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European Certification of HVAC products

Certified Performance Database

Energy efficiency label for central ventilation units

Heat pump certification

Indoor Environmental Quality (IEQ)

Ventilative Cooling

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REHVA Journal is a technical, practical journal for the HVAC industry professionals. It is read by Designers, Consultants, Manufacturers, Investors, Mechanical Contractors, Sales and Representative Companies, Architects Energy sector's professionals, governmental institutions authorities, etc.

From product to system and building performance declaration and certification

All new buildings after 2020 in Europe and Globally Nearly Zero Energy Performing?

JAAP HOGELING
Editor-in-Chief

United nations conference on climate change
COP21/CMP11

The outcome of COP21 in Paris, last December, adds to the urgency to achieve an energy efficient build environment. All countries around the globe have the duty to reach the targets formulated in Paris. Does this lead to more Zero Energy Buildings or Positive Energy buildings globally? That depends on the way we assess the energy performance and determine the cost effectiveness. If investors and building developers weigh the investment to reach ZEB or PEB level over a longer period and award the added value due to this rating in a correct way. The answer will be positive.

ISO 52000 will enable to assess the overall energy performance of a building. Helping to decarbonize the building sector is the goal of the new holistic approach being developed by the ISO joint working group for the energy performance of buildings (EPB), an approach which reconciles climate and energy needs. And with the future ISO 52000 series of standards under development, the building industry is expected to be much better positioned to attain energy efficiency improvements with the best available technology and practice. The ISO 52000 series 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. Countries using the approach for several years have experienced large-scale implementation and cost savings on a variety of new technologies. This includes thermal insulation concepts, windows, heating, cooling, lighting, ventilation or domestic hot-water systems, building automation and control, and renewable energy sources.

What does this mean for our business? For new building and system design we have to be more innovative to reach the Zero Energy Performance of Buildings level, toward energy positive buildings.

In this issue the importance of certified performance product data supporting the development of high performance buildings is discussed. In several articles we focus on ventilative cooling, a technology that can be applied where outdoor temperatures are below the indoor temperature when cooling is needed. Applicable in Europe but also in similar climate regions globally. This "Free" cooling approach is to be considered where possible, this to avoid unnecessary application of mechanical cooling. ■

The new Eurovent energy efficiency label for central ventilation units

The energy efficiency requirements for air handling units are increasing. Apart from the increased customer needs, legal energy efficiency requirements regarding central ventilation units have tightened too. According to the Ecodesign Directive for ventilation units (EU) No 1253/2014, new minimum energy efficiency requirements shall apply from January 2016.

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The purpose of an energy label is to indicate to customers or users the energy quality of a product in order to help them with their purchase decision. The Eurovent Energy Efficiency Labelling for central ventilation units has become firmly established in Europe. After using the former Eurovent Energy Label /1/ for a six-year period, the new legal minimum energy efficiency requirements with regard to these products make an update of the energy labelling imperative. Moreover, the requirements of the Ecodesign Directive have been incorporated in the new Eurovent Certification and the energy classifications. The new energy efficiency classes apply from January 2016. Furthermore, a new Eurovent energy efficiency class A+ is being introduced, characterising devices with the currently highest available energy efficiency level. In the lower efficiency range, the classes "C" and "D" correspond roughly to the legal minimum requirements for ventilation units.

In general, the Eurovent calculation process for the definition of the energy label has not undergone significant changes. The criteria for the calculation of the energy label are still the thermal efficiency and the pressure drop of heat recovery, the air speed in the cross-section area of the ventilation unit as well as the efficiency of the fans in their operating points. The possibility of compensation between the individual requirements as well as the consideration of different climate zones remained unchanged. Changes have been implemented regarding the energy requirements for the achievement of efficiency classes as demonstrated in **Table 1**.

Table 1. Criteria for the definition of the Eurovent energy label classes for air handling units.

Class	max. air speed (m/s)	min. efficiency HRV (%)	max. pressure drop HRV per airway (Pa)	min. efficiency level ventilator NG_{ref}
A+	1.4	83	250	64
A	1.6	78	230	62
B	1.8	73	210	60
C	2.0	68	190	57
D	2.2	63	170	52
E	–	–	–	–

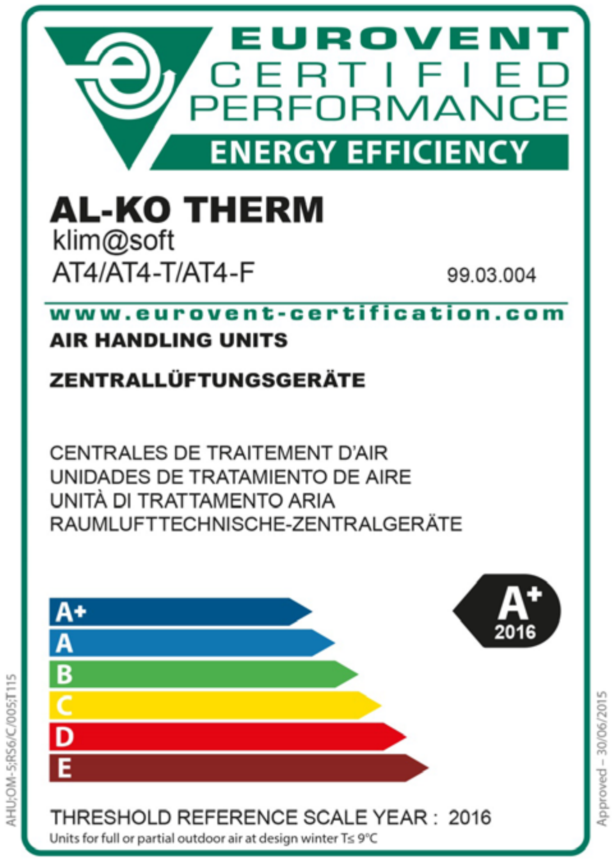
For ventilation units of the highest efficiency class "A+" ambitious criteria apply. It should be noted here that the required temperature efficiency of at least 83% can no longer be described in economic terms with all available heat recovery processes. While it can be realised with rotary heat exchangers and reverse flow exchangers (only in the lower air flow range), these values cannot be depicted economically with the heat transfer systems and cross-flow plate heat exchangers with the available technology today.

Table 2. Simulated operating costs for air handling units of the same performance from different energy efficiency classes.

Costs	Efficiency class according to Eurovent					
	A+	A	B	C	D	
Eta-HRV	83%	78%	73%	68%	63%	(--)
$PM_{V,ZUL}$	6.98	7.21	7.44	7.83	8.56	(kW)
$PM_{V,ABL}$	6.04	6.23	6.43	6.76	7.4	(kW)
Electricity	30 834	31 829	32 847	34 552	37 796	(€)
Cooling	4 606	4 698	4 697	4 877	5 216	(€)
Heating	1 879	5 153	8 383	11 491	14 325	(€)
Total	37 320	41 660	45 927	50 920	57 337	(€)
Saving	35%	27%	20%	11%		

The legal minimum efficiency for ventilation units from 2016, equipped with a heat recovery system (HRE > 63%) corresponds approximately to class "D". Appliances which feature a plate or rotary heat exchanger according to the Ecodesign Directive (HRE > 67%) correspond approximately to class "C". The provision for complying with the legal minimum Ecodesign requirements is also reviewed by Eurovent during the annual recertification process.

How can the best way to use an energy label be established for customers or users? The presentation of the energy and eventually economic differences between appliances in single efficiency classes demands a comparison of the life cycle costs, i.e. the calculation of the total operating costs of an air handling unit over a time period of e.g. 5 years. **Table 2** shows results of such calculations for air handling units of different energy efficiency classes. All appliances have an air supply performance of 14,500 m³/h and operate 5 days a week, 12 h daily (supply air winter = 22 °C, supply air summer = 18 °C). Electricity and thermal energy costs were estimated as follows: Electricity 13 cent/kWh, Heating 0.065 cent/kWh, Cooling 0.040 cent/kWh. The qualities of heat recovery and air supply were changed in air handling units.



Eurovent energy label class A+ (2016).

Table 2 shows that approximately 10% of the operating costs can be saved for air handling units per better energy class. This means that when an appliance belonging to energy class A is used instead of one belonging to class C, around 20% of energy costs are saved. However, this statement cannot be generalized as the sample calculation applies only to standardized operating hours and defined energy costs. An assessment of profitability requires that investment costs be included too in order to arrive eventually at the right purchase decision. ■

Certified Performance Database as a tool for quality and compliance

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The fields of Heating, Ventilation, Air-Conditioning and Refrigeration (HVAC&R) have been experiencing a very challenging regulatory and normative background in the past years. In this context it is often hard for manufacturers, consultancies and end-users to have a clear view of the quality and compliance of HVAC&R components, products and systems. The Eurovent Certified Performance (ECP) certification has been used for now more than 20 years to provide guidance on the real performance of HVAC products in the European market.

Third party certification of HVAC&R products and systems

The Eurovent Certified Performance (ECP) certification is a voluntary, third party certification managed and accredited according to the ISO 17065 requirements (COFRAC accreditation n°5-0517, international recognition EA/IAF). Accreditation is a proof for independence and competence. It also ensures that all manufacturers are allowed to have their products certified without any restriction providing that the products fulfil the requirements given in the certification reference documents which are freely and publicly available.

The certification process is based on continuous (yearly) verifications based on tests by independent accredited laboratories, factory audits and check of selection software.

As of today the ECP mark covers 19 certification programmes in all fields of HVAC&R. It covers residential, tertiary and industrial products from the residential air conditioners to the industrial chillers. More than 1,300 tests, 160 factory audits and 100 checks of selection software are carried out every year.

European database of certified performance for HVAC&R components, products and systems

All certified references and performances are listed in an online directory freely available (www.eurovent-certification.com). This directory gathers more than 300 certified trademarks and more than 50,000 references.

For each product category characteristics and certified performances are listed according to the same data structure and the latest European and international standards. This allows finding and comparing the certified data easily and with the assurance that the data have been checked.

Example of use

The availability of such database allow to get reliable and exhaustive set of performances which can be used to assess some trends of the market over time.

As an example the evolution of the energy efficiency of Fan Coil units can be seen in the **Figure 1** below. A Eurovent energy efficiency classification was created in 2011 for these products based on their average energy consumption at three different speeds[1]. It can be seen that there is a clear trend towards better energy efficiency as the energy classes are moving from classes E and D to C, B and A.

[1] For a detailed description of the Eurovent energy efficiency classification for Fan Coils units see RS 6/C/002-2015 and RS 6/C/002A-2015 available at www.eurovent-certification.com

Another example can be found regarding the energy efficiency of air filters. For these products a Eurovent energy classification has been put in place since 2012. This classification is based on the estimated annual energy consumption derived from the average pressure drop of the filter[2]. A more classical way to assess the energy consumption of an air filter is to look at its initial pressure drop. The **Figure 2** below shows the evolution of both the mean initial pressure drop and the mean annual energy consumption for the certified F7 bag filters of a constant panel of manufacturers between 2011 and 2015.

Unlike what has been seen for Fan Coil Units the evolution of the mean energy efficiency is not linear during this period: the energy consumption and the initial pressure drop increases to reach a maximum in 2013 and then it decreases until 2015. This behaviour can be explained knowing the standardization context behind. A revised version of the European testing standard was introduced in 2012 and applied in the Eurovent certification programme first in 2013. This revised version introduced stricter requirements for F7 filters related to the discharge efficiency (see EN 779:2012). In order to fulfil this new requirement European manufacturers had to improve the filter media in order to increase the filtration efficiency. As a consequence the mean pressure drop of the filters increased. After the introduction of the new standard the pressure drop started to decrease as manufacturers are seeking to propose to their customers more energy efficient products.

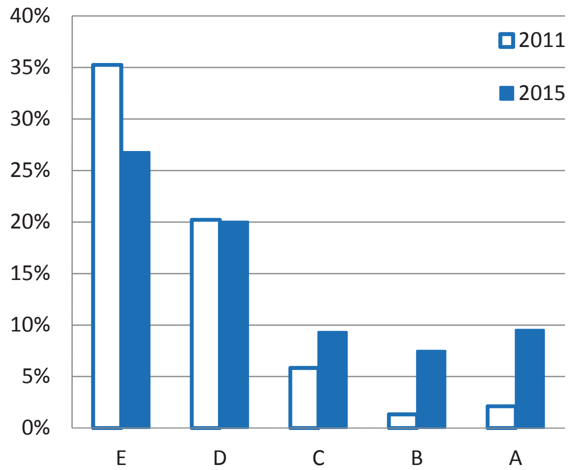

Figure 1. Evolution of the distribution of the energy efficiency class for Fan Coil units between 2011 and 2015.

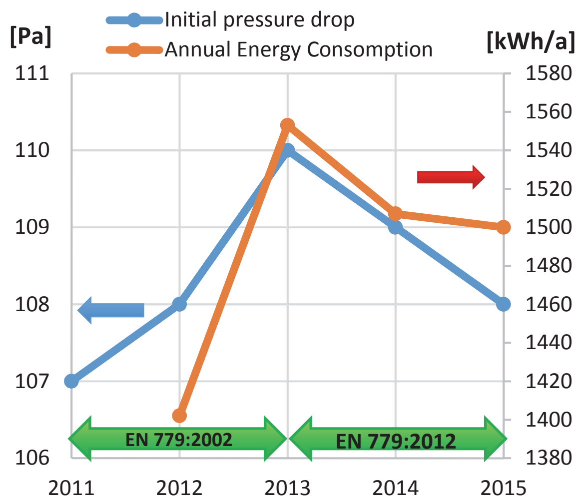

Figure 2. Evolution of the energy efficiency for F7 bag filters between 2011 and 2015.

Other use of certified performance database

Database of certified data can be used in many instances: tax incentives, national implementation of EPBD, building energy labels, green public procurements, white certificates. As certified performances provide confidence in the quality and the compliance of the products they can be required in voluntary schemes (e.g. building energy labels, green public procurements, white certificates) or being considered with an advantage over non certified products in regulatory schemes (e.g. national implementation of EPBD).

Example of such use can be found in the French Building energy efficiency calculation method which applies a penalty for non-certified heat-pumps and air to air heat exchangers. Consultancies use approved software in order to assess the compliance of a building with the French EPB regulation (RT 2012). This software is linked to database of products which are fed directly with Eurovent certified performance data.

Conclusion

The challenging normative and regulatory background in the fields of HVAC&R induces a complex environment. Assessing the quality and compliance of products is therefore more and more difficult for end-users. In this context the Eurovent Certified Performance online directory provides an easy and straightforward way to get up to date, trustful and exhaustive data. Such information can be (and are already) used in various voluntary and regulatory compliance schemes. ■

[2] For a detailed description of the Eurovent energy efficiency classification for Air Filters see RS 4/C/001-2015 available at www.eurovent-certification.com

New challenges for heat pump certification

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There is no doubt that the heat pump technology has now reached a prominent position in Europe in the field of heating, air conditioning and hot water production and the number of marketed units is expected to keep on increasing on next years. Just as an example, in France, the biggest market in Europe at the moment regarding heat pumps, more than half of all newly built houses are equipped with heat pumps. Even though the currently low prices of oil make power driven products less competitive at first view than previously compared to other solutions relying on fossil fuels, this is more than balanced by the need to reduce the carbon print and to improve energy efficiency. This development has triggered a proliferation of new products and technologies, the performances of which it is all the more important to be able to compare and ascertain. This is the duty of product certification and moreover, the broader and more competitive the market is, the more efficient and reliable the certification must be. It is proposed in this paper to show how the different certification schemes managed by Eurovent Certita Certification are responding to the current situation and to describe some recent breakthroughs.

Product certification, what for?

Product certification is a conformity assessment whereby a third party- the certification body - issues a statement that fulfilment of specified requirements has been demonstrated for a given product [1]. Typically in the field of HVAC-R this encompasses the voluntary certification of the performances of products which are published by the certification body after implementation of a process including verification tests and assessment audits. The first aim of product certification is to provide confidence to the market and all the stakeholders thanks to an assessment carried out by an independent third party. As a result it actually enables to compare the properties of products on the basis of the same reference standards and incentive schemes used to foster energy efficiency are often referring to certification. As far as recognition and independence are concerned, it is critical to distinguish third part certification from other schemes. Accreditation against ISO 17065 [2], the relevant international standard, is the ultimate, internationally recognized proof of the competence and impartiality of a certification body. It can be seen as the certification of certification bodies and is viewed by the European Commission as "*part of an overall system, including conformity assessment and market surveillance, designed to assess and ensure conformity with the applicable requirements*" [3].

Different certification marks for different expectations

Eurovent Certita Certification (ECC) is a top European accredited third party certification body active in the field of indoor climate, ventilation and air quality as well as refrigeration and food cold chain. We have been certifying heat pumps for years, which is shown on the market by the 2 voluntary certification marks (**Figure 1**).

Figure 1. The 2 certification marks granted by Eurovent Certita Certification for heat pumps.

The Eurovent Certified Performance (ECP) mark has been granted by our company since 1995 and has gained a very large international recognition: 66% of HVAC-R products sold in Europe are ECP certified.

The NF mark is a French mark of conformity owned by AFNOR, the French member of CEN and has been used for more than 60 years in the framework of hundreds of certification programmes. The programme related to heat pumps [4] has been developed and managed since its inception by ECC.

The reason for proposing different certifications for a single family of products is that the 2 schemes are responding to different market expectations. Indeed, although it is based on European product and testing standards, the NF mark is tailored to the needs and demands of the French market, including specific input for the thermal regulation. Whereas the ECP mark [5] is providing its wide international recognition on a larger market which uses the same set of European standards.

On top of that, Eurovent Certita Certification has recently developed a European Heat Pump certification programme, "**Euro Heat Pump**" which is a bridge between the NF Heat Pump programme and the ECP mark. It allows to obtain both certifications through a single entry point and using the same set of verifications. We are thus offering to manufacturers a cost effective, one stop certification.

A brief history of Heat pump certification by Eurovent Certita Certification

Recent events and breakthroughs which happened for the different programmes managed by ECC are shown on **Table 1**, with some of them being further commented elsewhere in the paper.

A world of proliferating technologies

To pay heed to various climates and respond to quite different demands related to residential buildings but also collective ones or industrial facilities, manufacturers are using the whole range of available technologies when producing and marketing heat pumps. This is seemingly a never ending process where what is at stake is increasing the versatility of products whilst improving their energy efficiency. The development of certification must follow the same pace and be in line with the evolution of technologies, lest its link with the market is severed.

Table 1. A brief history of Heat pump certification: recent milestones.

Date	Event
2007	Introducing ESEER(European seasonal energy efficiency ratio) in the Eurovent Programme for Chillers and Heat Pumps.
	Launching the NF Heat Pump programme.
2012	Extending certification to dual service heat pumps.
2013	Extending certification to gas heat pumps.
	Introducing certification of seasonal performances.
2014	First certification of hybrid systems.
2015	Extending certification to heat pumps producing collective sanitary hot water.
	Creation of the Euro Heat Pump programme, first certificates granted on spring 2015. An agreement between Eurovent Certita Certification and DIN CERTCO enables to grant up to 3 quality marks through a single entry point.

Table 2 shows the different technologies of heat pumps and related products currently covered by the certification programmes managed by Eurovent Certita Certification.

Table 2. Technologies and operation modes under the scope of programmes managed by ECC.

Technologies of heat pumps	Operation modes
Air to air	Heating and cooling modes
Air to water	Dual mode: space heating and sanitary hot water production
Water to water	
Brine to water	
Gas fired absoption and adsorption heat pumps	
Swimming pool heat pumps	
Production of collective sanitary hot water Hybrid systems using heat pumps	
Other related thermodynamic devices	
Rooftop units	
Variable refrigerant flow (VRF)	

For certification programmes to cover all these technologies or operation modes, just using the relevant standards and updating the test methods are not enough, otherwise for instance one would end up asking for an irrealistic number of verification tests. This is where the know- how of the certification body and the expertise of its network of laboratories are crucial to set up the appropriate balanced process providing confidence in the certified values on the basis of a time and cost acceptable programme. An example of such an approach is given, *infra*, for heat pumps operated in dual mode.

The Ecodesign whirl

To reduce energy consumption the European union has decided to introduce requirements for energy efficiency and to set up energy labelling with new energy classes. The corresponding general framework is given in the two European Directives 2009/125/EC [6] and 2010/30/EU[7], and requirements are further described in a number of regulations, including the Ecodesign Regulations Nos 813/2013 [8] and 814/2014[9] for space heaters and combination heaters on the one hand and water heaters and water storage tanks on the other hand. These regulations have deep consequences on the market, where the less performant products will gradually vanish.

For heat pumps one of the major changes is the introduction of seasonal performances which take into account the fact that during the whole year a thermodynamic system works according to the needs at part load conditions and for specific climates.

Thus, since 2013, nominal performances (EER for cooling mode and COP for heating mode) according to EN 14511[10] standard are gradually been replaced by seasonal performances (SEER and SCOP respectively) according to EN 14825 [11] standard.

To enable comparing results from different technologies, a seasonal energy efficiency is introduced, using a conversion coefficient *CC* to express it in terms of primary energy.

For instance, for heat pump space heaters and heat pumps combining space heating and hot water production, the seasonal space heating energy efficiency is expressed as:

$$\eta_s = \frac{SCOP}{CC} - \sum F(i),$$

where $CC = 0.5$ and $F(i)$ are corrective factors.

For heat pumps, the provisions related to Ecodesign and Ecolabelling have been in force since September 26th, 2015 and will be strengthened and enlarged from 2017 onwards.

Coping with these regulatory changes is a real challenge for product certification because in many cases new test methods have to be used to determine the efficiency in terms of seasonal performance.

Eurovent Certita Certification manages its certification programmes so as to anticipate regulatory evolutions and especially revise reference documents to be in line with the implementation of the Ecodesign and Ecolabelling directives.

Here are some recent examples:

- 2010: thresholds for sound power levels (indoors and outdoors) are introduced for NF Heat pumps,
- From January 1st, 2013: for ECP certified air conditioners ≤ 12 kW, SEER and SCOP have to comply with the eco-design thresholds,
- Autumn 2014: SCOP and η_s can be certified for NF Heat pumps,
- December 2014: the ECP programme for chillers and heat pumps includes the certification of SCOP and η_s.

Versatile products and hybrid systems

One of the most notable and growing current trends is the development of versatile systems achieving several different functions, for instance space heating and hot water production as in the case of dual mode heat pumps. Some of them are using different types of energy, such as typically hybrid heat pumps combining a fuel or gas boiler and a heat pump. These latter systems can in some cases be controlled so as to switch from one type of energy to another depending on the outdoors temperature or on the power cost, allowing therefore to optimize the energy efficiency and the overall operating costs. The first "NF Multi energy" certificates have been granted on November 2014

These breakthroughs offer a real challenge to product certification, because the great quantity of components (heat pumps, storage tanks, exchangers…) and of their possible combinations can result in a very large amount of marketed systems which are quite long and expensive to test. Among the array of means Eurovent Certita Certification is using to address this issue, one of the most promising is the use of predictive models.

If we take the example of certified dual mode heat pumps, the systems are first classified by ranges, depending on the technologies of the main components and on their sizes (see **Figure 2**).

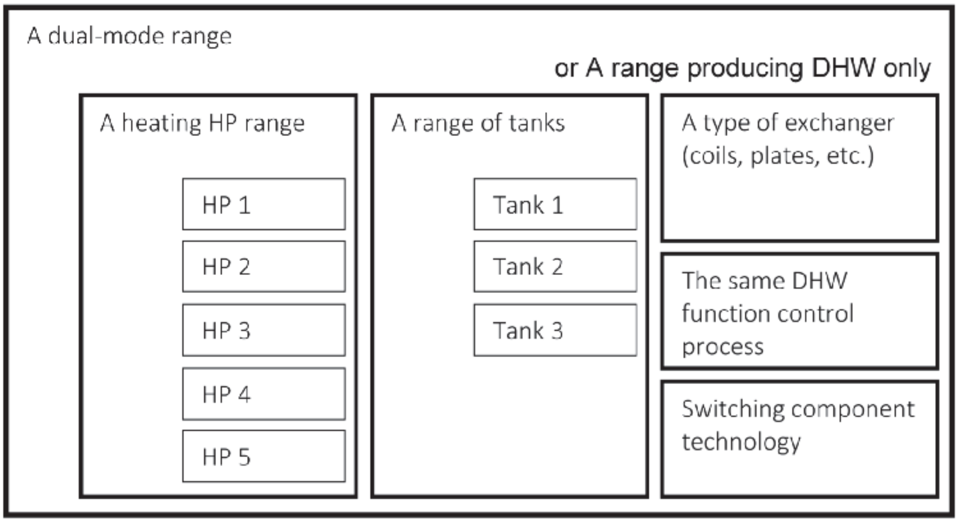

Figure 2. definition of ranges of NF certified dual mode range or domestic hot water (DHW) heat pumps.

For a given range of models, the performances are determined from testing one model and using simulation for the other models. Once the simulation tool has been validated on the basis of an appropriate assembly of test results, it allows to decrease dramatically the number of needed tests.

A truly European coverage

It was once said that Europe will not be actually built when all European people speak one single language, but when they all speak several European languages. To some extent it is such an approach which is followed by Eurovent Certita Certification: we promote certification at the European level while acknowledging local recognition of influential brands, in keeping with the demands of the market. It is the reason why the Euro-HP programme was launched under the Eurovent Certified Performance brand on 2015, on the basis of NF Heat Pump specifications, with dozens of manufacturers having now their heat pumps performances published on our web site [5]. This is also underlying the cooperation agreement Eurovent Certita Certification has signed on 2015 with the German certification body DIN CERTCO to broaden its certification offering as summarized on **Figure 3**. In the framework of this agreement, the first DIN Plus certificates were granted on November 2015.

Figure 3. A one-stop shop for 3 certification marks.

The overall result of this continuous certification development is shown on **Table 3** where the numbers of certified models are given per technology of heat pumps.

Table 3. Models of certified heat pumps per technology (Dec.2015).

Type	Number of models certified by Eurovent Certita Certification
Space heating or cooling	
Air/air	2,860
Air/Water	13,400
Water/Water	3,660
Glycol Water/Water	305
Dual service	505
Rooftop units	470
Variable Refrigerant Flow	185
Total number	**21,385**

Conclusion

Product certification is a key point on the heat pump market as it is necessary to bring confidence between all stakeholders. However to deliver in a fully satisfactory way, it has to evolve in line with the development of new technologies and systems and to anticipate regulatory constraints as well as market expectations. Eurovent Certita Certification has taken up this challenge and is the leading European certification body for heat pumps on a business area where Ecodesign requirements and market surveillance are focused on transparent and reliable product performances. ■

References

[1] ISO/IEC 17000: 2004- Conformity assessment — Vocabulary and general principles.

[2] ISO/IEC 17065: 2012 - Conformity assessment — Requirements for bodies certifying products,processes and services.

[3] Regulation No 756/2008 of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation No 339/93. *Official Journal of the European Union – L218, 13.8.2008 –p. 30 - 47.*

[4] http://www.certita.fr/en/certita-mark/nf-heat-pumps

[5] http://www.eurovent-certification.com

[6] Directive 2009/125/EC of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products. *Official Journal of the European Union* – L 285, 31.10.2009, p.10-35.

[7] Directive 2010/30/EU of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products. Official Journal of the European Union – L 153, 18.6.2010, p. 1–12.

[8] Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters. Official Journal of the European Union – L 239, 06.09.2013, p.136-161.

[9] Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks. Official Journal of the European Union – L 239, 06.09.2013, p.162-183.

[10] EN 14511 – 1 to -4: 2013 - Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling.

[11] EN 14825: 2012 - Air conditioners, liquid chilling packages and heat pumps,with electrically driven compressors,for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance.

Designing an energy efficient and comfortable building

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It's not often you get to work on a project with an enthusiastic, knowledgeable client, a renowned architect and a very resourceful contractor.

The building has a gross area of 182,000 sf, and contains a basement with 4 levels above grade. The spaces are distributed in the following manor:

- Server room, classrooms, a parking garage and mechanical and electrical rooms in the basement,
- The 1st and 2nd floors contain a mix of classroom studios as well as office and support facilities;
- The 3rd and 4th floor contains the main administrative offices, faculty offices and ancillary support spaces.

Early on, it was decided that occupant comfort and energy conservation would be a priority. The goal was to provide comfort levels at 10% PPD (Percentage of Person Dissatisfied) or less for each space and at the same time consume the least amount of energy against both California's Title 24 requirements and ASHRAE 90.12007 for LEED points.

Engineering the Architecture

The place to start in creating comfortable spaces is with the architectural design and not the conditioning systems. IBE spent considerable time working with the architects, analysing different glazing alternatives and investigating the inside surface temperature for the glass as this drives the mean radiant temperature (MRT) in the occupied spaces. A dynamic comfort simulator was used that could analyse space conditions for a single day, month or year. Having a better understanding of the building shade characteristics and thermal conditions, the overall thermal comfort was improved in addition to reducing energy consumption by implementing some or all of the investigated strategies.

Claremont McKenna College is located in Claremont, California at 34.1 degrees Latitude. Using a software program, a sun path diagram was created to show the total solar radiation on south and west facing surfaces of a 90degree structure. The sun path diagram reveals the maximum solar radiation potential for September and July are 450 W/m² (144 Btu/h ft²). and 530 W/m² (168 Btu/h ft²) respectively. The design peak days selected for the analysis were July 30th for the western facing windows and September 24th for the southern facing windows.

On the fourth floor of the southern façade of the college there are 0.45 m (1.5 ft.) long fins protruding from both sides of the windows. There is also a 0.45 m overhang above the windows.

The material characteristics of the fins are very important. The material should have a high reflective factor to reflect solar radiation from being absorbed into the shade. In Claremont California the peak solar intensity is 530 W/m² (168 Btu/h ft²). By allowing only minimal radiation to hit the windows, the solar gain to the space is reduced significantly. At the same time, the solar radiation penetrating the fins must be utilized to enhance the natural day lighting of the spaces.

The inside surface of the fins must also be carefully selected., If the surface has a higher reflectance than any radiation reflected from the glass, after being allowed to hit the glass, could be reflected back into the building from the shade. If the inside surface of the fins is not reflective, the solar radiation reflected from the glass will be absorbed by the fins.

The glazed surfaces of the college were carefully selected as the glass had to perform to reduce solar loads, yet permit natural day light to enter the spaces. During the winter the glazing must have a low U value to reduce heat losses. A low U value is most often obtained by having a coating on either the second or third surface of the double glazed construction. The ideal glazing is one with a balance between a high visible light transmittance and low shading coefficient. This is often a difficult compromise to maintain a clear appearance yet achieve the required shading performance.

The glazing type used in the analysis for the College was an insulating glass with a low shading coefficient of 0.32 and high visible transmittance of 62%, a winter night-time U value of 1.65 W/m² K and a summer U value of 1,42 W/m² K.

System choice

The choice of an appropriate conditioning system was based upon the required comfort compliance requirements. But the different characteristics of classrooms and offices would lead to two different conditioning systems.

Classrooms

Based upon previous design for academic buildings such as Cooper Union, we had some excellent operational feedback that would help us select a system for CMC. Each classroom was designed for 30 students, with and without computers. Experience in designing academic buildings over the years requires a flexible solution, taking into consideration the amount of students attending classes and at what time of day will the classes be held. The basis of the design is a variable volume ventilation air supply; we chose to provide 20 CFM of outside air for each person present. By providing 34 m3/h the ventilation rate qualifies for the LEED point for extra ventilation. The cooling provided by supplying 34m3/h per student and with a maximum of 30 students in the room is nearly sufficient to maintain a space temperature of 23,5°C. But we were looking for comfort compliance so a radiant ceiling was introduced mainly for heating during the brief and relatively mild winters in California. The choice of a radiant ceiling was based upon the system being able to control radiant

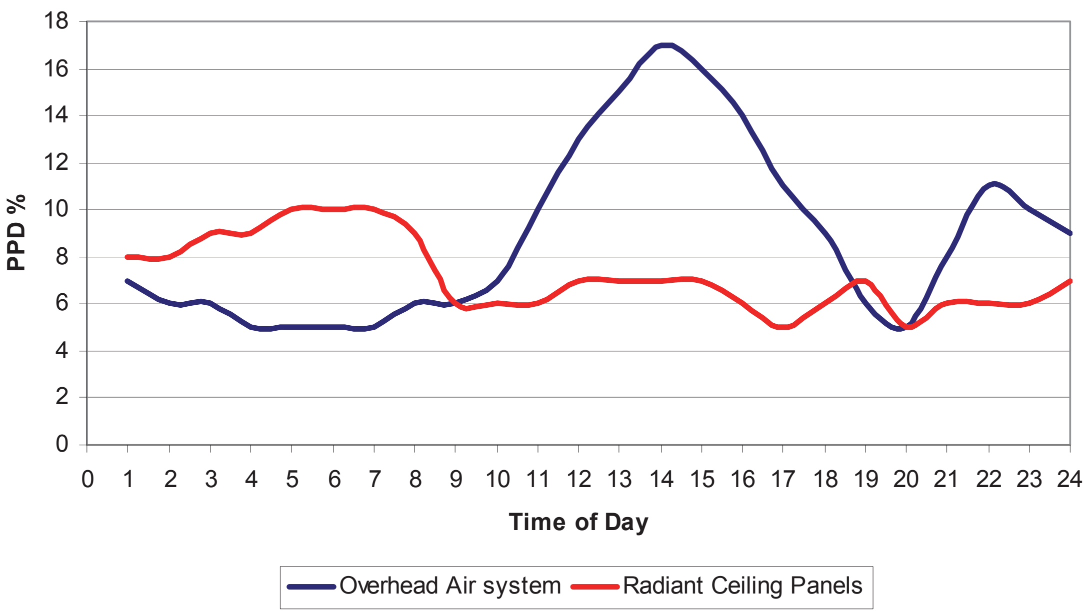


Figure 1. Percentage of people dissatisfied for different air conditioning methods for the classroom.

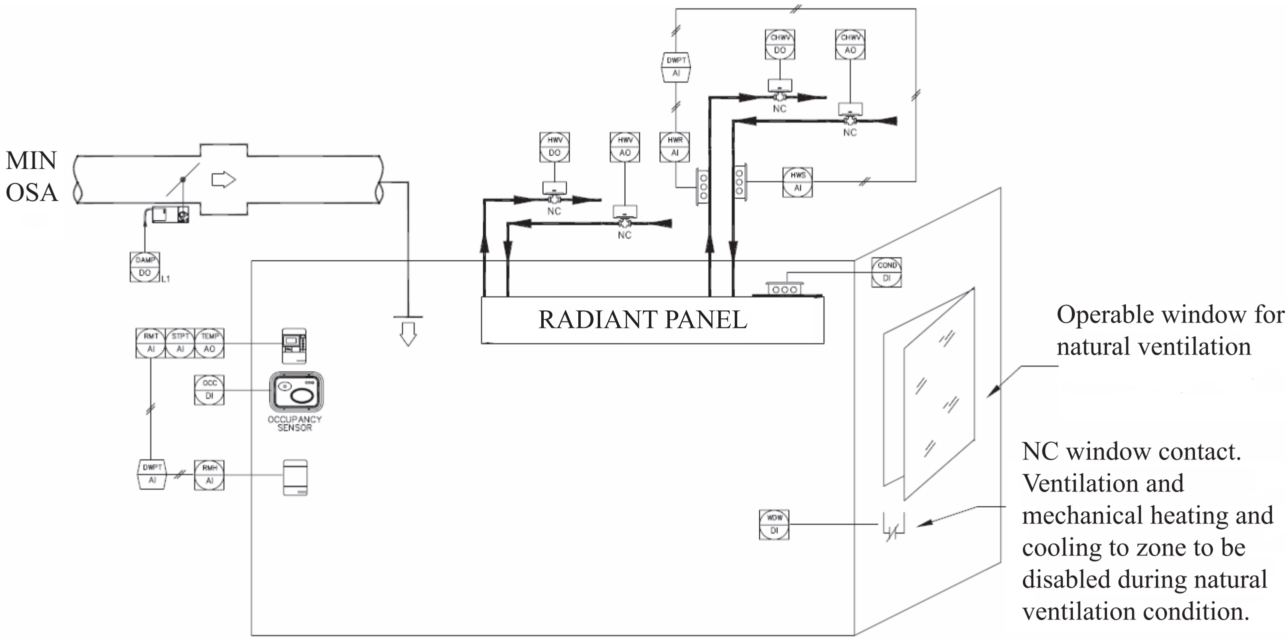


Figure 2. Controls for the classrooms and meeting rooms at CMC.

temperatures in the space, especially for the first lesson of the day and with only a minimum of students present. The radiant ceiling would provide heat to the space and control space radiant temperatures and the ventilation air would be supplied in amounts determined by individual space CO_2sensors. Another spin off from this methodology is the reduction in fan power for the ASHRAE 90.1 energy performance. Once the choice for a radiant ceiling was made, investigations then took place to look at the utilization of cooling from the radiant ceiling. It was basically the same scenario as heating, if the class was partially occupied the ventilation air would be reduced and the cooling and radiant temperature control would be performed by the radiant ceiling.

The results show that comfort conditions comply with ASHRAE standard 55 when a radiant ceiling is introduced as part of the conditioning system for the classrooms.

Offices

We decided to use active beams to condition the offices and administrative spaces at CMC. The choice was based upon our quest for occupant comfort and individual control in each space. Constant volume primary air is supplied to each beam; the sensible cooling from the primary supply air is only about 15–20% of the space sensible cooling load. The larger portion of the cooling load is provided by the control of cooled water flowing through the beam. By putting the control emphasis on the water side control of the system, the response time is improved and this increases the efficiency of the system.

Figure 3. One of the meeting rooms at CMC which is conditioned in the same manner as the classrooms.

Figure 4. Typical office space with floor to ceiling glass.

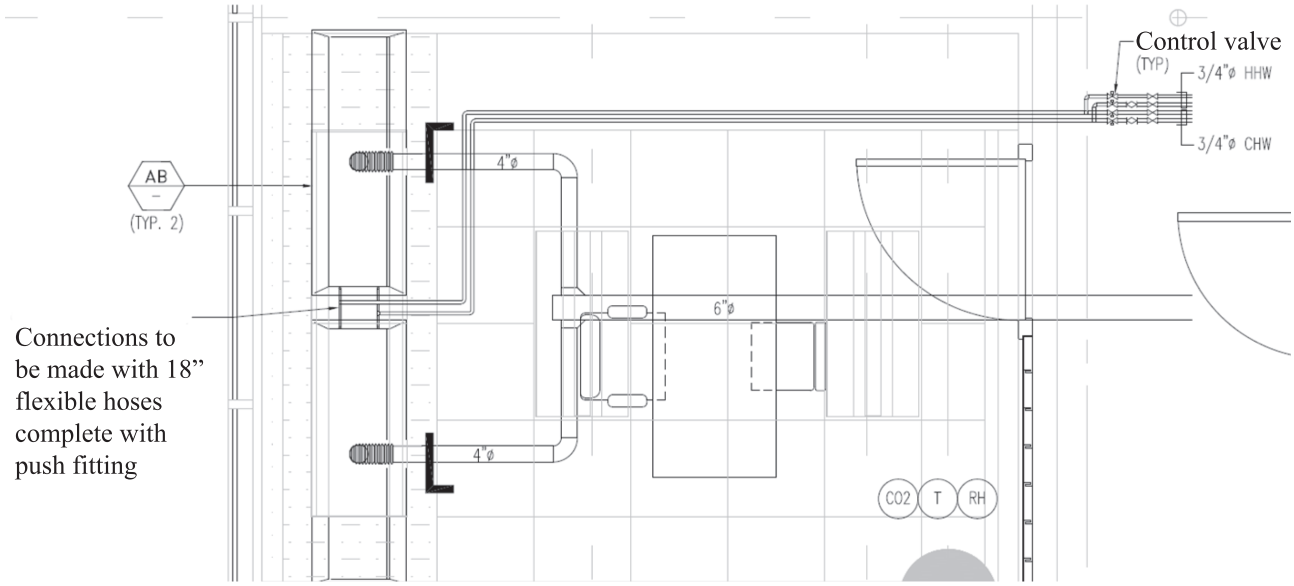


Figure 5. A plan view of the active beams and primary air connections for each space. The temperature, humidity and CO_2 sensors are also shown for each space.

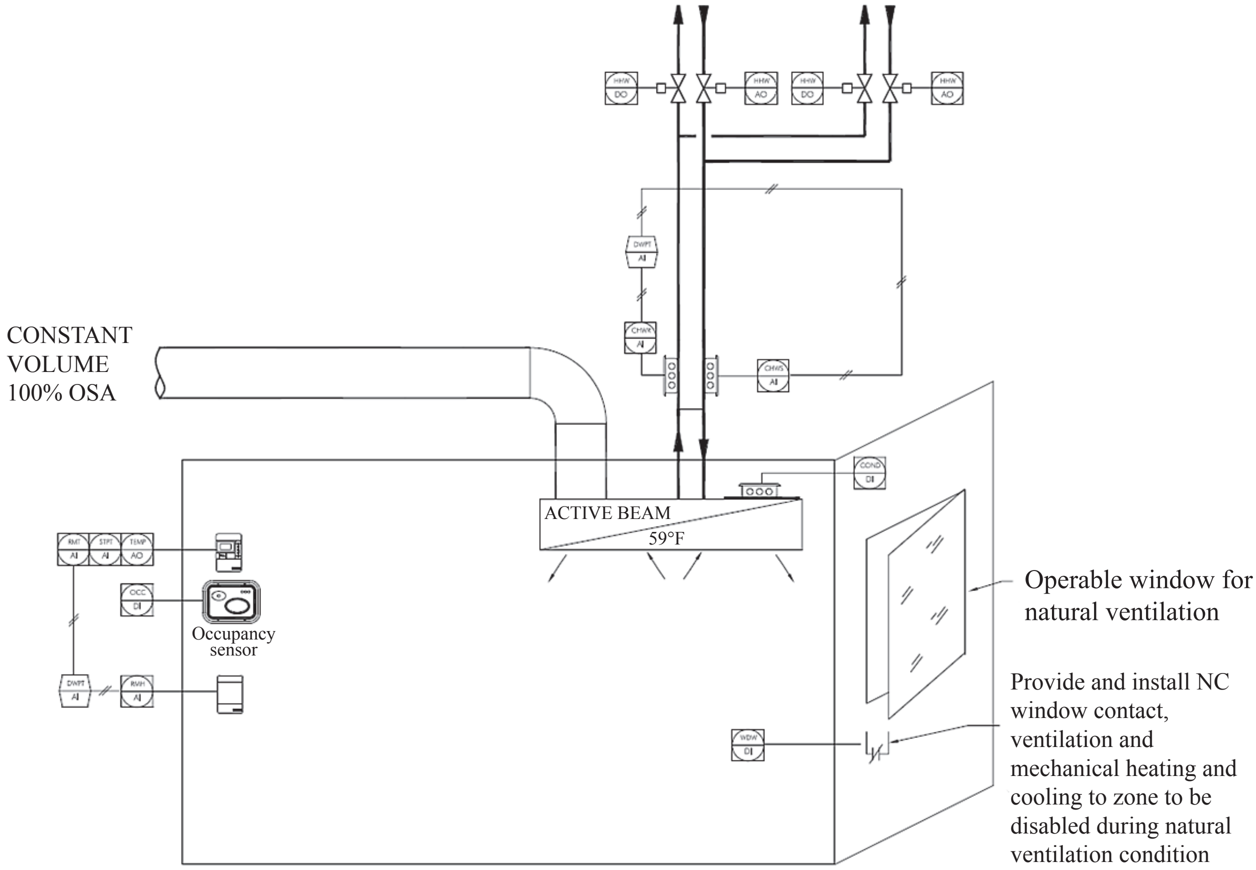


Figure 6. Control systems for offices conditioned by active beams.

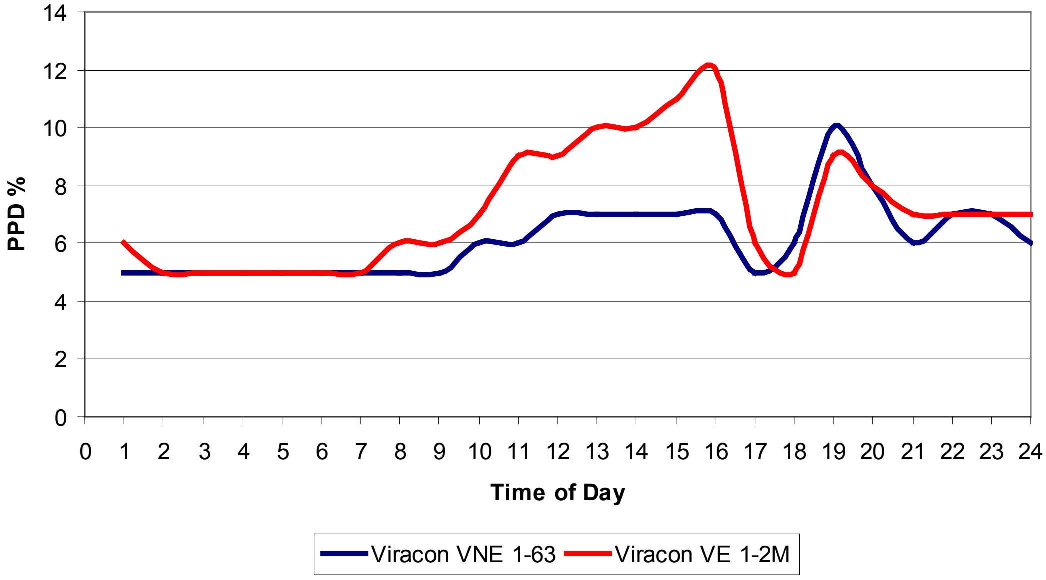


Figure 7. Percentage of people dissatisfied for two different glass types for the corner office.

Energy efficiency

A central cooling and heating plant was provided to serve this building. The central plant is located at the basement level to the north of the building.

The chiller plant consists of two 560 kW frictionless chillers. Each chiller has a variable speed primary pump. The chillers also have the capability of having their speed varied to improve efficiency. Condenser water for the chillers is cooled by a single cooling tower having variable speed fans. The condenser water loop is constant volume.

There are two variable volume chilled water loops:

1. There is a 5.5°C loop that transports water to the air handling units, CRAC units and fan coils in the IDF rooms.
2. The second loop has a variable supply temperature from 12.8°C to 14.4°C for the active beams and the radiant ceiling panels.

Two boilers each with a 580 kW capacity provide water at a constant volume to a common header.

There are two variable volume heating hot water loops:

1. There is an 80°C loop that transports water to the air handling units.
2. The second loop has a variable supply temperature for the active beams and the radiant ceiling panels.

Energy Analysis

An energy model was constructed to explore the building's performance against the California Energy Code (Title 24). This code provides a measuring stick based upon the size and use of a building.

The Reference Baseline building shell is comprised of metal frame wall with R13 batt insulation, insulated glazing with a T24 maximum shading coefficient and roofing with a R19 insulation.

Lighting systems were specified to meet Title 24 allowances of 15,5 W/m².

The Reference Baseline mechanical system was an overhead VAV system and a central heating and cooling plant as allowed by Title 24 standards.

Figure 8 shows the EnergyPro output for the energy analysis. The reference Standard Design is a building of the same size and usage built in accordance with the prescriptive requirements of Title 24. By taking the performance approach, we do not need to follow the prescriptive requirements as long as our proposed building out performs the standard building.

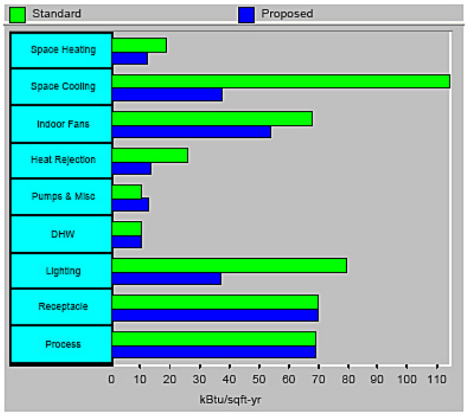
Based on the preliminary model, the proposed building is performing 32.3% better than the standard model, although the value of 37.9% better than Title 24 is used for Savings by Design as this excludes process loads.

PERFORMANCE CERTIFICATE OF COMPLIANCE Part 2 of 3 **PERF-1**

PROJECT NAME: Kravis Hall ECM 3 | DATE: 5/29/2009

ANNUAL TDV ENERGY USE SUMMARY (kBtu/sqft-yr)

ENERGY COMPONENT	Standard Design	Proposed Design	Compliance Margin
Space Heating	18.45	11.78	6.67
Space Cooling	113.98	37.22	76.76
Indoor Fans	67.55	53.54	14.01
Heat Rejection	25.75	13.28	12.47
Pumps & Misc.	9.92	12.36	-2.44
Domestic Hot Water	9.94	9.94	0.00
Lighting	79.07	36.90	42.17
Receptacle	69.76	69.76	0.00
Process	68.70	68.70	0.00
TOTALS:	463.13	313.49	149.64



Percent better than Standard: 32.3% (37.9% excluding process)

BUILDING COMPLIES

Figure 8. Annual TDV Energy Use Summary (kBtu/sqft.yr) compare with kWh/m^2 per year.

The building includes the following features to increase the performance of the building to exceed Title 24 minimum standards by 37.9 percent:

- High performance lighting systems in classrooms, seminar rooms, meeting room and offices, with occupancy sensors and daylight harvesting sensors.
- High performance glazing
- High efficiency frictionless chillers
- Wall insulation increased to R19 and roof insulation increased to R30.
- Daylight harvesting sensors.

For the LEED submittal the percentage of Energy savings was 63.5% and the cost savings were 46.7%, which was good for 10 LEED points. ■

Experiences with ventilative cooling in practical application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Recently built Active Houses provide experience with ventilative cooling in practical application as a means to prevent overheating in energy efficient residential buildings. Detailed measurements of energy performance and indoor environment have been made in five single family houses, located in Austria, Denmark, England, France and Germany. The houses have generous daylight conditions, with a design target to reach a Daylight Factor of 5% in the main habitable rooms. This increases the risk of overheating, but the measurements show that the houses generally achieve thermal comfort category 1 of EN 15251 during summer, which means that overheating has not occurred. To succeed, natural ventilative cooling and dynamic solar shading was applied and controlled to avoid overheating (which is possible under European climate conditions, where humidity is not a main issue during summer). Some of the experiences from applying ventilative cooling can be generalised to other houses and are presented in the article.

Some barriers limit the use of ventilative cooling. Firstly, the current methods in standards and legislation that are used to determine the performance of ventilative cooling need to be further strengthened. Secondly, affordable, intuitive and simple control systems for residential hybrid ventilation and dynamic solar shading are needed to tap the full potential of ventilative cooling.

The Active House Specification is based on a holistic view on buildings including Comfort, Energy and Environment. It uses functional requirements to indoor air quality and thermal comfort.

Keywords: Active House, ventilative cooling, natural and hybrid ventilation, standards, controls systems.

Introduction

Overheating is an important issue for building designers. Even in Scandinavia, demonstration houses have frequently experienced problems with overheating, often due to insufficient solar shading and use of natural ventilation (Isaksson, 2006, Larsen, 2012, Rohdin 2013). Similar results were found in a review on the situation in UK, stating that in certain cases, dwellings that were recently built or refurbished to high efficiency standards have the potential to face a significant risk of summer overheating (AECOM, 2012). Porritt et al. (Porritt, 2011) found that living room temperatures could be maintained below the CIBSE overheating thresholds, as a result of a combination of intervention measures that include external wall insulation, external surface albedo reduction (e.g. solar reflective paint), shading (e.g. external shutters) and intelligent ventilation regimes. Orme et al. found that night ventilation is a particular important measure to prevent overheating (Orme et al., 2003), and also found that the risk of overheating will increase in the future due to climate change.

The Active House Specification (Eriksen et al., 2013) has requirements in three categories, and has a main ambition that the three categories should have an equally high focus. The three categories are:

- Comfort (incl. indoor environmental quality)
- Energy
- Environment

Four categories of maximum operative temperature are defined, setting requirements to air-conditioned and non-air-conditioned buildings, using the definitions of EN 15251. For non-air conditioned buildings, the adaptive approach is used:

1. $\Theta_{i,o} < 0.33 \cdot \Theta_{rm} + 20.8°C$, for Θ_{rm} of 12°C or more
2. $\Theta_{i,o} < 0.33 \cdot \Theta_{rm} + 21.8°C$, for Θ_{rm} of 12°C or more
3. $\Theta_{i,o} < 0.33 \cdot \Theta_{rm} + 22.8°C$, for Θ_{rm} of 12°C or more
4. $\Theta_{i,o} < 0.33 \cdot \Theta_{rm} + 23.8°C$, for Θ_{rm} of 12°C or more

Where Θ_{rm} expresses the average outdoor temperature (°C) weighted over time according to EN 15251 and $\Theta_{i,o}$ is the indoor operative temperature (°C).

Natural ventilation in combination with dynamic solar shading is a key instrument to avoid overheating with minimal use of energy, but there are no specific requirements in the Active House Specification to use the measures.

Daylight is important for humans, and the requirements are based on average daylight factors on a work plane in the main living room, which must be determined by a validated simulation tool. The criteria are:

DF > 5% on average
DF > 3% on average
DF > 2% on average
DF > 1% on average

Criteria for energy and environment are found in the Specification (Eriksen et al., 2013), which can be downloaded at no cost from the website of the Active House Alliance.

Experiences from completed active houses

Ventilation System Configurations

Many of the realized Active House have been built with demand-controlled, hybrid ventilation systems for optimal IAQ and energy performance.

An example is from the project Sunlighthouse in Austria. Natural ventilation is used during warm periods and mechanical ventilation with heat recovery is used during cold periods. The switch between mechanical and natural ventilation is controlled based on the outdoor temperature. The set point is 12.5°C with a 0.5°C hysteresis. Below the set point the ventilation is in mechanical mode, above the set point the ventilation is in natural mode. In both natural and mechanical mode, the ventilation rate is demand-controlled. CO_2 is used as indicator for IAQ, and a set point of 850 ppm CO_2 is used.

LichtAktiv Haus in Germany is an example of a house where natural ventilation is used as the only ventilation system.

Measured IAQ

Temperatures and CO_2-concentrations have been measured continuously for 1–2 years in several inhabited Active Houses, e.g. in LichtAktiv Haus (LAH), Germany. The measurements were supplemented with systematic qualitative feed-back from the inhabitants. LAH is designed with a demand controlled IAQ, with the aim to achieve category 1 (500 ppm above outdoor levels) or 2 (750 ppm above outdoor levels) (Feifer et al., 2013). The measured CO_2-concentration in the living/dining room is presented in **Figure 1**.

It is seen in **Figure 1** that category 1 or 2 is achieved for 60% to 70% of the time during winter, and approx. 100% of the time during summer. The CO_2-concentration is lowest during the summer period as natural ventilation is also used to prevent overheating in this part of the year. Good summertime IAQ is thus a positive side-effect of applying ventilative cooling to prevent overheating. CO_2 concentration above category 2 during winter is caused by user override of automated controls. These results are similar to those seen in Active Houses with mechanical/hybrid ventilation.

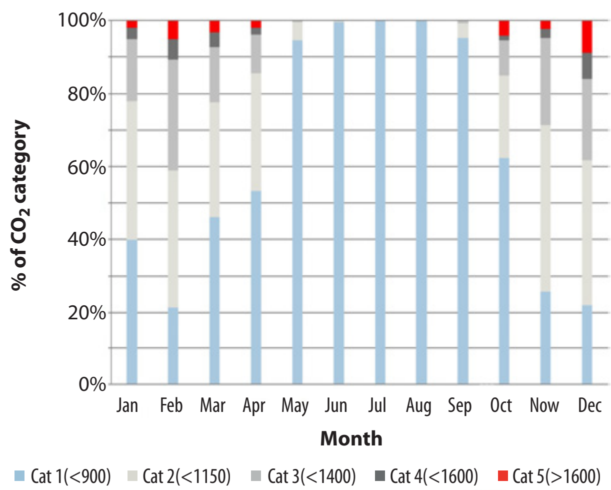

Figure 1. Measured CO_2 concentration in the kitchen/living room of LichtAktiv Haus, Germany. The data is categorized according to the Active House Specification. The outdoor CO_2 level is assumed to be 400 ppm.

It is the general experience that both natural, mechanical and hybrid ventilation systems are able to deliver the right ventilation rates and achieve the right IAQ. The key issue is that the systems must be designed, installed and maintained correctly, and most importantly, the controls must be transparent and intuitive for the occupants of the buildings.

Measured Thermal Comfort

Foldbjerg (Foldbjerg et al., 2013) reported on the thermal comfort in LAH and two other Active Houses. A typical characteristic of the realized Active Houses is that they have very generous daylight conditions. It is seen on **Figure 2** that the living-dining room in LAH achieve category 1 in most months, with the exception of a limited number of hours during the three summer months. Annually, the room achieves category 1. There are very few hours with temperatures below category 1. This means that there is no issues with overheating or low temperatures (undercooling).

Prevention of overheating is a key issue, as low energy buildings can easily overheat, as reported by Larsen (Larsen, 2012) and others. It is the general experience from the realized Active Houses those good thermal conditions with only insignificant periods with high or low temperatures can be achieved. The important elements to consider are natural ventilation and dynamic solar shading, as combined in ventilative cooling (venticool, 2014).

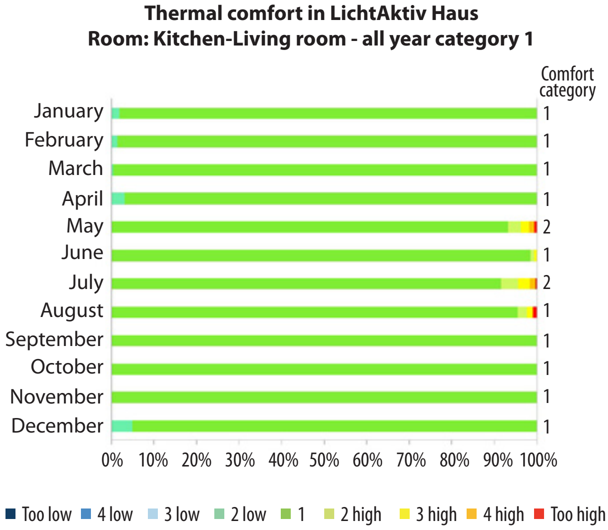

Figure 2. Measured indoor temperature in the kitchen/living room of LichtAktiv Haus, Germany. The data is categorized according to the Active House Specification. The number on the right side of the figure is the Active house category achieved for each month (max 5% of the time can exceed the category).

Ventilative Cooling in Standards

Peuportier (Peuportier et al, 2013) measured the air change rates achieved with natural ventilation as the means of ventilative cooling in the Active House called Maison Air et lumière near Paris, France. Air change rates in the range of 10 to 22 ACH were achieved. These results were confirmed by simulations in CONTAM. However, later calculations with the methods presented in EN 15242 show much lower results despite similar geometry and boundary conditions. This is to some extent explained by the fact that EN 15242 only includes single-sided ventilation. BS 5925:1991 presents a method that allows for a two-sided window configuration, still with very conservative results. In the on-going revision of EN 15242 it is being discussed if a more accurate and generally applicable method can be included. The work in IEA Annex 62 will further support this goal.

Ventilative Cooling in legislation

Ventilative cooling is only to a limited extend addressed in legislation through building codes and compliance tools. Recent years, several national building codes have included ventilative cooling with simplified calculation of ventilation flow rates that are not directly addressing the performance of the actual ventilation and building design. To correctly account for the effect of ventilative cooling, more accurate methods are needed. A method was recently implemented in the Danish Be10 compliance tool, and there is currently work on-going in France to improve the methodology for the calculation of ventilative cooling and to integrate summer comfort better in the French national code and compliance tool.

Also in France and Denmark, requirements to thermal comfort are likely to be more elaborated in coming revisions of the national building codes. This is a necessary step to prevent overheating, but requires that the underlying methodology adequately accounts for the actual performance.

Experience with Control Systems in Active Houses

An effective control of dynamic shadings and natural ventilation is important for achieving good summer comfort. Such control may be based on manual operations, knowledge and good habits but in the Active Houses described here, the full step towards fully automated control was taken. The automatic control was in general appreciated by the users, though the users needed some time for adjusting to the system. The user feed-back showed clearly that they appreciated the automatic control if override was possible. It is essential to offer intuitively manually operable devices such as windows, doors, and awning blinds allowing the users to override the automatic system.

There are few control systems currently available that deliver control of both mechanical and natural ventilation (as a hybrid solution), and which controls both ventilation, window openings and dynamic solar shading in a combined effort to maintain both good IAQ and good thermal comfort. Such systems should be cost-effective and are needed for the residential market to tap the full potential of dynamic building elements and to reach the ambitious nZEB targets of EU-28.

Conclusions

Good IAQ can be achieved with both natural, mechanical and hybrid ventilation systems. The important lesson is that they must be planned, installed and maintained right. This has been achieved in the investigated houses. By correct planning in the design process good IAQ can be reached with a minimum use of energy. Particular good IAQ during the summer period has been observed as a positive side-effect of applying ventilative cooling.

Whereas the above themes have been relatively unproblematic, some issues, mentioned below, have a greater need for increased focus regarding quality and compliance.

The realized houses are characterised by generous daylight conditions, which could potentially lead to overheating. This has not been the case. The houses show that good thermal comfort can be achieved in all seasons, regardless whether natural, hybrid or mechanical ventilation is used. But a strong relation between efficient natural ventilation in the summer (ventilative cooling) as well as dynamic solar shading has been a key element in achieving this, supported by windows being located towards more than one orientations in each room and not mainly towards the south as sometimes seen in low energy houses.

There is currently only limited support in standards and legislation to give a true and fair account of the performance of ventilative cooling and dynamic solar shading, and this needs to be improved.

There remains a need to identify and to discuss how ventilative cooling can become a standard solution in legislation and standards throughout Europe especially regarding renovation but also regarding Nearly Zero Energy Buildings.

Transparent and intuitive control systems scaled for residential buildings with regards to system architecture and price are needed. Such a control system should be able to control ventilation and dynamic solar shading to maintain both good IAQ as well as good thermal comfort. ■

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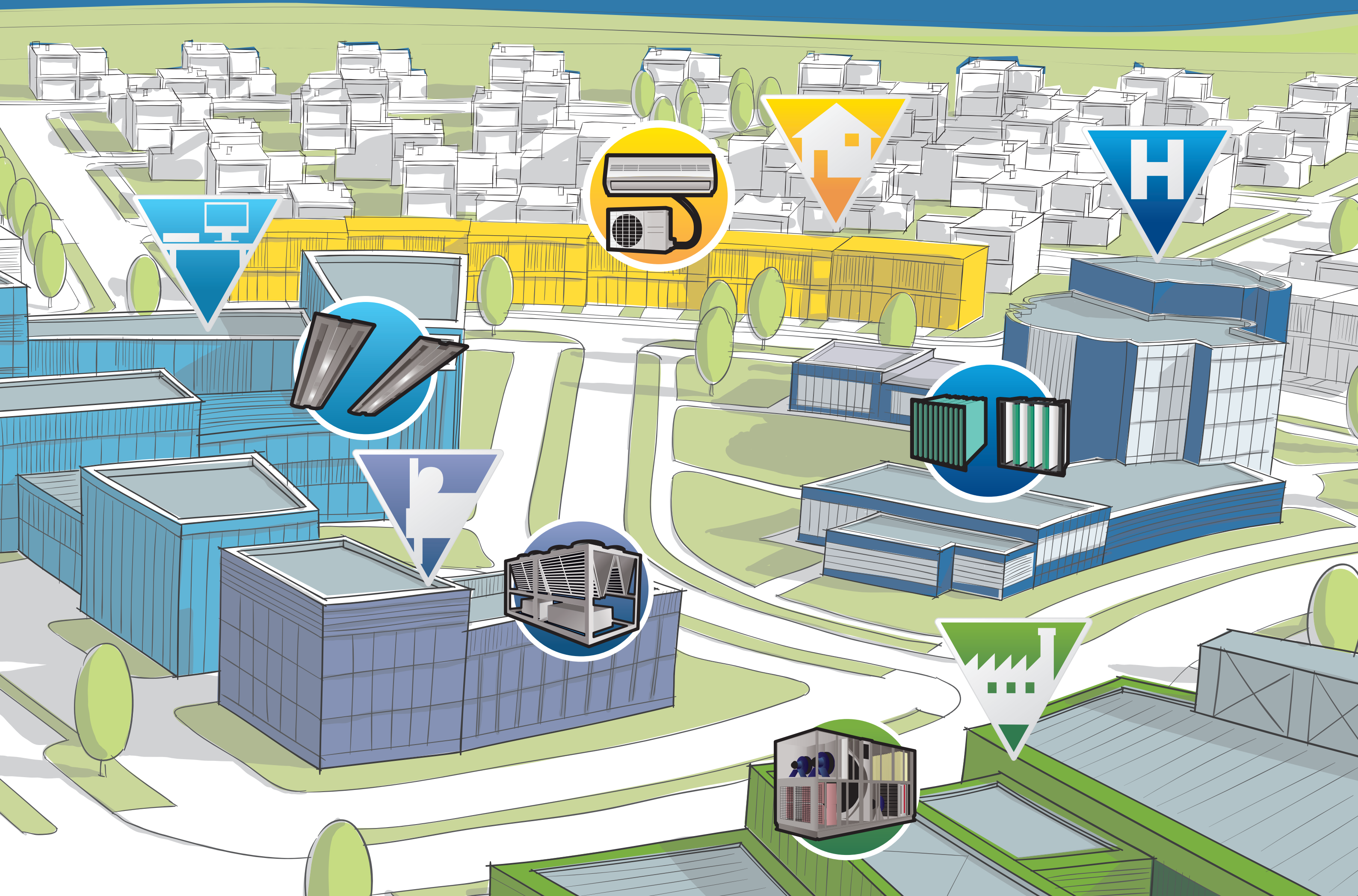

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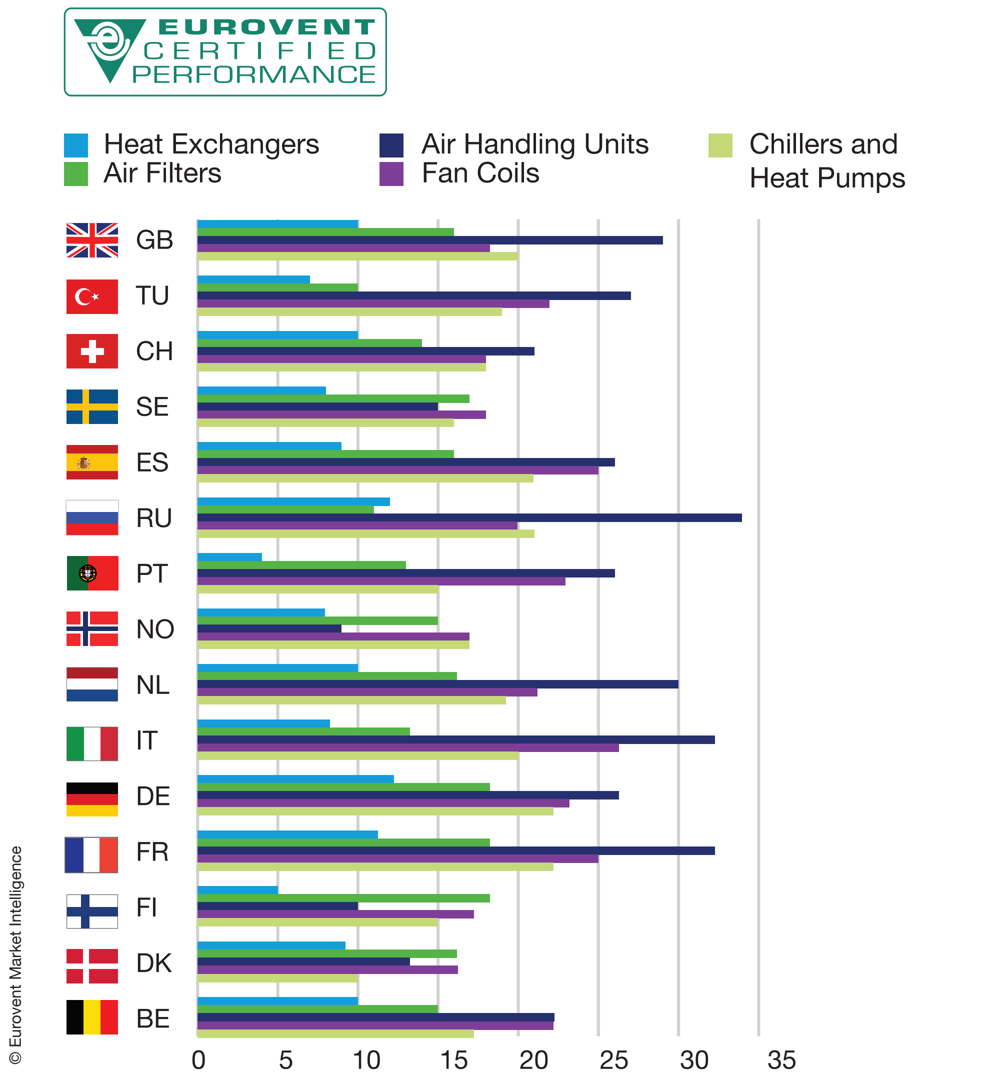

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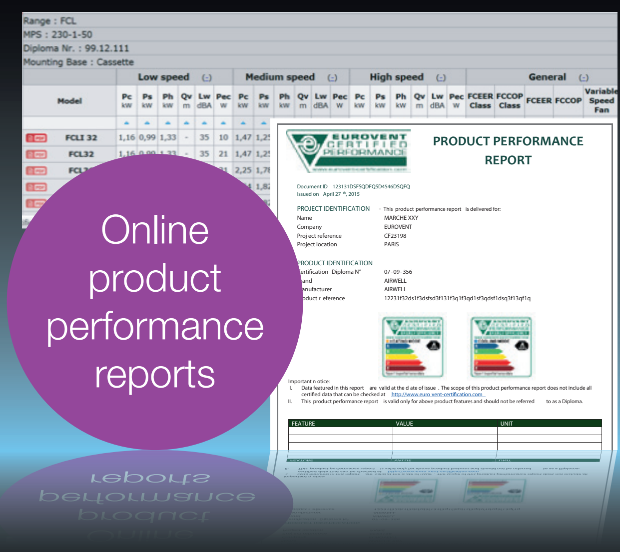


CERTIFICATION PROGRAMMES

FOR DOMESTIC, COMMERCIAL AND INDUSTRIAL FACILITIES

Indoor Climate	Ventilation & Air Quality	Process Cooling & Food Cold Chain
European Heat Pumps	Air to Air Plate Heat Exchangers *	Cooling Towers
Chilled Beams *	Air to Air Regenerative Heat Exchangers *	Cooling & Heating Coils
Close Control Air Conditioners *	Air Handling Units *	Drift Eliminators
Comfort Air Conditioners *	Air Filters Class M5-F9 *	Liquid Chilling Package & Heat Pumps *
Rooftop (RT) *	Residential Air Handling Units (RAHU)	Heat Exchangers *
Fan Coils Units *		Remote Refrigerated Display Cabinets
Variable Refrigerant Flow (VRF) *		

* All models in the production have to be certified

Indoor Climate

European Heat Pumps

Scope of certification

- Electrically driven heat pumps for space heating (incl. cooling function)
- Electrically driven heat pumps used for heating swimming pool water (outdoors or inside)
- Dual-mode heat pumps, i.e. designed for space heating and domestic hot water production,
- Gas absorption heat pumps (incl. cooling function)
- Engine-driven gas heat pumps (incl. cooling function).

Certification requirements

- Qualification campaign : 1 audit/factory + tests depending on products declared
- Repetition campaign: 2 machines/year + 1 audit/year/factory

Main certified characteristics and tolerances

- Heating and/or Cooling capacities *Ph* and/or *Pc* [kW], Electrical Power inputs *Pe* [kW] and Coefficient of performance *COP*
- Design capacity *Pdesignh*, Seasonal Coefficients of Performance *SCOP*, $SCOP_{net}$ and Seasonal efficiency η_s
- Minimum continuous operation Load Ratio *LRcontmin* [%], *COP* at LRcontmin and Performance correction coefficient at LRcontmin *CcpLRcontmin*
- Temperature stabilisation time *th* [hh:mm], Spare capacity *Pes* [W], Energy efficiency for water heating [COP_{DHW} & WH] or Global performance coefficient for a given tapping cycle COP_{global}, Reference hot water temperature θ'_{WH} and Maximum effective hot water volume V_{MAX} [l]
- Daily consumption for the draw-off cycle in question (Qelec)
- Annual consumption (AEC)
- Sound power levels *Lw* [dB(A)]

ECC Reference documents

- Certification manual
- Operational manual OM-17
- Rating standard RS 9/C/010

Main testing standards

Thermal performance:

- Heat pumps with electrically driven compressors
- Space heating & cooling: EN 14511-1 to 4; Seasonal performance: EN 14825
- Domestic hot water: EN 16147
- Direct exchange ground coupled heat pumps: EN 15879-1
- Gas-fired heat pump : EN 12309-1 to 5

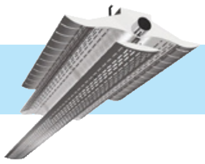
Acoustics:

- Heat pumps and dehumidifiers with electrically driven compressors: EN 12102
- ISO 3741: Reverberant rooms or ISO 9614-1: Sound intensity, measurements by points

▼ Indoor Climate

Chilled Beams

CERTIFY ALL



Scope of certification

This Certification Programme applies to all Active and Passive Chilled Beams. Chilled Beams are presented by ranges but all ranges must be certified. This applies to all product ranges which have either catalogue leaflets with product details including technical data or similar product information in electronic format.

Certification requirements

For the qualification procedure (yearly): 3 units are selected from regular production and tested in the independent Laboratory selected by Eurovent Certification.

For the repetition procedures: the number of units selected is limited to 1 unit/range.

Obtained performances shall be compared with the values presented in the catalogues or electronic selection from manufacturer's website.

Certified characteristics & tolerances

Cooling capacity: 3 conditions are required.

- Active: 80 – 100 – 120% of the nominal air flow rate (for 8°C temperature difference)
- Passive: 6 – 8 – 10°C temperature difference

Tolerance = 12% for the 3 single values; 6% for the average value.
Water pressure drop : tolerance = maximum (2 kPa ; 10%)

ECC Reference documents

- Certification manual
- erational Manual OM-12
- Rating Standard RS 2/C/007

Testing standards

- EN 14518: "Testing and rating of Passive Chilled Beams"
- EN 15116: "Testing and rating of Active Chilled Beams"

Comfort Air Conditioners

CERTIFY ALL

Scope of certification

This certification programme includes:

- AC1: comfort air cooled AC and air to air HP with cooling capacity up to 12 kW, except double duct and single duct units.
- AC2: comfort units with cooling capacity from 12 to 45 kW
- AC3: comfort units with cooling capacity from 45 to 100 kW

This programme applies to factory-made units intended to produce cooled air for comfort air conditioning (AC1, AC2, AC3). It also applies to units intended for both cooling and heating by reversing the cycle. For the AC1 programme units out of Regulation 206/2012 are excluded.

Participating Companies must certify all production models within the scope of the programme they enter. However concerning multi-split air conditioners, only systems with maximum two indoor units are included, same mounting type, capacity ratio 1+/- 0.05.

Certification requirements

For the qualification & yearly repetition procedures: AC1 : 8% of the units declared are selected and tested by an independent laboratory, and 30% of the selected units are tested at part load conditions. AC2 & AC3 : 10% of the units declared are selected and tested by an independent laboratory.

Certified characteristics & tolerances

- Capacity (cooling and heating) –5%
- Efficiency (EER and COP) –8%
- Seasonal Efficiency (SEER and SCOP): –0% (the product is downgraded (or rerated) as soon as partload efficiency is out of tolerance
- A-weighted sound power level +0 dB (A)
- Auxialiary power +10%

Minimum continuous operation Load Ratio: LRcontmin [%], COP/EER at LRcontmin and Performance correction coefficient at LRcontmin CcpLRcontmin.

ECC Reference documents

- Certification manual
- Operational Manual OM-1
- Rating Standard RS 6/C/001 - RS 6/C/001A - RS 6/C/006

Testing standards

- EN 14511 • EN 14825 • EN 12102

▼ Indoor Climate

Close Control Air Conditioners

CERTIFY ALL

Scope of certification

This Certification Programme applies to factory-made units intended for Close Control Air Conditioning. This programme includes units with cooling capacities up to 100 kW under the specified test conditions.

Participating companies must certify all production models within the scope of the programme.

Certification requirements

For the qualification & repetition procedures: 10% of the units declared will be selected and tested by an independent laboratory.

Certified characteristics & tolerances

Air-Cooled and Water-Cooled Close Control Air Conditioners

- Total cooling capacity : –8%
- Sensible cooling capacity :–8%
- EER : –8%
- A-weighted sound power level : +0 dB

Chilled-Water Close Controls Air Conditioners

- Total cooling capacity : –8%
- Sensible cooling capacity : –8%
- Effective power input : +8%
- A weighted sound power level : +0 dB
- Water pressure drop :+10%

ECC Reference documents

- Certification manual
- Operational Manual OM-1
- Rating Standard RS 6/C/001
- Rating Standard RS 6/C/004
- Rating Standard RS 6/C/006

Testing standards

- EN 14511
- EN 12102 - EUROVENT 8/1

Rooftop (RT)

CERTIFY ALL

EUROVENT CERTIFIED PERFORMANCE ENERGY EFFICIENCY CHECK ENERGY CLASS ON www.eurovent-certification.com

The Eurovent rooftop certification (RT) program covers air-cooled and watercooled packaged rooftop units below 100 kW in cooling mode, with an option to certify units from 100 kW to 200 kW. The Rooftop program participants represent the five main European rooftop manufacturers.

Eurovent certifies indoor and outdoor sound levels, cooling and heating capacity and efficiency. Certified performances provide transparency and fair comparison between manufacturers. It is also the basis for the reliable study of HVAC system energy performance.

Currently the program evolves towards part load efficiency (SEER, SCOP) and certification of performance simulation tool data. Current work done on EN 14825 aims to address rooftops in the calculation hypothesis. The software certification is a key item to comply with existing and coming certification of building energy calculations in the EU countries.

Mr Philippe Tisserand
Product Manager for rooftop & commercial unitary for Trane EMEIA – Chairman of Eurovent Rooftop program compliance committee

Scope of certification

- This Certification Program applies to air-cooled and water cooled rooftops rated below 100 kW.
- Models with cooling or heating capacity ranging from 100 kW to 200 kW can be certified as an option.
- Models of rooftops using gas burners for heating shall be only certified for cooling.

Certification requirements

- For the qualification and repetition procedures (yearly) between 1 & 3 units are selected and tested by Eurovent Certification, depending on the number of products declared.

Certified characteristics & tolerances

- Capacity (Cooling or Heating): –5%
- EER or COP: -8%
- Condenser water pressure drop: +15%
- A-weighted Sound Power Level: +3 dBA.
- Eurovent Energy Efficiency class (cooling and heating)

ECC Reference documents

- Certification manual
- Operational Manual OM -13
- Rating Standard RS 6/C/007

Testing standards

- EN 14511 for Performance Testing
- EN 12102 for Acoustical Testing

Indoor Climate

Fan Coils Units

CERTIFY ALL

Scope of certification

This Certification Programme applies to Fan Coil Units using hot or chilled water. It concerns both non ducted and ducted fan coils:

- Non ducted units: Fan Coil Units with air flow less than 0.7 m³/s and a published external static duct pressure at 40 Pa maximum.
- Ducted units: Fan Coil Units up to 1 m³/s airflow and 300 Pa available pressure.
- District cooling units and 60 Hz units can be certified as an option

Participating companies must certify all production models within the scope of the programme. Selection tools (software) are checked.

Certification requirements

Repetition procedure: the number of units to be tested each year will be proportional to the number of his basic models listed in the Directory, in an amount equal to 17% for Fan Coil Units with a minimum of one test.

Certified characteristics & tolerances

- Capacity* (cooling, sensible, heating): –5%
- Water pressure drop*: +10%
- Fan power input*: +10%
- A-weighted sound power: +1 / +2 dB(A)
- Air flow rate: –10%
- Available static pressure 0 Pa for medium speed and –5 Pa for other speeds
- FCEER & FCCOP
- Eurovent energy efficiency class

(*) **At standard and non standard conditions**

ECC Reference documents

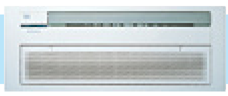
- Certification manual
- Operational Manual OM-1A
- Rating Standard RS 6/C/002
- Rating Standard RS 6/C/002A

Testing standards

- Performance testing: EN 1397:2015
- Acoustic testing: EN 16583:2015

Variable Refrigerant Flow (VRF)

CERTIFY ALL



VRF systems have shown the highest growth amongst cooling systems during the past 10 years and indeed the highest potential for the next 10 years.

Until recently, VRF systems were the only type of direct expansion cooling system that was not covered by a dedicated Certification programme.

The Eurovent Certification scheme was therefore critical.

It was my privilege to Chair the Launching committee from the first meeting to its introduction. Whilst it took 2 years to complete, I believe it was worth the time and effort.

We at Toshiba are pleased as a manufacturer to work with Eurovent Certification Company as they guarantee the consistency of thermal testing and they increase the integrity of the products on the market.

Nick Ball
Toshiba EMEA
Engineer Director

Scope of certification

The certification programme for Variable Refrigerant Flow (VRF) applies to:

- Outdoor units used in Variable Refrigerant Flow systems with the following characteristics:
- Air or water source, reversible, heating-only and cooling-only.

VRF systems with data declared and published as combinations are excluded from the scope.

Heat recovery units are included in the scope but the heat recovery function is not certified.

High ambient systems are included in the scope but tested under standard conditions as specified in RS 6/C/008.

Certification requirements

- Qualification: units selected by Eurovent Certification shall be tested in an independent laboratory selected by Eurovent Certification.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.

Certified characteristics & tolerances

- Outdoor Capacity (cooling and heating): –8%
- Outdoor Efficiency (EER, COP): –10%
- A-weighted sound power level: 2 dB

ECC Reference documents

- Certification manual
- Operation manual OM-15
- Rating Standard RS 6/C/008

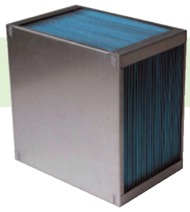
Testing standards

- EN 14511
- EN 12102

Ventilation & Air Quality

Air to Air Plate Heat Exchangers

CERTIFY ALL



Scope of certification

This Certification programme applies to selected ranges of Air to Air Plate Heat Exchangers. Participants shall certify all models in the selected range, including:

- cross flow, counter-flow and parallel flow units
- all sizes
- all materials
- all airflow rates
- all edge lengths
- plate heat exchanger with humidity transfer

Heat Exchangers with accessories such as bypass and dampers shall not be included.

Manufacturers shall declare production places and provenance of products is randomly chosen. The programme does not cover other types of Air to Air Heat Exchangers like Rotary Heat Exchangers or Heat Pipes. Combination of units (twin exchangers) are also included in the scope of the program.

Certification requirements

For each range to be certified, 3 units for qualification and 1 for yearly repetition will be selected by Eurovent Certita Certification and tested in an independent Laboratory.

Certified characteristics & tolerances

- Dimensions: ± 2 mm
- Plate spacing: ± 1% or ± 1 plate
- Temperature efficiency Dry: –3 percentage points
- Temperature efficiency Wet: –5 percentage points
- Humidity efficiency: -5%
- Pressure drop: +10%, minimum 15 Pa

ECC Reference documents

- Certification manual
- Operational Manual OM-8
- Rating Standard RS 8/C/001

Testing standards

- EN 308

Air to Air Regenerative Heat Exchangers

CERTIFY ALL

Scope of certification

This Certification Programme applies to all ranges of Air to Air Regenerative Heat Exchangers (RHE) including sealing systems. Units sold without casing and sealing systems are also included. Participants shall certify all models in the ranges, including:

- all classes: condensation (non hygroscopic, non enthalpy) RHE, hygroscopic enthalpy RHE, hygroscopic sorption RHE
- all RHE geometry (wave height, foil thickness)
- all sizes (rotor diameters and rotor depths and surface areas of Alternating Storage Matrices - ASM)
- all materials
- all airflow rates
- all different types of sealing (if available)

Certification requirements

For the qualification procedures 1 unit per class of rotor will be selected and tested by an independent laboratory. For yearly repetition, 1 unit will be selected.

Certified characteristics & tolerances

- Temperature Efficiency: –3% points
- Humidity Efficiency: –5% points (min. tolerance 0.2 g/kg in absolute humidity of leaving supply air)
- Pressure Drop: +10% (min 10 Pa)
- Outdoor Air Corrrection Factor (OACF): 0.05
- Exhaust Air Transfer Ratio (EATR): +1% point

ECC Reference documents

- Certification manual
- Operational Manual OM-10
- Rating Standard RS 8/C/002

Testing standards

- EN 308
- ARI 1060

Air Handling Units

CERTIFY ALL

Swegon has participated in the program for Air Handling Units from the start. The first priority at that time, and still is, was to find a way for fair competition. This is a long term struggle were we try to cover all aspects from manufacturing to software performance predictions and its agreement with tests. We discuss and take decisions about mandatory performance in software printout, rules for the energy labelling, how to test and what to apply in the, on site, auditor check. Customers should go for Eurovent certified products, to get reliable data, and then they can cut the main cost and take care of the environment by minimising the use of energy.

Committee chair:
Mr Gunnar Berg
Development Engineer, Swegon

Scope of certification

This Certification Programme applies to selected ranges of Air Handling Units.

Participants shall certify all models in the selected product range up to the maximum stated air flow.

A range to be certified shall include at least one size with a rated air volume flow up to 3 m^3/s.

Certification requirements

For the qualification procedure: the selection software will be verified by our internal auditor. A visit on production site will be organized. During that visit, the auditor will select one real unit per range, as well as several model boxes that will cover all mechanical variations.

The selected units will be tested and performances delivered by the selection software will be compared to the performances measured in an independent laboratory.

For the repetition procedures, the auditor will annually check the software conformity against the production data, and tests will be repeated every 3 to 6 years.

Certified characteristics & tolerances

- External Pressure: 4% or 15 Pa
- Absorbed motor power: 3%
- Heat recovery efficiency: 3%-points
- Heat recovery pressure drop (air side): max. of 10% or 15 Pa
- Water coil performances (heating/cooling): 2%
- Water coil pressure drop (water side): max. of 10% or 2 kPa
- Radiated sound power level casing: 3 dB(A)
- Sound power level unit openings:
  - 5 dB @ 125 Hz
  - 3 dB @ 250 – 8 000 Hz
- Casing Air Leakage : same class or higher

ECC Reference documents

- Certification manual
- Operational Manual OM-5
- Rating Standard RS 6/C/005

Testing standards

- EN 1886: "Ventilation for buildings – Air handling units – Mechanical performance"
- EN 13053: "Ventilation for buildings – Air handling units – Rating & performance for units components and sections"

▼ Ventilation & Air Quality

Air Filters Class M5-F9

CERTIFY ALL

Today, people spend most of the time inside of buildings. Hence, indoor air quality is a key factor to human health. Air filters removing fine dust from the air stream are the key component in building heating, ventilation and air conditioning systems to supply air of the required cleanliness and to ensure a high level of indoor air quality. With the air filter certification program, reliable and transparent filter data are ensured to customers. On a yearly base, four different filters are selected out of the product range of each participant for testing at independent laboratories according to EN 779:2012, verifying the initial pressure drop, the filter class and the initial and minimum efficiency, as well as the energy efficiency class to Eurovent document 4/11. Additionally, with the new energy efficiency label, Eurovent provides valuable data to enable users to select the most energy efficient air filters.

Committee chair:
Dr. Thomas Caesar
Head of Filter Engineering Industrial Filtration Europe
Freudenberg Filtration Technologies SE & Co. KG

Scope of certification

- This Certification Programme applies to air filters elements rated and sold as "Medium or Fine Air Filters M5-F9" as defined in EN 779:2012 and with a front frame size of 592 x 592 mm according to standard EN 15805.
- When a company joins the programme, all relevant air filter elements shall be certified.

Certification requirements

- For the qualification procedures: 6 units will be selected and tested by an independent Laboratory selected by Eurovent Certification.
  Then each year 4 units will be selected & tested

Certified characteristics & tolerances

- Filter class: no tolerance.
- Initial pressure drop: +10% + 5 Pa (minimum 15 Pa)
- Initial efficiency for F7 to F9: 10% – point
- Discharge efficiency for F7 to F9: 10% – point
- Annual energy consumption +10% +60 kWh/a

ECC Reference documents

- Certification manual
- Operational Manual OM-11
- Rating Standard RS 4/C/001

Testing standards:

- EN 779:2012
- Eurovent 4/21

Residential Air Handling Units (RAHU)

CERTIFY ALL

Scope of certification

This programme applies to balanced residential AHUs (supply and exhaust) with heat recovery systems such as:

- Air-to-air **plate** heat exchangers
- Air-to-air **rotary** heat exchangers
- **Heat-pumps** with a nominal airflow below 1 000 m³/h.

Certification requirement

- Qualification test campaign: 1 test per heat recovery type.
- Repetition test campaign: 1 test every 2 years for each heat recovery type.
- Units are sampled directly from selling points.

Certified performances

- Leakage class
- Aeraulic performances:
- Airflow/pressure curves
- Maximum airflow [m³/h]
- Electrical consumption [W]
- Specific Power Input SPI [W/(m³/h)]
- Temperature efficiency / COP
- Performances at cold climate conditions
- SEC (Specific Energy Consumption) in [kWh/(m².an)]
- A-weighted global sound power levels [dB(A)]

Tolerances

- Leakage class 0
- Airflow +/-10%
- Temperature efficiency –3%-point
- Temperature efficiency at cold climate –6%-point
- COP / EER –8%
- A-weighted global sound power levels +2dB(A)
- Electrical consumption +7%
- Specific Power Input SPI +7%

ECC Reference documents

- Certification manual
- Operation manual OM-16
- Rating standard RS 15/C/001

Testing standards:

- European standard EN 13141-7:2010

Cooling Towers

The importance of air conditioning and industrial cooling is constantly increasing in modern architecture and industrial process cooling. The human perception of comfort and the new challenges to reduce the electrical power consumption and CO_2 footprint have designers striving for optimal system performances with the highest possible efficiencies. Reliable thermal performances are crucial to ensure these best efficiencies which are typical for cooling circuits driven by evaporative cooling equipment. On a yearly basis, one random picked cooling tower of each Eurovent-CTI certified product line will be full scale thermal tested by applying the CTI standard 201.

Eurovent Certita Certification guarantees the consistency of thermal testing and manufacturing of European and non-European companies that subscribe to the program.

Committee chair:
Mr Rob Vandenboer
Product Manager, Quality Manager
Evapco Europe, BVBA

The first ECC / CTI collaborative certification program for Cooling Towers

The Eurovent Certification Company (ECC, Brussels, Belgium) is pleased to announce the Certification programme for cooling tower thermal performance developed in cooperation with the Cooling Technology Institute Est.1950 (CTI, Houston, Texas, USA). The scope of the program includes standardized model lines for open circuit cooling towers, typically factory assembled. Standardized model lines are composed of individual models that are required to have published thermal rating capacities at corresponding input fan power levels.

Thermal performance certification via this program offers a tower buyer assurance that the capacity published for the product has been confirmed by the initial and on-going performance testing per the requirements of the program using CTI STD-201. It also offers for regulators of energy consumption related to cooling towers, that the capacity of the towers has been validated. Minimum energy efficiency standards such as ASHRAE 90.1, which requires cooling tower energy efficiency validation by the CTI certification process, are used by governments and by green building certification programs such as LEED™.

Scope of certification

This Certification Programme for Cooling Towers applies to product ranges (or product lines) of Open-Circuit series and Closed Circuit Cooling Towers that:

- Are manufactured by a company whose headquarter or main facility are located in Europe, Middle-East, Africa or India. After getting the Eurovent Certification, the CTI certificate could be requested.
- Have already achieved and hold current certification by the Cooling Technology Institute (CTI) according to CTI STD-201.

Certification requirements

For the qualification & yearly repetition procedures our internal auditor visits the production place and reviews the conformity of Data of Records. One unit per range is selected and tested by an independent test agency.

Certified characteristics & tolerances

- Certified characteristic shall be per CTI STD-201
- Entering wet bulb temperature: 10°C to 32.2°C (50°F to 90°F)
- Cooling range > 2.2°C (4°F)
- Cooling approach > 2.8°C (5°F)
- Process fluid temperature < 51.7°C (125°F)
- Barometric pressure: –91.4 to 105.0 kPa (27" to 31" Hg)

ECC Reference documents

- Certification manual
- Operational Manual OM-4-2015
- Rating Standard RS 9/C/001-2014

Testing standards

- CTI STD-201 RS
- ECC OM-4-2015

▼ Process Cooling & Food Cold Chain

Cooling & Heating Coils

Heating Cooling Coils (HCCs) which enable the conditioning of different zones and flexibility in application in buildings are generally employed in compact and central station AHU. To meet the required extra capacity in various processes, they are also used as heating or cooling devices.

With the application of these coils to high energy efficient heat recovery systems, the entire system becomes more compact as well as it avoids occupation of large spaces. Besides, they can be applied to Variable Air Volume (VAV) systems used for conditioning of hospitals, shopping centers and convention facilities.

The Certification programme for the HCCs has increased integrity and accuracy of the industrial performance ratings which provides clear benefits for end users who can be confident that the product will operate in accordance with design specifications. Also, by means of this certification programme users can collect reference data on the fundamental characteristics of the HCCs, such as capacity, pressure drop, mass flow complying with the standard of EN 1216.

Committee chair:
Engin Söylemez
R&D Test Engineer, Friterm A.Ş

Scope of certification

The rating standard applies to ranges of forced circulation air cooling and air heating coils as defined in ENV1216.

Certification requirements

- Qualification and repetition procedures: units declared will be selected and tested by an independent laboratory.
- The number of units will depend on the variety of coil material configurations and their applications for the applied range.
- The selection software will be verified in comparison with the test results.

Certified characteristics & tolerances

- Capacity: –15%
- Air side pressure drop: +20%
- Liquid side pressure drop: +20%

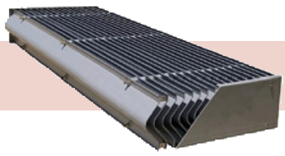
ECC Reference documents

- OM-9
- RS 7/C/005

Testing standards

- ENV 1216

Drift Eliminators



Scope of certification

The Certification Programme for Drift Eliminators applies to Drift Eliminators used for evaporative water-cooling equipment.

Certified characteristics & tolerances

The following characteristics shall be certified by tests:
- For counter-flow and cross-flow film fill, the average drift losses of the two tests at 3.5 m/s are less than 0.007% of circulating water flow rate.
- For cross-flow splash fill, the average drift losses of the two tests at 3 m/s are less than 0.007% of circulating water flow rate.

No tolerance will be applied on the average drift losses.

ECC Reference documents

- Certification manual
- Operational Manual OM-14
- Rating Standard RS 9/C/003

Testing standards

- CTI ATC-140

▼ Process Cooling & Food Cold Chain

Liquid Chilling Package & Heat Pumps

Certification is a strong way to supply safe information in the right language

Offering guaranteed performances to customers has always been a fundamental benefit thanks to the accredited independency of this certification program. Today the need for certified performances is emphasized by several directives and it is essential for customers to:

- demonstrate the high performance efficiency of their buildings,
- compare safety performances of the products selected with the requirements of the regulations implementing ERP Ecodesign & labelling directives,
- be sure of the return of their investment or energy savings,
- have the ability to compare fairly between chillers, heat pumps or other type of heaters.

In addition to being certified, performances must be seasonal, in line with the new regulations, and assessed according to the new harmonized standards as soon as they apply.

This program is also a great opportunity for fruitful exchanges between independent laboratories, certification body and manufacturers. It also facilitates the understanding and application of new regulations or standards in a regulatory context in perpetual evolution.

A certification is a guarantee of fair competition (for customers/manufacturers). It also helps increase the number of applications using RES, and represents a commitment in the reduction of consumption and emissions.

Didier Perales
Manager of Technical Relations & Concept Projects
CIAT Group France

ECC Reference documents

- Certification manual
- Operational Manual OM-3
- Rating Standard RS 6/C003 - RS 6/C/003A

According to New Regulations for Space heaters Eco Labelling No 811/2013 - ErP No 813/2013.

Seasonal efficiency for heating (η_s) for Chillers & Heatpumps with a design capacity below 70kW is certified since 26 September 2015. (For units above 70kW it is optional).

Scope of certification

- This programme applies to standard chillers and hydronic heat pumps used for heating, air conditioning and refrigeration.
- They may operate with any type of compressor (hermetic, semi-hermetic and open) but only electrically driven chillers are included.
- Only refrigerants authorised in EU are considered. Chillers may be air cooled, liquid cooled or evaporative cooled.
- Heating-only hydronic heat pumps, 60 Hz units and Higher capacities (between 600 kW and 1500 kW) units can be certified as an option.

Certification requirements

Qualification and repetition: a certain number of units will be selected by Eurovent Certification and tested every year, based on the number of ranges and products declared.

Certified characteristics & tolerances

- Cooling & heating capacity and EER & COP at full load: < −5%
- Performance SCOP & Seasonal Efficiency for Heating η_s: automatically rerated when Part Load efficiency criteria fails
- Seasonal Efficiency ESEERfor cooling: automatically rerated when Part Load efficiency criteria fails
- A-weighted sound power level: > +3 dB(A) (> +2 dB(A) for units with Pdesignh below 70kW)
- Water pressure drop: +15%

Testing standards

- Performance testing: EN 14511
- Seasonal Performance testing: EN 14825
- Sound testing: EN 12102

Process Cooling & Food Cold Chain

Heat Exchangers

Air coolers for refrigeration

Dry coolers

Air cooled condensers

The purpose of the Eurovent "Certify-All" certification programme for heat exchangers is to encourage honest competition and to assure customers that equipment is correctly rated.

The programme covers 3 product groups:
- Unit Air Coolers
- Air Cooled Condensers
- Dry Coolers

The "Certify-All" principle ensures that, for heat exchangers, all models in the three product categories are submitted for certification, not just some models chosen by the manufacturer.

A product energy class scheme has been incorporated into the certification programme, based on 7 classes from "A++" to "E" in order to provide a guide to the best choice of product: this enables the user to minimize life-cycle costs, including running costs which account for a much superior sum than the initial investment cost.

Committee chair:
Stefano Filippini
Technicalmanager - LUVE

Scope of certification

The Eurovent Certification Programme for Heat Exchangers applies to products using axial flow fans. The following products are excluded from the Eurovent Certification Programme for Heat Exchangers:

- Products units using centrifugal type fans.
- Units working at 60 Hz

In particular, the following products are also excluded from the Eurovent Certification programme for Dx Air Coolers and Air Cooled Condensers:
- Products using R717 refrigerant (ammonia), CO_2, and refrigerants with high glide like R407C or without correction factors
- Product ranges of Dx Air Coolers where maximum standard SC2 is below 1.5 kW.
- Product ranges of Air Cooled Condensers where maximum standard capacity under DT1 15K is below 2.0 kW

Certification requirements

- Qualification: units selected by Eurovent Certification shall be tested in an Independent Laboratory selected by Eurovent Certification.
- Repetition procedure: units selected from regular production shall be tested on a yearly basis.

Certified characteristics & tolerances

- Standard capacity –8%
- Fan power input +10%
- Air volume flow ±10%
- External surface area ±4%
- Energy ratio R
- Energy class

For Dry Coolers:
- Liquid side pressure drop +20%

For Air Cooled Condensers and Dry Coolers:
- A-weighted sound pressure level: +2 dB(A)
- A-weighted sound power level: +2 dB(A)

ECC Reference documents

- Certification manual
- Operational Manual OM-2
- Rating Standard RS 7/C/005

Testing standards

- Thermal Performance EN 328
- Thermal Performance EN 327
- Thermal Performance EN1048
- Acoustics EN 13487

Process Cooling & Food Cold Chain

Remote Refrigerated Display Cabinets

CERTIFY ALL

Remote refrigerated display cabinets (RRDC) are the appliances for selling and displaying chilled and/or frozen foodstuff to be maintained within prescribed temperature limits.

Typically, food and beverage retailers are the direct customers of the refrigeration industry while the supermarket's customers are the end users of food and beverage retailers.

Food and beverage retailers ask for food safety and also for appliances with high-energy efficiency, supermarket's customers ask for food safety. Refrigeration industry has to face the hard challenge of satisfying both needs.

How is it possible to assure that the refrigeration appliances perform accurately and consistently to the reference standards? How is it possible to assure that what is rated by the manufacturer is properly rated?

There is only one way: It is necessary to join a globally recognized and industry respected certification program.

Eurovent Certita Certification program for RRDC is the only certification program in Europe that can assure that performance claims have been independently measured and verified. The factory audits and the product's performances tested in an independent and third-party laboratory make the difference!

Since 2011, Eurovent Certita Certification has also launched a voluntary energy label certification scheme, anticipating what only nowadays EC DG Energy is doing in the framework of Ecodesign and Energy Label Regulations. What better way to rate RRDC's energy consumption and to promote their energy efficiency?

What would you trust more: a self-declaration by the Manufacturer or what an independent, globally recognized and forerunner certification program is able to assure? Which one is better?

Maurizio Dell'Eva
Project manager
EPTA S.p.A. – MILANO (ITALY)

Scope of certification

- 100 basic model groups divided in 5 categories of remote units : semi-verticals and verticals (with doors); multi-deckers; islands; service counters; combi freezers.
- At least two references per basic model group representing 80% of sales shall be declared.
- One Bill of Material for each declared reference.

Certification requirements

- Qualification: sampling and test of one unit & Audit of one factory.
- Repetition test of one unit per brand every 6 months & Annual audit of each factory.

Certified characteristics & tolerances

- Warmest and coldest product temp. ±0.5°C
- Refrigeration duty (kW) 10%
- Evaporating temperature –1°C
- Direct elec. Energy Consumption (DEC) +5%
- Refrigeration elec. Energy Cons (REC) +10%
- M-Package Tclass : ±0.5°C
- Total Display Area (TDA) –3%

ECC Reference documents

- Certification manual
- Operational Manual OM-7
- Rating Standard RS 14/C/001

Testing standards

- EN ISO 29953 and amendments

Ventilative cooling in shopping centers' retrofit

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Because of the customers' need of best possible comfort condition and satisfaction, shopping centers are conditioned by means of basic HVAC systems, often without considering the potential of natural ventilation to reduce energy consumption related to cooling and ventilation. Within the European project CommONEnergy, EURAC researchers are dealing with ventilative cooling strategies as retrofit solutions for shopping centers.

Keywords: Ventilative Cooling Potential, Ventilate Cooling Design Method, Shopping centers retrofit, Integrated Modelling Environment (IME), Cooling Energy Savings.

Introduction

Nearly all retail locations use full air HVAC systems to ensure adequate air exchange, primarily for hygienic reasons, and indoor comfort temperatures. Considering the trend towards longer opening hours and increased number of opening days, the electricity consumption due to ventilation and conditioning systems is expected to continue to rise across Europe.

Specific inefficiencies, related to cooling and ventilation topics, concern mainly energy losses in ventilation, absence of free cooling strategies and unmodulated airflow for different periods of the day.

Generally, mechanical ventilation systems are preferred to natural ventilation strategies because more controllable and reliable, since they are not affected by the uncertainty of natural forces. Thereby, within the design process the team never focused neither on opening sizing nor on control strategies definition for natural or hybrid ventilative cooling systems. So far, shopping centers design has included a small proportion of automated windows, sized for smoke ventilation only. Depending on the external climate conditions, acceptable levels of thermal comfort and IAQ can be reached without or with partial use of the mechanical systems, leading also to operational and maintenance cost savings.

According to the British Council of Shopping Centre (BCSC, 2012), in the UK climate annual electricity usage is known to be up to 50% less where natural ventilation is employed over mechanical ventilation depending on the mechanical systems. Furthermore, natural ventilation uses typically between 2–5% less plant space versus 5–8% used by HVAC, which can be utilized and improve net to gross ratios. Therefore, the CommONEnergy project (http://www.commonenergyproject.eu/) investigates ventilative cooling strategies among the energy efficient solutions for the retrofit of shopping centers' common areas (shop galleries and atria).

As case studies we referred to the reference buildings (**Table 1**) identified within the CommONEnergy project as representatives of the EU building stock, showing the typology they belong to (Bointer,R, 2014), and the climate classification according to (Cory S., 2011).

Technical components

Technical components for ventilative cooling are already available on the market and, according to the IEA Annex 62 state-of-the-art analysis, are structured in:

- Airflow Guiding Ventilation Components, such as windows, skylights, doors, dampers, flaps, louvres plus special effect ventilators;
- Airflow Forcing Ventilation Components, such as such as buoyancy chimneys, solar chimneys, atria, Venturi roofs, powerless roof ventilators, wind towers and wind scoops;
- Passive cooling elements, such as convective cooling components, adiabatic cooling components, phase change components

Some of the component and concept available on the market are shown in **Figure 1**.

Design concept

A ventilative cooling strategy involves the whole building envelope. Vents and openings can be located on both façade and roof to exploit buoyancy due to temperature difference between shops and central spaces and along the atrium height. Applying ventilative cooling is dependent on building design and indoor spaces layout. Where implementing ventilative cooling strategies, it is important to take into account the following features regarding shopping centers' internal layout:

- Interconnected galleries and atria;
- Building shape, number of levels and ceiling height;
- Location of parking areas, possibly avoiding the inlet of polluted air.

The assessment of the most suitable ventilative cooling strategy should also consider that, from an architectural point of view, most of the shopping centers are generally similar to atria with large open spaces between shops that are often heated, cooled and ventilated separately from the mall central space. The shops are connected with the common central areas by means of open doorways through which natural air exchange occurs bridging the two spaces.

For instance, common central areas can be seen as unconditioned buffer zones that temperate the outside and inside climate, resulting in more relaxed ranges of interior conditions respect to selling area. The exploitation of airflow driven both by thermal buoyancy and by wind pressure can prevent overheating within these buffer zones if solar radiation is properly controlled.

As last important consideration, typically the common areas are managed by a unique referent (e.g. owner, energy manager), which is also the one who makes the decisions during a retrofit easing the retrofit process. Furthermore, there is a higher degree of freedom in the common areas design compared to the "leasing" area,

Table 1. List of reference shopping centers' typology, location and climate (HD=heating dominated, CD= cooling dominated, H&CD= mixed dominated).

ID	Name of the shopping center	Shopping Center typology	Location	Country	Climate
CS	City Syd	Medium Shopping center	Trondheim	NO	HD
ME	Mercado del Val	Specialized and Others	Valladolid	ES	H&CD
GE	Genova Ex- Officine Guglielmetti	Specialized and Others	Genoa	IT	CD
KA	Centro Commerciale Katané	Medium Shopping center/ Hypermarket	Catania	IT	CD
MO	Modena Canaletto	Specialized and Others	Modena	IT	CD
DO	Donau Zentrum	Very Large Shopping center	Wien	AT	H&CD
BC	Brent Cross	Very Large Shopping center	London	UK	H&CD
ST	Studlendas	Small Shopping center	Klaipeda	LT	HD
GB	Grand Bazar	Small Shopping center	Sint-Niklaas	BE	H&CD
WA	Waasland Shopping Center	Large Shopping center	Antwerp	BE	H&CD
PA	Pamarys	Small Shopping center/ Hypermarket	Silute	LT	HD

where franchising companies characterized by their own standardized protocols, restraint the applicability of overall retrofit solutions.

Ventilative cooling potential

The potential of ventilative cooling strategies is evaluated for each reference building using the ventilative cooling potential tool (Belleri A., 2015). The tool, which is under development within the IEA EBC Annex 62 research project (IEA EBC Annex 62 - Ventilative cooling, 2014-2017), takes into account also building envelope thermal properties, internal gains and ventilation needs.

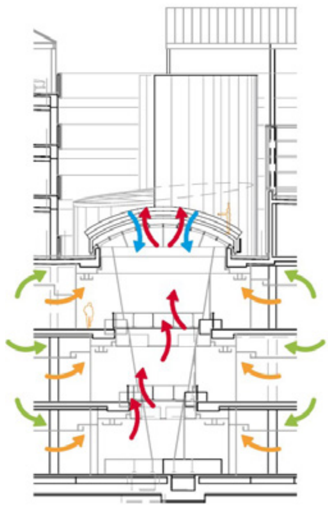
For each hour of the annual climatic record of the given locations, an algorithm splits the total number of hours when the building is occupied into the following groups:

- Ventilative Cooling mode [0]: no ventilative cooling is required because heating is needed;
- Ventilative Cooling mode [1]: natural ventilation can be exploited to meet the minimum ventilation rate required by the EN 15251 on indoor environmental quality;
- Ventilative Cooling mode [2]: ventilative cooling is needed and the ventilation rates needed to maintain indoor air conditions within the comfort ranges (calculated according to the adaptive comfort model – EN 15251:2007) are assessed according to the energy balance;
- Ventilative Cooling mode [3]: ventilative cooling is not useful and nighttime ventilation should be considered.

The graph in **Figure 2** reports the results of the ventilative cooling potential analysis for each reference building considering a specific lighting gain level of 30 W/m². The higher is the level of specific lighting gains the high is the cooling need and consequently the energy savings related to the use of ventilative cooling potential are higher. A parametric analysis for the definition of the ventilative cooling potential according to different levels of specific lighting gains is reported in (Avantaggiato M., 2015). Direct ventilative cooling strategy can potentially assure thermal comfort for the whole hours within a year in Trondheim and for more

(a)

(b)



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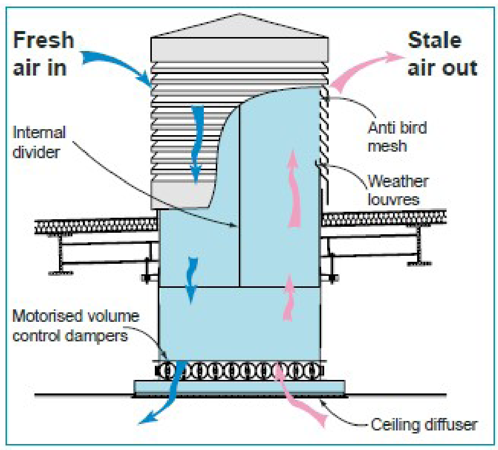

(d)

Figure 1. (a) Skylight window installation at Ernst-August Galerie in Hannover. Source: http://www.hs-montagen.de/archiv-montage-fassade-hannover, (b) Chain actuators for top hung windows. Source: http://www.topp.it, (c) Ventilation concept of the Ernst-August galerie in Hannover. Source: www.windowmaster.com, (d) Wind catcher application on Tesco supermarket. Source: Monodraught, 2015.

than 90% in seven climates over eleven. The cooling dominated climates of Genoa, Catania and Modena are the ones with the highest percentage of direct ventilative cooling with increased airflow rate potential use (ventilative cooling mode [2]).

Design method

Naturally ventilated buildings require a specific design service dealing with building shape, internal layout distribution and airflow paths along the building. Therefore, natural ventilation design shall be ideally part of an integrated design process since the early design stages.

Since shopping centers are mostly object of partial retrofitting actions, building shape cannot be modified and internal layout can be only partially modified. However, typical architectural archetypes of shopping centers such as atria and galleries revealed to be suitable for the integration of natural ventilation strategies.

Based on climate analysis previously described, the most suitable ventilation strategy can be assigned by identifying possible airflow paths and the air intake and exhaust locations. It is necessary to integrate the natural ventilation in the overall existing building design, especially in relation to area partitioning (shops, common areas, areas closed to visitors), air tightness, building geometry, HVAC system and envelope porosity.

Designers are faced with many and sometimes conflicting requirements by designing natural ventilation in shopping centers, related to urban regulation, indoor environment quality, aesthetic appearance, building standard and regulations (acoustic, fire, zoning..), safety, operative and maintenance costs and the need to maintain the shopping center open during the retrofitting works. Those constraints are related to the design complexity and can be easily identified through an integrated design process by discussing with design team, building owner, energy manager and other actors directly involved in the building design.

The scheme in **Figure 3** represents the design process adopted to define ventilative cooling solution.

Considering that an indoor space of a shopping center highly interacts among each other, a multizone based analysis of airflows is needed to evaluate the ventilative cooling strategy effectiveness and to assess potential energy savings.

The Integrated Modelling Environment under development within the CommONenergy project allows to predict airflows throughout a building by performing coupled thermal and airflow building dynamic simulations. Furthermore, by gathering in the same simulation model (i) building (ii) HVAC and refrigeration systems and components (iii) daylighting/shading/artificial lighting (iv) storage technologies (v) RES technologies (vi) natural ventilation and infiltration (vii) non-conventional envelope solutions (vegetation, multi-functional coating and materials, etc.), the Integrated

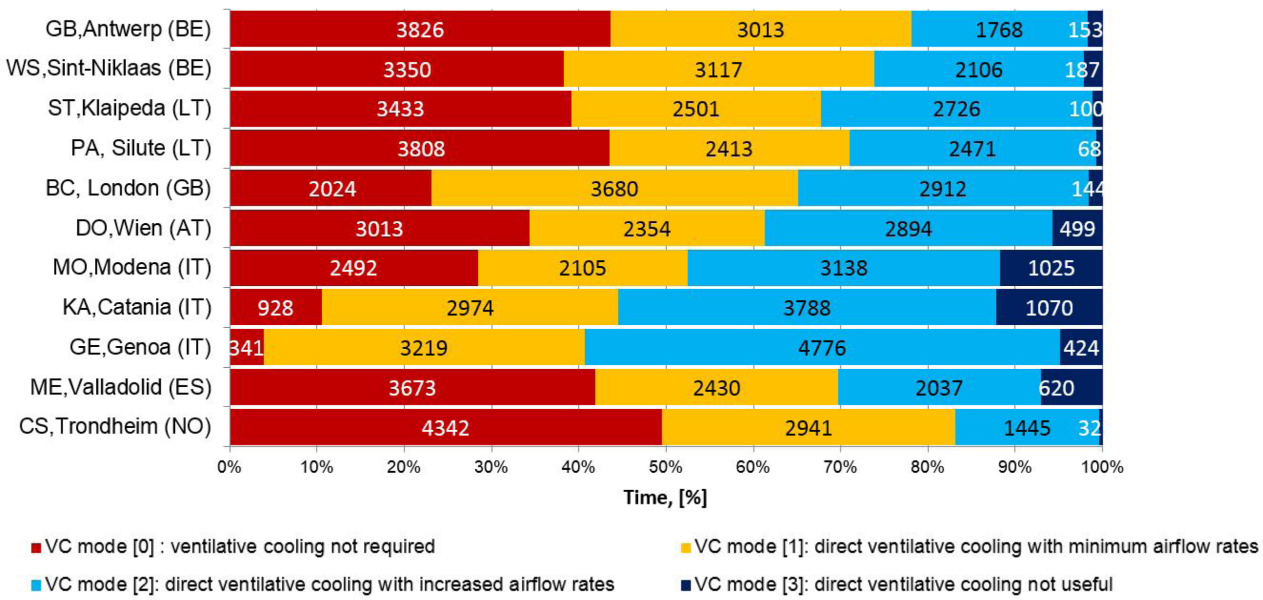

Figure 2. Percentage of hours within a year when direct ventilative cooling is required, useful or not useful in the eleven reference case climates when the specific lighting power is 30 W/m².

Modelling Environment allows to test the energy performance of ventilative cooling solutions in combination with other active or passive solution and to elaborate effective solution sets and control strategies.

Cost optimization can be performed by properly sizing each technical component (openings, actuators type, vents etc.). The modelling results are then used as basis for discussion with the building owner on the definition of the retrofit solution and its installation mode within the shopping center.

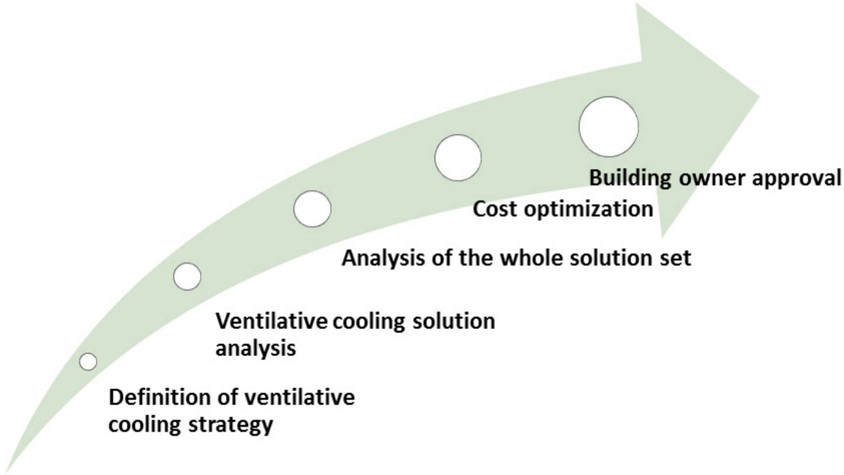

Figure 3. Ventilative cooling solution design process.

Conclusion

The CommONEnergy project investigates ventilative cooling strategies as energy efficient solutions for the retrofit of shopping centers. The paper investigates the retrofit opportunities to exploit ventilative cooling in retail buildings taking into account climate condition, architectural features and level of retrofit. As case studies we referred to the reference buildings identified within the CommONEnergy project as representatives of the EU building stock. Typical architectural archetypes of shopping centers such as atria and galleries revealed to be suitable for the integration of natural ventilation strategies. A climate analysis showed that the ventilative cooling potential is suitable for all the eleven climates analyzed with difference in the percentage of hours of utilization and in the airflows needed to offset the internal gains.

A ventilative cooling strategy involves the whole building envelope as vents and openings can be located on both façade and roof to exploit buoyancy due to temperature difference between shops and central spaces and along the atrium height. Technical components needed for ventilative cooling are already available on the market but the performance of a ventilative cooling strategy is strictly dependent on building design and indoor spaces layout.

Considering that an indoor space of a shopping center highly interacts among each other, a multizone based analysis of airflows is needed to evaluate the ventilative cooling strategy effectiveness and to assess potential energy savings. The Integrated Modelling Environment under development within the CommONenergy project allows predicting airflows throughout a building by performing coupled thermal and airflow building dynamic simulations. ■

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Single-sided ventilative cooling performance in a low energy retrofit




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Externally applied building envelope retrofit measures intent on upgrading thermophysical properties and air tightness performance can result in substantially modified cooling and ventilation requirements for a given internal space. Field studies presenting demonstrated performance of such situations are still relatively infrequent. The article presents findings from a case study retrofit project (zero2020 testbed) at Cork Institute of Technology in Ireland. Measured performance of an externally applied fenestration module incorporating purposed provided ventilation openings is presented and discussed. Findings show that, depending on configuration, acceptable ventilations rates and internal thermal environments are possible using a single sided ventilative cooling strategy.

Keywords: retrofit, single sided ventilation, purpose provided openings, thermal comfort, zero2020 testbed.

Introduction

Ventilative cooling coupled with exposed thermal mass is widely accepted as an important strategy for reducing summer overheating in non-domestic buildings. Extended monitoring has shown that naturally ventilated buildings typically use less than 50% of the corresponding energy consumption of air conditioned buildings and assessment of ventilative cooling techniques in Europe have shown they may contribute highly to reducing the cooling needs of buildings (Kolokotroni et al, 2008) and be an effective tool for tackling climate change adaptation in existing buildings. Furthermore, increased ventilation rates can also lead to improved work performance. Recently, focus for market activation in the construction sector has shifted towards dealing with the overhaul of the existing building stock. The Irish National Energy Efficiency Action Plan 2013–2020 report has identified refurbishment of existing public sector buildings as a key focus. The report states that there are over 10,000 existing public sector buildings in Ireland. In responding to these external drivers Cork Institute of Technology in Ireland (CIT) have recently completed a pilot project/research testbed, zero2020, for the low energy retrofit of their existing 29,000 m² teaching building constructed in 1974. The retrofit pilot project covered 1.5% of the total building floor area and is shown in **Figure 1**. At both concept and design stage there were no guidelines within the Irish context upon which to base performance targets to achieve a near zero energy building (NZEB) through retrofit.

The design proceeded along a simple strategy of firstly, ensuring compliance with the environmental specification for occupant comfort and secondly to achieve the best fabric and energy performance subject to constraints imposed by budgets and retrofit/structural limitations. The final solution consisted of design and installation of a structurally independent external envelope solution. This resulted in U-values for opaque element 3 times better than current regulations and glazing U-values 6 times better. Further details of the design and specification of the retrofit solution can be found in (O'Sullivan et al. 2013). The objective of this article is to present measured performance of the retrofitted single sided natural ventilation system that utilises a purpose provided slot louvered opening (see **Figure 2**). Ventilation rate performance along with objective and subjective thermal comfort performance of the retrofit building have been experimentally investigated.

Purpose provided ventilative cooling components

For most enclosed spaces in the existing building (left of **Figure 1**) the ventilation system is based on single sided top hung pivoting window sections. There is generally one opening window per structural grid. In the retrofit space fenestration system, the ventilation module uses a flush faced external louvre with individual air inlet sections with 2 ventilation sections per structural grid. On the internal side of the slot louvres there are automated high level insulated doors and manual low level insulated doors providing different control mechanisms. The installed slot louvre system has a net 50% free open area for airflow and overall structural opening dimensions are 0.30 m (w) x 1.60 m (h) with a net opening area of 0.102 m² (e.g. in a single cellular office space there are 2 openings at low level and 2 openings at high level in the test space). Each of the ventilation openings has 17 airflow slots across

Figure 1. External facades; existing 1974 building (left) and retrofitted zero2020 test-bed building (right) where red indicates the location of the thermal comfort study and yellow indicates the location of the ventilation rate performance experiments.

Figure 2. Ventilation system configurations, from left to right: existing building window (CS.01), Retrofit space no ventilation scenario (RS.01), bottom manual louvre only (RS.02), top automated louvre only (RS.03), both louvres opened (RS.04).

the louvre bank. The overall thermal transmittance performance of this unit including doors and linear transmittance is 0.84 W/m²k. The new fenestration module resulted in an overall opaque/transparent area ratio reduction of 20%. Unwanted ventilation through adventitious openings has also been greatly reduced. The retrofit envelope air permeability was tested in accordance with BS EN 13829:2001. The envelope achieved an air permeability of 1.76 (m³/hr)/m² at 50Pa building pressure. The existing structure was measured as 14.77 (m³/hr)/m². In order to quantify the actual range of ventilation rates achievable 38 tracer gas concentration decay tests were completed as part of an experimental field study during summer 2013. The results are summarised in the following section.

Ventilation & thermal performance in cooling mode

To investigate ventilation performance in cooling mode in the retrofitted space an isolated, 6.0 m² west facing, first floor cellular office (highlighted in yellow in **Figure 1**) employing single sided ventilation was used to measure ventilation rates under various boundary conditions. A similar space in the existing building was used for comparative purposes. The field tests were completed in accordance with the procedures set out in ASTM E741-11. Details can be found in (O'Sullivan et al. 2014). All ventilation rate values presented have been calculated using the decay regression technique. **Figure 3** presents boxplot distributions of results from all tracer gas tests completed under each of the different operating configurations in **Figure 2**.

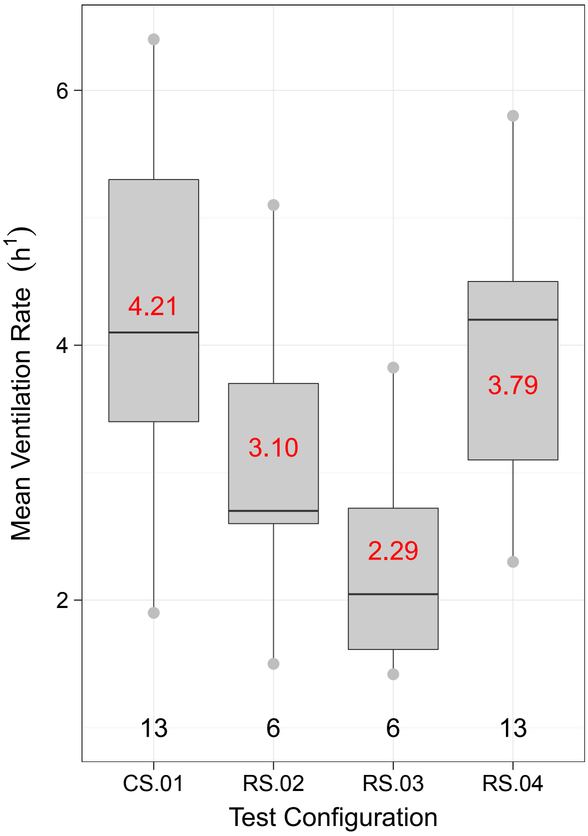

Figure 3. Boxplot distributions of measured mean ventilation rates grouped according to configurations in Figure 2 above (no of tests shown for each, mean ACH shown in red, median shown as bar).

The results show that for a similar spread of boundary conditions the existing control space (top hung window, CS.01) has consistently higher time-averaged ventilation rates with a mean value of 4.2 h^{-1} and standard deviation of 1.5 h^{-1}. In the retrofit space the full height configuration had the best performance profile with a mean value of 3.8 h^{-1} and standard deviation of 1.0 h^{-1} indicating a slightly more concentrated spread of results. Based on the guideline values for indoor air quality classification in BS EN 13779:2007 both the existing control space and retrofit space time averaged ventilation rates can be classified as IDA1 (High). Ventilation rate values were on average lower for the low level RS.02 & high level RS.03 configurations although there were individual instances of values above 5.0 h^{-1}.

As well as ventilation rate performance the potential risk to overheating was also evaluated for each ventilation configuration. Indoor air temperature is often used as an index for evaluating long term risk of overheating in buildings. The extent of exceedance of acceptable conditions is often based on the percentage of annual occupancy hours with indoor air temperatures above a reference exposure threshold value compared to a maximum acceptable percentage exceedance (i.e. 5% of hours above 25 °C for CIBSE, 1% above 28 °C for BRE). To investigate long term performance of the ventilative cooling system, indoor air temperatures were recorded in the single cell retrofit office (highlighted in yellow in **Figure 1**) during an extended period of warm summer conditions (May to October 2013). A range of different configurations were employed in the office during this time. **Figure 4** presents monthly binned percentage of hours' exposure for different reference threshold value. There was some overheating present during July, even with some night cooling in place but in general conditions were acceptable according to the criteria proposed. It should be noted that the percentage will reduce when the full annual hours are factored in.

Thermal comfort perception

In order to evaluate the thermal perception potential of the thermally decoupled low energy space and ventilative cooling system a subjective thermal comfort study was designed and carried out in May 2015 (O'Donovan et al, 2015). The study evaluated all four of the retrofitted ventilation configurations shown in **Figure 2**. The study gathered feedback from 35 participants (10 females, 25 males) as to thermal environment during controlled tests in the open plan seminar room of the building. This is a 42 m² first floor, north facing room employing single sided ventilation (see red in **Figure 1**). Participant feedback on perceived thermal state during the four tests was gathered using two standardised questionnaires based on ISO 10551.

Objective continuous environmental data was also gathered in order to calculate predicted response of participants for each test using the Predicted Mean Vote (PMV) index. **Table 1** indicates the ISO 7730 categories used in this comparison where the values presented are for cooling season performance only. The study was designed to evaluate the capabilities of all ventilation configurations to provide thermal comfort in a simulated overheating scenario, where before each test the seminar room was preheated to 26°C (±1°C).

Figure 5 presents predicted (objective) and subjective frequency of thermal vote for each configuration. Configurations RS.02 (high level only) and RS.03 (low level only) experienced the largest percentage of neutral responses (40%, 43%) with mean thermal sensation votes of –0.40 and –0.49 respectively (Category B). The full height opening configuration (RS.04) had a mean vote of -1.06 putting it outside all ISO7730 thermal environment categories. Subjectively no configuration tested achieved Category A (see **Table 1**).

Table 1. Categories of a thermal environment.

Category	PMV	t_o (°C)
A	-0.2 < PMV < +0.2	24.5 ± 1
B	-0.5 < PMV < +0.5	24.5 ± 1.5
C	-0.7 < PMV < +0.7	24.5 ± 2.5

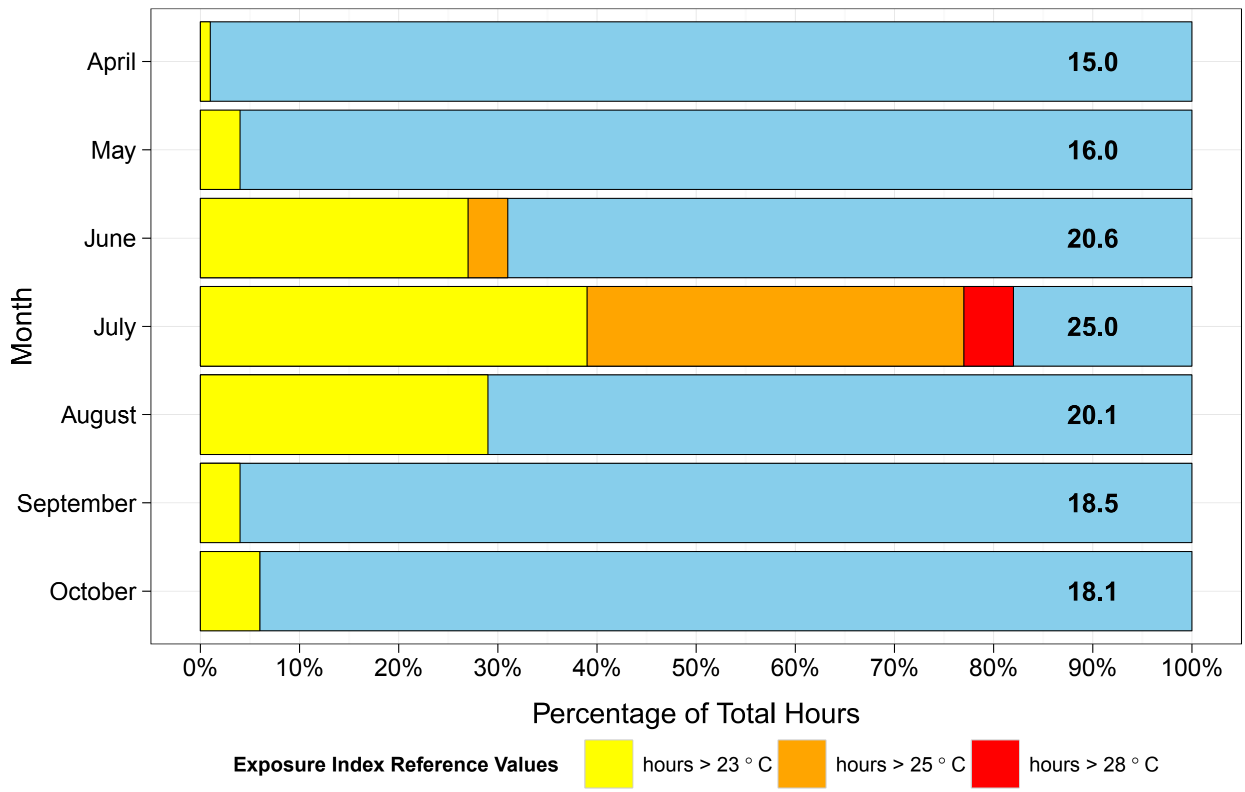

Figure 4. Percentage time exceedance of long term index reference values during extended cooling period in 2013 (Monthly 95th percentile T_{ex} values shown in each month).

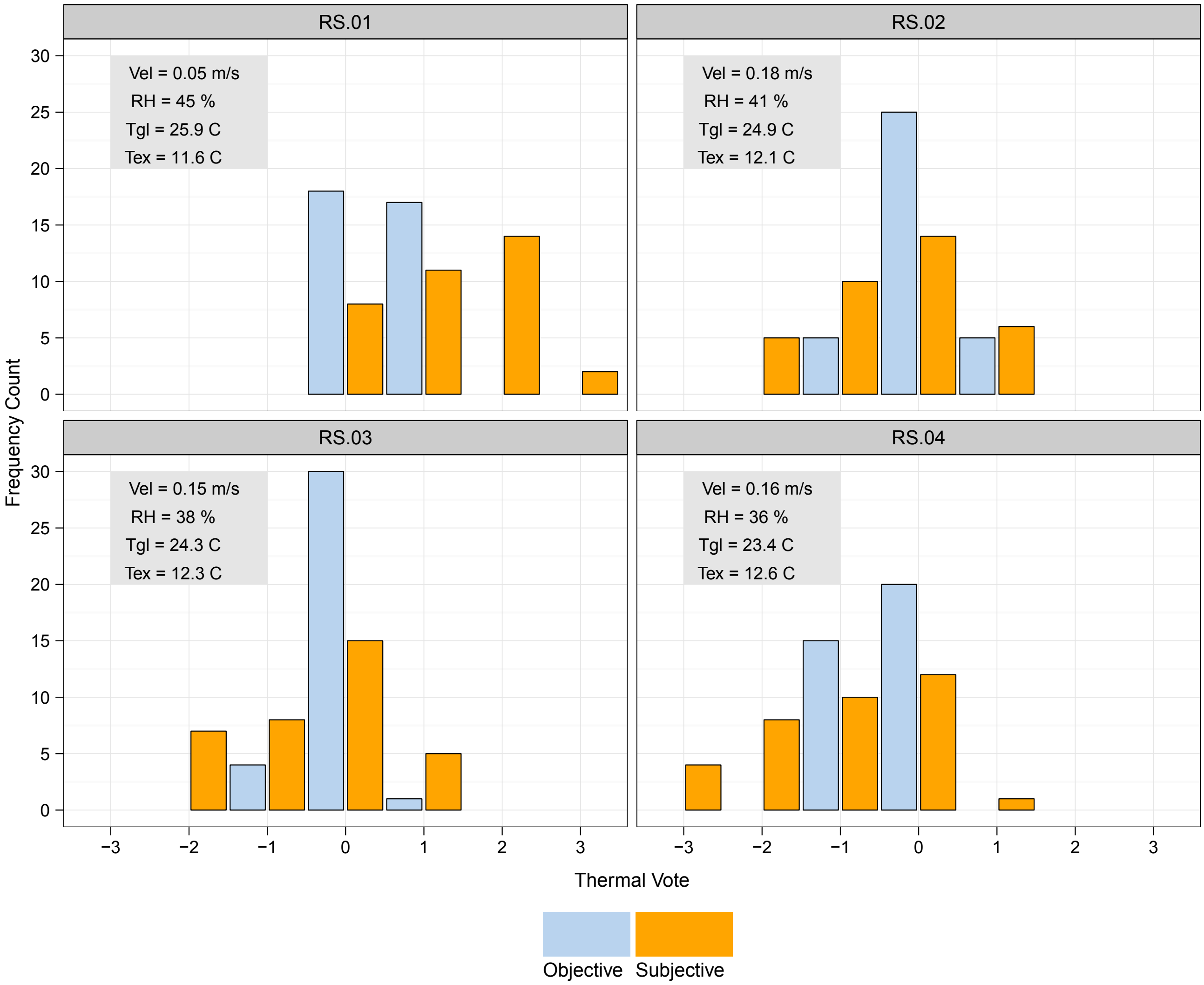

Figure 5. Results thermal comfort study showing objective and subjective thermal sensation votes for retrofitted space ventilation configurations shown in Figure 2 (Vel = Indoor air velocity, Tgl = Indoor Globe Temperature, Text = External Air Temperature, RH = Relative Humidity).

Conclusion

Overall good ventilation rates were achievable in the retrofit space with the new purpose provided slot louvred openings operated using a single sided ventilation strategy. Although there was a reduced envelope temperature difference due to the improved thermal performance of the building resulting in weaker buoyancy forces compared with the existing building the large opening height of the RS4.0 configuration seemed to ensure comparable performance. The thermal comfort study suggests that using high level only openings or low level only openings provided the most satisfactory thermal environments. It is therefore possible to achieve effective ventilative cooling using certain configurations but care must be taken when low external air temperatures are present using large openings that provide air flow directly to the occupied zone resulting in potential overcooling and local thermal discomfort. ■

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Ventilative cooling of a seminar room using active PCM thermal storage


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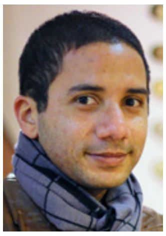
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One-year monitoring results of environmental conditions in a UK seminar room where the Cool-phase® ventilation and PCM battery system has been installed indicate thermal comfort and good indoor air quality throughout the year. CFD analysis indicates that air temperature and air distribution is uniform at occupants' level.

Keywords: ventilative cooling, seminar room, thermal comfort, thermal storage, phase change materials, operational data.

Thermal comfort and indoor air quality requirements for the case-study

Thermal comfort evaluation is usually based on current guidance on avoiding overheating in buildings. In the UK, current guidance for schools is provided by the Education Funding Agency [1]; it includes guidelines on ventilation, thermal comfort and indoor air quality, including the Services Output Specification [2], the Baseline Design Environmental Services and Ventilation Strategy [3] and the Building Bulletin 101 [4]. These documents are aligned with CIBSE's guidance on prevention of summertime overheating [5,6 ,7 ,8] which refer to calculations according to European Standard BS EN 15251 and UK Building Regulations Parts L (Conservation of Fuel and Power) and F (Ventilation) [9].

Until recently overheating criteria for schools were based on fixed air temperature (28°C which can be exceeded for 120 hrs and 32°C not to be exceeded) outside the heating season and during the occupied period from 1st May to 30th September.

Currently, the adaptive thermal comfort approach is used which follows the methodology and recommendations of European Standard EN 15251 to determine whether a building is overheated, or in the case of an existing building whether it can be classed as overheating. The new criteria are based on a variable (adaptive) temperature threshold that is generated from the outside running-mean dry-bulb temperature. There are three criteria, two of which must be met for compliance, as follows [3]:

(a) Hours of Exceedence: The number of hours operative temperature exceeds the maximum acceptable operative temperature (θmax) by 1K, must not exceed 3% of the total occupied hours or 40 hours, during the five summer months.

(b) Weighted Exceedance: The sum of the weighted exceedance for each degree K above θmax (1K, 2K and 3K) is ≤ 10.0.
(c) Threshold/Upper Limit Temperature (θupp): The measured/predicted operative temperature should not exceed the θmax by 4K or more at any time.

The case-study analysed in this paper was built to comply with the older requirements so operational data are analysed following both approaches.

In terms of IAQ based on CO_2 concentration, until recently the guidance was that when measured at seated head height, during the continuous period between the start and finish of teaching on any day, the average concentration of carbon dioxide should not exceed 1,500 parts per million (ppm). This criterion is changed to the following criteria [3]:

(a) Ventilation should be provided to limit the concentration of carbon dioxide measured at seated head height in all teaching and learning spaces.
(b) Where mechanical ventilation is used or when hybrid systems are operating in mechanical mode, i.e. the driving force is provided by a fan, sufficient fresh air should be provided to achieve a daily average concentration of carbon dioxide during the occupied period of less than 1,000 ppm and so that the maximum concentration does not exceed 1,500ppm for more than 20 consecutive minutes each day.

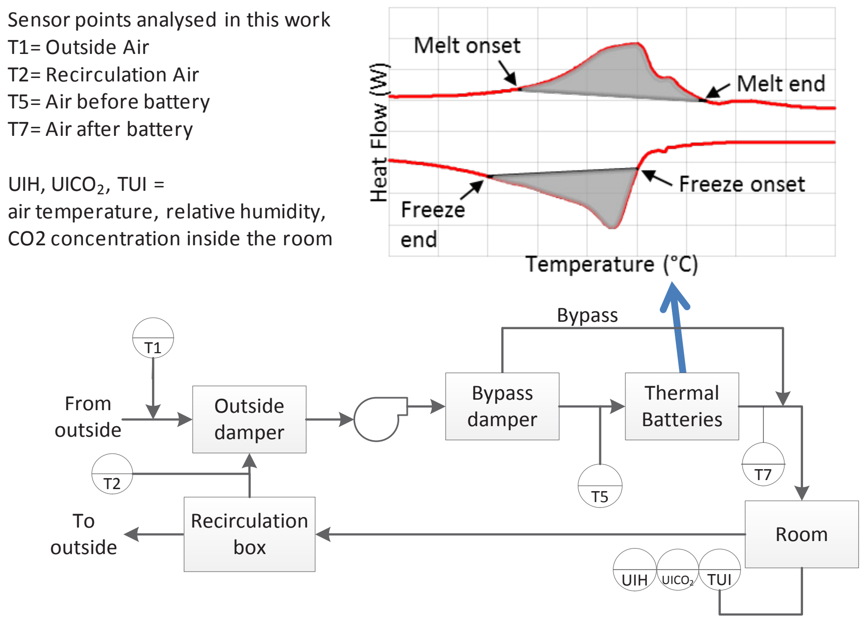

Figure 1. Schematic of Cool-Phase system with a graphical explanation of the PCM thermal battery principle of operation.

Description of the case-study computer seminar room

The case-study is a seminar room at a university campus in West England. Cool-Phase® systems have been installed in other spaces of the university but the seminar room was chosen because of its use (computer laboratory) with higher internal heat gains than other spaces. The room has a floor area of 117 m² and includes 26 desk top computers, peak occupancy of 26 students, and artificial lighting comprising of 24 luminaires each equipped with one 48 W lamp. The total internal heat gain in the room is 60 W/m². The room has one external wall facing west with U-value of 0.56 W/m² K while 23 % is glazing (U-value 1.82 W/m² K) with internal blinds. Ventilation and cooling is provided via a 8 kW Cool-Phase® unit. Heating is provided through perimeter hot water radiators and windows are operable. Climate is temperate maritime with 2,684 Heating Degree Days and 196 Cooling Degree Days; 20 year average, base 15.5°C, south west England [10].

Description of the ventilative cooling system

A Cool-Phase® system by Monodraught Ltd was installed in May 2013 to provide ventilation for indoor air quality and cool the air for thermal comfort. The Cool-Phase® system uses the concept of a thermal battery consisting of Phase Change Material (PCM) plates within the ventilation path to capture and store heat. Therefore, the thermal batteries use the latent heat property of materials to store energy, which is charged and discharged by passing air through a heat exchanger. A diagram of the system is shown in **Figure 1** where the principle of the PCM thermal battery function is shown. The system is concealed in the false ceiling and its appearance to the user is that of a conventional ventilation system with two air supply terminals and one air extract terminal. Air is drawn from outside or the room using a variable speed fan. During operational hours and depending on internal air quality (monitored through CO_2 sensors) the air is mixed with recirculated air from the room to conserve energy. The air is then directed through the PCM thermal battery to be cooled if necessary (determined by air temperature sensors and control rules) or by-passes it if cooling is not needed. Outside operational hours, ambient air is used to recharge the PCM thermal battery the duration of which is determined by air temperature sensors and control rules according to the season.

Figure 2 shows how the system works based on monitored data during one day in August 2013. The system starts with a charging-purge mode between midnight and 1:00 and continues with charging mode from 1:00 to 7:00 am. Inlet and outlet temperatures through the PCM thermal battery are decreasing with a temperature difference between them indicating the battery is charging. The system is off between 7:00 and 8:00 am when the cooling mode is initiated and continues until 21:00. In the morning (8:00-~13:00) the temperature outside the intake damper is lower than the set-point for summer (22°C) so the PCM thermal battery is by-passed. At around 13:00, set-point temperature is exceeded and the inlet air is directed to the PCM thermal battery through recirculation. Inlet air is cooled to below room temperature until shortly before 21:00 when the system is off until midnight. Maximum temperature in the room is 24.5°C below max external temperature.

System performance

Figure 3 shows temperatures in the case-study room during operational hours in the summer of 2013 (May – September). According to adaptive thermal comfort criteria, it can be observed that the system has achieved internal temperatures within the upper and lower limits and therefore complies with all conditions. Also, air temperatures do not exceed 28 or 32°C and daily average inside/outside temperature difference is less than 5°C and therefore achieves comfort according to static thermal comfort criteria.

An analysis of monitored room CO_2 concentration was carried out for the whole year that data are available. **Table 1** presents the results. Daily average concentration during the occupied period is always less than 1.000 ppm and the 1.500 ppm limit was not exceeded with the exception of one occasion for 22 min when occupancy was higher than designed and there was a conflict between IAQ and thermal comfort.

The fan energy used by the system for the year was calculated to be 90 kWh. This equates to 0.77 kWh/m²/annum. Annual electricity energy use intensity for secondary schools has a median of 51 kWh/m² [8]. This increases by 5 kWh/m² when moving from 'heating and natural ventilation' to 'heating and mechanical ventilation' buildings. CIBSE TM57 [8] presents good case-studies with cooling energy intensity of 12.5 kWh and 3.5 kWh/m².

Room temperature and air velocity distribution using CFD

In the previous section average environmental conditions in the room were reported. However, the distribution is also important to examine whether there are areas within the room that deviate from thermal comfort requirements. This was investigated using a CDF model of the room. A 3D model of the room was constructed with summer boundary conditions; the hour in July with the highest internal temperature was selected as the worst case scenario and a steady state simulation was performed with full occupancy and internal heat gains. **Figure 4** shows the air temperature at 1.2 m height (student sitting plane) and velocity fields at the plane of one air inlet.

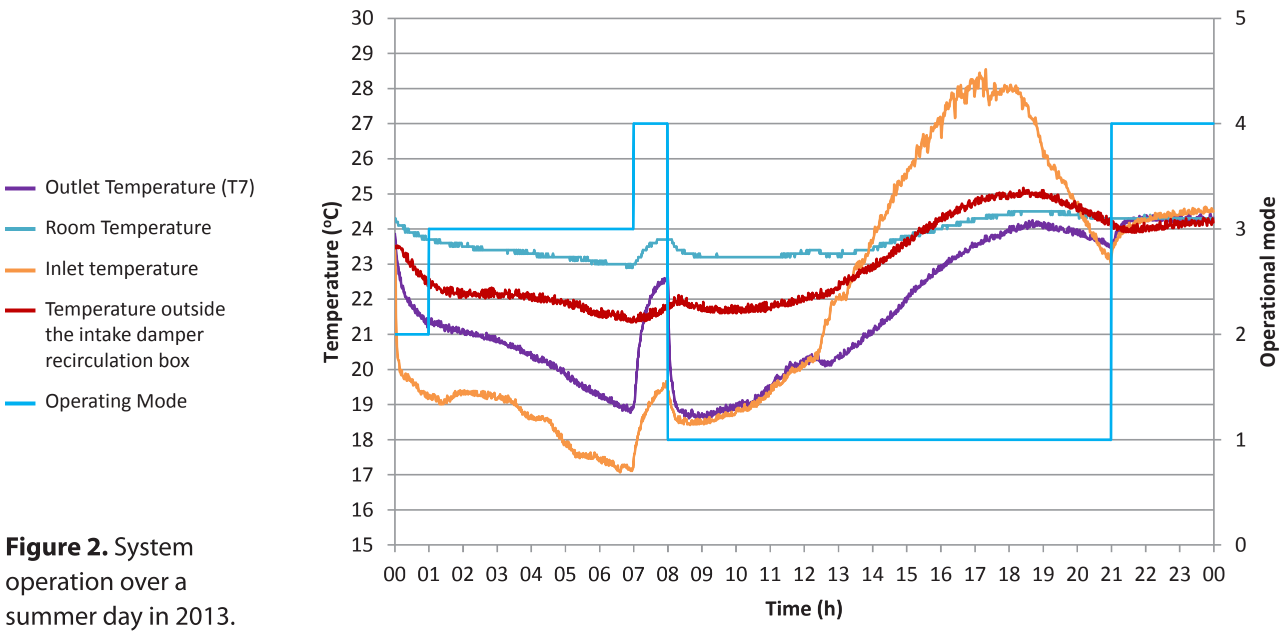

Figure 2. System operation over a summer day in 2013.

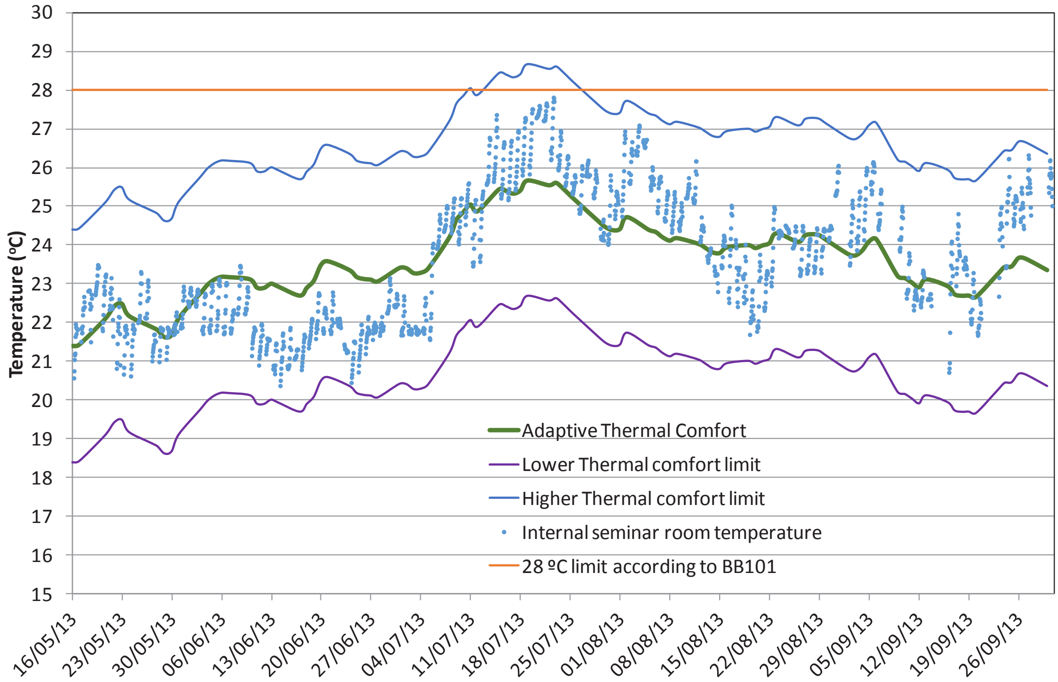

Figure 3. Thermal comfort performance over the summer months.

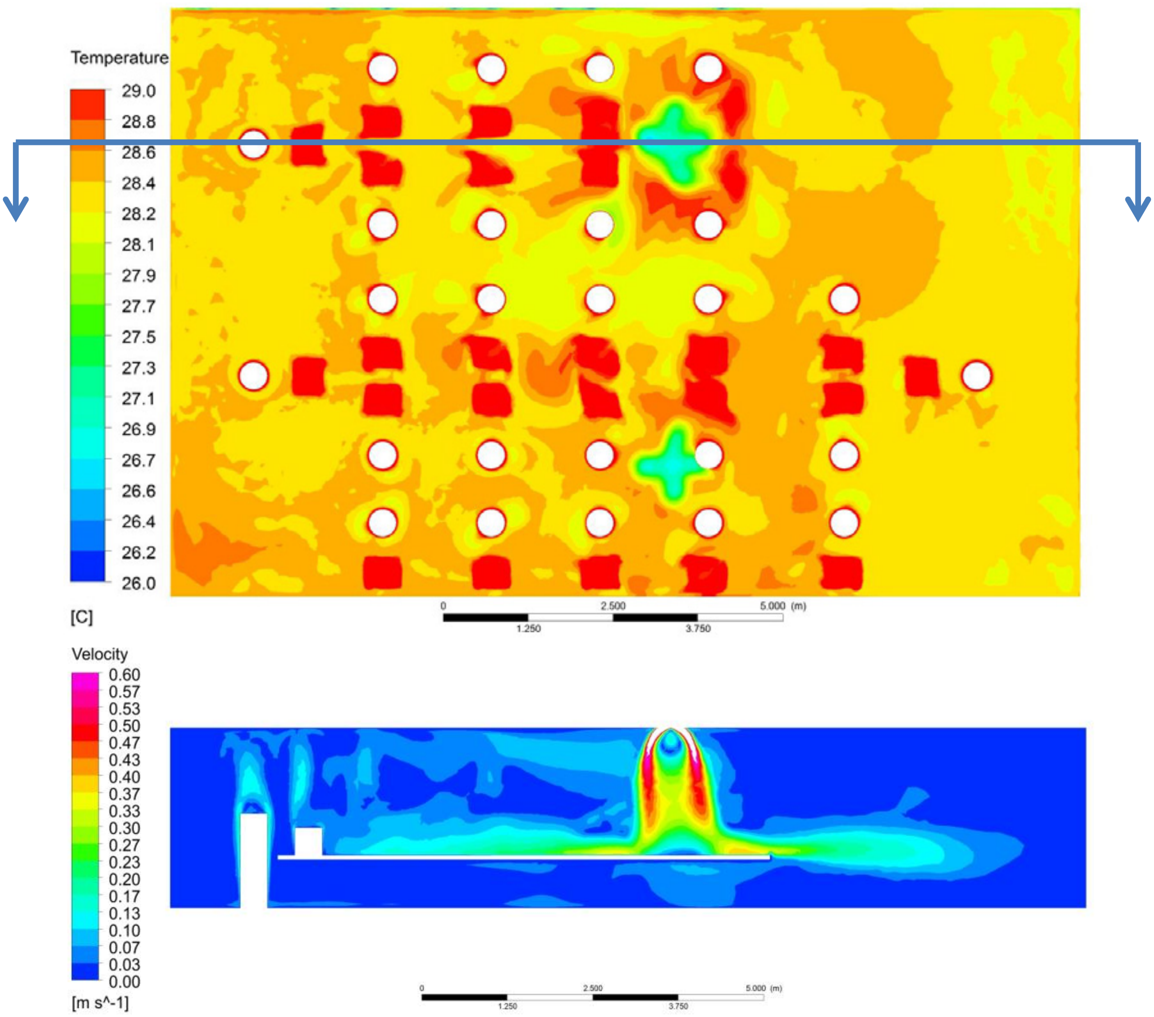

Figure 4. Air temperature and velocity in two sections of the seminar room during the hour with highest internal temperature (see **Figure 3**) and full occupancy and internal gains.

It can be observed that air temperature is uniform across the room and there are no areas with much higher air temperature which will cause discomfort. The air velocity contours indicate that at occupancy level underneath the air inlet velocity is in the range of 0.1–0.2 m/s with some small areas reaching 0.37 m/s Air velocity is lower in the rest of the room. Changing the direction of inlet louvres would reduce air velocities if this is required although higher velocities might aid thermal comfort.

Concluding remarks

Analysis of one-year operational environmental data for a seminar room equipped with a Cool-Phase® system to provide cooling indicate that the system performs well throughout the year in terms of IAQ and thermal comfort for an IT intensive seminar room. Further analysis of a second year of operational data plus additional monitoring to study the distribution of environmental conditions in the room and feedback by users is under progress and will be reported in a case-study being developed for EBC Annex 62. ■

Table 1. CO_2 concentration (ppm): daily average and exceeding 1500 ppm for more than 20 consecutive minutes.

Month	Average	> 1,500 ppm
May	502	0
June	423	0
July	413	0
August	416	0
September	500	0
October	595	0
November	741	0
December	566	Once*
January	601	0
February	719	0
March	695	0
April	579	0

* CO_2 concentration exceeded 1,500 ppm for 22 min on mid-morning on 6 Dec 2013 when occupancy in the room was more than its maximum and external air temperature at ~7°C. The control system restricted outside air to the room to less than maximum capacity to avoid thermal comfort issues.

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Control of indoor air quality by demand controlled ventilation


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This article discusses the advantages of using carbon dioxide concentration as a measure of indoor air quality and the possibility of improving it by choosing the optimal air distribution scheme and reducing energy consumption by indoor ventilation systems, which also reduces the emission of carbon dioxide into the atmosphere

Keywords: Air quality, health, carbon dioxide, ventilation, air exchange, energy efficiency, energy saving.

Environmentalists, physicians and diagnosticians as well as engineers and designers of ventilation and air conditioning systems all pay special attention to the influence of indoor air quality on human well-being. A person's physical condition depends on air quality; where it is unsatisfactory, people feel unwell, lose concentration, develop diseases, etc.

All kinds of pollutants may be released into indoor air and affect its quality (carbon dioxide released by humans; phenol/formaldehyde, acetone, ammonia and other components released by furniture and decoration materials). Both Russian and international experts have done a lot of studies [1, 2, 3, 4] that led to the adoption of carbon dioxide concentration as an indicator of indoor air pollution. In 2011, Russian standard GOST 30494 was amended to include this [5].

Highlights

- The human health depends on the indoor air quality.
- The carbon dioxide concentration is an indicator of the indoor air pollution.
- The indoor air quality was considered with different schemes of the air distribution.
- DCV systems – optimal indoor air quality and low power consumption.

Air quality is a key component of a healthy microclimate at the workplace.

The human breathing process under normal conditions mainly alters the concentration of two air components, oxygen and carbon dioxide. The metabolic processes in the human body reduce oxygen content in exhaled air from 20.9% to 16.3%, while increasing carbon dioxide concentration from 0.03% to 4% [6]. It should be noted that carbon dioxide concentration increases more than a hundred times. Both Russian and international experts have done a lot of studies [1, 2, 3, 4] that led to the adoption of carbon dioxide concentration as an indicator of indoor air pollution. Other hazardous gas emissions into the air of residential and public buildings (phenol/formaldehyde, acetone, ammonia and other components released from furniture and decoration materials) are converted into carbon dioxide equivalents [7].

General

GOST 30494-2011 'Residential and Public Buildings. Microclimate Parameters for Indoor Enclosures' [5], developed with the participation of the authors of this article, includes four indoor air quality classes depending on the concentration of carbon dioxide:

- Class 1 (optimal microclimate, high quality) – carbon dioxide level not higher than 400 ppm;
- Class 2 (optimal microclimate, medium quality) – carbon dioxide level between 401 and 600 ppm;
- Class 3 (acceptable microclimate, acceptable quality) – carbon dioxide level between 601 and 1000 ppm;
- Class 4 (unacceptably high carbon dioxide level, low air quality) – more than 1000 ppm.

The advantages of this approach to assessing air quality and the air exchange requirement over the traditional one (based on the relative blowing rate or air exchange rate) are as follows:

- air exchange calculations can take into account outdoor air pollution;
- higher ventilation efficiency is promoted: fresh air supply into the breathing area, no fresh air streams blowing across 'dirty' zones on the premises, etc.;
- the fresh air in the room can be taken into account before the room is filled by people;
- 'background' air exchange for removing hazardous emissions of furniture and decoration materials at non-working hours can be determined correctly;
- control of air quality becomes more adequate and accurate due to measuring carbon dioxide concentration directly in the room area serviced.

Information on carbon dioxide concentration in outdoor air is provided by weather observation stations. For reference: according to [5], approximate average annual values of carbon dioxide concentrations are:

- in the countryside, 350 ppm;
- in small towns, 375 ppm;
- the polluted center of a big city, 400 ppm.

The air exchange rate for the most widespread 'mixing' ventilation system is calculated from the formula:

$$L = 55 \cdot 10^4 \frac{G}{g_{out} - g_n} \quad \text{m}^3/\text{h} \qquad (1)$$

where G is the amount of carbon dioxide entering the enclosure, g/h;
g_n and g_{out} are the normative and outdoor carbon dioxide concentrations, respectively, ppm.

Mixing ventilation is supposed to spread air evenly across the room, and the concentration of pollutants, including carbon dioxide, is expected to be the same everywhere (**Figure 1, A**). Mixing ventilation usually features a high air exchange rate, at least 3 1/h.

Mixing ventilation systems include air recycling systems and those combined with fan terminals of air conditioning systems (split systems and fancoils).

In many public and office buildings, false ceilings are used to house both air supply and exhaust devices. In traditional solutions, air exchange rates usually do not exceed 1 – 1.5 1/h. In some cases of isothermal ventilation or slightly overheated incoming air, a large share of fresh air is drawn into the exhaust grids, forming what is called 'short circuit' circulation (**Figure 1, B**). This is an example of inefficient organization of ventilation.

An example of efficient ventilation is 'displacement' ventilation [8, 9]. Fresh incoming area is supplied into the serviced area at a small velocity through air diffusers with a large surface area to effectively 'flood' it. Polluted air, lifted by convective flows from occupants and office and other equipment, will be displaced into the upper tier and then exhausted (**Figure 1, C**). In this case, concentration of carbon dioxide in the serviced area may be lower than in the air removed.

Formally, in all the three cases (**Figure 1**) the same air exchange rate may be adopted under the traditional design approach, but the resultant air quality will differ widely.

The air volume required for ventilating the premises should be calculated according to [5] taking into account the air distribution efficiency factor:

$$L = \eta \cdot L_b \quad \text{m}^3/\text{h} \qquad (2)$$

where L_b is the base amount of external air according to the current Russian norms, m³/h.

The value of the air distribution efficiency factor is shown in **Table 1**.

Thus, if the statutory concentration of carbon dioxide is 800 ppm, and in the outdoor air its content is 400 ppm, for a workplace in an office building where a person exhales 45 g of carbon dioxide per hour (a quantity adopted according to [10] for adult brainworkers), the flow of external air in the ventilation system can be calculated from the formula (1):

$$L = 55 \cdot 10^4 \cdot \frac{45 \cdot 10^{-3}}{800 - 400} = 61.875 \text{ m}^3\text{/h} \approx 60 \text{ m}^3\text{/h}$$

This is the exact volume of air per workplace that the mixing ventilation system must supply to the premises. A 'short circuit' system will need more, 66 to 78 m³/h in the light of **Table 1**, while 'displacement' ventilation will permit a lower air exchange rate, 36 to 48 m³/h, and personal ventilation, 18 to 30 m³/h.

In other words, with air quality being the same, the air exchange rate and, consequently, energy consumption (on air transportation through ducts and heating/cooling) may differ 1.5 to 2 times.

The distribution of carbon dioxide concentration fields across the volume of premises can be calculated accurately enough. Still, in most cases the air and heat regime modeling effort is made for unique facilities only [11]. **Figure 2** shows approximate carbon dioxide distribution patterns for displacement ventilation (A) and in the vicinity of a fresh air stream (B) based on the calculation assumptions [17].

Table 1. Air Distribution Efficiency Factors.

S/N	Ventilation Systems	Air Distribution Efficiency Factor
1.	Mixing ventilation systems with air exchange rates higher than 2.5 1/h, including those using recycling, split systems and fancoils	1.0
2.	Isothermic ventilation systems or those combined with air heating that have a 'top to top' air distribution system and air exchange rates not exceeding 1.5 1/h	1.1 – 1.3
3.	Displacement ventilation systems	0.6 – 0.8
4.	Personal ventilation systems supplying fresh air into the breathing area	0.3 – 0.5

The efficiency of ventilation systems can also be characterized by the lifetime of fresh air – the time that air flowing from the air distributor takes to reach the breathing area. In personal ventilation system it takes

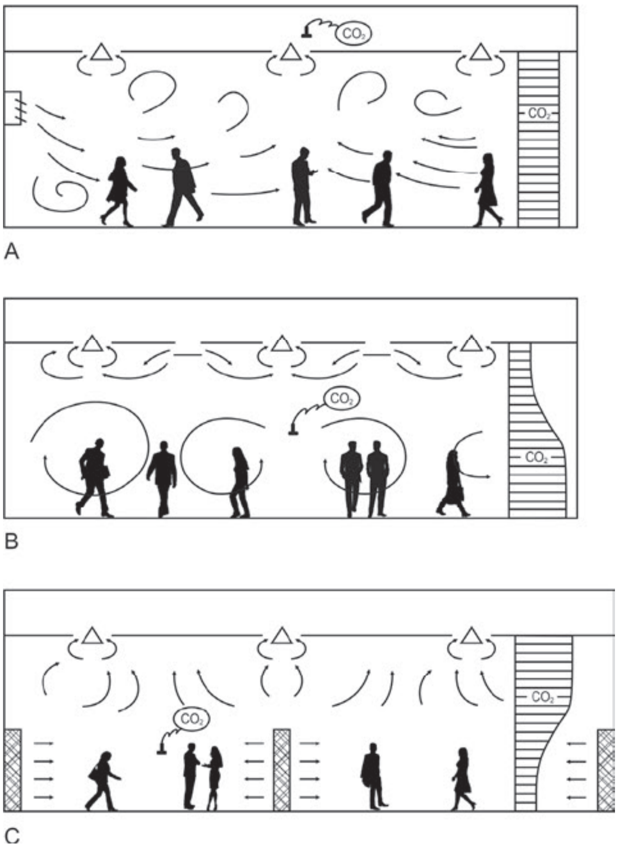

Figure 1. Carbon Dioxide Distribution Pattern with Mixing (A), Short-Circuit (B) and Displacement (C) Ventilation Installed.

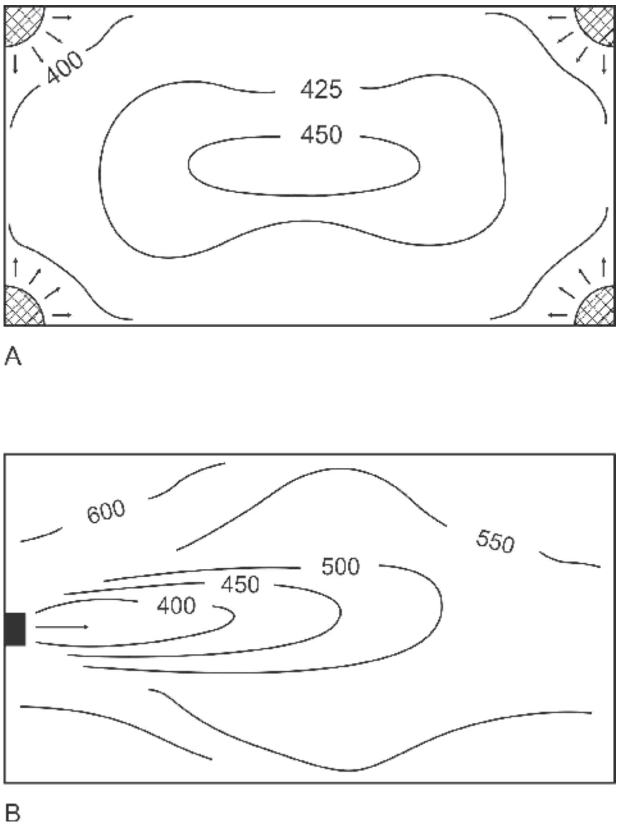

Figure 2. Lines of Equal Carbon Dioxide Concentrations on a Room Plan with Displacement Ventilation Installed (A) and in a Stream of Incoming Fresh Air (B).

less than a second; in 'displacement' systems, 20 to 30 seconds, and in 'short circuit' systems, up to ten minutes.

The efficiency retention of the air distribution system can thus be considered the criteria of the adaptability of ventilation systems (DCV systems). Demand Controlled Ventilation (DCV) stands for a special type of variable air velocity (VAV) ventilation systems that permit wide-range control of air exchange in individual areas and at different times depending on the actual occupancy of the premises [12, 13, 14, 15,16].

Another adaptability criterion should be the correspondence between the amount of the pollutants released (in this case, carbon dioxide) and the air exchange rate.

Traditional ventilation systems are designed for the rated occupancy of the premises and cannot adjust air exchange.

E.g., if the standard staff number in an office is 1,000 persons, the system will keep supplying and exhausting 60,000 m³ of air per hour. On the other hand, if holidays, sick leaves and business trips are taken into account, the actual number of personnel in the office will be just 70% of the rated figure, or fewer. Moreover, even if the business has fixed office hours, the first employees will come an hour or two earlier, and the last ones will leave three or four hours later than required to.

A traditional ventilation system will thus operate in its design mode since the first employees arrive and until the last leave.

Plotted in **Figure 3** are the working cycles of a traditional ventilation system with a constant air exchange rate and of demand-controlled ventilation depending on the number of personnel present at the office. The hatched area on the plot represents the power and air saving in the demand-controlled ventilation system than can reach 40 to 50%.

Air exchange control in a demand-controlled ventilation system can be governed by carbon dioxide levels measured by a special sensor. Following the sensor's signal, regulated gates will adjust the flow of air entering

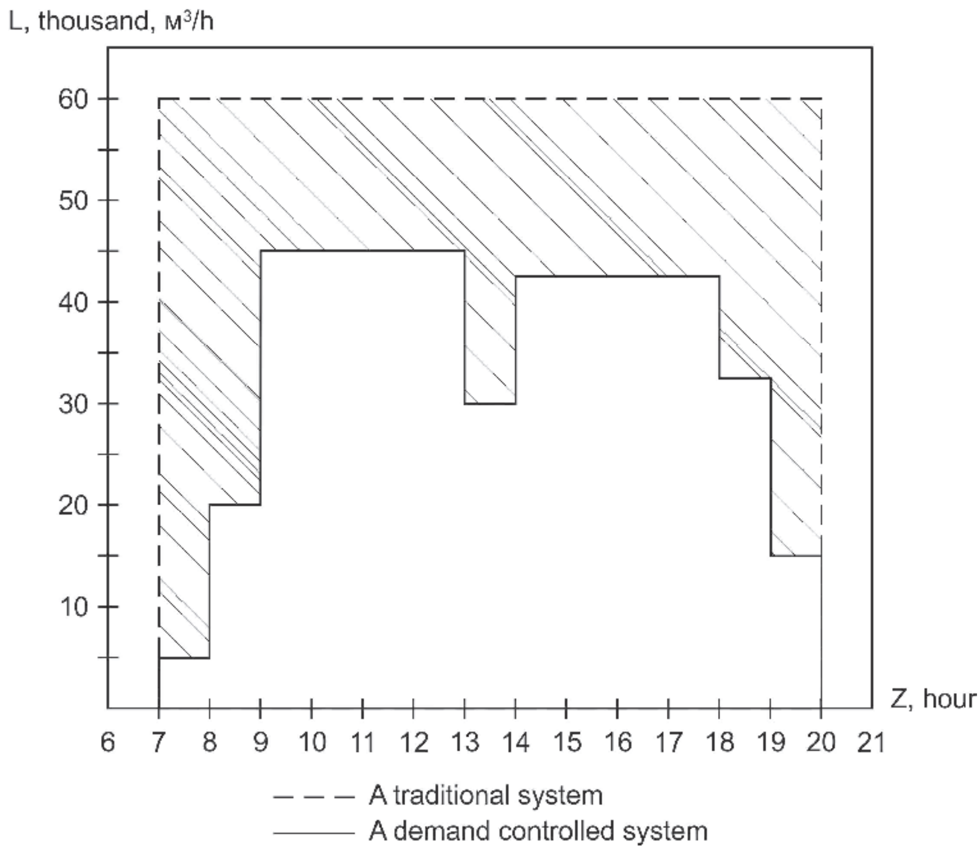

Figure 3. A Ventilation System Operation Schedule.

the premises. The signal is then forwarded to the air-supply unit and the exhaust unit equipped with variable-frequency drives for adjusting fan delivery.

The place where the carbon dioxide level sensor is installed is important. In a mixing ventilation system, the sensor may be installed in the exhaust air manifold, and in other cases, in the serviced area or breathing area (**Figure 1**).

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Conclusions

1. The concentration of carbon dioxide can serve as an indicator of air quality in residential and public buildings.
2. The efficiency retention of air distribution is an important adaptability criterion to be used in selecting ventilation systems. The target should be for fresh air to reach the breathing area by a short trajectory, without crossing 'dirty' zones where hazardous substances are released.
3. It is important to make the fresh air inflow match the number of people on the premises. While a high air quality is maintained in buildings with variable numbers of personnel or visitors (such as railway stations, airports, trade centers, sports or recreational facilities, offices), demand controlled ventilation can save 40 to 50% of energy as compared to traditional ventilation systems. ■

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COP21 – Decarbonising the build environment by 2050

Aftermath of COP21

After many years of disappointing UN climate change negotiations COP21 delivered a historic, ambitious and balanced agreement. This is the first major multilateral deal of the 21st century setting out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. The European Union has played an important role in brokering the agreement in Paris, where 195 countries adopted a new universal, legally binding global climate deal. Now it's time for every stakeholder to take concrete actions from global to local level to ensure that the Paris agreement is implemented in real life in the coming decades.

COP21 has crossed many thresholds needed for the planning and implementation of global climate change actions. One of them is that it gave a clear message that from the technology point of view the smooth transition to near-zero emissions in buildings is feasible. A key message of the COP21 side events was to feature available solutions enabling the achievement of the ambitious zero emission targets. Another novelty of COP21 was that for the first time ever the energy sector – including among others buildings energy efficiency and construction sector – was involved in the UN climate discourse. This approach was followed by many side events organized in Paris during the two weeks of negotiation.

Symposium "Zero Emissions by 2050: How to decarbonise the built environment"

9 December 2015 a symposium was organised on the decarbonisation of the build environment by 2050. The COP21 side event was initiated by the Edward Mazria, the internationally recognized architect and founder of Architecture 2030, a think tank aiming at rapidly transforming the building sector from a major contributor of greenhouse-gas emissions to a central part of the solution to the global-warming crisis. The event was hosted by the French Building Federation and co-organised by global architecture, construction and urban planning NGO-s.

After setting the scene by a high level panel of World Bank, World Economic Forum and the Global Word Building Council the symposium was structured in 3 sessions featuring flagship initiative panels in the domains:

1. City/District Building Initiatives
2. Building Design and Planning Tools
3. Innovative Building Sector Financing

Building sector – the elephant in the room

The panellists stressed that the decarbonisation of the built environment is a key in the climate process and that construction sector innovation can accelerate the process even more. The event focused on cities and urban environment where the importance of the building sector's decarbonisation is even more obvious. The first panel presented the global challenges faced by the cities around the world and especially in China and North America. By 2030 urban population will increase by 1.1 billion people, while China and North-America will be in charge of 38% of the global CO2 emission by 2050. The elephant in the room are buildings, which have a massive share within the total emissions in urban areas. As an example 73% of New York's CO2 emission comes from buildings. The solutions and answers to this challenge have to be global with cities as a priority. The Green Building Council announced its global commitment to deep refurbish 2.1M m2 of buildings by 2030 and train construction sector workers to be able to answer the demand. 3 GBC chapters from Canada, Africa and Australia launched a Net zero certification scheme for buildings.

The panellists agreed that the only ways to force the market to invest in the decarbonisation of buildings are the prescriptive codes and mandatory performance requirements that are incentivized. The good news is that the change has started. By 2016 building codes in the world became by 50% stricter compared to the previous decades. Even China is committed to introduce stricter building codes and launch investments to comply with them in the big cities was confirmed by the Chen Zhen, the Secretary-General of the China Exploration and Design Association Architecture Branch (CEDAAB).

Hal Harvey, CEO of Energy Innovation, a US think tank promoting sustainable urban planning, presented their excellent guidelines elaborated for sustainable urban planning for metropoles in China, while Brett Phillips, Co-Founder and Chairman of the Seattle 2030 District project presented an innovative and interpectoral local initiative for the decarbonisation and sustainable development of Seattle, Washington. The speakers pointed out that achieving 80% CO2 emission reduction via buildings in urban areas is not a technical, neither a financial challenge. It's a practice challenge requiring training, skilled professionals and smart / innovative practice. And it also requires cooperation between the different involved public and private sector stakeholders.

In the second panel IT companies presented innovative building design and planning tools providing architects and designers with tools to design high energy performing buildings and energy refurbishments. The event was closed by a panel presenting innovative building sector financing tools.

The symposium was an excellent example of the novel dialog between UN stakeholders and the building energy efficiency sector as it brought together the high level UN climate change community and environmental policy makers with energy policies and the related sectors such as buildings & construction industry, architects, designers, public and private finance sector, NGO-s and technology providers in the same discussion. It also highlighted flagship initiatives that are on the way to decarbonise major cities by 2015. This is the way we need to go to successfully implement the COP21 political agreement in practice.

ANITA DERJANECZ
REHVA Policy and Project Officer

REHVA grants auspices to FOR THERM, a HVAC trade fair to be held on 20-24 September 2016 in Prague, Czech Republic

The HVAC sector is on the rise in the Czech Republic as the government continues to financially support installations of new, more ecological heat sources through a system of subsidies and allocation of EU funding resources. This is why both businesses and end clients are willing to invest in new heating and AC systems. And this is why now, half a year before the event takes place, the FOR THERM trade fair witnesses an unprecedented interest of companies seeking to exhibit at the trade fair.

The 2016 FOR THERM, the 7th trade fair for heating, alternative sources of energy and air conditioning, will be held on 20-24 September 2016 in Prague's largest exhibition centre. Co-located with FOR ARCH, the largest and longest-standing Czech construction exhibition, FOR THERM annually presents solutions and presentations of leading companies of the HVAC sector. In 2015, the set of concurrent exhibitions was visited by more than 74,000 visitors and attended by 830 exhibitors from 13 different countries, which makes it the top event of the building industry in the Czech Republic.

Due to its location in Prague, an important hub of Central-European business, FOR THERM is a unique opportunity for both domestic and foreign exhibitors to present their services and products within an international competition. If you want to address the Czech region, FOR THERM is the one place you need to meet new partners, dealers, suppliers and customers.

Besides exhibits and stand presentations, the trade fair furthermore offers a rich accompanying programme, awards for the best solutions presented, lectures, professional seminars, conferences, and much more. The fact that this is a second time in a row that REHVA has granted auspices to FOR THERM proves that FOR THERM can easily compete with the top HVAC exhibitions in Europe. To further strengthen the international scope of the event, a set of organized B2B meetings entitled Matchmaking Business Meetings will be held. The meetings are designed to help international participants to introduce themselves on the Czech market and to find new business partners, suppliers, manufacturers, producers and wholesalers.

For more information: Both visitors and potential exhibitors are welcome to visit www.for-therm.cz

IAQVEC 2016

IAQVEC2016, the 9th International Conference on Indoor Air Quality, Ventilation and Energy Conservation in Buildings, will be held in Seoul (Songdo), Korea on October 23–26, 2016 (http://www.iaqvec2016.org).

The conference will be organized by AIK (Architectural Institute of Korea) in co-operation with KIAEBS (Korean Institute of Architectural Sustainable Environment and Building systems), and KICT (Korea Institute of Civil Engineering and Building Technology).

Topics

The conference scope encompasses IAQ and ventilation for creating energy efficient, healthy and productive environments in an environmentally sustainable manner in all types of buildings.

Topics to be covered in the conference:

- Indoor Environment Quality & Climate
- Ventilation & Airtightness
- Ventilation in relation to IAQ & Health Aspects
- Smart Technologies for Building Performance
- HVAC Systems
- Building System Integration and Optimization
- Sensors, Controls and Information Management
- Modelling and Simulation Tools

Venue: Seoul (Songdo), Korea

Songdo International City, well known as a model city for Ecopolis is located just besides of Seoul.

It only takes about 20 minutes from Incheon international airport to Songdo.

Contact: www.iaqvec2016.org; Info@iaqvec2016.org

Important dates: Deadline for Abstracts submission: November 13 2015, Abstract acceptance December 18, 2015. Deadline for Full papers: March 25, 2016; Acceptance notification: May, 2016.

Nordbygg is the platform we are using to enter the Swedish market

Jonas Brennwald, Regional Vice President North-West Europe at Grohe, views Nordbygg as the platform for the company's major push to enter Sweden.

Nordbygg 2014 marked the start of our big push to enter the Swedish professional construction market. Our participation was successful. At Nordbygg 2016 we will follow up by further establishing our position and launching new, sustainable products.

A lot of interest in the right target groups

"There was a lot of interest and we made some good contacts in our most important target groups – architects, specifiers and installers. We successfully spread our message that Grohe is one of the top brands in the world for faucets and sanitary fittings for the bathroom and kitchen and that we had fully adapted our products for the Swedish market," says Jonas Brennwald.

After Nordbygg 2014 Grohe successfully marketed its water and energy calculator, which helps property owners monitor and influence their water and energy consumption.

"We also started collaboration with Bravida, the leading installation and service company, which will now be launched," explains Jonas Brennwald.

Positioning and new products at Nordbygg 2016

At Nordbygg 2016 Grohe will have a large stand to take its investment in the Swedish market to the next level.

"Next time we will focus on cementing our position as a global market leader with a long list of new products that have been adapted to the Swedish market. Our design is an important factor, but it is primarily innovations in sustainability that will be in focus," explains Jonas Brennwald.

Grohe has a very large in-house development department and invests a lot of resources into designing fittings and systems that optimize the use of water and energy in the bathroom and kitchen.

"There is an inherent conservativeness in this area that we want to challenge. At Nordbygg 2016 we will show that Grohe is constantly creating new, innovative and sustainable products and we will demonstrate their potential," says Jonas Brennwald.

Nordbygg at a glance

Nordbygg is held in March/April every even year at Stockholmsmässan and attracts around 900 exhibitors and 53,000 visitors. Next event will take place 5-8 of April in 2016. Nordbygg is organized in partnership with leading associations in the Swedish industry. We also collaborate with a number of other industry organizations in various projects related to Nordbygg.

Nordbygg has the position as the Nordic region´s largest and most dynamic meeting place for the construction and real estate industry, offering new knowledge and business opportunities. The event offers everything from discussions about construction conditions and urban planning to products and services for property production, maintenance and management.

NF-Air Cleaners

Eurovent Certita Certification has developed a new NF mark certification for Air Cleaners under a mandate from AFNOR Certification. A dedicated working group gathered four times between May and November 2015 and the reference document is currently going through the approval process with an expected date of release in early January 2016.

This NF mark aims at certifying air cleaning devices for residential and tertiary applications as foreseen in the scope of the standards XP-B44-200:2011 and XP-B44-013:2009, chosen as product performance testing method references.

The Air Cleaners certification enables to verify the accuracy of the performance ratings claimed by manufacturers in terms of effectiveness with respect to several categories of pollutants: particulate matters (PM), Volatile Organic Compounds (VOC), micro-organisms (bacteria and fungi) and cat allergens, but also regarding the power consumption and the sound power level. The product testing also enables to verify that no dangerous products are emitted (ozone, VOC by-products…). The certification scheme comprises factory audits to check that the quality management system in place ensures the manufacturing process reliability. Besides, the reference document establishes a consistency principle between the air volume flow rate delivered by the device and the surface area of the room that can be cleaned.

In the near future, the NF-Air Cleaners mark will most certainly evolve to cover industrial applications and duct mounted installations.

For more information: please contact Gregory Kelijian g.kelijian@eurovent-certification.com.

The HVAC&R market in the EMEA region – Eurovent Market Intelligence

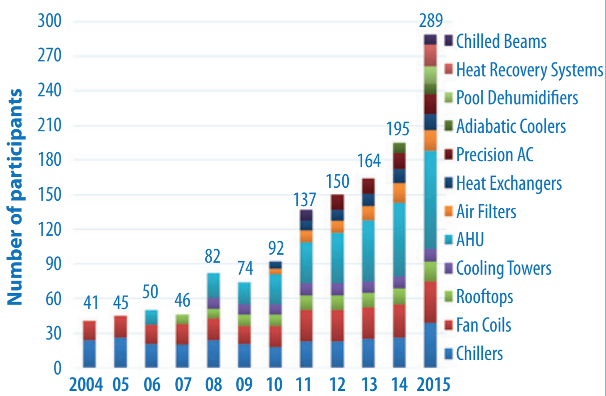
On 4 January, Eurovent Market Intelligence (EMI), the European statistics office for the HVAC&R market, launched its new annual data collections for 2016 (see info box below). The aim is to collect sales data from manufacturers in the sector so that we can provide them with a reliable and precise market map for HVAC&R in Europe, the Middle East and Africa (EMEA).

GHITA BOUDRIBILA
Analyst

YANNICK LU-COTRELLE
Market Intelligence, Manager

Last year, 289 manufacturers had joined EMI, a new participation record and a 48% increase on the previous year. This year, 350 participants are expected, which promises to provide the most comprehensive and reliable ever overview of the market, and thus become the largest collection of data on the HVAC&R market in terms of number of market players.

Eurovent Market intelligence Programmes (all products) : 12-year overview



One of the major changes last year was the significant improvement in quarterly reports (Market Evolution), which in just around 20 pages also includes qualitative, technical and macro-economic data in addition to the usual market data.

EMI is also aiming to go even further this year, offering customised reports as of March/April. These individual market reports, packed with between 100 and 200 pages, compare market characteristics for each country in the EMEA area (size, segmentation, main players, growth, etc.) and the position of the manufacturer in the market (market share, rank, progress, etc.). The aim is to offer each participant a full overview of his situation so that in a glance he can see his strong points and areas where he needs to improve.

All of the information will also be available – under private access only – on the Eurovent Market Intelligence website. A new marketing tool is currently being developed for this, which should be operational by April 2016 at the latest. This tool will allow users to carry out all possible market analyses in a single click, as simple as using a flight comparison tool, and export the results to an Excel file.

Also new for 2016 is that a new programme will be launched and an old one will be restored, relating to residential air handling units and chilled beams respectively, where representativeness already promises to exceed 80%. The programme for precision air conditioners has been expanded to include all solutions used for cooling IT devices (data centres, telecoms, etc.), in order to better take into account the development of less energy-intensive alternative in this sector.

From January to March 2016, Eurovent Market Intelligence is launching its thirteen annual data collections

- Liquid chilling packages
- Fan coil units
- Air-handling units
- Rooftop units
- Cooling towers
- Air filters
- IT cooling (formerly precision air conditioners)
- Heat exchangers
- Adiabatic coolers
- Heat recovery systems
- Pool dehumidifiers
- Cold beams
- Residential air handling units

Last but not least, EMI will launch the dissemination of bilingual English/Arabic market reports looking specifically into the Middle East this year. This expansion comes as a result of the ever-increasing role of EMI in this region, where the construction sector still remains relatively dynamic, where demand for air conditioning is very high. To this end, EMI attended the BIG5 exhibition in Dubai last November, where interest from local manufacturers was particularly high. As usual, EMI will also be attending the Mostra Convegno Expocomfort exhibition in Milan, Hall 22 P – Stand F 55, which will be held from 15 to 18 March 2016.

For additional information or to receive these reports:
https://www.eurovent-marketintelligence.eu /
statistics@eurovent-marketintelligence.eu

ASHRAE winter meeting 2016

REHVA organised a successful seminar at the ASHRAE winter meeting 2016 as part of the track: Cutting-Edge Technologies

Energy Performance Run By Data, Chaired by REHVA President Karel Kabele

A consistent strategy for energy saving and sustainability should benefit from the all the opportunities opened by scientific and technological development. One of the biggest challenges in a building is to find the right equilibrium between the energy demand and the well-being provided to occupants. The evolution of information and communication technologies, together with the decrease of the cost of sensors and monitoring systems, opens new perspectives. Nowadays the decision making process is much better and based on performance indicators, which are widely used in energy and environmental rating systems for buildings.

Data Driven IEQ Control in Low Energy Buildings
(Prof.Dr.Ing Karel Kabele, President of REHVA)

Reduction of the energy use in the buildings is the objective, which changed traditional approach to building construction and has impact to the architecture, materials and building technologies used in modern buildings. Energy performance of the buildings, given by the European laws, is defined as a set of parameters describing efficiency of the components as well as the whole building. Those requirements must be nowadays fulfilled by law in the new buildings and in future will lead to the status, that all new buildings will be nearly zero energy buildings. The current pressure to reduce energy consumption of buildings but leads also to actions that significantly adversely affect the quality of indoor environment and in many of such buildings we can meet unexpected decrease of indoor environment quality and complains of occupants. This approach has impact to the building industry mainly in the field of intelligent buildings, new high efficient building services system, new building materials. Results of two case studies, related to heating system and natural ventilation control evaluation were presented.

Occupant Behaviour Monitoring and Engagement: Low Investment Measures to Optimize IEQ and Save Energy in Buildings (Prof.Dr. Stefano Corgnati, President-elect of REHVA)

Actual energy performance of buildings shows a significant difference with respect to what measured and what is estimated by calculation: in general, most buildings do not perform as well as expected. Among the different influencing factors, the behaviour of building occupants has the most significant effect on building energy use, and this can result in a wide gap between real and predicted building energy consumption.

International research program promoted by the International Energy Agency, in particular EBC Annex 53 and Annex 66, started to deepen the knowledge on the effect of user behaviour on final energy uses in buildings. Statistical models describing the user actions in rooms of different building types, especially houses and offices, were developed and implemented in dynamic energy simulation tools, opening new scenario in energy forecasting for different occupant lifestyles.

At the same time, in field campaigns for occupants energy engagements, aimed at increasing the user consciousness on energy savings, were set-up and appreciable results were highlighted about the potentialities in reducing energy needs while keeping indoor comfort at the required level. Results shows that energy saving from 10% to 15% can be achieved by user education.

Indoor Environmental Quality Monitoring system developed to be installed in a medium-size building located in the city of Horst, in the Netherlands (Prof.Dr. Manuel Carlos Gameiro da Silva Vice President of REHVA)

The system has been designed in a modular configuration to allow the connection of sensors or meters with an USB digital output to Mini PCs that communicate through the power line with the building manager computer. In the current configuration the system includes sensors to monitor indoor thermal comfort, indoor air quality (CO_2, VOCs and PM_1, $PM_{2,5}$ and PM_{10}), Interior noise level, indoor illuminance and outdoor weather conditions. Two software packages were developed, the first one to assure the data acquisition and saving process and the second to be used has a data viewer, including a dashboard display and graphical interfaces for the download, the processing and the analysis of data.

Translation of building performance into monetary performance
(F. Hovorka vice president of REHVA)

Collecting and having access to good data is unquestionably an essential part of ensuring we understand effective quality and performance of real estate. The deployment of rating tools has created quality tags that could drive contemporary best practice outcomes. In addition, the market penetration of Building Information Modelling (BIM) could help organized the huge amount of data available for Life Cycle Assessment and performance evaluation. There is thus a new opportunity to look beyond and leverage rich data sets 'au naturel', organized around common baselines. The question is now how we incorporate the information collected into our investment decisions to pave the way for a more responsible real estate sector.

The translation into the valuation process and the assessment of the sensitivity to future changes is the bridge we should built to achieve this necessary transformation The translation into value will help foster the necessary trust and alignment of interests between stakeholders required to create a virtuous mechanism of joint value creation. The transparency on uncertainty (spread between theoretical data and reality) will also definitively be needed in order to aggregate (without huge mistakes) the projects into a portfolio. This is the demand from financial institutions in order to initiate the massification of energy efficiency retrofit.

FOR THERM

7th trade fair for heating, alternative sources of energy and air conditioning

FOR THERM

20-24 September 2016
Prague – PVA EXPO PRAGUE,
Czech Republic

FOR THERM is an annual Czech trade fair which is held in Prague together with four concurrent fairs – FOR ARCH, FOR WOOD, FOR STAV and BAZÉNY, SAUNY & SPA. This set of construction-related fairs is the single most attended and most important building event in the Czech Republic. In 2015, more than **74,000 visitors** have attended and **830 exhibitors** from **13 different countries** have participated in this exhibition. Due to its location in Prague, an important center of Central-European business, FOR THERM is a unique opportunity for both domestic and foreign exhibitors to present their services and products within an international competition. If you want to address the Czech region, FOR THERM is the one place you need to meet new partners, dealers, suppliers and customers.

The event is organized under the auspices of the President of the Czech Republic, REHVA and the Association of Building Entrepreneurs of the Czech Republic. A rich program will accompany the trade fair.

Webpage: www.for-therm.cz/en

The Cold Climate 2015 conference and the industrial ventilation conferences in China during 19-28.10.2015

This article summarizes the two international conferences: the 8th International Cold Climate HVAC (heating, ventilation and air-condition) Conference (Cold Climate 2015) (October 21~23, 2015) in the seaside city of Dalian, China and the 11th International Conference on Industrial Ventilation (26-28.10.2015) in Shanghai, China. The Cold Climate conference attracted 180 participants from 12 countries and the Industrial Ventilation conferences attracted 210 participants from 15 countries.

GUANGYU CAO
Norwegian University of Science and Technology, Norway

RISTO KOSONEN
Aalto University
Finland

The 8th International Cold Climate HVAC Conference (21-23.10.2015), Dalian, China

The Cold Climate conference is a series conference initiated by the Scandinavian Federation of Heating, Ventilation and Sanitary Engineering Associations (SCANVAC) in 1994. This year's conference was organized by Dalian University of Technology, Tsinghua University and Technical Research Centre of Finland (VTT). The theme of this conference is sustainable buildings and the energy utilization in cold climate. There were altogether about 180 participants in the conference. They came from three continents (Europe, America and Asia): 12 countries (Denmark, Finland, Norway, Sweden, German, Russia, the Republic of Kazakhstan, USA, Canada, Korea, Japan and China). All participants represented 70 different universities and institutions around the world, thirty percent of the delegates were from overseas. The conference received 179 papers and 145 of them were finally accepted.

Photo 1. The SCANVAC President, Per Rasmussen, gave a speech in the opening ceremony on 21.10.2015.

In total 113 papers were presented by oral presentation and 18 by posters. In the conference, a REHVA workshop, which was purposed to disseminate the new REHVA Guidebook - mixing ventilation, was organized by Risto Kosonen.

Photo 1 shows that the SCANVAC President, Per Rasmussen, gave a speech in the opening ceremony on 21.10.2015 and Photo 2 shows that he was in the Workshop of Indoor climate design for nearly Zero Energy Buildings (NZEB) in cold climate.

The 11th International Conference on Industrial Ventilation (26-28.10.2015) in Shanghai, China

The 11th International Conference on Industrial Ventilation (Ventilation 2015) was held on October 26 to 28, 2015 in Shanghai, China. This conference was organized by Tongji University, co-organized by VTT (Technical Research Center of Finland) and Tsinghua University. Prof. Xu Zhang chaired this conference. More than 210 participants originated from 15 different countries/regions attended this triennial event to celebrate the 30 years' anniversary of this international conference series on industrial ventilation. In total 125 papers were peer-reviewed and included in the Proceedings of this conference.

During the opening ceremony, besides Prof. Goodfellow was awarded for his 30 years' service to industrial ventilation society. Meanwhile, Prof. Wei Xu and Prof. Xu Zhang from CCHVAC were awarded by Prof. Karel Kabele, President of REHVA, for their outstanding services to the collaboration between REHVA and CCHVAC (see Photo 3).

The Rehva President, Prof. Karel Kabele, was invited to give keynote speech in the plenary session. The title of his keynote speech was: Ventilation for better IEQ in Nearly Zero Energy Buildings (see Photo 4).

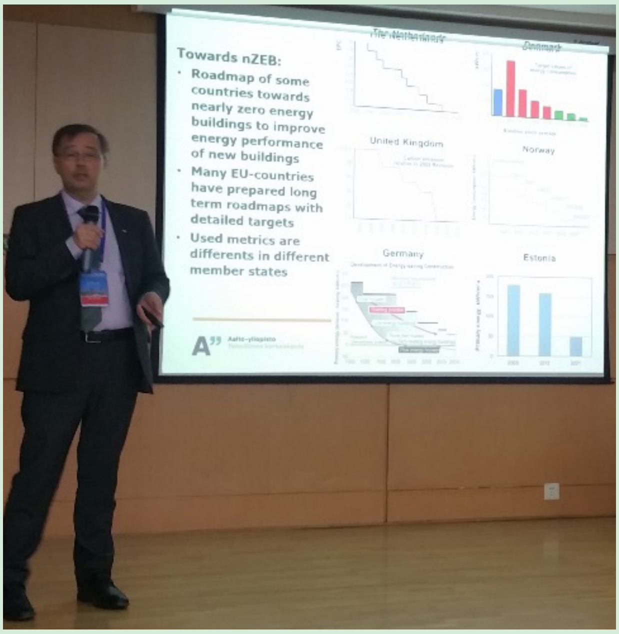


Photo 2. *Risto Kosonen was presenting the presentation about Nearly Zero Energy Building in the Workshop of Indoor climate design for nearly Zero Energy Buildings (NZEB) in cold climate.*

Photo 3*. Opening ceremony 26.10.2015: REHVA's award – REHVA's Certificate of Merit to: Prof. Wei Xu, President of CCHVAC and Prof. Xu Zhang, Tongji University, Vice president of CCHVAC.*

Photo 5*. SCANVAC workshop: Advanced airflow distribution methods for reduction exposure to indoor pollution 27.10.2015.*

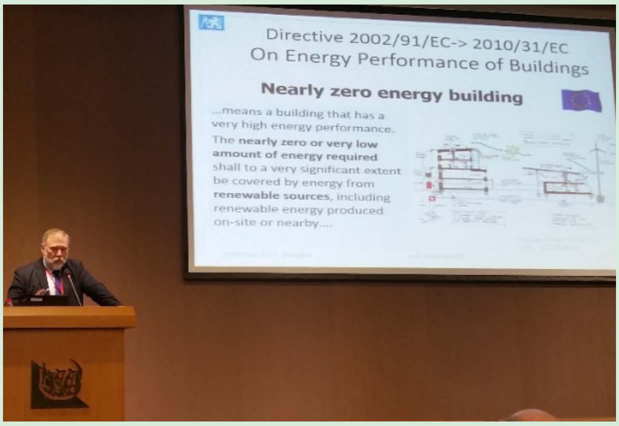


Photo 4*. Keynote speech from the REHVA President Prof. Karel Kabele in the Industrial Ventilation 2015 conference.*

During the conference, a SCANVAC workshop was organized entitled: Advanced airflow distribution methods for reduction exposure to indoor pollution. Four presentations were made by Prof. Peter Nielsen from Aalborg University, Prof. Arsen Melikov from DTU, Prof. Risto Kosonen from Aalto University and Prof. Guangyu Cao from NTNU (see **Photo 5**).

Remarks

The two conferences provided wide and solid platforms for experts to share and exchange ideas and insights in developing a healthy, productive, safe and comfort indoor environment in an energy efficient manner. The Cold Climate conference in Dalian included a few main topics including zero energy building, sustainable district heating, renewable energy and low exergy energy utilization. Discussions also covered: whether different countries have different zero energy building roadmaps, how to heat and cool a zero energy building, whether the type of space heating system is the key method to improve the efficiency of CHP system, what is the fourth generation district heating system which is the future trend of district heating system, what can be done in HVAC field facing the era of big data, etc. During the Industrial Ventilation conference in Shanghai, five domains of ventilation science and engineering were covered: 1) occupational health; 2) ventilation and sustainable development; 3) industrial ventilation and pollutant control; 4) air distribution design, measurement and products; and 5) specialized ventilation applications. ■

Halton

Halton Vario – Latest total indoor climate solution

Halton Vario is the latest total indoor climate solution from ventilation products to controls for rooms, zones and at the system level. Halton also verifies the performance of your system so you can be sure that your building's indoor climate is exactly as designed from day one.

Halton claim that Vario chilled beam solution not only can reduce energy consumption by up to 50% but also that this solution can be up to 50% more energy-efficient than conventional air-conditioning systems. For the first time in the history of chilled beam systems, the system monitors space usage, controlling and adjusting cooling and ventilation according to the demand. Thanks to the smart controls the indoor environment conditions are maintained at an optimal level.

Radically lower churn costs with a fully flexible system. Applying Halton Vario solution office spaces can be converted in to a meeting room (and vice versa) in 15minutes or less.

Halton Vario controls ventilation, room air temperature and air quality demand-based to provide "A-class" indoor environmental quality that is specified in regular cited international standards (ISO EN 7730, EN15251 and CR 1752).

Comfortable thermal conditions and indoor air quality create productive working conditions thus users' complaints on indoor conditions are minimal.

This solution not only makes green buildings a reality, it makes them more energy efficient, more flexible to layout changes and more comfortable to work in than ever before.

More information: www.halton.com

Swegon

Great savings with the new generation PARAGON

Besides friendly staff and great location, one of the top priorities of hotel guests is a comfortable room climate – requiring perfect supply of fresh air, the right air temperature and low noise level. As a solution to all these requirements, Swegon has created the PARAGON comfort module, providing the perfect indoor climate in a highly energy efficient way. The solution has proven itself in hotel rooms, as well as nursing homes and hospital rooms, since year 2009 with over 13000 units installed.

The secret behind the PARAGON is to use the air pressure from a centrally placed air handling unit, together with small nozzles inside PARAGON, to create an induction effect, distributing the air along the ceiling. This results in a highly efficient mix of fresh air and room air, which together with a waterborne heat exchanger make sure the room is well ventilated at the right temperature, by adding heating or cooling according to demand. With the PARAGON solution, there are no noisy fans, condensation problems or cold draught in the room.

Now the new generation of PARAGON is here, with a unique Compact Change Over-valve integrated in the unit, increasing each unit's cooling capacity about 20%, and the heating capacity about 60%.

Product Manager Jonas Åkesson sees a great potential in the new product generation; "The gain in capacity can be used in several ways, one is to adjust the cooling and heating water temperatures, allowing for a more economical operating mode of the heat pump or chiller. For a typical heat pump, this may convert into an electrical energy saving of about 25%."

Jonas Åkesson also points out the advantages from a building process perspective; "PARAGON's increased capacity makes product dimensioning easier and provides a more robust system design, without any compromises concerning the indoor climate. In the end this makes PARAGON a crucial factor for hotel guest satisfaction and retention."

More information: http://www.swegon.com/

Eu.bac certifies Belimo actuator/valve combination

The French CSTB test lab accredited by eu.bac has tested the control accuracy (CA value) of the LR24ALON rotary actuator with integrated single room controller in combination with the 6-way zone valve in accordance with European standard EN15500 and awarded it the eu.bac certificate and AA energy efficiency label.

LR24ALON fitted on a 6-way zone valve.

Control accuracy test

The control accuracy was tested in the heating/cooling ceiling application intended for a 6-way zone valve and achieved the CA values of 0.3K for the heating sequence and 0.2K for the cooling sequence.

Certification process

The actual application test in the lab also involves the manufacturer (licence holder) being assessed by the accredited eu.bac test lab. On 16 July 2015 the head office of BELIMO Automation AG in Hinwil/Switzerland was audited by CSTB. The assessment of the relevant production line played a key role in this.

Direct connection and integrated single room controller

The FTT-10A transceiver fitted in the LonMark®-certified LR24ALON actuator permits a direct connection to LonWorks®. A single room controller (Functional Profile LonMark® #8060) is integrated into the actuator in order to reduce the costs of implementation of individual room controls. Thanks to an additional output variable, the 6-way zone valves fitted in the heating/cooling ceilings can be controlled directly by the LR24ALON. Additional controller versions, for CO_2 for example, can be implemented on request.

Free LNS plug-ins available on Belimo website

Free-of-charge LNS plug-ins can be downloaded from the Download Center at www.belimo.ch for the integration of LON actuators in LonWorks® systems. These work with common binding tools based on LNS.

Heating/cooling ceiling application

Both the heating and cooling control sequences can be activated with just one 6-way zone valve from Belimo (**Fig. 1**). As a result, just one actuator is needed for this assembly. This means fewer cables and data points and less installation work.

The system diagram (**Fig. 2**) shows a heating/cooling ceiling with room temperature sensor. Window contact, occupancy switch and dew point monitor are integrated directly by means of LonWorks®. The room temperature is controlled via the single room controller integrated in the LR24ALON actuator.

More information: www.belimo.eu

Grégory Picard, Certification Manager CSTB (2nd from left) with the production line managers at BELIMO Automation AG head office, Hinwil/Switzerland.

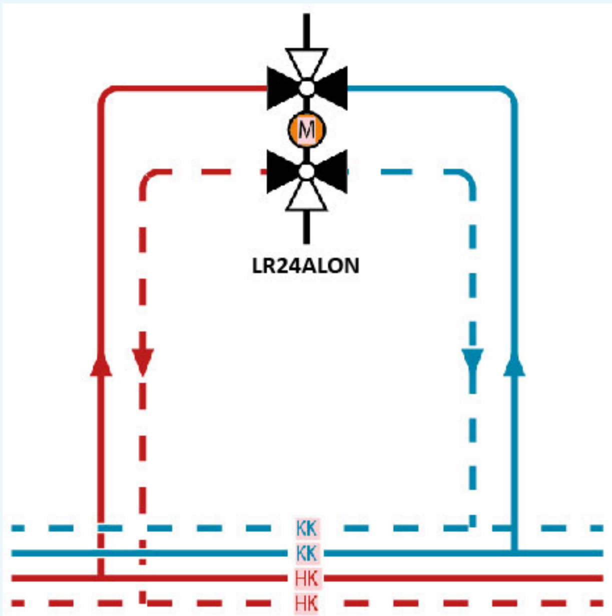


Fig.1

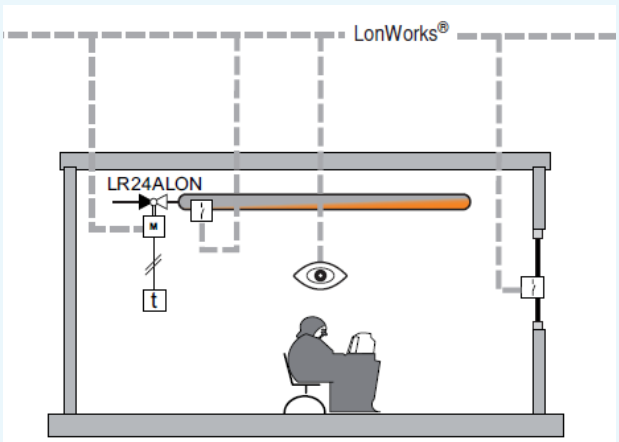


Fig.2

VDI- Standards published in January and February 2016

VDI 3805 part 17 (2016-01). Product data exchange in the building services; Drinking water system assemblies

Based on VDI 3805 Part 1, the standard describes a manufacturer and IT system independent and unified data format for the exchange of product data for drinking water system assemblies used in building services. German / English language.

VDI 3805 part 2 (2016-01). Product data exchange in the building services; Heating value assemblies

Based on VDI 3805 Part 1, the standard describes a manufacturer and IT system independent and unified data format for the exchange of product data for heating value assemblies used in building services. German/ English language.

D VDI 3805 part 23 *(Draft)* (2016-01). Product data exchange in the building services; Ventilation devices for flats

Based on VDI 3805 Part 1, the standard describes a manufacturer and IT system independent and unified data format for the exchange of product data for ventilation devices for flats. Only in German available.

VDI 6012 part 1.2 (2016-01). Integration of distributed and renewables-based energy systems in buildings; Fundamentals; System selection

This standard provides a method that can be used to determine which combination of regular, regenerative and/or possibly fossil-fueled energy systems could be installed in new or existing buildings. Included Excel spreadsheets facilitate the application of the described method. German / English language.

VDI 6012 part 1.4 (2016-01). Integration of distributed and renewables-based energy systems in buildings; Fundamentals; Fixing of solar modules and solar collectors on buildings

The use of solar energy is increasingly an integral part of energy generation. Both for photovoltaics and solar heating many systems are available that in part greatly differ in appearance and design. A viable and reliable mounting of modules and panels on buildings is indispensable required and creates inter alia, the preconditions for a desired long period of operation of these systems. Different connection and fastening systems are used for this purpose in practice. By attaching solar panels on buildings, the modules and panels and the mounting systems are exposed to external influences, such as force effects caused by wind, snow and temperature fluctuations, or other weather conditions. Moreover, the existing structurally optimised building structure and its protective functions, e.g. from rain or fire, may be effected by individual attachment means. The standard provides help on a professional and proper construction and gives advice for a proper selection of available mounting systems and mounting means and, therefore, helps to ensure the intended design and use of a building and the operation of the solar system to be used. German / English language.

VDI 6022 part 6 BER (2016-01). Ventilation and indoor-air quality; Air humidification on decentralised devices; Planning, construction, operation, maintenance

This standard applies to standalone units for the intended and local humidification of air as well as for decorative water-carrying devices (such as fountains, cascades and water walls) which affect the air humidity in a room. Units originally intended for residential use, which are used in workplaces, are also subject to the requirements specified by this standard. The standard factors the particular hazards incurring from such units arising from, e.g., the supply of unfiltered microbiologically contaminated breathing air and insufficient maintenance. German / English language.

D VDI 3805 part 100 *(Draft)* (2016-02). Product data exchange in the building services; Systems

Based on VDI 3805 Part 1, the standard describes a manufacturer and IT system independent and unified data format for the exchange of product data for systems. Only in German available.

VDI 6210 part 1 (2016-02). Demolition of civil constructions and technical facilities

The standard defines the procedures and assessment criteria for the planning and execution of demolitions of civil constructions and technical facilities for all involved personnel. It applies to the demolition of stationary and non-stationary variable structural and technical systems. The standard describes the planning, implementation and follow-up of such work as well as retrieving, deployment, (interim) storage, treatment and handling of the accumulating materials and waste. It does not include the requirements imposed on the reuse of resulting materials or the recycling or the disposal of waste. German / English language.

Events in 2016

Conferences and seminars 2016

Jan 23-27	ASHRAE Winter Conference	Orlando, Florida, USA	www.ashrae.org/orlando
Feb 24-26	World Sustainable Energy Days	Wels, Austria	www.wsed.at/en/world-sustainable-energy-days/
March 8-11	Sustainable Built Environment - SBE 2016	Hamburg, Germany	www.sbe16hamburg.org
March 16-18	9th International Conference Improving Energy Efficiency in Commercial Buildings and Smart Communities (IEECB&SC'16)	Frankfurt, Germany	http://iet.jrc.ec.europa.eu/energyefficiency/node/9096
March 31-April 2	12th International HVAC+R Technology Symposium	Istanbul, Turkey	www.ttmd.org.tr/sempozyum2016/eng/
May 22-25	12th REHVA World Conference - CLIMA 2016	Aalborg, Denmark	www.clima2016.org
May 30-June 3	CIB World Building Congress 2016 Intelligent built environment for life	Tampere, Finland	http://wbc16.com
June 22-24	Central Europe towards Sustainable Building Prague 2016	Prague, Czech Republic	www.cesb.cz
July 3-8	Indoor Air 2016	Ghent, Belgium	www.indoorair2016.org
August 21-24	12th IIR Natural Working Fluids Conference	Edinburgh, United Kingdom	www.ior.org.uk
September 21-23	International Conference on Solar Technologies & Hybrid Mini Grids to improve energy access	Frankfurt, Germany	www.energy-access.eu
October 23-26	IAQVEC 2016: international conference on indoor air quality, ventilation & energy conservation in buildings	Seoul, South Korea	www.iaqvec2016.org

Exhibitions 2016

January 25-27	2016 AHR Expo	Orlando, Florida, USA	www.ahrexpo.com
February 2-5	Aqua-Therm Moscow	Moscow, Russia	www.aquatherm-moscow.ru/en
February 24-26	Aqua-Therm Novosibirsk	Novosibirsk, Russia	http://www.aquatherm-novosibirsk.ru/en
March 1-4	AQUATHERM Prague	Prague, Czech Republic	www.aquatherm-praha.com/en/
March 13-18	Light and Building	Frankfurt, Germany	http://ish.messefrankfurt.com
March 15-18	Mostra Convegno Expocomfort	Milan, Italy	www.mcexpocomfort.it/
April 5-8	Nordbygg	Stockholm, Sweden	www.nordbygg.se
April 20-22	Aqua-Therm St-Petersburg	St-Petersburg, Russia	www.aquatherm-spb.com/en
May 4-7	ISK-SODEX 2016	Istanbul, Turkey	www.sodex.com.tr/
October 12-14	FinnBuild	Helsinki, Finland	www.messukeskus.com/Sites1/FinnBuild/

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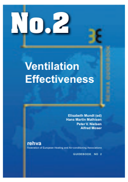
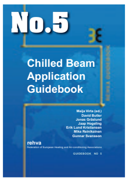
REHVA GUIDEBOOKS

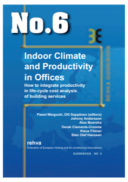
REHVA Guidebooks are written by teams of European experts



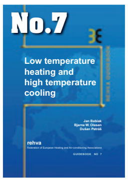
Ventilation Effectiveness. Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook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



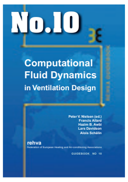
Chilled Beam Cooling. Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature 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 the heat exchanger.



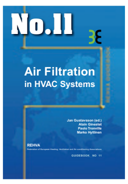
Indoor Climate and Productivity in Offices. This Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available.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



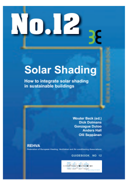
Low Temperature Heating And High Temperature Cooling. This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in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



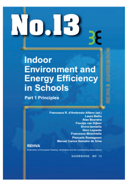
Computational Fluid Dynamics in Ventilation Design. CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary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



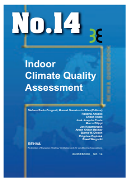
Air Filtration in HVAC Systems. This Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on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



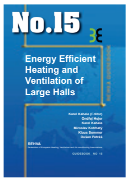
Solar Shading – ***How to integrate solar shading in sustainable buildings.*** Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy 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 control.



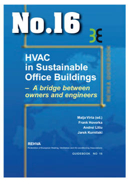
Indoor Environment and Energy Efficiency in Schools – *Part 1 Principles.* School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students. It focuses particularly on energy efficient systems for a healthy indoor environment.



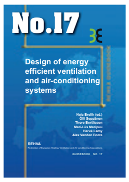
Indoor Climate Quality Assessment. This Guidebook gives building professionals a useful support in the practical measurements and monitoring of the indoor climate in buildings. Wireless technologies for measurement and monitoring have allowed enlarging significantly number of possible applications, especially in existing buildings. The Guidebook illustrates with several cases the instrumentation.



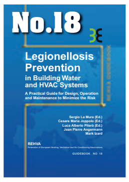
Energy Efficient Heating and Ventilation of Large Halls. This Guidebook is focused on modern methods for design, control and operation of energy efficient heating systems in large spaces and industrial halls. The book deals with thermal comfort, light and dark gas radiant heaters, panel radiant heating,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



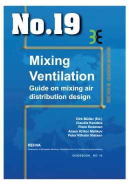
HVAC in Sustainable Office Buildings – ***A bridge between owners and engineers.*** This Guidebook discusses the interaction of sustainability and heating, ventilation and air–conditioning. HVAC technologies used in sustainable buildings are described. This book also provides a list of questions to be asked in various phrases of building's life time. Different case studies of sustainable office buildings are presented.



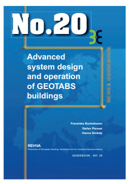
Design of energy efficient ventilation and air-conditioning systems. This Guidebook covers numerous system components of ventilation and air-conditioning systems and shows how they can be improved by applying the latest technology products. Special attention is paid to details, which are often overlooked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



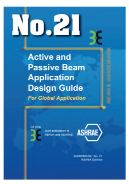
Legionellosis Prevention in Building Water and HVAC Systems. This Guidebook is a practical guide for design, operation and maintenance to minimize the risk of legionellosis in building water and HVAC systems. It is divided into several themes such as: Air conditioning of the air (by water – humidification),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



Mixing Ventilation. 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.



Advanced system design and operation of GEOTABS buildings. 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.



Active and Passive Beam Application Design Guide is the result of collaboration by worldwide experts. It provides 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 and maintain. 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.

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