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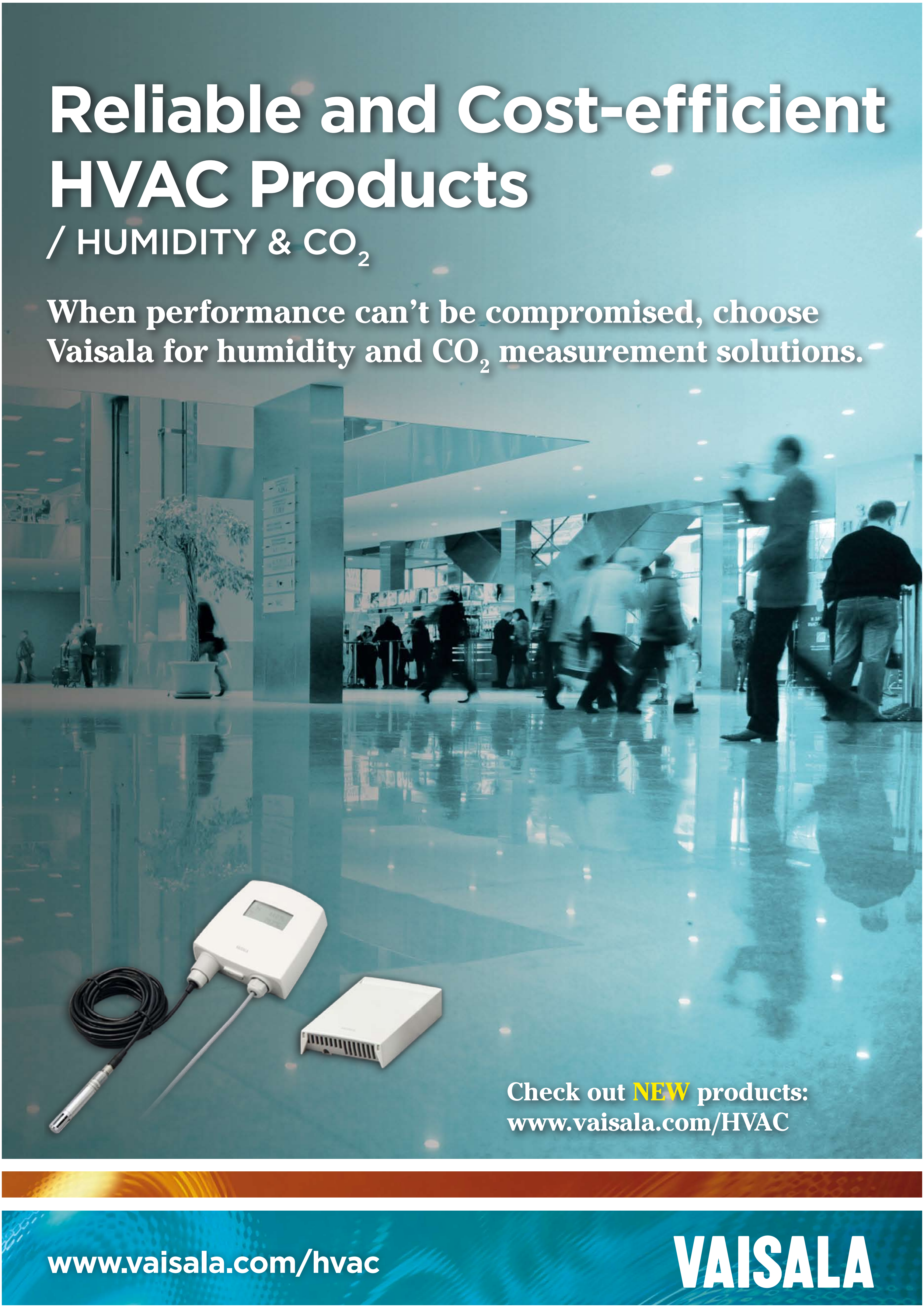
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REHVA OFFICE
Washington Street 40
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Tel: 32-2-5141171, Fax: 32-2-5129062
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Teknik Yayıncılık Tanıtım A.Ş.
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European Directives: Factors for innovation and progress

Jacques Benoist
Guest Editor
Foreign Affairs
AICVF French HVAC Engineer's association

Member States are sovereign in their national technical regulations subject to transpose the directives into national law adopted at the European Union level in the development which they participate.

At the beginning of Europe, directives, called "harmonization" proved impossible to be adopted by all Member States. Since the Single European Act in 1985 which amended the Treaty of Rome, the directives are "new approach". That is to say that the Directives set essential requirements and request that manufacturers establish into harmonized European standards, the technical specifications that will meet those requirements. These European standards, once adopted, are included in the collections of the National Institutes of Standardization (DIN, BSI, AFNOR etc.).

The directives 'new approach' transposed into national law are used as a model for Member States to prepare their technical regulations and are also considered as guides by manufacturers to induce industrial innovations and technological progress.

HVAC equipment manufacturers launched on the European market products and materials more and more efficient, able to cope with the requirements of the directives, not only in using traditional energy sources but also renewable energy sources too.

The EPBD recast which advocates the use of more efficient techniques indicates possible avenues for innovation; e.g. (Article 6) use of energy from renewable sources, use district heating or cooling, cogeneration or heat pumps and optimization the energy use of technical building systems (Article 8).

The Ecodesign Directive and recast on energy-using products which aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle, led manufacturers to design, built and sold on the market improved products not only in term of energy consumption but environmental impact too.

It is understood that the contribution of the manufacturers on buildings whose energy consumption is nearly zero, through innovative products or technical solutions can not be the only one.

A new integrated form of collaboration between all stakeholders: architects, consultants, manufacturers and contractors of all trades is essential not only to meet the requirements of the Directives but the quality of buildings with the promises related in terms of costs, consumptions and air quality too.

It is important to remember that buildings are meant primarily for people who are going to live or work in it and an affordable well-being for the greatest number will be the true measure of the progress and innovation.

Impact of low energy buildings on indoor air quality (IAQ)

Introduction

The building codes implemented during the last thirty years have led to a better insulation and air tightness of constructions in order to limit heat losses and save energy. In parallel, the available living space has been reduced to suit present day needs and to adapt itself to the increased costs of the real estate markets, leading in some cases to over occupancy of accommodations.

These factors have contributed to a deterioration of the indoor air quality (see report of OQAI "Observatoire de la Qualité d'Air Intérieur" (3) on IAQ in French accommodations). The current reinforcement of building codes following European directive, will make this situation even worse if they are not completed by further changes in how we ventilate these areas.

Eric Bataille
Atlantic
Marketing Director
ebataille@groupe-atlantic.com

Presence of moisture in housing

In France, forty percent of existing dwellings have fungus problem and more than twenty three percent have moisture problems. The main causes are a defect or an absence of the ventilation system and unfavourable climatic conditions (according to an ESMHA study (1), the age of building is not a relevant cause). In parallel, over occupancy is further increasing the risk of moisture problems in dwellings. Over occupancy rates are noticeable in cities with a combination of high real estate prices and low purchasing power, leading to difficulties in obtaining an appropriate accommodation (i.e. size of dwelling compared to family size) (5).

Effect of moisture on health conditions

Moisture problems in dwellings exist with 75% of the patients that have respiratory problems; they develop a further risk of allergy due to dust mites. A humid accommodation increases the frequency of respiratory problems from 30% to 50%, especially asthma (Professor D. Charpin (2)). Moisture increases allergies (already 30% of population is allergic), asthma, respiratory problems and microbic VOC (Professor De Blay (2))

Ventilation system in existing buildings

In recent French dwellings (built after 1982 or renovated with mechanical ventilation systems) the OQAI study (6) revealed a better indoor air quality thanks to mechanical ventilation systems. Nevertheless, approximately 50% of the measured air flows are below the rates of official French rules. It is mainly due to defective installations or the lack of maintenance. This point has to be improved by incentives or rules that allow for certifying contractors to install ventilation systems and perform the appropriate maintenance.

This point is particularly relevant in schools where there is a proven, direct link between air pollution and ventilation systems (7). The relation between the presence of ventilation systems and a healthy environment is frequently pointed out as positive.

Relation between building air tightness and Indoor Air Quality (IAQ)

The air flow entering through the infiltrations of the building (defects of construction and lack of insulation) are important and have to be taken into account to appreciate the IAQ. They are part of the renewed air and the French OQAI study (6) has highlighted the predominant part of air infiltrations in the total air renewal of dwellings.

In order to better understand how infiltrations are influencing IAQ, we have made simulations using SIREN software from French CSTB official body ("Centre Scientifique et Technique du Batiment").

The more the building is permeable and under negative pressure, the more the impact of infiltrations is high. The level of infiltrations will then depend on the type of ventilation system and level of air tightness of the building. In order to evaluate the IAQ in a simple manner we have used the classification of EN 13779 standard based on incoming fresh air flow per person.

In **Figure 3** and **Figure 4** one can see the origin of incoming fresh air in a detached house of 84 sq meter occupied by 4 persons depending on air tightness and ventilation system.

Figure 3 shows that in the case of a single way ventilation system (humidity controlled exhausted air) **more than 70% of the fresh incoming air is entering through building infiltrations.** So, if air tightness is improved, i.e. from 1.3 to 0.6 as required by French RT 2012 building code, it will lead to a reduction of fresh incoming air of 33% and change the IAQ from average to moderate level (EN 13779).

In the case of a cross ventilation system (**Figure 4**), fresh incoming air by the ventilation system is not influenced by air tightness as air is mechanically driven in the building. The increased air tightness of the house is still leading to a reduction of incoming fresh air but to a lower extent (minus 24%) due to the mechanical control of incoming air from the ventilation system and balanced air pressure in the house. Air tightness has a big influence on IAQ and needs to be taken into account to determine the air flow rates of the ventilation system; they should not be considered independently.

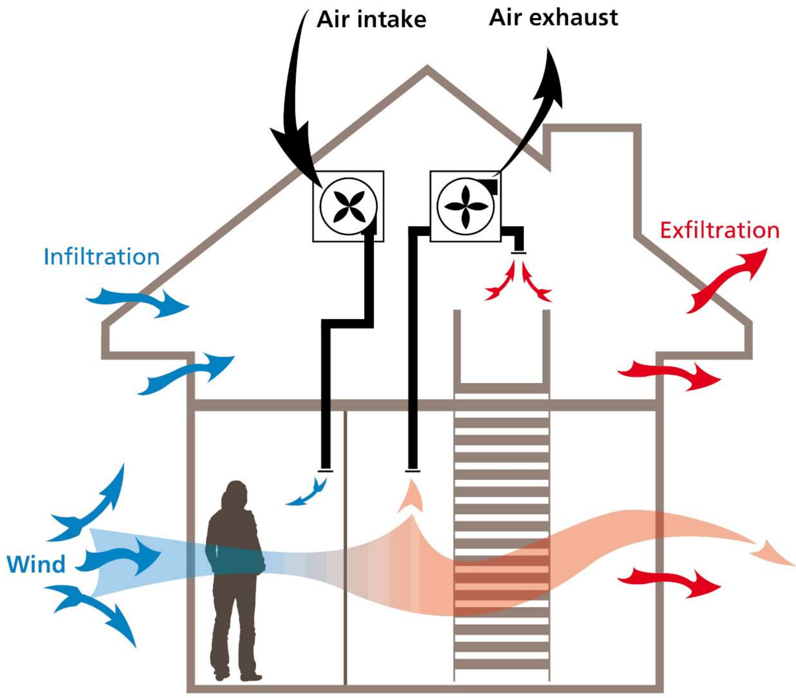

Figure 1. Building air flow.

Air quality category	CO2 concentration (ppm) above outdoor level	Fresh air flow
Excellent Air quality	< 400	> 54 m3/h/pers
Average Air quality	from 400 to 600	from 36 to 54 m3/h/pers
Moderate Air quality	from 600 to 1000	from 22 to 36 m3/h/pers
Poor Air quality	> 1000	< 22 m3/h/pers

Fresh air flow to respect in relation with Indoor Air Quality wished (EN 13779)

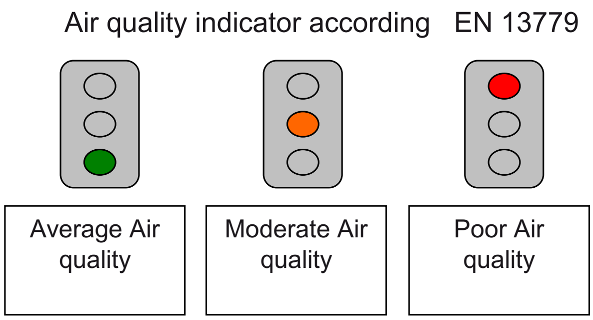

Figure 2. Air quality indicator.

International overview of specified air flow rates compared to IAQ standards

Each European country has its own recommendations or official rules regarding ventilation of buildings and minimum air flow rates re-

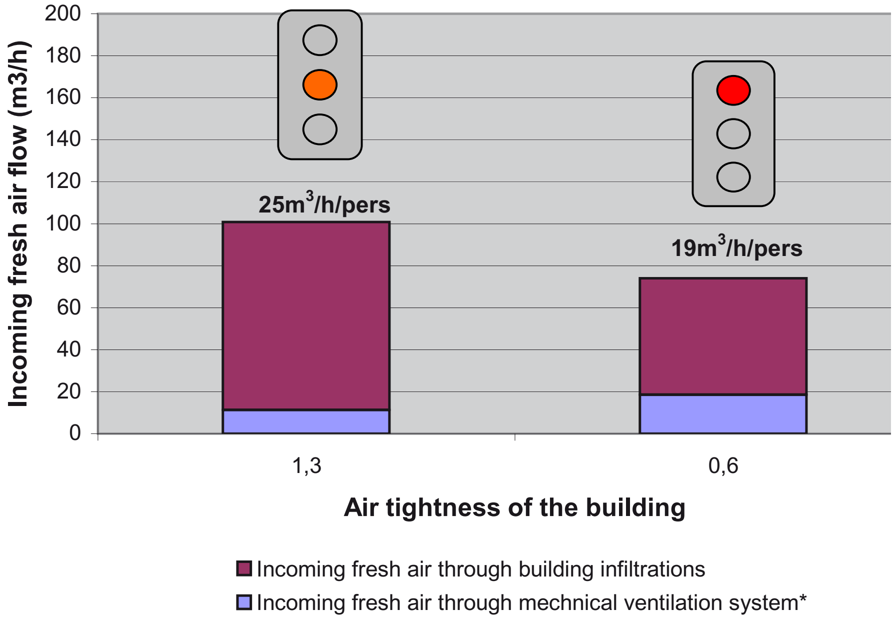

Figure 3. Incoming fresh air repartition with humidity controlled ventilation system.

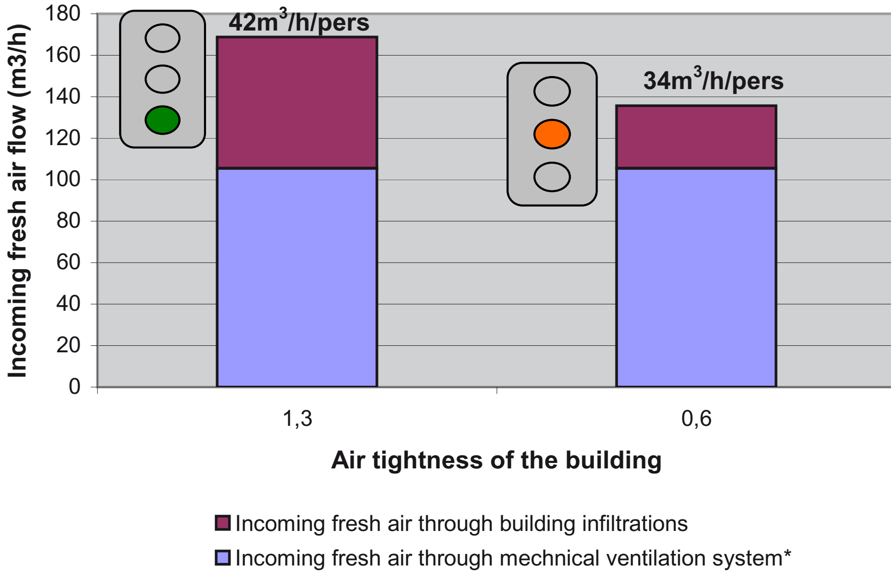

Figure 4. Incoming fresh air repartition with cross ventilation system.

quired. **Figure 5** shows the recommended ventilation rates (including building infiltrations) of the different European countries for a 110 sq meters detached house occupied by 4 persons. A focus has been made for France to compare the situation between current building code (RT 2005) and the upcoming one (RT2012) in order to measure the impact of the reduction of building infiltrations.

None of the airflow rates used in different European countries reaches the "normal" level of IAQ as defined in EN 15251 for newly built or renovated dwellings. Only the Netherlands reaches the "moderate" level.

In France the air flow rates of standard single way exhausted air ventilation systems are very close to the European "moderate level" but most of the systems already used in new French buildings are using humidity controlled ventilation systems with an average air flow rate inferior to the European standards. When taking into account reinforcement of building air tightness, required by the upcoming RT 2012, the airflow rates will be further reduced ensuring worse results than those of all other European countries and not compatible with the European standard. One can realistically predict very poor IAQ in new French dwellings, unless people go back to opening windows, which in turn would be in direct opposition of the RT 2012 goal of saving heating energy.

Relation between IAQ and window opening

The duration of window opening varies from 30 minutes to 1 hour per day depending on family size and types of rooms. It has been proven that window opening is not linked to the type of ventilation but is very specific to each person. Usually, people open the windows less during the heating season. Even during the peak of indoor air pollution some don't feel the need to open windows. Window opening cannot also be considered a solution for exhaust pollution originating from furniture and other products used for construction or decoration. In France, one third of dwellings have no windows in the bathroom where humidity levels are highest (4, 6 and 8). Window opening is a cultural behaviour and cannot be substituted to ventilation systems.

Conclusion

The coming new building codes designed for saving energy in new buildings is a clear threat to the IAQ if they are not completed by a

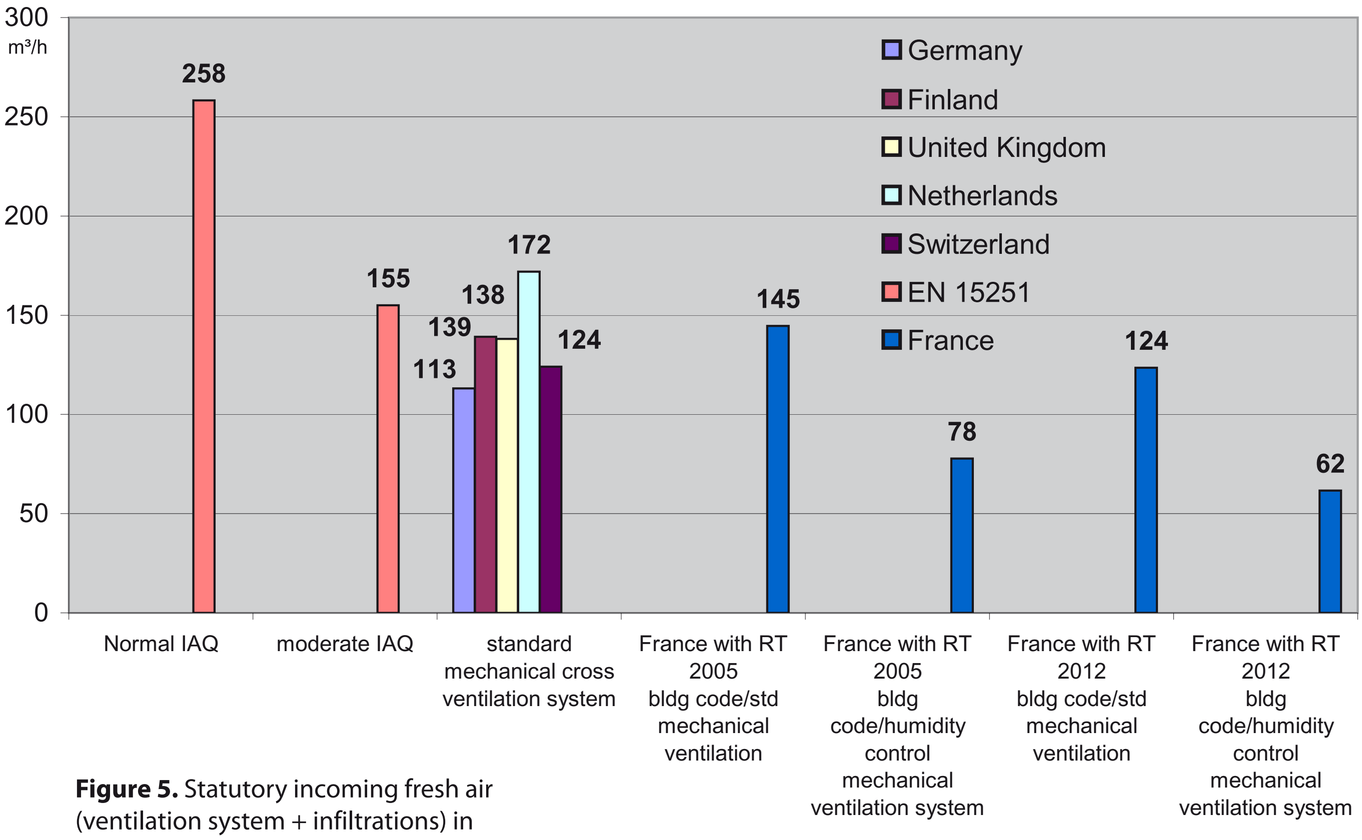

Figure 5. Statutory incoming fresh air (ventilation system + infiltrations) in different European countries compared to EN standard.

revision of the rules regarding ventilation. These new rules will have to take into account air infiltrations of the building which are today ignored, though they represent the majority of fresh, incoming air and will be largely decreased in low energy buildings. Ventilation systems will then become predominant as well as the quality of their installation and maintenance which is today largely disregarded in most European countries. Ventilation systems in accommodations are too often chosen only for price considerations while they are going to be one of the main HVAC product solutions for maintaining good IAQ and low energy consumption. Increasing total airflow rate is possible without creating additional heat losses and creating noise problems. Solutions already exist but are insufficiently used due to lack of concern and information.

Solutions for optimizing IAQ and energy consumption

- Heat recovery ventilation systems (static or using heat pumps). Heat recovered can be used in different ways (heating fresh incoming air, domestic sanitary hot water, water for central heating)
- Modulated ventilation on large air flow scales, based on real indoor pollution and taking into account real occupation
- Combination of both systems

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[10] Comparaison européenne des réglementations existantes sur la ventilation.

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Air cooling for gas turbines

Water chillers and electrical gain during summer season

Emilio Giuliano Bacigalupo
Captain, Marine Consultant
Former Ship Engineer Officer
Former AICARR Counselor

Abstract

Gas turbine inlet air cooling is a technology designed to increase gas turbine power output. That system can lead to substantial power gain along with significant reductions in heat rate at a fraction of the cost of new power equipment. The payback can be very short particularly for high capacities and in hot climate.

This technology has been described in the ASME-ASHRAE documents. Current combined cycles recover heat from gas turbines exhaust gases up to 100°C and therefore feeding of absorption chillers would be provided by the last stages of the steam turbine, which however would reduce its capacity. Currently, the best solution is using a high-capacity and high-efficiency electric centrifugal chillers, which are convenient due to their specific price, energy consumption, weight and dimensions, modern controls, and evaporative tower performances.

Introduction

The ASME (American Society of Mechanical Engineers) "GT250" document (1990) describes the available technological and energetic solutions aimed at increasing the electric power of gas turbines, in hot ambient temperatures and due to the laws of physics, the decrease of inlet air mass flow reduces fuel consumption and therefore also electricity generation.

In summer, together with the above reduction, there is an increase of the electric power needed by air conditioners (that are used to ensure comfort of building occupants): as a consequence of power reduction, the installation of further operational gas turbines is necessary.

The above situation can be solved by using a refrigerated water coil installed on the air inlet of the gas turbine: this additional heat exchange, even with a large exchange surface, causes a slight air pressure drop. To eliminate this drop in winter, the coil (split in two halves and after disassembling the flanges from the valves) can be placed upon rails and moved aside. Electric saving could be achieved by spraying some water on the gas turbine inlet, so as to reduce the sensible temperature of air at its maximum humidity (as it happens in evaporative towers). The result is limited in humid areas and considerable in dry areas, where, however, refilling water is not easily available and expensive. A better solution for the problem can be found by examining the most convenient compromise (i.e. the most favourable cost/benefit ratio) by means of thermodynamic/economic analyses included in different articles and reports: starting from the ASME/IGTI congress held in Bournemouth in February 1993 "Maximum energy from biggest gas turbines" AICARR/CDA journal of April 2007.

In small and mid-sized electric power plants, apart from other possible applications, thermal cogeneration of exhaust gases can be used in order to feed single stage absorption chillers; this is a low cost solution (only electric consumption of evaporator/coil pumps and of condenser/cooling tower pumps) and the pay-back time is also very short (**Figure 1**).

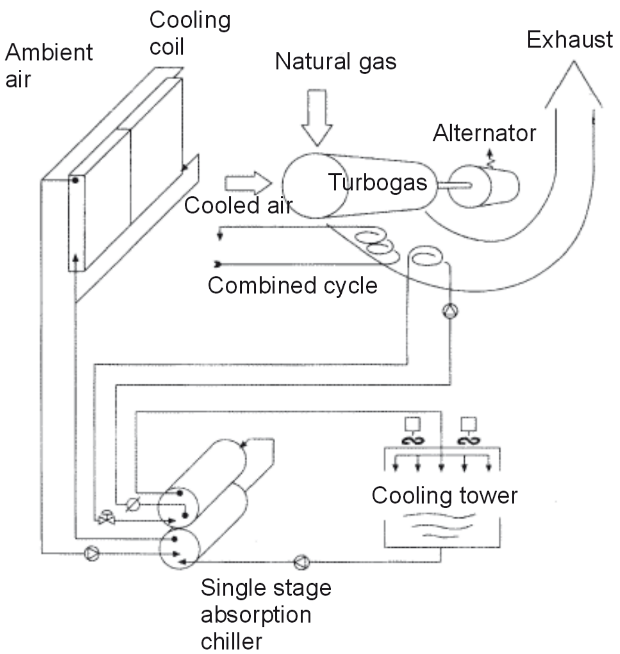

Figure 1. Turbogas air colling system with apsorption chiller in co-generation (downstream combined cycle).

Large power plants use high capacity combined cycles - gas/steam turbines up to (340+190=) 530 MWe with 15°C inlet air (ISO conditions) - and the remaining thermal recovery from exhaust gases is not sufficient. Another system may be recommended: high capacity and efficiency centrifugal chillers, resulting in a low electric consumption to be deducted from the extra production mentioned in the title of this article.

For a better analysis of this project, **Figure 2** shows a Cartesian diagram comparing ambient temperatures and operation hours throughout the year. The diagram covers the European and Mediterranean area (i.e. temperature above 10°C and up to 38°C) during the temperate and warm periods (5760 hours in total). In order to reduce the costs of an oversize chiller, a reduction of air temperature down to 20°C may be considered as satisfying for the last 760 hours; the remaining area of the diagram assumes the product "°C x h", i.e. an energy-like figure of 45000 to 49000, depending on the local climate. This thermal exchange value is multiplied by the gas turbine power as well as by its sensitivity factor, and the result represents the incremental percentage for each single °C decrease of inlet air temperature. By taking as a reference the intermediate value of 47000 °Ch, we can choose the most efficient gas turbines available on the market: 40 MW (aero derivative turbines) and 250 MW (frame-type turbines), which offer the excellent performance values of 0.4 and respectively almost 0.6; in addition with sensitivity factors of +1.4% and +0.7%.

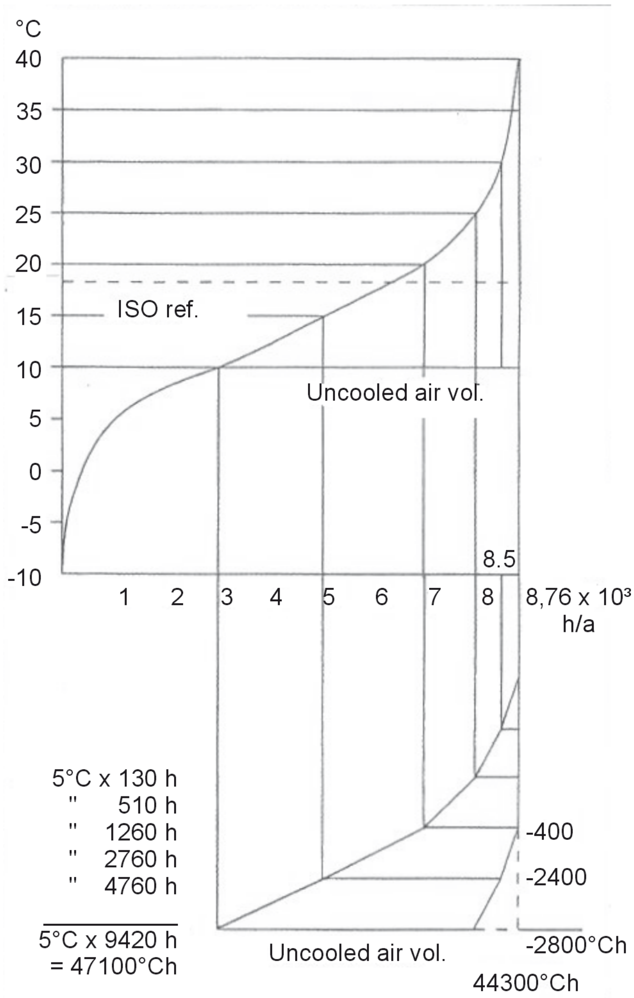

Figure 2. Outside temperature diagram (source: ENEL).

The above examples show a yearly extra electric production of (40 x 1.4% x 47000=) 26320 MWh and (250 x 0.7 x 47000=) 82250 MWh. If dividing these values by 0.4 and respectively by 0.6, we obtain natural gas consumption values of 65800 and 137080 MWh. Considering a lower calorific value of 9.59 kWh/scm, we obtain 6861300 and respectively 14294000 standard cubic metres (at 15°C). Assuming - for these gas turbines - a gas cost of 0.2 Euro/scm, as well as an electricity selling price of 0,075 Euro/kWh, costs for gas will be 1,372,260 and 2,858,800 Euro, against gross profits of 1,974,000 and 6,168,750 Euro: that's to say, 1.44 and respectively 2.16 times higher, if cooling weren't affected by the additional load of chillers and related pumps.

Consequently, it is necessary to make a realistic balance, by choosing centrifugal water chillers units in the range of 10/5°C up to 20/15°C (evaporator in/out) for temperate to warm ambient conditions, and - likewise- by choosing condensing water in the range of 25/20°C up to 38/32°C (cooling tower in/out), always when the air ambient temperature is varying. According to proven experience, the recommended cooling capacity is about 6% of the gas turbine electric power; consequently, the said centrifugal chillers would be 2.4 and 15 MW at ARI standard conditions. In order to better understand this innovation, we can choose the most complex system, including two chillers (7.5 MW each) with parallel water flow - see point 12 at **Figure 3**.

Both sketches have been traced on the same axes, i.e. ambient temperatures per running hour; let's say in a calculation range of 11 to 38°C and 240 to 6000 running hours.

Figure 3 shows air enthalpy (°C together with 100% to 40% humidity), i.e. kcal/kg; consequently, the temperature of chilled water in the coil determines the cooled air in the gas turbine. **Figure 4** follows the cooling cycle thermodynamic law in order to produce the chilled water according to the condensing water depending on weather conditions. The first centrifugal chiller starts at point no. 1, with 15-20% of its load at about 12°C am-

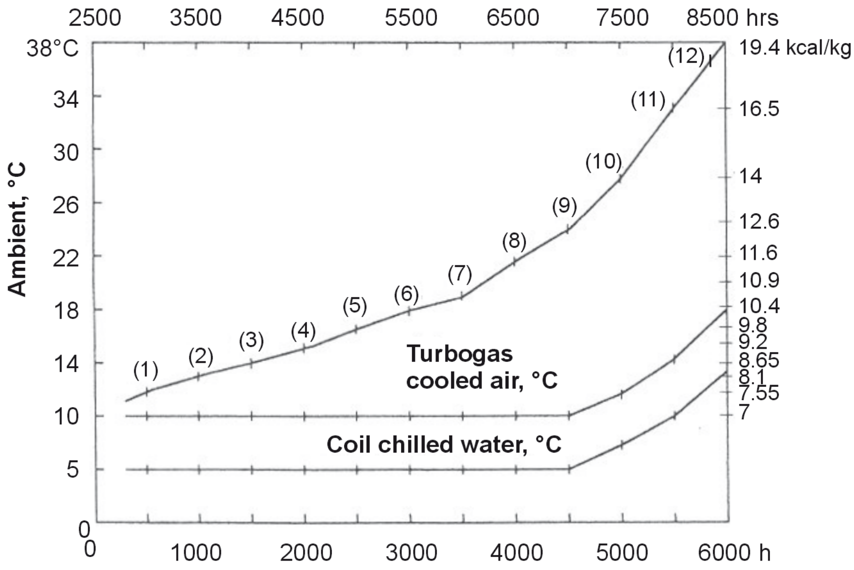

Figure 3. Chilled water/ cooled ambient air comparison.

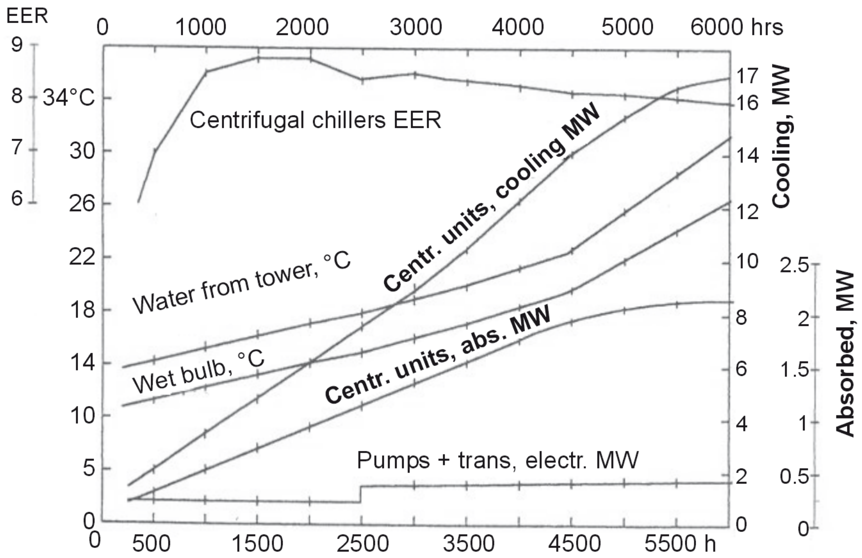

Figure 4. Cooling plant – comparison data.

bient, operating up to 100% capacity (50% of system capacity) at an outer temperature over 18°C. The other centrifugal chiller starts from point 6 in order deal with the load increase, what determines (after point 9 and up to point 12) inlet of air with temperature over 10°C. The cooling power line varies from 2 to 17 MW with an absorbed electric power of 0.25 to 2.17 MW, since the average COP is around 8. This balance varies from the favourable conditions of the condenser and the unfavourable conditions of the evaporator; the situation is reversed when ambient temperature increases.

Integrating the cooling and electricity areas, a rough calculation shows 50,000 and 6,250 MWh during 5760 hours per year. For the two pumps of each centrifugal chiller, we assess 0.2 MW up to point 5, and 0.4 MW up to point 12; through an optimization of the inverters we should obtain a consumption of 1,750 MWh. For this reason, net electric production is reduced to (82,250-6,250-1,750=) 74,250 MWh, corresponding to 5,568,750 Euro per year (given 0.075 Euro/kWh). The final difference - if compared to the gas cost of 2,858,000 - is a gain of 2,710,750 Euro, which is far higher than the preliminary financial charge of this system, which is suitable to improve performances: an attractive pay-back time! However, each single case must be dealt with and verified according to its specific features. 3E

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Requirements for well functioning Demand Controlled Ventilation

Mads Mysen
Senior Scientist
Oslo University College
SINTEF
Mads.Mysen@sintef.no

Peter G. Schild
Senior Scientist
SINTEF
peter.schild@sintef.no

Introduction

IPCC (The Intergovernmental Panel on Climate Change) recommends a 50% reduction of manmade CO2 emissions before 2050 to avoid severe problems of global warming. The IEA report "Energy Technology Perspective 2008" has presented the Blue Map scenario on how to achieve this emission reduction (IEA report, 2008).

A consequence for the building sector is that a widespread conversion of buildings to very low energy consumption and even zero energy buildings is necessary. The EU Parliament approved in 2010 a directive (EPBD Recast) that requires member states to implement ambitious plans to upgrade much of the existing building stock to nearly zero energy buildings (NZEB) by 2020, with intermediate goals to be set for 2015.

Ventilation constitutes a major share of the total energy use buildings of existing non-commercial buildings in the Nordic countries, typically 35-50% for office buildings (Wigenstad and Grini, 2010). Existing office buildings in Norway have an average energy use of 245 kWh/m² according to Enova (2010).

Most non-residential buildings have Constant Air Volume (CAV) ventilation leading to over-ventilation in periods with low or no occupancy. Comparison of perceived indoor climate in schools with CAV-systems and DCV-systems does not indicate that CAV-systems add extra quality to the indoor climate (Mysen Doctoral Theses 2005). The purpose of extra ventilation with CAV-systems is therefore questionable as it leads to additional energy use.

Demand controlled ventilation (DCV) considerably reduces the ventilation airflow rates and energy use compared to CAV systems. This conclusion is based on an inspection of 157 classrooms in primary schools (Mysen et al. 2005). Installation of variable air volume systems (VAV) can reduce the need for air heating by more than 90% and electrical energy for air distribution by 60% (Maripuu and Jagemar 2004, Maripuu 2009). DCV is probably a prerequisite to achieve the ambitious energy-goal for existing commercial buildings.

However, evaluation of real energy use demonstrates that this potential is seldom met. DCV-based ventilation systems must become more reliable to close the gap between theoretical and real energy-performance. This unfortunate experience with DCV seems to have many causes. Identified key factors for improvement so far are: to avoid wasted energy use because of unnecessary throttling, inadequate specifications, hand-over documentation and balancing report for DCV, and a clearly defined and placed responsibility for the overall functionality. This paper presents energy related differences between DCV-systems and recommends requirements for improved energy functionality.

Alternative DCV-systems

Figures 1 to 3 show the supply ductwork of in principle different DCV-systems: "Pressure Controlled DCV" (PC-DCV) and "Static Pressure Reset DCV", and "Variable Air Supply Diffusor". The exhaust system is similar in principle, or based on a master-slave concept related to the supply air flow.

Pressure controlled DCV

Traditional DCV systems (**Figure 1**) are based on static pressure control, PC-DCV. The purpose of static pressure control is to indirectly control the airflows by controlling the pressure in a strategic duct position. The solution can be improved by additional static pressure branch control. PC-DCV requires installation of active VAV-units controlling supply and exhaust air flows to each VAV-room/zone and static pressure tubes in the main duct. Ventilation systems covering vast areas or several floors will probably need additional VAV-units and static pressure tubes controlling the main branches. CAV terminals must be connected to specific CAV branches, or they must branch off close to the pressure sensor. If this is not possible, such rooms must have "individual VAV-units" with active control dampers to ensure constant air flow with variable duct pressure. Controlling fan speed to maintain a constant static fan pressure rise, will result in unnecessary throttling along the critical path during most of the AHUs operating time, and therefore unnecessary fan energy use. The worst case is only a proportional fan energy and flow rate reduction (Schild and Mysen, 2009), while the ideal case is energy reduction according to the cube fan law (ASHRAE, 1996). The latter case assumes no laminar flow elements in the AHU, and zero minimum pressure drops at control points. One unfortunate experience of pressure controlled DCV system is that minor changes in room demand just redistribute airflow in the duct system with the airflow in the AHU being more or less constant, and no energy saving is actually achieved. This is probably enhanced by factors like low sensor accuracy, poor ductwork air tightness and unfavorable location of the preassure sensor. This makes it questionable whether fresh air is supplied with sufficient accuracy and minimum possible energy use. Another challenge with pressure controlled DCV is where to locate the pressure sensor for optimal functionality.

Static Pressure Reset DCV

Figure 2 shows an implementation of modern Static Pressure Reset DCV. Static Pressure Reset Control (SPR-DCV) is used to make pressure controlled systems more energy-efficient by emulating direct flow control functionality.

SPR constantly tries to satisfy all air flow requirements with a minimum of the fan speed drive by ensuring that the VAV damper(s) along the present critical path (**Figure 2**) are in a maximum open position, thus the SPR controller is frequently called an "optimizer". The duct path with the greatest flow resistance from the AHU to any terminal is called the '*critical path*'.

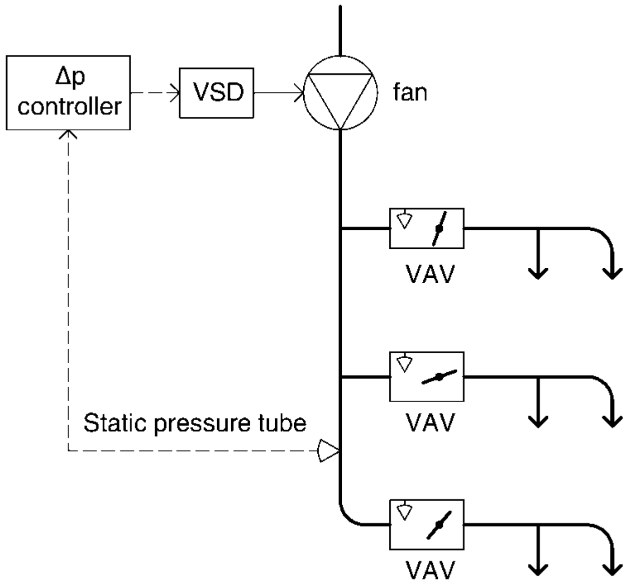

Figure 1. Principle of constant static pressure control. The critical path VAV damper is in max position only at times of maximum flow rate demand.

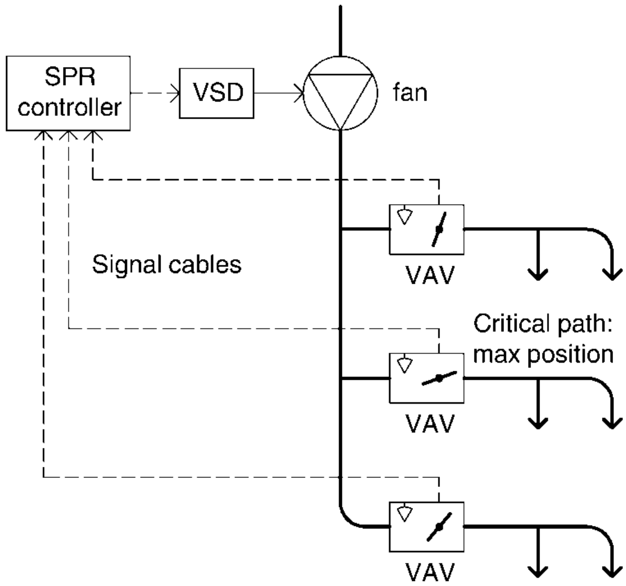

Figure 2. Illustration of SPR control. At least one VAV balancing damper is in max position (the critical path).

Dampers cannot be 100% opened due to need for control authority, i.e. to prevent excessive servo motor wear due to 'hunting'.

SPR-DCV requires additional controls (relative to Pressure controlled DCV) for continuously optimising the VAV-damper-position (either standalone controllers or BMS programming). A traditional SPR system will also have duct pressure sensors controlling the branch dampers, whereas modern systems need no pressure sensors.

Well-functioning SPR represents the ideal case in terms of energy use, and air flow rate accuracy. The catch is that SPR systems require more control components and hence are potentially more complicated and less robust. SPR-DCV has probably higher investment cost than pressure controlled DCV due to extra controls for continuously optimising the VAV-damper-positions.

Variable Supply Air diffuser DCV

Figure 3 shows the principle with Variable Supply Air Diffuser (VSAD-DCV). The air terminal units have a built-in VAV-unit and an occupancy and temperature sensor; hence there is no need for additional active control dampers in the duct system. Each VSAD covers the area beneath the air-terminal-device. Required air flow rate, actual air flow rates, temperature and corresponding opening percentage of the VAV-unit is communicated to the BMS regulating the fan speed drives in the AHU so that all the terminal devices are satisfactorily close to requirements and at any time, there is at least on fully open air terminal device. This solution requires variable supply air diffusers with good airflow control properties and with a low noise generation even at a high pressure drop over the device. Noise properties are especially important since potentially noise generating throttling appears so close to the occupied zone.

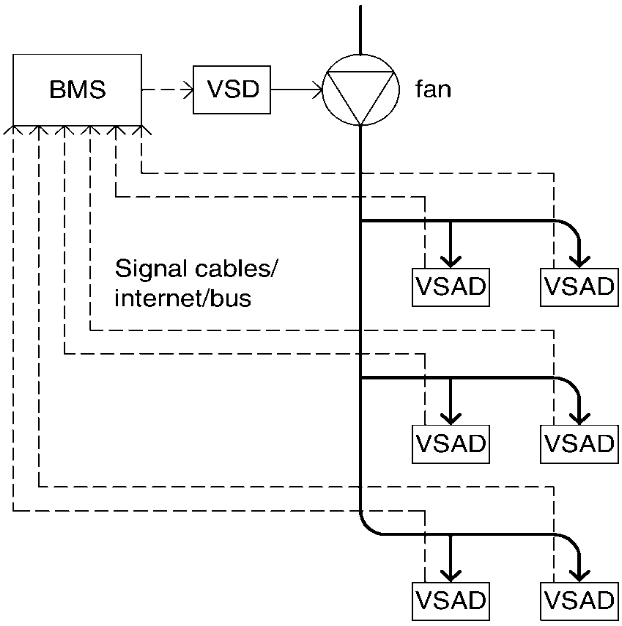

Figure 3. Principle of VSAD-DCV.

Requirements for well-functioning DCV

- 'Poor' represents systems with poor efficiency at part load. This includes mostly traditional methods that are now outmoded, such as inlet vane dampers, discharge dampers, variable-pitch fansand inefficient VSDs such as triacs. The efficiency of some of these systems varies greatly; some may be worse or better than the 'poor' curve. It also represents VAV systems for which the fan speed is controlled to maintain a constant fan pressure rise, irrespective of flow rate.
- 'Normal' represents systems for which the fan pressure drops marginally as flow rate is reduced. This includes VAV systems with the fan speed controlled to maintain a constant static pressure towards the end of the main duct.
- 'Good' represents systems for which the fan pressure decreases with flow rate. This includes best-practice VAV systems with fan speed regulated by a VFD with a typical Static Pressure Reset controller (SPR, also known as an 'optimizer'; see Figure 2). SPR constantly tries to minimize duct system resistance by ensuring that the VAV damper(s) along the present critical path are fully open. VFD controlled AC fans sized <3.7 kW cannot fall in this category, irrespective of pressure control scheme, because these small inverter VFDs have high losses.
- 'Ideal' represents real systems with efficient VSDs and where the fan pressure falls ideally at low flow rates. This includes VAV systems with perfect SPR control (i.e. 100% open control dampers along on the critical path), or reducing fan speed in CAV systems with fixed duct components (constant k-value). For example, night time operation of a CAV system with a flow rate of 20% (r = 0.2) will reduce the SFP to about 19% of $SFP_{max\ load}$. AC fans sized <15 kW cannot fall in this category, irrespective of pressure control scheme, due to higher losses in their VFDs.

An expert group from norwegian industry and R&D-partners, have suggested new requiremens for well-functioning and economical beneficial DCV based on indentified success criteria's (Mysen et al 2010). Here are some of the new requirements:

- Specific Fan Power (SFP) is normally required and controlled at maximum air flow. However a DCV system will have airflow between 30 and 80% of maximum air flow depending mainly on diversity factor for dimensioning and base ventilation level. At design level, there are only small differences between the system's SFP, but at lower airflow rates there are major differences depending on the control strategy (**Figure 4**). It is important to require maximum SFP-value for two operating scenarios, maximum airflow and reduced airflow, to ensure an energy efficient control strategy

- Fitting a DCV-system, typically involves several contracts including BMS (Building Management System), Ventilation system and Electrical Equipment. However, the overall responsibility for the system functionality must be clearly defined and placed in one contract.
- Adequate specifications, hand-over documentation and balancing report suitable for DCV-systems must be used.
- Components, such as sensors, that have proper functionality and acceptable measurement uncertainty throughout their predicted lift expectancy, for instance:
  - CO_2-sensors +/-50 ppm
  - Temperature sensors +/-0.5°C
- Some of the sensors should be controlled at site.
- Sensors must have an appropriate position (inner wall, not to close to doors or breathing zones)
- An airflow change in any room should give approximately the same change in the total airflow at the fan.
- Function of crucial components such as fan energy use, VAV-damper positions, air flow rates at room level etc. should be logged and controlled.
- Maximum diversity factors for dimensioning and assumed average use for energy calculations, together with specified running conditions during control procedure must be specified.
- Prospective economical penalty is agreed upon before performance test during final commissioning procedure
- There should be an inspection and review of the DCV- system after a period of normal operation, e.g. 1 year.

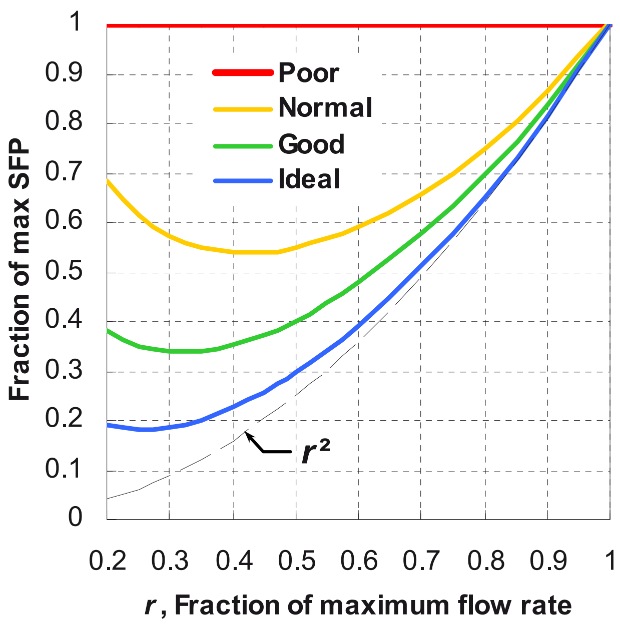

Figure 4. Illustration of covariation between airflow rate and SFP-value for Poor, Normal, Good, and Ideal DCV-systems (Schild and Mysen 2009).

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▶ Acknowledgements

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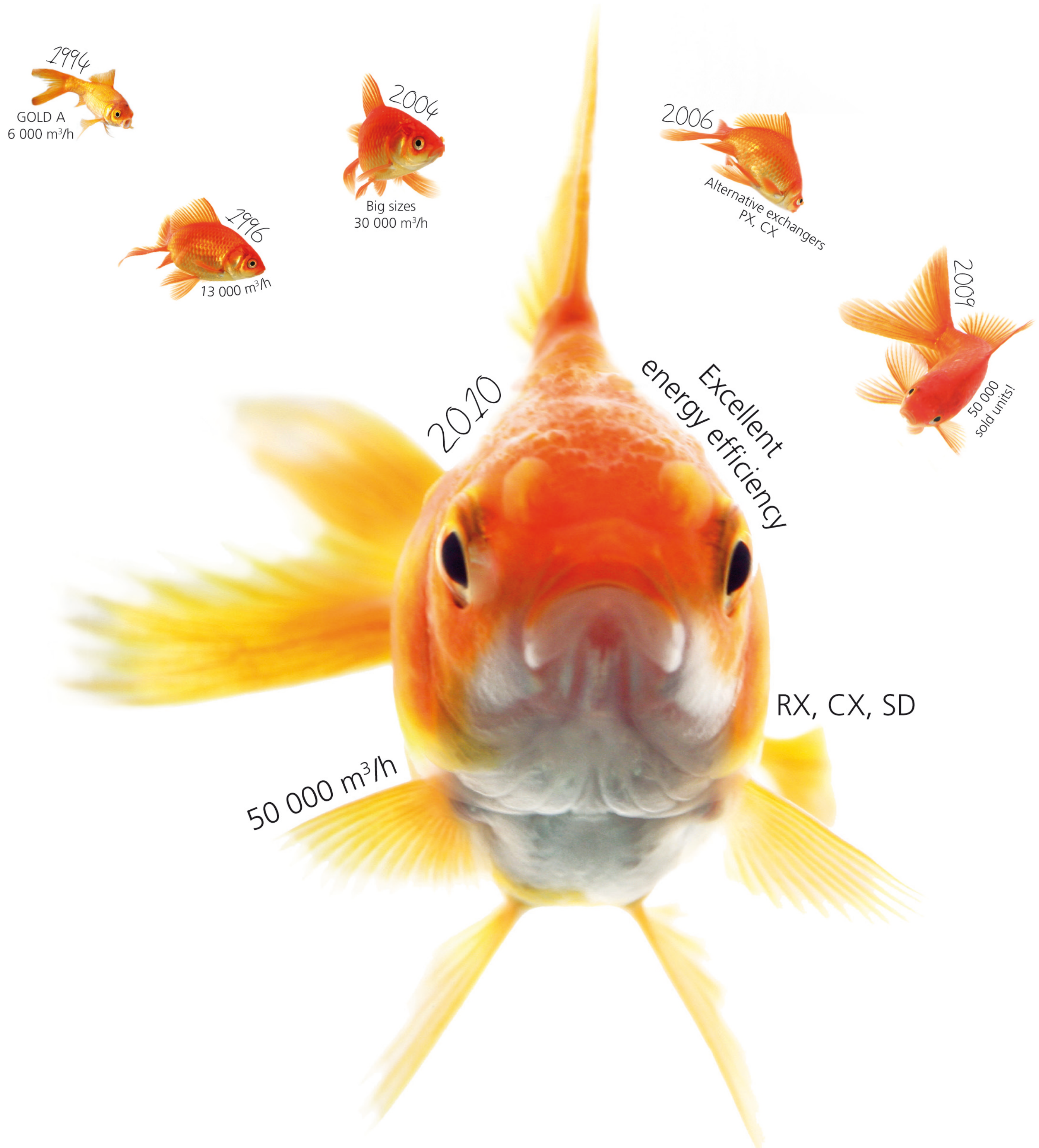

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High performance heat pumps and chillers are available in the market

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Introduction

The results of the European data collections on manufacturers' sales by the Eurovent Market Intelligence (EMI - http://www.eurovent-marketintelligence.eu) statistics bureau on the performance of chilling packages and heat pumps (LCP-HP) are unmistakable: data taken consistently from the same manufacturers' panel show that sales of heat pumps in "heating only" or "reversible" applications have been increasing over the past five years. Established at 32% of value sales in 2004, they surpassed the sales of "cooling only" equipment to account for 54% of value sales in 2009. Aided by a favourable legislative environment, manufacturers are placing more and more energy-efficient equipment on the market.

RES (Renewable Energy Source) Directive

Directive 2009/28/CE of the European Parliament and Council of 23 April 2009 promotes the use of energy from renewable sources and energy produced by renewable sources (ground, air and water). Thermal power generated by heat pumps is taken into account, providing that the final energy efficiency significantly exceeds the primary energy input. Appendix VII b of the directive describes in greater detail the method used to qualify equipment and label heat pumps as a "renewable energy" solution. Finally, it should be pointed out that there are also constraints in terms of objectives sought by the Member States. Appendix I B of the directive defines the renewable energy production thresholds to be achieved. The body of regulations evolving in favour of the selection of equipment that consumes less energy promotes increasingly intense competition among manufacturers and the entry onto the market of a product offering whose energy efficiency is constantly improving. In this rapidly changing market, a look at the real distribution of the products according to the energy efficiency criterion (here EER – energy efficiency ratio) can prove highly useful for understanding the demographic composition of the supply on the market, and for knowing in greater detail the comparative weights of product sets showing similar efficiency characteristics.

EER of Chillers based on the Eurovent Certification data

The analysis will cover the family of the liquid chilling packages and heat pumps, since this Eurovent certification program is the most developed. [Liquid Chilling Package Heat Pumps] (LCPHP). The analysis was applied to 2009 data; it examines a sample of 6,711 models produced by 31 manufacturers and distributed among ten product families.

Four major equipment families account for 86% of the sample[1].

- aerothermal, cooling only: 43%, or 2,900 models
- aerothermal, heating and cooling: 26%, or 1,700 models
- aquathermal, cooling only: 11%, or 750 models
- aquathermal, heating and cooling: 6%, or 400 models

Air-cooled, cooling only units analysis (2,900 models)

The analysis will be limited to the following two capacity power bands:

- From 0 to 99 kW
- From 100 to 599 kW

Since 2004, the LCPHP certification program has included an energy efficiency classification scale. The classes range from A to G, with specific thresholds for each application. The analysis will thus apply to the sample distribution in accordance with energy efficiency classes and the distribution sensitivity.

1 The geothermal units are not included in this sample.

Table 1. Distribution of EER class for air-cooled cooling only units.

EER class	Threshold	Distribution in %	Cumulative %	Distribution in %	Cumulative %
		0-99 kW	0-99 kW	100-599 kW	100-599 kW
A	Above 3.1	7	7	10	10
B	2.9 to 3.1	19	26	13	23
C	2.7 to 2.9	27	53	31	54
D	2.5 to 2.7	28	81	25	79
E	2.3 to 2.5	15	96	14	93
F	2.1 to 2.3	4	99	6	99
G	Below 2.1	1	100	1	100

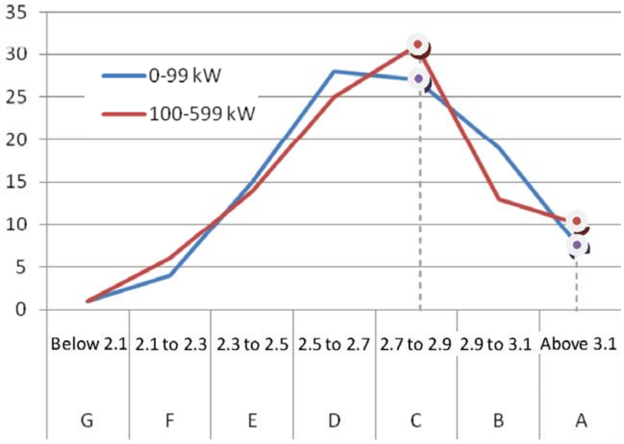

Figure 1. Distribution of the equipment (in %) according to EER energy class.

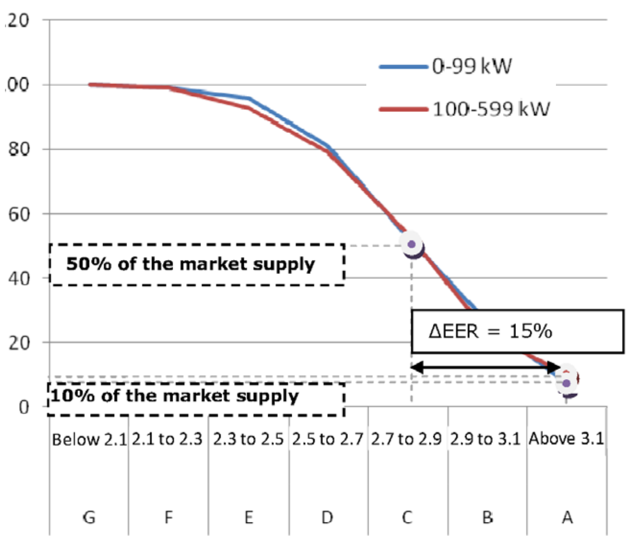

Figure 2. Distribution of the equipment (cumulative %) according to EER energy class.

Here are the conclusions of these graphs:

- Only 7 to 10% of the machines have a EER greater than 3.1
- 50% of the machines have a EER above 2.7

Fifty-five certified products have a EER of 2.7. On the other hand, for a 15% higher EER - i.e. a EER of 3.1 - only one product in ten among the supply analysed meets the criterion.

Water-cooled package, cooling only units analysis (750 models)

Table 2. Distribution of EER energy class for water-cooled cooling only packages.

EER class	Threshold	Distribution in %	Cumulative %	Distribution in %	Cumulative %
		0-99 kW	0-99 kW	100-599 kW	100-599 kW
A	Above 3.5	24	24	11	11
B	4.65 to 5.05	20	44	5	16
C	3.85 to 4.25	22	66	37	53
D	3.45 to 3.85	15	81	20	73
E	3.45 to 3.85	11	92	21	94
F	3.25 to 3.45	7	99	6	100
G	Below 3.25	1	100	0	100

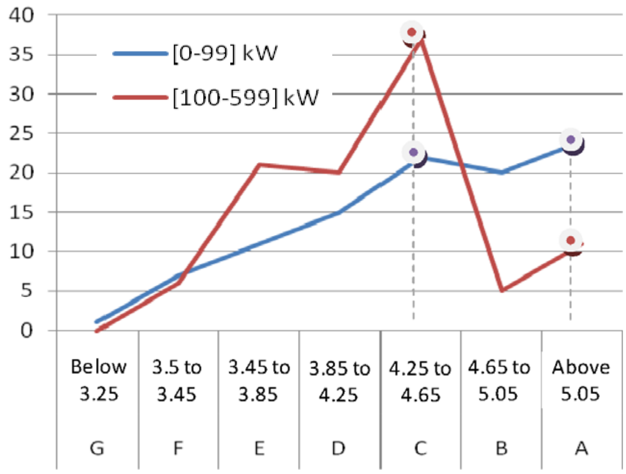

Figure 3. Distribution of the water-cooled cooling only packaged units (in %) according to EER class.

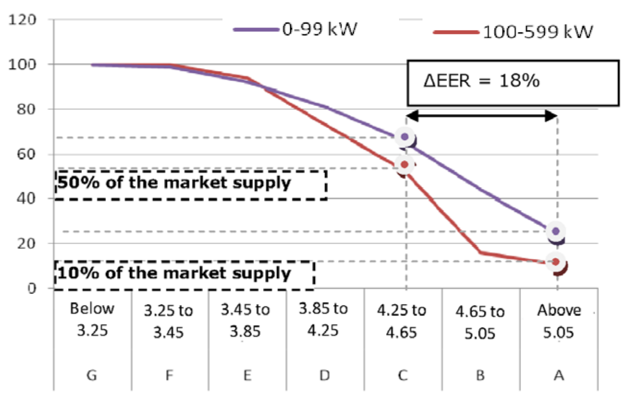

Figure 4. Cumulative percentage of water-cooled cooling packaged unit by EER class.

On the basis of these certified data, we can therefore make the following remarks:

For units of less than 100 kW capacity:

- 24% of the units have a EER above 5.05
- 67% of the units have a EER above 4.25

We can thus see that 7 in 10 certified products have a EER of 4.25. But only 2 in 10 units have energy efficiency levels above 18% (equivalent to a EER of 5.05).

For 100 to 599 kW capacity units:

- 11% of the units (100-599 kW) have a EER above 5.05
- 53% of the units (100-599 kW) have a EER above 4.25

Five certified equipment units have a EER of 4.25. However, only one in ten products can aspire to the highest efficiency category on the market (EER of 5.05), with 18% greater efficiency than a EER of 4.25. This slight difference between the quantitative core of the market and the top-scoring equipment shows the need to be able to compare these products in a perfectly controlled environment. Indeed, a swing of just 15%, with an error margin of +/- 7.5% in calculation or measurement, significantly alters the demography of a product family, since we move from a category representing 50% to one representing only 10% of the supply.

The distribution sensitivity of these products on the basis of the energy efficiency criteria shows the importance of the measuring rules. The following section is devoted to the qualification and measuring procedures of the Eurovent Certification certifying body for the program of chillers and heat pumps.

Eurovent Certification helps in developing and selecting best products

Voluntary third-party certification makes it possible to have a consistent supply of products whose energy efficiency is labelled by efficiency class. For this program, the Eurovent Certification mark requires a measurement tolerance less than 5% for the COP and the EER, which means latitude that is three times more limited than the tolerance authorised by the European regulation on residential air-conditioners (with some exceptions) and based on the self-declared claim regarding efficiencies made by the manufacturer.

*Directive 2002/31/EC concerning air-conditioners of less than 12 kW of cooling output, making reference to the EN14511-2007 standard.

Eurovent Certification is supported, among other elements, by:

- The free publication and export of all values certified for each product in the on-line catalogue: www.eurovent-certification.com
- The Eurovent Certification mark:
- A yearly certification update
- The preceding binding statement of numerous product characteristics
- The application of the certification principle to all ranges of a same product family by the manufacturer
- A scientific sampling by the certifier of the equipment to be tested
- Tests in independent laboratories accredited under ISO / EN 17025
- A certification protocol including the control of the test success rate
- In-plant auditing of manufacturing statements
- On-site auditing of compliance in the use of selection software by customers
- A certification protocol according to EN 45011 or ISO 65.

Conclusions

Heat pumps are definitely on the energy-saving hit parade; the directive promoting renewable energy source (RES) has granted this technological solution a lasting place. The importance of third-party certifications is growing and increasingly spreading. For example, certified efficiencies acquire all their significance for obtaining the Energy Saving Certificates or White Certificates as called in some countries. However, we should not limit their roles to the regulatory area: an EER, a real (certified) ESEER of equipment above 15% amounts to 30 cumulative years of energy savings, and above all, to savings on energy bills each year.

In order to be able to quickly validate the energy efficiency of products in the selection process, a new on-line catalogue, Certiflash citing Eurovent Certification references is now available. Certiflash will display on your screen the efficiencies certified under the Eurovent Certification mark, product by product. www.certiflash.com Certiflash

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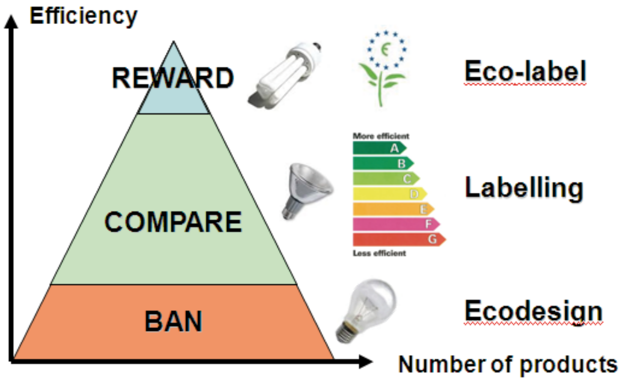


Figure 1. Overview of EU regulations regarding energy efficiency of products.

Introduction

For some years now, the European commission has pushed for energy efficient products to be sold on the European market. Currently three types of initiatives are pushing in this direction:

- The Ecodesign Directive (2005/32/EC and recast 2009/125/EC) on Energy Related Products (ErP) which aims to set minimum energy efficiency requirements for products sold in the European market.
- The Energy Labelling Directive (92/75/EEC and recast 2010/30/EU) which aims to set uniform labels for products of the same type.
- The Ecolabel Directive which aims to reward the most energy efficient products. The two first directives are closely linked as they cover identical product groups. The last one is a voluntary scheme and concern few products within the HVAC sector.

This article will first provide an overview of current and future EU product labelling related to the HVAC sector. Then an overview of current voluntary energy labels that are established by voluntary certification schemes which preceded and/or complete the EU labels is presented. Finally interactions between private voluntary labels and mandatory EU labels are assessed.

EU energy labels

EU regulation on energy labels is dealt by the so-called "Energy Labelling" directive (Council Directive 92/75/EEC[1]) and the subsidiary directives. The first set of directives arose in the 1990s and in the beginning of the century. The products concerned by these directives were, at that time, only household appliances like dishwashers, refrigerators, lamps, etc. The only products within the HVAC&R industry impacted by this first set of directives were the household air-conditioners (Commission Directive 2002/31/EC[2]) with a cooling capacity up to 12 kW.

A recast of this labelling directive was published in 2010[3]. The scope of this new directive was extended to energy related products which have a significant impact on the consumption of energy. This new directive together with the Ecodesign directive and the

1 Council Directive 92/75/EEC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0075:EN:NOT

2 Commission Directive 2002/31/EC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0031:EN:NOT

3 Directive 2010/30/EU, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0001:01:EN:HTML

Ecolabel regulation forms a complete European regulation scheme:

- Ecolabel regulation allows rewarding the most environmental friendly products;
- The labelling directive allow comparing products on an energy efficiency basis with a comprehensive A to G scale;
- Ecodesign aims at banning the less efficient products on the market.

Residential air conditioners

These products which were already concerned by the first set of Labelling directives were also the first product from the HVAC&R family to be concerned by the recast of this directive. The legal document has not been published yet (September 2011) but is likely to be in the following months. The scope of this directive still covers air-conditioners up to 12 kW in cooling capacity. Cooling only and reversible units are both covered. Contrary to the previous legislation, the energy efficiency is based on seasonal efficiencies: Seasonal Energy Efficiency Ratio (SEER) in cooling mode and Seasonal Coefficient of Performance (SCOP) in heating mode (see the corresponding label in **Figure 2**). This seasonal efficiency is calculated by integrating the efficiency of the product over all the cooling (res. heating) season. This method will be soon standardized in the up-coming new version of CEN standard EN14825.

It has to be noted that in heating mode three different climates are considered: warm, average and cold climates which corresponds to Athena, Strasbourg and Helsinki Climates respectively.

Water boilers and heaters

The corresponding directive has not been published yet. The scope covers all types of water boilers and water heaters including biomass, solid fuels, gas and heat-pumps. This label will therefore be able to compare units with different technologies having the same purposes. As for air conditioners, the energy grade is given for three standard climates (see corresponding label in **Figure 3**). For heat-pumps the energy class is based on the SCOP.

EU energy labels in preparation

Other HVAC products are likely to be covered by an EU energy label in the near future:

- Exhaust and balanced ventilation systems;
- Air conditioners with a cooling capacity higher than 12 kW (including rooftop units);
- Chillers;
- Air handling units;
- Fan Coils.

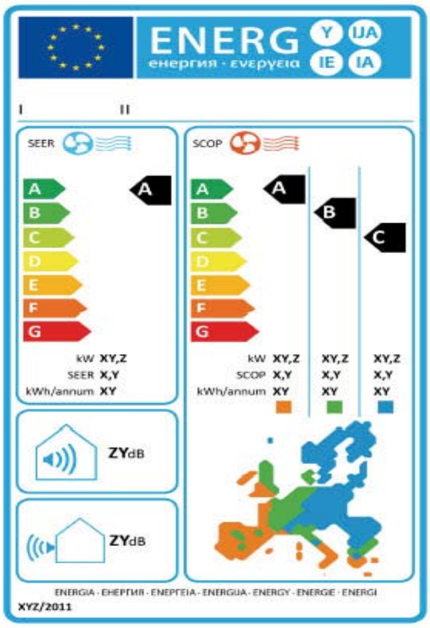


Figure 2. Proposed European Label for residential air conditioners.

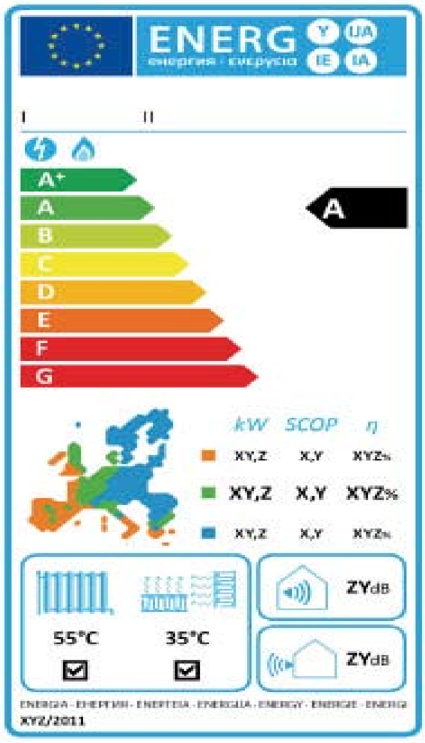


Figure 3. Proposed European Label for water heaters.

It is to be noted that all type of functions will be considered (ventilation, heating, cooling). Some products may then be covered by several directives as they can cover more than one function.

Voluntary energy labels

The European commission is not the solely body to develop energy labels. In the HVAC&R industry some organisms created voluntary labels in order to promote energy efficient products. This is the case of Eurovent Certification which put in place several labels in the past few years.

Chillers and hydronic heat-pumps

As soon as 2004 Eurovent certification defined energy efficiency classes for chillers and hydronic heat-pumps based on Energy Efficiency Ratio (EER) and Coefficient of Performance (COP) at standard conditions (see corresponding label and the definition of the energy classes in **Figure 5**).[4] This system covers both air-source and water-source units.

4 Eurovent Certification Company, http://www.eurovent-certification.com/

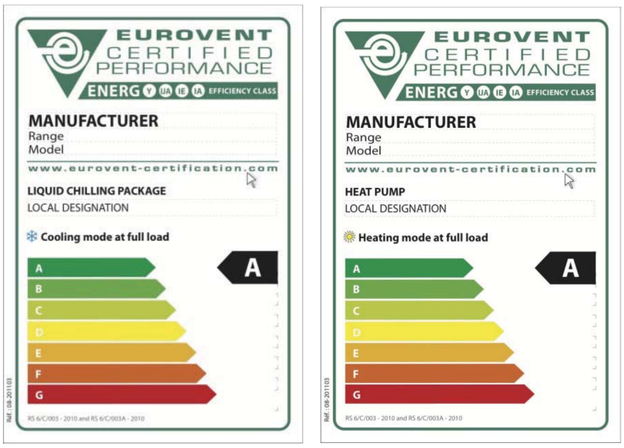


Figure 4. Eurovent Certification Chillers and hydronic heat-pumps labels.

Heat exchangers for refrigeration

Eurovent Certification Energy classes for Air cooled condensers units and Dry coolers were defined in 2005. The one for Dx air coolers arose in 2011. The energy efficiency is based on the energy ratio R which is equal to the nominal capacity in kW divided by the total power input of the fan motors in kW at standard rating conditions.

Cooling Mode					
Air-cooled condenser on roof	Air cooled condenser in a duct	Air-cooled, Floor *	Water-cooled	Water-cooled	EER Class
LCP/A/../../N/...	LCP/A/../../D/. . .	LCP/A/../../N/..	LCP/W/../../N/..	LCP/W/../../N/..	
Air conditioning application	Air conditioning application	Cooling Heating Floor application	Air conditioning application	Cooling Heating Floor application	
≥ 3.1	≥ 2.7	≥ 3.8	≥ 5.05	≥ 5.1	A
2.9≤EER<3.1	2.5≤EER<2.7	3.65≤EER<3.8	4.65≤EER<5.05	4.9≤EER<5.1	B
2.7≤EER<2.9	2.3≤EER<2.5	3.5≤EER<3.65	4.25≤EER<4.65	4.7≤EER<4.9	C
2.5≤EER<2.7	2.1≤EER<2.3	3.35≤EER<3.5	3.85≤EER<4.25	4.5≤EER<4.7	D
2.3≤EER<2.5	1.9≤EER<2.1	3.2≤EER<3.35	3.45≤EER<3.85	4.3≤EER<4.5	E
2.1≤EER<2.3	1.7≤EER<1.9	3.05≤EER<3.2	3.05≤EER<3.45	4.1≤EER<4.3	F
< 2.1	< 1.7	< 3.05	< 3.05	<4.1	G

Heating Mode					
Air-cooled condenser on roof	Air cooled condenser in a duct	Air-cooled, Floor *	Water-cooled	Water-cooled	COP Class
LCP/A/R/../N/..	LCP/A/R/../D/. . .	LCP/A/R/../N/..	LCP/A/R/../N/..	LCP/A/R/../N/..	
Air conditioning application	Air conditioning application	Cooling Heating Floor application	Air conditioning application	Cooling Heating Floor application	
≥ 3.2	≥ 3.0	≥ 4.05	≥ 4.45	≥ 4.5	A
3.0≤COP<3.2	2.8≤COP<3.0	3.9≤COP<4.05	4.15≤COP<4.45	4.25≤COP<4.5	B
2.8≤COP<3.0	2.6≤COP<2.8	3.75≤COP<3.9	3.85≤COP<4.15	4≤COP<4.25	C
2.6≤COP<2.8	2.4≤COP<2.6	3.6≤COP<3.75	3.55≤COP<3.85	3.75≤COP<4	D
2.4≤COP<2.6	2.2≤COP<2.4	3.45≤COP<3.6	3.25≤COP<3.55	3.5≤COP<3.75	E
2.2≤COP<2.4	2.0≤COP<2.2	3.3≤COP<3.45	2.95≤COP<3.25	3.25≤COP<3.5	F
< 2.2	< 2.0	< 3.3	< 2.95	< 3.25	G

* Air source condenser units for heating floor applications (+30/+35°C in heating mode and +23/+18°C in cooling mode)

Figure 5. Definition of Eurovent energy classes for Chillers and Hydronic Heat-Pumps.
(LCP: Liquid chilling packages, A: air source, W: water source, N: Non ducted, D: Ducted.)

Rooftop units

Energy efficiency classes for Rooftop units were defined in 2010 within the corresponding Eurovent Certification programme. The definition of the classes is based on the levels of the first EU energy label for air conditioners of the packaged type. These levels were found to be consistent with the values found on the market (see distribution of Rooftop units in **Figure** 7).

Fan Coil units

Eurovent Energy efficiency classes for fan coil units are available since January 2011. This scheme covers ducted and non-ducted units, two pipes and four pipes. The energy classes are based on "FCEER" and "FCCOP" (Fan Coil Energy Efficiency Ratio and Fan Coil Coefficient of Performance) for cooling and heating mode. These characteristics correspond to a weighted average efficiency of the unit at the low, medium and high speeds (see formula in **Figure 8**)

The scale is very ambitious as currently a small part of the market can reach A class (see **Figure 9**). However, in view of the up-coming of EC fan motors units in the near future, the A class might be reached more often.

$$FCEER = \frac{5\% \cdot Pc_{high} + 30\% \cdot Pc_{med} + 65\% \cdot Pc_{low}}{5\% \cdot Pe(c)_{high} + 30\% \cdot Pe(c)_{med} + 65\% \cdot Pe(c)_{low}}$$

$$FCCOP = \frac{5\% \cdot Ph_{high} + 25\% \cdot Ph_{med} + 70\% \cdot Ph_{low}}{5\% \cdot Pe(h)_{high} + 25\% \cdot Pe(h)_{med} + 70\% \cdot Pe(h)_{low}}$$

Figure 8. Formula of FCEER and FCCOP.

Air filters for ventilation

Energy efficiency classes for air filter intended for ventilation were recently defined in the Eurovent Document 4/11 [5] (downloadable free of charge).

This method defines an annual energy consumption of an air filter in kWh/year based on the average pressure drop of the filter and standard airflow conditions.

5 Eurovent Document 4/11 "ENERGY EFFICIENCY CLASSIFICATION OF AIR FILTERS FOR GENERAL VENTILATION PURPOSES", www.eurovent-association.eu

Class	Energy consumption	Condensers, Dry coolers $R_{Condensers,\ Dry coolers} = \frac{\text{Capacity SC wet}}{\text{Fan power cons}}$	Dx Air Coolers $R_{DXaircoolers} = \frac{\text{Capacity SC2 wet}}{\text{Fan power cons}} \times \sqrt{\frac{\text{fin spacing}}{4.5}}$
A++	Remarkably low	R≥ 240	R≥ 45
A+	Extremely low	160 ≤ R< 240	35 ≤ R< 45
A	Very low	110 ≤ R< 160	27 ≤ R< 35
B	Low	70 ≤ R< 110	21 ≤ R< 27
C	Medium	45 ≤ R< 70	16 ≤ R< 21
D	High	30 ≤ R< 45	12 ≤ R< 16
E	Very high	R< 30	R< 12

Figure 6. Eurovent Certification Energy Classes for Heat Exchangers.

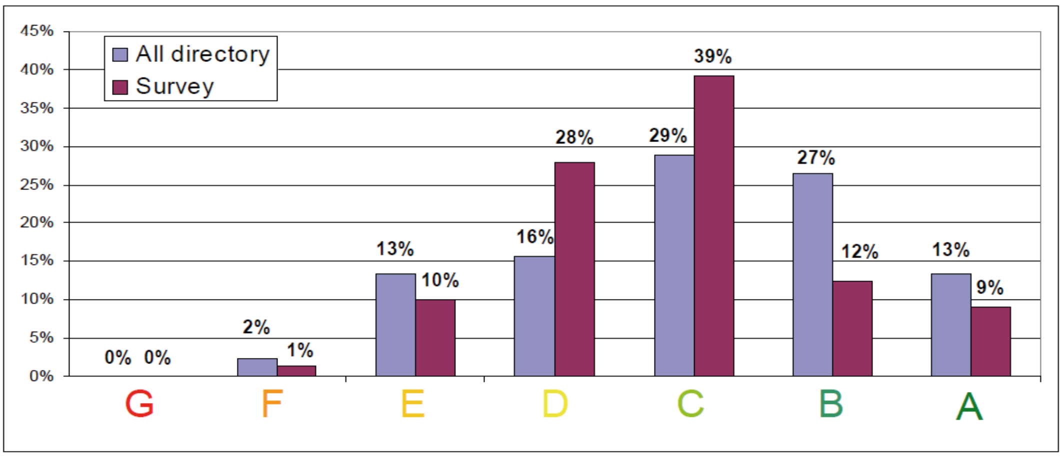


Figure 7. Distribution of Eurovent certified Rooftops units in 2010 according to the energy classes.

Interactions between EU labels and voluntary labels

Both positive (numerous) and negative (less numerous) interactions can be observed between the two approaches.

EU labels accelerate the standardization process

The EU commission is able to send mandates to CEN in order to create or modify existing standards allowing supporting published directives. This was the case notably regarding the directives on air conditioners and heat-pumps which will be based on seasonal efficiency. The corresponding CEN standard EN14825 has to take into account the method proposed by the directives and to include it. The new version of this standard is expected to be published at the end of 2011.

Voluntary labels prepare the work for EU labels

Sometimes voluntary labels precede EU labels. In such cases it is obvious that the work of the commission is facilitated as an already existing scheme is in place and used by the industry. For example, some references to the Eurovent energy labels are present in the studies to set-up a European label for Fan Coils, Rooftops and Chillers.[6]

Voluntary labels provide market data on energy efficiency

Voluntary energy labels like Eurovent Certification energy labels allow providing to EU commission useful data on energy efficiency. These data are crucial in order to prepare the most adequate regulation in terms of energy efficiency levels to be reached.

Case where EU labels and voluntary labels have different requirements

This case can be illustrated by the air conditioners up to 12 kW (AC1 programme within Eurovent Certification). As said before these products are in the scope of a labelling directive since 2002. This directive refers to a standard allowing 15% tolerance on energy efficiency. The corresponding Eurovent Certification programme considers a tolerance of 8% for exactly the same product. This means that some non certified products declared as class A, can only be rated B within the corresponding Eurovent Certification programme due to the stricter tolerance. This situation is not easy to manage for a certification scheme as some manufacturers are tempted to leave the certification programme in order to gain one energy class.

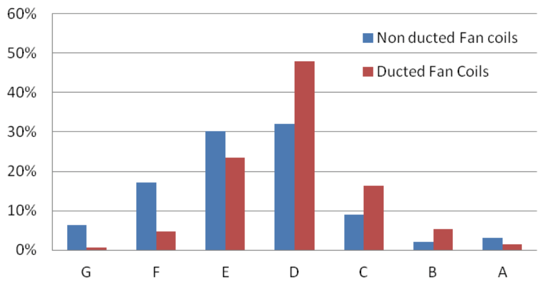


Figure 9. Distribution of Eurovent certified Fan Coil units in 2011 according to the energy classes.

Voluntary labels complete the market surveillance activity

Member states have the responsibility of the market surveillance regarding the Labelling directive. This market surveillance consists of checking the declaration of the performance of the products (correct labelling display on site) but also perform product testing. According to a study carried out in 2009 by the Fraunhofer institute[7] it can be estimated that between 0 and 10 tests are performed per year in Europe on air conditioners up to 12 kW. At the same time, a voluntary third party certification scheme like Eurovent Certification performs more than 120 tests per year since 2000 on this type of products.

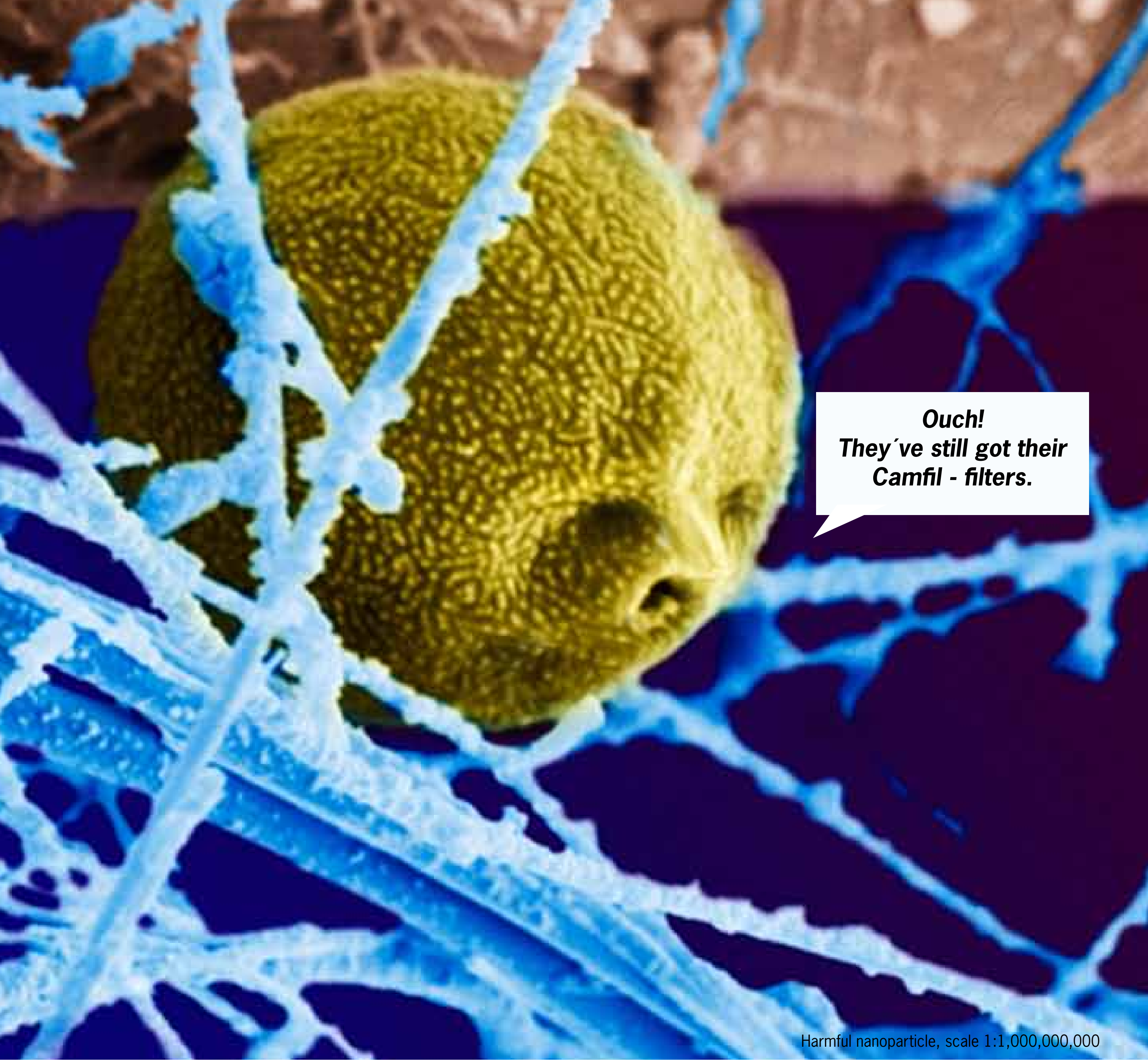
Given this role sharing out, market surveillance activities from member states should focus on non-certified products in order to complete the testing activity of voluntary certification bodies.

Conclusion

Energy efficiency labelling is a boiling subject. The impact it has on customer behaviour makes it a powerful marketing tool but also more and more a powerful regulation tool. Both public and private sector can be at its initiative. We have seen that the two approaches were complementary if well-coordinated. EU labels provide an impetus to standardization work at the European level whereas voluntary certification labelling schemes can accelerate the work of creation of EU labels if they are created before and allow for a given pool of products to have accurate market surveillance as soon as the EU label is put in place. Finally regarding market surveillance activity there is a clear possibility to have coordination between the two approaches in order to benefit from their complementarities.

6 "Ecodesign Preparatory Study ENTR Lot 6 Air Conditioning and Ventilation Systems" Task 1 Lot 6, http://www.ecohvac.eu/documents.htm

7 Survey of Compliance Directive 92/75/EEC (Energy Labelling), Fraunhofer Institute (2009)



Harmful nanoparticle, scale 1:1,000,000,000

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*EN 779:2011

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The efficiency of HVAC products goes beyond EU stipulations

Gert Bakkeren
GEA Air Treatment GmbH
Director Product Management
gert.bakkeren@geagroup.com

Christian Herten
GEA Air Treatment GmbH
Head of Business Development
christian.herten@geagroup.com
Vice President of Eurovent Association / Board Member of Eurovent Certification

Introduction

To achieve the ambitious energy-efficiency goals that it had set, the EU Commission made a number of efforts, including preparing bodies of directives to assure more efficient operation of HVAC facilities and, in turn, of the buildings in which they are installed. A number of these stipulations that apply to HVAC technology are being prepared at this very moment. The purpose of these bodies of rules is to provide manufacturers with a context for the design of efficient solutions. It does not always suffice, however, to build products merely in accordance with these rules. The present article shows where manufacturers' solutions can complement upcoming EU requirements, and how they can even go beyond. It also outlines what planners, investors, and operators should consider to promote optimal climate protection and lower operating costs.

Slow down climate change with efficient HVAC technology

It is undisputed that buildings in Europe are among the greatest energy consumers. In Germany, for example, space heating and hot water make up almost one-third of the total energy use. In the sector classified as "trade, commerce, and services" – which also includes shops and office buildings – around 45 % of the required energy is used for heating and hot water alone [1]. Around two-thirds of all commercial buildings and half of public buildings additionally use mechanical ventilation to ensure the required room-air quality in modern buildings with their insulated façades [2]. The tendency is upward here.

To achieve the goal of slowing down global warming, respectively to achieve a maximum increase of 2°C of the earth's temperature above the level of the preindustrial age, buildings must become more efficient. It is particularly also in residential and commercial construction where a potential of making a valuable contribution to reaching the 20-20-20 goals[1] of the EU can be allocated. By 2050, the objective is even to reduce emissions to a level of one-fifth of the reference value of 1990. It is not feasible to achieve this ambitious goal without progress in building services engineering.

Contribution from industry and trade associations

To provide constructive and effective support to the complex and dynamic process of preparing the above-stated bodies of rules by the EU Commission, the Eurovent Association has set up a dedicated task force. This task force, which consists of industrial experts from all relevant product areas, plays an active role in the regulation-preparation process. While also integrating the Eurovent Product Groups and the national member associations, the Eurovent Association proposes suggestions for detailed preparation of the bodies of rules, with the objective of enhancing the energy efficiency of the products and solutions in scope.

1 These goals for 2020 call for the following: 20 % less greenhouse gas than in 1990, renewable energy with a share of 20% of the energy mix, and an energy efficiency 20% greater than in 1990.

EU stipulations for HVAC products

The new EU stipulations currently being discussed for HVAC products are primarily aimed at achieving more energy efficiency and of preventing emission of fluorinated greenhouse gases (F-gases). The power consumption of air treatment and air conditioning facilities – with consideration taken of the respective energy-mix for power generation – directly correlates with CO_2 emissions. This means that each kilowatt-hour that can be saved in the transport and treatment of air will benefit the environment. This is particularly reflected in the discussion under Eco-design Energy-related-products ErP "Ventilation Systems, ENTR Lot 6" [2], which includes facilities with fans over 125 W that are typical for commercial applications.

The air handling units discussed in [2] – see **Figure 2** – for full or partial HVAC systems, as they are used for example in commercial facilities – serve for transport, filtering, pre-heating, cooling, and/or emission of exhaust air. They are classified as equipment for air transport, and as energy-related products (ErP), since they can contain heat exchangers for temperature control of supply air or for energy recuperation. Owing to their own power consumption, air handling units are subject, among others, to the regulations in Directive EC/640/2009 (which calls for the introduction of increasingly more efficient motors, presently at least at the level of IE2 motors), as well as the stipulations in Directive EU/327/2011 (which regulates fans driven by motors between 125 and 500 kW).

Eco-design Directive 2009/125/EC

- EU's most important legal instrument to improve the environmental performance of **energy-related products** (ErP)
  - Extension of scope of former Eco-design Directive 2005/32/EC (energy-using products, EuP)
- **Framework Directive**

  ➡ The requirements are introduced on a product-by-product basis via:
  - **Implementing measures** (IM) to be adopted by the Commission, or
  - **Voluntary agreements**
- Implementing measures only for products with:
  - Significant environmental aspects
  - Significant potential for improvement
  - Significant trade and sales volume (indicative threshold: 200 000 units per year)

Product Scope of Eco-design Directive 2009/125/EC

- Product scope defined in workplan 2009-2011 COM(2008) 660 (study on amended workplan ongoing)
  - Air-conditioning and ventilation systems
  - Electric and fossil-fuelled heating equipment
  - Food-preparing equipment
  - Industrial and laboratory furnaces and ovens
  - Machine tools
  - Network, data processing and data storing equipment
  - Refrigerating and freezing equipment
  - Sound and imaging equipment
  - Transformers
  - Water-using equipment

Proceedings Eco-design

- **Preparatory studies**: Technical, environmental and economic assessment of product groups done via consultants with input from stakeholders requested
- **Consultation Forum**: Discussion of suggestions for Eco-design requirements (Commission)
- **Impact assessment and interservice consultation**
- **WTO notification** (Technical Barrier to Trade agreement)
- Vote in **Regulatory Committee** (EU Member States)
- **Scrutiny** of the European Parliament and Council
- Regulations directly applicable in EU Member States

Preparatory Study → Consultation Forum → Draft Regulation → Approval Process → Publication Regulation

Sources: European Commission

Figure 1. Overview Eco-design – European HVACR policies.

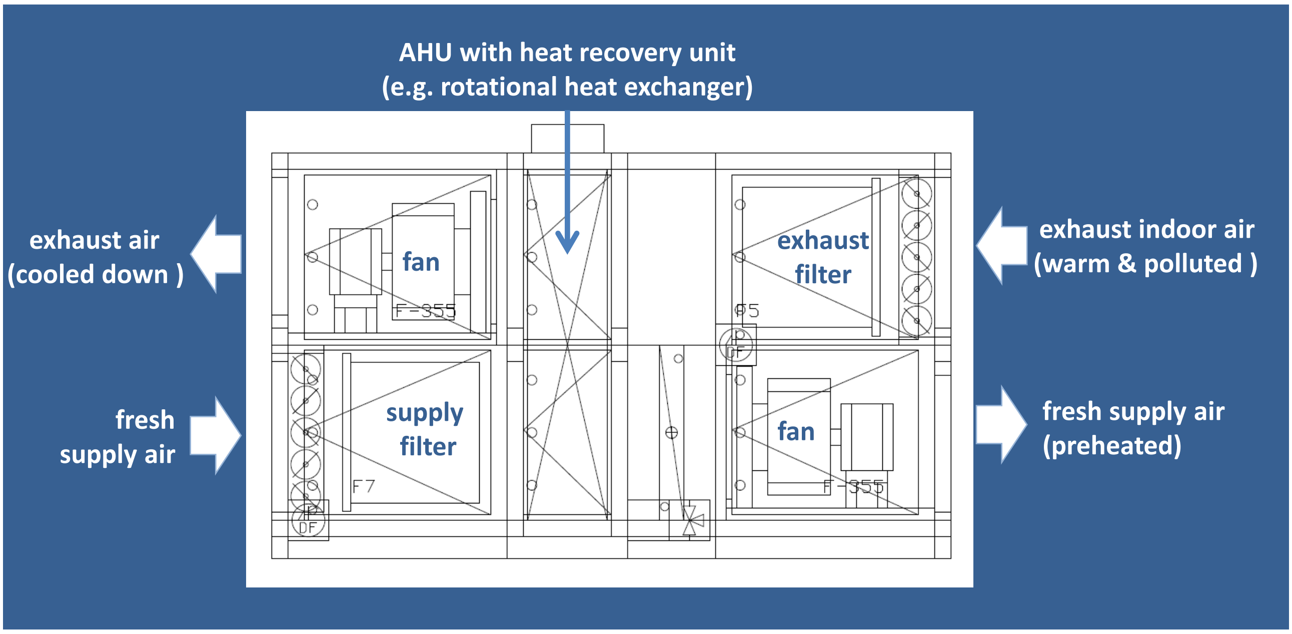

Figure 2. Air handling units (AHUs), as described in "Ventilation Systems, ENTR Lot 6". [2]

Energy-efficiency classes for orientation

The EU-requirements become applicable in a "compact" form in the various energy-efficiency classes for air handling units (AHUs), as set forth by Eurovent Certification. There, classification takes place on five levels, based on the criteria of air speed in the system cross section, power consumption of the fans, and efficiency of heat recovery. These classifications provide orientation for planners and investors. High-quality fans, as stipulated by EC/640/2009, as well as efficient heat recovery, lead to a more favorable classification on a scale from A-E. The Eurovent classification furthermore provides certainty to investors that manufacturers have observed the performance stipulations, since the Eurovent Certification actually tests sample equipment units to verify the performance claims of the equipment producers. At present, Class A is the best, but discussion has already begun at Eurovent Certification for addition of a Class A+.

Energy recovery

Further CO_2-emitters include heating plants fired by fossil fuels (see EuP 2005/32/EC, Lot 1 for Space Heating) and equipment for heating of sanitary water (see EuP 2005/32/EC, Lot 2, Sanitary Water). The use of energy recovery in central and decentral ventilation systems is a very effective measure for keeping consumption for heating as low as possible. As a result, heat recovery is classified as regenerative energy (also see EU Directive 2009/28/EG). With the installation of rotary heat exchangers, the degree of heat recovery achieves a level in practice of up to 70% (optimal level up to approx. 90%). This measure cuts approx. two-thirds of heating costs arising from air exchange.

Energy recovery can also apply for cooling

At the same time, however, neither the EU bodies of regulations nor energy efficiency classes for AHUs explicitly mention the recovery of cooling – although this matter is by all means of significance, for example, for southern European countries. The use of sorption rotary heat exchangers enables saving up to 40% of the energy used to cool supply air. Even though this aspect is not considered in EU regulations, investors and planners should take it into account for system design.

Control systems for enhancement of efficiency

AHUs are optimally operated when a control system regulates the volume of air according to demand: e.g., during working hours or other times of occupation, or as a function of the number of persons present in the ventilated rooms. In such cases, the AHU will bring the required air volume to moderate temperatures, such as 22°C during summer and 18°C during winter time. The temperature control of individual rooms takes place in the rooms themselves, which decouples air-volume demand from heating or cooling demand. This decoupling prevents the transport of air amounts that exceed those required for the fresh-air demand by persons present in the rooms. To achieve this beneficial decoupling, control technology is necessary that goes beyond satisfaction of the currently discussed EU rules for such equipment. Such systems would require CO_2 sensors, volume-flow controllers, a high-level building management system, and/or other components.

As with ventilation and heating, these matters involve the provision of air-conditioning cooling (with chillers/direct expansion). Here as well, control systems enhance efficiency by regulating the entire system, consisting of regulation of ventilation and heating (or air conditioning cooling) from a higher and more all-inclusive level, in accordance with demand.

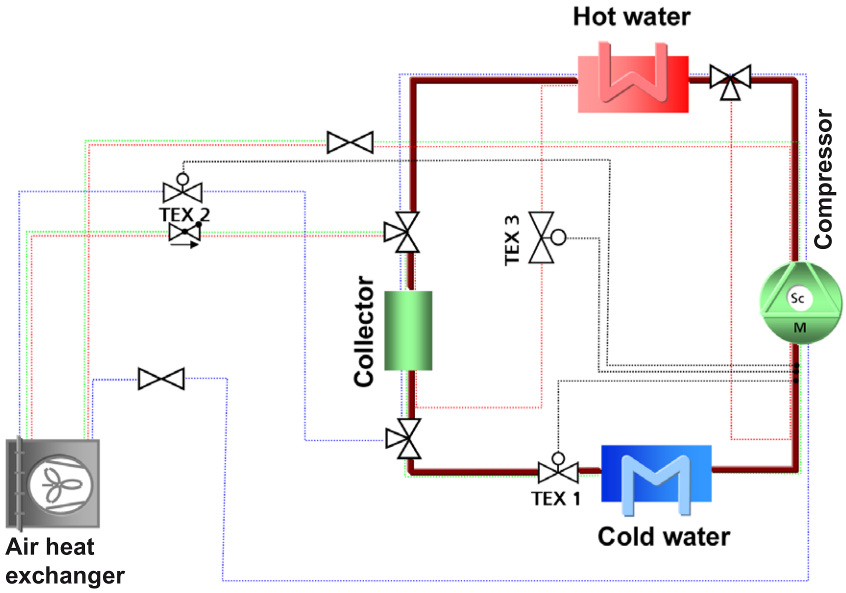

Figure 3. Combination of a chiller and a heat pump for simultaneous heating and cooling.

Combination solutions with chillers and heat pumps

Whereas cooling-only chillers and heat pumps as well as reversible chillers (with alternative operation as chillers or heat pumps) are covered by 2009/28/EC and other stipulations, and are recognized (according to function) as regenerative solutions, there is an equipment class on the market for which no EU directives or efficiency labels exist until now. These are hybrid solutions for bivalent heating and cooling: systems that combine chillers and heat pumps into one system (see **Figure 3**). Such systems can be efficiently employed when both heating and air-conditioning cooling are simultaneously required throughout relatively longer periods of the year: e.g., in office buildings with their own server rooms or in hospitals. Hotels also often simultaneously require cooling and heating during the summer: heating, for example, for pre-heating of hot water and for heating of swimming pools. Such systems, with employment of electrical energy or, for example, via water circuits, can deliver surplus heat to the areas in the hotel where heat is required. If the demand for heating and cooling does not exactly coincide, however, there is the possibility of exchanging the energy differential with the environment (air, soil, ground water). Although there is not even correlation of these systems to the coefficient of power (COP) or to the European Seasonal Energy Efficiency Ratio (ESEER), they exceed – during bivalent operational mode – the performance of the most efficient combination of heat pump and chiller. It would be highly advisable if these systems as well would be considered within the context of work with standards and EU rules.

Efficient use of perceived cooling

Fan coil units also offer potential savings when employed for individual room temperature control. EU stipulations and, for example, Eurovent efficiency labels promote the production of larger units (in favor of lower air resistance values) with better drive systems (i.e., more efficient motors). In addition – and in the same manner as for AHUs – heat exchangers with fewer tube rows lead to lower pressure drops and lower power consumption. Already within the next few years, it is planned to expand the energy classification applied for these systems at Eurovent Certification by adding the classes A+ and A++. It is planned in turn to delete the classes F and G.

Whereas the significance of performance characteristics is obvious to the investor, some underestimate the perceived cooling effect. In southern Europe, for example, where hot and moist conditions regularly prevail throughout a large part of the year, dehumidification already provides a more comfortable room climate under conditions of water supply and return temperatures, for example, of 7/12°C. As a result, the room temperature can be acceptable at levels a few degrees higher than without dehumidification.

A comprehensive consideration is indispensable

The above-stated examples show that the EU stipulations will indeed fulfil their purpose: e.g., the exclusion of technologies that are inefficient and no longer up to date. These rules, however, cannot serve as guides to best practice. It is within the capability of planners, investors, and/or building operators to compose the optimal solution for each individual project. At the same time, however, their attention should not be entirely focused on the efficiency of individual devices – but likewise on the overall efficiency of the entire equipment plant and for the operation that is required. The example of the mode of bivalent heating and cooling vividly shows that solutions not discussed in the EU set of rules yet can indeed provide an additional contribution to energy savings.

Suitable instruments exist to promote comprehensive, overall thinking approaches from the side of operators and investors. These instruments include the Energy Performance of Buildings Directive, 2010/31/EU (EPBD) as well as national implementations: e.g., the 'Energie-Einspar-Verordnung' in Germany, the 'Réglementation Thermique' in France, the 'Bouwbesluit' in the Netherlands, the 'Boverkets Byggregler' in Sweden, and Building Regulations (in greater detail in Part L) in Great Britain. Here as well, more stringent basic characteristic values will ensure that, in the future, the best available technology (BAT) will enter the bodies of legislation (i.e., the best next available technology, or BNAT, from today's standpoint).

Since energy and operation costs exceed investment costs by several times – for example, with regard to AHUs –, it pays to exactly consider the requirements regarding air quality and setpoint temperatures – and to select a solution in accordance with these factors, and with low life-cycle costs. As a rule, low operational costs go hand-in-hand with low consumption of resources. Rising prices for power and gas will further increase the ratio of operation costs to investment, with the result that investments in energy efficiency will pay off even more in the future.

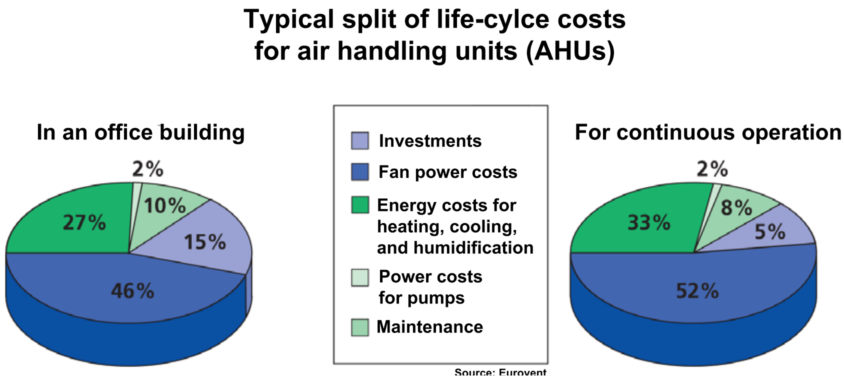

Figure 4. Life-cycle costs of an AHU (source: Eurovent).

Case-by-case consideration of refrigerants

From case to case, it likewise pays to determine whether the replacement of conventional refrigerants by alternative natural products is always goal-oriented in every individual case. Without doubt turning away from hydrofluorocarbons (which have a global warming potential (GWP) that is significantly greater than that of CO_2) will minimize the danger to the ozone layer from incorrect handling and leakages in refrigerant circuits. Total elimination of conventional refrigerants, however, is not advisable in every single case. Although natural refrigerants such as ammonia and CO_2 are already widely used today in plants with great levels of efficiency, they cannot be used in all cases in reversible systems. Indeed: reversible chillers, which also support heat-pump operation, cannot easily be manufactured for use with natural refrigerants – or cannot operate with equivalent efficiency. If refrigerants are properly handled, and if they are used to minimum degree in refrigeration cycles (which is the responsibility of the manufacturer), the use of conventional refrigerants cannot be negatively assessed in principle in all cases. If, for example, a reversible chiller contributes to prevention of CO_2 emissions, it can very well make a greater contribution to climate protection than a less versatile and less efficient plant with natural refrigerants.

In addition, it is necessary to remember that chlorinated hydrocarbons and hydrofluorocarbons – despite their great potential for depleting the ozone layer – are not the primary causes of the greenhouse effect. The most important greenhouse gases in the atmosphere, in the order of their relevance, are water vapor, CO_2, CH_4 (methane, the main constituent of natural gas),

N_2O, and O_3 (ozone), only then come chlorinated hydrocarbon and hydrofluorocarbon compounds. For this reason, approaches should also place high emphasis on minimization of the use of methane (natural gas). In addition to the CO_2 that results from combustion of natural gas, the following two processes contribute to environmental warming: the consumption of fuel required for transport and storage of fossil energy media, as well as leakage losses in the pipelines. Measurements made in the 1990s revealed, for example, that leakage in the Russian long-distance gas pipelines produced losses of around 1% of the total transported volume [3]. This seems inconsequential in regard to the thousands of kilometers covered by the pipelines; it must be considered, however, that methane – the main constituent of natural gas – has a global warming potential (GWP) around 24 times greater than that of CO_2.

Within this context, therefore, it is only logical to pose the following question: should one, in the case of reversible chillers, place priority on elimination of a refrigerant that can potentially destroy the ozone layer, or should the additional energy efficiency of such agents be favoured? The bodies of rules valid until now do not yet provide support in this matter, and must be adapted to the state of the art. Nevertheless, industry is attempting to develop solutions with climate-friendly refrigerants that at the same time offer a maximum of efficiency. In addition to EU stipulations, the responsibilities of individual companies and, not least, the wishes of investors, remain as the driving forces for these and further innovations in the sense of climate protection.

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Jarek Kurnitski
REHVA Fellow
Sitra, the Finnish Innovation Fund
Jarek.Kurnitski@sitra.fi

EPBD recast [1] requires Member States (MS) to ensure that minimum energy performance requirements of buildings are set with a view to achieving cost optimal levels using a comparative methodology framework established by the Commission. Cost optimal performance level means the energy performance in terms of primary energy leading to minimum life cycle cost. MS have to provide cost optimal calculations to evaluate the cost optimality of current minimum requirements due June 30th 2012 (Articles 4&5).

The draft methodology called "delegated Regulation supplementing Directive 2010/31/EU" is now published and can be downloaded from [2]. In addition to cost optimal policy, EPBD recast established the political target of nearly zero energy buildings (nZEB) for all new buildings by 1 Jan 2021 according to Article 9. Because of current understanding about nZEB as not cost efficient yet, these both requirements will have to be reconciled so that a smooth transaction from cost optimal requirements to nearly zero energy buildings could be guaranteed, as communicated by the Commission [3]. Therefore, the meaning of nZEB is not fully explicit before that reconcilement. That is clear, both cost optimal and nZEB performance level calculations are to be shortly conducted in each MS to be able to adopt EPBD recast. Cost optimal levels by 2013 can be seen as a first step towards the nZEB target laid down in EPBD recast.

To be able to perform such calculations one needs relevant system boundary definition and calculation methodology. The guidance by the EPBD recast is on general level. In the directive 'nearly zero-energy building' means a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby. So: **nZEB = very high energy performance + on-site renewables**. Definition of "a very high energy performance" and "significant extent of renewables" is left for MS.

In the following, systematic and robust procedure to determine cost optimal energy performance levels is discussed. Model calculations and detailed description are reported in [4]. To perform cost optimal and nZEB calculations, REHVA nZEB technical definition, including system boundary and energy calculation methodology [5] is used. The procedure is based on careful definition of construction concepts leading to very limited amount of energy calculations, which combined with systems and economic calculations result in cost optimal primary energy use.

General methodology

This systematic and robust scientific procedure includes seven steps in order to determine cost optimal energy performance levels:

1. selection of the reference building/buildings
2. definition of construction concepts based on building envelope optimization for fixed specific heat loss levels (from business as usual construction to highly insulated building envelope in four steps)
3. specification of building technical systems
4. energy calculations for specified construction concepts
5. post processing of energy results to calculate delivered, exported and primary energy
6. economic calculations for construction cost and net present value of operating cost
7. sensitivity analyses (discount rate, escalation of energy prices and other parameters)

All this steps are independent and they do not lead to iterative approach or optimization algorithm for residential buildings. Cost optimal calculation to obtain the minimum net present value (NPV) can just done by straightforward calculation of steps 2 to 6 for all specified cases (according to steps 2 and 3). If specified cases will not show the minimum of the NPV, additional cases are to be specified to obtain the minimum.

Cost optimal primary energy use is determined by the solutions leading to minimum NPV of 30 years period for residential buildings and 20 years period for non-residential buildings according to the draft regulation [2]. Reference buildings are needed for calculations. For new buildings, one representative reference building is enough [2], however it may provide valuable information if in the sensitivity analyses another reference building will be used. Construction concepts to be studied have to represent building envelopes from business as usual construction to highly insulated building envelope. With building envelope optimization only four construction concepts are enough to change insulation thickness mainly with 5 cm step and with 10 cm step for thicker insulations. Heat recovery efficiency is the feature belonging to the construction concept, because of the gain utilization in energy calculations. To keep calculations simple, fixed heat recovery efficiency is to be used for each construction concept. All relevant heating (and cooling) systems can be calculated with reasonable effort, if the same distribution and emission systems will be used for all cases simplifying cost calculations and to ensuring equal comfort level.

General nZEB technical definition format by REHVA Task Force "Nearly Zero Energy Buildings" [5] can be used as a framework for cost optimal and nearly zero energy buildings' energy performance calculations. This framework uses the detailed system boundary modified from EN 15603:2008 [6] with the inclusion of on-site renewable energy production within the system boundary. This inclusion follows EPBD recast requiring that the positive influence of on-site renewable energy production is taken into account, **Figure 1**.

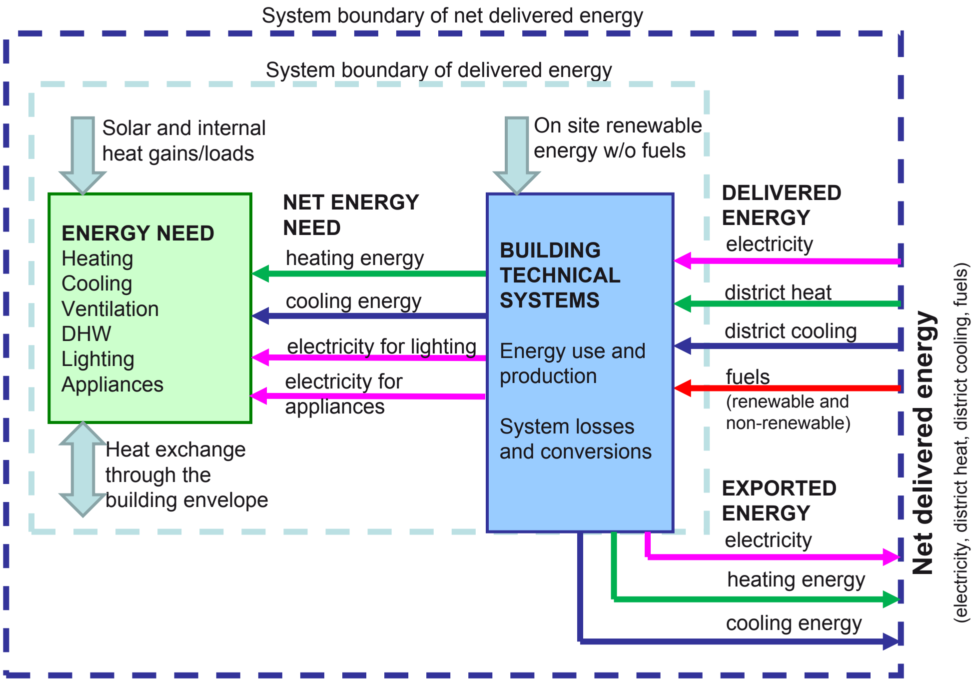

Figure 1. Energy boundary of net delivered energy and schematic representation, energy use of technical building systems, on-site renewable energy production, delivered energy and exported energy. The box of "Energy need" refers to rooms in a building and both system boundary lines may be interpreted as the building site boundary. (Adopted from REHVA Task Force "Nearly Zero Energy Buildings" [5])

Input data selection principles

Step 1. The reference building

It can be recommended that architects will select the reference building as a typical representative building of new construction. Single family building, multi family building and office building (one for new built and two for existing) are required by [2]. An example is calculated with Estonian detached reference house with heated net floor area of 171 m², **Figure 2**.

Step 2. Definition of construction concepts

Proper definition of the construction concepts (=building envelope + heat recovery) is the cornerstone of the method. Careful selection of construction works allows reducing calculation effort drastically. In the example, four construction concepts (**Table 1**) were specified based on the specific heat loss coefficient.

DH 0.42 construction concept represents the best practice technology of highly insulated building envelope which may be associated with nearly zero energy buildings. DH 0.96 represents business as usual (BAU) construction. Building envelope has to be optimized for each specific heat loss value, so that the most cost effec-

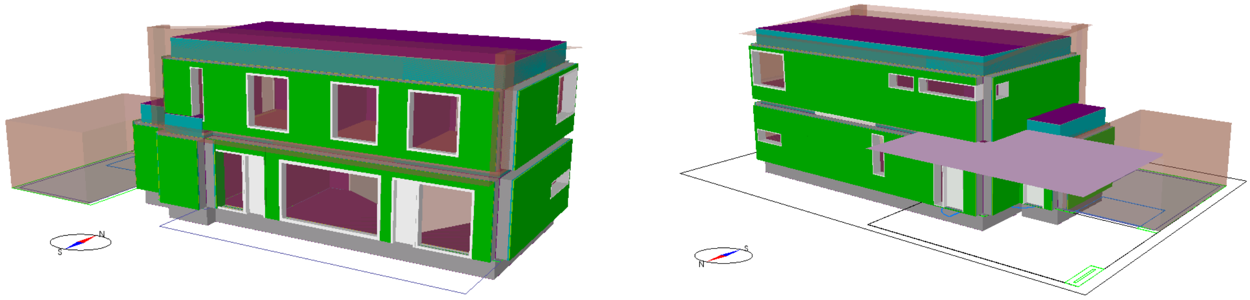

Figure 2. Energy simulation model of the reference detached house, perspective view from south-east in the left and from north-west in the right.

tive combination of insulation levels for windows, external walls, slab on ground and roof will used to achieve the given specific heat loss value. This means that one has to select a proper window and external wall insulation combination, to achieve the given specific heat loss value at the lowest possible construction cost. This is a basic construction cost calculation exercise, the professionals are doing daily. If this is followed, one will need to calculate net energy needs only once (four simulations in this case).

Step 3. Specification of building technical systems

All cases were equipped with effective heat recovery (as in a cold climate) and were calculated with almost all possible heating systems. For each construction concept, the following heating systems were considered with appropriate sizing:

- ground source heat pump
- air to water heat pump
- district heating
- direct resistance electrical heating
- condensing gas boiler
- condensing oil boiler
- pellet boiler

Sizing data of the systems is shown in Table 1 and performance data in **Table 2**. Because of the cold climate and dominating heating need, only one basic compressor cooling solution was used for all cases. Highly insulated DH 0.42 and DH 0.58 cases were calculated both with and without solar collectors of 6 m², providing an half of domestic hot water net energy need. Other cases were calculated without solar collectors. For nZEB, 5 kW solar PV installation was additionally used.

In principle, the number of technical systems to be studied can be high, because of the fast post processing of energy calculation results. All relevant technical systems could be relatively easily calculated (resulting mainly as the effort for cost calculations) to be sure that the combination leading to minimum net present value will not missed due to limited systems specification.

Table 2.
System efficiencies for delivered energy calculation.

Heat source (under floor heating)	Generation and distribution combined efficiency, -	
	Space heating/ cooling	Domestic hot water
Gas/oil condensing boiler	0.86	0.83
Pellet boiler	0.77	0.77
Air to water heat pump (elec)	1.98	1.62
Electrical heating	0.90	0.90
Ground source heat pump (elec)	3.15	2.43
District heating	0.90	0.90
Cooling (electricity)	3.0	

Step 4. Energy simulations for specified construction concepts

All relevant energy calculation tools can be used, however the validated dynamic tools can be recommended. Such tools are contrasted in [8]. For the example, energy simulations were conducted with dynamic simulation tool IDA-ICE [9] for specified four construction concepts. Simulated net energy needs are shown in Table 1.

Step 5. Post processing of the simulation results to calculate delivered, exported and primary energy

Delivered energy can be easily calculated with post processing from simulated net energy needs. Net energy needs are to be divided with relevant system efficiencies. System efficiency values used in the example (combined efficiency of the generation, distribution and emission) are shown in Table 2. To calculate the combined efficiency, under floor heating distribution was considered

Table 1. Construction concepts and simulated net energy needs of the reference detached house of 171 m².

	Construction concepts			
	DH 0.42 "Nearly zero"	DH 0.58	DH 0.76	DH 0.96 "BAU"
Specific heat loss coefficient H/A, W/(K m²)	0.42	0.58	0.76	0.96
External wall 170 m²	20cm LECA block, plaster + 35cm EPS-insulation U 0.1 W/m²K	20cm LECA block, plaster + 25cm EPS-insulation U 0.14 W/m²K	20cm LECA block, plaster + 20cm EPS-insulation U 0.17 W/m²K	20cm LECA block, plaster + 15cm EPS-insulation U 0.23 W/m²K
Roof 93 m²	Wooden beams, metal sheet, 80cm min. wool insulation, concrete slab U 0.06 W/m²K	Wooden beams, metal sheet, 50cm min. wool insulation, concrete slab U 0.09 W/m²K	Wooden beams, metal sheet, 32cm min. wool insulation, concrete slab U 0.14 W/m²K	Wooden beams, metal sheet, 25cm min. wool insulation, concrete slab U 0.18 W/m²K
Ground floor 93 m²	Concrete slab on ground, 70cm EPS insulation U 0.06 W/m²K	Concrete slab on ground, 45cm EPS insulation U 0.09 W/m²K	Concrete slab on ground, 25cm EPS insulation U 0.14 W/m²K	Concrete slab on ground, 18cm EPS insulation U 0.18 W/m²K
Leakage rate q50, m³/(h m²)	0.6	1.0	1.5	3.0
Windows 48 m² U-value glazing/frame/total	4mm-16mmAr-SN4mm-16mmAr-SN4mm Insulated frame 0.6/0.7 W/m²K 0.7 W/m²K	4mm-16mmAr-4mm-16mmAr-SN4mm Insulated frame 0.8/0.8 W/m²K 0.8 W/m²K	4mm-16mm-4mm-16mmAr-SN4mm 1.0/1.3 W/m²K 1.1 W/m²K	4mm-16mmAr-SN4mm Common frame 1,1/1,4 W/m²K 1,2 W/m²K
g-value	0.46	0.5	0.55	0.63
Ext. door, 6 m²	U 0.7 W/m²K	U 0.7 W/m²K	U 0.7 W/m²K	U 0.7 W/m²K
Ventilation rate l/s, specific fan power SFP, temperature efficiency AHU HR	80 l/s, SFP 1.5 kW/(m³/s), AHU HR 85%	80 l/s, SFP 1.7 kW/(m³/s), AHU HR 80%	80 l/s, SFP 2.0 kW/(m³/s), AHU HR 80%	80 l/s, SFP 2.0 kW/(m³/s), AHU HR 80%
Heating capacity, kW	5	6	8	9
Cooling capacity, kW	5	5	5	8
	Net energy need kWh/(m² a)			
Space heating	22.2	36.8	55.1	71.5
Supply air heating in AHU	4.1	5.7	5.7	5.7
Domestic hot water	29.3	29.3	29.3	29.3
Cooling	13.6	11.1	9.2	15.0
Fans and pumps	7.9	8.8	10.0	10.0
Lighting	7.3	7.3	7.3	7.3
Appliances	18.8	18.8	18.8	18.8
Total net energy need	**103.2**	**117.8**	**135.5**	**157.7**

with average distribution and emission efficiency of 0.9 according to Estonian regulation [7].

To calculate primary energy, exported energy has to be reduced from delivered energy. National primary energy factors are to be used, the example used Estonian ones:

- fossil fuels 1.0
- electricity 1.5
- district heating 0.9
- renewable fuels 0.75

Step 6. Economic calculations: construction cost and net present value calculations

Economic calculations include construction cost calculations and discounted energy cost calculation for 30 years. To save calculation effort, construction cost is accepted to calculate not as a total construction costs, but only construction works and components related to energy performance are to be included in the cost (energy performance related construction cost included in the calculations) [2]. Such construction works and components are:

- thermal insulation (with cost implications to other structures)
- windows
- air handling units
- heat supply solutions (boilers, heat pumps etc.)

In the example, in all calculated cases an under floor heating system was considered, that was not included in the energy performance related construction cost. The effect of maintenance, replacement and disposal costs is required to be taken into account [2]. However, in the example, sensitivity analyses showed only minor differences between calculated cases, and these costs were not taken into account to keep calculations as simple and transparent as possible. Labour costs, material costs, overheads, the share of project management and design costs, and VAT are essential to include in the energy performance related construction cost.

Global cost, the term of EN 15459 used in the regulation [2] (=life cycle cost), and net present value (NPV) calculation have follow EN 15459 [10]. Global energy performance related cost has to be calculated as a sum of the energy performance related construction cost and discounted energy costs for 30 years, including all electrical and heating energy use. Because the basic construction cost was not included, the absolute value of the global energy performance related cost will have a little meaning. Instead of that, the global incremental energy performance related cost was used. This can be calculated relative to the business as usual (BAU) construction:

$$C_g = \frac{C_I + \sum_{i=1}^{30}\left(C_{a,i} \cdot R_d(i)\right)}{A_{floor}} - \frac{C_g^{ref}}{A_{floor}}$$

where:

C_g global incremental energy performance related cost included in the calculations, NPV, €/m²

C_I energy performance related construction cost included in the calculations, €

$C_{a,i}$ annual energy cost during year i, €

$R_d(i)$ discount factor for year i

C_g^{ref} global energy performance related cost incl. in the calculations of BAU reference building, NPV, €

A_{floor} heated net floor area, m²

This global incremental cost calculation is illustrated in **Table 3** for one case. A global incremental cost is negative if BAU is not cost optimal, and positive if the case studied leads to higher global cost than BAU.

To calculate the global energy performance related costs, the real discount rate and escalation of energy price has to be selected on national bases. In the example, the real discount rate of 3% and escalation of energy prices of 2% are used as basic case. The draft regulation [2] pro-

Table 3. Global incremental cost calculation. Global energy performance related cost included in the calculations is divided by net heated floor area of 171 m^2 and the values of the reference building (DH 0.96) are subtracted in order to calculate the global incremental cost. The global cost data shown corresponds to the "Gas" case in **Figure 3**.

Global energy performance related cost included in the calculations, net present value, €	DH 0.42	DH 0.58	DH 0.76	**DH 0.96 (ref.)**
Building envelope (thermal insulation and windows, structures not incl.)	30602	26245	21167	17611
Ventilation units (ductwork not included)	5474	3445	3445	3445
Condensing gas boiler (distribution system not included)	6917	6917	6917	6917
Solar collectors 6m^2	4479	4479	0	0
Connection price: Gas	2455	2455	2455	2455
Energy cost for natural gas, NPV	10100	14063	22208	26196
Energy cost for electricity, NPV	20081	20081	20407	21422
Global cost included in the calculations, NPV, €	**80108**	**77685**	**76599**	**78047**
Global incremental energy performance related cost included in the calculations, relative to the reference building, net present value, €/m^2	DH 0.42	DH 0.58	DH 0.76	**DH 0.96 (ref.)**
Building envelope (thermal insulation and windows, structures not incl.)	75,9	50,5	20,8	0,0
Ventilation units (ductwork not included)	11,9	0,0	0,0	0,0
Condensing gas boiler (distribution system not included)	0,0	0,0	0,0	0,0
Solar collectors 6m^2	26,2	26,2	0,0	0,0
Connection price: Gas	0,0	0,0	0,0	0,0
Energy cost for natural gas, NPV	-94,1	-70,9	-23,3	0,0
Energy cost for electricity, NPV	-7,8	-7,8	-5,9	0,0
Global incremental cost included in the calculations, NPV, €/m^2	**12,0**	**-2,1**	**-8,5**	**0,0**

vides long term price development data for main fuels (oil, coal, gas) which can be utilized when estimating national energy price developments.

Step 7. Sensitivity analyses

It is required in [2] to test at least the sensitivity to the discounting interest rate and energy prices. This will mean the calculation with lower and higher values.

Example:
Estonian reference detached house

Global incremental energy performance related costs included in the calculations is shown in **Figure 3** for discounted interest rate of 1 % that corresponds to real discount rate of 3% and escalation of 2%. The global incremental cost is therefore presented as relative to the business as usual (BAU) construction concept DH 0.96 with gas boiler, that is very close to Estonian minimum requirement of 180 kWh/(m² a) primary energy.

The results show two cost optimal values, as the construction concept DH 0.76 with gas boiler or ground source heat pump achieved the lowest net present value (NPV) of the global incremental cost with marginal difference less than 2 €/m² NPV between these two heating systems. Negative NPV values compared to BAU show that the better construction standard can save some global cost. The lowest NPV defines the cost optimal performance level which is achieved for DH 0.76 construction concept with primary energy of about 165 kWh/(m²a) for gas boiler and about 110 kWh/(m²a) for ground source heat pump. As the global cost is less than 2 €/m² higher for ground source heat pump, the primary energy value of it would be relevant to select for the cost optimal energy performance level. This primary energy of 110 kWh/(m²a) is also achievable with reasonable global cost increase with air to water heat pump, gas boiler and district heating.

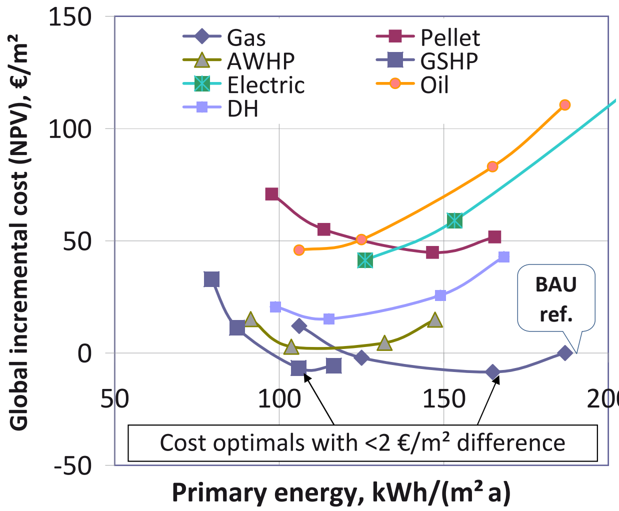

Figure 3. Global incremental energy performance related costs in the reference detached house calculated with the real discount rate of 3% and the escalation 2%, and 30 years time period. (AWHP – air to water heat pump, GSHP – ground source heat pump, DH – district heating.) For each heating system curve, the dots from left to right represent DH 0.42, 0.58, 0.76 and 0.96 construction concepts. The cost optimal values marked with arrows show that marginal, 2 €/m² change in the global cost led to highly significant change in the primary energy of about 55 units.

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The Lyon CAF:
A geothermal thermo frigo pump for 13 years

José Naveteur
EDF R&D and
C. Bruss, Lyon CAF,
jose.naveteur@edf.fr

For the last 13 years, the Lyon CAF (Family Allowances Office) has had a ground source heat pump. This system has been subject to energy performance monitoring by EDF R&D, the main results of which are presented here, demonstrating the success of the operation. This article looks at the technology of the thermo frigo pump as well as assessing energy consumption and running costs.

BUILDING DESCRIPTION

– Office building located in Lyon

– Offices, meeting rooms, conference room

– Total floor area of 16 633 m².

– Finished in August 97

– First use in October 97)

At the end of 1997, the Lyon CAF moved into new offices on boulevard Vivier-Merle in Lyon. The building has office space, meeting rooms, a conference room and a reception area for beneficiaries. Concerned about future running costs, the Lyon CAF asked its design division to look into the different heating and cooling systems that could be used for the site. **Research revealed the ground source heat pump to be the most efficient.**

Technical site characteristics

The building has a surface area of 16,633 m² with a coefficient of loss through the walls of 0.42 W/m³°C (for G1 ref. of 0.53 W/m³°C). The installation comprises two water/water heat pumps (600 kW hot, 600 kW cold) which feed a network of 4-pipe fan coils and processing units comprising recuperators to limit energy consumption.

The hydraulic systems are fitted with variable speed pumps. The well comprises two variable speed boring pumps with a maximum flow rate per unit of 100 m³/h.

It is important to mention that investment costs in 1995 stood at €149/m² for heating, ventilation and air conditioning and €21/m² for the BMS, making a total of €170/m².

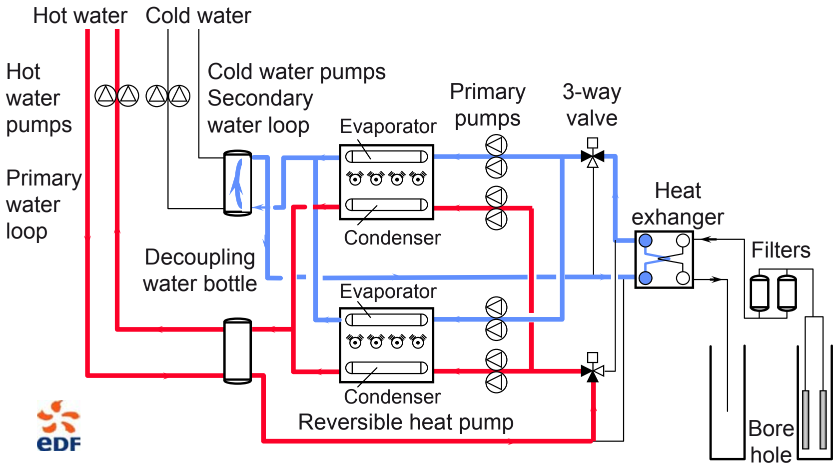
The heat pumps are controlled in thermorefrigerating pump mode. A thermo frigo pump is a reversible heat pump which can be used for both cooling and heating. ▶

HOW A THERMOREFRIGERATING PUMP WORKS

A thermorefrigerating pump has five different modes, including:

1. Heating mode

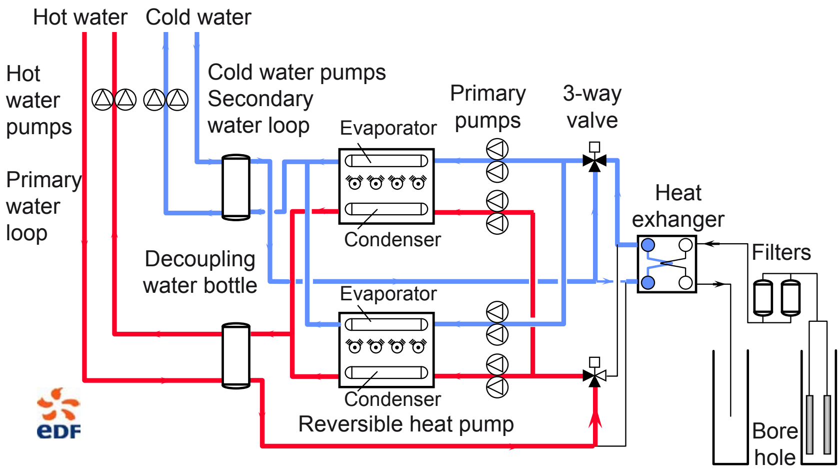
This mode is used during cold spells. To achieve thermal equilibrium, all the cold produced by the units is discharged into the well.



ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (Heating mode)

2. Majority heat and minority cold

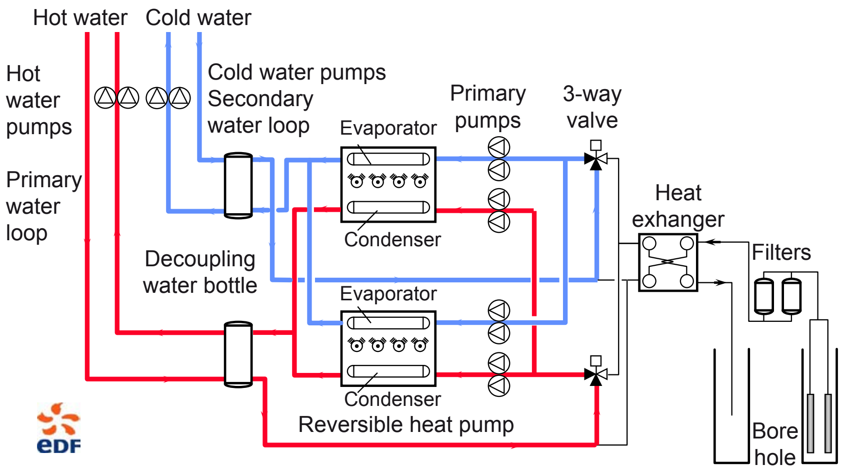
The building consumes more heat than cold (mid-season and start of winter). Surplus cold is discharged into the well.



ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (heating and cooling modes with cool sent to the underground water, heat > cool)

3. Heat equal cold

This mode is used when the building consumes all the cold and heat produced. The COP is at its maximum and no energy is discharged into the well.

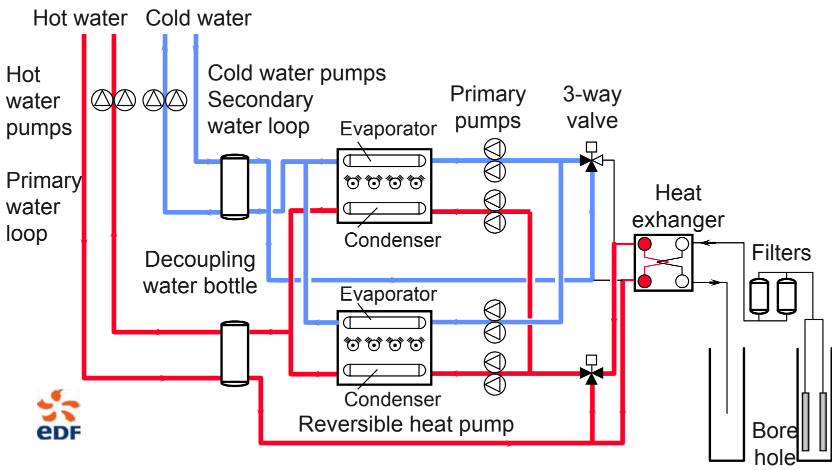


ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (heating and cooling modes, no energy exchange with the ground, heat = cool)

4. Majority cold and minority heat.

The building consumes more cold than heat (mid-season and end of winter). Surplus heat is discharged into the well.

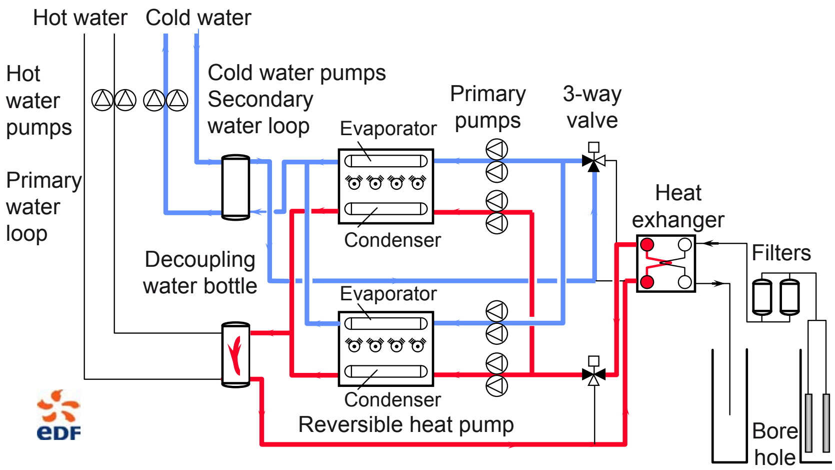
ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (heating and cooling modes with heat sent to the underground water, cool > heat)



5. Cooling mode

This mode is used during summer. To achieve thermal equilibrium, all the heat produced by the units is discharged into the well.

ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (cooling mode)



▶ It is an ideal solution in terms of energy costs for buildings which have both cooling and heating needs.

Operating conditions:

– Chilled water is 7-12 C in summer and 10-12 C in winter.

– Hot water is 35°C when it is above 20°C outside and 45 °C when it is 0°C outside. The whole installation is managed by a BMS (Building Management System).

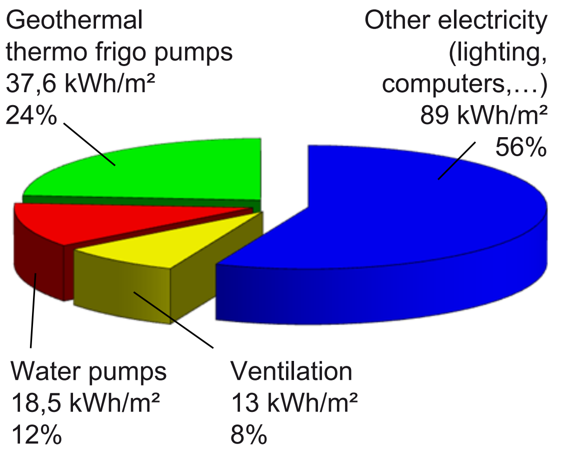
Control

This is based on a fundamental principle: *"always satisfy the highest demand"*. The BMS must continuously measure the differences in temperature between the two systems (hot and cold). Depending on which system has a higher demand, it determines the operating conditions for the thermorefrigerating pump by prioritising hot or cold operation.

Measurement results (1998-2010)

This site has been monitored for energy performance since 1998 with installation carried out by EDF R&D using 9 electricity meters (6 with remote reading), 1 calorie meter, 1 frigorie meter and 1 BMS remote investigation and monitoring system.

Below can be found the average consumptions and performances over 13 years (1998 to 2010).



Maximum power needed =
760 kW in July 2003 (50 W/m²)

Electricity consumption average
between 1998-2010
Total consumption =
2 623 198 kWh (158 kWh/m²)

- The total average consumption is 158 kWh/m² for an average cost of €8.8/m² excluding taxes and the maximum demand is 760 kW.

Consumption ranged from 145 kWh/m² in 2000 to 170 kWh/m² in 2008.

It should be noted that the average annual consumption ratio in the office sector is approximately 250 kWh/m².

- Operating costs ranged from €7.7/m² excluding taxes in 2000 to €10.45/m² excluding taxes in 2010.

For information, we can regard a building as having satisfactory energy operating costs if its operating costs are no more than €11/m².

- The consumption of the geothermal thermo frigo pump and the well pumps is 40 kWh/m² (€2.6/m² excl. taxes), supplying an average of 67 kWh/m² of heat and 83 kWh/m² of cold.

The average cost of producing MWh of heat/cold is **€17/MWh** excluding taxes.

Compared to a traditional system (gas heating and refrigeration unit), the ground source heat pump solution gives an annual saving of €2.2/m² excluding taxes, i.e. a reduction in energy costs for heating and cooling of 48%.

It results in a fall in CO_2 emissions of 14.8 kg/m², i.e. a 72% reduction.

The system's Coefficient of Performance (COP)* over the 10 years is 3.73 on average, **meaning that for every kWh of electricity consumed, the system supplied 3.73 in the form of heat or cold.**

Return on investment after 3 years for the variable speed pumps !

EDF recommended the installation of variable speed pumps for the hot and cold systems and for the boring pumps. The savings made from these variable speed drive units are as follows:

- For the bore hole pumps: 86,338 kWh or €4,055.

- For the cold water system pumps: 82,684 kWh or €4,179.

- For the hot water system pumps: 90,099 kWh or €4,277.

This gives an average saving of 259,121 kWh p.a. and €12,512 p.a. excluding taxes, which represents 10% of the building's annual consumption and 40% of the annual consumption of the reversible heat pumps.

The additional cost for hydraulic disconnection and the variable speed drive units was €36,000 excluding taxes, meaning a 3-year return on investment! Monitoring has shown that a ground source heat pump system is efficient in the long term and saves energy and money while reducing the impact on the environment.

*COP = Hot and cold energy supplied to the building / Electrical energy consumed by the heat pumps + the well pump.

Conclusion

With this monitoring, you can observe that the geothermal thermo frigo pump is economically efficient and respect the environment.

Improved energy efficiency of air cooled chillers

In these last 10 years awareness in energy saving has continuously increased in both industrial and HVAC applications, we strive to regulate the electrical consumption of cooling equipment using the most effective energy efficient techniques. In the refrigeration and heating pump sectors increasingly stringent European standards and directives are now applied to the appropriate and proper use of materials, innovation and in the application of new technologies to improve refrigeration system efficiencies.

Maurizio Burba
Hitema
Managing Director
burbam@hitema.it

HVAC designs for Data Centre - total load 2,6MW

In the refrigeration and air conditioning sector continuous attempts are made to reduce the energy consumption of all systems, by improving the management of cooling power, optimizing the use of water-glycol flow and providing greater temperature accuracy.

Recent research has developed the use of environmentally friendly refrigerants with lower ambient impact and excellent thermal performances. However, large refrigerant equipment still has very high power requirements, especially those demanded from very large air or water cooled chillers with screw compressors. The utilization of screw compressors is very high amongst large capacity chillers (>300 kW) and therefore the optimization of partial load performance, which is a condition present in almost all refrigeration plants at various stages throughout the year, is the goal prefixed by Hitema.

A modern and intelligent technology is to control the large power demands of screw compressors with the frequency control network, using inverter electronic devices.

What are the energy advantages offered by Hitema with the inverter technology?

An inverter (VFD) is an electrical device acting on the variation of voltage and frequency. The inverter uses the line alternate voltage (a.c.) to produce a direct voltage (Diode Bridge – d.c.). From this direct voltage an alternate voltage is regenerated (PWM technique) with a frequency f between 0 and f_{max} (maximum frequency) and voltage $V < V_{net}$ (electric net voltage).

Inverters are widely used in film-polyester capacitor configuration, which is a similar technique used on the photovoltaic plants. The absence of the electrolytic material avoids the early aging due to temperature, currents and stocking periods. The current distortion THDI is much lower than in electrolytic capacitors since the equivalent electrical capacity is lower. Moreover the compactness and longevity of inverters above film capacitors is also a consequence of the superior effectiveness of cooling directly with liquid refrigerant line. When the frequency increases the number of compressor revolutions increases linearly. As frequency increases compressors r.p.m. increases and as frequency decreases compressor r.p.m. decreases. The range of application typically used is between 30 Hz and 70 Hz.

Main advantages are:

- The starting current is effectively equal to 0, as current is directly proportional to frequency, the inverter starts the screw compressor with void frequency and it causes an absorption equal to zero.
- Cooling power increases until to 20% above the optimal cooling power referred to at 50Hz, this is because the screw compressor can rotate with higher gears reaching higher frequencies up to 70 Hz.
- Reduced electrical consumption at partial load between 30 and 50 Hz compared to a standard screw compressor with a slide valve capacity control. This results in a measured absorbed power of up to 15%.
- Superior control of water outlet temperature exhibiting less fluctuation around the set point temperature. Typically tolerances of +/- 0.5°C around the set point are possible.
- Reduced mechanical compressors wear, as the screws will rotate for most of year with reduced RPM (higher MTBF).
- Inverter technology with screw compressor variable Vi, that is the rapport between aspiration volume and discharge volume of gas as a function of condensation temperature. Therefore at every load and at every ambient temperature, compressor efficiency is always maximised.

Performance of a Hitema chiller with compressors driven by inverter

Figure 1 illustrates the first important point showing lower absorbed power of the screw compressor when installed with an inverter, compared against a standard screw compressor with slide valve.

With a slide valve the gas flow control is less accurate than the inverter controlled counterpart. With standard compressor the capacity steps are static and prefixed (e.g. 100%, 75%, 50% and 25%). With the inverter solution, the screw revolution decreases proportionally and the gas flow is modulated linearly.

Figure 2 shows the real data performance for air cooled chiller. The COP is ratio between the chiller cooling capacity and the required compressor power input. The EER is the relationship between the cooling capacity of chiller and the total power consumption of the refrigeration unit (compressors + fans).

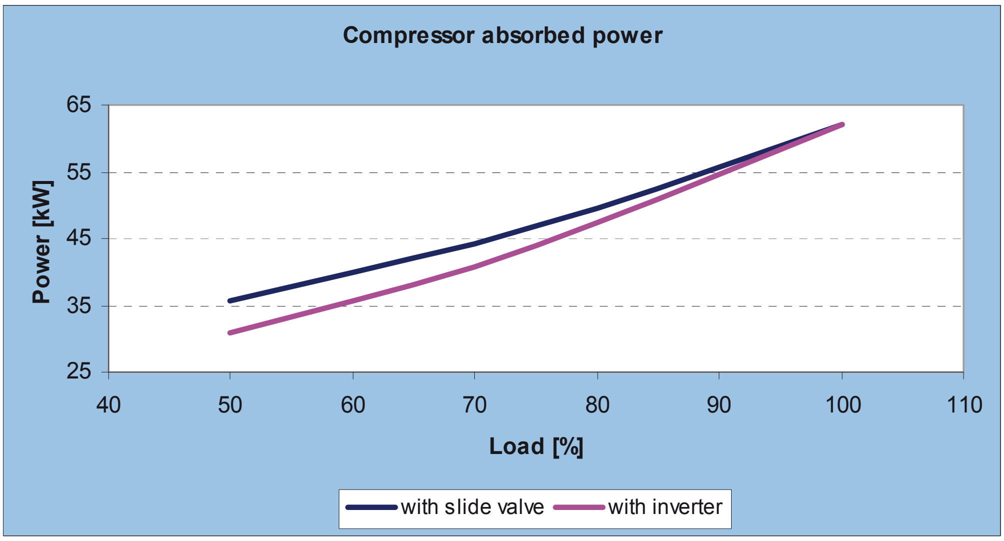


Figure 1. Comparison of performance of chillers.

If the cooling load decreases whilst the ambient temperature decreases, then the absorbed power of chiller decreases much more rapidly than the reduction in cooling capacity in a non-linear relationship.

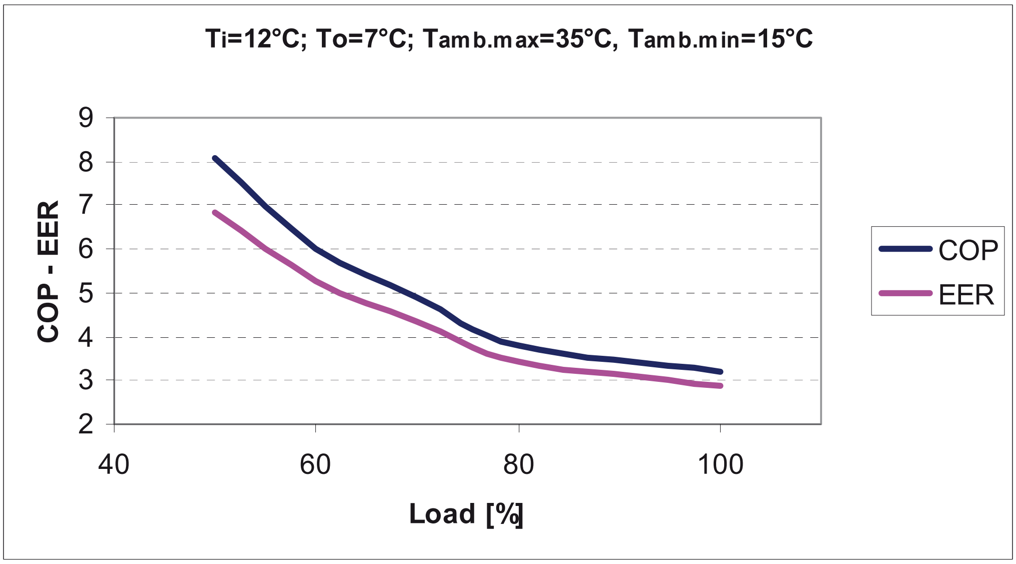


Figure 2. Performance for air cooled chiller.

These COP and EER values are very competitive with other available technologies (e.g. centrifugal compressors) and COP values with inverter screw compressors can attain > 8 and EER > 7. This chart above refers to an air cooled chiller with R134a refrigerant, with an inlet water temperature of 12°C and an outlet water temperature of 7°C. The graph illustrates the massively beneficial effect on the efficiency of the chiller unit as the ambient air temperature and the load on the chiller reduce from 100% load in a 35°C ambient (worse case), to a situation whereby the load on the chiller is 50% and ambient temperature is 15°C. As can be clearly observed, the EER for the unit at 50% load in a 15°C ambient is over double (~7) the value compared to when at 100% load in a 35°C ambient temperature (~3). The thermal performances indicated demonstrate that this unit easily qualifies for Class A efficiency categorisation.

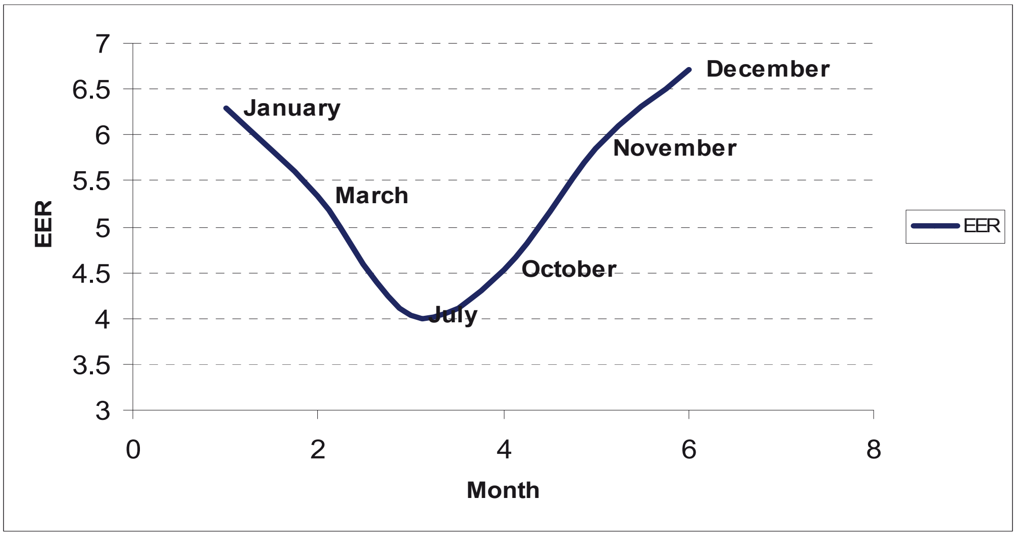


Figure 3. EER value of a chiller without free cooling.

It is clearly important to know the ambient temperature, the water temperature and the maximum load during the year (month by month) in order to assess the real operating efficiency of a chiller unit.

Figure 3 shows the EER value trend of a chiller without free cooling when operating with a water outlet temperature of 5°C.

This chiller is designed for 680kW at full load. During the warmer months of the season (June-August) the required load is 100%, whilst during the colder period (November-March), when ambient temperature is much lower, the chiller load is estimated between 50 and 60%. It is interesting to observe that the EER in the hotter months, during the worst ambient conditions, has minimum value of 4, whilst when the chiller load is around 60%, the EER values are typically between 6 and 7, much higher than a standard chiller. All these values refer to the maximum ambient temperature for each month so these EER are considered as a *minimum*.

Figure 4 shows the outlet water temperature trend. Inverter control achieves much greater water accuracy than is possible control with a standard screw compressor. It is evident that the water temperature fluctuation is only +/-0.5°C deviation from the set point. Furthermore the set point value is established much rapidly than on a standard chiller.

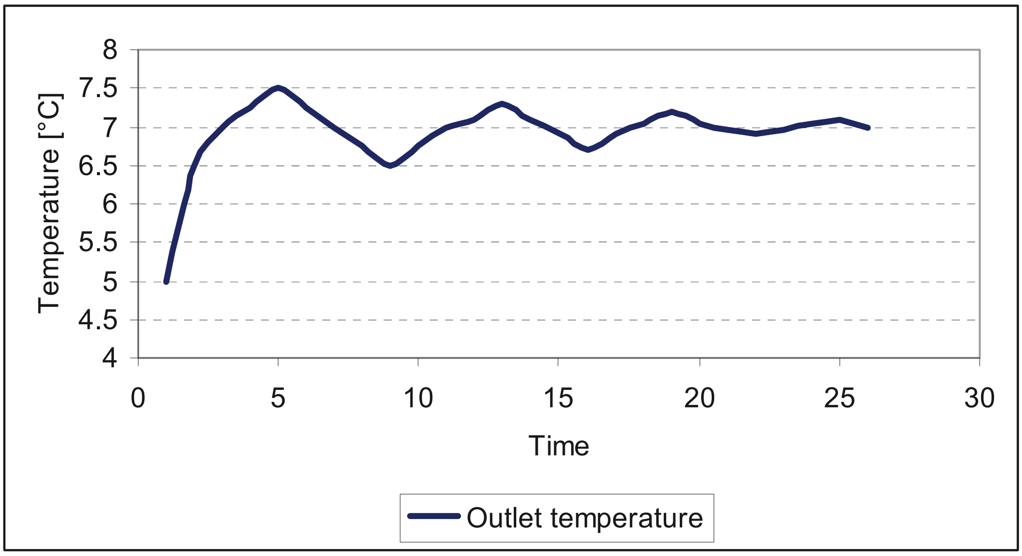


Figure 4. Outlet water temperature.

In the European market the adopted index to classify chiller performance is called E.S.E.E.R and this is in accordance with E.E.C.C.A.C. proposal (Energy Efficiency and Certification of Central Air Conditioner).

The formula used to calculate this is:

ESEER = 0.03 x EER (100%) + 0.33 x EER (75%) + 0.41 x EER (50%) + 0.23 x EER (25%)

The EER value (%) is the efficiency of the chiller at 100%, 75%, 50%, 25% of load under the various conditions in accordance with **Table 1**.

Table 1. EER value of the chiller at 100%, 75%, 50%, 25%.

Water leaving temperature	7°C (constant)			
Delta T full load	5°C			
Load	100%	75%	50%	25%
Water Cooled Chiller				
Condenser air temperature	30°C	26°C	22°C	18°C
Air Cooled Chiller				
Condenser air temperature	35°C	30°C	25°C	20°C
Weight in ESEER	3%	33%	41%	23%

For chillers with screw compressor installed with inverter control and variable Vi, the increase achieved in the ESEER is 15%.

Axial Fans with inverter

Hitema also offer the use of inverters applicable to standard axial fans. To control the volume of air circulated through the condensers in air cooled chillers simple fan speed regulators to cut the phase applied to the fan motor are currently widely used. With this method, it is possible to decrease the rotation of the motor by intervening directly on the supply voltage. However, with the use of inverters, which modulate the frequency from 20 Hz to 50 Hz it is possible to steadily reduce the air flow and achieve improved condensing control.

Benefits observed from the use of frequency variation with respect to voltage variation:

- **Reduced noise levels**
  This is a key point when using axial fans for refrigeration in the air conditioning sector, as air cooled chillers are widely used in residential, external applications; when installed with fans operating from a variable frequency drive, significant noise reductions up to 6 dBA for the same chiller unit are possible (ISO3744).
- **Lower energy consumption**
  For low-medium speed (rpm) the frequency variation allows reduced power consumption. However the motor efficiency is completely utilized with all cooling load. A cut phase adjustable fan-motor has an efficiency ratio between 72 -74%, whereas the same motor with frequency driver has a performance ratio of 80%.

Centrifugal process pump (2-4 poles) with inverter

Hitema propose the application of the inverter control on one or more centrifugal pumps, in order to obtain a non-dissipative regulation of power with the pump speed variation, depending on the heat load required.

Hence we have obtained significant results in energy saving as you trace the real load energy requirements without any additional loss or consumption being incurred by the process. To understand how the non-dissipative adjustment is able to act in this method, we can consider the operating curve of a centrifugal pump below. (**Figure 5**)

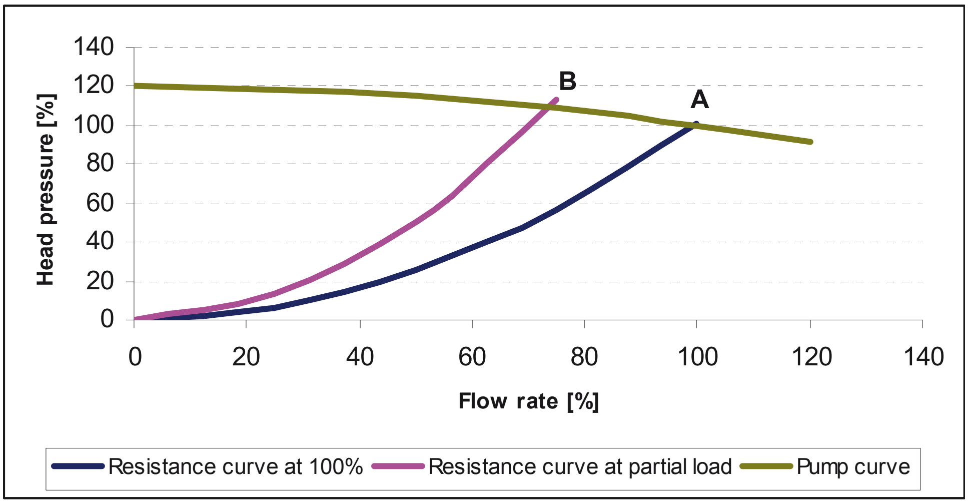


Figure 5. Operating curve of a centrifugal pump.

The intersection of the characteristic operating range for a centrifugal pump with a typical flow-pressure curve, can be used to identify the required point of working regime (point A = 100% design flow). If the load in the system requires a flow of 75% of the maximum design flow by the regulation by the classic choke valve installed after the pump then an additional pressure drop is artificially introduced and the system must overcome a higher pressure drop (kPa or m.c.a.) than is actually required by the load (point B). Furthermore by moving the operating flow point, the pump efficiency is also changed, which then introduces a further efficiency loss.

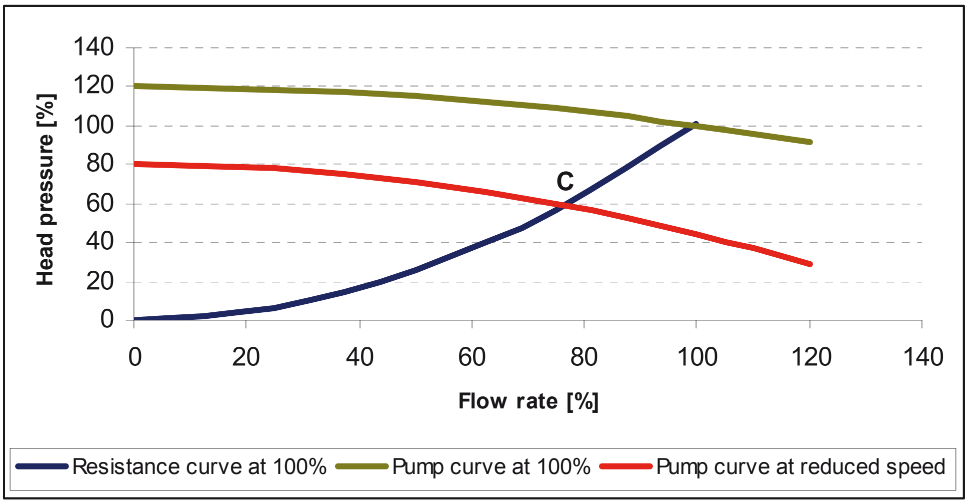


Figure 6. Operating curve with speed pump variation.

By adjusting inverter frequency instead, it follows the *real load demand* by altering the pump curve (**Figure 6**). Varying the speed of the pump changes its actual operating curve, which will move vertically downwards and thus we reach into the new operating point (point C) without any artificial valve introduction. This result in a real energy saving of 30%.The process pumps when installed with an inverter can effectively have zero starting current if the water flow can be gradually increased up to the maximum flow, which again avoids potentially damaging water hammer. The correct management of the inverter location completes the full system optimization.

Conclusion

Today there are many applications that require effective and innovative solutions to reduce the absorbed powers requirements of refrigeration hardware in process cooling industries, commercial air conditioning and data centres facilities. The optimum operation of refrigeration equipment at partial loads is especially significant in conditions where the medium annual ambient air temperatures are between +5°C and +20°C, typical for the vast majority of European conditions. For even lower ambient temperatures the combination of inverter technology coupled with that of free-cooling, whereby chilled water can be produced using only fans energy, can be effectively used to produce chiller units with even greater efficiencies than previously considered possible.

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New technology for air cleaning

Over the last few years, many people working in the HVAC industry have put great effort in obtaining a better indoor air quality and reducing the energy consumption.This is what happened specifically in the filtration business where the Filtech group (Swiss, Holland, France) developed new solutions for the application of vacuum cleaners.

Michel Duclos
Titanair
michel.duclos@titanair.fr

Ruud Poppelaars
Filtech
ruud.poppelaars@filtech.eu

Ratis™

For this industry a lot of Research & Development has been made together with several OEM's to find out the new goals to achieve: high efficiency, low pressure drop, optimized operating life time and high dust holding capacity. (Please note that nowadays modern vacuum cleaners have an E12, H13 HEPA outlet filter, where the other captains of the ventilation industry still argue whether they should install an F6 or an F7 filter).

The several research programs were successful and resulted in the introduction in the market in 2009 of a new product. The Ratis™ medium is a HPE-medium (High Performance Energetic). This full synthetic medium guarantees an extremely low pressure drop which results in spectacular energy savings. The media is moisture resistant and biologically inert - Ratis™ blocks bacterial growth during the lifetime of a filter module. The Ratis™ medium respects the AFSSET recommendations (the French agency for hygienic security for the environment, food and labor), and is 100 % glass fibre free filtration media.

About 70 % of the total cost (Life Cycle Cost) of an air filter is energy related

The energy needed, depends in great part on the average pressure drop of the air filter.

"Comparing air filters that use the same filtration media type, we find that the difference in average pressure drop; the key elements for the energy consumption are rather small. There might be differences between manufacturers and models, but if we consider that the product has been made in a correct way, the differences will not be significant. It get's different when using innovative filtration media that are polypropylene or polyethylene based." says Groupe Titanair CEO Michel Duclos.

Ratis™ has a very low electrostatic charge; it has a much higher efficiency than media made with coarse synthetic fibers. With the new micro-fiber technology and polypropylene or polyethylene based media, air filters with an extremely low-pressure drop become reality. With the right conception and processing, they will keep their efficiency over the economical lifetime of the filter.

Economical lifetime of an air filter

Still, the lifetime of an air filter is considered to be one of the most important characteristics. The longer a filter lasts, the better. While we still keep finding this argument in publicity ads, there is always a tradeoff between lifetime and energy consumption. Inevitably, the longer the lifetime of a filter, the higher the average pressure drop and therefore the higher the energy consumption, (see **Figure 1**).

Michel Duclos - Groupe Titanair - on the left and Ruud Poppelaars - CEO Filtech - on the right receiving the French Energy award Enéo d'Or in Lyon on 17 February 2011.

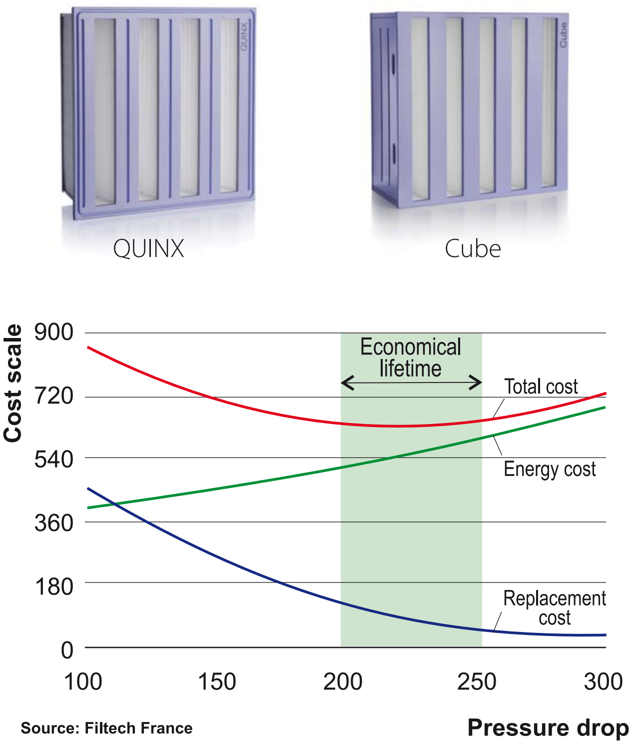


Figure 1. Total cost of an air filter.

"With the rising energy costs, a long "life time" is not what we should be aiming at.

Here innovative filter media like we use in our QUINX, Doran and Cube filters come into play.

Trying to "maximize" the lifetime of a filter might be justified in cases where the access to the filter house is very difficult or where for other reasons changing the filters, has a considerable cost.

We cannot think of any other reason to justify a longer lifetime than the economical (final) pressure drop. Beyond this point the continued usage of a filter is more expensive than replacing it by a new one." comments Filtech CEO Ruud Poppelaars.

Groupe Titanair, the technical distributor for the French market, won the ENEO D'OR in the category "Indoor Air Quality" during the latest ENEO - the trade fair for Energy, Climate Control and Water Management that was held in Lyon in February 2011. 3E

Jan Andersson is Deputy Managing Director and Head of Marketing for Camfil Farr in the Nordic countries. He is also Product Manager for the company's Comfort Air Filters in Europe and Chairman of Product Group 4B "Air Filters" (PG4B) within Eurovent.

New European standard for air filters FprEN 779:2011 - a step in the right direction

Jan Andersson
Deputy Managing Director and Head of Marketing
Camfil Farr
jan.andersson@camfil.se

The air filter market is expanding in Europe. It is expected to grow even more when all new buildings have to meet "zero-energy" requirements by 2020/21 (2018/2019 for public buildings). A zero-energy (ZEB) building is a popular term to describe buildings with zero net energy consumption and zero carbon emissions annually. A ZEB is basically a residential or commercial building with greatly reduced energy needs through efficiency gains. These "ZEBs" will need effective ventilation supplying high indoor air quality (IAQ), which in turn will require the use of high-quality air filters.

Evolution of filter classes

Over the years, our industry has seen the basic purpose of air filtration shift. Air filters used to be selected to protect ventilation equipment – today, their main function is to improve the indoor climate and protect the health of people. Today's polluted air in urban environments may cause headaches, cardiovascular and respiratory problems. Clean filtered air, on the other hand, leads to improved work performance, reduced absenteeism due to illness and enhanced well-being.

Over the years, filter classes have also progressed from low filter levels, such as G4 and F5, to today's high filtration classes, F7 and F9, with F7 being the most common and minimum class for guaranteeing acceptable IAQ. Unfortunately, there is a paradoxical relationship between filter classes and energy savings because the better the filter, the higher the energy consumption since a filter's resistance to air flow and pressure drop often increase. Due to their resistance to the air flow, air filters account for at least 30 percent of a ventilation system's energy consumption today.

With energy costs spiralling, the cost of cleaning, supplying and exhausting air in buildings has consequently become a major concern today and the choice of the right filters can help. Improving the energy efficiency of HVAC systems is another way to make buildings greener and combat climate change. Filters with the lowest pressure drop development, such as those manufactured and marketed by Camfil Farr, help customers reduce energy costs. Simply put, less energy is required to "push" air through the filters, which also maintain their efficiency longer, compared to low-cost products with poorly functioning filter media and/or insufficient filtration area.

In Eurovent's Product Group 4B "Air Filters" (PG4B), we have discussed pressure drop considerably and the energy classification of filters. The Eurovent Guideline 4/11 – "Energy Efficiency Classification of air filters for general ventilation purposes" – is ready and published on Eurovent's website. Starting in January 2012, Eurovent Certification will certify all fine filters that will be assigned an energy efficiency class (A to G) tested ac-

Table 1. New classification of air filters according to FprEN779:2011.

Classification of air filters [1]					
Group	**Class**	**Final pressure drop (test) Pa**	**Average arrestance (A_m) of synthetic dust %**	**Average efficiency (E_m) for 0.4 µm particles %**	**Minimum efficiency [2] for 0.4 µm particles %**
Coarse	G1	250	$50 \leq A_m < 65$	–	–
	G2	250	$65 \leq A_m < 80$	–	–
	G3	250	$80 \leq A_m < 90$	–	–
	G4	250	$90 \leq A_m$	–	–
Medium	M5	450	–	$40 \leq E_m < 60$	–
	M6	450	–	$60 \leq E_m < 80$	–
Fine	F7	450	–	$80 \leq E_m < 90$	35
	F8	450	–	$90 \leq E_m < 95$	55
	F9	450	–	$95 \leq E_m$	70

Note

1) The characteristics of atmospheric dust vary widely in comparison with those of the synthetic loading dust used in the tests. Because of this, the test results do not provide a basis for predicting either operational performance or service life. Loss of media charge or shedding of particles or fibres can also adversely affect efficiency.

2) Minimum efficiency is the lowest of any of the following three values: initial efficiency, discharged efficiency or efficiency throughout the test's loading procedure.

cording to FprEN779:2011. They will also be labelled according to their annual energy consumption, initial efficiency and minimum efficiency (ME).

Let me now comment on FprEN779:2011.

A welcomed initiative

The new European standard for air filters (FprEN779:2011) is coming into force this autumn. Its purpose is to classify air filters based on their minimum filtration efficiency (ME) on 0.4µm particles.

Camfil Farr, in its position as a leading air filter manufacturer, welcomes the new standard and considers it a step towards improving IAQ. The industry has now voted for tougher requirements for air filters. National versions will be available, after which the former standard will no longer apply.

In Camfil Farr's view, the new standard will help eradicate a number of problems related to filter performance.

One of these problems is associated with electrostatic-charged synthetic filters. These filters usually demonstrate good initial filtration efficiency while they keep their charge, but tend to discharge extremely rapidly, often after just a few weeks of operation. F7 performance in the lab for an electrostatically charged filter can therefore decrease to F5 in real operating conditions, and sometimes even more. Their cleaning ability deteriorates considerably as a result. Unfortunately, far too many European buildings are now using electrostatically charged F7 filters that have medium efficiency (ME) values between 5 and 10 percent. As a consequence, as much as 90 to 95 percent of the contaminants in outdoor air find their way into buildings and pollute the indoor environment.

By basing classification on an ME of at least 35 percent for F7, the new FprEN779:2011standard will force these filters out of the market. At the same time, it will contribute to the development of synthetic filter materials offering considerably higher particle separation.

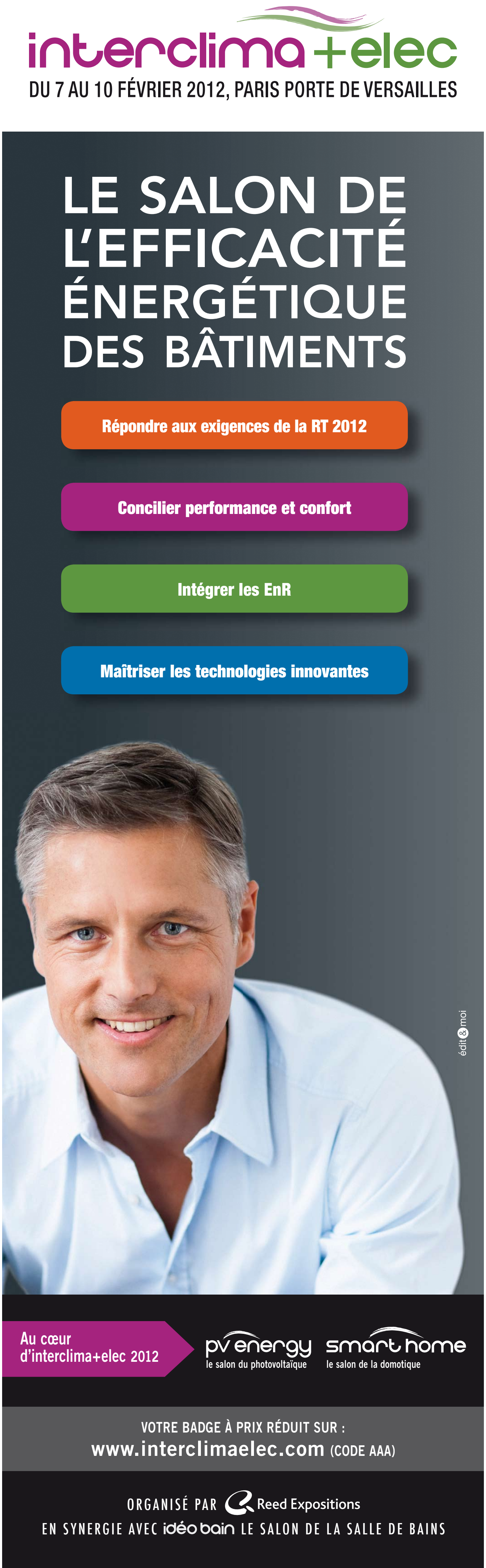
Not all filters are the same – even in the same class

Regrettably, the price for this will include higher pressure drops and increased energy consumption. Camfil Farr has one concern about the new classification: while the "worst" filters will vanish from the market, there is a possibility that "good" filters will be made "worse". Although energy savings can be achieved by having the lowest possible pressure drop, such development could be retrograde.

For example, on 0.4µm particles, Camfil Farr's Hi-Flo XLT7 (class F7) filter has an ME value of 56 percent. However, to be classified as an F7 filter, the standard requires no more than 35 percent. Camfil Farr's position on this is clear: we will not lower the efficiency of our Hi-Flo filters. Air quality would deteriorate approximately 40 percent if we did. However, there is a risk that other manufacturers will not think like us. They may see the standard as an opportunity to reduce pressure drop and, thereby, energy consumption. This could unfortunately result in poorer air quality.

At Camfil Farr, we have always put every effort into improving IAQ. Thus, no one is more pleased than us that the new FprEN779:2011air filter standard imposes tougher requirements even if the requirements are not as tough as we would have liked and do not meet the quality standards set for our own air filters.

We welcome further debate and discussion on this.



News from the European Commission

The cost efficient framework for EPBD regulations

Regulation supplementing EPBD Directive 2010/31/EU on a cost optimal framework methodology for energy performance requirements in buildings

The Inter service consultation submission consists of two documents.

The first document if the Draft supplementing Directive 2010/31/EU which establish a comparative methodology framework for calculating cost optimal levels of minimum energy performance requirements for buildings and building elements. Directive 2010/31/EU now stipulates that Member States shall ensure that minimum energy performance requirements are set with a view to achieving cost-optimal levels for buildings, building units and building elements using a comparative methodology framework established by the Commission, completed with the relevant national parameters.

The cost-optimal methodology framework can, if properly designed and applied, create a legal framework for raising Member States' minimum energy performance requirement levels to ensure that all economically rational measures are implemented. Cost optimality can also provide a good evidence base to improve the bankability of refurbishment projects, including those funded by European Investment Bank instruments and the European Regional Development Fund. Finally, the cost-optimal methodology framework can have the advantage of being technology neutral.

The second document is a Guideline which provides relevant additional information to the Member States and reflects accepted principles for the cost.

Find all documents on REHVA website under EPBD section cost efficiency paragraph:

http://www.rehva.eu/en/epbd#cost-eff

The final versions of these documents will be available at the latest in October 2011.

Building labelling

Criteria proposal for Eco-label and GPP, Summary of the 1st AHWG Meeting – July 2011

The main purpose of this meeting was a discussion on the proposed criteria areas and not on the precise values or formulations of the criteria. The discussions at the 1st AHWG and the resulting feedback will form the input into development of the draft final criteria proposal for Eco-label and GPP. This draft final will be discussed in the 2nd AHWG Meeting that is planned in November this year in Brussels. More detail on REHVA website [1].

1 http://www.rehva.eu/en/labelling-of-products-and-buildings#eco-label

Energy efficiency directive draft

On the 22 of June, the EU commission published the document Directive on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC. The main purpose of the proposal is to make a significant contribution to meeting the EU 2020 energy efficiency target.

The EU has set itself the objective of achieving 20 % primary energy savings in 2020. Latest estimations suggest that the EU will achieve only half of the 20 % target in 2020. A new ambitious strategy on energy efficiency need to be adopted for determined action to tap the considerable potential. On 8 March 2011 the Commission put forward a new Energy Efficiency Plan (EEP) setting out measures to achieve further savings in energy supply and use. This legislative proposal transforms certain aspects of the EEP into binding measures. The main purpose of the proposal is to make a significant contribution to meeting the EU's 2020 energy efficiency target. For it to be successful, the proposal must be promptly adopted and implemented in the Member States.

Eco-design of energy related products directive (ErP)

The Amended Ecodesign Working Plan will provide the European Commission and the stakeholders of the Consultation Forum with background information and analysis in order to establish the (second) Working Plan. The Working Plan sets out an indicative list of product groups which are considered priorities for the adoption of implementing measures under the Ecodesign Directive. The study is being carried out for the European Commission (DG Enterprise and Industry) by VHK, The Netherlands. It was discussed in on Sept 16th in a stakeholders meeting in Brussels.

A new draft document called "Task 1-2-3 main report" has been published on the 18 July 2011. Download the full document on: http://www.ecodesign-wp2.eu/index.html. The draft Task 3 & 4 reports are also available for download on the project website: http://www.ecodesign-wp2.eu/documents.htm

ErP Group Analysis: Lot 6 – Air conditioning and ventilation systems

The draft air conditioning reports task 4 and 5 of Lot 6 and of the Executive summary regarding the air conditioning part have been published. The European Commission will provide detailed comments to the contractor on the draft task 4 and 5 air-conditioner reports following the second stakeholder meeting on 30 September 2011. Regarding the draft reports tasks 1 to 5 for air conditioning and for ventilation comments are expected until 31 October 2011.

REHVA NEWSLETTER

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Database for the energy use of AC systems – iSERV-project

Project iSERV collects a benchmarking database on energy use of A/C systems.

This project aims to collect sub-hourly HVAC system energy use data from around 1600 HVAC systems in the EU Member States and analyse this information.

REHVA will play an active role to get participants enrolment in this project and disseminate the results of the study. REHVA supporters are invited to participate.

The main benefits for the project participants are:

- feedback on their building energy use patterns and comparisons with similar systems
- detailed understanding of their HVAC energy consumption
- get key directions on how to improve in-use energy efficiency of their HVAC systems
- avoid HVAC system inspections when identified as performing

The overall aim of iSERV

- Is to provide some reward to HVAC system owners/operators and manufacturers for addressing the energy efficiency of these systems in their operation and design.
- To establish that the continuous monitoring and benchmarking of HVAC processes will provide energy saving benefits equivalent to or better than those achievable by Physical Inspection alone
- To produce benchmarks of energy consumption by HVAC systems against end use activities derived from measured data around Europe
- To encourage the rapid adoption of more energy efficient HVAC systems through demonstrating their in-use benefits

Should you be interested in a direct participation, please do contact the project via the iSERV website http://www.iservcmb.info/ - contact the project Coordinator, Dr Ian Knight, at knight@cf.ac.uk. See all details in the announcement on the Build Up portal: http://www.buildup.eu/news/15861.

42nd international congress and exhibition for heating, refrigeration and air-conditioning

The HVAC&R congress held in Belgrade, Serbia on November 30th to December 2nd 2011 is organized by the Serbian Society for heating, refrigeration and air-conditioning. The topics of this congress are directly associated with the economics of maintaining thermal comfort in construction buildings through reduction of energy demands, control of the building energy systems' operation, use of renewable energy sources and design parameters which constitute every energy efficient solution.

The new segment of the exhibition – the exhibition of software, IT and green programs and networks, which was held last year for the first time and which aroused great interest, will be organized at the same place.

The second congress day will also include special program for students and young colleagues who select HVAC&R profession and other specialties directly associated with HVAC&R systems and buildings which use energy for heating, refrigerating, ventilation, domestic water heating and natural and artificial lighting.

To register, please visit www.kgh-kongres.org.

23rd IIR International Congress of refrigeration

Organized every four years, IIR International Congress of Refrigeration, ICR, brings together large numbers of refrigeration stakeholders from all parts of the world. The 23rd IIR International Congress of refrigeration was held in Prague, Czech Republic last month. From August 21st to August 26th more than 944 delegates from 52 countries attended the Congress. The theme of this new edition was ***Refrigeration for Sustainable Development***. During this busy week several topics were covered in depth and important technical issues were discussed. More than 600 papers were presented on important topics such as: cryology, gas processing, thermodynamics, equipment and systems, biology and food technology, storage and transport, air conditioning, heat pumps and energy recovery. Overall, the organizers have done a fantastic job in getting a scientific programme of high caliber together.

In 2012 from August 31 to September 6, the next edition, the 24th ICR will be held at Yokohama, Japan. The programme, calls for papers, registration, technical tours and a wide range of historic and exciting places will be announced on the congress website. www.ICR2015.or.jp.

For more information on the International Institute on Refrigeration IIR, please visit www.iifiir.org.

interclima+elec 2012

interclima+elec
du 7 au 10 février 2012 Paris Porte de Versailles

Organized every two years, interclima+elec will be held on the 7 – 10 February 2012 in Paris, Porte de Versailles. This new edition reflects the convergence in the field of multi energy and multi technology in the building sector (hvac & refrigeration, home & building management systems). Every two years in Paris, this is the landmark event where the entire trade community (installers, contractors, architects, engineers, distributors) enjoy the opportunity of discovering the most innovative solutions which combine energy efficiency, use of renewables and comfort in the home and building. It's the one and only platform where they can exchange, learn, and find concrete answers for their projects. interclima+elec, actively contributes to the success of a sector totally committed to the environmental challenges of today and tomorrow: global warming reduction, low-energy and positive energy building.

For more information, please visit www.interclimaelec.com.

Halton foundation grants promote better indoor air around the world

Halton
CARE FOR INDOOR AIR

Halton Foundation is a charity organization that promotes wellbeing of people suffering from poor indoor environmental quality due to environmental or economic conditions. Annual grants are awarded to non-profit organisations, research programs or initiatives promoting the wellbeing of people in indoor environments. The Foundation covers initiatives related to indoor air quality, thermal conditions, breathable particulates and illnesses, conditions or diseases that may result from sub-standard indoor environmental quality. Two global indoor air quality problems have been identified by the Halton Foundation: indoor air pollution from cooking process in developing countries and high level of outdoor contaminants in indoor air in developed countries. Halton Foundation is looking for new and innovative ways of solving indoor environmental problems. Therefore Halton Foundation welcomes grant applications for different kinds of undertakings supporting the Foundation's mission. An application can be filled out at Halton Group website www.halton.com and applications must be submitted by latest on October 15, 2011. Decision on grants will be made in November 2011.

New! REHVA eGuidebooks

We are proud to announce that our two new Guidebooks are available online.

- No. 14 Indoor Climate Quality Assessment
- No. 15 Energy Efficient Heating and Ventilation of Large Halls

To purchase, please visit www.beuth.de

The full text of the article describing the student competition is available at
http://www.rehva.eu/en/444.rehva-international-student-competition-at-annual-conference-19-may-2011-tallinn-estonia

REHVA International Student competition 2011 in Tallinn

Summary by Jan Aufderheide, TVVL, The Netherlands

REHVA Education Committee under its chair, prof. Dr. ing. Karel Kabele, organized again the international student competition at REHVA Annual meeting in Tallinn. Five 'young masters' sent by their national HVAC societies participated. None of the candidates was a native speaker so there was an equal playing field for all of them concerning that aspect of the presentation (oral and poster). And the winner was R.C.G.M. (Roel) Loonen MSc. from Eindhoven University of Technology (TU/e), Unit Building Physics and Systems, Netherlands. His graduate teacher was prof. dr. ir J.L.M.(Jan) Hensen. The work by competitors in summarized below.

All the competitors with the chair of the REHVA jury in front of their posters, from left to right: F. Schmahl; R. Loonen; prof. dr. K. Kabele (chair of the jury); A. Ribeiro; Z. Šestáková; A. Litiu.

Climate adaptive building shells

R.C.G.M. Loonen, TU/e-Netherlands

Because building shells are at the interface between interior and ambient climate, they fulfill a number of vital functions that dictate most of the building's energy consumption. The building's environment is changing over time (short-term weather conditions, diurnal and seasonal cycles), and this also applies for occupants' behavior and comfort preferences. In spite of these changing conditions, conventional building envelopes are 'rigid systems' with fixed thermo physical and optical properties that cannot adapt to this variability. Climate adaptive building shells (CABS) on the other hand do have the ability to repeatedly and reversibly change their functions, features or behavior over time. By adapting their behavior in response to prevailing weather conditions, these façades can seize the opportunity to save energy for heating, cooling and/or lighting. At the same time, CABS are also expected to introduce positive contributions to indoor air quality and thermal and visual comfort levels.

The study started with a systematic review of CABS characteristics and an analysis of specific requirements for simulation of adaptive rather than fixed building envelopes. In a second stage it was studied how the capabilities of building performance simulation (BPS) can fulfill this demand. The applicability of BPS in relation to CABS was then demonstrated in the case study of smart energy glass (SEG). Based on laboratory tests and a description of underlying physics, an integrated model for performance prediction of SEG was developed.

Calculation of maintenance costs of HVAC components

F. Schmahl, RWTH Aachen – Germany

Because of the growing importance of reliable life cycle costs calculations for construction and construction services companies, the analyses of the current state of research concerning life cycle costing is important. It appears that some elements of costs, e.g. energy costs, can already be anticipated quite accurately – at least the expected energy consumption. However, there is no focus on maintenance costs in recent research activities so that a forecast of maintenance costs is rather rough compared to other elements of costs – although maintenance costs out value other elements of costs (energy costs included) in most cases.

Within buildings maintenance costs it is easy to identify building services (HVAC systems) as cost drivers as the service life of HVAC components is rather short compared to the building structure. A deeper analysis shows that costs of continuously conducted maintenance activities (planned preventative maintenance such as inspections and minor repairs) can be predicted on a quite high level of accuracy. Uncertainty exists with regard to major repairs, i.e. refurbishment, replacement, renovation etc. The need for these activities occurs discontinuously, i.e. the corresponding costs arise at discrete points in time breaking through the continuous cost plot as peaks.The study concentrated on the architecture to create the condition profile. The derivation of the cost consequences and the acquisition of expert knowledge should be investigated in future research activities.

Energy and environmental assessment of the revitalized cargo ship "Josef Boček"

Z. Šestáková, Czech technical university Prague – Czech Republic

The goal of this study was to evaluate by an energy audit, the existing state and to find potential savings of energy on the floating multifunctional leisure-time facility of the freestyle park Modřany. Originally that facility was a double bladed river cargo ship, built in 1956 and was used for transport of loose material. The energy and environmental efficient measures were defined. The audit with its recommendations has to fulfill requirements of the law Energy Management Act 406/2000 Coll. with its revisions.

The mean technical units were analyzed in the study: The heat source and heating system; water heating (hot water supply) system; ventilation; cooling; lighting; electrical appliances; other systems (a.o. elevators, mechanical drainage, diesel power generator back up). It was analyzed that the heat loss of the ship is 64 044 kW, from which 69% is lost via heat transmittance through constructions and 31% is heat loss of ventilation. Infrared camera measuring has been applied with the result that the exterior construction does not have any massive thermal bridges.

By installing a new heat source - heat pumps (air - water type, high temperature use) and pumping river water for washing down toilets, cleaning and watering plants the energy performance of the "building" can be decreased (i.e. improved) in terms of EPBD-ranking from class D to class B.

Analysis on renewable energy sources – case study for a school

A. Liţiu, Politechnica University Timişoara - Romania

A comparable study as Mrs. Z. Šestáková did in her work (see above) for an old cargo ship, transferred to a leisure-time facility, Mr. Liţiu, did his study for a school and analyzed which renewable energy sources are best fitted, from both technically and economically points of view, for that school (from 1st to 8th grade) situated in the rural environment. To be more exact the location is Beregsău Mare village, approximately 18 km from Timişoara, Western Romania. The energy obtained from these sources will be needed in providing hot water for heating purposes and domestic use. The following options were taken into account: Geothermal energy; solar energy; heat pumps soil/water; water/water; air/water). After analyzing all the possible renewable energy sources, the ones that fit best the needs and circumstances are the solar hot water panels and the air / water heat pump. Together they would not only assure the necessary heat demand but also a higher energy performance. Using these energy sources the most viable heating system would be radiant surfaces heating, e.g. radiant floor heating. Another discussed topic in the study was indoor air quality. Poor indoor air quality has both short term negative effects (headaches, difficulty to concentrate, fatigue and lethargy) and long term effects (respiratory infections – e.g. asthma).

Design and automation of passive and active systems to a net zero energy school building

A. Ribeiro, Trás-os-Montes e Alto Douro University - Portugal

In this study a new school building model, developed to enable an energy-efficient and sustainable building was made. The bioclimatic framework and the organization of space, allied with the integration of passive techniques, in which emerges the incorporation of renewable energy, complemented by active ones, creates a high potential of self-sustainability in buildings. The building automation through passive and active systems, via centralized technique management, led us to create integration of actuators, with innovative perspectives, in the natural ventilation systems and renewable energy production in school building. With the proposed model, it is expected a radical change in the way to designing the building, making it possible to obtain a Net Zero Energy Building balance. This is reflected by the annual balance between demand and supply energy in the building equal to zero and "Zero" Carbon. It was given particular attention to natural light components and its relationship to artificial lighting minimization and cooling systems or heating ventilation through air-ground heat exchanger, air collector, cross effect or chimney effect, ensuring excellent air quality and indoor comfort conditions.

EVENTS 2011-2012

12 - 13 October 2011	32nd AIVC Conference and 1st TightVent Conference	Brussels, Belgium	www.aivc.org
12 - 14 October 2011	Solar Air-Conditioning - 4th International Conference	Larnaca, Cyprus	http://www.otti.de/
17 - 19 October 2011	PHN11 4th Nordic Passive House Conference	Helsinki, Finland	www.phn11.fi/
18 - 21 October 2011	SB11 Helsinki World Sustainable Building Conference	Helsinki, Finland	http://www.sb11.org/
20 - 21 October 2011	ESTEC 2011 - 5th European Solar Thermal Energy Conference	Marseille, France	http://www.estec2011.org
20 - 22 October 2011	46th Edition of National Installation Conference with theme installations for the Beginning of 3rd Millenium	Sinaia, Romania	
26 - 28 October 2011	XXVIII Conference and Exhibition "Moscow: problems and ways to improve energy efficiency"	Moscow, Russia	www.abok.ru
27 October 2011	International Seminar "Energy Saving and Greening of Data Centers"	Moscow, Russia	www.abok.ru
10 - 12 November 2011	Sustainable Energy-CSE - International Conference	Brasov, Romania	www.unitbv.ro/cse
14 - 16 November 2011	Building simulation 2011	Sydney, Australia	www.bs2011.org
24 - 26 November 2011	RENEXPO® Austria 2011	Salzburg, Austria	www.renexpo-austria.at
30 Nov. - 2 December 2011	41th International congress of Heating, Air Conditioning and Refrigeration	Belgrade, Serbia	www.kgh-kongres.org/
21 - 25 January 2012	ASHRAE Winter Meeting	Chicago, USA	www.ashrae.org
9 - 11 April 2012	5th Internation conference on energy research & development (ICERD-5)	Kuwait	www.icerd5.org
17 - 20 April 2012	REHVA Annual Conference and Meeting	Timisoara, Romania	www.rehva-am2012.ro
26 - 27 April 2012	Focus on Renewable District Heating and Cooling	Copenhagen, Danmark	www.euroheat.org/
30 April - 2 May 2012	X. International HVAC+R Technology Symposium	Istanbul, Turkey	www.ttmd.org.tr/2012sempozyum

FAIRS 2011-2012

12 - 13 January 2011	ACRECONF India	New Delhi, India	www.acreconf.org/
23 - 25 January 2012	AHR Expo	Chicago, USA	www.ahrexpo.com
7 - 9 February 2011	Chillventa Russija	Moscow, Russia	www.chillventa-rossija.com/en/
7 - 10 February 2012	Interclima + elec	Paris, France	www.interclimaelec.com
7 - 10 February 2012	Aqua-Therm	Moscow, Russia	www.aquatherm-moscow.ru
23 - 25 February 2012	ACREX 2012	Bangalore, India	www.acrex.org.in/
29 February - 3 March 2012	SINERCLIMA 2012	Batalha, Portugal	www.eventseye.com
20 - 22 March 2012	ecobuild 2011	London, United Kingdom	www.www.ecobuild.co.uk
20 - 23 March 2012	NORDBYGG 2012	Stockholm, Sweden	www.nordbygg.se
27 - 30 March 2012	MCE - Mostra Convegno Expocomfort 2012	Fiera Milano, Italy	www.mcexpocomfort.it
15 - 20 April 2012	Light + Building	Frankfurt, Germany	www.light-building.messefrankfurt.com
2 - 5 May 2012	ISK - SODEX 2012	Istanbul, Turkey	www.hmsf.com

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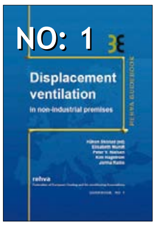
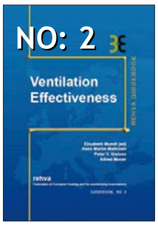
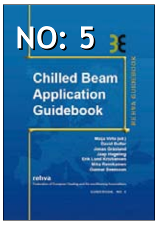


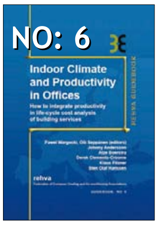
Displacement Ventilation Guidebook serves as a comprehensive and easy-to-understand design manual. It explains the benefits and limitations of displacement in commercial ventilation and outlines where ventilation should be applied. Various case studies are included. The benefits of displacement ventilation are that less cooling is needed for a given temperature in the occupied spaces, longer periods with free cooling and better air quality in the occupied spaces.



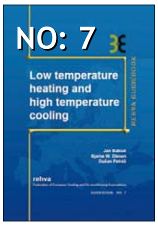
Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook provides easy-to-understand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



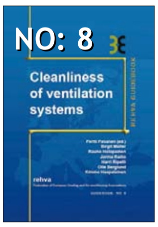
Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature hot water system.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



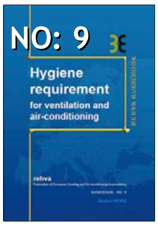
Indoor Climate and Productivity in Offices Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available. The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



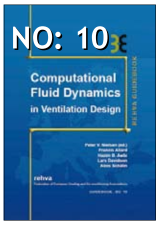
This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in all types of buildings and work with heat carriers at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



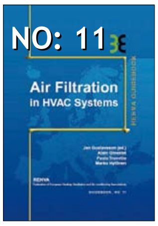
Cleanliness of ventilation systems Guidebook aims to show that indoor environmental conditions substantially influence health and productivity. This Guidebook presents criteria and methods on how to design, install and maintain clean air handling systems for better indoor air quality.



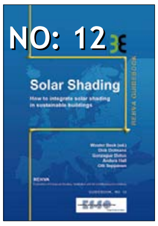
Hygiene requirement is intended to provide a holistic formulation of hygiene-related constructional, technical and organisational requirements to be observed in the planning, manufacture, execution, operation and maintenance of ventilating and air-conditioning systems. These requirements for ventilating and air-conditioning systems primarily serve to protect human health.



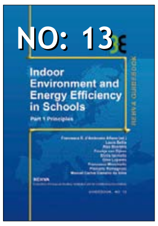
CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary conditions. Computational Fluid Dynamics (CFD) –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



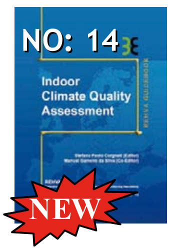
Air filtration Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on external conditions such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



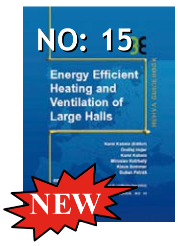
Solar Shading Guidebook gives a solid background on the physics of solar radiation and its behaviour in window with solar shading systems. Major focus of the Guidebook is on the effect of solar shading in the use of energy for cooling, heating and lighting. The book gives also practical guidance for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



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



This new REHVA 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 has allowed enlarging significantly number of possible applications, especially in existing buildings. The Guidebook illustrates with several cases the instrumentation for the monitoring and assessment of indoor climate.



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

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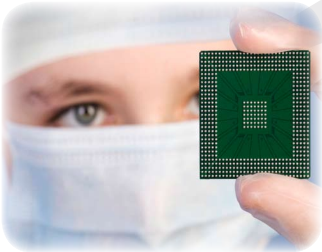

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