ventilation system** (**Figure 4**) [5]. The consequences are growing issues with mould and poor IAQ. For ensuring good IAQ it is essential that provisions are made to encourage proper installation of ventilation systems in the renovation market.

In most Member States, there are requirements to install dedicated ventilation systems in new residential buildings. There is however no EU legislation dealing with the issue of IAQ in renovation and there is no provision

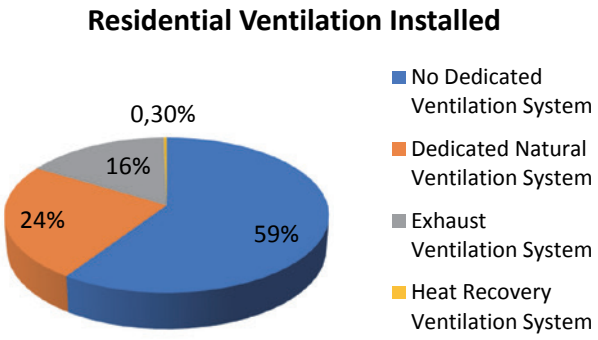


Figure 4. Ventilations systems in Building stock. [5]

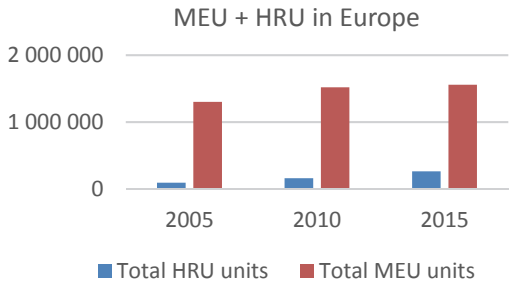


Figure 5. Ventilation in Europe. [6]

in the EPBD requiring IAQ information to be included in the Energy Performance Certificates. The architect, designing engineer, consumer and users of the building are required to take decisions with insufficient guidance on IAQ impacts, with the associated risk that designers might pursue and consumers seek energy optimisation at the expense of efficient ventilation.

Despite this drawback, the ventilation market has grown robustly in recent years due to the introduction of the EPBD. Mechanical extraction units (MEU) still dominate the market, but heat recovery units has begun to constitute a larger share of the market.

However, the picture does vary significantly from Member State to Member State, in large part due climate variations. Nordic Member States tend to have a larger share of Heat Recovery units, in a moderate climate there is more or less a balance and in Southern Member States MEUs and intermittent fans remain the norm.

Variation among Member States is illustrated effectively by comparing the French and German markets. In Germany, a strong rate of growth is evident in sales of single room units with heat recovery and units with an alternating air flow (push-pull) which are directly mounted in the façade.

In France, heat recovery units represent very small market share of about 5%, in contrast to some markets where the market share for MEU/MVHR can range from 60/40 to 50/50 in new-builds.

Is this enough? As EVIA we say no, because problems with bad IAQ are growing much faster, and regulations (national and European) has to take notice of this fact and should provide:

- Minimum requirements (either national or European)
- Consumer information in existing documentation and EPC.

Smartness of a Ventilation System

Could "smart home" solutions provide the answer to our issues?

If we listen to the ongoing discussions, some people might think so, forgetting that nobody knows what "smart" really means in this context. A definition cannot extend only to a simple connection to any network which allows for remote on and off, or changing the operation hours or setpoints.

Smartness could mean that IAQ sensors (CO_2/VOC/Humidity/temperature) are used to continuously measure and monitor ambient conditions in the house and provide real time feedback to a zone controller which manipulates the ventilation rate to match the specific use and occupancy of the building whilst ensuring the lowest possible energy consumption possible.

A recent European study [8] on smartness and user behaviour concluded that "*Home Energy Management systems as a combination of intelligent controls for heating ventilation and lighting consistently result in the lowest primary energy use for the lowest cost … The fact that innovative intelligent control systems can currently not be valorised within the official Energy Performance evaluation tools of the different EU member states clearly slows down the large scale deployment of these promising energy saving measures.*"

In addition, smart ventilation systems could secure further energy efficiency improvements by informing the building owner when servicing is needed or what exact element needs replacing.

Therefore, any definition of smartness in the context of ventilation should include objectives beyond energy efficiency including:

- Providing good IAQ using adequate demand control solutions,
- high thermal comfort,
- filtration depending on outdoor air quality,
- service and maintenance,
- network connectivity and functions.

Installation

New buildings, as well as renovations of the existing building stock, should aim not just for good energy performance but also for high quality standards with regard to the work undertaken, as this is a prerequisite for high building energy performance. Various experiences show that there are cases where the quality of the works is a (major) issue of concern [9]. Some EU Member States have imposed or will impose in the near future independent compliance checks to ensure the correct installation of ventilation systems.

Figure 6. Installations of residential ventilation systems.

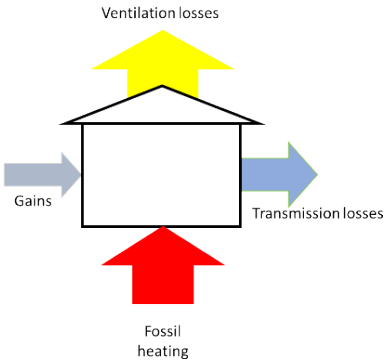
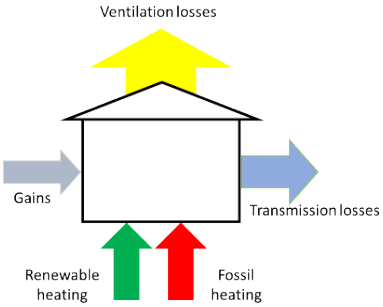
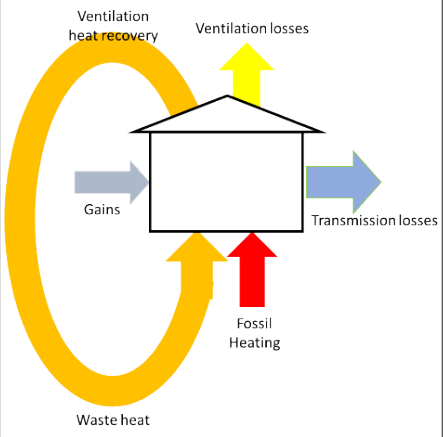
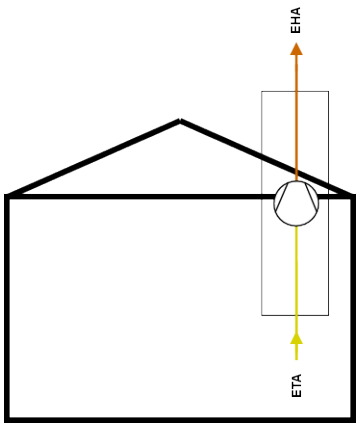
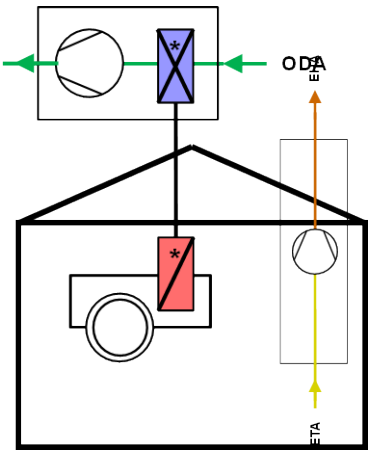
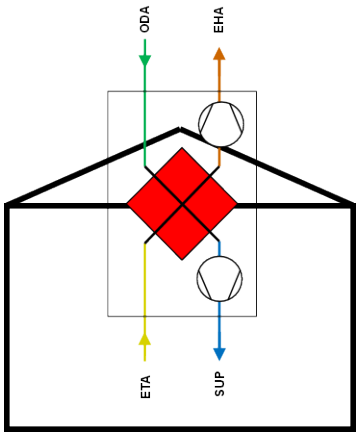
1 Fossil Heating	2 Renewable share Heating	3 Heat recovery
		
		
External and internal gains (solar, people, machines etc.) – same in each case		
Transmission losses though the building envelope – same in each case		
Fossil heating to cover the losses	Fossil heating to cover the losses not covered from renewables	Fossil heating to cover the losses not covered from waste heat use
Ventilation losses (airing + infiltration etc.)	Ventilation losses (airing + infiltration etc.)	Ventilation losses infiltration only
No waste heat recovered	No waste heat recovered	Energy recovered from ventilation losses. Heat recovery or heat pump
	Renewable heating (current regulation)	Waste heat use leads to the same result

Figure 7. Energy flow in a building and renewable and waste energy.

Heat Recovery and Waste Heat

The Renewable Energy Directive (RED) recognises heat pumps as a renewable energy technology and it is commonly accepted that outdoor air is a source of Renewable Energy. In this context, other technologies using exhaust air (which will become outdoor air once it has left a building) should be treated in the same manner as renewable energy in the revised Directive.

There is no technological or physical reason to handle recovered exhaust air differently from ambient air (see **Figure 7**).

In highly efficient NZEBs, the heating and cooling power demand for ventilation is the dominant component of the energy consumption. The most effective device to "generate" or recover the heating and cooling energy demand is heat recovery in ventilation units (using passive systems or heat pumps in ventilation systems).

Summary

The ongoing revision of the EPBD is a great opportunity to drive much needed improvements in the existing building stock and to promote systems and solutions that combine to deliver high Indoor Air Quality, low energy consumption and consumer empowerment. It is an essential tool to meet the EU's climate and energy targets and improve citizens' health, comfort and productivity. Therefore, EVIA and other organisations (REHVA among them) have requested the MEPs and the Member States to take up the following issues during the inter-institutional negotiations on the revision of the EPBD-directive:

1. Ensuring adequate indoor air quality in European buildings
2. Regular inspections of ventilation systems to achieve healthy and energy efficient buildings
3. Compliance checks to ensure a correct installation ■

Literature

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[3] Is CO_2 an Indoor Pollutant? Higher Levels of CO_2 May Diminish Decision Making Performance; William J. Fisk, Usha Satish, Mark J. Mendell, Toshifumi Hotchi, Douglas Sullivan, Lawrence Berkeley National Laboratory Berkeley, CA; State University of New York Upstate Medical University Syracuse, NY.

[4] Methodology for assessing the air-exchange performance of residential ventilation systems Rob C.A. van Holsteijn, Jelle Laverge, William L.K. Li; AIVC 2017.

[5] Ecodesign Lot 10 Study and Supplementary Study, FGK, 2010.

[6] EVIA estimations on current ventilation market.

[7] FGK BDH statistics – residential ventilation units with heat recovery 2016

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A short impression of a Dutch conference with the title

"Day of Indoor Air" [1]

Energy-efficient, comfortable and healthy, these are the core concepts of housing construction today. The importance of healthy indoor air has so far often been an underexposed theme. With an overwhelming attendance of 150 participants, a diverse mix of health specialists, ventilation equipment manufacturers, installers, residents' organizations and builders discussed a wide range of topics.

JAAP HOGELING
Editor-in-Chief

Presentations on the nuisance of asthma patients due to roasting of muesli, baking bacon pancakes in butter and lung diseases caused by dirty indoor air. About the importance of a effective extraction hood and sufficient extract flows. But also about those cosy candles by the fireplace and the noise from the ventilation box. And yes, the usefulness of opening a window. The Day of the Indoor Air is organized by VLA (the Dutch Association of Suppliers of Ventilation Devices), ISSO (knowledge institute installation technology), TVVL (Technical association for installations in buildings) and stakeholder parties like builders, developers and corporations for very energy-efficient new construction participating in the so called "Spring agreement".

A presentation of "Longfonds" (the Dutch Lung Foundation helping people with long diseases and promoting a healthy indoor environment) payed attention to the disastrous consequences of smoking, particulate matter in the air in the city and people with asthma. But the Lung-fondation's dream that nobody gets sick lungs through the air that he inhales, also applies to the home. "Because indoors, the air is often dirtier than outside. Not talking about just bad smells, but decent pollution with fine dust. "The indoor air is more important than we think. After all, more than 20 hours a day we are at home or in the office."

Just an example of normal household cooking activities: roasting muesli in the oven. Measurements with a new PM sensor showed that the concentration of very small particulate matter particles (PM2.5) increased to 100 micrograms per m^3. A level immediately noticed by asthma patients. People with respiratory diseases are often "the canary peeps in the mines". They respond immediately with breathlessness to unhealthy or insufficient air. In the Netherlands, 10% of the population suffers from asthma; 32 thousand children in the Netherlands are diagnosed with asthma and of 12 thousand people who die of lung cancer every year, of which 1200 people who have never smoked. Other effects of unhealthy air are cardiovascular diseases and in pregnancy there is a greater chance of preterm birth and lower birth weight. Dirty air leads to 4800 emergency admissions per year and on average to a shortening of the lifespan by 13 months.

The Lung Foundation notes that despite these shocking facts there is little knowledge, awareness and support for measures. "We should all become ambassadors today to change this", Mr.Rutgers of the" Longfonds" continues to his audience. "An alliance of dozens of organizations could be involved in a business network such as 'how healthy is the air in your office?' Because there is indeed an action perspective. "From the bottom up, we started a movement a few years ago to allow a generation of children to grow up in a smoke-free environment; that intention is now included in the coalition agreement of the new cabinet. Something like this can be done with healthy indoor air. "A test with a sensor from Philips in homes should show in mid-December whether households are prepared to intervene if the concentration of CO_2 or particulate matter indoors is too high, says Rutgers. "In schools, earlier tests showed that children react well to a traffic light model. They inform the teacher that the meter is in orange or red in the classroom."

[1] This text is based on the report as held November 2nd 2017 in Den Bosch in the Netherlands written by René Didde and published in Dutch at https://www.lente-akkoord.nl/binnenlucht-moet-en-kan-beter/

Keynote speech Jacqueline Cramer

Although the quality of the indoor air has to do with the outside air, Jacqueline Cramer knows more about the latter, says the former Dutch Environmental Minister (2007–2010). Yet Cramer presents a number of lessons that can be drawn from the increased attention to the quality of the outdoor air. "If there is to be more priority for indoor air, you have to consider that there must be urgency for the problem, there should preferably be a pact with stakeholders and there should be public support for the problem and the solutions," says Cramer. In regards to her experience in the field of outdoor air quality a pact with stakeholders was working. The EU requirements threatened a construction shutdown if the quality of the outside air did not improve significantly, municipal authorities woke up and Ministries put a lot of money at the disposal of research and innovation and they found measures such as speed limits of up to 80 and 100 km/h for cars on the road and the highways near cities.

Even in Cramer's reign it was already difficult to schedule indoor air. "Research showed that poor indoor air in schools led to sleepy and not concentrated pupils, but it was difficult for school boards to take measures, even if they would pay off for themselves within five years,". In short, it takes time and effort to get a process of source-oriented approach, urgency and social support in motion. There is another handicap. "The trend of Danish cosiness is now completely hip. Atmospheric candles, open fire, nice smells, lots of rugs and plaids. "They are all bad for the indoor air quality. But try to oppose it. The citizen can start thinking 'what do you steal away from me'. That can backfire in the residential sector. So, bring your message good and honest.

How to communicate with residents, frivolous videos instead of thick manuals?

Jacqueline Cramer herself lives in a new home, equipped with all modern gadgets. "I have a nice kitchen with a steam oven, mechanical ventilation, heat recovery, underfloor heating and a cooking island with a hood. And my coffee machine is also a whole thing. "But do not expect Cramer to go through all the manuals that are supplied. "All those big books, with all those fine print. It is far from being consumer-friendly. So urgently different, says Cramer. 'Does the cooker hood do something against the dust or not, under which conditions? I use the steam oven instead of baking and roasting on my stovetop. Is that okay? Can you use consumer fine dust meters to point out the new risks in a fair way? Make sure you have better hoods in the foreseeable future. Start thinking from the consumers point of view, provide them with action perspective, give information with frivolous videos instead of thick manuals."

Wrap-up the various sessions where professional and residents exchanged their views

1. Session 'An air-tight home ventilates better'

Residents: Thanks to videos and appealing examples, there is more insight into unintentional air leaks in the home. There are many misunderstandings among residents and professionals about the statement 'a 100% air-tight home ventilates better', but in the end everyone agrees that structural air leaks disturb the ventilation system. That is something different than opening a window for 30 minutes to air the house. That the misunderstanding is persistent is also evident from an interactive survey of this statement after the congress: 'I believe so, but I cannot explain' and 'yes, but it goes against my gut feeling'.

Professionals: Measure the airtightness of the house, not by one way of sampling, but always. Do not calculate based on assumed airtightness properties, but measure.

2. Session 'Cooking air'

Residents: TNO practice research at home and at the lab provides a wealth of tips. (see article Piet Jacobs in this REHVA Journal) Switch on the exhaust hood and ensure a flow rate of 300 m^3/h, preferably with discharge directly to the outside. Set the general mechanical ventilation system to the highest capacity and let it run for four hours. Use the rear pits of the cooking appliance and do not bake in butter (given its low burning temperature).

Professionals: Professionals need to better understand how much pollution, particularly by particulate matter, gets produced in the kitchen. Design better range hoods that, for example, turn on automatically when the stovetop is switched on, or vice versa, like an alcohol lock in the car, stoves that do not turn on when the cooker hood is not turned on.

3. Session 'The wonderful world of indoor air'

Residents: Residents learned that 'air must flow'. Ventilators and grids in the facade, residents have to do more with this. Many tips are given, such as 'open a window after the shower, but don't leave it open.'

Professionals: The performance of ventilation equipment has priority over energy efficiency. Ensure sufficient flow, so arrange good supply and discharge grills.

4. Session 'Indoor air specialist in 60 minutes'

Residents: Ventilation is an eye-opener. One does not know what balanced ventilation is and when you open the facade grilles you also have to open the interior door, for example in the bedroom. After all, exhausted air must be supplied again. Do not put draft stoppers in front of the interior doors.

Professionals: All too often ventilation systems are installed in the wrong places in the home, such as balanced ventilation grilles right next to the head of the bed. This requires problems for the resident. Think integrally and look at the whole house.

5. Session: 'Management and renovation of ventilation'

Residents: The housing corporation has responsibility, but the resident / tenant must also do something for it. Clean grilles and replace filters in time.

Professionals: There is a ventilation door for companies. Five companies are participating. This gives both clients and residents confidence in the cleanliness and capacity of the installations and guarantees for their operation. Communicate clearly with residents. ■

Cooking exhaust systems for low energy dwellings

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Especially in airtight low energy dwellings cooking exhaust systems are of utmost importance, as cooking can be a major source of $PM_{2,5}$ exposure. Dwellings should be designed including facilities enabling extraction of at least 83 dm³/s (300 m³/h) directly to outside. Residents should be able to select an effective hood.

Keywords: Cooking exhaust, $PM_{2,5}$, NO_2, capture efficiency, exhaust flowrate, low energy dwellings

Cooking emissions have long been seen as an odour problem. However recent studies show that Particulate Matter is the main health risk of indoor air (Logue, 2012) and cooking can be a major source of the total exposure (Kluizenaar, 2017). The exposure to Particulate Matter due to indoor sources like cooking can significantly increase in low energy dwellings, due to the airtight construction. Peaks remained for several hours, see **Figure 1**, in measurements that were part of a small field study in 9 Dutch dwellings (Jacobs, 2016a). In three dwellings, inadequate cooking exhaust caused in the evening an increase of the $PM_{2,5}$ concentration in the kitchen / living room of about 10 µg/m³. In 2010, the World Health Organization has indicated that the $PM_{2,5}$ guideline value of 10 µg/m³ yearly averaged is also applicable to indoor spaces. (WHO, 2010).

The two questions which we try to address in this article are:

- what is the effect of relative short cooking events on the yearly averaged value;
- which systems are required for adequate cooking exhaust in low energy dwellings.

We use the term cooking exhaust system as the combined effect of type of exhaust hood, exhaust ducting and air supply is of importance.

From mixing ventilation to source control

One of the first guideline (TV 187) for kitchen ventilation in Dutch was set up by WTCB (Wouters, 1993). TV 187 does not provide a value for capture efficiency of a hood. The guideline assumes that the hood will not capture all cooking fumes directly and therefore the air in the kitchen will be polluted. Based on this assumption the guideline gives as a rule of thumb that the exhaust flow of a hood in m³/hour should be 6 to 8 times the volume of the kitchen to keep the lag time, the time required to keep the hood on after cooking, within an acceptable time period. This allows, for a closed kitchen, to remove 95% of the pollutants within 20 to 25 minutes after cooking. This rule of thumb is based on closed kitchens with a limited volume. In a typical kitchen of 25 m³ this amounts to an exhaust flow for the hood of 150–200 m³/hour. In the last years, in the Netherlands the layout of dwellings has

changed rapidly from closed kitchens towards open ones. The combined floor space of kitchen and living room is often in the order of 40–60 m², leading to volumes around 100–150 m³. Application of the same rule of thumb requires a hood exhaust flow up to 1200 m³/hour (333 dm³/s). This high flowrate is difficult to realize, as it requires sufficient air supply to prevent uncomfortable under pressure in air tight dwellings. Without preheating, this may introduce comfort problems due to draught and a serious energy penalty due to increased heating energy. The conclusion is that in dwellings with an open kitchen it is essential to directly capture the cooking fumes before they diffuse to the large air volume of the living room which is in open connection with the kitchen.

Effect of capture efficiency on exposure

Source strength

Recently, TNO and the university of Nottingham have measured the Particulate Matter source strength of four meals typical for western European cooking under laboratory controlled conditions, see **Table 1**. The results indicate that frying meat and vegetables at high temperature generates the most particulate matter. The average $PM_{2,5}$ emission based on these four meals was 35 mg. In literature, large differences can be found with regard to source strength for the preparation of the 'same' dish under lab conditions. For example, for frying chicken Dacunto (2013) found 5,7 mg, while Fortmann (2001) found values between 70 and 464 mg. The latest value was obtained as a worst-case scenario: oil very hot and frying during a long time. However, the average emission of 35 mg coincides well with a field study by Chan (2017) in 18 dwellings during two weeks in which the average source strength of the in total 836 events amounted 30 mg.

Dilution and deposition

For the decay of the $PM_{2,5}$ concentration, aside ventilation also deposition plays an role, as shown in **Figure 1**. Deposition is the precipitation of particulate matter on surfaces. In lab measurements, the deposition rate was of the same order as the ventilation rate. This effect has also been observed during the field test. The decay

Table 1. $PM_{2,5}$ source strength for four typical dishes.

Meal	$PM_{2,5}$ emission [mg]
Chicken fillet, French beans with cooked tomatoes	21,7
Chicken fillet, French beans with fried tomatoes	19,1
Pasta Bolognese	46,3
Stir fry chicken filet with vegetables and noodles	52,2
Average per meal	*34,8*
Average per day (assuming 5 days of cooking per week)	*24,9*

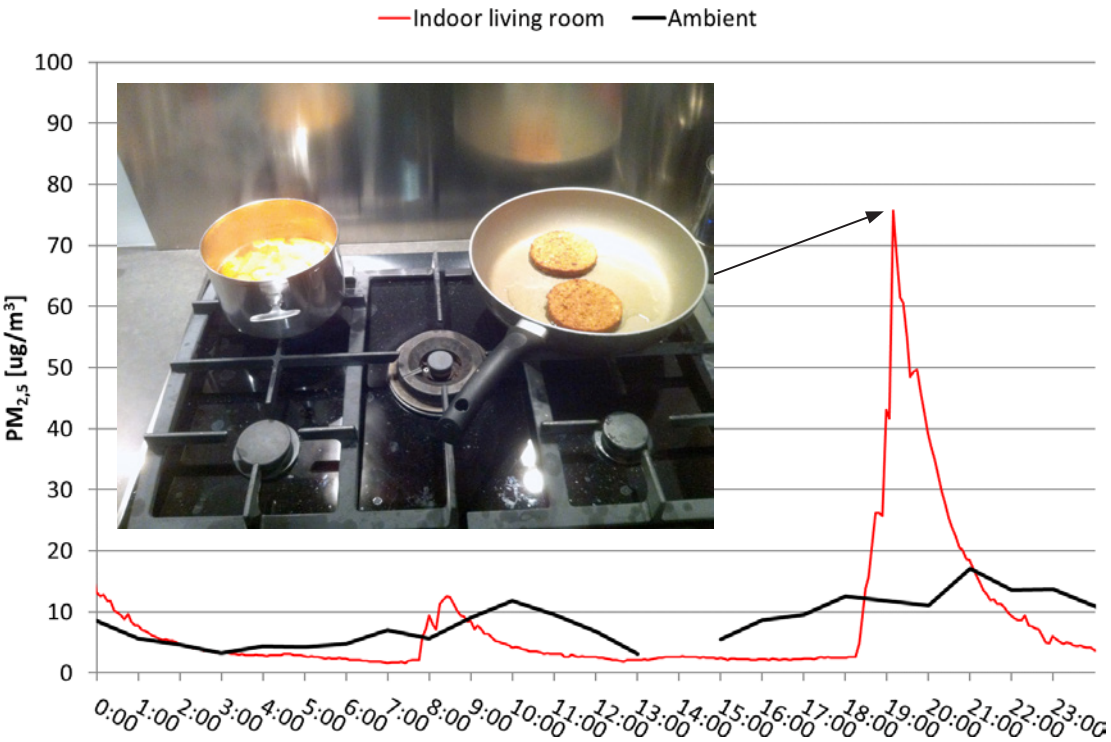


Figure 1. Typical particulate matter concentrations during a day, the peak concentration is caused by hamburgers frying, note that it takes more than 4 hours to dilute this cooking contamination.

could be explained with a dilution of 28 dm³/s, of which 40% could be explained on the basis of the ventilation rate. The other 60% was caused by infiltration and deposition. In general, the decay will vary by dwelling type, occupant behaviour, meteorological conditions, etc. As best guess for this study, a decay rate corresponding with a ventilation rate of 28 dm³/s for the kitchen / living room is taken.

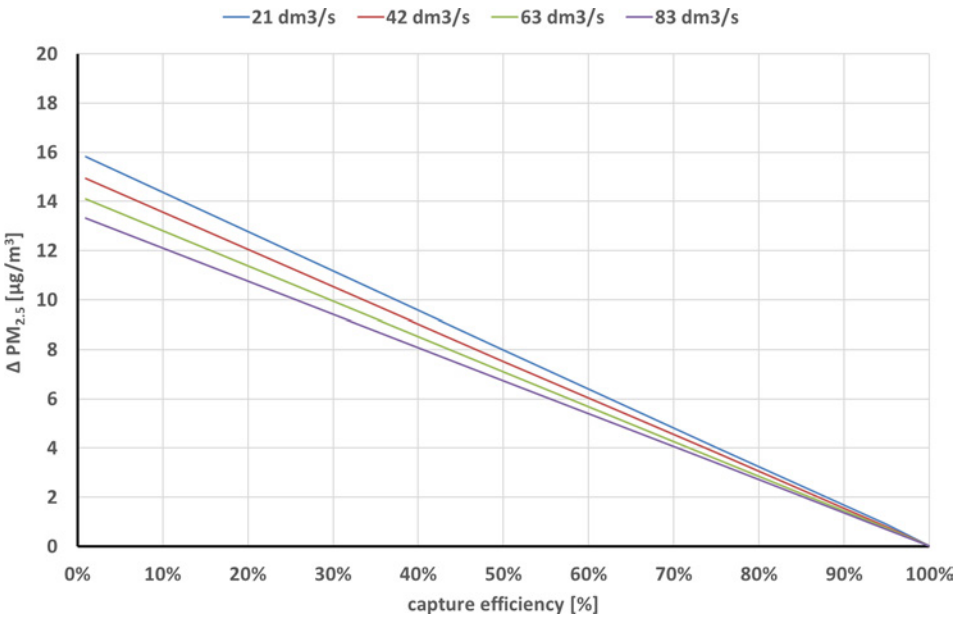


Figure 2. Residence time averaged $PM_{2,5}$ concentration increase in dwelling as function of hood capture efficiency and flowrate.

Indoor $PM_{2,5}$ exposure due to cooking

Figure 2 shows the increase in $PM_{2,5}$ concentration to which residents are exposed to during their stay in their dwelling due to cooking emissions. This figure is based on calculations with a 2-zone COMIS model. Cooking was simulated by a 10 minutes emission period, starting at 18.00 hour with an emission of 25 mg/day. After the cooking period, the decay due to ventilation and deposition was simulated with a volume flow of 28 dm³/s. During cooking the exhaust flow through the hood varied between 21 and 83 dm³/s. With higher exhaust flows, the escaped cooking fumes are more diluted. As discussed earlier, this dilution effect is a relatively small effect compared to the capture efficiency itself. The exposure was calculated over the period 18.00–23.00 h, which is a typical duration for stay in the kitchen/living room. It was assumed no exposure during the time that the persons are in the sleeping room (9 hour per day) and during the time they stay in the kitchen/living room before the cooking. Additional no exposure was accounted during 58 hours per week when occupants are outside the dwelling. The additional exposure of $PM_{2,5}$ due to cooking ($\Delta PM_{2,5}$) was averaged over a 15.7 [1] hour stay per day in the dwelling.

The exposure in the dwelling also depends on the infiltration of ambient $PM_{2,5}$. Hoek (2008) measured the relation between indoor and outdoor concentration in 50 Dutch dwellings in Amsterdam. He found an average infiltration factor of 0.39 during winter time. Research of MacNeil (2014) in 50 Canadian dwellings in Halifax, a city near the coast with a similar climate as in the Netherlands, showed that the infiltration due to open windows in summer (0.8) can be much higher than in winter (0.53). Based on these findings, the assumption of a yearly average infiltration coefficient of 0.5 for Dutch dwellings seems reasonable. The yearly averaged Dutch $PM_{2,5}$ concentration amounts to 15 µg/m³. Based on these assumptions (the infiltration level and the 15 µg/m³ level), the average $PM_{2,5}$ indoor concentration due to ambient sources would be 7,5 µg/m³. In order to limit the indoor exposure to the WHO $PM_{2,5}$ guideline value of 10 µg/m³, in the Netherlands a $\Delta PM_{2,5}$ of at most 2.5 µg/m³ would be permitted, although lower values are preferred. Based on **Figure 2**, for a typical dwelling and cooking behavior capture efficiencies in excess of 80% are required.

Minimum capacities for adequate cooking exhaust

In the TNO kitchen lab, a measurement method for the capture efficiency of cooking hoods in combination with inductive cooking is being developed. **Figure 3** shows the relation between the capture efficiency and the exhaust flow rate for three typical hoods at 83 dm³/s (300 m³/h). The capture efficiency of the chimney hood is 95%, the X-hood 84% and the slanted hood 70%. With an 'efficient' hood, an exhaust flow of 300 m³/h is advised. However, to reach a capture efficiency of 80% with the slanted hood, a two times higher exhaust flowrate is required as with the chimney hood. These differences can be explained by geometrical factors such as the presence of a damp buffer (Jacobs, 2016b) and the

[1] 7 x 24 = 168 hours/week: 168–58 = 110 hours, which results in 110/7 = 15,7 hours/day.

coverage of the burners by the overhang (see **Figure 4**). The chimney hood almost completely (95%) covers the skillets, which are placed on the front burners. With the slanted hood, the exhaust part of the hood is behind the front burners, and here the coverage of the front burners is 0%. The finding that the coverage of the front burners by the overhang is an important factor was also found in a field study in 15 dwellings (Singer, Delp, Price, & Apte, 2012). This finding was confirmed in a later study (Lunden, Delph, & Singer, 2015) under laboratory conditions. Capture efficiencies in this study varied by hood and airflow: 34–38% for low (51–68 dm³/s) and 54–72% for high settings (109–138 dm³/s) with front gas burner use for stir frying. The lower capture efficiencies found by Lunden et al. can be explained by the high gas burner

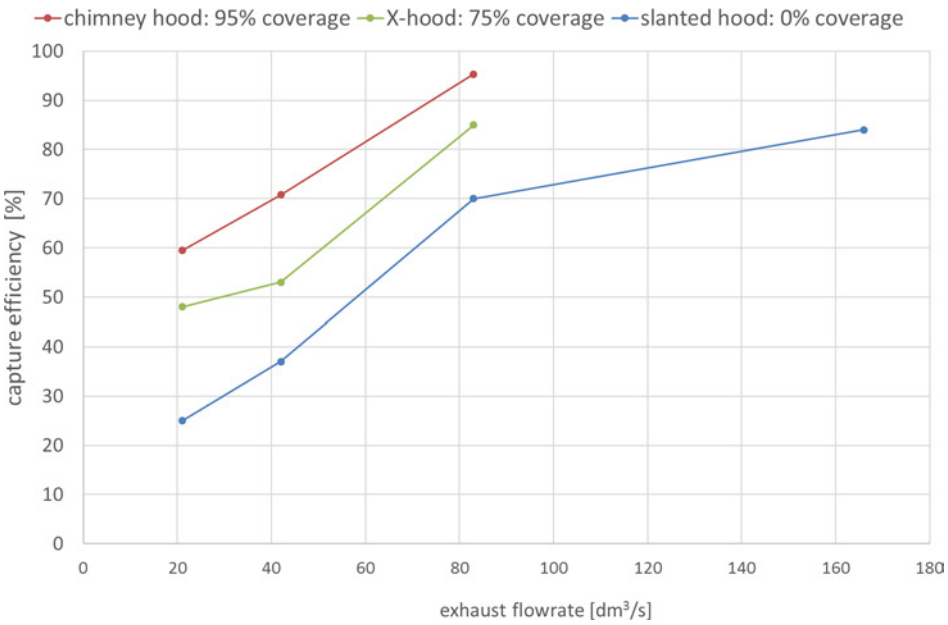


Figure 3. Relation between the capture efficiency and the exhaust flowrate for three typical hoods.

Figure 4. Laboratory setup for cooking: left chimney hood with 95% coverage of front burners, right slanted hood with 0% coverage of front burners.

power of about 2300 W used for stir frying. Assuming a heating efficacy of 50% for gas heating, about 1250 W are lost, causing a larger thermal plume compared to the TNO method for inductive cooking, where 400 and 500 W heat is released by the left and right front burner respectively. When cooking on gas, it is advised to have an exhaust capacity higher than 300 m³/h.

Combustion gasses due to cooking on gas

Gas burning produces pollutants including carbon monoxide (CO), nitrogen dioxide (NO_2), formaldehyde (HCHO) and ultrafine particles. Research by Mullen (2016) in 352 Californian homes showed an average NO_2 concentration increase of 48 µg/m³ in homes with gas cooking without kitchen exhaust compared to electric cooking. A simulation study by Logue (2014) estimated that in homes with gas cooking without coincident use of venting range hoods 62%, 9%, and 53% of occupants are routinely exposed to NO_2, CO, and HCHO levels that exceed acute health-based standards and guidelines. Logue's simulation results suggest that regular use of even moderately effective venting range hoods would dramatically reduce the percentage of homes in which burner generated concentrations exceed health-based standards.

Recirculation hoods are not recommended

Research by Jacobs (2017) suggests that recirculation hoods based on carbon filters remove $PM_{2,5}$ only for about 30%. Applied with cooking on gas, a fresh carbon filter removes about 60% of the NO_2, dropping within a few weeks of cooking to 20%. For both types of cooking it is not recommended to use such recirculation hoods, but to directly discharge the cooking fumes to outside.

Design implications

In the design phase of a dwelling, especially in case of serial housing construction, it is often not known what kind of kitchen and cooker hood will be installed later. In these cases, it is important to offer the possibility to the residents to connect a cooker hood with discharge to the outside. This is of special importance in apartments, were kitchens are often not directly near a façade. There are two possibilities:

- A motor less extractor hood with a high-quality grease filter (class A EU energy label for cooker hoods) that can be connected to the ceiling extract valve of the ventilation system with a minimum capacity of 83 dm³/s (300 m³/h). The so-called cooking mode of the ventilation system is only used during

REHVA Annual Meeting 2018

The next Annual Meeting that will be held in Brussels, Belgium from **Saturday 21 April 2018 to Monday 23 April 2018**.

REHVA Annual Meeting 2018
Brussels, 21-23 April
Hosted by ATIC

The schedule will be the following:

- **Saturday 21 April 2018**: the Committee meetings and a Member Associations roundtable discussion followed by the REHVA Welcome Cocktail;
- **Sunday 22 April 2018**: the REHVA General Assembly in the afternoon followed by the ATIC Anniversary Dinner and REHVA Professional Awards;
- **Monday 23 April 2018**: the REHVA/ATIC Conference with in parallel the part 2 of the Technical and Research Committee in the morning in which our Supporters are invited, while, in the afternoon, the Supporters Committee meeting.

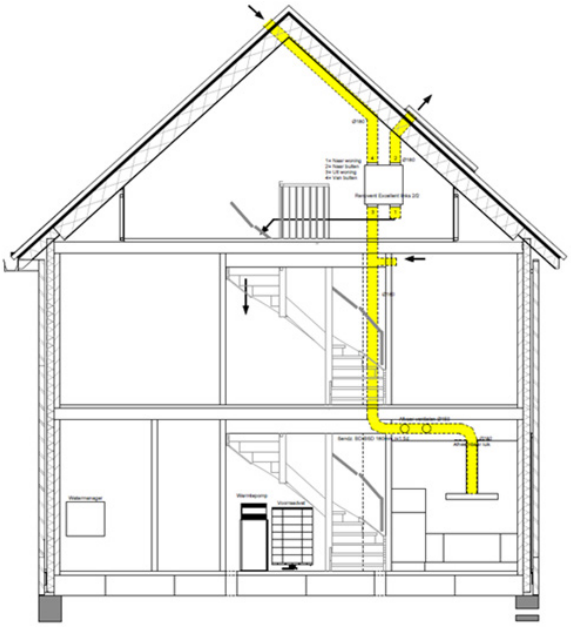
For more information: www.rehvam2018atic.eu

REHVA World Congress CLIMA2019

The next REHVA World Congress, CLIMA2019 was promoted during the last REHVA Annual Meeting by the new REHVA Board Member Catalin Lungu as vice – president of AIIR, the REHVA Member organizing it. The next CLIMA Congress will be held in the Romanian Parliament Palace in Bucharest between **26-29 May 2019**.

For more information: http://clima2019.org/

CLIMA 2019
Built environment facing climate change
REHVA 13th HVAC World Congress
26 - 29 May, Bucharest, Romania



the cooking. An example for a balanced ventilation system in single-family house is shown in **Figure 5**.

- An air duct direct towards the façade or towards the ridge of the house with a maximum pressure drop of 50 Pa at 83 dm³/s (300 m³/h). This should be implemented in combination with a supply air provision that keeps the under-pressure in the kitchen below 10 Pa. ■

Acknowledgements

The VentKook project has been financed with TKI subsidy of the ministry of Economic Affairs for TKI Urban Energy, Topsector Energie, www.tki-urbanenergy.nl.

Figure 5. Nero Zero house, motor less hood connected to balanced ventilation system with 180 mm ducting and minimum number of bends. To be visited from March 1, 2018, consult: info@koppenbouwexperts.nl.

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The Air Infiltration and Ventilation Centre's new Technical Note 68 "Residential Ventilation and Health"

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The AIVC Technical Note 68 "Residential Ventilation and Health" summarises studies that prioritise pollutants in the indoor environment and presents a summary of pollutants driving the indoor health risks and their sources. It also describes methods to reduce exposures of contaminants using different control strategies with a special emphasis on the role of ventilation.

TN68 is freely available for registered users to AIRBASE service*. Conditions for on-line access to AIVC publications are explained on AIVC website.

This AIVC Technical Note has been endorsed by the IEQ-GA, the Indoor Environmental Quality Global Alliance (www.ieq-ga.net), whose full members are:

- The American Society for HVAC Engineers (ASHRAE)
- the American Industrial Hygiene Association (AIHA)
- Air Infiltration and Ventilation Centre (AIVC)
- the Air & Waste Management Association (A&WMA)
- the Indoor Air Quality Association (IAQA)
- Federation of European Heating, Ventilation and Air-conditioning Associations (REHVA).

The vision of the IEQ-GA is to be the world's primary source for information, guidelines and knowledge on the indoor environmental quality in buildings and places of work around the world.

* http://www.aivc.org/resource/tn-68-residential-ventilation-and-health

Technical Note highlights

Exposures in houses constitute the major part of exposures to airborne pollutants experienced through the human lifetime. They can constitute from 60 to 95% of our total lifetime exposures, of which 30% occurs when we sleep. The airborne pollutants constituting these exposures have sources outdoors and indoors. Pollutants having sources outdoors penetrate building envelope through cracks, gaps, slots and leakages, as well as through open windows and ventilation systems. Indoor pollutant sources include humans and their activities related with hygiene, house cleaning, food preparation, laundry, etc.; also building construction materials, furnishing, and decoration materials; mould, bacteria, and fungi; tobacco smoking and combustion processes; as well as pollutions from pets and pests.

Exposure controls should be designed to minimize health hazards and avoid unwanted odours. To do this, we must identify the pollutants driving the health risks and identify the best control strategies for those pollutants. High concentrations are not necessarily indicative of a health hazard. Pollutant concentration data alone cannot be used to identify pollutants driving health hazards. Toxicity

varies widely from pollutant to pollutant and extensive research has been undertaken to link exposures levels of specific pollutants to specific adverse health outcomes. Toxicology and epidemiology have traditionally been used to link concentrations/ exposures to health outcomes. However, in-silico and in-vitro based assessments of toxicity are gaining prominence.

Several studies have attempted to prioritize pollutants for mitigation in the indoor environment based on the prevalence of disease in the community, occupant exposure estimates, and the research derived links between exposures and health outcomes. The key pollutants identified as driving chronic health impacts include: PM2.5 (particulate matter with a diameter less than 2.5 microns), mould/moisture, radon, environmental tobacco smoke (ETS), formaldehyde and acrolein. To reduce the exposure of contaminants different control strategies can be applied. The most effective are (1) source control and reduction of pollutant sources and (2) enclosure and encapsulation of sources. Ventilation plays a key role in reducing exposures that cannot be controlled by these measures. Effective local ventilation, such as cooker/ range hoods, are critical for removing pollutants from periodic high emission sources such as cooking. Other contaminants can be removed by making use of mixing ventilation or displacement ventilation. The correct amount of ventilation is still an area of debate.

A new AIVC project is a study of the ratio behind ventilation regulation and standards in different countries. In many countries odour and moisture play an important role but some countries formaldehyde is an important source. Because the level of ventilation differs a lot over the several countries it is interesting if we can explain the reasons behind this. Although we already received valuable input of different countries your input is most welcome. We think it would be important information as input for a metric based on exposure. ■

Indoor environmental input parameters for the design and assessment of energy performance of buildings

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EN16798-1 is the future European standard dealing with all indoor environmental parameter, replacing EN 15251. Within the new set of EPB standard, EN16798-1 is essential for the whole calculation of energy performance of buildings and related certification safeguarding acceptable indoor environmental quality. While the standard will be out for formal vote on January 2018, its accompanying technical report CEN TR 16798-2 has already been accepted. The formal acceptance of both documents will enable EU experts to benefit of a holistic approach to buildings energy performance calculation.

Keywords: EPB standards, prEN16789-1, CEN TR 16798-2, Indoor environmental parameters

The first international standard that dealt with all indoor environmental parameters (thermal comfort, air quality, lighting and acoustic) was published in 2007 as EN15251. This standard prescribed input parameters for design and assessment of energy performance of buildings and was a part of the set of standards developed to support the implementation of the Energy Performance of Buildings Directive in Europe.

This standard was revised and issued for public comments with a new number: prEN16798-1. Besides the standard, a Technical Report, 16789-2, is also being developed to support and explain in more details the standard. There were many comments received and the document was revised for formal vote Fpr16798-1 in 2016. Unfortunately, the standard was with a small margin not-accepted whereas the Technical Report was accepted. The reasons for not-acceptance were for some countries technical and significant problems with the format, that unfortunately was changed and did not comply with the basic rules for the EPBD-standards.

Both documents have now gone through an editorial review so that they fulfill the basic format requirements. A new formal vote will start in January 2018. There are no fundamental technical changes compared to the versions voted on early 2017.

The standard prEN16798-1

The scope of the standard is:

- to specify requirements for indoor environmental parameters for thermal environment, indoor air quality, lighting and acoustics and specify how to establish these parameters for building system design and energy performance calculations.
- to include design criteria for the local thermal discomfort factors, draught, radiant temperature asymmetry, vertical air temperature differences and floor surface temperature.
- to be applicable where the criteria for indoor environment are set by human occupancy and where the production or process does not have a major impact on indoor environment.
- to specify occupancy schedules to be used in standard energy calculations and how different categories of criteria for the indoor environment can be used.
- to be used in national calculation methods. This standard sets criterion for the indoor environment based on existing standards and reports listed under normative references or in the bibliography.
- not to specify design methods, but to give input parameters to the design of building envelope, heating, cooling, ventilation and lighting.

This standard is essential for the whole calculation of energy performance of buildings and related certification. The standard is now written in normative language and should be clearer as all the informative text will be included in the technical report. The standard does include default criteria in three or four categories for the various indoor environmental parameters. These default values are included in a series of tables in an informative Annex B. Individual countries can decide if they want to use these default values, only use one category, or use quite different values, which will be included in a normative national Annex A with similar structure as Annex B.

The calculated energy performance and energy use of buildings depends significantly on the criteria used for the indoor

environment (heating, cooling, ventilation and lighting) and building (including systems) design and operation. Indoor environment also affects health, productivity and comfort of the occupants. Recent studies have shown that costs of poor indoor environment for the employer, the building owner and for society, are often considerably higher than the cost of the energy used in the same building. It has also been shown that good indoor environmental quality can improve overall work and learning performance and reduce absenteeism. In addition, uncomfortable occupants are likely to take actions to make themselves comfortable which may have energy implications. There is therefore a need for specifying criteria for the indoor environment for design and energy calculations for buildings and building service systems.

The present standard specifies how design criteria shall be established and used for dimensioning of systems. It defines how to establish and define the main parameters to be used as input for building energy calculation. The standard also gives default criteria for design and energy calculations in an informative Annex B. A similar normative Annex A is included for specifying national criteria in a normative way. The national Annex A may specify different criteria for design compared to criteria for energy calculation. The national annex may also specify different criteria for different building types (offices, schools, hospitals, new, existing, etc.).

The present standard does not require certain criteria to be used. This is up to national regulations or individual project specifications.

The corresponding technical report CEN TR 16798-2

The full title of the corresponding technical report is: TR 16798-2: Energy performance of buildings – Part 2: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics – Module M1-6 – Technical report – interpretation of the requirements in EN 16798-01.

The document has a completely informative nature and its scope is:

- to deal with the indoor environmental parameters for thermal environment, indoor air quality, lighting and acoustic.
- to explain how to use EN 16798-1 for specifying indoor environmental input parameters for building system design and energy performance calculations.
- to specify methods for long term evaluation of the indoor environment obtained as a result of calculations or measurements.
- to specify criteria for measurements which can be used if required to measure compliance by inspection.
- to identify parameters to be used by monitoring and displaying the indoor environment in existing buildings. This Technical Report is applicable where the criteria for indoor environment are set by human occupancy and where the production or process does not have a major impact on indoor environment.
- to explain how different categories of criteria for the indoor environment can be used.

The Technical Report is a guide to EN 16798-1 and can help the users in application of the standard and provide them additional background information. Besides this, the Technical Report describes and recommends additional topics related to the evaluation of the indoor environmental quality and new possibilities to improve the indoor environmental quality and reduce energy use of buildings like personalized systems, air cleaning technologies, consideration of adapted persons, etc.

The Technical Report explains how design criteria can be established and used for dimensioning of systems. It explains how to establish and define the main parameters to be used as input for building energy calculation and long-term evaluation of the indoor environment. The Technical Report also describes how gas phase air cleaning in the future can improve the indoor air quality and partly substitute for outside air. Finally, it identifies parameters to be used for monitoring and displaying of the indoor environmental conditions. Different categories of criteria can be used depending on type of building, type of occupants, type of climate and national preferences. The report explains how these different categories of indoor environment can be individually selected as national criteria, be used in project agreement for design criteria and for displaying the yearly building performance in relation to indoor environmental quality. The designer can also define other categories using the principles from EN 16798-1 and the Technical Report.

In parallel a similar work has been going on within ISO under a joint working group between ISO TC163 and ISO TC205. During the formal vote on ISO level, both documents ISO 17772-1 and TR 17772-2 have been accepted. The two documents are now being printed.

A future goal is to combine the CEN and ISO documents into an ISO-EN standard and technical report.

It is however of outmost importance that FprEn16798-1 is accepted at this second formal vote, to enable us to have a complete set of standards for energy performance evaluation of buildings and that can help to safeguard an acceptable indoor environmental quality. ■

The set of Energy Performance of Buildings (EPB) standards:

spotlight on the (EN) ISO 52000 family

The set of Energy Performance of Buildings (EPB) standards has been published in summer this year (2017). About 30 documents as European standards (CEN) and about 17 as international standards at global level (ISO), in collaboration with CEN (EN ISO standards). All new EN ISO EPB standards are part of the new (EN) ISO 52000 family of EPB standards. These include the backbone of the whole set of EPB standards. The series will help architects, engineers and regulators assess the energy performance of new and existing buildings in a holistic way. Technical support and more information is found at the website of the EPB Center.

Keywords: energy performance of buildings, EPB, EPB regulations, energy performance rating, ISO 52000, EPB Center

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A comprehensive series of European (CEN) and international (CEN & ISO) standards has been prepared, aiming at international harmonization of the methodology for the assessment of the overall energy performance of buildings. This set of EPB standards has been introduced in earlier issues of the REHVA Journal (e.g. [1], [2], [3], [4], [6]).

This article focusses specifically on the subset formed by the (EN) ISO 52000 family [5] and the option of a step-by-step implementation at national level.

Complete overview now available at EPB Center

More information on the set of EPB standards, with extensive background information and explanation, is provided at the website of the EPB Center [7].

One of the recently added features of the website is a complete overview of all EPB standards and their accompanying technical reports (http://epb.center/support), with information about how the documents can be obtained. For each document a link is provided to the page in the ISO catalogue or CEN database where a summary and other information about the document can be found.

Holistic approach

From energy using product to energy efficient building systems

In the past, energy performance requirements were set at component level: minimum thermal insulation levels and minimum efficiencies of products. However, a product or component with a high performance under standardized conditions may perform significantly less good when installed in a building, due to fluctuating weather conditions, varying occupants' demands and a possible negative influence of or interference from other components. And vice versa: several new technologies are designed to make the best out of varying operating conditions. Thus, energy performance requirements that are restricted to the performance of individual components create a barrier to the necessary technology transitions.

The holistic approach to assess the overall energy performance of buildings and the built environment, provided by the set of EPB standards (inclusive the EN ISO 52000 family of standards), is a key tool to overcome these barriers.

The EN ISO 52000 family of standards will enable to assess the overall energy performance of a building. This means that any combination of technologies can be used to reach the intended energy performance level, at the lowest cost. Due to this 'competition' between different technologies, the holistic approach is a key driver for technological innovation and change.

CEN and ISO

In CEN, the set of EPB standards has been prepared to support the EU Directive 2010/31/EC on the energy performance of buildings (EPBD).

This implies that the EPB standards need to be fit to be used in the context of building regulations and codes. Therefore, all EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency.

At the same time, all EPB standards provide certain flexibility with regard to the methods, the required input data and references to other EPB standards. This enables national or regional authorities to tailor the energy performance assessment to a specific (national or regional) situation. For each option, a clear template is provided in Annex A of each EPB standard, supplemented by an Annex B with informative default choices, as mentioned above.

Global relevance of the set of EPB standards

This approach also facilitates the applicability of the EPB standards at global (ISO) level. A good example is the overarching EPB standard, ISO 52000-1 (EN ISO 52000-1) that offers choices to tailor the assessment to any national situation, worldwide. The choices range from policy factors (e.g. primary energy factor values, choice of perimeter of the assessed object, appreciation of renewable energy surplus exported to the grid, …), building and space categorization, specification of standard indoor conditions for each building or space category, choice of the metric for the building size, etc.

One of the frequently asked questions concerning the preparation of EN ISO standards (collaboration between CEN and ISO) is the following:

Each International (ISO) Standard is relevant at global level, so also in Europe. So why are these standards published as combined European and global international (EN ISO) standard, instead of simply just ISO standards?

The short answer to this very relevant question: ISO standards are voluntary. European (CEN) standards may be mandatory in the context of European regulations. Take for example the CEN standards needed for or to support the declaration of performance of products as defined in the Construction Products Regulation (CPR) and to affix the CE marking. As mentioned above, the set of EPB standards supports the implementation of the EPBD.

New: the (EN) ISO 52000 family of EPB standards

Already 17 of the about 50 EPB standards are EN ISO standards, the result of collaboration between CEN and ISO. The other EPB standards are up until now only available at European (CEN) level.

Except for already existing standards that underwent only (minor) revisions, these EN ISO standards received an ISO 52xxx number, the series of numbers which have been reserved for the EPB standards. Only standards that meet the specific requirements for all EPB standards will be awarded such number.

This first series in the (EN) ISO 52000 family comprises the overarching EPB standard (EN ISO 52000-1), complemented by a set of standards dealing with the calculation methods for heating and cooling needs and indoor temperature, performance of building elements, as well as aspects regarding energy performance indicators, ratings and certificates.

The (EN) ISO 52000 family was prepared in a unique collaboration between

- ISO technical committees ISO/TC 163, *Thermal performance and energy use in the built environment*,
- ISO/TC 163/SC 2, *Calculation methods*,
- ISO/TC 205, *Building environment design*, and
- the CEN (European) technical committees CEN/TC 371, *Energy Performance of Buildings project group*, and CEN/TC 89, *Thermal performance of buildings and building components*.

ISO 52000 family of standards: road ahead

Additional ingredients to expand the holistic approach are expected to be added to the EN ISO 52000 family in the near future, in cooperation with other technical committees in ISO and CEN. First new work

item proposals have already been launched, dealing with specific parts of heating and cooling systems and building automation and control.

The intention is to come (eventually) to a complete and consistent set of EN ISO standards on the Energy Performance of Buildings (EPB).

Clear and consistent policy targets play an important role in driving innovation in the building sector. International Standards will be needed to harmonize the terms, definitions, assessment procedures and indicators in order to develop new concepts and technologies as well as monitor and evaluate progress.

Common quality criteria

For all EPB standards, including the (EN) ISO 52000 family

One of the main purposes of the EPB standards is to enable their use in laws and regulations to, in some cases, make them compulsory. This calls for a systematic, clear, comprehensive and unambiguous set of energy performance procedures.

The holistic approach to assess the overall energy performance of a building requires that many of the EPB standards are applied in an interactive way. Standards that do not properly fit in the set (with respect to input-output relations, methods, common features and overall quality) may compromise the quality of the whole set.

Consequently, each EPB standard (both in CEN and in ISO) needs to respect specific requirements (http://epb.center/epb/common-rules-all-epb-standards) to ensure overall integrity, consistency and quality of the whole set, as well as usability in the context of building regulations.

Thanks to these profound specific quality criteria, the ISO 52000 family is expected to become a strong brand mark.

Modular approach and national choices

In CEN, the set of EPB standards has been prepared to support the EU Directive 2010/31/EC on the energy performance of buildings (EPBD).

The aim is a systematic, clear, comprehensive and unambiguous set of energy performance procedures. At the same time, differences in national and regional climate, culture and building tradition, as well as policy and legal frameworks have to be taken into account.

In each EPB standard, different options are given, thus enabling specific choices in:

- Calculation procedures (e.g. monthly or hourly calculation; specific simplified or detailed calculation method).
- Input data and boundary conditions (e.g. national default values, climatic data, policy related data)
- References to other EPB standards; see further on (Modular structure and step-by-step implementation)

For the correct use of the EPB standards, each EPB standard typically contains a normative template in Annex A to specify these choices. And informative default choices are provided in Annex B.

Example of a table from Annex A and Annex B is given in **Figure 1a** and **Figure 1b**.

Table A.2 — Choice between hourly or monthly calculation method (see 5.2)

Type of object and/or application	**….. [b]**	**…. [b]**
Description	Choice [a]	Choice [a]
Only hourly method allowed	Yes/No	Yes/No
Only monthly method allowed	Yes/No	Yes/No
Both methods are allowed	Yes/No	Yes/No

[a] Only one Yes per column possible.

[b] Add more columns if needed to differentiate between type of object, type of building or space, type of application or type of assessment. Use the list of identifiers from ISO 52000-1:2017, Tables A.2 to A.7 (normative template, with informative default choices in Tables B.2 to B.7).

Figure 1a. Example of the normative template for national choices (EN ISO 52016-1, Table A.2).

Table B.2 — Choice between hourly or monthly calculation method (see 5.2)

Type of object and/or application	**All applications [b]**	
Description	Choice [a]	
Only hourly method allowed	Yes	
Only monthly method allowed	No	
Both methods are allowed	No	

[a] Only one Yes per column possible.

[b] Add more columns if needed to differentiate between type of object, type of building or space, type of application or type of assessment. Use the list of identifiers from ISO 52000-1:2017, Tables A.2 to A.7 (normative template, with informative default choices in Tables B.2 to B.7).

Figure 1b. Example of the informative default option for national choices (EN ISO 52016-1, Table B.2).

Note that in each EPB standard there may be many tables with a wide variety of choices, ranging from choices between calculation options to choices of specific coefficients or correction factors.

National annex or national data sheet

The main target groups for this document are architects, engineers and regulators.

In case an EPB standard is used in the context of national or regional legal requirements, mandatory choices may be given at national or regional level for such specific applications. These choices (either the informative default choices from Annex B or choices adapted to national / regional needs, but in any case following the template of this Annex A) can be made available as national annex or as separate (e.g. legal) document (national data sheet).

Note that in this case:

- the regulators will **specify the choices**;
- the individual user will apply the standard to assess the energy performance of a building, and thereby **use the choices** made by the regulators

Topics addressed in a standard can be subject to public regulation. Public regulation on the same topics can override the (informative) default values in Annex B of the EPB standard.

Legal requirements and choices are in general not published in standards, but in legal documents. In order to avoid double publications and difficult updating of double documents, a **national annex** may refer to the legal texts where national choices have been made by public authorities.

Different national annexes or national data sheets are possible, for different applications.

If the default values, choices and references to other EPB standards in Annex B are not followed due to national regulations, policy or traditions, it is expected that:

- national or regional authorities prepare data sheets containing the choices and national or regional values, according to the model in Annex A. In this case the national annex (e.g. NA) refers to this text;
- or, by default, the national standards body will consider the possibility to add or include a national annex in agreement with the template of Annex A, in accordance to the legal documents that give national or regional values and choices.

Template for national annex or national datasheet at the EPB Center

The EPB Center has developed a template for national annex or national data sheet to EPB standards. This template consists of a model national annex or national data sheet with extensive guidelines and useful tips. It is intended as a tool for the implementation of the EPB standards at national or regional level.

This template for national annex or national data sheet to EPB standards can be downloaded from the support section of the website (http://epb.center/support/support).

Modular structure and step-by-step implementation of the set of EPB standards

Modular structure

For the set of EPB standards, an overarching modular structure is used:

- to identify all required parts of the assessment procedure and to provide an overview;
- to identify the modules covered by the EPB standards;
- to identify the input-output connections between the EPB standards (e.g.: calculation, expression of the energy performance).

The over-arching modular structure has the following four main areas:

- M1 Overarching standards
- M2 Building (as such)
- M3 - M11 Technical Building Systems under EPB
- M12 - M13 Other systems or appliances (non-EPB)

More details can be found at the EPB Center website (http://epb.center/implementation).

Step by step implementation at national level

The modular EPB structure and the "Annex A/Annex B" approach, in particular with the option to (preferably for a limited transition period) reference to a specific national standard instead of a specific EPB standard, strongly facilitates a step by step implementation of the set of EPB standards by individual countries or regions.

In order to make this possible, in the EPB standard the other EPB standards are not referenced by the standard number, but by the module number.

Example (from EN ISO 52016-1):

- Instead of referring to the other EPB standard directly:

  $q_{V,k;t}$ is the airflow rate of air flow element, k, as provided by EN 16798-7, in m³/s.

- The reference is to the module number:

  $q_{V,k;t}$ is the airflow rate of air flow element, k, as provided by the relevant standard(s) under EPB module M5-5, in m³/s.

This is further illustrated in **Figures 2a, 2b and 2c.** The left columns in the tables presented in these figures contain the referenced module numbers, the other columns are: empty (template, **Figure 2a**), completed with informative default choices (**Figure 2b**) and completed with (an example of possible) national choices (national annex or national data sheet, **Figure 2c**).

The references, identified by the EPB module code number, are given in Table A.1.

Table A.1 — References

Reference	Reference document [a]	
	Number	Title
M1-4		
....		
M1-13		
....		
....		
M5-5		
....		
....		
M10-1		

[a] If a reference comprises more than one document, the references can be differentiated.

Figure 2a. Example of the normative template for national choices in references to other EPB standards (extract from EN ISO 52016-1, Table A.1).

The references, identified by the EPB module code number, are given in Table B.1.

Table B.1 — References

Reference	Reference document [a]	
	Number	Title
M1-4	ISO 52003-1	*Energy performance of buildings – Indicators, requirements, ratings and certificates – Part 1: General aspects and application to the overall energy performance*
....		
M1-13	ISO 52010-1	*Energy performance of buildings - External climatic conditions - Part 1: Conversion of climatic data for energy calculations*
....		
....		
M5-5	EN 16798-7	*Energy performance of buildings — Ventilation for buildings — Part 7: Calculation methods for the determination of air flow rates in buildings including infiltration (Module M5-5)*
....		
....		
M10-1	EN 15232-1	*Energy performance of buildings – Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10*

[a] If a reference comprises more than one document, the references can be differentiated.

Figure 2b. Example of the informative default choices in references to other EPB standards (extract from EN ISO 52016-1, Table B.1).

The references, identified by the EPB module code number, are given in Table NA.1.

Table NA.1 — References

Reference	Reference document [a]	
	Number	Title
M1-4	ISO 52003-1	*Energy performance of buildings – Indicators, requirements, ratings and certificates – Part 1: General aspects and application to the overall energy performance*
....		
M1-13	ISO 52010-1	*Energy performance of buildings - External climatic conditions - Part 1: Conversion of climatic data for energy calculations*
....		
....		
M5-5	National standard number xxx	*Title of the national standard with calculation method for the determination of air flow rates in buildings including infiltration*
....		
....		
M10-1	EN 15232-1	*Energy performance of buildings – Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10*

[a] If a reference comprises more than one document, the references can be differentiated.

Figure 2c. Example of national choices in references to other EPB standards (extract from a possible Table NA.1 in a national annex or national data sheet for EN ISO 52016-1).

The EPB Center

Having these standards available is a first step. Implementing them needs dissemination actions at the level of building regulators as well in our professional community.

The EPB-Center, where REHVA is a stakeholder and where the current expertise is concentrated, is expected to support this process.

The EPB Center activities are to plan, coordinate and guide the process of promoting implementation, use maintenance and further development of the set of EPB standards and safeguard the coherence of their technical content.

It is also important to support regulators and national standardization bodies in the implementation of the standards by providing guidance on the completion of the national annexes or national data sheets.

More information, including an overview of all EPB standards, extensive background information and explanation, is already provided at the website of the EPB Center [7]. ■

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[6] The REHVA European HVAC Journal, *Boosting energy efficiency of buildings through ISO's holistic approach*, Jaap Hogeling, Volume 54, Issue 4, August 2017.

[7] The EPB Center: see website: www.epb.center.

Improvement of ventilation with latent heat storage

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In the present paper improvement of the air solar collector ventilation system with latent heat storage (LHS) for the heating period is presented. LHS in phase change materials (PCM) improves effectiveness of the ventilation system and resolves mismatch between obtained heat from the air solar collector and its use for ventilation of the office. Application of LHS in the ventilation system increases average temperature of air for ventilation.

Key words: ventilation, latent heat storage, phase change materials (PCM), solar collector, thermal storage.

System operation principle

Operation principle of the ventilation system with the air solar collector and the LHS unit presented in **Figure 1** is divided into the heating and cooling mode, meaning that the system can be used during the whole year. Operation principle in the **cooling** mode consists of two consecutive cycles. The first cycle (charging period) is carried out at night when the cold outside air is supplied with the fan to the LHS unit (number 1 on **Figure 1**), where air flows around compact storage modules (CSM) filled with the PCM. The heat in the PCM is transferred to the air flow and causes cooling of PCM, which solidifies and in this way accumulates cold. Air is then transported outdoors (2). The second cycle (discharging period) is carried out during daytime when cooling demand occurs. In the second cycle, warm outside air enters in the LHS unit (1) and transfers the heat to the solid PCM, which then melts. In this instance, the air flow cools down and then enters the room (3). In the **heating** mode, the cold outside air is transported with the fan through the air solar collector (4), where it is heated under influence of solar radiation. Heated air is then transported through the LHS unit (5) where it transfers the heat to the PCM, which liquefies and accumulates the heat in form of latent heat. In the morning or evening, or when the solar radiation intensity is insufficient, the cold outside air is transported through the LHS unit (1) where the PCM solidifies and with that releases the heat. Released heat from the PCM heats the passing air flow, which is than supplied to the room (3) at the temperature level that reduces the risk of thermal discomfort [1].

Air solar collector

The air-heating flat-plate solar collector, a commercial product of SolAir company [2], was installed in the investigated system. The air solar collector has an area of 1.638 m² and it was mounted vertically on the parapet below the office window (90° tilt angle of the collector) on South side of the building of the Faculty of Mechanical Engineering in Ljubljana with 17° azimuth. The solar absorber plate is made of aluminium with fin thickness of 0.2 mm and with fin width of 30 mm. Solar absorptance of the absorber is 93% with tolerance of ±2%. Its hemispherical emittance is 35% with tolerance of ±3%. The absorber is painted with black thickness insensitive spectrally selective (TISS) paint. The air flow channels are connected with no spacing in between and the air solar collector is connected to LHS unit inside of the office. The glazing of the air solar collector is made of extruded solid polycarbonate sheets with thickness of 4 mm and with solar transmittance of 90% ±1%. The thermal insulation is made of polyethylene and it is located on the backside of the air solar collector while there is no sidewise insulation.

Performance measurements of the air solar collector were done at Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany [3]. Power output of the air solar heating collector has been obtained through measurements under the steady-state conditions with the calorimetry method. The efficiency of the air solar collector reduced to the aperture area with radiation of normal incidence is 0.703. The value is obtained at the solar irradiation on the air solar collector plane of 961 W/m², thermal power output of 1290 W and air mass flow rate of 250 kg/h.

Latent heat storage

The casing for CSM plates was made of 8 mm thick PMMA with external dimensions of 725 mm x 460 mm x 420 mm. The LHS unit was thermally insulated with 50 mm thick EPS. The LHS unit contained 29 CSM plates filled with paraffin Rubitherm RT22HC [4] which has the melting range between 20°C and 23°C with the melting peak temperature of 22°C. The heat capacity of RT22HC between 14°C and 29°C is 200 kJ/kg ± 7.5%. The melting temperature of the PCM was chosen in a way to ensure maximum melting and solidification

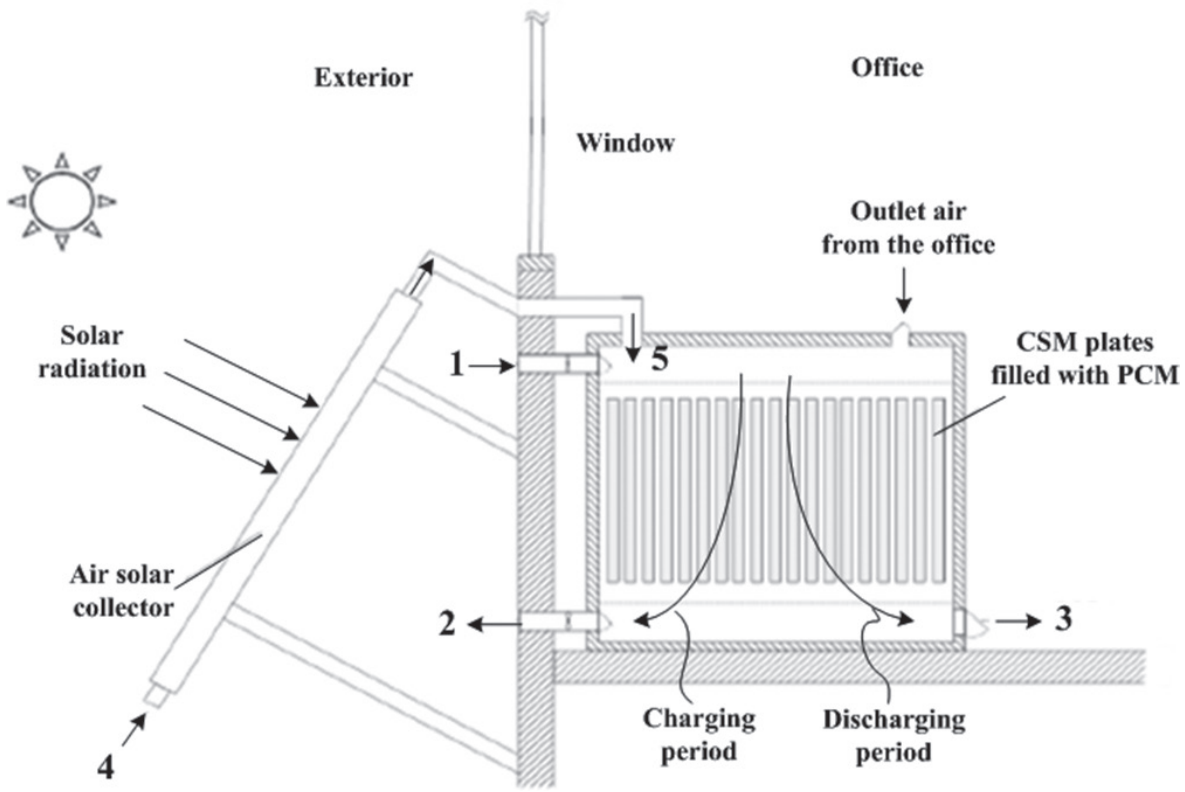

Figure 1. Schematic principle of ventilation system operation [1].

during the operation of LHS with consideration for both heat and cold storage. During discharge period of heat, the PCM should release heat within its own melting range which is within the comfort level. The melting point for used PCM is appropriate for Slovenian climate which is between 22°C and 23°C [1].

On the left side of **Figure 2** the LHS unit with visible CSM plates inside the LHS unit is presented. External dimensions of CSM plates were 300 mm x 450 mm x 150 mm and they were horizontally positioned in the LHS where the longer side was perpendicular to the air flow direction. The distance between panels (air gap) was 10 mm. Average mass of the filled CSM panel was 1361 ± 5 g, weight of the PCM (RT22HC) in the panel was 1003 ± 5 g, the volume of each panel was 1.42 L and the volume of the PCM was 1.3 L. Approximately 9% of the panel volume is empty in order to compensate for the volume expansion of the PCM and to avoid deformation of the panel due to higher pressure. Compactness of the LHS is 133 m^2/m^3 (ratio between surface of plates and volume of plates), density of stored heat is 16 kWh/m^3 (ratio between stored heat and volume of LHS) [1].

Other elements of experimental system

Elements of the experimental system are shown on the right side the **Figure 2**. On the inlet of the LHS unit, the streamer is attached because of the air flow separation possibility. On the outlet side of the LHS unit, a grid is attached for mixing the air flow. Inlet and outlet air ducts that are connected to the LHS unit are made of PVC ducts with 100 mm diameter and are thermally insulated with 20 mm thick thermal insulation. In the inlet duct in front of the LHS unit there is the axial fan with nominal power of 30 W. Fan is connected to the speed regulator which regulates the fan speed according to five different speed settings. The speed regulator is controlled with a programmable time switch. At the same time, the motor hatch is controlled with a programmable time switch. The motor switching hatch is installed in the outlet duct of the LHS unit and it enables to redirect the air flow outdoors or in the office.

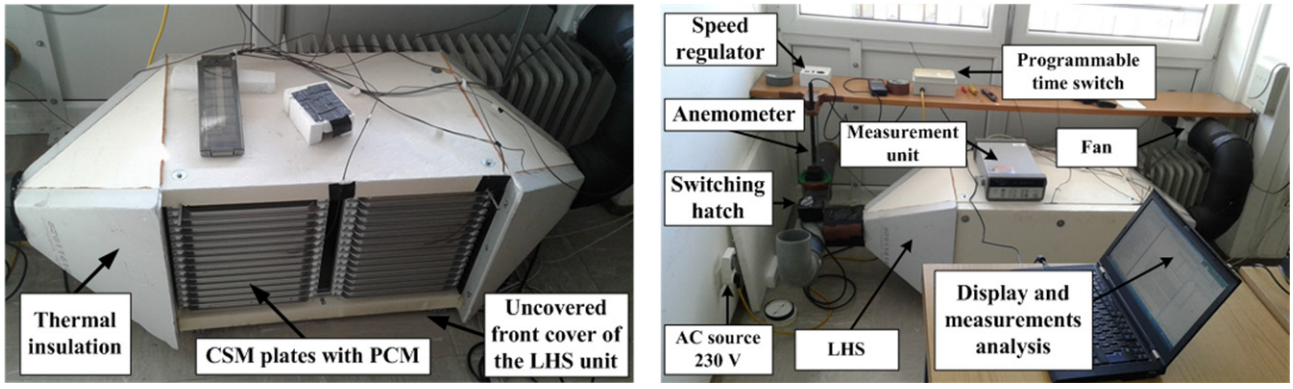

Figure 2. The LHS unit with CSM plates (left) and elements of experimental system (right).

Operation of investigated system

The investigated ventilation system operated in the heating mode for continuous ventilation of the office. Operation of the investigated system consists of charging period (**Figure 3a**) and discharging period (**Figure 3b**).

In the charging period, the heat is stored in the LHS unit during presence of solar radiation which heats the cold outside air in the air solar collector. Heated air transfers the heat to the PCM in the LHS unit and is then supplied to the office (**Figure 3a**). The discharging period is taking place when air is not heated in the air solar collector due to insufficient solar radiation. The cold outside air is then heated in the LHS unit, where accumulated heat in the PCM releases and transfers to the passing air flow which is supplied to the office with the suitable temperature level for thermal comfort (**Figure 3b**).

Experiment

The experiment was performed with constant air flow rate through the LHS unit. The LHS unit stored heat during daytime and released it during night-time by transporting it outdoors. Therefore, the fan operated the whole time and the switching hatch directed air to the outlet duct of the system which led outdoors. As a

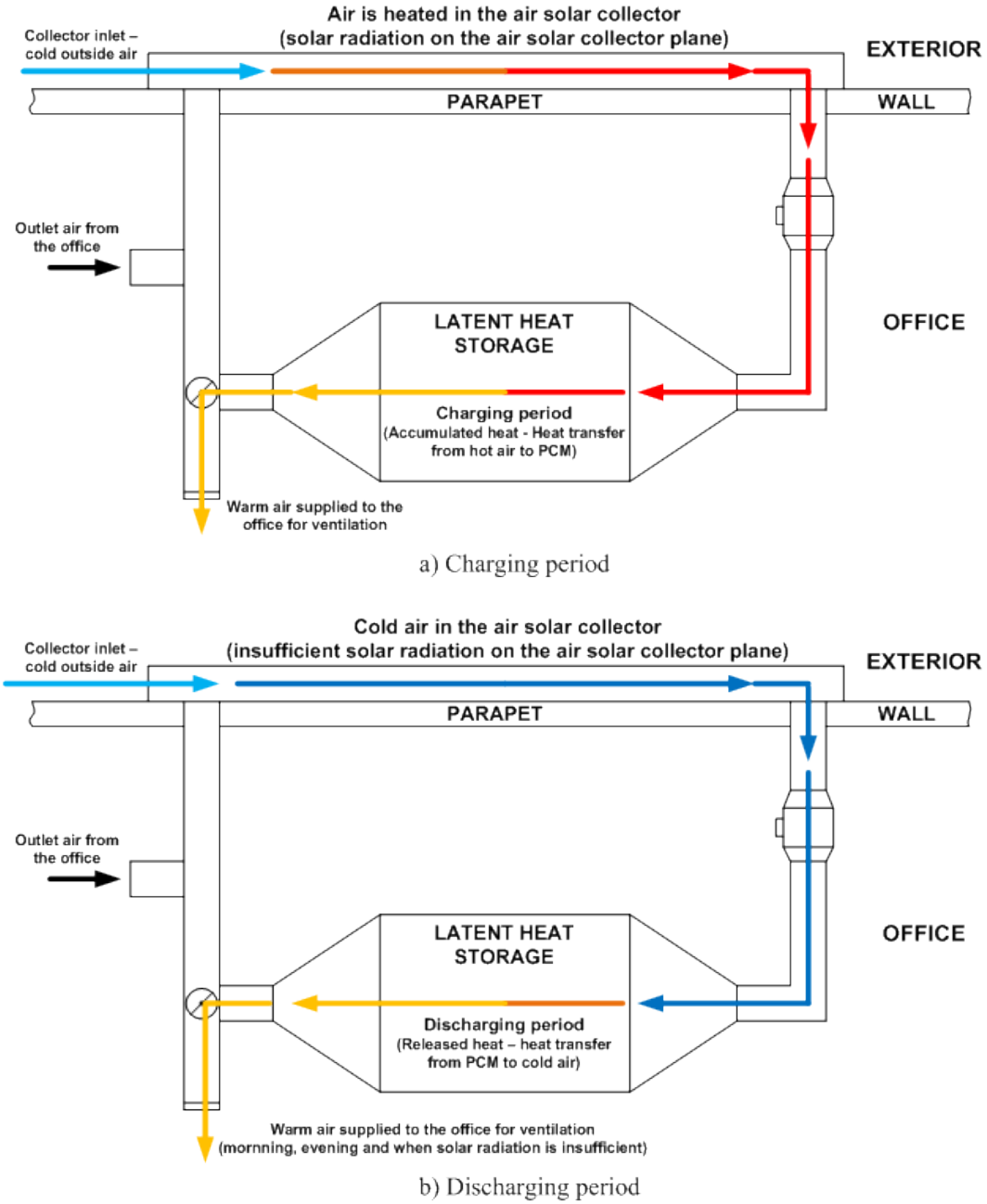

Figure 3. Ventilation of the office in the heating mode in the charging period (a) and in the discharging period (b).

result, we achieved maximum heat flows because the LHS unit completely released the heat during night time and accumulated maximum capacity of the heat during daytime when solar radiation was present. The measurements were performed over six sunny days at the end of March. **Figure 4** shows the measured air temperatures for the mentioned time period: the room temperature (relevant for calculating heat losses of LHS unit), inlet air temperature of the air solar collector, the air temperature at the inlet of the LHS unit (which is essentially the outlet temperature from the air solar collector) and the outlet air temperature of the LHS unit.

The collector inlet air temperature was mainly between 6°C and 34°C with the average temperature of 18°C (**Figure 4**). On March 28, the air temperature increased up to 45°C. The reason for such high amplitudes was the measurements of the air temperatures near the south side of building envelope (facade), where the air solar collector is installed. The building envelope (facade) was heated by solar radiation and thereby the radiation from the building envelope heated the surrounding air. Higher temperatures near building envelope are favourable from the energy performance point of view as the air temperature close to the facade tends to be higher (sometimes significantly) than the outdoor air temperature.

During the system operation the peaks of the outlet air temperature from the air solar collector were around 70°C, as we can see from **Figure 4**. The maximum air temperature reached 74°C while the minimum air temperature was 14°C. The maximum outlet air temperature from the LHS unit was 65°C, at which the temperature level became too high for direct ventilation of the office and we had to reject the excess heat. The minimum air temperature from the LHS unit was 21°C, which was suitable for direct ventilation of the office.

Outlet air temperatures are presented in the organized diagram (**Figure 5**), where a comparison between different ventilation systems is shown. The comparison is made between ventilation system with no additional system (direct supply of the outside air to the office), ventilation system with the air solar collector and ventilation system with the air solar collector including the LHS unit. The interest of the presented experiment was the comparison between the air solar collector ventilation system with LHS unit and without LHS unit. Difference between outlet air temperatures of the air solar collector and the LHS unit (**Figure 5**) presents accumulated or released heat in the LHS unit. When the curve of the outlet air temperature from the air solar collector is higher than the curve of the outlet air temperature from the LHS unit, the heat is accumulated in the LHS unit. When the curve of the air solar collector is lower than the curve of the LHS unit, the heat from the LHS unit is released.

Conclusion

In this experiment the investigated ventilation system with the air solar collector which includes the LHS unit increased average air temperature of the office ventilation in the temperature range up to 23°C. This statement implies a good potential for the application of

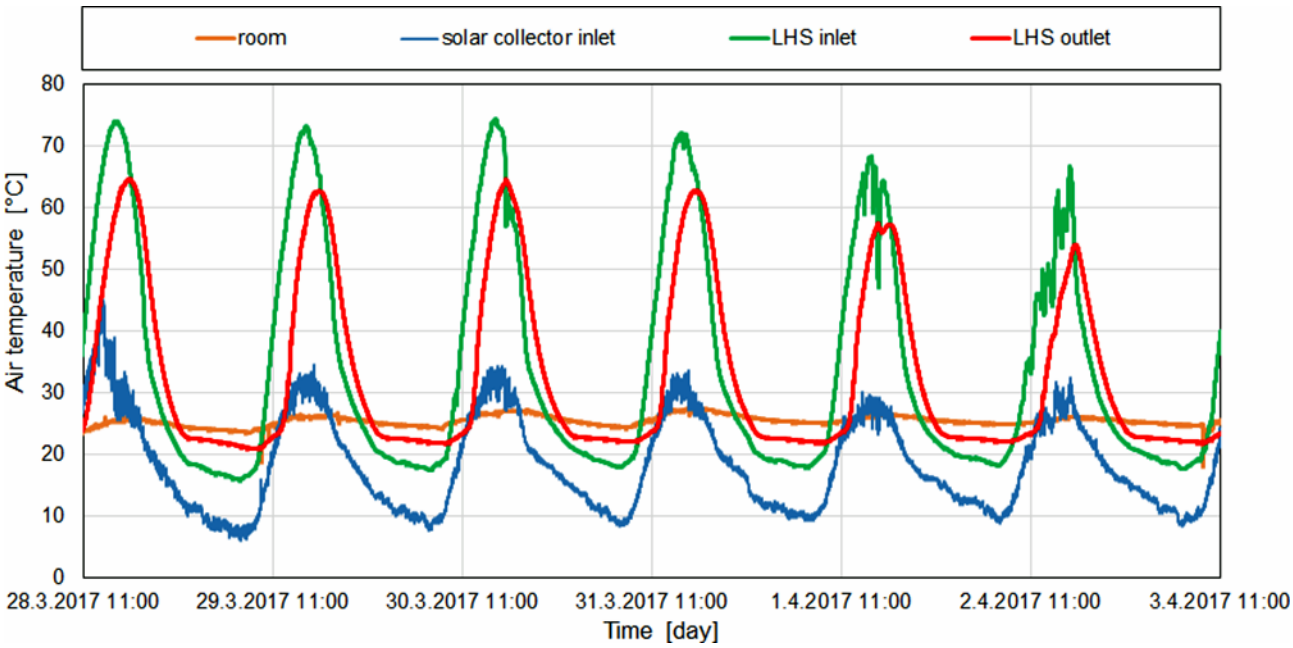

Figure 4. Measured air temperatures.

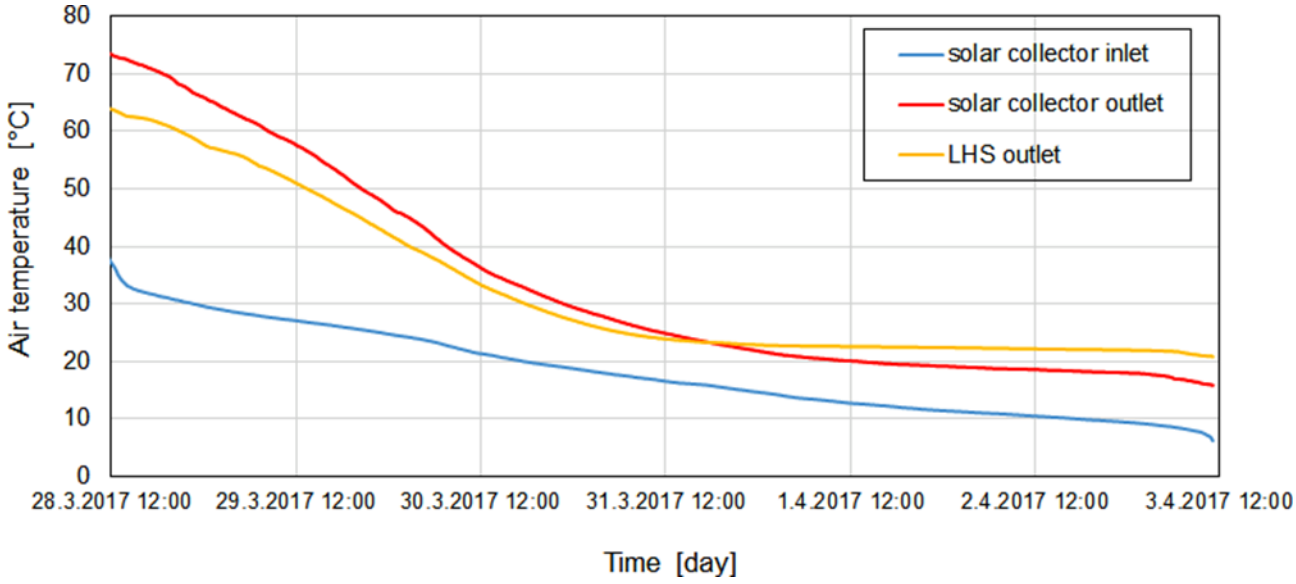

Figure 5. Organized diagram of outlet air temperatures.

LHS in the ventilation system. Outlet temperature from the LHS unit (supply temperature for the office ventilation) with value from 20°C to 23°C appeared in 43% of the total ventilation time which presents the positive impact of the LHS unit on the indoor thermal comfort.

Average daily energy savings of the ventilation system without LHS in the period of the experiment (6 days at the end of the March) were 89%, according to the required heat for covering total ventilation losses. In case of the integrated LHS unit in the ventilation system, maximum energy savings (100%) were achieved in the same time period. This means that ventilation losses were completely covered and no auxiliary heating was required. In the ventilation system without the LHS unit, average energy savings of the ventilation system with the LHS unit were 11% for the period of the experiment, while maximum energy savings were 21% and minimum were 7%. For analysis of the whole heating season it is recommended to consult work of Stritih et al. [5], where analysis on monthly basis was made through numerical simulation of the investigated system.

The availability of energy from renewable energy sources presents a problem in energy supply, when the energy from renewable source is not available at the best possible conditions. That is why the advantage of the short-term energy storage in PCM is in levelling the mismatch between energy supply and demand. PCM can be used in different kind of applications of active ventilation system where energy is stored at the time when the source of energy has the highest potential, and is released when energy demand occurs. Since the indoor thermal comfort is of significant importance, the melting temperature of PCM used in ventilation system is selected at the temperature of indoor thermal comfort because PCM releases heat at almost constant temperature in the latent region of heat. ■

Acknowledgements

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Figure 1. The Chemnitz Opera House is an architectural and cultural gem.

Perfect air conditioning for one of Europe's most modern theatres

The Chemnitz Opera House attracts well over 90,000 visitors a year to enjoy opera, ballet and musical performances. Automation systems and specialized HVAC drives play a key role behind the scenes. The result is that both the performers and audience experience perfect air-conditioned comfort delivered with maximum energy efficiency.

Keywords: Chemnitz Opera House, Building Renovation, Energy Performance Contracting, Building Automation Systems

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One of the most well-known cultural institutions in Germany, the Opera House was first opened in 1909. It was destroyed during the

Second World War and reopened in 1951. Following extensive reconstruction work on the building in 1992, Chemnitz Opera House is regarded as one of Europe's most modern theatres. It has recently been modernized to further improve ventilation and air conditioning for the 180 or so performances that take place every year while reducing energy consumption to meet current best practice.

The peak of energy efficient performance

The main opera house as well as the theatre were completely modernized as part of an energy saving contract between the city of Chemnitz, the theatre and the contractor WISAG Energy Management. The project covered the ventilation and air conditioning equipment, hot water systems and lighting. (**Figure 2**)

An automation system was installed to provide optimized control and energy management for the HVAC equipment and hot water circuit. The system comprises three ABB AC500 PLCs (Programmable Logic Controllers) as well as two specialized ACH550 low voltage HVAC drives, together with fuses and relays.

A refinance model for energy saving

The modernization of its outdated heating and ventilation systems has long been on the agenda of the Chemnitz Municipal Theatre. The concept of energy performance contracting based on guaranteed savings over a specified period offered the opportunity to finance the conversion work. WISAG emerged as the most economical bidder and was entrusted with the project.

The contractor invested almost 930,000 euros in new, energy-efficient systems for the opera house and the playhouse. The aim was to reduce the cost of district heating by 35 percent and electricity by 32 percent. There is also a guarantee in place that the energy costs will be reduced by 121,670 euros a year compared to the reference year of 2013.

Comprehensive modernization

As part of the renovation work, the ventilation, air conditioning and hot water production in both the opera house and playhouse were completely modernized together with the installation of cutting edge lighting technology. The new ventilation systems are equipped with heat recovery systems so that in winter unused heat is reused rather than being exhausted into the atmosphere.

The new energy technology systems were installed in a six-week break in the summer of 2015. "Everything really had to be fitted at once," says Jens Israel, project manager for technology at WISAG energy management.

Specialized HVAC drives cut energy consumption by 50 percent

Two PLCs (programmable logic controllers) execute the control functions in the opera house, processing hundreds of I/Os (inputs/outputs) from other control units, substations and the drives. Another PLC is installed in the theatre. Communication between the controls in the opera house and the theatre is handled by one central unit which collects the information, evaluates it and transmits the appropriate response to the relevant panels and the building automation and control system. (**Figures 3 and 4**).

Figure 2. All controls are operated via the touch screen of the CP430 control panel.

The central unit also communicates with the two specialized HVAC drives integrated into the building automation system, which control the pumps in the district heating station. Rather than requiring the electric motors that run the pumps to run constantly at full speed, the drives facilitate stepless speed control based on the actual

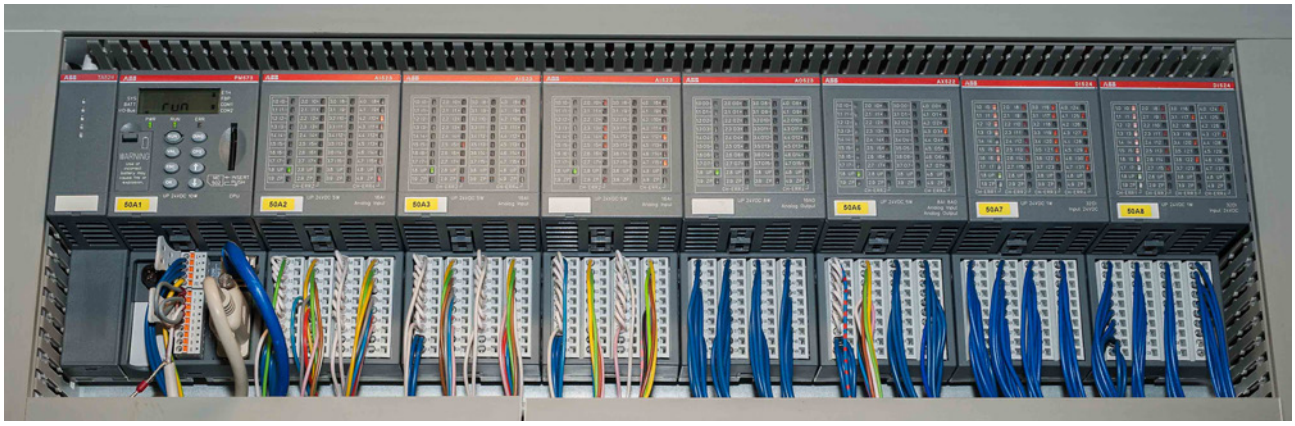

Figure 4. The PLC in the pipe cellar regulates six heating circuits of a large and complex ventilation system.

Figure 3. The AC500 PLC in the boiler room is responsible for all communications in the opera house.

Figure 5. Two HVAC ACH550 drives regulate the pumping of the substation.

demand. Reducing the motor speed by 20 percent lowers the power required by up to 50 percent. Typically, HVAC drives (**Figure 5**) offer a return on investment within months, based on energy savings alone.

A second central unit controls the heating as well as the large and complex ventilation systems of the opera house. The environment is adjusted according to the outdoor temperature, indoor conditions and several time-based programs.

A model for other municipal organizations

The modernization of power engineering at the opera and the theatre went smoothly and to the satisfaction of all parties "on the stage". Most importantly, the targeted energy savings have been achieved. With the Chemnitz Municipal Theatre as a pilot project, it is now hoped that the Saxony State Ministry for Environment and Agriculture will roll the concept out to other municipal organizations. ■

Liquid chillers: water versus air cooled condensers

– energetic and economic comparison

The use of air condensed liquid chillers has seen a continuous growth, if compared to tower water condensed units. The main reason is the easier design and fewer installation problems of the whole system.

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Meanwhile, the costs for electricity, exception made for some nations with prevailing production of nuclear energy, has risen drastically.

Furthermore, all EU countries have subscribed the Tokyo protocol and the later COP-23 Paris agreement on Climate Change and additional restriction on CO_2 emissions have been recently agreed by EU Member States.

This analysis, which considers the performance of liquid chillers equipped with the two traditional condensing systems (water and air), is aimed at a realistic comparison between the two systems in energetic and economical terms.

This presentation shows that water condensing systems, in spite of all the related issues (which however can be solved), are more efficient than air condensing systems, both in terms of energy consumption and of pollution.

Introduction

- This analysis compared two liquid chillers sizes: 600 & 1200 kW capacity, air cooled and water cooled via tower.
- Two climate conditions were assumed, in order to gather a comprehensive perspective:
  - Continental (air: D.B. +28°C, tower water: W.B. +18°C);
  - Mediterranean: (air: D.B. +35°C, tower water: W.B. +25°C).
- Spring/autumn operation were simulated, 1800 hours running, typical of building office applications in European installations.
- High efficiency chiller units, two screw compressors each, two independent refrigerant circuits, dry expansion evaporator were considered in order to avoid any possible comparison errors.
- For a correct evaluation, water cooled chiller absorbed power also included inverter assisted tower fan motor and condenser pump.

Methods

The energy efficiency analysis was based on EER and ESEER calculations.

The IPLV and ARI standards mentioned were not taken into consideration, since they aren't applicable in the EU.

- EER (Energy Efficiency Ratio):
  this parameter defines the energy efficiency of liquid chiller under standard conditions, normally available in any chillers technical catalogue;
- ESEER (European Seasonal Energy Efficiency Ratio):
- it defines the average seasonal energy efficiency under the four load conditions and with decreasing air/water temperatures to condenser. If not listed in the catalogues it can be calculatedby implementing

in Equation 1 the data displayed in **Table 1**.

Results

As shown in **Figures 1 and 3**, a huge difference among water and air-cooled condensers is evident in terms of efficiency, with the ESEER ranging from approximate 5 to 7/7.4. The graphs clearly display that water cooled chillers are more efficient than air cooled chillers.

There is also an evident difference between the grey and red line in **Figures 2 and 4**, and the area between the two lines represents a considerable difference of consumption in favour of water cooled chiller systems.

Discussion

To avoid any possible misunderstanding, it must be highlighted that the values shown in the charts are referred to different calculation methods:

- EER values (operation with water and air) are at constant temperatures and different from the ESEER ones;
- There's no liquid chiller operating under these conditions, as both air and water continuously vary during the day, the months and the year;
- Such information, shown in any commercial catalogue, can lead to assessment mistakes, as it doesn't represent the chiller real working conditions, which depend on the effective ambient situation;
- ESEER values are to be applied for a correct technical selection.
- For energy calculations hourly based (bin method) calculation procedures as described in the EPB standard EN16798-13 "Energy performance of Buildings, part 13: Module 4-8 Calculation of cooling systems – Generation" should be used to calculate the expected yearly energy use and connected CO_2 emission.

Table 1. ESEER calculation basis.

Load and temperature conditions:		
Chilller steps, %	Condens. ambient air temp., °C	Tower water temp., °C
100	35	30
75	30	26
50	25	22
25	20	18

Data workout → EER

$$ESEER = \frac{3\,EER_{100\%} + 33\,EER_{75\%} + 41\,EER_{50\%} + 23\,EER_{25\%}}{100}$$

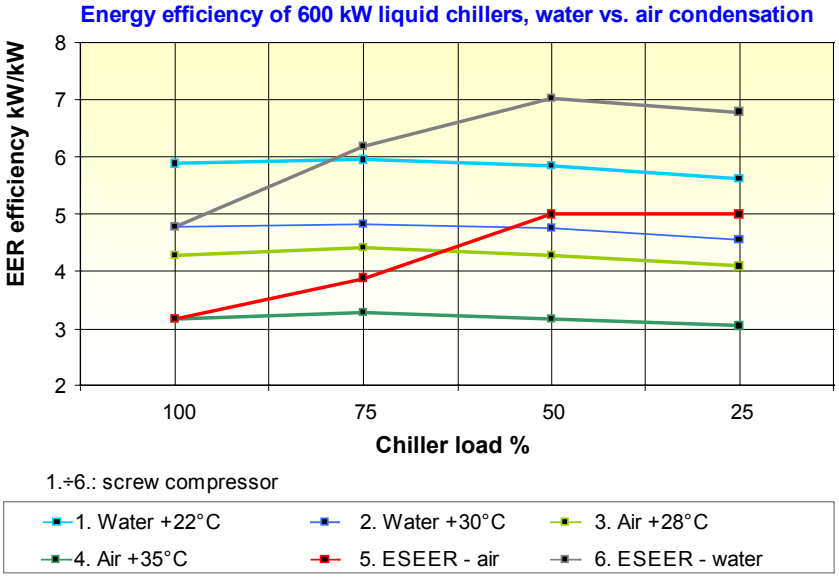

Figure 1. Energy efficiency of 600 kW liquid chillers: with water and air-cooled condensers.

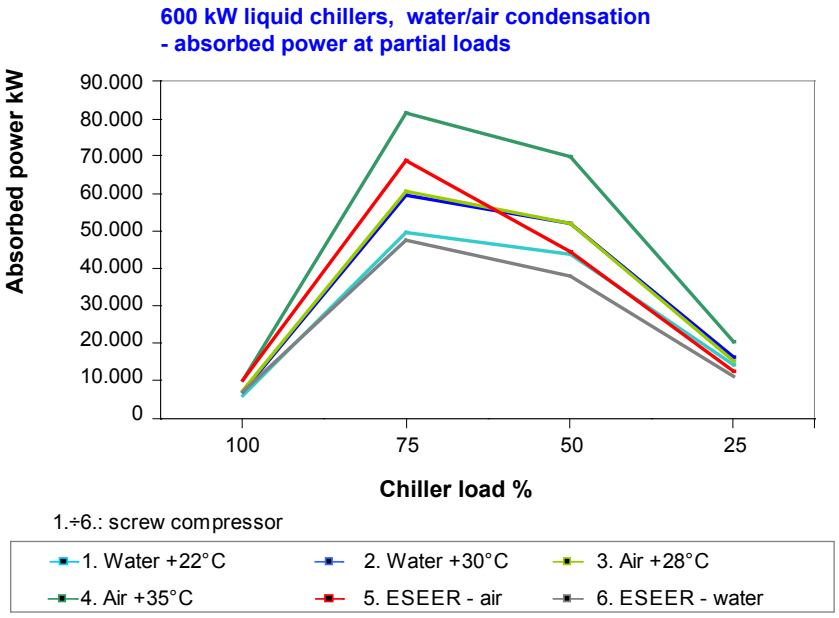

Figure 2. 600 kW liquid chillers, absorbed power at partial loads for water and air-cooled condensers.

The analysis of performance, consumption and energy efficiency shows a big difference between water condensed and air cooled liquid chillers.

The substantial differences are the annual electricity saving (kWh/year) and consequently the less CO_2 emissions into the environment. (see **Figures 5–7**).

The use of water condensed liquid chillers shows an evident economical advantage (faster R.O.I). Furthermore, as the average plant life is over 15 years, the total saving can be easily assessed. (see **Table 2**).

Moreover, the installation of water condensed liquid chillers is strongly suggested both to comply with Tokyo

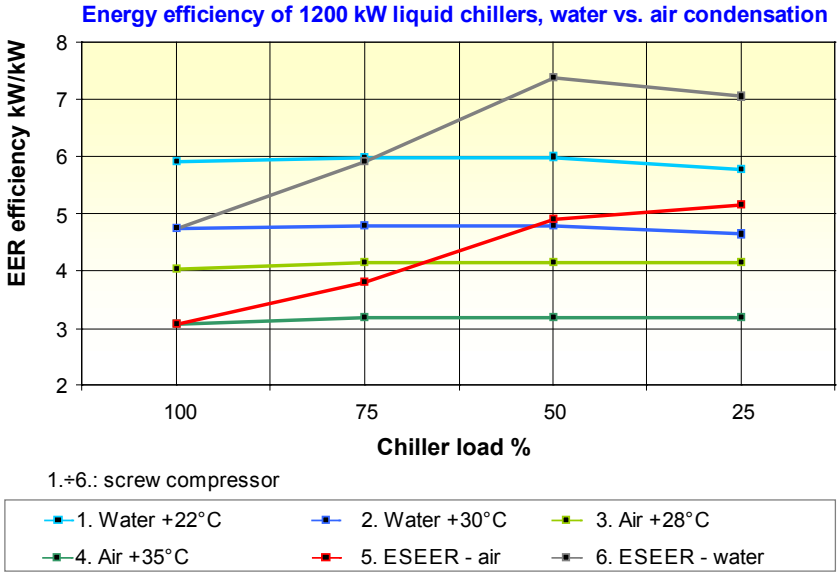

Figure 3. Energy efficiency of 1200 kW liquid chillers with water and air-cooled condensers.

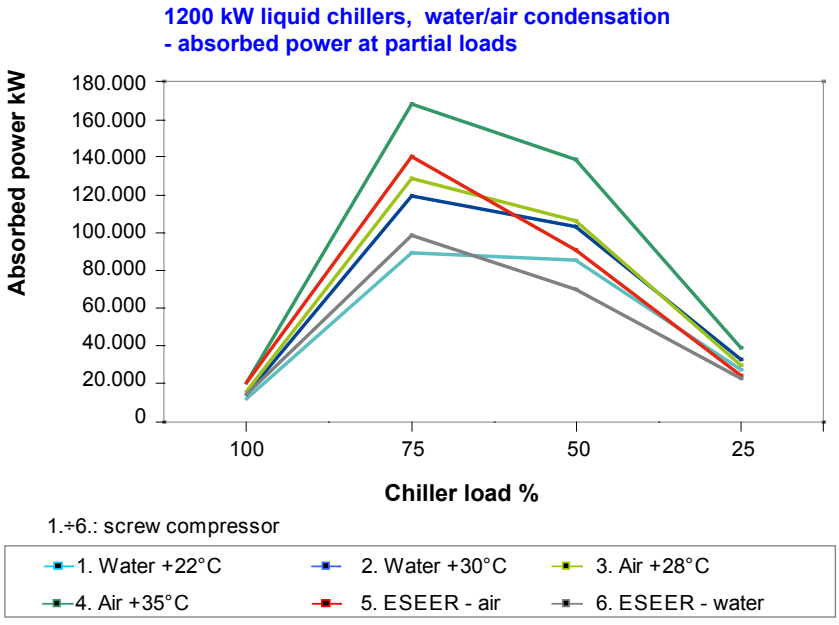

Figure 4. 1200 kW liquid chillers, absorbed power at partial loads for water and air-cooled condensers.

Table 2. Cost comparison.

600–1200 kW liquid chillers, water vs. air – Economic comparison

Description	Price (€)	
	600 kW	1200 kW
1. Cooling tower	10,800	18,000
2. Piping, filters, valves…	3,900	7,800
3. Condenser water pumps	2,100	4,200
4. Water treatments, bleed-off…	7,100	8,500
5. Inverter control panels for tower and pumps	2,700	4,100
6. Electric cable cost reduction	-4,000	-5,000
TOTAL	22,600	37,100
7. Water condensed liquid chiller	44,200	84,500
TOTAL (1÷7)	66,800	121,600
8. Air cooled chiller	58,500	107,250
(A) Water-air cost difference	8,300	14,350
(B) Water-air consumption difference (kWh 33490/69765) x 0.15 €/kWh	5,023	10,465
(A-B) R.O.I. = Return on Investment (years)	1.65	1.37

protocol and with the 20-20-20 target prescribed by European Union.

Last but not least, some final considerations:

- The use of air cooled chillers requires less design effort than that of chillers/cooling tower system. Obviously, designers tend to adopt the solution which is easier for them…
- In addition, one of the most popular reasons used is the issue concerning "Legionella risks", however this is often an excuse only, as current technologies make it possible to control and avoid this problem in the chiller/tower system. However a stringent maintenance protocol is required and any airborne water particle spills from the cooling tower shall be prevented. The "Legionella risks" problem is much more serious in air handling units, because air is supplied (and breathed!) to the buildings such as in hospitals, schools, offices etc. Nevertheless, this issue is often underestimated or neglected. ■

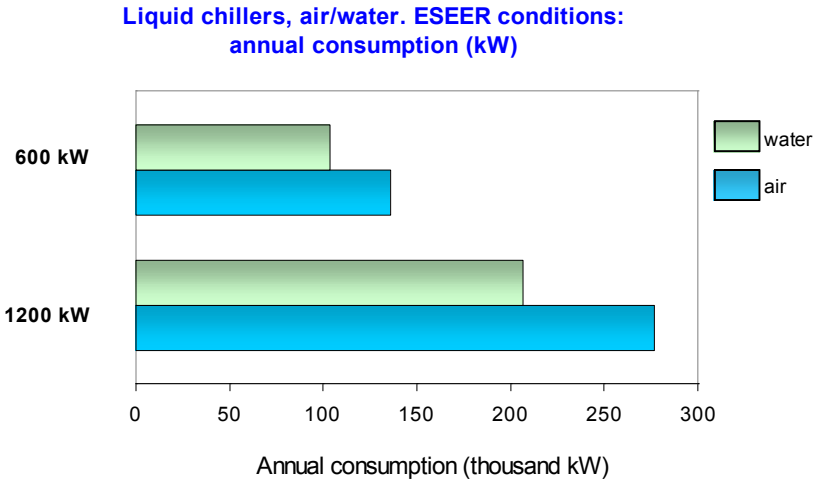

Figure 5. Annual consumption in MWh of two liquid chillers with air and water-cooled condensers.

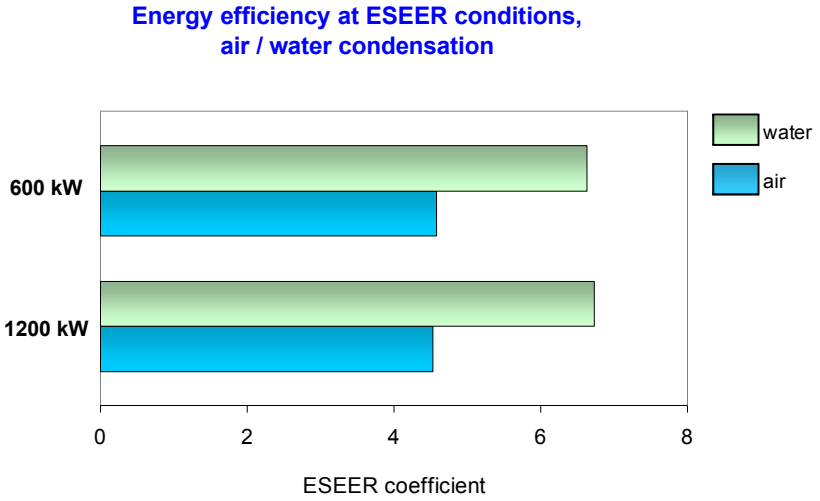

Figure 6. ESEER's of two liquid chillers with air and water-cooled condensers.

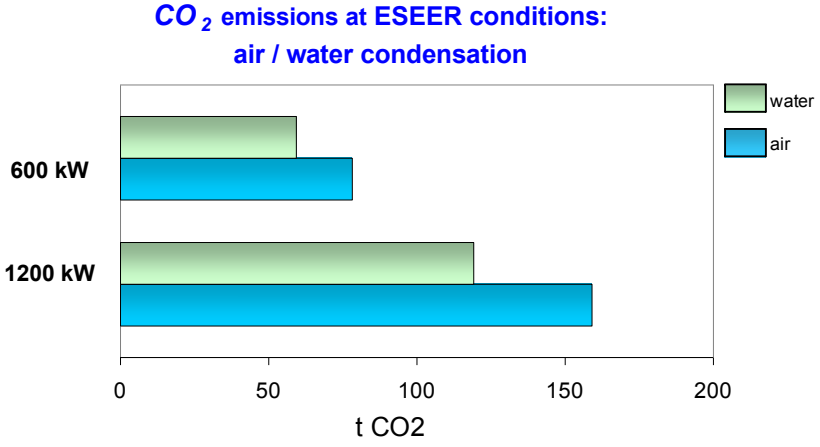

Figure 7. CO_2 emission compared at ESEER conditions for the two liquid chillers with air and water-cooled condensers.

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Adaptive ventilation to improve IEQ:

the case study of Chapel of Holy Stairs

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This paper presents a study performed on the Pilgrimage Chapel of Holy Stair in Rumburk, Czech Republic, where high values of air moisture leading to degradation historical interior were detected. In order to understand hydrothermal conditions in the chapel, the monitoring of air temperature and relative humidity of interior and exterior was carried out in a sufficiently long-time period. The measured data were used as the basis for the calibration on the simplified numerical model, which works in simplified form on the physical principles and heat balance method. A suitable algorithm for timing of natural ventilation was applied, and consequently a presumed influence on the indoor environmental quality and overall reduction in the amount of air humidity.

Keywords: Historical interiors, Adaptive ventilation, Regression-based numerical model, Indoor environmental quality

Historically valuable interiors require special attention in terms of the indoor environmental quality, especially hydrothermal parameters play a significant role. Relative humidity value and its fluctuation over the time have a fundamental influence on the preservation of the cultural monuments. Other important parameters are air temperature and surface temperature. Unfortunately, in many cases, these parameters lie far beyond the tolerance zone. In the most common cases, these interiors contend with unacceptably high relative humidity level caused by structural problems, as well as moisture-producing occupants.

Historic interiors contain hygroscopic materials whose moisture content is directly dependent on the relative humidity of the surrounding air [2]. Changes in the relative humidity of the ambient air lead to a decrease or increase of moisture content of the materials and can cause irreversible damage to the material [3]. The ideal problem solving could be to install air conditioning systems that can maintain the exact require parameters. However, this solution is unacceptable in terms of operational cost and often difficult to implement for many objects [4]. In this case, the use of adaptive ventilation is provided. Natural ventilation with correct definition of the algorithm can lead to

improvement of the indoor parameters with minimal energy input.

The paper presents a simplified numerical design model describing actual behaviour of the object in the corresponding detail. The goal of this model is to find a suitable algorithm, able to indicate proper time and regulation of natural ventilation (e.g. window opening). The aim of the paper is to verify the hypothesis that the quality of indoor environment can be improved by applying a suitable adaptive ventilation algorithm.

Case study

The Pilgrimage Chapel of the Holy Stairs (**Figure 1**) is part of the important cultural monument called Loreto, in Rumburk in the north of the Czech Republic. Since 2014, it has been included among the significant places on the "Via Sacra" Pilgrims' Way. Although the chapel has recently undergone extensive reconstruction, the interior shows signs of damage due to the high level of air moisture. In order to understand the overall airflow and moisture movement in the chapel, the monitoring of hydrothermal parameters was carried out between 8 November and 20 June. The results of analysis which evaluated the measures data were described in publication [5] and confirm the assumption of the moisture supplying from the adjacent corridor. From the previous analysis it is possible to assume that adaptive ventilation would have a beneficial effect on the reduction of moisture in the chapel.

Theory

The key factor to ensure appropriate internal environment consists mainly in a moisture balance between hydroscopic material in the interior and ambient air, where the change in the specific humidity of materials reflects on their dimension. Exposing the interior to air with high relative humidity causes a volume increase of material and, thus, its destruction. On the other hand, constant natural ventilation leads to significant fluctuation in relative humidity, causing damages due to the frequent shrinkage and increased volume of the materials [7]. Adaptive ventilation takes into account the change in air temperature and level of air moisture in the exterior and interior and, based on the evaluation of the current condition, recommends the supply of fresh air. Adaptive ventilation cannot replace full air control system, which is used for accurate environmental management. It only tries to improve the condition from not satisfying to yet acceptable.

Tolerated zone determination

Parameters of the indoor environment for historical interior are defined in the ASHRAE standard [1], which divides the indoor environment into several categories according to the degree of preservation risk. An acceptable risk is defined by values with ±10% RH and ±5 K deflection from ideal values of 50% RH and 20°C. Extremely high risk is defined for relative humidity values higher than 75% [1]. At the same time, it is necessary to check the maximum fluctuation during the day, when critical values are considered those with a larger difference than 15% RH throughout the day.

Figure 1. The Pilgrimage chapel of Holy stairs [10]. Frost on the frescoes leading to damages.

Historic buildings are characterized by massive structures with high heat and moisture accumulation capabilities which are characterized by frequent occurrence of condensation. This phenomenon occurs especially during the transition period, when humid exterior air condenses on the still cold surface of the walls.

Heat balance

The total heat energy of the space is influenced by the heat fluxes shown in **Figure 2**. The law of energy conservation expresses that heat fluxes have to always be in equilibrium with the total heat energy of the space.

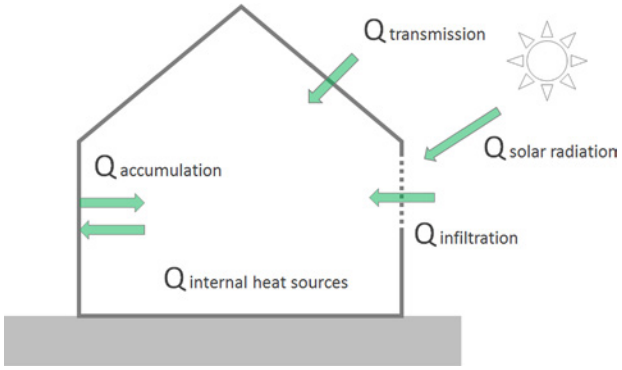

Figure 2. Heat flux diagram in space.

Thermal equilibrium is valid at each time step. For this reason, it is possible to say that total energy of space at time $\tau_{(x-1)}$ with the count of all heat fluxes is equal to the total thermal energy of the space at time $\tau_{(x)}$. The heat balance of the space can be written according to formula (1).

$$Q_{total,\tau(x-1)} + Q_{trans} + Q_{inf} + Q_{accu} + Q_{source} + Q_{sol} = Q_{total,\tau(x)} \quad (1)$$

Where:

- Q_{total} total thermal energy of the space [J]
- Q_{trans} thermal energy supplied to the interior based of the transmission structure [J]
- Q_{inf} thermal energy including infiltration and ventilation [J]
- Q_{accu} thermal energy including heat accumulated in structures [J]
- Q_{source} thermal energy including all added heat sources (occupants, heating, …) [J]
- Q_{solar} thermal energy including heat from solar radiation [J]

Model method

Different methods can be used to model buildings' behaviour. Most of the software available on the market (eg. DesignBuilder, WUFI, etc.) work on the principle of explicit method, when parameters of object properties are known and behaviour of the object can be calculated. In cases when building behaviour is known and some of input parameters are missing, regression method is used. One of the regression methods describing nonliner function is the neural network method.

The task of the regression analyses is to find the appropriate theoretical regression function to describe the dependence, determine the point, interval estimates of regression coefficients, estimation of regression function values for prognostic purposes and verification of compliance between the proposed regression function and experimental data [7].

In case of examining parameters of hydro-thermal microclimate dependent variable represent T_i, x_i, T_m as a function (2), (3) and (4).

$$Ti,\tau_{(x)} = Ti,\tau_{(x-1)} + f(m,c,A,U,Te,Tm,h,\rho,d,Ve,Vi) \quad (2)$$

$$xi,\tau_{(x)} = xi,\tau_{(x-1)} + f(c,A,bm,xe,Ti,\Delta p_v,Vi,Ve) \quad (3)$$

$$Tm,\tau_{(x)} = Tm,\tau_{(x-1)} + f(c,A,h,U,Te,Ti,\rho,d,Vi,Ve) \quad (4)$$

Model description and calibration

The simplified numerical model created in MS Excel works on the principle of the regression method. The model was calibrated based on measured data for a period of 10 days and subsequently verified for other period with measured data. Calculation of dependent variables T_i and T_m was determined on the principle heat balance method described in (1). The calculation of dependent variable x_i took into account the amount of outdoor humidity by ventilation and infiltration and the ability of the material to absorb moisture. Due to the complexity of the issue related to the accumulation of the moisture in the structures, the parameter of moisture accumulation was determined by the regression method from measured data as a function relative humidity. This assumption was further verified through simulations in DesignBuilder, which generated identical results with simplified model in MS Excel.

The choice of appropriate time step was required for proper model operation. The above described model works with 5-minutes time steps that correspond to the time steps obtained from the dataloggers in object

monitoring. Additional source of moisture was applied to the model in an amount that correspond with results of previous analysis published in [5].

The model is not able to take into account the possibilities and limits of natural ventilation in terms of buoyancy-drive and wind drive ventilation and it was only set to two modes (infiltration: 0,2 ach, or infiltration with natural ventilation 1,5 ach). Determination of air change based on differences in temperature and wind effect is subject to further investigation.

Boundary conditions

The following conditions were applied in the model (5), (6), (7) and (8). The main aim of these conditions was moving parameters of air temperature and relative humidity closer to the tolerance zone and at the same time prevent significant fluctuation of relative humidity.

$$T_i < T_e \wedge T_i < 25 \Leftrightarrow \text{„}OPEN\text{“} \quad (5)$$

$$x_i > x_e \wedge RH_i \Leftrightarrow \text{„}OPEN\text{“} \quad (6)$$

$$\left|max(RH_{\tau,0} - RH_{\tau,30min}) - \min(RH_{\tau,0} - RH_{\tau,30min})\right| > 1{,}5 \Leftrightarrow \text{"}CLOSE\text{"} \quad (7)$$

$$T_{dp,i} > T_m \Leftrightarrow \text{"}CLOSE\text{"} \quad (8)$$

In case the model evaluated at least one of the conditions as a “CLOSE” mode, it considered only infiltration.

Results of calibration

The graphs (**Figure 3**, **Figure 4**), show the results of the model verification for the period 10 days (10.6. - 19.6.). The air temperature results are almost identical to the measured values in all periods that have been verified after calibration. The specific humidity values show

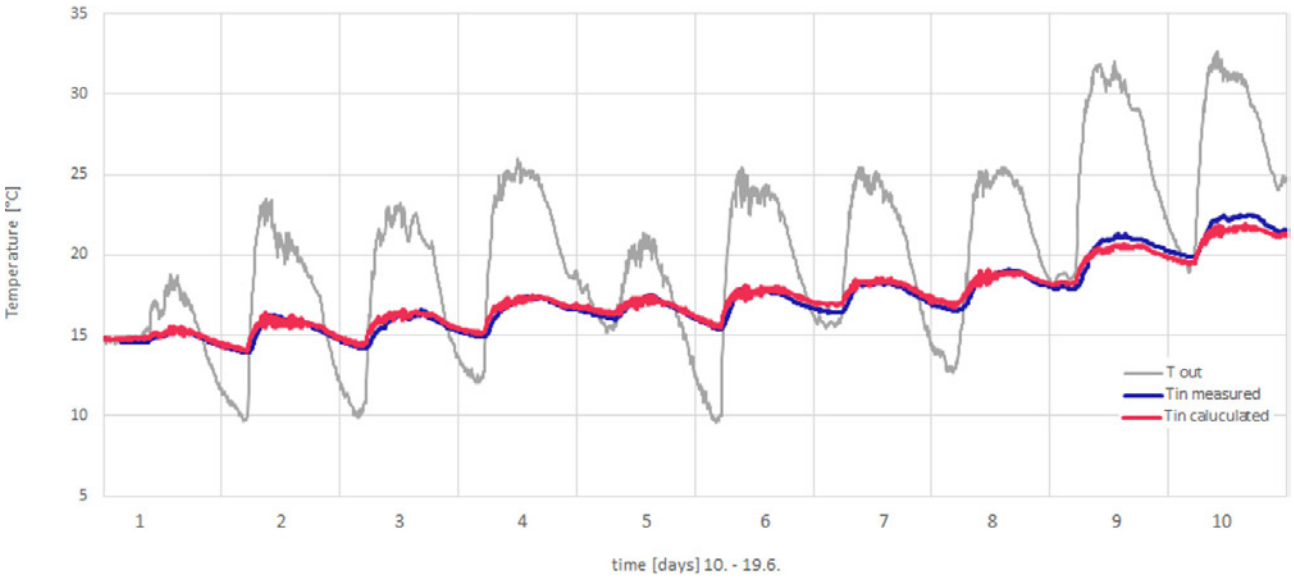

Figure 3. Comparison of measured and calculated air temperature values in the chapel.

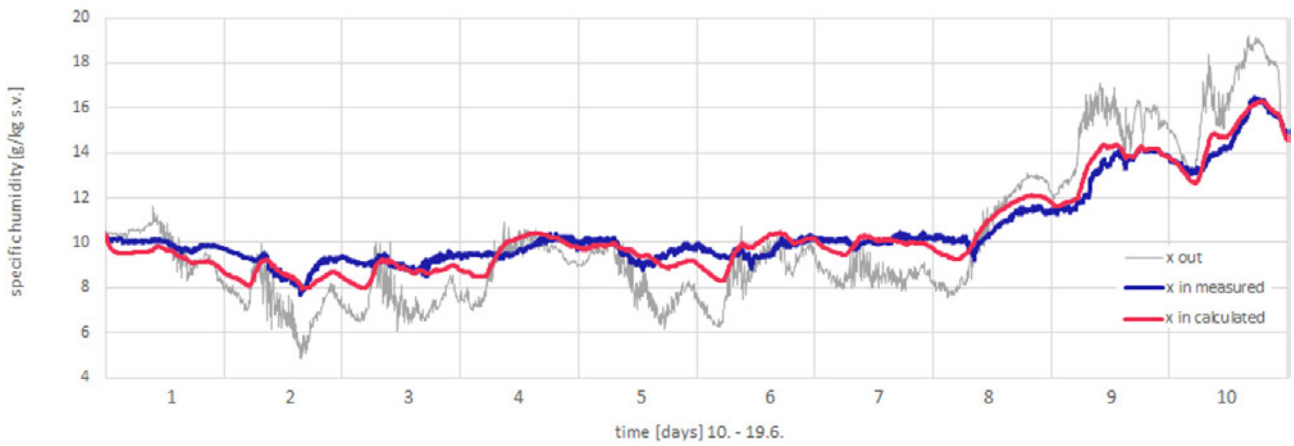

Figure 4. Comparison of measured and calculated specific humidity values in the chapel.

acceptable deviations. These differences can be attributed to the considerable simplification of the extensive problems of moisture accumulation in the masonry and the non-linear influence of the measured values by the additional air humidity coming from the adjacent corridor.

Results

The graph in **Figure 5** assesses relative humidity values in three possible ventilation modes for a selected period of 10 days:

- Only infiltration: constant 0,2 ach
- Permanent ventilation: constant 1,5 ach
- Adaptive ventilation: 0,2 ach or 1,5 ach depend on conditions

The relative humidity results with only infiltration mode show the minimal fluctuation, however, these values almost never fall below the critical value of 75% RH. On the other hand, permanent ventilation results show extreme daily fluctuations reaching almost 30% RH. Moreover, in some cases, it also could lead to increase values. Adaptive ventilation represents an acceptable rate of relative humidity decrease and leads to overall decrease relative humidity values.

The adaptive ventilation effect assessment was based on Performance Index (PI) determination, defined as the percentage of time in which the parameters (in this case air temperature and relative humidity) lie within the required (tolerance) parameters [9]. The graphs in **Figure 6** represent always one month in winter, middle and summer period (from left to right in **Figure 6**), where is possible to see the moving of values with adaptive ventilation closer to the tolerated zone.

Discussion

The general knowledge about the need for ventilation of interiors is quite widespread. However, the proper

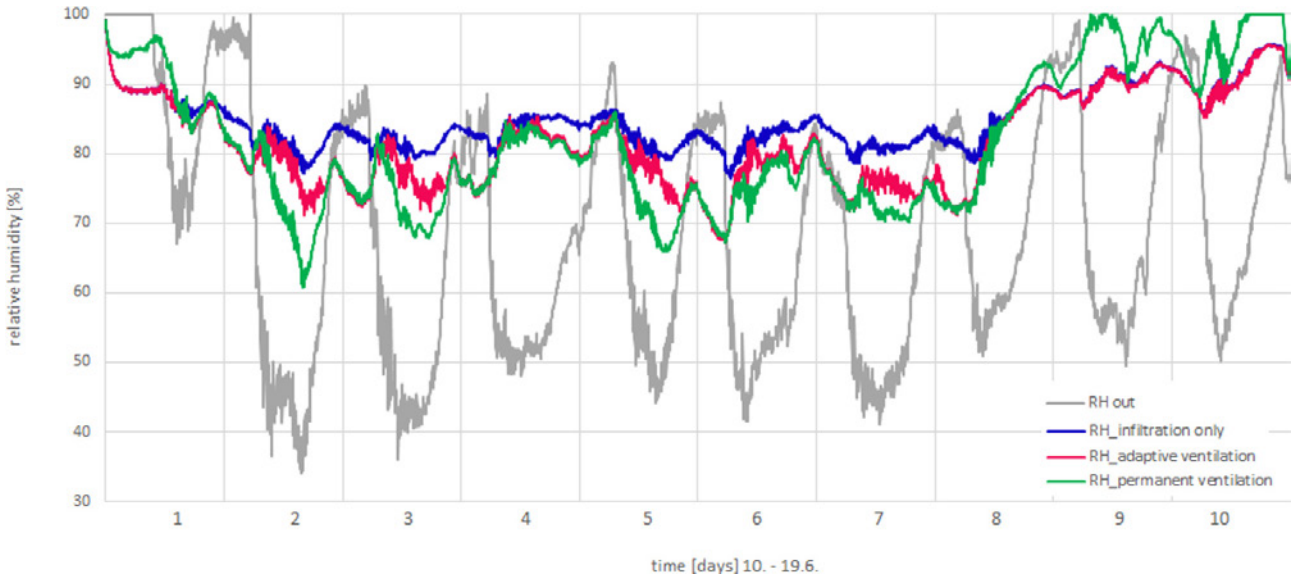

Figure 5. Comparison of different ventilation modes during the selected period of 10 days.

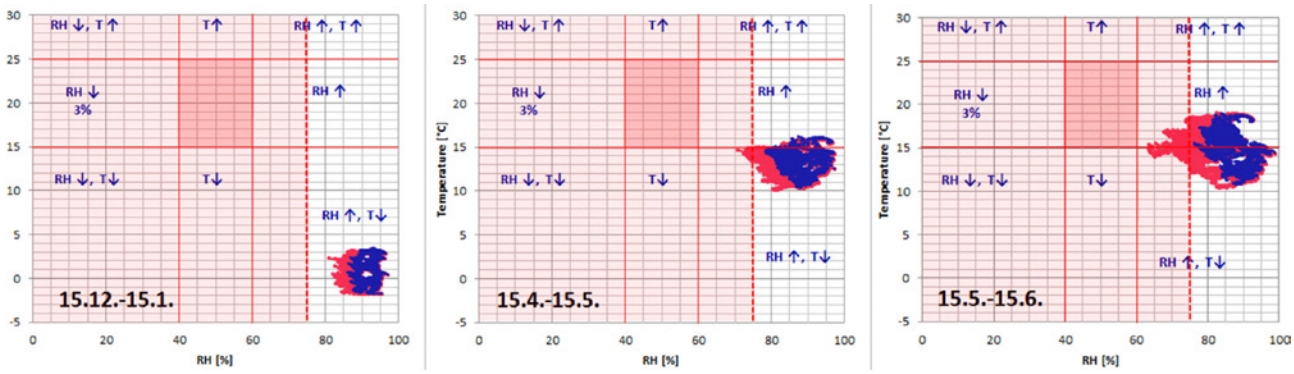

Figure 6. Comparison of calculated air temperature and relative humidity values (blue dots: with infiltration only, red dots: with adaptive ventilation).

timing of natural ventilation is essential and failure to observe the basic conditions can cause a negative effect for preservation.

As expected, adaptive ventilation is not able to offer significant change in the quality of the indoor environment. However, the results achieve improving parameters with minimal energy input. It can be assumed that the influence of adaptive ventilation on the quality of the indoor environment will not be similar for building with different operations. A positive effect is expected especially in buildings with some added source of moisture, which can be characterized by occupants or structural defect. In this case, adaptive ventilation could provide a way to cheaply achieve still acceptable parameters that would not destruct the interior.

Subsequent development of the numerical model will be address to the issue of natural ventilation limits and value of air change intensity.

Conclusion

The presented simplified numerical model demonstrates that if a suitable algorithm is chosen, adaptive ventilation can have a positive effect on the quality of the indoor environment. The model was created by regression method using the measured data of air temperature and relative humidity in the interior and exterior. The paper describes the boundary conditions ensuring that the interior will not be damaged due to the sudden change of internal parameters and large amount of outside air. The results of the numerical model confirmed the positive effect of adaptive ventilation on buildings with some additional source of moisture (e.g. occupants). At the same time, the assumption of different efficiency in individual periods was verified, proving that in winter the influence on parameters is minimal. ■

List of symbols

c	Specific heat capacity	[J.kg^{-1}.K^{-1}]
T_i	Indoor air temperature	[°C]
T_e	Outdoor air temperature	[°C]
T_m	Temperature of the mass	[°C]
T_{dp}	Dew point temperature	[°C]
RH	Relative humidity	[%]
r	Density	[kg.m^{-3}]
A	Area	[m^2]
V_i	Volume of indoor air	[m^3]
V_e	Volume of outdoor air	[m^3]
U	Overall heat transfer coefficient	[W.m^{-2}.K^{-1}]
d	Effective thickness	[m]
h	Convection heat transfer coefficient	[W.m^{-2}.K^{-1}]
x_i	Indoor specific humidity	[kg.kg^{-1}]
x_e	Outdoor specific humidity	[kg.kg^{-1}]
τ	Time	[s]

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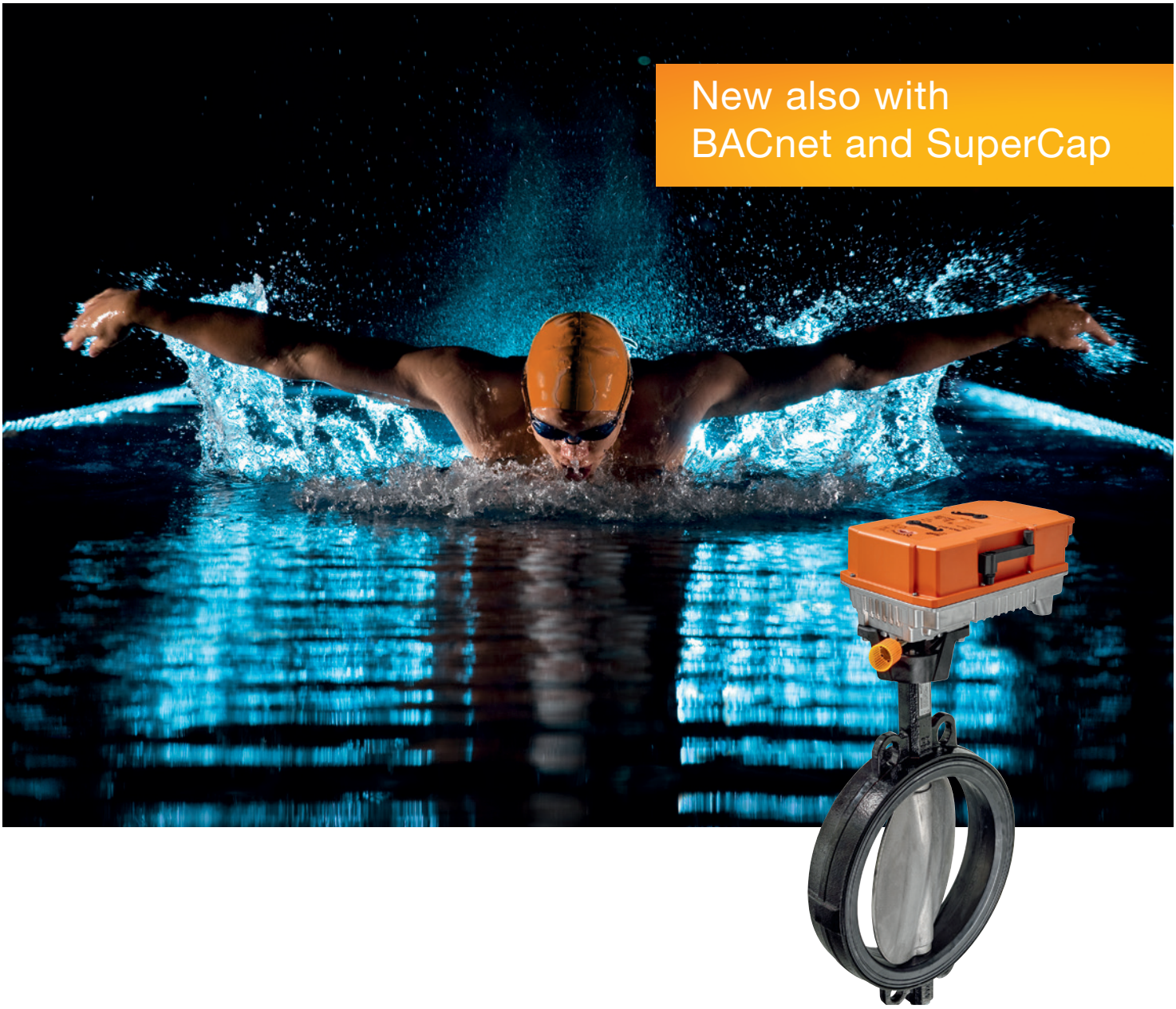

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- Guaranteed reliable operation through intelligent self-adjusting valve design
- 80% energy savings thanks to the combination of butterfly valve and actuator
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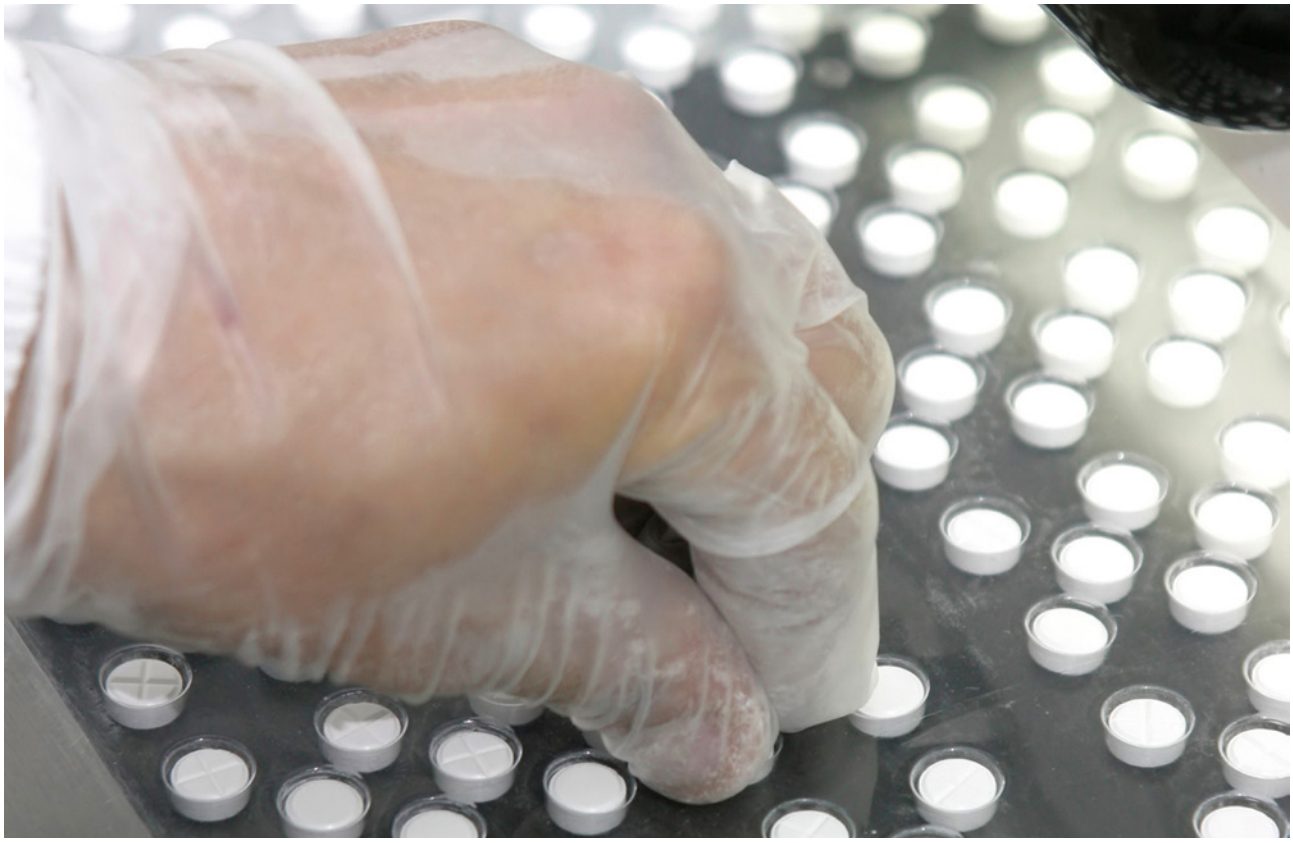
BELIMO®

SwissCo Services AG: New chiller with communicative butterfly valve actuator

Reliability, security and energy efficiency achieved with Belimo



A reliable cooling circuit is particularly important for the pharmaceutical company SwissCo Services AG in Sisseln (CH). The temperature and above all the humidity in the production plants are decisive for manufacturing the company's effervescent and tablet products. Alongside reliable operation and keeping temperature and humidity levels constant, the aim of refurbishing the cooling plant was to optimise energy consumption.

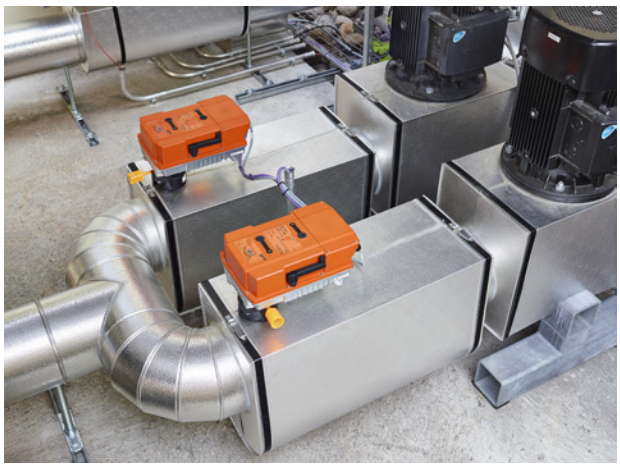
SwissCo Services AG Building.

SwissCo Services AG is part of the Aenova Group and specialises in manufacturing and packaging humidity-sensitive solid medicines, such as effervescent tablets The requirements of the new cooling circuit and its control were immense, deviations in temperature and /or humidity can shut down production or destroy batches already produced. That is why a reliable and safe cooling plant is indispensable. An ideal solution has been found with the new Belimo communicative PR actuator combined with the new butterfly valves. This butterfly valve / actuator combination has made it very straightforward for the company to implement the issues of greatest importance to it, namely plant safety and energy efficiency.

Controlling production conditions influences the HVAC system

Production conditions in the pharmaceutical industry are strictly controlled and particularly in the manufacture of moisture-sensitive tablets, humidity and room temperature play an important role. This means that the products manufactured in Sisseln need to be produced at max. 20% humidity and max. 18 degrees Celsius. The manufacturing process for tablets only works if the right pressure, the right temperature and post-hardening processes are coordinated correctly. The production plant in Sisseln runs 24 hours a day every day. To keep production flexible, SwissCo keeps refitting the production facilities. This means that it is also possible to produce small batches. The chilling and dehumidification process is particularly important here, and distinction is made between two phases:

1. In the preliminary dehumidification process, most of the humidity is removed from the air.
2. The remaining humidity is removed from the air at various temperatures with silica gel driers (first cold and then at 130 degrees Celsius).



Belimo Butterfly Valve and PR Actuator Combination.

The two chillers support this process (see figure abowe), although generally only the new plant is in operation. Only if the outside temperature rises above 35 degrees Celsius or if there is a breakdown are both chillers required at the same time. The older plant from 2005 is also to be refitted in the medium-term. It currently can't meet the company's energy saving requirements in particular.

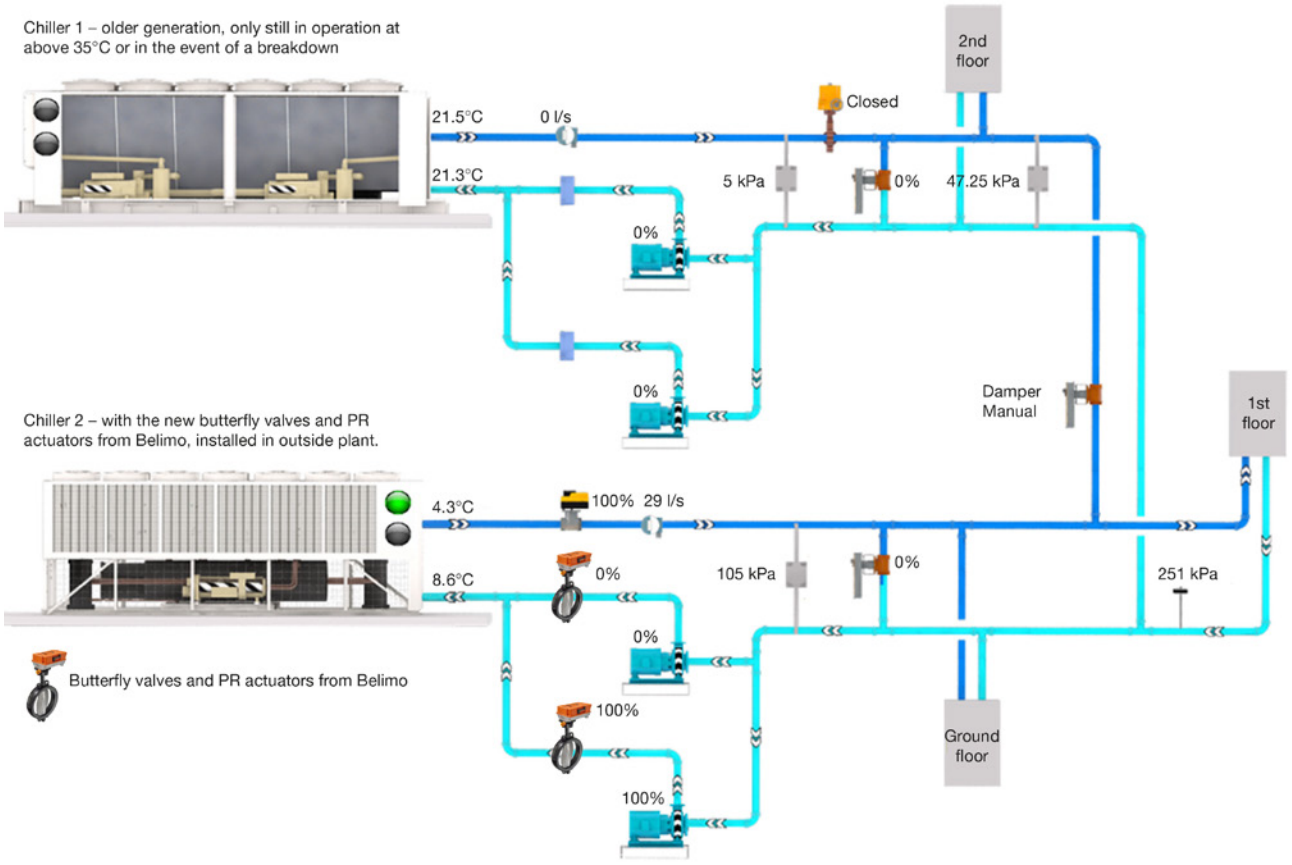
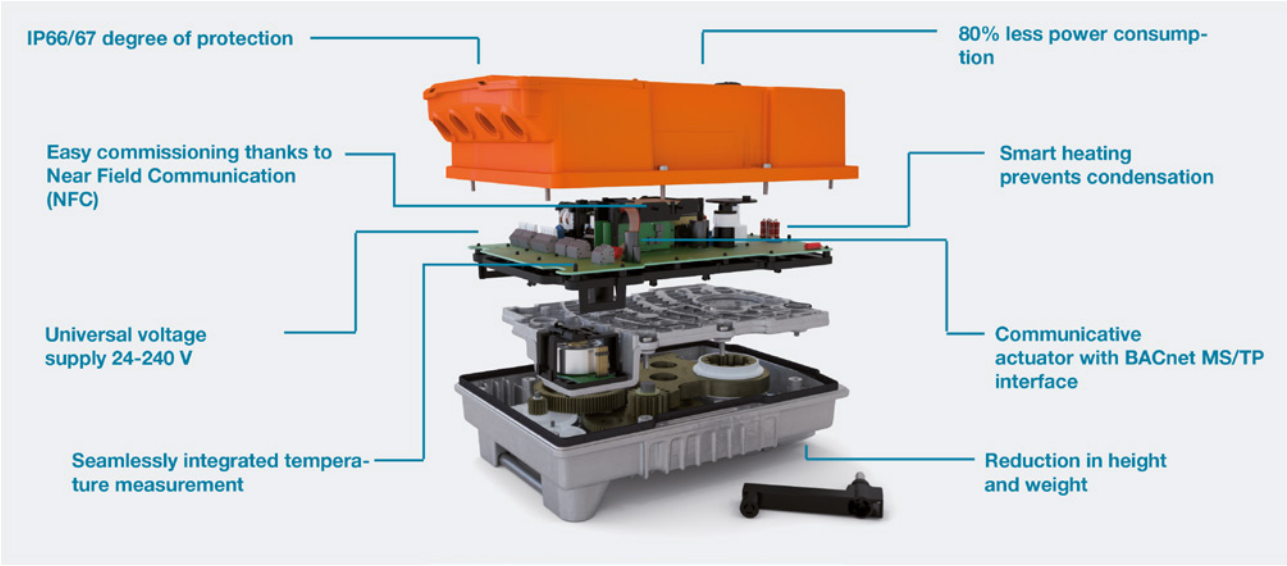


Figure of the two chillers with their circuits at SwissCo Services AG. Chiller 2 has been equipped with the new butterfly valves and PR actuators.



Belimo is synonymous with reliability and energy efficiency

The challenge for the HVAC system is that the temperatures and humidity required need to be kept constant the whole year round, regardless of the weather conditions. That is why a reliable and precise plant is hugely important. "We like working with Belimo because we can depend on the reliability of the products," explains Andreas Wechner, Project Manager & Field Controls Representative at Trane (Schweiz) GmbH. SwissCo also wanted to reach a new level when it comes to energy efficiency. Compared with the energy consumption of the previous year, the company was able to save a total of 128 000 kWh of energy between March and August 2017.

Communicative actuator with diagnostics capability

The fact that the new Belimo PR actuator is communicative makes it unique. "The communicative PR actuator allows us to see at any time whether the system is working properly so we can intervene rapidly if there are any deviations. That provides both us and our customer SwissCo with the necessary safety and peace of mind." Thanks to the BACnet® MS/TP interface which is easy to integrate, the plant operator and plant installer can access the PR actuators from anywhere via secure web access and thereby obtain information on the plant's current operation.

At SwissCo Services AG, two passive temperature sensors have also been connected to the communicative PR actuators so that precise measurement data can be transferred via the BACnet® MS/TP protocol.

Simple commissioning thanks to NFC

Another advantage of the PR actuator is that commissioning, setting parameters and maintenance are easy. "With NFC (Near Field Communication) I was able to commission the PR actuators in just a few minutes from my own smartphone. It is really easy to do and saves a lot of time," confirms Andreas Wechner.

Using Near Field Communication makes simple diagnosis possible even during operation. This means for example that the health status of the actuator can be queried at any time. This function is another important element for guaranteeing the reliability and user-friendliness of the PR actuator.

Practical position indicator

As it is not possible to see the position of butterfly valves from the outside once they have been installed, Belimo has developed a new position indicator.

"The position indicator is practical because it allows you to see the position of the valve from a distance," says Andreas Wechner. When the new cooling circuit was to be implemented, the Project Manager was quite clear that he wanted to work with Belimo: "Belimo does all it can to find a solution quickly and if anything should ever not go quite to plan, then the company is very accommodating."

SwissCo Services AG

SwissCo Services AG has 150 employees. In most cases, the drugs produced in Sisseln are supplied to the customer's companies ex works. The most well-known products at the moment are the Nicotinell tablets and sticks. The company manufactures various products for companies like Ratiopharm. Both the drugs and the blister packaging are produced in Sisseln.

In the new chillers, SwissCo Services AG not only uses the butterfly valve / actuator combinations but also a Belimo Energy Valve™. Actually, Belimo products are installed throughout the building, including in fire protection and in the air handling units.

Trane (Schweiz) GmbH

According to the company's slogan, Trane doesn't just follow industry standards. We define them. In collaboration with building owners and operators, Trane creates high performance buildings that contribute measurable, year-over-year benefits. First of all, options are discussed as to how the building environment can have a positive effect on the company and these are implemented correspondingly. From a preliminary energy audit through to a complete performance analysis, Trane examines each building's critical systems and energy consumption — and considers how they stand up to the customer's objectives. Trane is also committed to delivering sustainable performance, innovations and knowledge – for the lifecycle of buildings. Working with Belimo, the company has been able to successfully implement many projects for other companies.

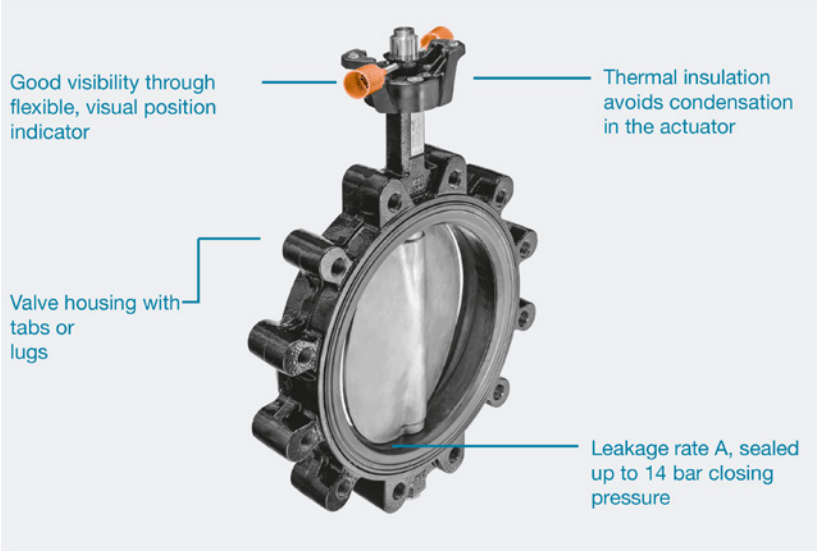
BELIMO

The new generation of butterfly valves and actuators from Belimo, the HVAC solution

In addition to the communicative PR actuator, the Belimo butterfly valves have also been technically optimised. The new Belimo butterfly valves / actuator combination was exclusively designed for the heating, ventilation and air conditioning industry and meets all of its requirements. When developing the new generation, user-friendliness and reliability were given top priority and an innovative solution was found.

Installation is now incredibly easy thanks to the reduced height of the actuator and the fact that it weighs approx. 2/3 less. With Near Field Communication (NFC), the butterfly valve / actuator combination can be started up in a matter of minutes. The housing has IP66/67 degree of protection and is also ideally protected for use outdoors. The thermal insulation and smart heating inside the actuator prevent condensation which also contributes towards increased operating safety and a longer service life.

The new valve design ensures low torque which, in combination with the actuator, results in a reduction in energy consumption of 80%. In addition to that, the valve housing is available with tabs or lugs and is sealed up to a 14 bar closing pressure (leakage rate A). With the new generation of butterfly valves and actuators, there is no longer any need to compromise. They are the best solution for every plant.



MCE – Mostra Convegno Expocomfort 2018 is approaching fast

Preparations are in full swing for MCE - MOSTRA CONVEGNO EXPOCOMFORT, the world's leading biennial exhibition dedicated to residential and industrial installations, air-conditioning and renewable energy scheduled for 13th – 16th March 2018 at Fiera Milano, that will once again act as an international platform to bring together even more visitors and exhibitors from around the world.

By now, over 1,500 companies have already secured their places, with a 11% rise in foreign exhibitor numbers, a clear sign of the exhibition's growing international dimension and its willingness to bring together even more visitors and exhibitors.

The major industry sector, represented on MCE floor, is one of the most dynamic in the world and increasingly strategic in the International and European economic scenarios, characterized over the last years by investments in innovative integrated technologies offering ground-breaking products, systems, and solutions to improve energy performance of buildings, as well as thermal comfort to improve comfortable interior living conditions.

Buildings construction future is going to use technologies with integrated functionality, control and management tools and this will be one of the major focus of MCE 2018 thank to a busy programme of dedicated conferences, company workshops and special events that will integrate synergistically with the wide exhibition area.

To highlight, the workshop organised by AICARR in collaboration with REHVA and ASHRAE on "IEQ (indoor environmental quality): requirements and practices" to be held on March 14 as well as REHVA seminar on "EPBD 2nd recast: opportunities and critical aspects".

A unique opportunity for skills training and updating aimed at professionals involved in the designing and management of residential, commercial and industrial buildings such as engineers, architects, designers, planners, maintenance technicians, and energy managers.

Amongst the new features in store for MCE 2018, there is the first edition of BIE – BIOMASS INNOVATION EXPO that will run simultaneously alongside MCE, a new trade show dedicated to heating systems and thermal power production through direct combustion of wood pellets, wood chips and other sources of dry biomass. New activities that will be added to traditional initiatives like THAT'S SMART, the workshop format combined with an exhibition area dedicated to home & building automation and the new shape of "Percorso Efficienza & Innovazione" that offers an overall showcase of the most innovative products and solutions that focus on high energy efficiency.

Moreover, to facilitate contacts between exhibitors and visitors, the new matchmaking platform by Reed Exhibitions at disposal of all actors to generate visit recommendations based on interests and business.

All the latest updates on MCE – MOSTRA CONVEGNO EXPOCOMFORT 2018 are available online at www.mcexpocomfort.it, on Facebook.com and Twitter.com MCE's pages. ■

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light+building 2018 continues its success with all the latest issues and 2,600 exhibitors

"Connected – Secure – Convenient" is the slogan for the upcoming Light + Building in Frankfurt am Main. The world's leading trade fair in its field will be held from 18 to 23 March 2018, with this as its central theme. All the market leaders have signed up and some 2,600 exhibitors are expected. They will be coming to present their innovative products in the fields of lighting, electrotechnology, home and building automation and security technology – many of them for the first time anywhere in the world. Overall, Light + Building will occupy an additional exhibition hall and thus continues to grow once again.

At the centre of concerns are the driving issues 'smartification in everyday life' and 'aesthetics and comfort in harmony'. At this, the world's biggest trade fair for lighting and building services engineering, the industry will be showcasing intelligent, networked solutions, ground breaking technologies and the latest design trends, which both increase the energy efficiency of buildings and enhance the comfort and sense of security of the users. The trade fair for innovation par excellence, Light + Building brings together all electrically driven building services systems, thus promoting integration in the planning of buildings, with a spectrum of products that is unique in both breadth and depth – from the 'smart home' to the 'smart building'.

There is a major emphasis, in 2018, on security technology. The integration of a variety of security systems, such as video surveillance and access control, their networked inclusion and integration into the technology of the building automation system are all aspects that are of relevance to the sector. So that, for the first time at Light + Building, the two product groups, home and building automation and electrically controlled security technology, will be grouped together in Hall 9.1. This provides a common port of call, a centre for all the integrated building services technology, offering visitors an all-round overview of the entire spectrum of home and building automation, together with electrically based security technology. In addition, both product groups will also exhibit in Halls 11.0 and 11.1. The new exhibition hall will, additionally, be enhanced with the special show entitled 'SECURE! Connected Security in Buildings' and the Intersec Forum, which will be held in parallel on four days of the show.

The special exhibition, **'SECURE! Connected Security in Buildings',** shows visitors how a building's efficiency can be improved, whilst, at the same time, the security requirements and the individual needs of the users are taken into consideration. Quite separate from the presentations by the exhibitors, all the different tasks required in three practical applications (hotel, office and industry), considered from the point of view of the user interface, will be conflated in a single unit.

A key area of focus, in the **Lighting** product group, is the presentation of the latest design trends in the lighting market and the high levels of competence of the exhibitors in terms of design. Digitalisation has opened the way for a whole new dimension in lighting design. Innovations in lighting technology are putting human beings and their personal needs at the centre of focus. This is shown in the increasing importance of Human Centric Lighting (HCL). This is, amongst other things, about the way in which lighting affects human beings and about the impact of light on their health, efficiency and well-being. As in the case of HCL, digitalisation also makes it possible to manage street lighting and, moreover, provides the framework for additional services – such as charging points for electric vehicles, for instance, or broadband infrastructure, surveillance sensors, loudspeakers for emergency announcements or alarm buttons. Enriched with such additional functionality, street lighting offers some interesting 'smart-city' lighting concepts and thus contributes to the potential creation of 'smart cities' themselves. The entire spectrum covers designer luminaires, in various styles, technical luminaires and lamps, in a variety of versions, for all kinds of application, together with a large selection of technical lighting components and accessories, as well as exterior and street lamps – and they can all be found in Halls 1 (Trendspot Design) to 6 and Hall 10, as well as in the Forum.

A key role in the creation and operation of intelligent, networked building services – whether it be the 'smart home' or the 'smart building' – is played by electrical and electronic engineering, as well as by the home and buildings automation sector. **Electrotechnology**, with its inter-disciplinary approach, focussed on holistic, all-round solutions, has a central part to play in building services engineering generally. So, at Light + Building, we find electrical and electronic solutions in the context of the work of other trades such as lighting, home and building automation and security technology. Through this unique combination, industry is able to present an integrative range of products and services, which make a crucial contribution to fully exploiting the potential energy savings within buildings. And, because it involves bringing together all the technical trades, the **automation of buildings**, too, has a major role to play: the successive networking and digitalisation of electrotechnical installations enhances the quality of life both at home and at work. At Light + Building, the industry will be showcasing solutions that aim as much at low energy consumption and modern security requirements as they do at preserving opportunities for individual design and high levels of comfort and convenience. The trade visitors at the show will find the range of energy-efficient solutions for building services systems, electrical installations and building services infrastructure on offer in Hall 8.0. In Hall 11.0, everything revolves around electrical installations and network technology. Design-oriented electrical installations and building services engineering find a home in Hall 11.1.

In addition to the broad range of products and services offered by the exhibitors, much of the appeal of Light + Building lies in its varied complementary programme, which, for the first time, is to be grouped thematically under a number of headings, including: 'Emotion', 'Skills', 'Career' and 'Selection'. There are specific features aimed at all trade visitors, such as architects, engineers, planners, interior architects and designers, tradesmen and women, retailers, wholesalers and representatives of industry, ranging from special exhibitions to specialist lectures and presentations of current trends.

More information: www.light-building.com.

aqua THERM MOSCOW
February 6-9, 2018
Moscow | Crocus Expo

Opportunities of the Russian HVAC & Water supply market that should be discovered at Aquatherm Moscow

Russian HVAC & Water supply market has always been extremely attractive for international producers: vast territories, huge population, and climate conditions require various types of equipment – from gas heating to solar panels and electric boilers, from air conditioners to refrigeration systems, from industrial pipes to plumbing fittings.

In the beginning of 2017 the Russian market started receiving positive assessments after 3 years of economic difficulties: Standard & Poor's improved Russian rating from stable to positive and forecasted that statistics on the Russian economy will lead to higher foreign portfolio investment.

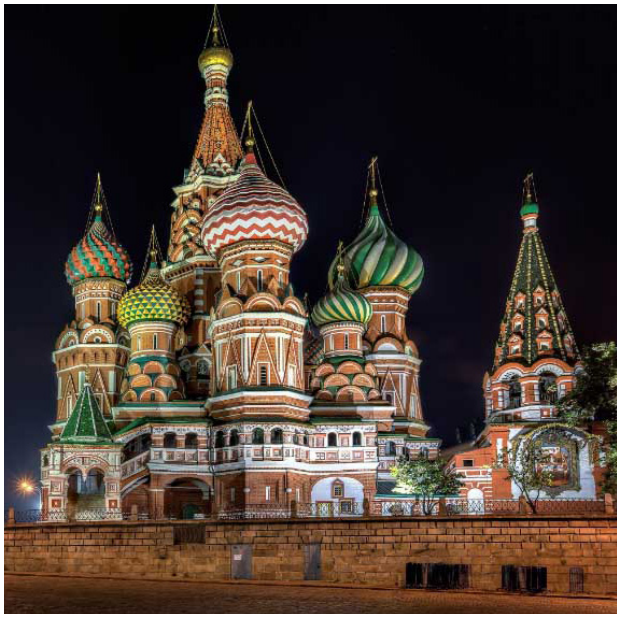
Now, the figures of external trade turnover approve the economy's recovery: in the first half of 2017 it reached 270.4 billion USD which is 32% less than in the same period of pre-crisis 2014 mainly due to export decrease, but… 28% more than in January–June of 2016!

The Top-10 Russian principal trade partners remained the same showing that China, Germany, the Netherlands, Belorussia, Italy, USA, South Korea, Turkey, Kazakhstan and Japan business saved its strong ties with Russia.

The market of HVAC and water supply systems is essentially connected with construction industry which impressive volume in residential sector has reached 3.2 billion sqm in 2016 (93% are in private property). Building installation is accounted at 4 billion USD (2016) with stable 2.8% CAGR up to 2023. As a result, according to Ministry of Construction, in 2016, there were signed over 580 contracts on public utilities with total volume 1.1 billion USD.

Buying potential

HVAC & water technologies industry is experiencing changes that promise good opportunities for business growth. In 2016, total sales of equipment including its installation in Russia reached 6.3 billion USD with



56% of sales referring to imported products without considering local products made from imported parts and consumables.

Impressive number of trade companies, including construction retail chains, provide targeted coverage by regions and products or sell the full HVAC product range in all Russian regions: over 5700 specialise in heating equipment, 2100 in water supply equipment, 1800 in plumbing equipment, 1600 sale pipes, 5000 – fittings and valves, 170 – HVAC & water supply automation systems, 200 – water treatment equipment, over 1200 companies are installers, 330 – engineering systems constructors.

There are 20 specialised major federal wholesalers such as Interma, Terem, Duym, Termoros, MasterWatt, Santeam, MTK Group (Moscow Heating Company), Laboratoriya Otopleniya, Bautherm, Hogart, Heisskraft, Taym (TeploNet), Lunda, Elso and others. Over 5000 construction and real estate development companies operate in the market.

Major market drivers

- FIFA World Cup 2018 preparations influenced reconstruction and building of 281 objects in 10 Russian regions including engineering systems, sportive venues, transport networks and hotels. Total investment is accounted at 11.2 billion USD;
- Federal programme of resettlement of emergency housing to be finalized by 1 September 2017 resulting in replacement of 7,5 million sqm of residential space;
- Programme "Housing and utilities sector and urban environment" will get investments of 400 million USD and annually;
- Programme of development of Moscow metro: 20 km of new fully equipment lines to be constructed annually, 52 new stations will be constructed by 2019;
- Programme for renovation of dilapidated housing in Moscow: by 2032 over 5000 old law-rise buildings will be replaced by the new ones boosting construction and equipping;
- Energy-efficient trend reflected in the changes of official standards in 2017: required resistance to heat transfer of external walls was raised from 1.75 up to 3.15 sqm x °C/W, automated individual heat point became obligatory (instead of heat distribution station), as well as mandatory automotive regulation of heat supply equipment by thermostat and heating metering systems.

Aquatherm Moscow – the proper place to enter the market

Aquatherm Moscow as the leading show in Russia and Eastern Europe for heating, water supply, engineering and plumbing systems, ventilation, air conditioning and equipment for pools, saunas and spas, annually welcomes international HVAC equipment suppliers from over 30 countries that are interested in developing business in the promising Russian market.

The next exhibition that will be held on February 6–9, 2018 in Moscow, Russia, will become a meeting point for over 700 HVAC equipment suppliers from all over the globe with 28 000 buyers looking for new products. The show is characterized by a highly-professional visitor audience represented by the major Russian and CIS wholesalers and distributors, engineering design and installation, construction and real estate development companies.

It's Aquatherm's value for international companies that is approved by Country Pavilions of Germany, Italy, China, Turkey, Spain, Japan and India supported by trade and government organisations. The following well-known international companies are among regular show participants: ACV, Baxi, Berke, BWT, Bosch, Comisa, De Dietrich, Dizayn, Espa, Fraccaro, Fondital, Frisquet, Gebo, Genebre, Giacomini, Grando, Gruenbeck, Herz Armaturen, Honeywell, Jeremias, Judo, Kiturami, Max Weishaupt, Meibes, Minib, Navien, Oventrop, Pahlen, Reflex, Rehau, REMS, ROLS Isomarket, Rothenberger, Schiedel, Sermeta, Siemens, Speck Pumpen, TECE, Unipump, Vaillant, Valtec, Viega, Viessmann, Wavin, Wilo, Wirquin and many others.

To provide direct sales to the Russia's distant economic centres – Siberia and North-West – Aquatherm brand welcomes companies to join Aquatherm Novosibirsk (February 13–16, 2018, Novosibirsk, Russia) and Aquatherm St. Petersburg (April 17–19, 2018, St. Petersburg, Russia) and establish fruitful relations with thousands of local buyers.

What is Aquatherm Moscow for its international participants?

Ilya Chaplinsky, Marketing Director, Danfoss LLC (Russia): "Aquatherm Moscow is, of course, a key event for heating and water supply, ventilation and air conditioning industry gathering the entire spectrum of the professional community. We choose this exhibition to find new contacts and meet with existing partners: engineering design companies, influential real estate developers, equipment manufacturers which use our components."

Aldo Olli, Export Area Manager, GECA Srl (Italy): "Aquatherm Moscow has confirmed our expectations. It is an excellent showcase for Russian market and neighboring countries like Belorussia, Kazakhstan and Uzbekistan. The visitors are numerous and they are really qualified. Aquatherm is the show you cannot miss!" ■

Based on the sources: www.aquatherm-moscow.ru, riarealty.ru, www.c-o-k.ru, www.minstroyrf.ru, all.biz, RNS Agency, www.abok.ru

Organisers: Reed Exhibitions Russia, ITE LLC Moscow

Summary of the 10th International Symposium on Heating, Ventilation and Air Conditioning – ISHVAC

The 10th International Symposium on Heating, Ventilation and Air Conditioning – ISHVAC 2017 was held in Jinan, China from October 19th to 22nd, 2017. ISHVAC 2017 organized by Shandong Jianzhu University, and co-organized by Tsinghua University, The Hong Kong Polytechnic University, The University of Maryland, The University of Sydney and UiT The Arctic University of Norway. The ISHVAC conference series was initiated by Tsinghua University in 1991. It is the premier international HVAC conference initiated in China and has played a significant role in the development of HVAC and indoor environment research and industry in China. ISHVAC 2017 in numbers:

- 641 participants,
- 20 countries,
- 830 abstracts,
- 539 papers in 38 sessions, including oral and poster
- 582 papers published, in <Procedia Engineering>

Rehva organized a topical workshop regarding HVAC education in Europe in the ISHVAC 2017. Six speakers from REHVA made presentation in the workshop: Prof. Vojislav Novakovic, Norwegian University of Science and Technology, Norway; Prof. Risto Kosonen, Aalto University, Finland; Prof. Stefano Paolo Corgnati, Politecnico di Torino, Italy; Prof. Guangyu Cao, Norwegian University of Science and Technology, Norway; Prof. Bjarne W. Olesen, Technical University of Denmark; Prof. Manuel Carlos Gameiro da Silva, University of Coimbra, Portugal.

REHVA president, Prof. Stefano Paolo Corgnati, made a key-note speech on "nZEB concept evolution in Europe". Stefano and Risto also brought REHVA experience on nZEB in the WS "Towards Nearly/ Net Zero Energy Building" where EU, Chinese and Japanese experiences were compared.

During the ISHVAC 2017 conference, a REHVA-CCHVAC meeting was held.

CCHVAC will host next HVAC World Student Competition (HVAC-WSC) in 2018. An agreement will be signed between CCHVAC and REHVA in early 2018. An organizing committee of HVAC-WSC will be build up by CCHVAC supported by REHVA.

In addition, a systematic strategy plan for the collaboration between REHVA and CCHVAC was discussed covering several areas: research, education, publication & dissemination and industrial collaboration. A significant "syntonic" with our Chinese colleague of CCHVAC promoted that we are setting up a strategic 3 years plan to enforce our mutual cooperation in the near future. ■

GUANGYU CAO, RISTO KOSONEN, STEFANO CORGNATI

ECEEE receives prestigious award for its work on evidence-based information, opinion and analysis

ECEEE – The European Council for an Energy Efficient Economy – has been awarded in Lund (Sweden) with the Swedish "Future-Builder of the Year", Sweden's most prestigious sustainable energy award. The award, in the category "Opinion Leader of the Year", was presented by the Lund University Board Chair Mr. Jonas Hafström to eceee's Executive Director Mr. Nils Borg.

The Future-Builder of the Year is awarded by the *Foundation for Developing Energy Efficient Buildings* (SUEB) in cooperation with the University of Lund.

"We are very happy that our long and consistent work for promoting evidence-based information and analysis on energy efficiency is recognised" said ECEEE's Director Mr. **Nils Borg.** "But I must stress that it is in ECEEE as a community where opinions and positions are developed. Our members, Summer Study participants, panel leaders, experts, our secretariat and our active board represent an incredible wealth of experience and knowledge. This prize is for all of us."

"Energy efficiency is quite simple in principle, but we need to keep redefining what it means as technology, policy and markets develop", said Mr. Peter Bach, ECEEE's President and one of ECEEE's founders. "But we have come a long way to hear IEA call it the first Fuel and the European Commission make it the No 1 priority".

The SUEB Foundation points out that ECEE is Europe's oldest and largest energy efficiency NGO (founded 1993) within the area of energy efficiency, and it has worked with opinion-making and awareness-raising on making buildings, transportation and products more energy efficient.

The jury motivated the award as follows: "Through in-depth and evidence-based analysis, ECEEE has become a credible and important actor to move energy efficiency in the EU and Brussels policy processes forward. ECEEE's contributions on NZEB (Nearly Zero Energy Buildings) are good examples of this. This long-term and systematic work on energy efficiency, not the least its focus on buildings, is a strong justification for the recognition as *Future-Builder of the Year*".

ECEE's Executive Director Mr. Nils Borg with the jury.

Audience at the 17th Climatization Days in Lisbon.

The 17th Climatization Days in Lisbon organized by Ordem dos Engenheiros was again a success

The 17th Climatization Days of *Ordem dos Engenheiros* (OdE, Portuguese Association of Engineers) was held in Lisbon on the 26th October 2017. The theme this year was "Building automation, controls and technical building management". REHVA was invited to present the Guidebook Nr. 22 that has been translated this year into Portuguese by OdE.

This years' theme was welcomed with expectation and interest by the audience, the participants filled the auditorium. Around 200 registered participants attended the event, representing HVAC engineers, manufacturers and building specialist, and academics.

Serafin Graña, the Coordinator of the OdE Climatization Chapter, opened and chaired the seminar. REHVA was also on the Agenda of the event. Manuel Gameiro, Vice-President of REHVA and Chair of the REHVA Education and Training Committee presented REHVA's objectives and strategic activities, which was complemented by a presentation of Isabel Sarmento, the ASHRAE Portugal Chapter Delegate, who summarised the priorities and key activities of the ASHRAE Portuguese Chapter. Carlos Mineiro Aires, OdE President, praised the remarkable work accomplished by the Climatization Chapter over the past years and highlighted the good relation and fruitful international cooperation between OdE, REHVA and ASHRAE.

Panellists from OdE, REHVA and the ASHRAE Portugal Chapter.

Francisco Pombas, an electrical engineer with a long-standing experience gained since 1990 in this field presented and moderated a working session around the theme of "The design and implementation of a technical building management systems".

REHVA was represented also by Vice-President Catalin Lungu, who presented in the session the REHVA Guidebook No 22 on "Introduction to Building Automation, Controls and Technical Building Management, which is a joint publication of REHVA and eu.bac, the European Building Automation and Controls Association. Mr Lungu thanked OdE for promoting knowledge exchange by continuously translating REHVA Guidebooks, and welcomed the Portuguese translation, which was offered to all registered attendees of the event.

Serafin Grana, Coordinator of the OdE Climatization Chapter.

The event proceeded with technical in-depth analysis, as three interesting case studies were presented, providing details and lessons learned from the experiences:

- Food Retail - Integration of Refrigeration Systems and HVAC
  Presented by Luis David - Portugal
- Keeping Environments in Light-Commercial Buildings Comfortable and Efficient
  Presented by Jorge de La Torre - Spain
- Solutions for Health Care and Life Sciences - The problem of room pressure - Design considerations for tight rooms in critical applications
  Presented by R. Schulze - Germany

The case studies generated an interactive and vivid debate between participants and speakers before Serafin Graña closed of the successful event. ■

REHVA JOURNAL Publishing Plan 2018

The REHVA European HVAC Journal

Issue	Publication date	Events where the Journal will be distributed	Deadlines
1/February IEQ and EPBD	14.02.2018	• *WSED Wels, Austria 28 February - 2 March 2018* • *Cold Climate HVAC Conference 2018 Kiruna, Sweden 12-15 March 2018* • *MOSTRA CONVEGNO Milan, Italy 13-16 March 2018* • *Light and Building 2018 Frankfurt, Germany 18 - 23 March 2018*	10.01.2018
ACREX Special Edition European HVACR Technologies	14.02.2017	• *ACREX Bangalore International Exhibition Centre, Bengaluru, India 22-24 February, 2018*	10.01.2017
2/April NZEB and CO_2 footprint	09.04.2018	• *REHVA Annual Meeting Brussels, Belgium 21 - 23 April 2018* • *Roomvent & Ventilation 2018 Espoo, Finland 2-5 June 2018*	05.03.2018
3/June Sustainability, circular economy and LCA	11.06.2018	• *EUSEW 2018 - EU Sustainable Energy Week June 2018* • *2017 ASHRAE Annual Conference Houston, TX, USA 23 - 27 June 2018*	07.05.2018
4/August Cold Climate	29.08.2018	• *FinnBuild 2018 fair Helsinki, Finland 10 – 12 October 2018* • *Chillventa, Nuremberg, Germany 16 – 18 October 2018*	19.07.2018
5/October BIM and Digital	22.10.2018		17.09.2018
6/December TBD	20.12.2018	• *2019 AHR Expo Atlanta, GA, USA 12-16 January, 2019*	15.11.2018

The audience of the REHVA Brussels Summit Conference.

REHVA Brussels Summit highlights

13 and 14 November were two intense days for REHVA. The REHVA Brussels Summit brought together REHVA Members, Supporters, MoU Partners, EU stakeholders and several present and future collaborators to involve them in a busy schedule of meetings and social events.

REHVA committees

Day one, Monday 13 November, was dedicated to REHVA committees and to bilateral meetings with REHVA MoU partners hosted at the REHVA Headquarter in the *Maison des Associations Internationales*.

REHVA experts exchanged views about current and future HVAC technology trends, technical collaborations, EU policy developments and the European and international student competitions organized by REHVA, in four dedicated standing committee meetings: Technology and Research, Publishing and Marketing, Supporters, and Education and Training.

REHVA launches new Guidebooks and Task Forces

REHVA launched at the Brussels Summit the new Guidebook on **Displacement ventilation**, available in printed and digital version. The REHVA Technology and Research Committee also announced three more guidebooks, available early next year:

- Residential Heat Recovery Ventilation
- Fire safety and smoke management in buildings
- Energy efficiency of historical buildings

These guidebooks will be officially announced during the REHVA Annual Meeting 2018, that will take place in Brussels on 21-23 April 2018, hosted by ATIC.

Some new REHVA Task Forces have also started their work to develop future publications, such as the one about IEQ in schools, in cooperation with ISHRAE, the Task Force on Building Commissioning, and the one about hygiene in drinking-water supply systems. Task Forces are also active to update existing guidebooks, such as Guidebook 11 on Air filtration in HVAC systems, and Guidebook 9 on Hygiene in air-conditioning systems.

Meetings with international REHVA partners from around the world

Delegations from ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), ISHRAE (the Indian Society of Heating, Refrigerating and Air Conditioning Engineers), and SHASE (the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan) came to Brussels to join the REHVA Brussels Summit and discuss with REHVA Board Members about future collaborations at the global scale.

After a long day of intense meetings, participants, guests, and hosts were rewarded with a reception and informal networking opportunity in the evening, enjoying an amazing view on Brussels with an excellent dinner at the 26th floor of the iconic "The Hotel", in Brussels city centre.

REHVA conference on "Delivering healthy & energy efficient buildings with EPBD"

The second day of the REHVA Brussels Summit was dedicated to the traditional REHVA Conference. The topic of the event, "Delivering healthy & energy efficient buildings with EPBD", gathered around a hundred participants among EU stakeholders, experts and HVAC industry representatives, in the conference room of The Hotel. The agenda foresaw 3 sessions of presentations, tackling the main theme of the conference from different point of views. All presentations are available on the REHVA website.

Session 1

The first half of the morning, chaired by the REHVA President Stefano Corgnati, was dedicated to the ongoing review of the EPBD, included in the Clean Energy Package that was launched by the European Commission one year ago. Anita Derjanecz, REHVA Managing Director, updated the audience about the ITRE report on the EPBD review, released in October and currently under discussion in the Trialogue of Parliament-Commission-Council. Ms. Derjanecz also presented REHVA position and initiatives in this process, such as the REHVA position paper published in June 2017.

REHVA Vice-president Jarek Kurnitski added technical contents to the discussion by presenting to the public the three main items that require REHVA's attention in the EPBD: a) harmonized minimum ventilation requirements; b) persisting technical challenges in the transparent definition of nZEB level at the Country level; c) the Smart Readiness Indicator, as a way to link energy infrastructure and energy production to the energy use of buildings and their systems.

Gordon Sutherland, Senior Project Adviser at EASME, drove back the discussion to the policy level. In his presentation, he went through the key aspects of the future EPBD, smart, simpler and supportive of building renovation, with digitalization as a pivotal aspect. Mr. Sutherland also stated that the long implementation process is much more a matter of politics rather than of technical contents, because "directives, exactly as HVAC systems, do not have a one-fit-all application".

Jens Laustsen, coordinator of the EPBD Concerted Action (CA), presented the ongoing fourth phase of the CA, ending in March 2018 and prepping the ground for the 2019/2021 legislation novelties. The cost-optimal level of energy performance will become lower and

Hideharu Niwa, from SHASE, presents the Japanese nZEB design approach.

Ann Marie Aguilar presents the WELL certification.

lower thanks to the reduced costs of high performing technologies, paving the ways for most ambitious energy reduction policies. The fifth phase of the CA will closely follow the forthcoming legislative developments, where smart buildings will come in the picture.

The morning session was closed by a panel discussion involving the speakers and representatives of three EU level umbrella Associations, EVIA with Arthur Corbin, EPEE with Andrea Voigt and Eurovent Association with Igor Sikoncyzk. Panellists were asked about their position on the EPBD review ahead the Trialogue, their views on the challenges and impacts of EPBD implementation on HVAC manufacturers, and their opinion and thoughts on health and energy performance of buildings.

Session 2

The last question of the panel discussion well introduced the topic of the second morning session, "health performance of energy efficient buildings", chaired by Jaap Hogeling, editor-in-chief of the REHVA Journal.

Roberta Savli, Senior EU Policy Adviser at EFA (Federation of Allergy and Airways Diseases Patients' Associations), opened the discussion with a presentation about the effects of Indoor Air Quality on respiratory diseases, reduction of healthy years and even deaths. For instance, research data shows the around 90% of respiratory diseases is caused by bad IAQ. Such figures justify the advocacy activities EFA with regard to the current review of the EPBD, for which they proposed to display IAQ certificates beside the mandatory EPCs.

Atze Boerstra, REHVA Vice-president, presented to the audience the innovative concept of "HEAnZEBs", as a solution to combine excellent energy and health performances. As explained in his speech, nowadays an integral approach is very much needed when designing nearly Zero Energy Buildings, keeping in mind that occupants want/need/expect health and comfort in such buildings. The health criteria (HEA) used in many well know certifications schemes (such as BREEM or WELL) can be the starting point for this combined new building design strategy.

Ann-Marie Aguilar, Director of Operation at the previously mentioned WELL Institute, closed this session by presenting the WELL certification scheme. The scheme was launched in 2013 and is nowadays collecting increasing consensus from private investors willing to certify their buildings. The core idea is that buildings are agents of public health, improving occupants' well-being from several standpoints, not just related to IAQ or energy use. Another important aspect of the WELL scheme is that buildings are certified based on on-site performance verifications. Depending on the number of criteria met, silver, gold or platinum certificates are released, valid for 3 years. Last data of Ms. Aguilar's presentation displayed the high market appreciation for WELL certified buildings, able to improve occupants' health and productivity and the building value. The speeches were followed by an interesting debate with and among the audience, which prolonged also during the lunch break.

Session 3

The afternoon session of the Conference opened with the introduction by Catalin Lungu, REHVA Vice-president, of CLIMA2019, the triennial REHVA world congress that will be held in Bucharest in May 2019.

Panel discussion about the ongoing EPBD review.

The REHVA Brussels Summit dinner at The Hotel.

The chair of the Session, Prof. Kurnitski, gave then the floor to the representatives of the SHASE delegation, Hideharu Niwa, responsible for the guidelines for nZEN design in Japan, and Gyo Onishi from Taisen Corporation. Their presentation gave on one side information about the Japanese policy direction about nZEB, which will become the norm from 2030, on the other side about ZEB demonstration buildings in Japan. Specifically, Mr. Onishi presented to the audience the energy use and innovative technological solutions adopted in the Taisei Corporation Building.

The following presentations aimed at offering an overview of activities resulting from the application of the currently in force EPBD recast. Niels Christensen, Product Manager at Lindab, presented the company's approach and technological solutions to face to the challenges posed by combining comfort and energy efficiency in different building types. Erick Melquiond, President of Eurovent Certita Certification, focused his speech on the certification of air flows related products, which are the first step for providing a healthy indoor environment.

Stijn Verbeke, Researcher at EnergyVille/Vito, gave a speech as representative of the consortium developing the support study for the European Commission on the Smart Readiness Indicator (SRI), mentioned several times throughout the whole conference. Dr. Verbeke displayed the work carried out by the consortium so far, mainly related to the definition of a "catalogue" of smart ready services, and the ongoing discussion about the indicators to include in the definition of Smart Readiness.

Jaap Hogeling gave the last presentation of the day about EPB Center, an initiative born from the collaboration between REHVA and ISSO, which aims at supporting the coherent implementation of the new set of EPB standards at national level, providing technical support to interested parties and in turn assisting the improvement of the standards themselves. After a last round of questions and answers directed to all the speakers of the afternoon, the Conference closed at 16:30, leaving to participants the time for continuing to network in front of a coffee.

Technical tour with the SHASE delegation to an exemplary nZEB building

As a side event of the REHVA Brussels Summit, in the morning of Wednesday 15 November REHVA representatives and the SHASE delegation visited an nZEB public school building, the *Ecole Les Trefles* in Anderlecht. *Les Trefles* means "The Clover", referring to the four-leaf clover echoed in the shape of the complex. The project was selected as exemplary building in the *Be Exemplary* Programme of the Brussels Capital Region, that award outstanding sustainable construction projects.

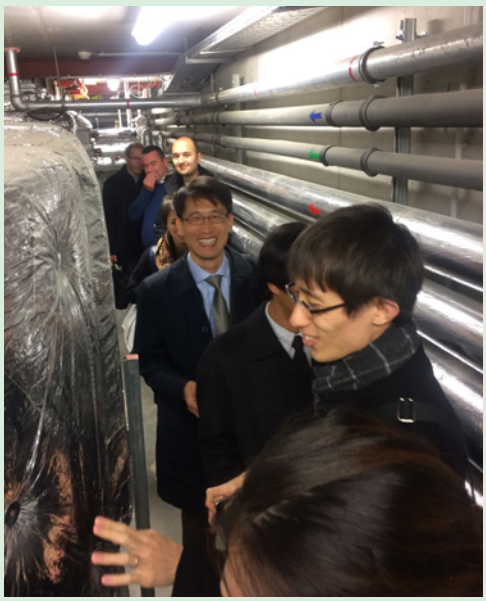
The building is an excellent example of an nZEB complex including a nursery, a primary school and a gym. The building designers from the architectural firm ARTER and the engineering company POLYTECH and DOSET impex (REHVA Supporter) offered to the delegation exhaustive presentations about the design concept and building operation strategy and walked them around the building and the technical rooms, displaying the adopted technological solutions.

The project of the Les Trefles community school in Anderlecht is characterised by progressive, energetic and environmental achievements, meeting the passive standards. The designers' holistic approach to sustainability started with the selection of the building shape. The round shaped layout is here used not just a way to improve the Surface/Volume ratio, but also to stimulate kids' movement. Research results reports a potential average increase in physical exercise of 20% in round buildings. Additionally, the complex style of these shapes improves interpersonal relationships and offers an interesting architectural statement for the neighbourhood, of which the development is moving ahead quickly.

Building envelope properties comply with the current minimum requirements, and shadings and high thermal inertia also allowed the designers to avoid the installation of active cooling systems. The building has a flat green roof, which contributes simultaneously 1) to maintain indoor stable comfort conditions, 2) to drain rainwater, to be used in toilets and 3) to contribute to the biodiversity of outdoor spaces. Indeed, the green roof is part of an overall design of green areas of the school complex, which include ponds for rainwater retentions and vegetable gardens to be used at the community level.

The building technical building systems include two condensing boilers and a CHP plant for heating, and dedicated ventilation units for each building area (i.e. one ventilation unit per classroom). Heating and ventilation systems are separately managed by a BMS.

REHVA-SHASE site visit to the Ecole les Trefles - presentation of the project.



REHVA-SHASE Site visit to the Ecole les Trefles - technical tour.

The technical tour delegation found the four-leaf clover

The project sets an example of energy performance and sustainability, but it also wants to raise the children's awareness of energy management by teaching them the correct way to use it carefully. This means that sustainability makes up a vital element of the educational project. ■

TIZIANA BUSO, PH.D., REHVA PROJECT OFFICER

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ISHRAE-REHVA Commissioning Guidelines published in India

The ISHRAE-REHVA guidebook on Commissioning was officially published by ISHRAE in India in November. This guidebook is just the latest outcome of the fruitful cooperation between REHVA and ISHRAE, which has been continuously evolving since the first Memorandum of Understanding, signed in 2012. This collaboration has resulted over years in several joint seminars during ACREX, exchange of articles and REHVA Journal Special issues released for ACREX, as well as the joint work on certain technical topics.

The REHVA version of the guidebook is expected in 2018

Maija Virta, REHVA fellow and ISHRAE member, is the editor if this guidebook, created by collecting from REHVA and ISHRAE experts material related to the Commissioning Process, as well as the technical aspects of Commissioning of various systems, and entering these contents in a framework as described by the International Energy Agency in ECBCS Annex 47. The result is a guidebook that describes a process compatible with the routines in the building sector almost everywhere on our globe. This is the first work that describes both the process in a very hands-on manner and details the commissioning activities for various types of systems, complete with theoretical background, guidance & checklists. ■

REHVA President Stefano Paolo Corgnati and ISHRAE President Vishal Kapur display the new joint guidebook.

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E: mansi.chawla@nm-india.com
mehak.mamtani@nm-india.com

Organiser: ISHRAE
Event Producer: NÜRNBERG MESSE
Endorsed By: ASHRAE

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ISHRAE gears up for its 19th edition of ACREX India in February 2018

After the resounding success of ACREX India 2017 organized by the The Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE), the society is steadily gearing up for the 19th edition of the exhibition that is slated to happen from **22nd to 24th of February, 2018** at BIEC, Bangalore. One of the highlights for the annual exhibition this year will be ISHRAE's collaboration with United Nations Environmental Programme (UNEP) to discuss the technological developments in zero-ODS and low-GWP RAC technologies as well as the regulatory and policy measures needed to scale up their adoption, thereby maximizing ozone, climate and energy efficiency benefits. At ACREX 2018, UNEP will be hosting an exclusive 'Ozone Pavilion' which will serve as a platform for organizations to come and showcase their respective Ozone2, climate friendly technologies and products. The 'Ozone Pavilion' will serve as a testimony to efforts shown towards building ozone and climate friendly refrigerant technologies or systems.

Sharing his views, **Mr. Nirmal Ram Chairman – ACREX India 2018 & ISHRAE Presidential Member**, said: "ISHRAE is committed to address contemporary issues and deliver innovative solutions through ACREX India every year and this year we are excited about the unique product offerings that we will be introducing. The 2018 edition of ACREX will be all the more memorable because of ISHRAE's collaboration United Nations Environment Programme (UNEP), one of the leading organizations globally for environmental activities. ACREX India is a flagship event of ISHRAE and has always played an essential role in bringing the industry together while working closely with key brands and partners. We at ACREX believe in organic development and sustainable living which runs parallel with the world we live in and this year, we will continue to strengthen our mission."

"UN Environment is pleased to co-organize the Ozone to Climate Technology Roadshow and Industry Dialogue at ACREX India 2018. This is the result of a decade-long successful partnership between ASHRAE and UN Environment", said **Shamila Nair-Bedouelle, Head of OzonAction – Montreal Protocol.** "This can be easily demonstrated by many similar events as well as other products jointly developed and offered to best serve the needs of developing economies in complying with the Montreal Protocol and advancing alternative refrigeration & air-conditioning technologies and practices. The joint work plan for 2017-2018 of our two organizations is structured around the theme "Working beyondHigh-GWP Refrigerants" to reflect international movement to reduce dependency on high-GWP technologies especially in light of the adoption of the Kigali Amendment to the Montreal Protocol. Cooperation with ISHRAE is an example of how the ASHRAE-UN Environment cooperation is shaping to actively engage with regional and national associations, ensuring the global messages and programmes respond to the specific needs of developing economies" she added.

About ACREX

ACREX is South Asia's Largest Exhibition on Refrigeration & Cold Chain, Air Conditioning, Ventilation and Intelligent Buildings. With more than 500 exhibitors and 50,000 businesses participating in the exhibition, every year, ACREX witnesses the participation of major global players from more than 25 Countries.

Organizer

ISHRAE (Indian Society of Heating, Refrigerating and Air Conditioning Engineers), was founded in 1981 at New Delhi by a small band of die-hard HVAC&R Engineers. Today, ISHRAE has over twelve thousand Members and, over three thousand Student Members organized in thirty-nine chapters all across India. ISHRAE organizes Exhibitions and Catalog Shows, conducts Seminars, Workshops, Training Programs, Certification Programs and Product Presentations throughout the country to achieve its primary objective of Advancement of the Sciences of Heating, Ventilation, Air Conditioning, Refrigeration Engineering & Related Services. ISHRAE Publications strive to help readers keep up to date with the happenings, learn new techniques, improve old designs and use new devices to improve Energy Efficiency and enhance Indoor Air Quality in the Built Environment.

For more information: www.acrex.in

REHVA ANNUAL MEETING 2018 – Brussels, Belgium

REHVA is pleased to invite its Members and Supporters to the 2018 REHVA Annual Meeting hosted by Atic in Belgium, but at the same time, most of the meetings will take place in the REHVA venue as REHVA is seated in Brussels, which gives us this great opportunity. The 2018 Annual Meeting is held on Saturday April 21st to Sunday April 22th 2018. The schedule of this year's Annual Meeting was planned to provide for a for more interactive discussions.

See the whole schedule at **https://www.rehvam2018atic.eu/rehva-meetings**

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Send information of your event to Ms Chiara Girardi cg@rehva.eu

Events in 2017—2018

Exhibitions 2018

Feb 27 - Mar 2	AQUA THERM Prague	Prague, Czech Republic	http://www.aquatherm-praha.com/en/
May 22-24	ISH China & CIHE 2018	Beijing, China	http://ishc-cihe.hk.messefrankfurt.com/beijing/en/visitors/welcome.html
July 17-19	ASEAN M&E	Kuala Lumpur, Malaysia	http://aseanmne.com/
Sep 3-5	ISH Shangai & CIHE 2018	Shangai, China	http://ishs-cihe.hk.messefrankfurt.com/shanghai/en/visitors/welcome.html
Oct 10-12	FinnBuild 2018	Helsinki, Finland	http://finnbuild.messukeskus.com/?lang=en
Oct 16-18	Chillventa	Nuremberg, Germany	https://www.chillventa.de/en

Conferences and seminars 2018

Jan 22-24	2018 AHR Expo	Chicago, IL, USA	www.ahrexpo.com
Feb 7-10	ISK - Sodex	Istanbul, Turkey	http://www.sodex.com.tr/en
Feb 22-24	ACREX 2018	Bengaluru, India	http://www.acrex.in/home
Feb 28 - Mar 2	WSED	Wels, Austria	http://www.wsed.at/en/world-sustainable-energy-days.html
Mar 12-15	Cold Climate HVAC Conference 2018	Kiruna, Sweden	http://www.cchvac2018.se
Mar 13 - 16	MCE – Mostra Convegno Expocomfort 2018	Milan, Italy	www.mcexpocomfort.it
Mar 18 - 23	Light + Building 2018	Frankfurt, Germany	https://light-building.messefrankfurt.com/frankfurt/en.html
Apr 12-14	13th International HVAC&R Technology Symposium	Istanbul, Turkey	https://goo.gl/H9Wpvj
Apr 21-23	REHVA Annual Meeting	Brussels, Belgium	http://roomventilation2018.org/
Jun 3-6	ROOMVENT & VENTILATION 2018	Espoo, Finland	http://www.roomventilation2018.org/
Sep 11-12	Building Simulation and Optimization 2018	Cambridge, UK	https://www.bso2018.event.cam.ac.uk/

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SUPPORTER

REHVA Supporters packages contract 2018

We would like to contract for a REHVA Supporters package in accordance with the details set out below.

❑ **Platinum** package includes:

- Annual Membership
- 6 full page advertisements in the REHVA Journal
- 50 Guidebooks
- 50 REHVA Journal copies and REHVA Restricted area access
- 1 speaker to REHVA seminar (Brussels event) with free entrance
- Logo and link on website
- 10 copies of new Guidebooks
- Video advertisement 250x250 upload on YouTube and shared on social media
- Long article in REHVA HVAC Journal (4-5 pages)
- 3 months of Static/GIF Banner 250x250 on the REHVA Website
- 1 Special Newsletter (5500 contacts) and REHVA news on the website (Short news)

Total Value 18 200 €
Additional Discount = 16 500 €

❑ **Gold** package includes:

- Annual Membership
- 4 full page advertisements in the REHVA Journal
- 50 Guidebooks
- 50 REHVA Journal copies and REHVA Restricted area access
- Logo and link on website
- Short article in REHVA HVAC Journal (1-2 pages)
- 10 copies of new Guidebooks
- 2 months of Static/GIF Banner 250x250 on the REHVA Website
- 1 Special Newsletter (5500 contacts) and news as REHVA news on the website (Short news)

Total Value 15 400 €
Additional Discount = 14 000 €

❑ **Silver** package includes:

- Annual Membership
- 4 full page advertisements in the REHVA Journal
- 20 Guidebooks
- 30 REHVA Journal copies and REHVA Restricted area access
- Logo and link on website
- 10 copies of new Guidebooks
- 2 months of Static/GIF Banner 250x250 on the REHVA Website
- Video advertisement 250x250 upload on YouTube and shared on social media
- 1 Special Newsletter (5500 contacts) and news as REHVA news on the website (Short news)

Total Value 12 900 €
Additional Discount = 12 000 €

❑ **Bronze** package includes:

- Annual Membership
- 2 full page advertisements in the REHVA Journal
- 30 REHVA Journal copies and REHVA Restricted area access
- 20 copies of new Guidebooks
- Logo and link on website
- 1 Special Newsletter (5500 contacts) and news as REHVA news on the website (Short news)
- 1 month of Static/GIF Banner 250x250 on the REHVA Website
- Video advertisement 250x250 upload on YouTube and shared on social media

Total Value 9 800 €
Additional Discount = 9 000 €

❑ **Customized** package (please select the services listed below) **-10% of the total amount above 6 600€**

❑ Annual Membership
3 000€

❑ Advertisements in the REHVA Journal
- ❑ 2 ads / 3 200€
- ❑ 3 ads / 5 600€
- ❑ 6 ads / 7 200€

❑ REHVA Journal copies and REHVA Restricted area access
- ❑ 30 copies / 1 800€
- ❑ 50 copies / 3 000€

❑ 1 months of Static/GIF Banner 250x250 on the REHVA Website / 300€

❑ Guidebooks (shipping and handling of 10% not included)
- ❑ 20 copies / 800€
- ❑ 50 copies / 1 500€

❑ Special Newsletter (5500 contacts) and news as REHVA news on the website (Short news) / 500€

❑ Video advertisement 250X250 upload on YouTube and shared on social media / 200€

❑ Short article in REHVA HVAC Journal (1-2 pages) / 800€ upon REHVA Journal Editor's Approval, possibility to deliver extra copies to a major event of the supporter

❑ Long article in REHVA HVAC Journal (4-5 pages) / 1 200€ upon REHVA Journal Editor's Approval, possibility to deliver extra copies to a major event of the supporter

❑ 10 copies of new Guidebooks / 400€

❑ REHVA specialist expert participation in any event organised by the Supporter / 1 600€

❑ Supporter presenting at a REHVA international seminar (Brussels event) – 1 expert with free entrance / 1 600€

❑ Any specific service defined by Supporter
– price to be agreed depending on the service

Please select the issues you want to insert your advertisement:	
❑ **1** / IEQ and EPBD (February)	❑ **3** / Sustainability, circular economy and LCA (June)
❑ ACREX Special Edition / European HVACR Technologies (February) — *Please contact Giulia Marenghi at gm@rehva.eu to place an advertisement and/or an article.*	❑ **4** / Cold Climate (August)
	❑ **5** / BIM and Digital (October)
❑ **2** / NZEB and CO2 footprint (April)	❑ **6** / TBD (December)

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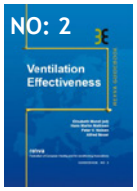
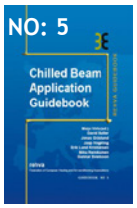
REHVA GUIDEBOOKS

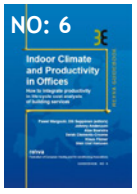
REHVA Guidebooks are written by teams of European experts



Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook provides easy-to-understand descriptions of the indices used to mesure the performance of a ventilation system and which indices to use in different

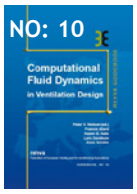


Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature hot water system. Primary air supply induces room air to be recirculated through the heat exchanger of the chilled beam. In order to cool or heat the room either cold or warm water is cycled through

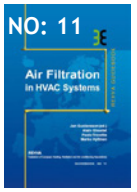


Indoor Climate and Productivity in Offices Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available. The quantitative relationships presented in this Guidebook can be used to calculate the costs and benefits of running and operating the building.

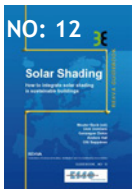
This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in all types of buildings and work with heat carriers at low temperatures for heating and relatively high temperature for cooling.



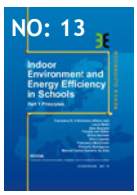
CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary conditions. Computational Fluid Dynamics (CFD) - in Ventilation Design models is written by a working group of highly qualified international experts representing



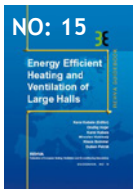
Air filtration Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on external conditions such as levels of existing pollutants, indoor air quality and energy efficiency requirements.



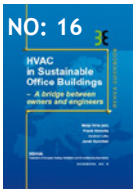
Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy for cooling, heating and lighting. The book gives also practical guidance for selection, installation and operation of solar shading as well as future trends in integration of HVAC-systems with solar con-



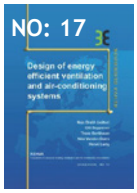
School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students. It focuses particularly on energy efficient systems for a healthy indoor environment.



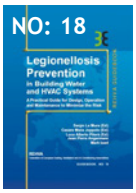
This guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating, floor heating and industrial air heating systems. Various heating systems are illustrated with case studies. Design principles, methods and modeling tools are presented for various



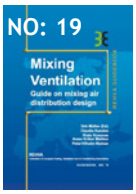
This guidebook talks about the interaction of sustainability and heating, ventilation and air-conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be asked in various phrases of building's life time. Different case studies of sustainable office buildings are presented.



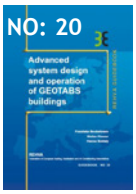
This guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked in the daily design practice, resulting in poor performance of high quality products once they are installed in the building system.



This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systmes. It is devided into several themes such as: Air conditioning of the air (by water - humidification), Production of hot water for washing (fundamentally but not only hot water for washing) and Evaporative cooling tower.



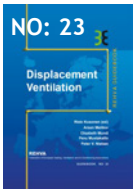
In this guidebook most of the known and used in practice methods for achieving mixing air distribution are discussed. Mixing ventilation has been applied to many different spaces providing fresh air and thermal comfort to the occupants. Today, a design engineer can choose from large selection of air diffusers and exhaust openings.



This guidebook provides comprehensive information on GEOTABS systems. It is intended to support building owners, architects and engineers in an early design stage showing how GEOTABS can be integrated into their building concepts. It also gives many helpful advices from experienced engineers that have designed, built and run GEOTABS systems.

The Active and Passive Beam Application Design Guide is the result of collaboration by worldwide experts. Active and Passive Beam Application Design Guide provide energy-efficient methods of cooling, heating, and ventilating indoor areas, especially spaces that require individual zone control and where internal moisture loads are moderate. The systems are simple to operate, with low maintenance requirements. This new guide provides up-to-date tools and advice for designing, commissioning, and operating chilled-beam systems to achieve a determined indoor climate and includes examples of active and passive beam calculations and selections.

This guidebook aims to provide an overview on the different aspects of building automation, controls and technical building management and steer the direction to further in depth information on specific issues, thus increasing the readers' awareness and knowledge on this essential piece of the construction sector puzzle. It avoids reinventing the wheel and rather focuses on collecting and complementing existing resources on this topic in the attempt of offering a one-stop guide.



Displacement ventilation has been originally developed in Scandinavian countries over 30 years ago and now it is also a well-known technology in different countries and climates. Historically, displacement ventilation was first used for industrial applications but nowadays it is also widely used in commercial premises.

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