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Federation of European Heating, Ventilation and Air-conditioning Associations

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Special issue for ACREX India 2012 exhibition

EUROPEAN HVACR TECHNOLOGY

EU TOWARDS ZERO ENERGY BUILDINGS

EU TIGHTENS ENERGY EFFICIENCY REGULATIONS

EUROPEAN CASES FOR NEARLY ZERO ENERGY BUILDINGS

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Contents

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

Sharing and learning together

Maija Virta
Fellow of REHVA
CEO of FIGBC
Guest Editor

Everybody needs to act. We are agreed that the relationship between human activities and climate change is a proven fact. As buildings are producing one third of the greenhouse gas emissions and account for 40% of the used energy it is not possible to prevent climate change without focusing on buildings.

Buildings are built for people. The environment they create indoors is vital for people's wellbeing and sustainability. Whatever we do with our buildings; we will always prioritize the indoor environment. But a healthy and comfortable indoor environment should be made so that it does not create an unnecessary environmental load.

We can all share our experiences. The world should learn from the lessons of the first energy crisis in Europe in the 1970´s, when, due to improper energy saving measures, buildings were made too airtight, ignoring ventilation and indoor air quality issues. Moisture and mould problems increased the prevalence of respiratory illnesses. The sick building syndrome was created due to unprofessional energy saving techniques. We also made mistakes in urban planning by developing too homogenous neighbourhoods which later led to many social problems and criminality. We also demolished many old, historical buildings. The value of cultural heritage was not appreciated at that time. We did not focus on the total life cycle approach taking into account e.g. energy used for manufacturing materials and components (embodied energy).

We can learn together. During Acrex 2012 ISHRAE and REHVA will sign the Memorandum of Understanding. This gives a new platform for sharing and learning together. India faces a major challenge at becoming one of the world leaders in green buildings by 2015, by not only building new buildings but also developing new neighbourhoods. In Europe, we have a major challenge when implementing all the policies related to the built environment before 2020. The Energy Performance of Buildings Directive (EPBD) is a major regulative action dealing with buildings in Europe, but many other directives also have a link to our industry. According to the EPBD, all new buildings must be nearly zero energy buildings from 2020 onwards. We must increase the renewable energy production by up to 20% of the total energy use. We also need to speed up energy refurbishments in Europe. The ultimate target is to reduce 80% of greenhouse gas emissions by 2050.

We do not have all the answers but we may have some pertinent questions. As our climates and cultures are different, as well as our existing building types and energy production, we cannot all use the same solutions to solve our problems. But because of our different backgrounds we should ask the each other relevant questions, share the experience, and learn together.

Buildings in the key role in the EU Energy Efficiency Action Plan

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Energy efficiency is at the heart of the EU's Europe 2020 Strategy for smart, sustainable and inclusive growth and of the transition to a resource efficient economy. Energy efficiency is one of the most cost effective ways to enhance security of energy supply, and to reduce emissions of greenhouse gases and other pollutants. In many ways, energy efficiency can be seen as Europe's biggest energy resource. This is why the European Union has set itself a target for 2020 of saving 20% of its primary energy consumption compared to projections, and why this objective was identified in the Commission's Communication on Energy 2020 as a key step towards achieving our long-term energy and climate goals.

Substantial steps have been taken towards this objective – notably in the appliances and buildings markets. Commission estimates suggest that the EU is on course to achieve only half of the 20% objective. The EU needs to act now to get on track to achieve its target. Responding to the call of the European Council of 4 February 2011 to take determined action to tap the considerable potential for higher energy savings of buildings, transport and products and processes, the Commission has therefore developed this comprehensive new Energy Efficiency Plan 2011 [1].

The Energy Efficiency Action Plan 2006 [7] defined ten priority actions covering the main energy-using sectors and key horizontal issues (**Table 1**).

Energy efficiency measures in the building sector provide enormous potentials to reduce CO_2 emissions in Europe. The energy use of the building segment accounts for 40% of the total energy use in the EU and represents Europe's largest source of emissions (nearly 36% of EU CO_2 emissions). This high amount of emissions could be reduced up to 80% through integrated design solutions, e.g. better insulation of the different components of the existing building stock, of already refurbished dwellings, as well as for new buildings (EURIMA, ECOFYS 2005a,b, Wuppertal Institut 2005). Energy performance of buildings is key to achieve the EU Climate & Energy objectives.

The **Figure 1** illustrates that for the final energy sectors, even though some of the potential is currently being used, the cost-effective savings potential in each sector would not be fully utilized in 2020. Further savings are possible but not cost-effective.

Energy used in residential, commercial and public buildings for space and water heating, cooling, ventilation, lighting, etc. makes up 40% of the EU's final energy consumption. The major Community legislation addressing the energy performance of buildings is the Energy Performance of Buildings Directive (EPBD) of 2002 [11]. The Action Plan tackles energy efficiency in buildings by pushing for the full implementation of the EPBD and by putting forward its revision - as the second priority action.

The recast of the EPBD [12] suggests that all EU Member States endorse national plans and targets

Table 1. Structure of the Energy Efficiency Action Plan 2006. [7]

85 (sub-) measures	6 priority areas	10 priority actions
	SECTORS	
• Regulatory instruments	Energy-using products Energy services	(1) Appliance & equipment & minimum energy performance standards
• Economic & market-based instruments	Residential, commercial & public buildings	(2) Building performance requirements and very low energy buildings
• Information & support programs	Energy transformation	(3) Making power generation and distribution more efficient
• Voluntary actions	Transport	(4) Achieving fuel efficiency of cars
	HORIZONTAL ISSUES	
	Financing	(5) Facilitating financing of energy efficiency investments for SME and Energy Services Companies
	Economic incentives	(6) Spurring energy efficiency in the new MS
	Energy pricing	(7) Coherent use of taxation
	Energy behaviour	(8) Raising energy efficiency awareness (9) Energy efficiency in cities
	International partnerships	(10) Foster energy efficiency worldwide

in order to promote the uptake of nearly zero energy buildings. So far, around 20 000 low energy houses have been built in Europe. The plan focuses on instruments to trigger the renovation process in public and private buildings as well, to improve the energy performance of the appliances used in them and to foster energy efficiency in households and the industry.

The Action Plan promotes the exemplary role of the public sector and proposes a binding target to accelerate the refurbishment rate of the public sector building stock. Public authorities should be required to refurbish at least 3% of their buildings each year. This is roughly double of the actual renovation rate. It also introduces energy efficiency criteria in public procurement. Each refurbishment should bring the building up to the level of the best 10% of the national building stock. When public bodies rent or buy existing buildings, these should always be in the best available energy performance class. The public sector can create new markets for energy efficient technologies, services and business models. Member States need to reform subsidies promoting energy use, for example by reorienting them to improve energy efficiency and address energy poverty.

The Action Plan aims to trigger the renovation process in private buildings and to improve the energy performance of appliances. In residential buildings, retrofitted wall and roof insulation offer the greatest opportunities, while in commercial buildings, improved energy management systems are very important. Improved appliances and other energy-using equipment still offer enormous energy savings opportunities. Member States are called upon to introduce measures – in line with national property law - to address the problem of split incentives. This means how the costs of renovation are split between the tenant and the landlord in case of rented buildings and apartments. At the same time, Member States are called on to support the uptake of Energy Service Companies as catalysts for renovation. Energy Service Companies renovate private houses and apartment at their own costs and make profits by receiving the difference between the energy costs before and after the renovation over a defined period of time. The Action Plan also focuses on the roll-out of smart grids and smart meters providing consumers with the information and services necessary to optimise their energy consumption and calculate their energy savings.

Large companies have to do regular and independent energy audits. They have to organize these themselves. Member States are encouraged to develop incentives for companies that introduce an energy management system as a systematic framework for the rational use of energy. Exchange of best practices in energy efficiency and projects aimed at building capacity on energy management are proposed for micro and small companies.

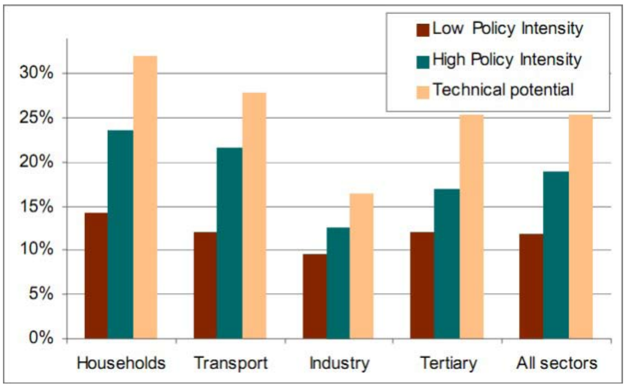

Figure 1.
Final energy savings potential in EU 27 in 2020. [6]

The Plan also includes a reference to the launch of a new initiative – Smart Cities and Smart Communities – to develop a European framework for excellence in innovative low-carbon and energy efficient solutions at the municipal level. A great challenge is the refurbishment of the existing building stock, and in particular how to finance the necessary investments. The final actors (e.g. EU citizens, public authorities and service companies) in both sectors face similar market and regulatory failures that limit the uptake of energy savings measures, namely: high initial costs, incomplete markets (lack of trained staff, infrastructure, information), lack of information/ knowledge/ motivation, split incentives (landlord-tenant problem), poor enforcement of legislation, and rebound effect. Some Member States are already pro-actively using structural funds.

Energy efficient building solutions are often technically demanding. There is a lack of appropriate training for architects, engineers, auditors, craftsmen, technicians and installers, notably for those involved in refurbishment. Today, about 1.1 million qualified workers are available, while it is estimated that 2.5 million will be needed by 2015 The Commission is therefore launching the 'BUILD UP Skills: Sustainable Building Workforce Initiative' to support Member States in assessing training needs for the construction sector, developing strategies to meet them, and fostering effective training schemes. This may lead to recommendations for the certification, qualification or training of craftsmen. Investments in energy efficiency enhance competitiveness and support security of energy supply and sustainability at low cost.

The combined effects of full implementation of the existing and new measures has the potential to generate financial savings of up to €1 000 per household each year; improve Europe's industrial competitiveness; create up to 2 million jobs. The EPBD recast [12] is expected to have a major impact on the future final process of the existing building stock as well as the construction of nearly zero-energy houses will have significant quantitative and qualitative impacts on employment. The higher level of qualifications of the workforce as well as the acquired knowledge on state-of-the-art low energy buildings will bring an additional competitive edge to the European building industry.

Table 2. Scenario of depth and speed of the renovation. [13]

Name	Scenario	Type of energy-efficiency intervention	Renovation rate, per year
S-BASE	Baseline scenario	No intervention	"Business-as-usual" (1.3% of the total floor area)
S-DEEP1	Deep retrofit, fast implementation rate	Deep retrofit	Around 20 million sqm (eq. to 250,000 dwellings, 5.7% of the total floor area)
S-DEEP2	Deep retrofit, medium implementation rate	Deep retrofit	Around 12 million sqm (eq. to 150,000 dwellings, 3.4% of the total floor area)
S-DEEP3	Deep retrofit, slow implementation rate	Deep retrofit	Around 8 million sqm (eq. to 100,000 dwellings, 2.3% of the total floor area)
S-SUB	Suboptimal retrofit, medium implementation rate	Suboptimal retrofit	Around 12 million sqm (eq. to 150,000 dwellings, 3.4% of the total floor area)

In Hungary a study [13] investigated the depth of retrofits and the speed of renovation assumed. For an overview of the scenario description shows the **Table 2**.

The focus was on existing residential and public sector buildings, and emphasised scenarios that support "deep" retrofits, which bring the buildings as close to passive house standards as realistically and economically feasible. The research has demonstrated that up to 85% of Hungarian heating energy use, and the corresponding CO_2 emissions, can be avoided by a consistent and wide-spread deep retrofit programme in the country (**Figure 2**). The investigation has also highlighted the important risk related to less ambitious renovation programmes. As can be see in **Figure 2**, this sub-optimal renovation scenario saves only 40% of final heating energy use, locking 45% of 2010 building heating-related emissions at the end of the programme. This means that reaching ambitious mid-term climate target, such as often quoted 75 – 85% reductions that are needed by 2050, will become extremely difficult, and expensive, to achieve. ЗЄ

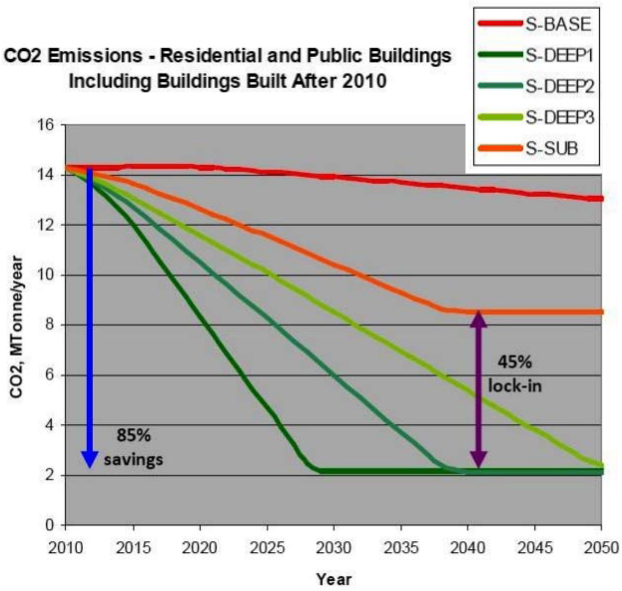

Figure 2.
CO_2 emission reductions of the Hungarian building stock for all scenarios considered in the study. [13]

References

[1] Energy Efficiency Plan 2011 http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm.

[2] Energy Efficiency in Buildings http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm.

[3] Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries. http://ec.europa.eu/energy/efficiency/studies/doc/2009_03_15_esd_efficiency_potentials_final_report.pdf.

[4] Low energy buildings in Europe: Current state of play, definitions and best practice http://ec.europa.eu/energy/efficiency/doc/buildings/info_note.pdf.

[5] European Energy Efficiency Plan http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/271&format=HTML&aged=0&language=en&guiLanguage=en.

[6] Impact Assessment Energy Efficiency Plan 2011 http://ec.europa.eu/energy/efficiency/action_plan/doc/20110308_efficiency_plan_impact_assesment_en.pdf.

[7] Progress report of the Energy Efficiency Action Plan 2006 http://ec.europa.eu/energy/efficiency/action_plan/doc/20110308_efficiency_plan_progress_report.pdf.

[8] European council 4 February 2011 Conclusions http://europa.eu/rapid/pressReleasesAction.do?reference=DOC/11/1&format=HTML&aged=0&language=EN&guiLanguage=en.

[9] A Roadmap for moving to a competitive low carbon economy in 2050 http://ec.europa.eu/clima/documentation/roadmap/docs/com_2011_112_en.pdf.

[10] Action Plan for Energy Efficiency: Realising the potential http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0545:FIN:EN:PDF.

[11] Directive 2002/91/EC of the European Parliament and the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, Brussels, 2003.

[12] Directive 2010/31/EU of the European Parliament and the Council of 19 May 2010 on the energy performance of buildings (recast), Official Journal of the European Communities, Brussels, 2010.

[13] Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary, Central European University, Budapest (on behalf of the European Climate Foundation), 2010.

Labelling and certification of HVAC products

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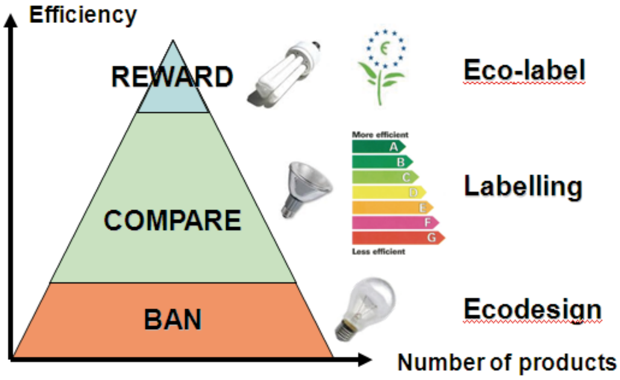

Figure 1. Overview of EU regulations regarding energy efficiency of products.

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.

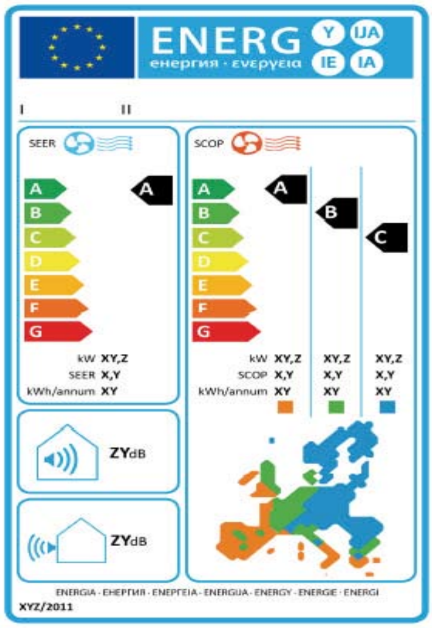

Figure 2. Proposed European Label for residential air conditioners.

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.

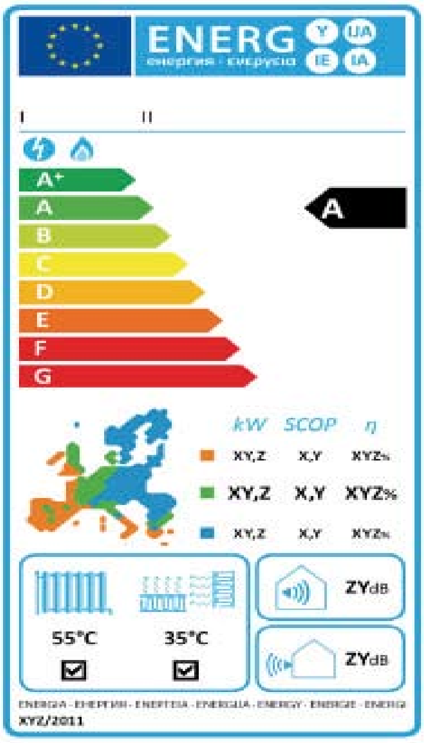

Figure 3. Proposed European Label for water heaters.

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.

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/

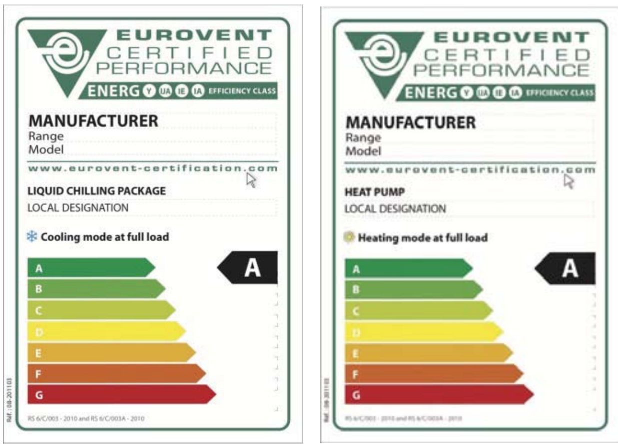

Figure 4. Eurovent Certification Chillers and hydronic heat-pumps labels.

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: $R_{Condensers, Dry coolers} = \frac{Capacity\ SC\ wet}{Fan\ power\ cons}$	Dx Air Coolers: $R_{DXaircoolers} = \frac{Capacity\ SC2\ wet}{Fan\ power\ cons} \times \sqrt{\frac{fin\ spacing}{4.5}}$
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.

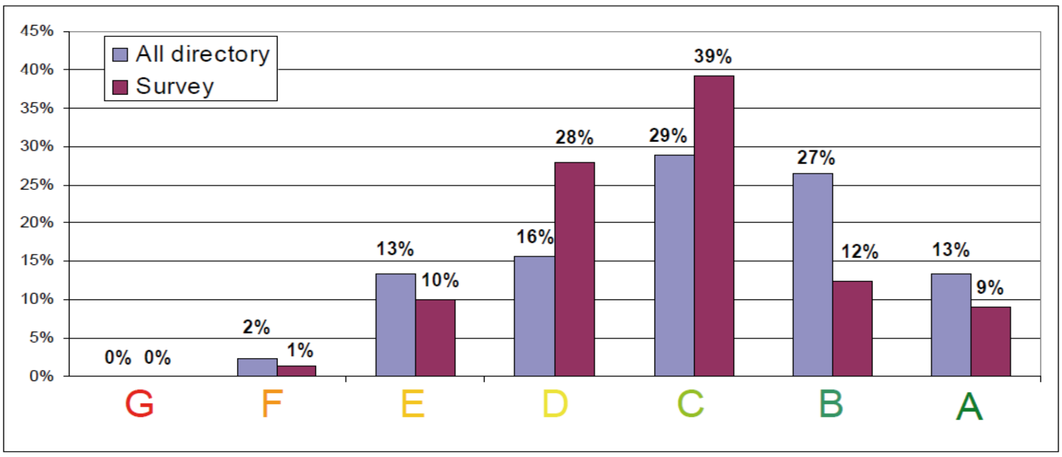

Figure 7. Distribution of Eurovent certified Rooftops units in 2010 according to the energy classes.

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.

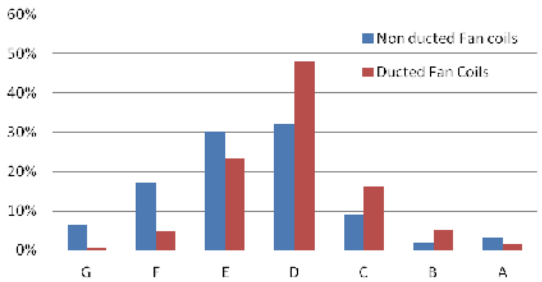

Figure 9. Distribution of Eurovent certified Fan Coil units in 2011 according to the energy classes.

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)

European ventilation standards

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Introduction

European Standards on ventilation are published by the European Committee for Standardization (CEN). Standards are shaped by consensus among enterprises, public authorities, consumers, and trade unions, through a consultation process organised by independent, recognised standardisation bodies at national, European and international level. They are sets of voluntary technical and quality criteria for products, services and production processes, also called technical specification. Standards are voluntary to follow, except if they are referred or used as a part of national legislation. Before a final draft version is adopted as EN standard, it is submitted to 30 CEN Members for a weighted Formal Vote. After its adoption, each of the 30 National Standards Bodies publishes the new EN as an identical national standard and withdraws any national standards that conflict with it. Hence, one EN becomes a national standard in the 30 member countries of CEN.

Standards and technical reports related to IAQ

The ventilation related work in the CEN is coordinated in technical committee CEN TC 156 – Ventilation for buildings, which currently consists of 11 workgroups that cover different interest fields of ventilation. At the time of writing of this article, there were currently 65 European Standards published by the CEN TC 156. The purpose of this article is to filter these 65 articles and extract those, which are directly related to indoor air quality (**Table 1**). Being directly related to indoor air quality means that in some point they are directly addressing measures which can help to improve indoor air quality. The standards deal either residential buildings or non-residential or both. The list of standards in **Table 1** includes standards that mostly deal with functional properties of ventilation systems or equipment. Other standards produced by the CEN TC 156, which do not appear on the list of IAQ related standards, mostly includes standards that deal with mechanical properties and testing of ventilation systems and equipment.

Among the above list of standards, only a few directly address the indoor air quality issues, while others address it indirectly. Only standard EN 15251 and report CEN/TR 14788 are directly dedicated to indoor air quality while the others tackle only some specific IAQ related considerations like air flow rate, requirements on prevention of uncontrolled humidity in systems, etc. List below provides insights into the contents of standards that are the most directly related to IAQ.

CEN/CR 1752:1998. Ventilation for buildings – Design Criteria for the indoor environment

This Technical Report specifies the requirements for, and methods of expressing the quality of the indoor environment for the design, commissioning, operation and control of ventilation and air-conditioning systems. This report does not have a status of a standard but has relevant information on indoor air quality and climate. It covers indoor environments where the major concern is the human occupation, but excludes dwellings. It does not cover buildings where industrial processes or similar operations requiring special conditions are undertaken. The practical procedures, including selection of parameters to be measured during commissioning, control and operation, are also not covered.

EN 15251:2007. Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics

This European Standard specifies the indoor environmental parameters which have an impact on the energy performance of buildings. - The standard specifies how to establish indoor environmental input parameters for

Table 1. Directly indoor air quality related standards.

Standard reference	Title
CR 1752:1998	Ventilation for buildings - Design criteria for the indoor environment
EN 15251: 2007	Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics
EN 13779:2007	Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems
CEN/TR 14788:2006	Ventilation for buildings - Design and dimensioning of residential ventilation systems
EN 12097:2006	Ventilation for Buildings - Ductwork - Requirements for ductwork components to facilitate maintenance of ductwork systems
EN 13053:2006	Ventilation for buildings - Air handling units - Ratings and performance for components and sections
EN 15239:2007	Ventilation for buildings - Energy performance of buildings - Guidelines for inspection of ventilation systems
EN 15240:2007	Ventilation for buildings - Energy performance of buildings - Guidelines for inspection of air conditioning systems
EN 15665:2009	Ventilation for buildings - Determining performance criteria for design of residential ventilation systems
prEN 15780:2008	Ventilation for buildings - Ductwork - Cleanliness of ventilation systems
FprEN 779:2011	Particulate air filters for general ventilation - Determination of the filtration performance

building system design and energy performance calculations. The values of indoor environmental parameters in this standard are based on CR 1752 and other earlier published standards. It specifies methods for long term evaluation of the indoor environment obtained as a result of calculations or measurements. It specifies criteria for measurements which can be used if required to measure compliance by inspection. It identifies parameters to be used by monitoring and displaying the indoor environment in existing buildings. This standard is applicable mainly in non-industrial buildings where the criteria for indoor environment are set by human occupancy and where the production or process does not have a major impact on indoor environment.

EN 13779:2007. Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems

This European Standard applies to the design and implementation of ventilation and room conditioning systems for non-residential buildings subject to human occupancy, excluding applications like industrial processes. It focuses on the definitions of the various parameters that are relevant for such systems. The guidance for design given in this standard and its annexes are mainly applicable to mechanical supply and exhaust ventilation systems, and the mechanical part of hybrid ventilation systems. Applications for residential ventilation are not dealt with in this standard. Performance of ventilation systems in residential buildings are dealt with in CEN/TR 14788. The classification uses different categories. For some values, examples are given and, for requirements, typical ranges with default values are presented. The default values given in this standard are not normative as such, and should be used where no other values are specified. Classification should always be appropriate to the type of building and its intended use, and the basis of the classification should be explained if the examples given in the standard are not to be used.

CEN/TR 14788:2006. Ventilation for buildings – Design and dimensioning of residential ventilation systems

This Technical Report specifies recommendations for the performance and design of ventilation systems which serve single family, multi-family and apartment type dwellings during both summer and winter. It is of particular interest to architects, designers, builders and those involved with implementing national, regional and local regulations and standards. Four basic ventilation strategies are covered: natural ventilation; fan assisted supply air ventilation; fan assisted exhaust air ventilation; fan assisted balanced air ventilation. Combinations of these systems are not excluded and a ventilation system may serve only one dwelling (individual system) or more than one dwelling (central system). The ventilation aspects of combined systems (ventilation with heating and/or cooling) are covered. The ventilation of garages, common spaces, roof voids, sub-floor voids, wall cavities and other spaces in the structure, under, over or around the living space are not covered. 3E

Inspection of air-conditioning systems - Results of the IEE HARMONAC project

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Introduction

The energy inspection of Air-conditioning (AC) systems has been introduced in 2002 by Article 9 of EPBD (article 15 of the EPBD recast). The practical implementation of AC inspections in most European countries has nevertheless been very slow, due to a number of reasons, clearly identified by the IEE AUDITAC project (Jan. 2005 – Dec. 2006), namely that

- there was little publicly available information on how AC systems consumed energy in practice,
- there were likely to be insufficient qualified Inspectors to be able to examine all AC systems that would fall within the scope of the EPBD,
- that the available international standards on AC inspection were unlikely to be adequate for a cost-effective inspection process (i.e., one that would yield significant energy benefits with respect to the time and money invested in the inspection).

The follow-up project HARMONAC - which ran from Sept. 2007 to Aug. 2010, involving eight EU Member States (Austria, Belgium, France, Greece, Italy, Portugal, Slovenia and UK) - was therefore funded with the following aims:

- to **understand more clearly how air-conditioning systems consume energy**. This was achieved through measurements and investigations of case studies of working AC systems from across Europe – a vital first step for assessing the real energy saving opportunities available from such systems;
- to **assess the opportunities for energy savings** that the current standards for Inspection of Air-conditioning systems would identify in practice, and compare these to the Case Study Energy Conservation Opportunities (ECOs) found. These ECOs are based on, and add to, those initially proposed in AUDITAC;
- to **propose**, as a result of the project, **a series of AC inspection procedures** that provide the project partners views of AC Inspection;
- to provide new **field-tested materials and tools** to aid Inspectors in the Inspection process;
- to ensure the **information is presented to the main actors** in the field concerned with regulating this area; this will help to produce

regulation and legislation in this area that maximises the energy and cost benefits to the system owners, and hence to Europe, from the time and money invested in these inspections.

The project deliverables (newsletters, training material, software tools, etc.) may be found at www.HARMONAC.info. The results of 42 detailed case studies (CS), involving long-term monitoring of entire buildings and AC systems, and nearly 400 more focused field trials (FT), aimed at testing specific aspects of the Inspection procedure, are accessible at http://paginas.fe.up.pt/~HARMONAC/site/.

Energy conservation opportunities

The main purpose of the inspection procedure is to identify a suitable set of ECOs that should lead to significant energy savings, within specified operational and financial constraints.

The HARMONAC partners have identified 141 ECOs, grouped into the following categories and subcategories (**table 1**):

- "Envelope and Loads", aimed at reducing the building cooling load;
- "Plant", involving more or less radical intervention on the AC system (to be carefully assessed in technical and economical terms);
- "Operation & Management" (the costs of such ECOs are generally limited if not negligible: application is therefore normally recommended, provided their technical feasibility is assessed).

More than 3000 ECOs were detected in the 42 case studies and 400 field trials undertaken during

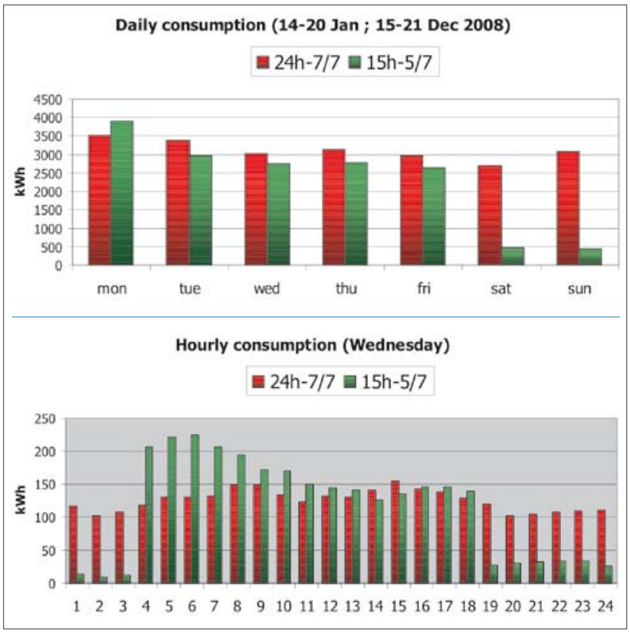


Figure 1. *Daily and hourly electric energy demand of VRF system with different schedules*

Table 1. Structure of the Energy Conservation Opportunities (ECOs) list

Category	No. of ECOs	ECO category description
		E. ENVELOPE AND LOADS
E1	7	Solar gain reduction / Daylight control improvement
E2	8	Ventilation / Air movement / Air leakage improvement
E3	9	Envelope insulation
E4	10	Other actions aimed at load reduction
		P. PLANT
P1	8	BEMS and controls / Miscellaneous
P2	14	Cooling equipment / Free cooling
P3	15	Air handling / Heat recovery / Air distribution
P4	5	Water handling / Water distribution
P5	5	Terminal units
P6	2	System replacement (in specific limited zones)
		O. OPERATION AND MAINTENANCE (O&M)
O1	7	Facility management
O2	9	General HVAC system
O3	20	Cooling equipment
O4	22	Fluid (air and water) handling and distribution

the project. The 54 best documented ECOs are described according to the following format:
- "existing subsystems" on which the ECO may apply, to recognize opportunities on a site visit.
- "technical data to request to owner/manager or to find directly (manufacturer data)" before going on site.
- "technical observation to be made on site", such as data visible on nameplate of system parts to supplement manufacturer or engineering documents.
- "monitoring of existing situations" providing the required measurement to achieve a quantification of the ECO.
- "criterion for ECO applicability" presenting the options of the considered ECO.
- "recommendation for realisation of ECO" gives recommendation to realize the installation/ modification of the considered subsystem.
- "additional support" indicating methods, formulas, definitions to help the Inspector to make use of monitoring results.

An example of ECOs evaluation is shown in **figure 1.** The system consumption was measured during two weeks with similar climate but with different operation schedules: without (red) and with (green) night time and weekend control setback. In the specific case, The measured energy savings were 9% on working days and 85% on weekends, yielding a 26.7% weekly saving.

The ranges of savings found for each Category of ECO to date are significant. For example, the annual electricity consumption for typical UK office buildings is around 31 kWh/m^2 for cooling and 226 kWh/m^2 in total:
- Envelope ECOs (including small power equipment). Usual saving ranges appear to be 2 – 9 kWh/m^2 electricity (6 – 29% savings in cooling, and 1 – 4% total).
- Plant ECOs. Most common saving range appears to be 1 – 8 kWh/m^2 electricity (3 – 26% savings in cooling, and 0.5 – 3.5% total).
- Operational ECOs. Most common saving range appears to be 1 – 20 kWh/m^2 electricity (3 – 65% savings in cooling, and 0.5 - 9% total)
- Overall average potential energy savings identified per Case Study system are in the range of 25 – 50% of AC system use.

In European terms, AC systems accounted for 0.75% of the total electricity use in the EU-27 in 2007 (neglecting ventilation systems and circulators which account for a further 3.34% and 1.81% each). If the average 25 – 50% potential energy savings identified by HARMONAC were achieved in AC systems throughout Europe then a 0.19 – 0.38% reduction in the EU MS electricity use would arise. This is equivalent to a reduction of between 5.45 and 10.91 TWh in the EU-27 electricity consumption of 2,870 TWh in 2007. If we were to introduce the savings achievable in ventilation systems as well then the potential savings become more than 1% of the EU annual electricity consumption.

HARMONAC AC Inspection methodology

HARMONAC has used CEN Standard EN15240 "Guidelines for inspection of air-conditioning systems" as the basis for the Methodology it has assembled and tested during the three years of the project. The HARMONAC Methodology breaks the CEN Standard into a number of discrete Inspection items in order to assess the time taken to undertake each item and the associated ECOs.

The HARMONAC Methodology splits the Inspection into two elements – **pre-inspection and inspection**. Pre-inspection items are those which it is considered reasonable for the building owner to know and have available for an Inspector to assess prior to arriving on site, and Inspection items are those that can only be properly assessed by a site visit.

Three versions of "Methodology" have been made available at the end of the project:
- The HARMONAC **FULL** version. The intention is to make available to European Member States all the information derived about the AC Inspection elements from the HARMONAC Project. It contains a number of Inspection items that may not lead directly to energy savings but will provide a greater insight into the interaction of the building and the AC system.
- The HARMONAC **PREFERRED** version. This contains all those Inspection elements that the HARMONAC Partners think in practice might lead to worthwhile energy savings.
- The HARMONAC **SHORT** version. This contains the bare minimum information needed to be

obtained during an Inspection to identify the most likely sources of energy inefficiency in an AC System. It is designed to identify only those ECOs that provide the largest savings and which are the most frequently occurring. It is intended that this version should act as a guide to the minimum set of Inspection items that should be required by Member States.

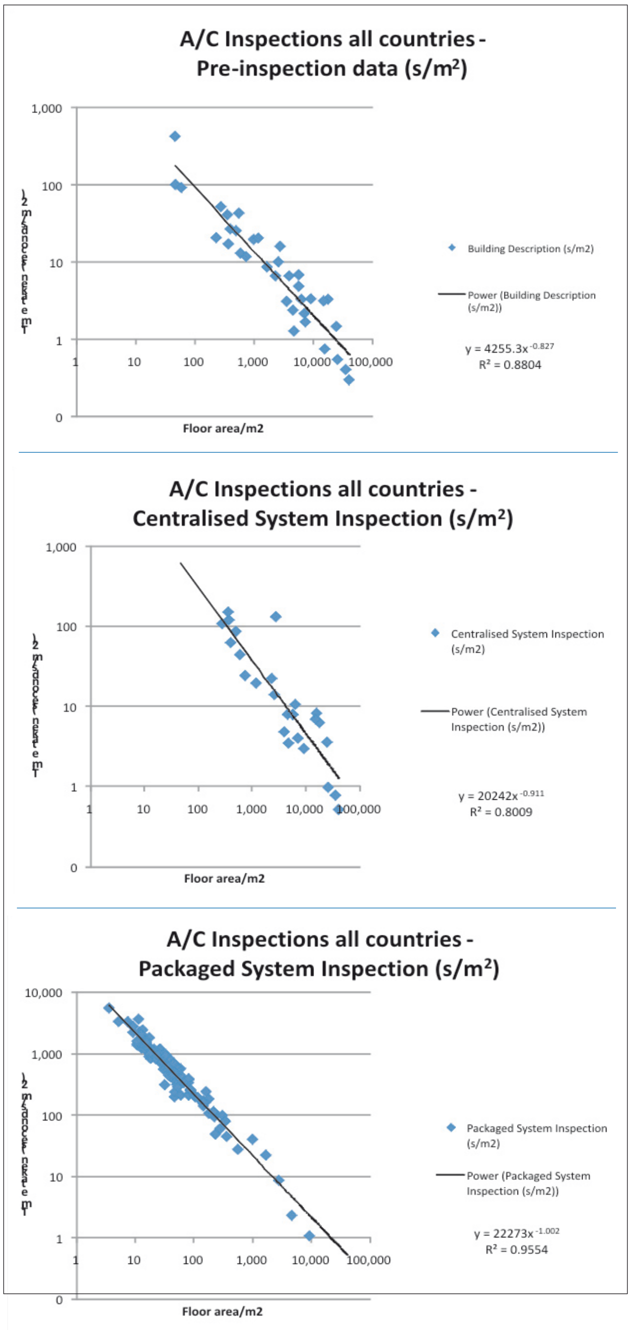


Figure 2. Correlation between time taken (in seconds/square meter) for the inspection and floor area. The two graphs on the left / centre refer to centralised system pre-inspection (data gathering) and site inspection; the graph on the right refers to the entire packaged system inspection

The main elements of the HARMONAC Inspection Methodologies are:

- **Data collection** about the actual building, the installed HVAC system, its current and designed use, and building occupancy. This includes analysis of data to help identify possible areas of concern or just to reassure the Inspector that the system operation is normal and reasonable.
- **Physical inspection – site visit**: Determination of the existence or otherwise of faults or possible improvements to the AC system within the following suggested time periods (determined from HARMONAC field trials):
- Potentially **short tests** of functional performances but without, or with very limited, additional instrumentation (may be just a few checks in order to verify that the main equipment is in "normal" use, that the control system is "normally" active, and that system air flows and temperatures being achieved are those expected).
- **Analysis and reporting:** The final report should summarise all the main findings from the Inspection and be clear as to the ECOs identified to minimise the obstacles to their implementation.

The project showed that there is a good correlation between floor area and time taken to complete an inspection **(figure 2)**. An inspection will take from around **half a day** for a small packaged system to around **three days** on-site for the largest systems for visual verifications, analysis of as-built records, system manuals, possible complaints and operating costs, and report writing.

HARMONAC case studies and field trials

The purpose of the 42 long-term case studies was to provide underpinning 'real-life' data to assist in identifying and quantifying ECOs and to provide boundary parameters for the modelling tools produced in HARMONAC. Typically, the case studies provided measured values of electrical energy consumption of chillers, pumps, fans, humidifiers, etc separately at time intervals of between 5 to 30 minutes, over a period of more than one year where possible.

The almost 400 field trials of the HARMONAC Methodologies have been undertaken to provide understanding of which inspection items identify

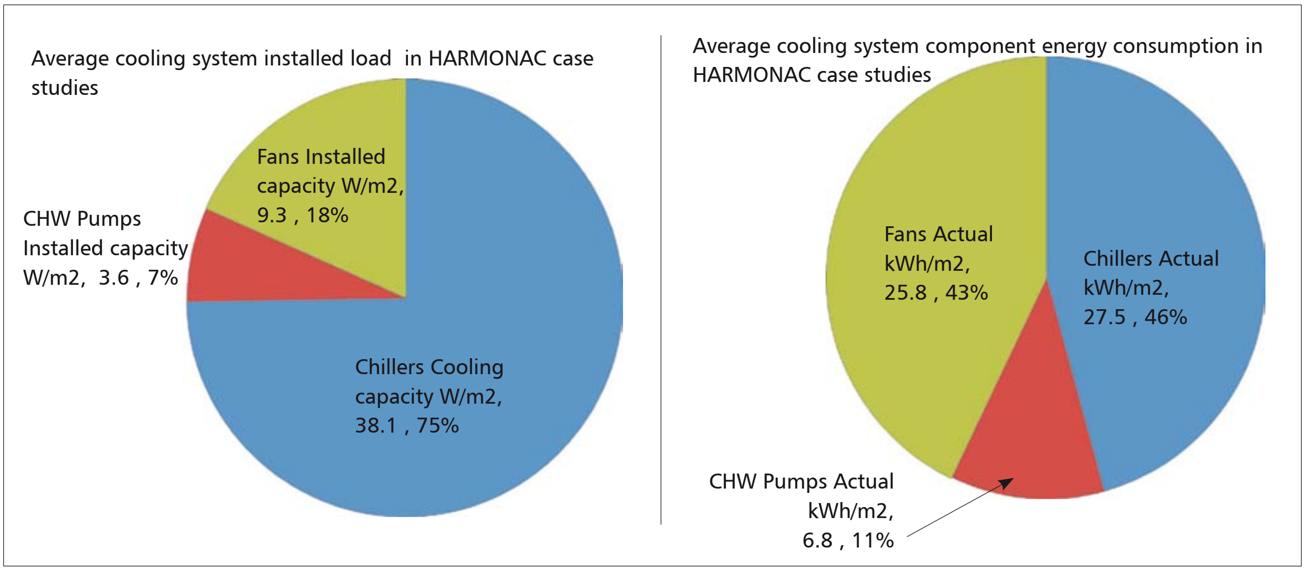


Figure 3. *Average component specific installed power and average system specific energy consumption among the HARMONAC case studies*

ECOs in practice, to understand the time taken for each Inspection item, to inform the development of the Inspection Methodologies so that they are based on practical implementation experience, and to explore use of HARMONAC tools and methodologies in practice and to refine their use. For any Case Study and Field Trial a complete description of the building and system was provided, including: construction type, occupation schedule, services, etc.

The HARMONAC database was made with the purpose to allow all public to have access to the main outcomes of the case studies and field trials. The large majority of the case studies (more than 90%) have centralized HVAC systems, while the majority (67%) of the field trials have packaged systems, for which a quick a simplified inspection is applicable.

The two pie charts of **figure 3** show how the Cooling services components break down in terms of installed loads and actual annual consumptions: while the Chillers comprise 75% of the installed capacity, they consume just 46% of the cooling system energy use. The next highest consumer is the Fans with 43% of the energy consumption from 18% of the installed load, with the final major consumer being the CHW pumps with 11% of the annual cooling system electrical energy consumption from 7% of the installed capacity.

Software tools

Besides a more accurate estimation of the energy flows in the building, simulation tools allow the user to explore innovative solutions and potential improvements of the energy performance of the inspected system. This allows the inspection to be more cost-effective.

The following SW tools to assist the Inspectors have been developed by HARMONAC:

- **AC Cost** is an Excel-based quick tool for looking at economics of potential system-related energy saving options.
- **Bill Analyzer** is dedicated to a preliminary analysis of the recorded data (comparison between actual and reference consumptions, thermal and electrical signatures, degree-days data normalization…).
- **CAT** is a building envelope energy demand tool suitable for first estimation of options for reducing building energy demand through envelope changes.
- **Simbench** The simulation-based benchmarking consists in a comparative evaluation of the building performance realized by means of the developed building energy simulation (BES) model.
- **SimAudit** is a model that requires a calibration of the energy model to make it correspond to the reality of the investigated building. The consumption records can be used to adjust some of the parameters of the simulation models.

- **System Performance Calculator Workbook** is an onsite Inspection and Maintenance Tool allowing quick estimation of the actual performance of single room AC systems from simple measurements

Training material

To spread the findings and outputs of the HARMONAC project, a wide range of training and dissemination materials has been developed. The training package is intended to assist those who will be training future AC system inspectors and consists of the following PowerPoint presentations:

- **Purpose of training package**
- **Legal background:** EPBD, EN 15239 / EN 15240 standards.
- **Air-conditioning systems basics:** design data, thermodynamic processes, AC components and systems.
- **HARMONAC Inspection procedures:** most important part of the teaching package, presents the three HARMONAC inspection procedures.
- **On-site data collection and analysis tools:** equipment to be used for system monitoring and available software to simulate the operation of the AC system
- **Inspection report and recommendations**
- **Examples** of use of inspection procedures on real systems.

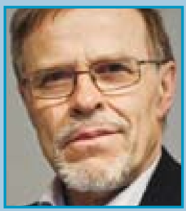
Conclusions

HARMONAC aimed at establishig how effective the current AC Inspection process is likely to be at achieving substantial energy savings in practice. To achieve this aim, HARMONAC has dissected the AC System Inspection process, undertaken case studies and field trials investigating the use of energy in AC systems in practice, produced modelling tools for AC systems and buildings, and presented its findings to many of the main actors in the area.

From these studies and its other activities, the following main conclusions have been drawn:

- The opportunities for saving energy in AC systems appear substantial and occur regularly across all system types in all areas of Europe.
- Small AC systems appear to offer some of the largest average energy savings with potential average savings of around 60% being identified in the 270 UK field trials of the Inspection Methodology.
- Owner/operators of AC systems are generally not taking energy efficiency seriously. Anecdotally the majority are either simply having compliance Inspections undertaken or are not yet to have an Inspection at all. They appear to see little benefit to them of investing time and effort into energy efficiency and the penalties for non-compliance are generally either non-existent or not persuasive enough to encourage more interest.
- Control ECOs are amongst the most frequently occurring ECOs in the case studies, offering some of the largest savings for little or no investment. However, many of the control ECOs will not be identifiable through the current Inspection process as they occur over time and need detailed metered data to identify.
- Data that relates directly to the system being investigated appears to be the main catalyst in motivating owners/operators to invest time and money into rectifying a situation. General recommendations are too vague and are normally ignored. This is of concern to the EPBD which requires Inspection reports to provide recommendations for improvement. It is very likely that most of these recommendations will be generic in nature – probably using HARMONAC and similar material as a basis.
- An Inspection will generally take between 0.5 to 3 days provided the basic data is available on the building and AC system to be inspected. If this data is not available then for larger systems the Inspection can take months to complete in elapsed time if all the data requested is to be included in the report. For many first time inspections this latter situation is the most likely scenario.
- The European Standards covering AC Inspections appear too cumbersome and time consuming; ask for detail and information that are generally difficult or impossible to obtain for the large majority of systems; cannot address some of the major opportunities for reducing energy use in AC systems.

Inspections of air-conditioning and ventilation systems – status, standards, future



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Existing standards

In the first set of EPBD standards to support the implementation of the EPBD, inspection standards were drawn up separately for

- air-conditioning systems (Article 9 of the first EPBD) – EN 15240
- ventilation systems (only indirectly addressed in EPBD) – EN 15239
- boilers and heating systems (Article 8 of the first EPBD) – EN 15378

This separation was originally defined by the first EPBD Mandate, and the work proceeded in parallel for the first two work items in CEN/TC 156, while the work for boilers and heating systems proceeded separately in CEN/TC 228. Already during the preparations suggestions were made in order to merge at least standards for air-conditioning and ventilation inspections, but finally also these two were kept separate, more or less following the same structure.

EN 15240, for inspections of air-conditioning systems, has been reported to be one of the most widely adopted standards of the EPBD package. However, the most recent feedback indicates that adoption has been either "on paper only" or limited to only parts of the system, mainly to the refrigeration plant. Furthermore, the level of adoption varies a lot from country to country, due to different interpretations of the EPBD Articles in different countries. Even basic issues like "what is included in the air-conditioning system?" are understood in many different ways. The existence of a parallel standard for "inspection of ventilation systems" adds to the confusion, because these systems are very often integrated together. Inspection of "ventilation only" systems has been mandatory in Sweden for nearly 20 years, but in the rest of Europe these are voluntary.

Future development

Inspections of air-conditioning and ventilation systems have been discussed in different REHVA events since 2005. Workshops have been arranged at CLIMA 2005, 2007 and 2010 (reports available from REHVA Bookstore). Ideas for a REHVA Guidebook within this field have been, and still are, under development. Needs for a more detailed guidance have been identified, because of the limited possibilities to cover all types of buildings and all types of systems for all Europe in one or two standards. On the other hand, the variety of buildings and systems – new and existing ones - makes it very challenging to cover all applications in a handbook, either.

Recently, arguments like "AC inspections useless and not cost effective" and "none of the MS have started AC inspections" have been taken up in discussions. How much this is due to the quality of the standards, and how much to the lack of clear practical guidance, is not yet known.

The inspection standards have also been analysed in CENSE project, see below. More information about the existing inspection standards can be found from CENSE Information Papers IP 109, 115 and 116, see www.iee-cense.eu

CENSE project has given a set of recommendations

This issue was taken up especially during the REHVA General Assembly (Amsterdam, 14-16 May 2009). A workshop was organised there by the HARMONAC project, and the results of this workshop was also discussed at the REHVA Technology and Research Committee (TRC) and the CENSE Workshop during those days.

There is a need to build up the "big picture" of inspections, including also links to the other elements of the EPBD (EP requirements and calculations, Certificates), and including clear definitions of "air-conditioning systems". The basic definition should include a list of functions, allowing a few different interpretations of the scope but strictly within a common framework. Only when the picture is complete and clear, it would be possible to:

- discuss the topic without misunderstanding
- make any judgement about appropriateness of inspection times, extents and frequencies
- judge the impact of inspections
- leave the door open for developments, in a controlled way
- avoid to regard inspections as an isolated issue, and enable to see inspections as an integral part of the whole "EP package", closely linked to certificates and also to EP calculations.

The recast EPBD gives a modified definition of "air-conditioning system", which still could be interpreted in many different ways. The next revision (and possible merger) of EN 15240 and EN 15239, and supporting more detailed guidance for e.g. different building types, new and existing, as recommended by the discussions in REHVA GA 2009, should also clarify this definition further. A modular approach, i.e. to develop the structure of EN 15240 and any REHVA document to deal with each inspection item separately where possible, but within a framework which will in the end cover all technical building systems, allowing also simple inclusion of further inspection items where heating and ventilation aspects are included whenever relevant. This approach could allow an answer to the revealed "tendency to escape inspections" due to a somewhat ambiguous definition of "air-conditioning system".

CLIMA 2010 Workshop 14 in Antalya asked for REHVA actions

There is an idea to combine air-conditioning and ventilation into one system inspection in cases where air-conditioning is separated. Therefore one standard covering both ventilation and AC is recommended. Even though heating is in many cases integrated into the same system with cooling and/or ventilation (and these integrations will probably increase a lot in the future), it was still generally regarded as a separate issue.

All system inspections must be based on cost-effectiveness (and not allow the inspection expenses to exceed the potential possible reduction of energy usage). Simple indicators would be useful to give a good first impression about the status of the system and need for quick actions – a visual check of the quality of air filters is a good example of such indicators. Sometimes a quick look of the documentation is enough to give the first impression.

The final target should be to make external inspections unnecessary – in other words to include all elements of inspections in the regular maintenance and monitoring of the systems. However, for the near future this target requires some work to achieve and therefore inspections will be needed in a vast majority of systems – especially in existing buildings, but the inspections should include proper advice to put the users and owners on the right track towards the final target. The recast EPBD actually recognises tools to accelerate this kind of development.

Finally, the Workshop agreed to establish a REHVA Task Force to work on a Guidebook which will put together the findings of HARMONAC, and other existing knowledge in the subject, into a practicable guideline.

HARMONAC project collected practical experience

Extract from the overall conclusions: "To ensure the information is presented to the main actors in the field concerned with regulating and implementing this activity. The HARMONAC findings have already helped in amending those aspects of the Recast Energy Performance of Buildings Directive covering air-conditioning inspection. Future work already planned includes a REHVA Guidebook covering the practical implementation of AC system inspections which should be complete for 2012. This will have input from members of the CEN Standards committee responsible for updating the AC Inspection Standard for 2014. The overall intention is that the findings from HARMONAC help to produce guidance, regulation and legislation in this area that optimises the energy and cost benefits to the system owners, and hence to Europe, from the time and money invested in these inspections."

So, the need for a Guidebook has been taken into account in the preparation of the final report of HARMONAC, which has very recently reached its final stage. Reports are now available from: http://www.cf.ac.uk/archi/harmonac/project_outputs.html

More holistic view needed

As shown above, inspections of air-conditioning systems have been subject to a number of serious discussions. The whole issue has also been questioned in many ways. Whatever the reasons for this questioning are, these must be seriously discussed. Obviously practical guidance is needed, as well as also a different way of thinking. Instead of looking at the AC inspections only (or even just at the refrigeration plant), the whole issue has to be seen in broader contexts - within the whole EPBD, within the whole building and its all technical systems, taking into account the whole lifetime of the building, etc…

The outcome from HARMONAC (quotation above) gives an interesting approach for the future: make next a practical guidebook for AC (and ventilation when relevant) system, and then revise the CEN standards. How this approach will work, taking into account the increased challenges of the recast EPBD will be seen probably very soon. Some of the "big questions" should be discussed further in all possible connections, preferably well before these come up in CEN "as a surprise":

- will the inspections really give good and reliable tools to owners and users to improve (or even rebuild) their systems in a cost-effective way
- how to make the inspection system really rewarding to those who maintain their systems properly? Even though these may today make a small minority of European buildings within the scope of the relevant EPBD Articles, extern inspection is just an unnecessary additional burden to this minority. And for the rest – today's vast majority - the CEN standards should provide tools to the long way towards the final target: no external inspections.

Particle filtration is essential for healthy buildings

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Health effects of the indoor air pollutants

In the late 20th century, the understanding of health impact of air pollution has been improved. Local and international institutions have released recent science reviews and recommendations for creating healthy indoor environment in building we live study and work in.

It is estimated, according to World Health Organisation, more than **2 million people are dying prematurely from the negative health effects of air pollution, worldwide**.

In European Union, according to Clean Air for Europe CAFE project, **air pollution reduces life expectancy by nine months and could cost the EURO 80 billion per year and causes premature death of 310 000 people every year**.

In China, Resource for the Future, an international NGO, evaluated air pollution kills every year 350 000 persons who live in Chinese cities.

These figures could be even higher today since developing countries and fast growing economies are known to have serious air quality problems, related to lack of control of to traffic, domestic heating and industry emissions.

The report "Air Quality in Europe 2011" published November 9, 2011 shows that levels of SO_X, NO_X heavy metals and coarse particles have decreased since the implementation of Air regulation, but PM 10 concentrations (particle matter above 10 micrometres (µm) in diameter) and ozone levels remain alarming. As a result, **20 percent of the EU urban population are living in areas where the 24-hour limit value for PM 10 concentrations exceeded in 2009. However, 80-90 percent of the EU urban population is also exposed to levels of PM 10 that exceeded the more stringent air quality guidelines of the World Health Organization (WHO)**.

Epidemiological studies have recently found the correlation between chronic exposure to particle matter and cardiovascular disease. In the United States, thanks to the Clean Air Act, PM 2.5 concentrations have been monitored for more than ten years, allowing a better understanding of their chronic health effects. Results show that ultrafine down to nano-size particles are the most harmful fraction, as they are small enough to penetrate deeply into the lungs, enter the walls of blood vessels and directly harm our organs, such as the heart, brain, liver or endocrine system.

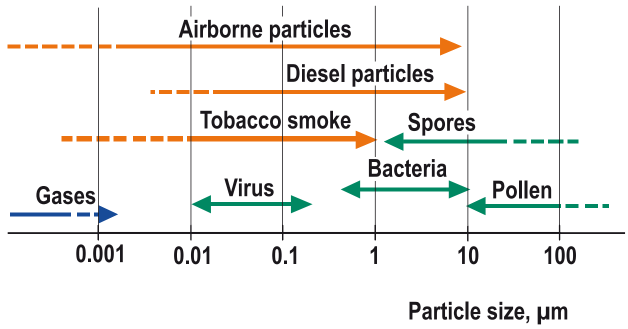
Therefore, air pollution is a silent killer. It will kill people, without revealing its face, after years and years of chronic exposure, or because pollution has sudden effects on people who tend to be vulnerable to it.

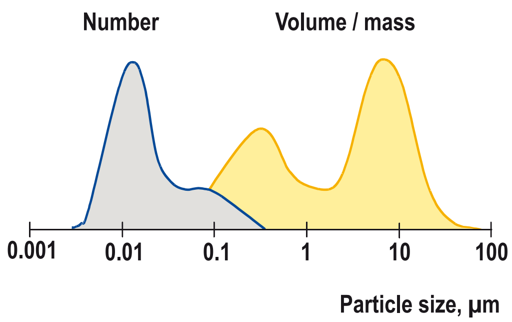
The most paradoxical aspect of air quality is that outdoor air pollutants infiltrate into or are produced in our buildings, where they can accumulate and combine or

> We spend close to 90 percent of our life indoors, and could expect living in safe indoor environments. Unfortunately air in the indoor environment can be up to 50 times more polluted that outdoor air. Fortunately technologies and regulations to reduce people's exposure to air pollutants are converging to support the creation of healthy indoor environments.

react with other air pollutants and particles generated by building materials, the burning of wood in stoves and fireplaces, DIY products, painting and cleaning products, cooking, pets, candles, incense sticks, air fresheners and other sources.

In 2008, we learned from the European Commission EnVIE report that more than 50 percent of the diseases caused by poor indoor air quality (mainly cardiovascular and chronic obstructive pulmonary diseases, COPD) were due to the health impact of outdoor air combustion particles infiltrating the indoor environment cumulating effects of in-house heating and cooking devices.





Typical particle diameters of some pollutants in the air and distribution of particles by number and mass by particles diameter.

Source emission control strategies associated to building ventilation systems are essential for renewing indoor air at rates that keep indoor contaminants levels low. **Air cleaning technologies and air filtration are highly needed to prevent outdoor combustion particles from entering buildings**.

In the context of energy sources shortage and cost increase as well as necessary climate change mitigation measure through energy efficiency policies design, ventilation systems are expected to become more energy-efficient and the energy needed to filter air has to be reduced to a minimum. Buildings are being increasingly insulated and it has been known for a long time that such "tightly" insulated indoor environments have a detrimental effect on health and productivity, unless they are balanced by appropriate ventilation.

Particles aerosol entering into a filter are removed from the air flow by different mechanism by filter media. Good removal efficiency provides good material and thorough testing

Air Filtration technology is essential for sustainable buildings

Solutions for effective ventilation and air filtration exist and have proved to be energy-efficient. The existing regional EN13779 and EN 779 European or ASHRAE 62.1 and ASHRAE 52.2 American standards and ongoing developments of new ISO Standards for indoor air quality, air filtration and building ventilation systems, should be integrated in all related regulatory frameworks for reducing energy consumption in order to design energy-efficient ventilation systems and buildings that could also fulfil the essential requirement for indoor air quality.

The development of Green building council international chapters provides as well the basis for a common understanding and platform for promotion of best practices and HVAC industry standards worldwide.

Using the correct filters with the required particulate efficiency and lowest possible pressure drop will reduce the energy consumption of HVAC systems sharply while maintaining a healthy indoor climate for occupants and enhancing the building performance in terms of sustainability. Experience shows that selection of the right filters with the right pressure drop can have a significant impact on energy consumption and carbon footprint of buildings.

Energy savings with proper filter selection

A Norwegian case building

GK AS Company, the leading indoor climate contractor in Scandinavia, installed 90,000 Camfil Farr Hi-Flo XLT filters in the air handling units (AHUs) of its customers in Norway to reduce their energy consumption. GK estimates that the filters will save customers at least 10 GWh of electricity per year. "10 GWh is actually a conservative estimate of the total projected annual savings when all the filters are installed," says Peder Midtstøl, purchasing manager for the GK Concern AS, which has a share of 20–30 percent of the professional construction market in Norway. Camfil Farr's Hi-Flo XL is a new generation of "green" low-energy filters that cuts the overall operating costs for ventilation systems and improves indoor air quality (IAQ).

Camfil Farr Hi-Flo XLT F7 has large surface area of filter media. It reduces the pressure drop and the energy use of fans. In Norway GK company has installed 90 000 units of these filters with estimated annual savings of 10 GWh of electricity.

Battling urban pollution

For better IAQ in Norway's urban areas, GK is also taking the next step in filtration by recommending customers to install Camfil Farr's City-Flo XL for particulate and molecular filtration. This filter is specially designed to battle urban pollution and has a proven broad spectrum capability against concentrations of most indoor and outdoor pollutants.

"As an example, I can mention that we're now in the process of changing to City-Flo XL at a fire station in central Bergen," says Midtstøl. "IAQ has improved considerably since we started replacing existing filters with City-Flo XL," he ends.

Due to the phenomenon called temperature inversion, Bergen (photo above) suffers periodic declines in air quality during cold winter spells and city officials are stepping up efforts to keep risk groups from being exposed to outdoor air pollution. This has also led to initiatives by facility owners and contractors to improve IAQ, which is directly impacted by air pollutants entering buildings.

A case from the UK

Land Securities, the largest commercial property management company in the UK, now owns and manages more than 29 million ft² of commercial property, from London offices and high street shops to major shopping centers and out-of-town retail parks. Land Securities saves annually £250 000 and 650 tons of CO_2 by installing Low Energy Air Filters.

Camfil were asked by the Engineering Director of Land Securities to evaluate the effect of installing Low Energy Air Filters into the air conditioning system of buildings in the London Portfolio.

The project was managed locally by Portfolio manager for Land Securities, who identified a suitable site at New Street Square in London.

In July 2009 Camfil engineering staff working together with Inviron FM on site at New Street Square, completed a detailed evaluation of the air filters within one of the air conditioning systems.

Change of Camfil filters in an air handling unit is easy.

Camfil Farr, a Swedish-based company with global operations, believes that **clean air is a human right**. Camfil Farr has been designing energy-efficient filtration solutions of high quality since 1963 to meet the need for sustainable ventilation solutions that create the right balance between healthy indoor air and energy savings. More at www.camfilfarr.com.

This evaluation involved collecting performance details on the standard air filters in use at the time, and comparing them to an alternative selection of Camfil Low Energy Air Filters.

This pre study identified the following savings:

- Replacement air filters – 15% reduction
- Labor to change filters – 64% reduction
- Energy to move air through the filters – 16% reduction in electricity use
- Tones of CO_2 – 16% reduction in emission

These savings were available by fitting Camfil Low Energy Air Filters into the existing filter holding frames as part of the normal maintenance regime. No further investment was required and the new filters were fitted in September 2009.

Prior to this implementation, the air filters were routinely replaced as part of an established Planned Preventative Maintenance (PPM) regime. During this trial project Camfil demonstrated that using Low Energy Air Filters not only reduced the energy consumed, but also doubled the service life of the filters. Consequently the annual air filter cost reduced, together with a reduction in labor and waste cost.

Crucially, because the Low Energy Air Filters are better engineered, the air being supplied into the buildings is now much cleaner (four fold decrease in the amount of particulate in the air).

This project has now been rolled out with estimated savings in the London portfolio alone of £250k and 650 tons of CO_2 every year. 3E

Building Integrated System Design for Sustainable Heating and Cooling

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WaterTraditional water based systems operating at optimal temperature levels represent a low tech but easy and accessible potential for energy optimisation and integration of renewable energy in the construction sector.

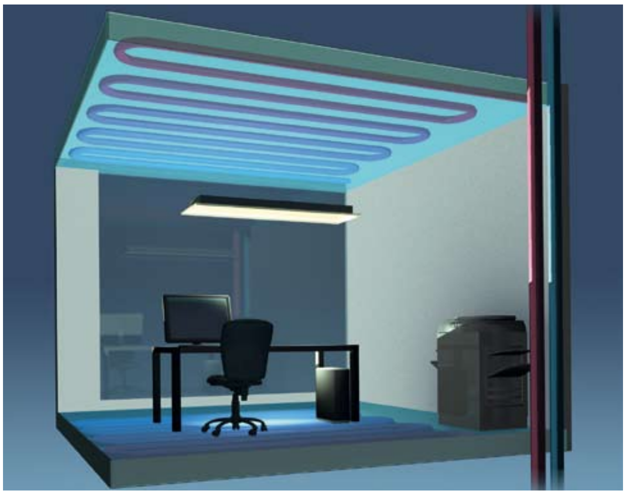
Good Indoor Environment with Low Energy Use Required

The requirements to modern buildings are numerous. Energy consumption must be minimised and the necessary building services must be provided in the most sustainable way in order to ensure adequate indoor climate and healthy conditions for the users. Improved energy efficiency is among the fastest and most cost efficient ways of lowering energy consumption but is often not offered the same attention as new and more exotic technologies.

Several tendencies indicate that the cooling needs in buildings are increasing due to changed indoor comfort requirements, more extreme weather types and new building codes with stricter requirements for the tightness of building envelopes. A promising strategy for sustainable cooling is water based solutions utilising large radiant surfaces at relatively high temperatures, coupled with free cooling sources. By using large surfaces, both heating and cooling can be obtained at temperatures close to ambient, which offer optimal operating conditions for integration of renewable energy and free cooling. In buildings where occupancy pattern yields large cooling loads during day time, embedded water based systems can in addition yield substantial peak load reduction and consequent plant size reduction (Thermo active construction/building).

Sustainable Heating and Cooling

The building sector account for approximately 40% of the total energy consumption and the majority of



Thermo active constructions works by activating the building's thermal mass with embedded piping. This gives an optimal indoor climate while energy consumption for heating and cooling is minimized. The TAB system is a combined heating and cooling system with pipes embedded in the structural concrete slabs or walls of multi storey buildings, typically applied for buildings where occupancy pattern yields large cooling loads during day time. As the system is often operated asynchronously to the thermal loads of the building, parts of the loads can be shifted from day time to night time, resulting in substantial peak load plant size reduction.

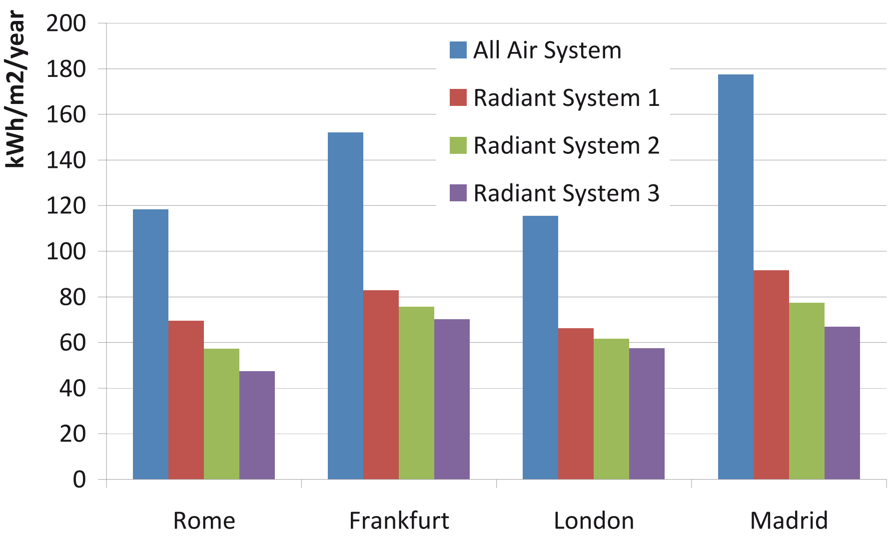
this energy is used to maintain adequate indoor climate conditions by heating, cooling and ventilation. It is estimated that about a third of this energy consumption can be eliminated by using known technologies with a very short pay back time. There exist thus a big savings potential that can be achieved by an integrated optimisation of the buildings architecture, thermal envelope and the technical HVAC systems.

A sustainable strategy for both heating and cooling is water based solutions utilising large radiant surfaces applying high temperature cooling and low temperature heating. Low energy consumption is this achieved by maintaining a mean operating water temperature (18–28°C) that is close to the ambient temperature. This increases the efficiency of heat sources such as heat pumps and enables the use of renewable energy and sources of free cooling. Radiant systems are embedded in the building's structure, which leaves visually clean surfaces, with no obtrusive and disturbing appliances, and flexible indoor architecture.

Low exergy systems

Both heating and cooling can in principle be obtained at temperature levels that are close to the ambient environment. A low delta T only requires that the heat transmission takes place over relative big surfaces as for example applied in under floor heating systems. The favourable temperature levels make it possible to utilise energy that in principle has a low quality, or more correctly a low exergy content. The exergy concept can be seen as a measure for the quality and availability of a given energy stream. I the recent years a number of international research and demonstration projects have been accomplish focusing on exergy optimisation of energy systems, including the LowEx programme under the international energy agency IEA. The conclusions underline that the future interaction between collective supply systems and the individual building will be a key element for improving the total energy efficiency on district level.

	System 1		System 2		System 3	
	T (°C)	*Efficiency*	*T (°C)*	*Efficiency*	*T (°C)*	*Efficiency*
Condensing boiler	80	0.95	80	0.95	80	0.95
Air-cooled chiller	7-12	3.1	7	3.1	7	3.1
Condensing boiler	55	1.0				
Air-cooled chiller	18	3.5				
Heat pump			55	4.05	55	4.05
Reversible heat pump			18	6.50		
Free cooling (ground water)					18	



Example of simulated radiant system performance based on a comparison between a system based on a radiant floor and ceiling for heating and cooling and an all air reference system. (Annual primary energy use per square meter of the conditioned area). The simulations are done with EnergyPlus v.3.1.0. and climatic conditions adapted from the IWEC (International Weather for Energy Calculation

Optimal utilisation of energy sources

Water based systems such as under floor heating and under floor cooling are born as low exergy systems since they facilitate heating and cooling at temperatures close to the ambient environment. Consequently the systems can utilise all sort of energy supply very efficiently, in particular renewable energy sources such as solar, biomass, ground heating and heat pumps. The over all efficiency of most energy sources strongly depends on the supply temperature in the heating system, the lower the supply temperature, the higher efficiency. This is in particular the case for heat pumps and for condensing boilers (natural gas and biomass). For heat pumps a rule of thumb says that lowering the supply temperature in the heating system by 1°C will yield a reduction of the annual energy consumption by approximately 2%. If the heating system is designed with under floor heating operating at a supply temperature on 30°C instead of radiators with a supply temperature on 50°C this will yield and annual saving on the energy bill of about 30–40%, dependant of course on the heat pump type and other parameters.

Radiant systems

Heating and cooling systems with water conducted in pipes integrated in the floors, ceilings or walls of a building are named radiant systems, as more than 50% of the energy exchange is by radiation. Typically applied radiant systems for office environments spans from traditional under floor heating and cooling systems over various wall and ceiling integrated systems to thermally active building systems where pipes are embedded into the concrete slabs. Heat output of up to 100 W/m² can typically be achieved with floor and ceiling systems whereas cooling output of typically 60 W/m² is achievable with thermally active building systems and up to 75 W/m² cooling can be achieved with comfort panels for suspended ceilings.

Low temperature heating and high-temperature cooling is the key to energy efficiency in high-performance buildings. With a low-temperature radiant heating system, energy source efficiency will significantly increase in comparison to traditional, high-temperature systems and air heating. This results and reduced primary energy consumption. The feasibility and performance of thermally active building systems has been investigated with results showing energy savings of 25–60 % and thermal comfort yielding a decrease of extended air circulation of 25–75 %.

Integration of renewable energy sources

Using large surfaces as emitters allows heating and cooling at temperatures very close to that of the ambient environment. This means that renewable energy available from the ground, water, sun and air can be integrated and utilised with ease. Ground-source heating can be incorporated into the system via ground heat pumps. Combining a radiant cooling system with a free cooling source can reduce energy consumption by 80–90%, since traditional chillers can be eliminated and only electricity for circulation pumps is needed. Natural-ground water has ideal temperature levels for radiant cooling systems. Alternatively, the systems can be operated with sea-water cooling or solar cooling that uses absorption chillers.

Need for sustainable cooling

Several tendencies indicate that the cooling needs in the entire building mass will increase in the future. This is partly because we experience more extreme weather types with warmer summers and partly because people's requirements for indoor comfort are increasing continuously. New improved building codes with stricter requirements for the tightness of building envelopes also introduces significant cooling demands in summer. This applies in office and industrial buildings, where cooling is already widely used, but also increasingly in private housing.

Using a combined under floor heating and cooling system, the cooling need can be met by using floor cool-

BOB (Balanced Office Building), Aachen, Germany. A highly energy efficient office building controlled by advanced building technology. Heating cooling is provided by a TAB system fed by borehole heat exchangers in combination with a heat pump.

BO CAFOD Headquarters, London, England. Occupying a difficult triangular site, the building is an exemplar of sustainable workplace design with cooling provided by a Thermally Active Building System in the exposed thermal mass in situ concrete structure.

ing with a flow temperature relatively close to room temperature, typically at 15–17°C. With this favourable temperature level the cooling needs can be covered with minimal energy consumption, for example via free cooling with a ground-coupled heat pump.

Energy efficient cooling is also required for office and industrial buildings. In these building types it is in similar way favourable to utilise high temperature cooling solutions that can exploit free cooling sources and thus reduce energy consumption to an absolute minimum. Water-based cooling solutions in the form of chilled beams and cooling panels are well known in most European markets. Thermo-active constructions, primarily known from Central Europe, are gradually increasing their market share due to their favourable comfort characteristics and energy performance. The principle of a thermo active construction is that pipes integrated into the concrete and floors, whereby the building mass is activated. This is optimal for the thermal indoor climate, and in addition peak loads can be reduced substantially, as a part of the cooling needs are shifted to the non-occupied night hours when the building's thermal mass is cooled down.

In office buildings, the need for cooling is often much greater than that for heating. A major advantage of radiant cooling us the possibility to integrate free cooling sources for example in the form of ground water, sea or lake water. Combined with a radiant cooling system this can reduce the energy consumption for cooling as traditional chillers can be eliminated, and only electricity for circulation pumps is needed. Also with conventional cooling technology such as traditional roof top chillers, a radiant system will potentially yield energy savings.

In particular when using thermally active building system, it is possible to run the system during periods when the building is unoccupied. The system utilises the concrete's thermal mass storage and discharge of thermal loads. This conserves energy by reducing the load on traditional HVAC systems and allows using off-peak energy rates for lower operation costs.

Minimizing losses

In addition to a building's net heat requirements there will typically be a loss of up to 20% from the total heating system. This additional loss can be assigned to boilers, pumps, control, distribution, emissions, etc. Emission losses depends on the choice and positioning of heat emitters (under floor heating, radiators etc.) and the system's ability to maintain an optimum temperature profile and compensate for changes in heat demand over time.

This airport in Bangkok provides cooling and thermal comfort by combination of two separate systems: a displacement ventilation system with variable flow volume and an underfloor cooling system supplied by Uponor.

A significant portion of these system losses can be minimized by proper design and layout of system parameters such as emitter location in the construction, pipe spacing and dimensions. There are also significant savings to be gained through developing and implementing dedicated control algorithms. For example, Uponor has developed a self-learning control algorithm for floor heating systems based on pulsed heat input, which virtually eliminates control loss with a documented annual energy savings of up to 8%.

Conclusion and perspectives

A radiant heating and cooling system makes commercial buildings more energy-efficient, also when it is paired with a traditional HVAC system. The radiant system works with water temperatures close to the ambient temperature, which allows low-exergy design, resulting in reduced primary energy consumption. In order to utilise our energy resources in an optimal way, it is suggested that integrated low temperature water-based systems are a key element in the future construction design practice and energy system design. Thermal comfort with minimum energy consumption can be achieved using radiant heating and cooling systems in combination with appropriate conditioning of the indoor air. Heating can be provided at optimal efficiency using large emitters with temperatures close to ambient and the cooling loads can be efficiently removed at favourable temperature levels by using free cooling sources with a ground coupled heat pump.

Old cooling methods benefit from using new technology

Cooling tower control systems depend on accurate and reliable humidity measurement to increase energy efficiency and reduce maintenance costs.

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Cooling towers are among the oldest and most effective methods of removing heat from a building. Unfortunately, tradition can lead operators to use familiar but unreliable devices that result in inaccurate relative humidity (RH) measurements that compromise tower efficiency. Adopting advanced technology for accurate and reliable RH and temperature measurements is essential for lowering energy use and maintenance costs.

Purpose is to Remove Heat

In HVAC applications, evaporative cooling towers remove heat from the condenser water – water used to cool the refrigerant – in chillers of HVAC systems. During this refrigerant-to-water heat exchange, the refrigerant temperature decreases and the condenser water temperature increases. The heated condenser water is then circulated to the cooling tower, where it is sprayed or splashed onto complex ventilated surfaces, maximizing evaporation that removes heat from the water. The cooled condenser water is then returned to the chiller to continue the cycle.

Wet-bulb Temperature Sets Cooling Limit

How much the condenser water can be cooled is limited by tower design, tower quantity, operating equipment including fans and pumps, and by environmental factors – it can be cooled only as low as outdoor wet-bulb temperature, a function of RH and temperature.

In a perfectly efficient cooling tower, the water leaving the tower is as cold as the wet-bulb temperature. Since no tower is perfectly efficient, tower designers consider its limitations to determine the approach – the approach is the practical difference between the possible and realistic temperatures of water leaving the tower.

The approach is added to the wet-bulb temperature to determine the actual condenser water set point. For example, 21°C (70°F) wet-bulb temperature with 4°C (7°F) approach results in an actual set point of 25°C (77°F) for condenser water discharged from the tower.

"Wet-bulb temperature measurement is similar to a temperature gauge in your car. It tells you how hard you can

run the engine," says Tim Wilcox of WPI, a U.S.-based consulting firm specializing in energy efficiency on a broad range of projects.

"Its information is also used like the speed governor to avoid overrunning the equipment. Inaccurate measurement in either case can do great harm," he adds.

Sources of Error

Inaccurate RH sensors are a common source of erroneous wet-bulb temperatures, misleading control systems and operators. Another source of error is locating the RH sensor too close to the cooling tower, where it is affected by discharge air. Since the wet-bulb measurement must be true measurement of the outdoor ambient air, the RH device needs to be located away from any discharge air.

"If the control systems are receiving a wet-bulb reading much cooler than possible, the operating engineers or the controls will attempt to drive down the condenser water temperatures by engaging more pumps, fans and tower cells. The hardware can't achieve the bogus temperature but the false information will waste energy and risk fouling – if not harming – the cooling towers. A second-rate RH device will lead to an impossible condition," Wilcox says.

Costs of Overrunning

Excessive operation leads to several areas of avoidable operational and capital costs: wasting energy to run the fans more than needed, premature equipment repair, acceleration of mineral build up in the tower fill, and inefficient water use from adding more water to the sump to replace the evaporated water.

In one case that Wilcox cites, investigations concluded that inaccurate readings from an on-site RH device contributed to a cooling tower at a landmark hotel being so excessively run that the tower fill became nearly rock solid with calcium carbonate deposits.

Uneven air flow rising through the plugged fill caused the tower system to be on the verge of shaking apart, damaging the fans and fan shrouds. Operators used fire hoses to keep the chiller plant operating at the height of the summer tourist season. Avoidable capital costs added up to hundreds of thousands of dollars to replace the tower fill.

Vaisala Recommended

"Humidity measurements need to be accurate and maintainable. We specify Vaisala humidity sensors that

Vaisala HMT330 series transmitters deliver high accuracy and excellent long-term stability. RH accuracy is within 1% up to 90% RH and within 1.7% up to 100% RH. Temperature accuracy is within 0.2°C (0.36°F).

we can count on not to migrate into error. We avoid recommending instruments that can go out of calibration in six months, misinforming the control systems and building operators," says Wilcox.

"We see projects that can spend $200,000 a year on cooling tower-related operating costs operated by a $50 sensor that goes unreliable in months. Life is too short to deal with error-prone devices."

The Vaisala Humicap® HMT330 Series Humidity and Temperature Transmitter delivers high accuracy and excellent long-term stability, even in harsh outdoor conditions. RH accuracy is within 1% up to 90% RH and within 1.7% up to 100% RH. Temperature accuracy is within 0.2°C (0.36°F). The transmitters calculate wet-bulb temperature and can be field calibrated to meet the operator's quality management protocol.

Accuracy Leads to Free Cooling

Wilcox recently reviewed cooling tower performance at an undisclosed data center in Utah. One of the recommended upgrades was to replace their RH device with the more accurate Vaisala instrument.

Now using accurate RH in the wet-bulb temperature measurement, the facility could reduce energy costs by using more free cooling. Free cooling can be used when the outdoor wet-bulb temperature plus the approach is lower than the requirement for primary chilled water. Under these conditions, the condenser water cools the primary chilled water, bypassing the chiller entirely. Free cooling reduces mechanical cooling costs, is more energy efficient, and is recognized as a green energy effort.

With accurate wet-bulb temperature measurements, the data center was able to convert to free cooling for more than half the year and still meet its cooling requirements.

New Ways are Better

The value of accurate RH measurements is increasing as more cooling tower builders, operators, and HVAC professionals learn – still too often the hard way – that more reliable sensors using advanced technology can pay for themselves many times over. 3E

Requirements for well functioning Demand Controlled Ventilation

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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.

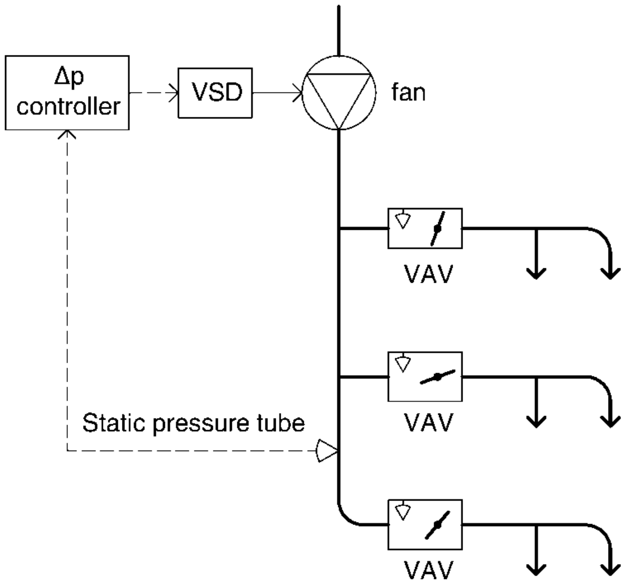

Figure 1. Principle of constant static pressure control. The critical path VAV damper is in max position only at times of maximum flow rate demand.

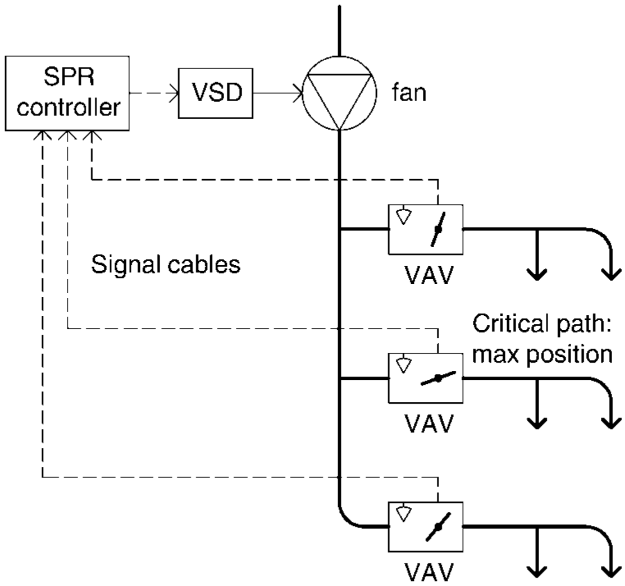

Figure 2. Illustration of SPR control. At least one VAV balancing damper is in max position (the critical path).

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*'. 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.

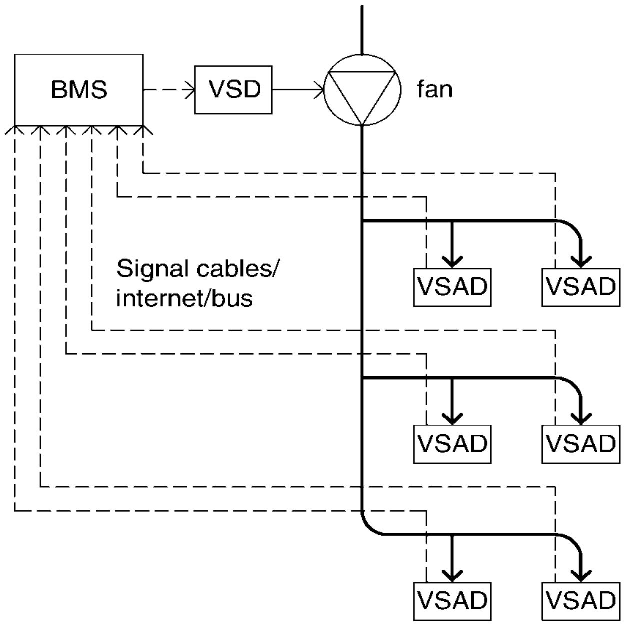

Figure 3. Principle of VSAD-DCV.

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.

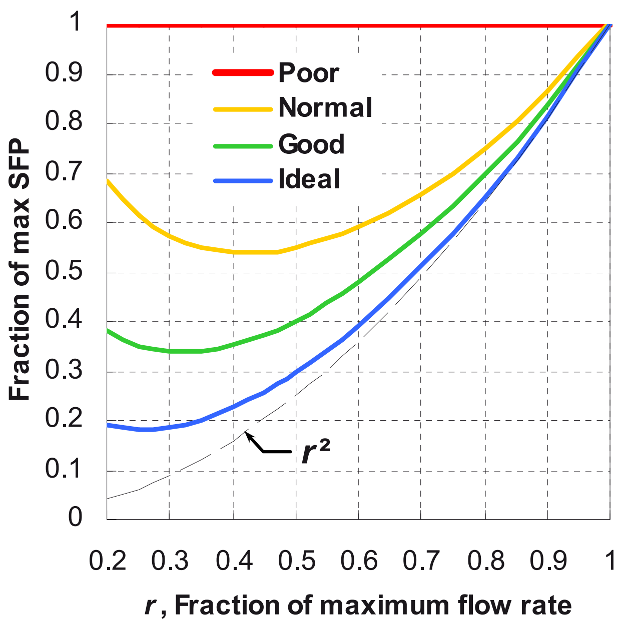

Figure 4. Illustration of covariation between airflow rate and SFP-value for Poor, Normal, Good, and Ideal DCV-systems (Schild and Mysen 2009).

Acknowledgements

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References

ASHRAE handbook (1996) Systems and equipment, refrigerating and Air-Conditioning, Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Enova (2010) Byggstatistikk 2008 (Buildings statistics 2008 (in Norwegian)) Enova report 2010:2, Norway, ISBN 978-82-92502-43-3

Maripuu, M., Jagemar, L. (2004) Energy savings by installing variable air volume systems (VAV) in existing office buildings. Experience from a new supply air terminal device concept, in Proceedings, 6th Int. Conf. Energy for Buildings, October 2004, Vilnius. pp 301-311

Maripuu, M. (2009) Demand Controlled Ventilation (DCV) Systems in Commercial Buildings Functional Requirements on Systems and Components, Thesis For The Degree Of Doctor Of Philosophy, Building Services Engineering Department of Energy and Environment Chalmers University of Technology Göteborg, Sweden

Mysen, M., Schild, P.G. and Drangsholt, F. (2010) Robustness and True Performance of Demand Controlled Ventilation in Educational Buildings – Review and Needs for Future Development, Proceedings, 31st AIVC Conference, 'Low Energy and Sustainable Ventilation Technologies for Green Buildings', Seoul

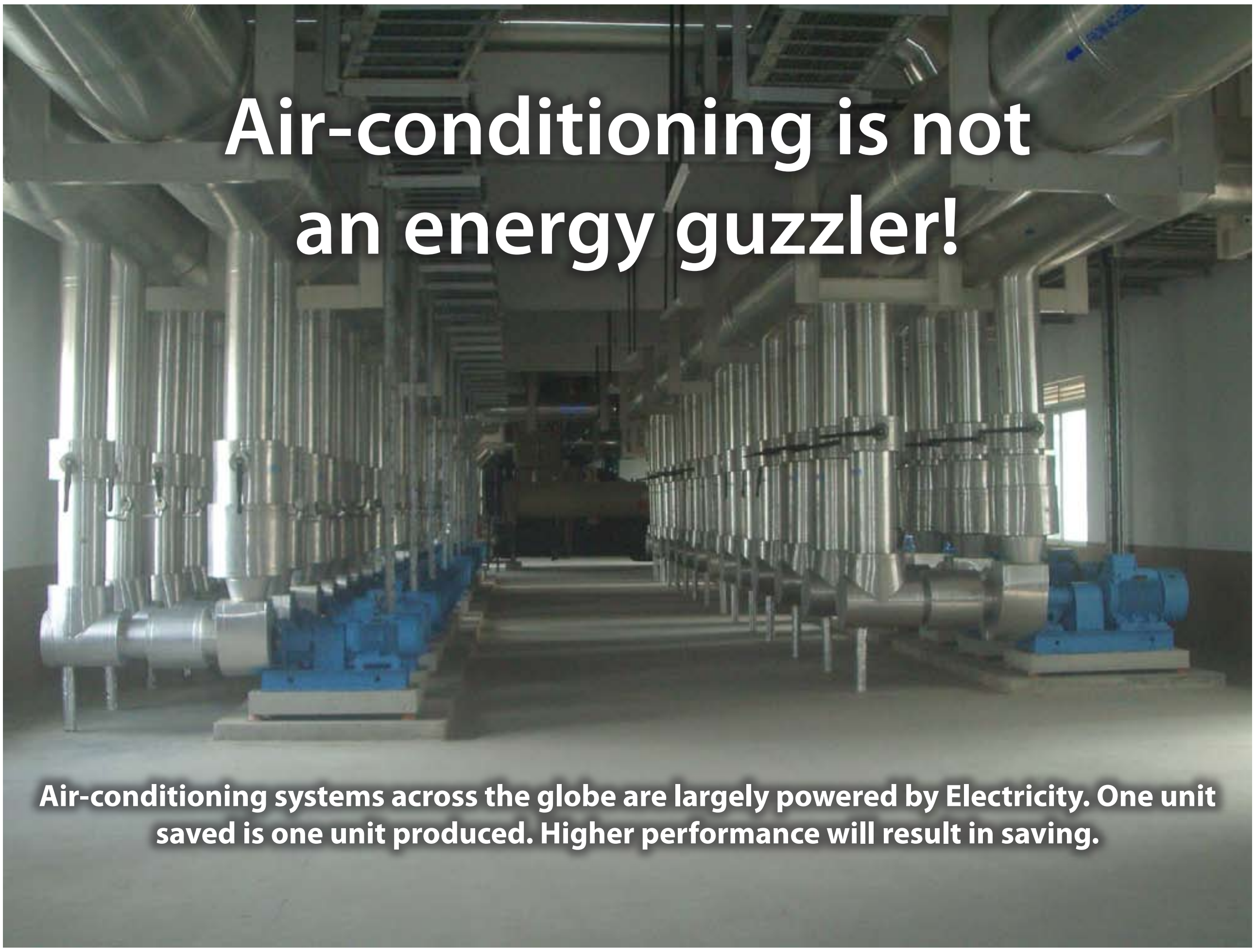
Mysen, M. (2005) Ventilation Systems and their Impact on Indoor Climate and Energy Use in Schools, Doctoral Theses at NTNU. Trondheim, Norway, 2005:111

Mysen, M., Berntsen, S., Nafstad P. and P, Schild P.G (2005) Occupancy density and benefits of demand-controlled ventilation in Norwegian primary schools, Energy and Buildings, 37 (2005) 1234-1240

OECD/IEA (2008) Energy Technology Perspectives, Scenarios & Strategies to 2050, International Energy Agency, Head of Communication and Information Office, Paris, France

Schild, P.G. and Mysen, M. (2009) Recommendations on Specific Fan Power and System Efficiency, Technical Note AIVC 65, International Energy Agency, Energy conservation in buildings and community systems programme.

Wigenstad, T. and Grini C. (2010) LECO Fra normbygg til Faktor 10 (LECO From standard building to factor 10 ((in Norwegian)), Project Report 51, SINTEF Building and Infrastructure, Norway, ISBN 978-82-536-1133-4. 3E



Air-conditioning is not an energy guzzler!

Air-conditioning systems across the globe are largely powered by Electricity. One unit saved is one unit produced. Higher performance will result in saving.

D. NIRMAL RAM
Chairman Acrex India 2012
Email: dnirmalram@acrex2012.com

Strategies

There are three fundamental strategies to increase energy performance:

1) Reduce Demand
2) Harvest Site Energy
3) Maximize efficiency

Demand reduction is accomplished by challenging initial use assumptions and by reducing internal loads and gains through the shell and lighting improvements.

Harvesting site energy includes using free resources such as daylight, ventilation cooling and solar heating to satisfy needs for space air-conditioning.

Finally the efficiency of the HVAC system should be maximized.

Orientation

The location of the building with reference to the compass points and avoiding exposure on West and East will result in an economical HVAC Design.

Ventilation

A demand controlled ventilation using CO_2-sensors controlling the dampers which in turn controls the Variable frequency drives for changing the speed of the blower will result in higher energy efficiency .For higher outdoor air quantity, heat recovery by means of heat recovery wheel, Run around coils and heat pipe will result in lesser system capacity.

Inside design conditions

Comfortable temperature is a relative figure and depends on outside temperature and humidity. Selecting a lower temperature than comfortable temperature is direct waste of energy. So compromise the need to use low temperature and humidity.

Equipment selection

Generally it is found that equipment selected on the actual instantaneous peak heat gain is oversized and therefore capable of maintaining much lower room conditions than the original design. One reason for such is the non-simultaneous occurrence of the peak in the individual loads (diversity) Also, if a smaller system is selected, and is based on the extended periods of operation at the peak load, it results in a more economical and efficient system at partially load condition.

Hybrid chilled water system

A hybrid chiller option with a combination of air cooled screw chillers, water cooled centrifugal chillers and absorption chiller with heat recovery boilers from DG sets will enable efficient operation.


The lotus (Nelumbo nucifera) flower is the national flower of India. To Hindus and Buddhists it is a sacred symbol of enlightenment.

Air handling units

Choice of Air handling units with supply and return/exhaust air fans will result in energy saving. During 'free cooling' conditions when the ambient temperature is comfortable, the supply fan will be drawing all outside air, whereas the return/exhaust fan will be exhausting the air from the conditioned area.

Toilet exhaust fans can be hooked with an infrared sensor/timer which will facilitate operation only during occupancy.

Server rooms and data center which are required to function round the clock can be contemplated with dual fluid precision units.

Chilled beams

Chilled beams offer a quiet indoor air free from draught.

Variable air volume units

Variable air volume units coupled with motion sensors will enable closure of the units to the minimum levels will result in energy efficiency.

Ducting

Size ductwork appropriately and install balancing dampers to reduce velocity losses. Ducts with lower aspect ratios offer lower resistance and can reduce fan energy significantly. Ducts should be insulated and sealed but indoor air quality issues should also be considered. Factory made ducts with good workmanship will result in the low leakage losses.

Thermal storage

Power tariffs and rationing during peak load hours - This becomes a potential tool for use by the designer to harness the sleeping giant of thermal storage. Thermal storage systems become handy in areas wherein due to water shortage the usage of water cooled chillers are limited.

Vapour absorption system

Alternate sources of energy particularly waste steam/heat can be used for refrigeration. Heat recovery from solar heat is also a possible option.

Variable speed drives

Variable frequency drives can be used for the primary and secondary chilled water circulation pump sets by sensing the temperature and pressure differential in the chilled water lines. Two way motorized valves in the air handling units can be actuated by a thermostat which will vary the flow according to the loads resulting in pressure changes which can be sensed and used for changing the speed of the pump sets.

Variable speed drives are used for the air handling units. Variable air volume units will regulate the airflow for various zones based on the occupancy and temperature by a variable air volume unit, which will give a pressure signal for the VFD to change the speed of the air handling unit.

A demand controlled ventilation system uses a variable speed drive operating based on the opening and closure of the fresh air dampers controlled by the CO_2-sensors.

A typical basement exhaust system can use a variable speed drive controlled by CO-sensors.

Centrifugal/screw chillers with variable speed drives are also available.

Building automation system

The main objective of the building automation system is to reduce the running and energy costs, improve the quality and supply of information on the air-conditioning system. The system can establish basis which will be good bench mark for energy efficient operation subsequently.

Good installation practices

A good equipment will not serve its purpose if it is not installed properly. Good installation practices with stringent quality control measures will result in easy maintenance and will pave a way to energy saving. Air leakage if any in the ducting system will result in serious energy loss.

Commissioning and handing over

Commissioning is a systematic process to ensure that the air-conditioning system performs according to the design intent and the owner's operational needs. Commissioning maximizes energy efficiency and thereby minimizes environmental impacts associated with energy production and consumption.

Operation and maintenance

A well drawn-out diligent operation and preventive maintenance schedule really saves energy.

Proper maintaining of inside design conditions does not mean that the system is working efficiently as peak load will not exist throughout the year and the plant is designed based on the peak load. As such proper preventive maintenance is to be performed for proper upkeep of the system to save electrical energy.

Operation shall be focussed only in areas, which can result energy saving without compromising the design intent. When there is a compromise, it is not a saving but a faulty operation!

Saving is only a relative term. Improvement is possible at every stage on continuous basis and there is no limit for energy saving.

Accompanying article is case study of a project for Energy Efficiency. It won the LEED Platinum rating. 3E

Case study:

Energy efficient HVAC system for an IT park, Bangalore

Project name: Pritech 2 Sez Park, Bangalore. Commissioned on December 2008

The project involves air-conditioning of Software and Hardware Park, Pritech 2 SEZ having an air-conditioned floor area of 116,043 sq.mt having three blocks namely block 5, 6 & 7. To cater to the air-conditioning needs a combination of water cooled centrifugal, air cooled screw and vapour absorption chillers are contemplated. 3 Nos Water cooled centrifugal chillers each having a capacity of 700 TR (2462 KW), 10 Nos air-cooled screw chillers each having a capacity of 350 TR (1231 KW) and 1 no vapour absorption chiller using waste heat from Diesel Generating Set/Diesel/Compressed Natural gas totaling to a capacity of 6300 TR (22150 KW) are envisaged. All chillers excepting the vapour absorption chillers are installed. The hybrid chiller combination with water cooled centrifugal chiller will use recycled water from Sewage Treatment plant and will run when the ambient is hot, the air-cooled screw chillers again with a combination of High and Normal Efficiency (5 nos of each type) will run during the periods of low/medium ambient temperatures while the vapour absorption chiller is mainly designed to run during the periods when DG sets are functional recovering the waste heat. This hybrid combination strike a perfect balance between energy efficiency and first and running costs. No standby chillers are envisaged owing to multiple chillers with multiple compressors. Further there is no separate critical chiller system (for 24/7 operating areas) as the same set of chillers can cater to the critical needs also thereby simplifying the chilled water distribution system. The chillers are located in the Utility block having the Lower level with DG sets, Middle level with pump sets and water cooled centrifugal and absorption chillers, intermediate level for chilled water and condenser water piping system and the upper level with air- cooled chillers and cooling towers. The Chiller platform is of RCC construction (compared to conventional metallic structure) which has a longer life span with no rusting/maintenance and lower first cost. The chiller power apportioning is using the state of the art ultrasonic BTU meters with software programming done to the exclusive need of the project. The BTU meters are protected from misuse/faulty operation by communicating the failure through mobile phones.

The system is being hooked with the phase 2 system with another Chiller Plant room with a ring main concept making the system totally failure free and free from sabotage if any thereby offering the combined advantages of the central chilled water and individual chilled water system

Chilled water circulation is with primary and variable secondary pump sets with two way motorized valves for the Air-handling units. The system provides installation of air-handling units and air distribution system by the tenants.

The facility has won the LEED Platinum rating.

Extraordinary features of the System

- Water cooled centrifugal chiller having a COP of 6.38 and an IPLV of 7.51, High performance Air cooled screw chiller having a COP of 3.05 and IPLV 4.56 and Normal Efficiency air cooled Screw chiller having a COP of 2.88 and an IPLV 4.56 – all installed with a space to install 700 TR Vapour absorption chiller using DG waste heat recovered by Heat recovery boiler. All chillers are with ozone friendly refrigerants.
- All chillers were installed in a multi level utility block – Level 1 DG sets, Level 2 Water cooled

chillers and pump sets, Level 3 Chilled and Condenser water Headers and Level 4 with air-cooled screw chillers and cooling towers on RCC platform compared to the conventional Metallic structure free from rusting and maintenance and offering a good maintenance.

– These chillers are to be hooked to the Phase 2 HVAC Plant room with a ring main concept offering total flexibility and free from any failure.
– State of the Art Power apportioning with BTU meters with special programming for this project with Auto SMS facility for failure.

Quantifiable and tangible benefits resulting from the innovation.

- There is a first cost saving of 0.6 million Euros with a centralized chilled water system compared to a standalone chiller system installed on the terrace of each blocks (see Annex).
- There is a running cost saving of 60,000 Euros per month with the Hybrid chiller configuration (see Annex).
  – The RCC chiller platform structure has a saving of 24,000 Euros over the metallic structure construction.

Annex: Advantages of a combined chilled water system

Advantages of installing the chillers in a service block common for all blocks as against chillers on roof top for individual blocks that has the following advantages:

Saving in running cost

Combination of Water cooled Centrifugal chillers, Vapour absorption chillers and air-cooled screw chillers pumping chilled water into a common header will result in a low KW/TR compared to individual block roof top air cooled chillers.

- Combined KW/TR for chiller combinations located in the service block – 1.166 KW/TR
- KW/TR for air-cooled chillers on the roof top for individual blocks – 1.527 KW/TR

Approximate saving in running cost for 12 hours operation/day for 26 days/month with combined chillers will work out to 60,000 Euros per month.

Further chiller operation after office hours for critical area air-conditioning requirements such as UPS, Server room, Data centre will be economical.

No air-conditioning failure

Since there are multiple chillers in a common plant room, one or more chiller failure will not seriously affect the air-conditioning. Incase of individual block air conditioning, failure of 1 or two chillers will affect the air-conditioning.

No chiller/pump noise on the top floor

Since there are no chillers and pumps installed on the roof of the occupied area, there is no issue of vibration and noise. Further the roof is clear for the cafeteria if any.

Maintenance at a single zone

Maintenance is at a single zone. This will result in lower AMC cost. The saving in AMC cost will work out to approximately 40,000 Euros per annum.

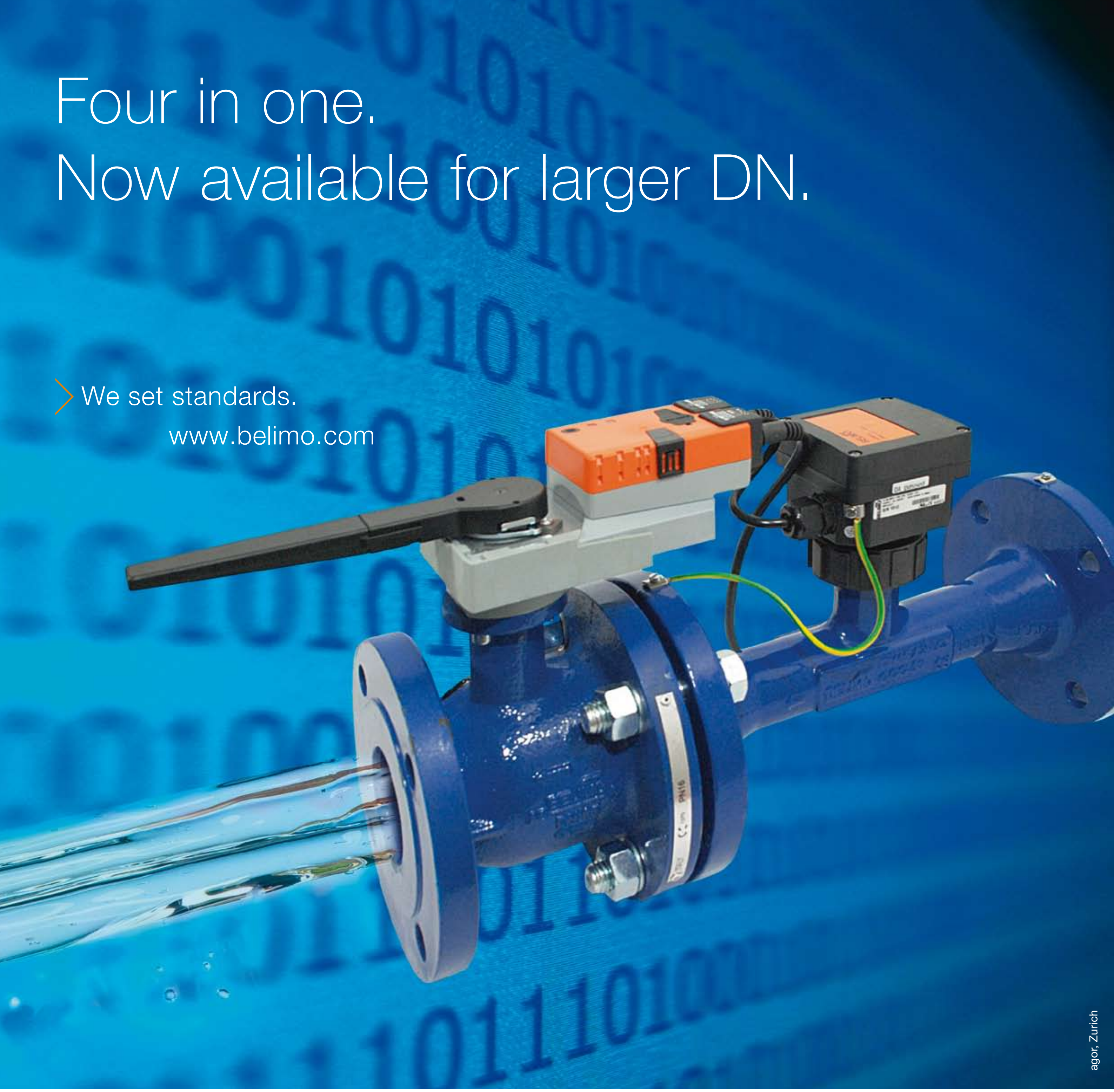
Chiller/pump power apportioning

Air-conditioning cost apportioning from common chiller and pump sets will be done for each tenants based on the actual usage in a scientific manner using BTU meters based on the usage and not on area basis.

Building Automation System

The features of the BAS are as follows:

- Remote switching On/Off of various equipments
- Remote adjustment of set points with levels of control
- Timed and event related functioning of equipments
- Run time equalization and sequencing of equipments
- Centralized alarm and maintenance schedules
- Trip indication status and Trouble shooting history
- Electrical power/capacity evaluation based on temperature of water, water flow, airflow and duration of operation.
- Chiller electrical power and other common services power apportioning to multiple tenants in a scientific way based on the actual usage
- Networking with multiple computers for remote operation at multiple locations.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North-east façade.

IUCN headquarter in Gland, Switzerland – an example for efficient energy design

The IUCN, as an international organisation which is active all over the globe to preserve the natural environment has set a high target for his extension of the Swiss headquarter in Gland.

Matthias Achermann
dipl. Ing. HES/SIA
Director of Amstein+Walthert Geneva
matthias.achermann@amstein-walthert.ch

Based on the wish of IUCN to crate a showcase of sustainable construction and high efficient building technology, the interdisciplinary team went to work in 2006. The building finally was inaugurated in the Spring of 2010. It complies with the Minergie-P-ECO and is aspiring the American LEED Platinum label. The key factor of success for the realization was the interdisciplinary collaboration. The close collaboration between architects and specialized engineers has made it possible to conciliate aesthetics, energetic performance and high flexibility for occupants with a very tight budget.

Interdisciplinary design – a key factor for an efficient building

The starting point for a successful energy-efficient structure is an architectural concept which takes into accounts passive solar heat gains and thermal losses. An optimized primary energy balance has been sorted through an iterative process changing the thermal performance of the envelope as well as the fraction of glazing and opaque wall parts and their thermal performances. The result of this optimization can now be identified with the work done: a relatively low rate of glazing compared to the surface of facades, a wall thickness of 35 cm, a high performing triple glazing as well as outside corridors for sun protection in summer and as emergency exits for users in case of fire.

A key element of this optimization was the glazing, which strongly influences the cooling needs and the comfort of users. The 25% glazing ratio of the facade can limit power peaks. To improve management of natural lighting without risking overheating due to solar radiation, movable blinds that are closed from bottom to top were established.

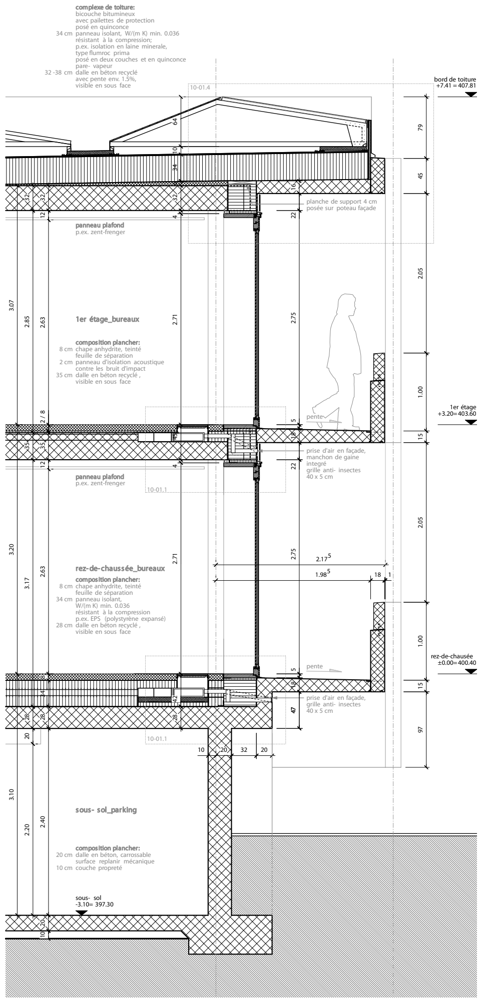

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Figure 1. Principle section.

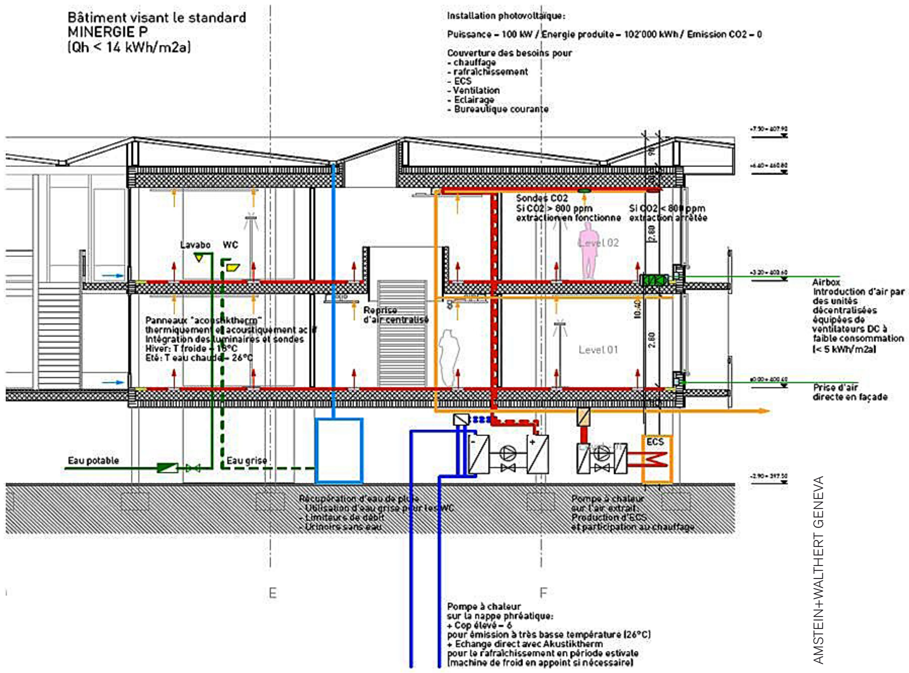

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Figure 2. HVACS diagram.

Energy from the basement and sun

Thanks to the thermal performance of the envelope, the heating need is very low. There is still necessary to heat the supply air of ventilation and domestic hot water. Requirements for space heating are secondary. Mainly because of an administration-bent working, the cooling need is by contrast predominant. It was then necessary to use a renewable source for cooling energy. Geothermal energy provided the answer. With a field of geothermal wells of a depth of 150 meters, 30% of cooling needs can be met by passive cooling. Cooling energy is produced by the reversible heat pump only when the free-cooling reservoir is exhausted. Through the dissipation of heat in the ground, in the second part of the summer heat warms the ground in order to optimize the performance of the heat pump in the following winter. In parallel to the heat pump connected to the geothermal probes a heat pump on the exhaust air was installed to preheat the air of the decentralized air intakes. This heat pump is also reversible and can cover smaller cooling needs of the fan coils without disrupting the geothermal free cooling storage.

A 1 400 m² photovoltaic installation on roof covers the annual electricity needs. Seasonal overproduction is fed back into the electrical grid.

Demand controlled ventilation

Given that the occupation of areas of work is very varied, constant flow ventilation would consume too much electrical energy and a traditional VAV facility would be too expensive. The adopted solution consists of small floor mounted decentralised outdoor air units contributing independently to the ventilation and thermal comfort of users. For the entire administrative area, except for large conference rooms, decentralised units have been positioned close to the facades at floor level. These units (marked as AIRBOX in **Figure 2**) are equipped with an air intakes from facade, a filter unit, a fan and a heating/cooling coil. The units operate only with outdoor air and there is no air circulation. They are controlled according to CO_2 in the room air. The CO_2 sensor is located at the exhaust damper, integrated into a multifunctional panel mounted on the ceiling. Each ventilation unit is connected to an exhaust damper, both attributed to one facade frame. This system avoids a complete supply air ductwork. It allows a much easier routing for technical installations. On the other hand, an air quality management based on demand is possible. If the CO_2 is high, the ventilation starts and if the air is clean again, the fan stops. If users are not present, two air flushes per day allow to keep a minimum fresh and good air quality.

The multifunctional ceiling panel, serving at the same time as thermal activation of the ceiling, as acoustic element and as light fixture, also includes an extract air terminal. In this solution, the activation of the thermal storage is through profiles/pipes fitted with hydraulic circuits spreading heat in both directions: on the surface of the panel for a direct exchange and to the concrete surface to activate the inertia of the concrete flagstone, **Figure 4**.

For efficient operation, 50% of the flagstone had to remain as raw concrete. Through the activation of the flagstone, the peak power was reduced by about 35%. This had a positive impact on the design of plants and helped to control investment costs.

Automation of the next generation

At the level of the building's automation, a new technology has found its application. The management of decentralized units and the recovered air dampers and

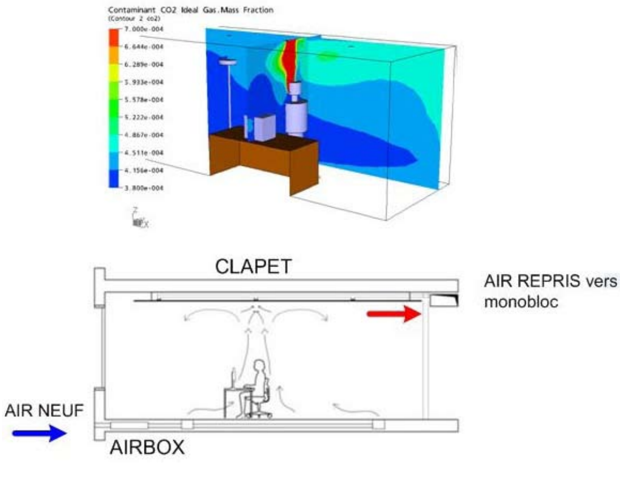


Figure 3. Ventilation, heating and cooling concept.

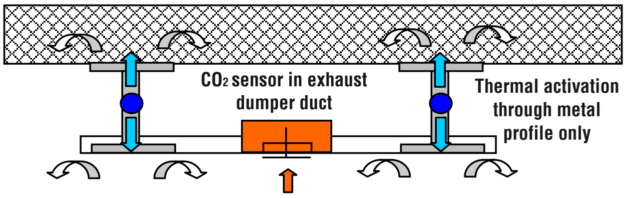
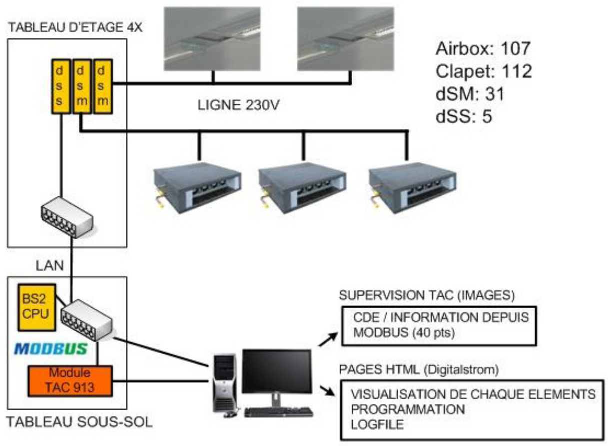


Figure 4. Ceiling panel for heating and cooling, with integrated extract air terminal and lighting.

Figure 5. Photo of a multifunctional ceiling panel.

CO_2 sensors are driven by Digitalstrom. This technique uses the electric power for the transmission of information and makes the installation of a conventional bus obsolete. Given that the implementation of this system was a world first and it was necessary to consider some "teething troubles", the system was limited to the installation of ventilation of the offices. For all other HVAC systems, lighting and blinds, a traditional LON system has been implemented.



AMSTEIN+WALTHERT GENEVA

Figure 6. Digitalstrom typology.

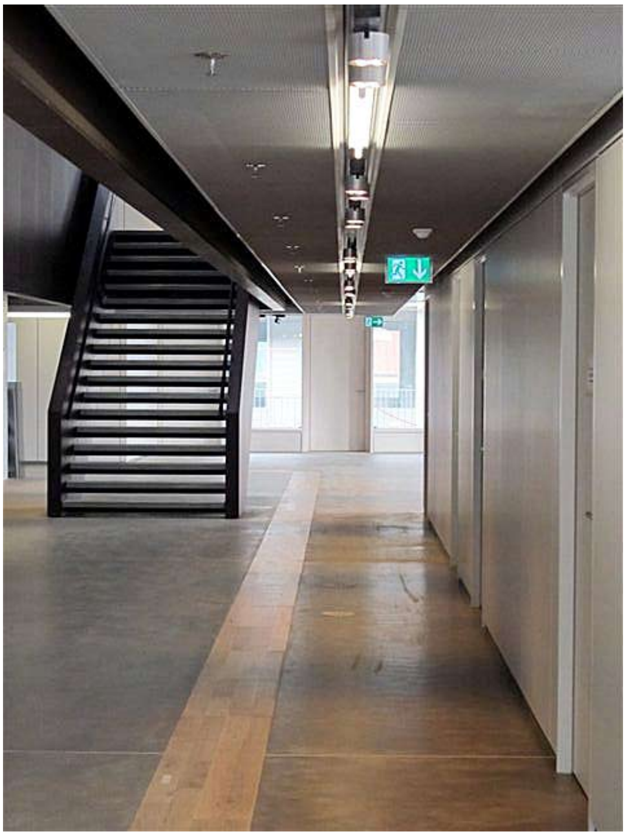


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Figure 7. View from inside the building.

Maximized day lighting

The lighting concept supports the use of daylight. Each workplace is located in front of a large bay window. The windows are generously sized, with 3.2 m² per workplace. The depth of the premises is 5 meters only. Most of the time work in day light is thus possible. Thanks to architectural measures, workplaces are protected from the solar glare. As light source, fluorescent tubes of TL5 type, with reduced mercury levels, were installed. The concept has been supplemented by LEDs. In offices, fluorescent tubes are used as basic lighting and LED table lamps serve as support lamp at the level of workplaces. In the corridors, the LEDs are used as decorative lighting and create a pleasant atmosphere. The meeting rooms are equipped with HIT lamps complemented by LED lights for atmosphere. With this combination of lighting, the specific power amounts to only 6.6 W/m². Only 6 different types of light fixtures are installed throughout the building enclosure and, thus, maintenance costs and servicing are considerably limited. Movement detectors and light intensity can further reduce consumption to a minimum.

Exterior lighting was kept to a minimum to avoid light pollution. The idea of a night enhancement of the façade and of the illumination of the natural garden has been abandoned.

Efficient water management

A system of efficient water management is based on three axes: the first is the reduced consumption of drinking water because it contains a significant proportion of energy for transportation and treatment. Drinking water is distributed in the kitchen for water fountains located in the building as well as in the wash-basins of the lavatory. The second axis is to use gray water for toilet flushing and garden irrigation. This water, collected on the roof, is carried in a tank of 70 m³. The overflow is led directly into the natural garden, and, in fact, into the groundwater. The last axis is the optimization of drinking water. Water flows in the taps were limited and the taps in the toilets were equipped with infrared detectors. Result of this concept: a saving of water of 4 000 litres per day.

First performance review after 8 months

As the real optimization phase hasn't begun jet, the only figures available today are the total electricity consumption for the new building. Compared to the dynamic building simulation including all electrical energy con-

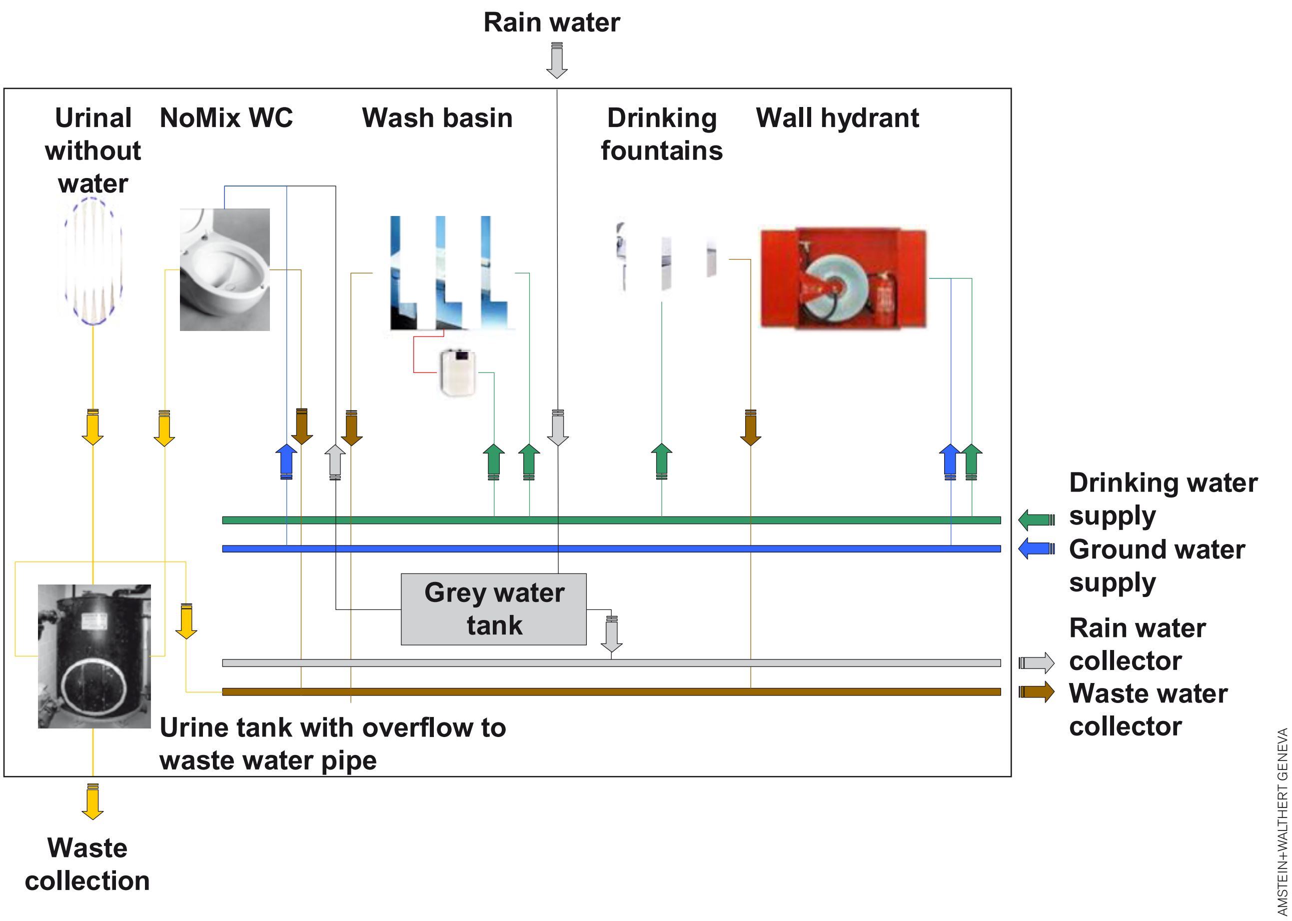

Figure 8. Principle of water management.

suming facilities, the one year consumption hit the simulation target quiet well. Breakdown of the simulated energy performance is shown in **Table 1**.

For the first year, the calculated values will overrun the calculated electrical consumption by 10%. This might be optimistic because the building is today occupied by 90%. In addition to that some troubles with the ventilation control system have been fixed during the last month. Focused on this early result, the analysis shows big discrepancies during October and November. Further investigations are necessary to improve the whole system. The goals for the next step is to break down the comparative results and analyze consumer one ▶

Table 1. Simulated energy performance of the building. All specific values are per net floor area.

	Net delivered energy use kWh/(m² a)	**Primary energy factor** -	**Primary energy use** kWh/(m² a)
Space, water and ventilation heating, electricity to heat pumps	6.0	2	12.0
Cooling, electricity to heat pumps	6.7	2	13.4
Fans (HVAC)	5.3	2	10.5
Pumps (HVAC)	2.8	2	5.6
Lighting	16.3	2	32.6
Appliances (plug loads)	26.8	2	53.6
PV power generation	-30.9	2	-61.8
Total	**33**		**66**

Inner courtyard of the building.

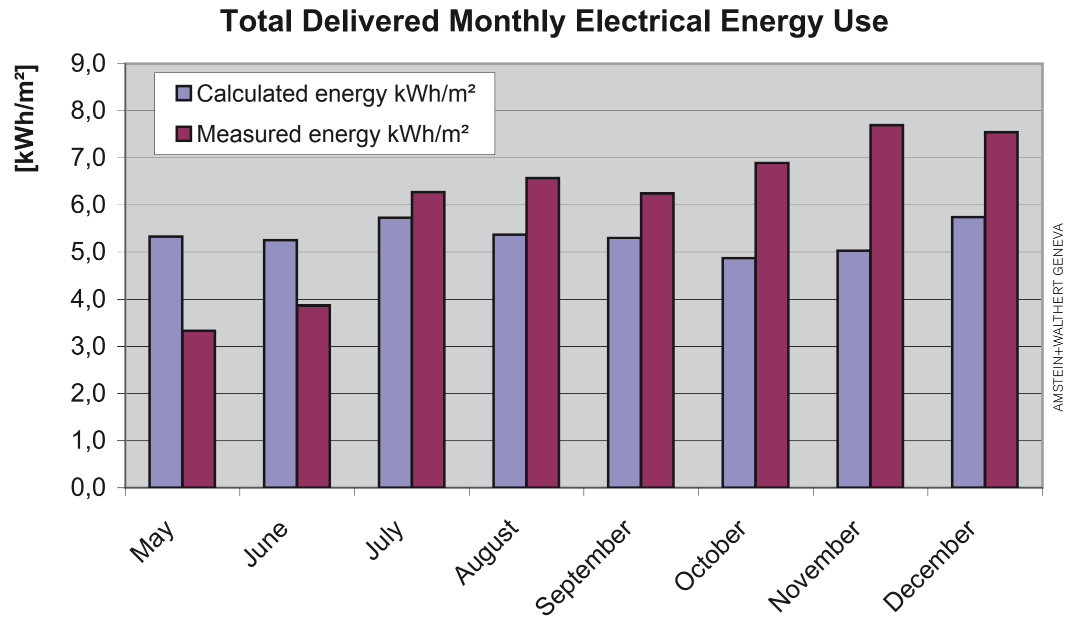

Figure 9. Comparison of calculated and measured delivered energy use.

A photo from construction phase.

PV panels installed on the roof.

by one to check if set points, operation schedules and the sensor technique is running correctly. Also user behaviour need's to be analyzed.

Even with the analysis not finished jet, the result of energy performance for the IUCN extensions building proves that the annual energy use is able to hit the MinergieP target.

In a general way, the building designed according to Minergie Standard shows a coherent behaviour between design parameter and real measurements. It is valid for peak power demand for heating and cooling and lighting power. On the other hand the calculated energy use doesn't fit that exactly to the real building consumption. The main reason for that is that standard calculation does not correspond to real behaviour and occupation scheduled. Variation from +/- 20% can be expected. Important for high performance buildings is that the variation between calculated and real measures varies in the same percentage range as in normal buildings. Based on a low net energy need for heating of 22 kWh/m² per year, the result can vary of 4.4 kWh/m². On this low level of energy consumption it is more than comprehensive that the user behaviour has a higher impact than on normal buildings. In general MinergieP buildings have kept their premises in terms of energy savings if used as designed.

Key figures	
Net floor area	4 530 m²
Volume of building according to SIA 116:	31 700 m³
Volume of building according to SIA 416:	26 115 m³

Technical concept of nnZEB:

- Optimized building envelope with **25% glazing ratio**
- External blinds for effective solar protection
- U value for exterior walls of 0.1 W/(m² K), for walls with triple glazing of 0.5 W/(m² K) and for windows 0.7 W/(m² K)
- Decentralised ventilation units for supply air with facade intakes
- Central exhaust units on the roof with heat recovery with reversible exhaust air heat pump
- Ceiling panel for heating and cooling, a multifunctional panel with integrated extract air terminal and lighting
- Boreholes for free cooling (30% of the cooling need)
- Ground source reversible heat pump for heating and cooling
- Rain water collector and grey water system

Annual total delivered electrical energy use (including user appliances)	289 MWh
Electrical output of photovoltaic system:	
PV installed power	150 kWp
Produced energy (calculated)	140 MWh/a
Delivered energy use (all electricity, including user appliances)	64 kWh/(m² a)
On site electrical energy production with PV	31 kWh/(m² a)
Net delivered energy use	**33 kWh/(m² a)**
Primary energy use	**66 kWh/(m² a)**
Saving of drinking water	around 4 000 litres a day

Simple and reliable constant pressure ventilation for nZEB

Skanska has cut energy use of ventilation to a quarter in ten years

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Jonas Gräslund, Technical Director in Skanska Commercial Development Nordic. Jonas has been in Skanska for 14 years. Before that HVAC designer in 14 years. M.Sc. degree in Mechanical Engineering. Skanska CDN does project development of offices, retail and logistics in the major Nordic cities.

There are many ways to reduce energy use and to achieve good energy performance in commercial buildings. Regarding ventilation and air conditioning, a popular way is a complicated decentralised system with many air handling units placed on the office floors and the reduction of the air flows locally by using a huge number of electromechanical equipment such as motorized supply air diffusers, one per office module. Another way is the non complex one, utilising the increased performance of the system by reducing air flow speed in both in the ductwork and through the air handling units, and keeping the number of motorized components on the office floors and number of AHUs low.

By using the second path, the non complex one, we have achieved a reduction of energy use for ventilation in our office buildings from 40 kWh/m² rentable area down to 11 kWh/m², including both supply air heating energy and fan energy. This has been achieved mainly due to increased performance of AHUs as a result of LCC-purchase procedure of AHUs as a routine in our project development. How is that possible?

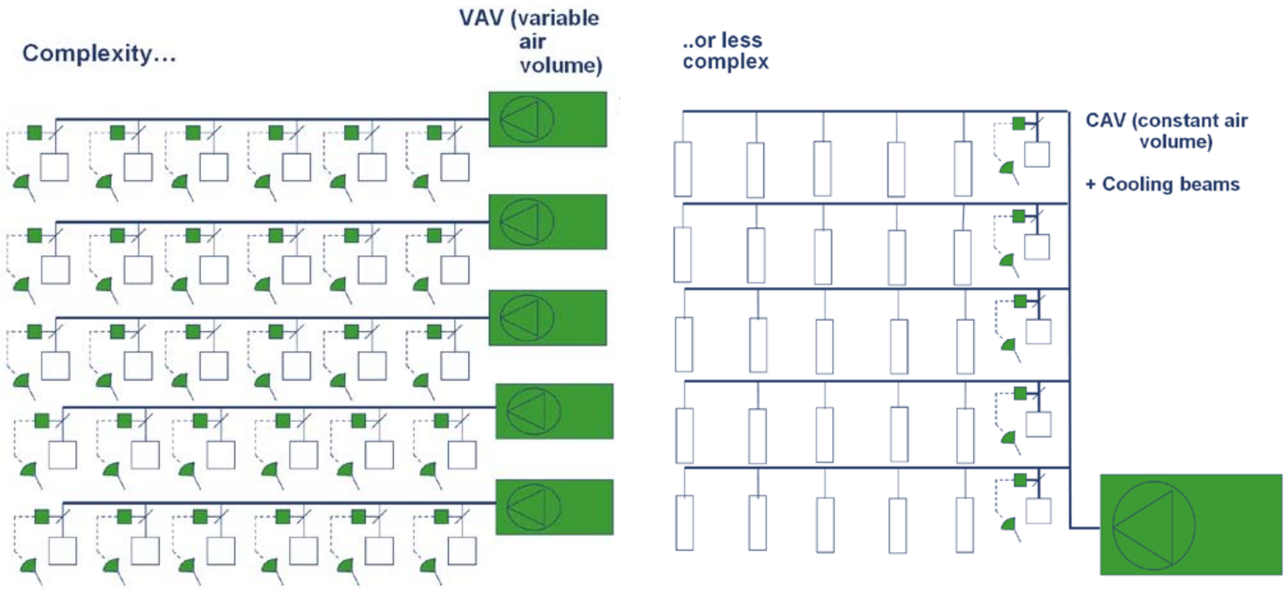


Figure 1. Complex solution vs. less complex solution. Left figure shows VAV system with motorized supply air diffusers for all office modules. In the right figure, dampers are used only to control air flows in the meeting rooms. Balancing, commissioning and maintenance are easier in more robust CAV system.

Duct work with final pressure drop

For a property owner, continuous tenant outfits are a part of the normal business. This causes problems due to expensive tenant outfit when having to do change of installations also in ductwork in distribution routes in the corridor above suspended ceiling.

The traditional sizing of ductwork with approx 1 Pa/m pressure drop gives almost constant speed in ducts and decreasing diameters of the ducts along the corridor and ends up with a small duct diameter at the end of the corridor. If a tenant wants to move a meeting room to the end of the corridor, the distribution duct has to be replaced for a number of meters by a duct with a larger diameter up to the point where you have the right diameter in the distribution duct. It could be many meters of ducts to be replaced. The rooms connected to the distribution duct from shaft to the end of the distribution duct have to be rebalanced when using the traditional sizing. Traditional sizing for a constant pressure drop results in a high static pressure in the shaft normally about 250 – 300 Pa and a low static pressure in the last supply air diffuser in the end of the corridor normally 40 Pa.

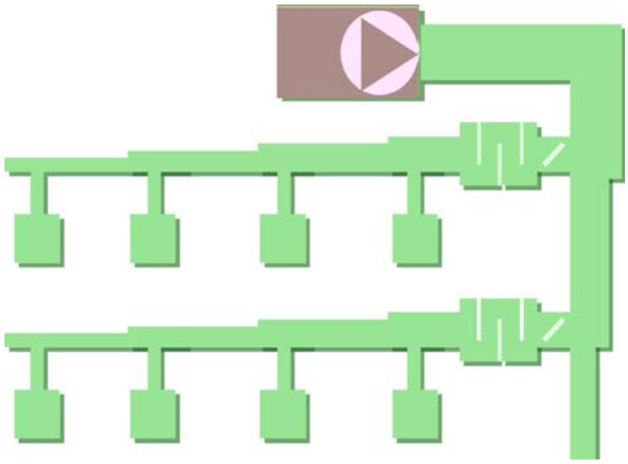
We have overcome this problem by using untraditional design, sizing for final pressure drop. The maximum speed in ducts are limited to 5 m/s in vertical duct in shafts and static pressure to 120 Pa, and the maximum speed 3 m/s in distribution duct on the office floors and static pressure to 100 Pa. The trick is to follow the maximum speed requirement with larger ducts and not to reduce the diameter of the ducts. The ducts on the floors are one size all the way.

That results in a reduced air speed in the distribution duct when air flow decreases all along the way to the last connected supply air diffuser. The pressure drop per meter will decrease instead of being constant. At the end of the duct in the corridor there will even be a slightly increased static pressure when dynamic pressure turns into static pressure:

$$P_{dyn} = \frac{\rho v^2}{2} = \frac{1.2 \times 3^2}{2} = 5 \text{ Pa.}$$

The requirement for the supply air diffuser to be able to use final pressure drop, is a pressure drop over the supply air diffuser including the damper in the supply air diffuser of 100 Pa and induced noise not higher than 28 dB(A). Most of the manufacturers have such products in their portfolio. When we check the static pressure in the distribution ducts on the office floors, the pressure is approx 100 Pa both in the beginning of the duct and in the end of the duct. It is really constant pressure in the ducts on the floors in the final pressure ductwork.

Traditional ventilation



Final pressure drop ventilation

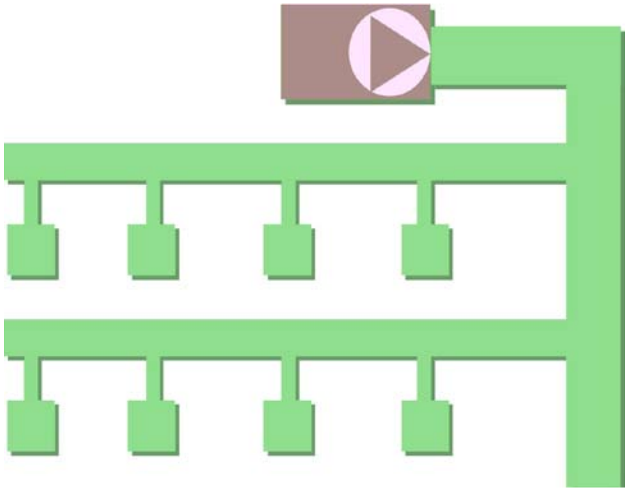


Figure 2. Traditional ductwork with dampers, silencers and decreasing diameters compared to final pressure drop ductwork with constant diameter and less components.

The static pressure in the ductwork will be kept constant by frequency controlled fans in AHU and pressure sensors placed in the main shafts. The ducting system will be less expensive to install, because the traditional balancing dampers and sound attenuators are replaced with larger ducts in the end of shafts and corridors. One dimension for ducts, one dimension for fittings, one dimension for brackets means less complicated mounting and logistic of material on site. No balancing dampers and sound attenuators are needed for balancing of supply air ducting system. All balancing are done in the supply air diffusers, by final pressure drop.

Figure 3. Free cooling coil as first step in the AHU. From the right: the heat exchanger that exchanges the heat from the glycol circuit in the coil in the AHU to the chilled water circuit for cooling beam system. Energy saving is approx 5 – 10 kWh/m^2 annually.

Extract ducting system is normally not problematic due to less terminals and less ducting, and they are normally more or less done with final pressure drop. For example, extract valves in toilets are excellent final pressure equipment.

LCC-purchased Air Handling Units

A Swedish industrial standard for purchasing energy consuming products such as fans, chillers etc were developed by the industry and community in cooperation to simplify the process. Both client and manufacturer use templates that standardize how to tender and how to bid, that is how to make a tender document and how to make an offer. This enables it for the client to compare the LCC offers of air handling units from different manufacturers.

We started to LCC-purchase for twelve years ago. Our specification of requirements for air handling units consists of big units between 10 m^3/s to 20 m^3/s in air flow and runaround coils (rotors) for heat recovery, and that the supplier shall be Eurovent-certified. We also require a free cooling coil as first step in the AHU that can manage all cooling beam circuit cooling demand during winter period. This coil also preheats the outdoor air in wintertime with the energy of internal heat gains, see a connection principle from **Figure 3**.

Our requirements for heat recovery efficiency and specific fan power have been increased step by step in around 30 different commercial building projects during the years.

The performance has increased from air speed of 2.3 m/s through AHU, corresponding SFP of 2.9 kW/m^3/s and heat recovery temperature efficiency of 54%, in steps during the years and developing about 400.000 m^2 rentable area in 30 projects to the latest project with air speed of 1.0 m/s through AHU, SFP of 1.3 kW/m^3/s and heat recovery temperature efficiency of 81%. When using such a low speed through AHU, sound attenuators between the AHU and the ducting system are not needed. The AHU turns "short and fat" instead of traditional "long and thin" by having large front area and no sound attenuator compared to the traditional AHU with small front area and sound attenuators in both ends of the AHU.

Figure 4. Low Speed Air Handling Unit without sound attenuators. The air flow is 13 m^3/s. The speed through the AHU is 1.6 m/s.

Air Handling Units, from 2,3 m/s to 1,0 m/s			
HagaPorten I (2000) [22 m^3/s, 2.3 m/s]	**"Trad alt"**	**Chosen alt**	
energy (fans & heating)	40 kWh/m^2	32 kWh/m^2	
heat recovery eff. η_t, %	54 %	63 %	
operation cost, €	471.000	367.000	
investment cost, €	124.000	131.000	(+7.000)
TOTAL cost, €	595.000	498.000	
Sundbypark (2003) [14.5 m^3/s, 1.6 m/s]	**"Trad alt"**	**Chosen alt**	
energy (fans & heating)	28 kWh/m^2	22 kWh/m^2	
heat recovery eff. η_t, %	60 %	66 %	
operation cost, €	211.000	168.000	
investment cost, €	72.000	94.000	(+22.000)
TOTAL cost, €	283.000	262.000	
Lustgården 14, prel. (2011) [14 m^3/s, 1.0 m/s]	**"Trad alt"**	**Chosen alt**	
energy (fans & heating)	20 kWh/m^2	11 kWh/m^2	
heat recovery eff. η_t, %	69 %	81 %	
operation cost, €	238.000	116.000	
investment cost, €	99.000	193.000	(+94.000)
TOTAL cost, €	337.000	309.000	

Figure 5. LCC evaluation and chosen alternatives. The life cycle energy cost has been calculated as net present value of 25 years of operation for supply air heating and fan power.

Increased investment cost due to chosen alternative of AHU during the years could be illustrated by the examples in the **Figure 5**. From being slightly more expensive in investment and giving a big reduction in operation cost over 25 years it becomes low-hanging fruit. As we now are doing extra investments that are more or less as big as the savings over 25 years of operation expressed as net present value, it has become high-hanging fruit.

To be sure that the equipment is according to the specification in the offer we do LCC-commissioning of AHUs. External temperature sensors are placed to the AHU, tracer gas measured air flows and current meters give the SFP and heat recovery efficiency that is compared with the specification and converted by the simulation program for the bought unit. When doing these commissions we have found wrong placed heat exchanger coils in AHU, wrong connected coils, wrong brine flow, etc. Thus, to do LCC-commission is essential.

A philosophical aspect regarding the solutions selected on LCC and LCA basis, is that it is also dependent of in which order you add the possible solutions. If you first recommend the complex system with demand controlled ventilation in all areas in order to reduce air flow, the resulting energy use will be reduced. The economical possibility also to choose the low speed AHU will then be reduced, because the remaining energy need after demand controlled ventilation in all areas is smaller. Therefore, the possibility to reduce the energy use a bit more by low speed AHU is less attractive. If you first recommend to use a low speed and high efficiency AHU and then add the demand controlled ventilation in all areas, it will be economically difficult to choose demand controlled ventilation, as the remaining energy need is low because of the energy use reduction already achieved by using the low speed AHU.

Finally, now only the high hanging fruits are left to be picked. But we are convinced that we have to stick to our strategy of simple solutions and high performance equipment in order not to get lost in all maintenance issues. 3E

Elithis Tower in Dijon, France

Elithis Tower, located in Dijon, France, provides strong evidence that net zero energy office buildings are achievable in near future. The building, which was designed by Arte Charpentier Architects, also produces six times fewer greenhouse gas emissions than traditional office structures.

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Elithis Tower: development, planning and actors	
Financing:	ADEME, Conseil Regional de Bourgogne
Net construction costs:	EUR 7 millions, 1 400 € per m² (equals the cost for a standard building in France)
Project Team:	Elithis Ingénierie, ARTE Charpentier.

The Elithis Tower is an experimental and demonstration building. Experimental because many R&D are being done in order to improve energy performance. Demonstration because the principal objective was to erect a nnZEB building with architecture fitted to an urban environment.

An environmental protocol was signed by all the permanent co-owners of the Elithis Tower in order to ensure to lowest impact between user's behavior and the building. The energy production of the building in kW per hour and the greenhouse gas compensation is permanently projected to the advertising board on the public road.

Thermal comfort, indoor air quality and energy use are being constantly monitored with 1600 data points installed all over the building. In addition, occupant surveys are done for the users. Users are asked to fill in a questionnaire at the same time as the environmental variables are being recorded through the BEM system. The study began in June 2010 and the first results report a general comfort level of 72% (winter season) including thermal and visual comfort and indoor air quality.

Building description

The main aim of the building is to use passive means and natural resources such as sun and wood to achieve thermal and visual comfort in the building.

In order to improve the best performances in natural lighting the Elithis Tower was designed in an open plan distribution. Unfortunately, this configuration wasn't adopted all over the building (medical services). Most part of the offices are in an open plan distribution. But for the other offices a glass wall and insulated wall division was installed. The open plan distribution could ensures,the best internal air distribution, this solution gives the possibility to perform the air contact with the walls and to reduce the energy requirements for the cooling and heating

Table 1. Climate data.

Design outdoor temperature for heating	-11°C
Design outdoor temperature and RH for cooling	32°C / 38%
Heating degree days (base temperature)	2 650 Degree days (base 18°C)

Table 2. Summary of key building parameters.

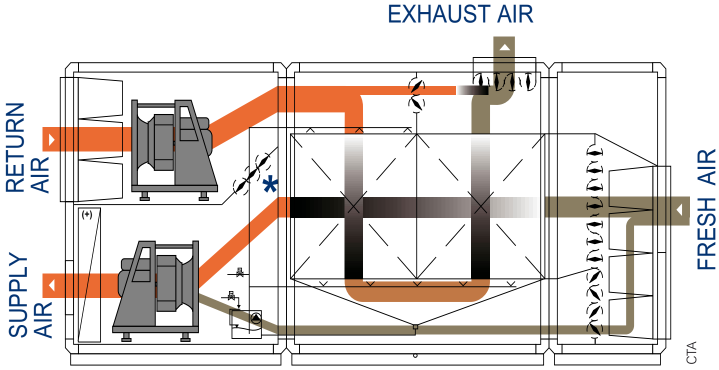
Building type	Office
Net floor area	4 500 m^2
Gross floor area	5 000 m^2
Gross volume	16 7500 m^3
Mean occupant density	15 m^2/person (overall average)
Occupied hours	2 450 h

Table 3. Building envelope data.

Window U-value	1.1 W/(m^2 K)
Window g-value	0.4
Exterior wall U-value	0.32 W/(m^2 K)
Base floor U-value	0.39 W/(m^2 K)
Roof U-value	0.22 W/(m^2 K)
Structural frame	Heavy weight (concrete & steel)

The Elithis tower is composed of 9 levels and 1 technical level (HVAC system). The height is 33.5 meters. 4 levels are occupied by Elithis engineering, and the others by the Ademe (Departmental Agency of Energy Management), radiological services, a restaurant and other civil engineer companies.

The building has a central core made of concrete and the facades are made of wood and recyclable insulation (cellulose wadding). The surface fenestration is about 75% of the facades. The windows are double-glazed with an argon air space. The thermal mass of the building can be considered as medium because the central core only is the exposed concrete.



Ventilation operation with controlled heat recovery during typical outdoor temperatures in the heating season.

A photo of the façade intake.

DESIGN CONCEPTS

1. Compact building shape

Elithis Tower has very compact rounded shape effectively reducing building envelope area. The architecture was carefully studied in the design. The building envelope area of the Elithis Tower is about 10% less than in a conventional tower. Reducing the surface has a positive effect regarding heat losses and solar gains. Similarly the exposure to the wind is reduced so the infiltration can be better controlled. In the same time, the air distribution in the mixed ventilation mode, can be more homogeneous thanks to the rounded shape.

2. The passive solar shading.

In order to combine natural light, avoid glare and reduce solar gains, a special solar shading shield was designed by the Elithis engineers and architects. This passive system gives to the building the necessary natural light and the solar glare protection in summer and mid-season, while excess heat is utilized to heat the building in winter. The system was carefully studied in order to retrieve the necessary solar energy during the winter season and to protect the building during the hot periods.

3. Ventilation strategy

The building is ventilated by mechanical supply and exhaust system with heat recovery controlled by the BEM system in order to comply with the French ventilations standards codes (25 m^3/h per person in offices). The ventilation system is operated in three modes depending on the season.

For typical heating season operation (outdoor temperature higher than 0°C), operation with controlled heat recovery is used to heat up supply air with heat recovered from extract air. Heat recovery is controlled/bypassed so that supply air temperature is between of 16 to 18°C. The full heat recovery operation is used for extremely cold or warm outside conditions (less than of 0°C in winter or higher than 26°C in summer).

In the mid-seasons (spring and fall) and summer operation, the triple flow mixed mode system which is an Elithis innovation, is used. It gives the possibility for ventilative cooling with fresh air intakes and central atrium exhaust ventilation in order to cool the building. 32 air valves in facades per level are used to have additional intake air. In this mode, air handling units are operated together with intake air from facades and atrium low pressure exhaust fans.

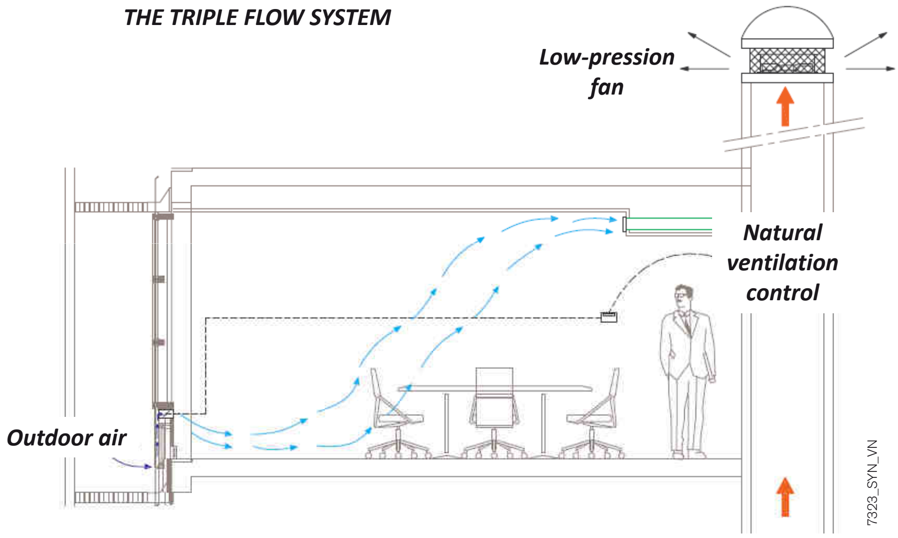
The third operation mode is the free cooling. Air handling units are stopped and atrium exhaust used in order to ventilate the building in night summer time. In this mode, the building can be ventilated with low pressure central atrium exhaust ventilation. The 32 air valves are opened in order to ventilate the building with two or three times higher flow rate than the design air flow rate.

4. Lighting system

In natural lighting, increased rate of the glass surface reduces energy use needed for artificial lighting. The passive solar shading of the Elithis Tower protects the users from the direct solar radiation and provides an excellent natural lighting for the office tasks avoiding the glare problems.

Light fittings in the ceiling provide the average lighting (300 lux-French building standard codes) over the entire office space. For the low lighting outdoors levels, at night or very cloudy days, motion sensors were coupled with lighting sensors. This solution provides the perfect compromise between energy use and lighting requirements. Installed lighting power is only about 2 W/m² of electrical energy. For tasks requiring a higher level of illumination, task lighting with "Nomadic lamps" is used. All this is controlled by the BEM system.

THE TRIPLE FLOW SYSTEM



In the mixed mode operation, façade intakes and low pressure atrium exhaust fans are used. This is used for the night time ventilative cooling, and in the midseason, when the ventilation by air handling units is forced for cooling purposes.

Chilled beams cassettes and lighting installation.

5. Heating and Cooling system

The major part of the heating needs is covered by solar and internal heat gains. For the rest of heating needs, one very low-power wood boiler provides the heat in order to ensure the thermal comfort. A second one wood boiler is used only for back-up. This system is used to maintain the 21°C room temperature all over the building.

The triple flow ventilation system covers the most important part of the cooling needs. When room temperatures reach 26°C, a cooling system consisting of adiabatic unit and heat pump are started to operate. This heat pump system with a high EER of (EER=11) provides air conditioning of the building. It's in a two stages. The first one is an adiabatic process; the heat is evacuated by the water evaporation. The second stage of the heat pump is only needed to operate for extremely outside weather conditions (outdoor temperature higher than 30°C).

6. Heating and cooling distribution

Chilled beams of a rectangular cassette size are use as room conditioning units both for cooling and heating and ventilation supply air. Chilled beams are induction devices circulating room air through the coil. Circulating air flow is induced by supply air nozzle jets integrated into chilled beams. 32 chilled beams are installed per level and controlled by the BEM system.

7. Water management

Water management is written in the policies of the Elithis Tower. A rain water recovery system is used to supply the toilets of the building. All fixtures and fittings such as sink faucets and toilets aims to very low water consumption in order to preserve the water resource.

Energy performance

The energy concept of Elithis Tower is to balance the primary energy of all energy uses with the PV electricity generation and the user behavior. A building by itself can't be nnZEB without a good operation and maintenance and users behavior. The Elithis Tower has a very low ratio of installed PV area to the floor area. The very low energy use of the building is balanced by only 500 m² of Photovoltaic's roof panels. The PV panels are

Table 4. Simulated and measured energy performance of the building after the first year of operation. All specific values are per gross floor area. For the net floor area values, the values in the table are to be multiplied with factor of 1.1.

	Design phase			Measured 2009
	Net delivered energy use kWh/(m^2 a)	**Primary energy factor** -	**Primary energy use** kWh/(m^2 a)	**Primary energy use** kWh/(m^2 a)
Space, water and ventilation heating, wood boiler	3.3	0,6	2.0	6.3
Cooling, electricity to heat pumps	4.1	2,58	10.6	6.2
Fans (HVAC)	5.1	2,58	13.1	14.1
Pumps (HVAC)	0.4	2,58	1.1	2.6
Lighting	4.1	2,58	10.5	9.5
Elevators	1.4	2,58	3.6	3.6
Appliances (plug loads)	9.4	2,58	24.2	54.6
PV power generation	-16.0	2,58	-41.3	-40.2
Total	**12**		**24**	**57**

installed with a horizontal inclination in order to maximize the generation.

An energy management system with 1 600 data points allows the control and the management of all technical systems (HVAC, lighting, elevators). Many energy meters are installed in all the building, to make it possible to know energy use on the system and component level. Simulated and measured energy performance of the building after the first year of operation is shown in **Table 4**.

The highest component in the energy balance are the appliances (plug loads), which include all user electricity, i.e. computers and other office equipment, cafeteria and also data servers. This component shows also highest deviation from the design value when all other components follow well design values. The differences between the theoretical patterns and the reality can explain this difference. As the user behavior has been the most important reason to explain the differences in the energy balance of the building, Elithis Engineering is currently analyzing the problem and there are many changes planned to be implemented in order to reduce that energy use.

Measured total primary energy use for the first year of operation year has been 63 kWh/(m^2 a) per net floor area, 57 kWh/(m^2 a) per gross floor area as calculated according to French standard, which is 33 kWh/(m^2 a) higher than designed, due to higher energy use of appliances. (Editor's comment: If compared to two other cases studies and calculated with primary energy factor 2.0 for electricity, the primary energy value of 63 will decrease to 50, being the lowest one of the case studies reported in this issue.)

The primary energy values reported include all energy use in the building, such as cafeteria, data servers and all other activities in the building. Even the monitored primary energy value of 57 kWh/(m^2 a) is higher than designed, it places the Elithis tower very close to high performance net zero energy building. The design value, not reached during the first year of operation, will remain the main objective in future operation.

Experience from the operation

After nearly two years of operation, some improvements have been made or forecasted:

- At the beginning, the electricity used to light the stairways was higher than the electricity for the elevators. The problem was in the stairways lighting control, which proved to be very important because there is no natural lighting. Today a new lighting programming is studied to solve the problem.
- The energy use predicted for the appliances was underestimated. The lesson is learnt and in future this will need more careful prediction. At the beginning the device cut-off computer power was not used as expected and an awareness protocol was implemented in order to reduce the electricity use. Today the systems seem to work and an energy reduction has been achieved.
- Occupants and visitors of the Elithis Tower are satisfied. The general feeling is very satisfactory because the environment is very attractive compared with other buildings

New REHVA website

During the REHVA Annual conference and meeting in Tallinn, Estonia in May 2011, REHVA launched a redesign website with new sections like **EU regulations** and **REHVA Journal**. In the **EU regulations** section you can find information related to the heating, ventilation and air conditioning in buildings. There you will find out what's new in EU legislations, EPBD, Eco-design, Renewable sources directive, Building labeling, IEQ, CEN and ISO standards, F-Gas and EU Projects. In the **REHVA journal** section, you can view all the 2011 issues of the REHVA journal, totally free of charge. You can also download your preferred articles. To view or download the articles of the latest REHVA journals in PDF and HTML formats, please visit **www.rehva.eu**.

REHVA Dictionary

For professionals by professionals

The REHVA dictionary is a reliable glossary of technical words and terms used in the building services. The dictionary is made by professionals for professionals. Available **freely** to everyone, with more than 12 000 words translated in 14 languages, it is an up to date user friendly glossary. Romanian and Croatian are the two languages that will soon be added to the REHVA dictionary.

Current 14 languages:
Danish, Dutch, English, Finnish, French, German, Hungarian, Italian, Polish, Portuguese, Russian, Spanish, Swedish and Turkish.

www.rehvadictionary.com

Alex Vanden Borre is REHVA's new Senior Project Engineer

Alex Vanden Borre started to work at the Brussels office at mid-May 2011 as REHVA's **Senior Project Engineer.** He holds a Mechanical engineering degree with automation specialisation. His career has been focused on the HVAC field within installers companies, engineering offices or suppliers of HVAC equipment. His last 5 years were dedicated to internal technical trainings on Controls of HVAC systems on the air and water side for fulfilment teams in Europe, Middle-East, India and Africa. You can reach him at: avb@revha.eu

REHVA Journal 2012 issues

3 The April issue of the REHVA Journal (3/2012) will focus on **Effect of EPBD on HVAC systems and buildings** – Articles are due by 20 February. The guest editor of this issue is Mr Eduardo Maldonado. E-mail: ed.maldonado@netcabo.pt

4 The August issue of the REHVA Journal (4/2012) will focus on **Ventilation and Indoor air quality** – Articles are due by 3 July. The guest editor of this issue is Bjarne Olesen. E-mail: bwo@byg.dtu.dk

News from the European Commission

Energy Efficiency Directive

A new set of measures for increased Energy Efficiency is proposed by the European Commission to fill the gap and put back the EU on track. This proposal for this new directive brings forward measures to step up Member States efforts to use energy more efficiently at all stages of the energy chain – from the transformation of energy and its distribution to its final consumption.

The Commission proposes simple but ambitious measures:

- Legal obligation to establish energy saving schemes in all Member States
- Public sector to lead by example
- Major energy savings for consumers

The Policy concepts in the new EED:

- Energy efficiency obligation: Member States make sure that an equivalent of 1.5 % of annually energy sales are saved through energy efficiency measures
- Public sector lead by example: annual renovation works covering at least 3% of total floor area of their buildings
- Consumers: individual metering for better energy management
- Industry: obligations for larger companies to undergo energy audits, incentives for small and medium sized companies
- Energy generation: monitoring of new energy generation capacities
- Energy transmission and distribution: national energy regulators should decide taking energy efficiency criteria into account

See the proposed directive at: www.rehva.eu/en/energy-efficiency-directive

Energy performance of buildings directive EPBD

What are the recent developments on EPBD?

Regulation on the cost optimal framework methodology:

Cost-optimal framework methodology was introduced at the previous issue of the Journal. The final version for Cost optimal framework has been accepted and will be published soon. REHVA has established a Task Force to help defining the required national reference buildings.

The EPBD recast instructs Member States on how to set energy performance requirements "with a view to achieving cost optimal levels". The Cost optimal is define as "the energy performance that leads to the lowest cost during the estimated economic lifecycle" (the latter determined by MS) Art 2 (14) EPBD. The purpose is to establish the cost optimal benchmark for every MS through calculation and using this to assess the current requirements of that MS. The purpose is not to compare across MS. The framework is to be used by MS authorities and not by the market.

There is an equivalent level of ambition in all MS, but no harmonisation of requirements. Cost optimality will also become the reference point for EU funding (EEE-F, ERDF).

Cost optimal and nearly zero energy building: Art 4 and Art 9(6) state MS may not be obliged to set net cost effective requirements over the estimated economic lifecycle. The method needs to ensure the phase in of nZEB and its technology. Boundary definition in CEN standard also needs to be adjusted to account the active RES. What is the priority for the Energy Efficiency?

- **Transposition of recast Directive** (deadline July 2012), 2002/91/EC to be repealed by Feb 2012: ongoing
- **Member States have to report on financial and other supporting measures** to the Commission: Deadline for 30 June 2012
- **CEN received mandate** for revision of 31 CEN standards
- **Development of a voluntary EU-wide certification scheme** for non-residential buildings: ongoing

Ecodesign of energy related products directive (ErP)

Lot 6 Air conditioning and ventilation systems

The preparatory study, analysing whether and which ecodesign requirements should be set for large air-conditioning and ventilation products (ENTR LOT 6), is running from 01/2010 until 5/2012. The selected contractor is Armines, France (Contact: Philippe Rivière, philippe.riviere@mines-paristech.fr). Stakeholders are encouraged to register at the website of the study: www.ecohvac.eu and contact the contractor.

The second stakeholder meeting was held on 30 September 2011 in Brussels. The documents for the meeting, including presentations, are available on the website of Lot 6. The "Ventilation" part of the study is now concentrating on air handling units (AHU's), possibly also including the heating function (see Lot 21). There are discussions ongoing among stakeholders about the ecodesign criteria, including how to deal with characteristics like SFP (Specific Fan Power) that depend on the air distribution system. Another "hot" discussion topic is about the borderline between "large" and "small" units/fans, or between "residential" and "non-residential" ones. Of course any fixed borderline is more or less artificial, but it is now under discussion to solve this borderline question by giving the manufactures an advice to state the intended use of the product (residential vs non-residential). One reason to this borderline discussion is the fact that standards for "residential" and "non-residential" ventilation are somewhat different. The discussions still go on.

Lot 21 Central heating products – Lot 20 Local room heating

For both studies, second stakeholder meetings were held in the end of September 2011. The documentation as well as the presentations are linked on the websites of the studies (these are also linked to each other). The "Documents" pages. According to the slide presentations, the scope and products concerned are now clearly proposed for both studies. Here just the main product groups:

- Lot 20 – Residential room heaters (electric, gas, liquid fuel), non-residential room heaters (warm air unit heaters, radiant heaters, air curtains)
- Lot 21 – Gas, oil and electric furnaces, multi-fuel furnaces, various heat pumps

The Lot 21 Documents page also contains an interesting document dealing with air handling units, advising to consider AHUs only in the ventilation part of ENTR Lot 6 study. This would be very welcome, avoiding a total split-up of product functions.

Lot 10, air conditioning: The launch of Inter Service Consultation happened in November 2010. The vote in Regulatory Committee was made on 31 may 2011. Scrutiny and right of objection ended in October 2011.

EU Ecolabel and Green Public Procurement Criteria for office buildings

Labelling of products and buildings – The second stakeholder workshop for office buildings will be held in Brussels on 30 November 2011. Documents for the meeting will be posted in the relevant webpage in early November. The second stakeholder workshop for Hydronic Central Heating Generators will be held in Brussels on 29 November 2011, documents also expected on the project webpage in early November. Green Public Procurement Procurement workshop tentatively for Wednesday 18th of January 2012 in Brussels.

Find more on:
www.rehva.eu/en/labelling-of-products-and-buildings

EU Ecolabel
www.ecolabel.eu

EVENTS 2012

13 March	Round table "Normative and methodological support in the design and construction. ABOK Standards System TM" in the framework of the "Climate World"	Moscow, Russia	www.abok.ru
22 – 23 March	Norwegian Cooling Technology Conference	Bodo, Norway	www.nkm2012.no
29 March	4th International Symposium Solar and Renewable Cooling	Stuttgart, Germany	www.cep-expo.de
30 March	6th International Conference on Application of Biomass Gasification	Stuttgart, Germany	www.cep-expo.de
29 – 31 March	CEP® Clean Energy & Passivehouse 2012	Stuttgart, Germany	www.cep-expo.de
28 March	REHVA and AICARR seminar at MCE, HVAC in Zero Energy Buildings	Fiera Milano, Italy	www.rehva.eu
9 – 15 April	Simurex 2012	Cargese, France	http://simurex.ibpsa.fr/
16 April	REHVA Seminar in Light and Building	Frankfurt, Germany	www.rehva.eu
17 – 20 April	REHVA Annual Conference and Meeting	Timisoara, Romania	www.rehva-am2012.ro
17 – 19 April	XVI European AVOK-EHI Symposium "Modern energy-efficient equipment for heating, water and air-conditioning of buildings"	Moscow, Russia	www.abok.ru
18 – 21 April	International construction forum Interstroyexpo 2012	St. Petersburg, Russia	www.abok.ru
26 – 27 April	Focus on Renewable District Heating and Cooling	Copenhagen, Danmark	www.euroheat.org/
30 April – 2 May	X. International HVAC+R Technology Symposium	Istanbul, Turkey	www.ttmd.org.tr/2012sempozyum
24 – 25 May	Romanian International Conference on Energy Performance of Buildings "European Solutions and Policies for Sustainable Urban Development: Theory and Practice"	Bucarest, Romania	www.aiiro.ro
24 – 25 May	Conference on "Creating a Climate for the Desired Objects of Cultural Heritage: Monuments, Museums, Buildings for Religious Purposes"	Moscow, Russia	www.abok.ru
6 – 8 June	Conférence IBPSA France 2012	Chambery, Fance	http://www.ibpsa.fr/
18 – 22 June	EU Sustainable Energy Week 2012 in Brussels	Brussels, Belgium	www.eusew.eu
25 – 27 June	10th IIF/IIR Gustav Lorentzen Conference on Natural Refrigerants	Delft, The Netherlands	www.gl2012.nl
25 June – 8 July	Holiday Housing Fair	Lappeenranta, Finland	www.asuntomessut.fi
8 – 12 July	Healthy Buildings	Brisbane, Australia	www.hb2012.org/
12 July – 12 August	Housing Fair 2012	Tampere, Finland	www.asuntomessut.fi/en/housing-fair-2012-tampere
3 – 7 September	ICCCS 2012 - International Symposium on Contamination Control 2012	Zurich, Switzerland	www.icccs2012.ethz.ch
14 September	33 rd AICVF Congress	Brodeaux, France	http://aicvf.org/blog/agenda/congres-2012/
17 – 19 September	Ventilation 2012	Paris, France	www.inrs-ventilation2012.fr
10 – 11 October	33rd AIVC Conference and 2nd TightVent Conference	Brussels, Belgium	www.aivc.org
17 – 19 October	47th Conference of Plants – "Plants for the Early Third Millennium"	Sinaia, Romania	www.aiiro.ro
12 – 14 November	7th International HVAC Cold Climate Conference	Calgary, Alberta, Canada	http://ashraem.confex.com/ashraem/icc12/cfp.cgi
5 – 7 December	43th International congress of Heating, Air Conditioning and Refrigeration	Belgrade, Serbia	www.kgh-kongres.org/

FAIRS 2012

23–25 February	ACREX 2012	Bangalore, India	www.acrex.org.in/
29 February - 3 March	SINERCLIMA 2012	Batalha, Portugal	www.eventseye.com
20 – 22 March	ecobuild 2012	London, United Kingdom	www.www.ecobuild.co.uk
20 – 23 March	NORDBYGG 2012	Stockholm, Sweden	www.nordbygg.se
27 – 30 March	MCE - Mostra Convegno Expocomfort 2012	Fiera Milano, Italy	www.mcexpocomfort.it
15 – 20 April	Light + Building	Frankfurt, Germany	www.light-building.messefrankfurt.com
17 – 19 April	XVI European AVOK-EHI Symposium "Modern energy-efficient equipment for heating, water and air-conditioning of buildings"	Moscow, Russia	www.abok.ru
2 – 5 May	ISK - SODEX 2012	Istanbul, Turkey	www.hmsf.com
10 – 12 May	RENEXPO® CENTRAL EUROPE, 6. International Energy Trade Fair	Budapest, Hungary	www.renexpo.hu
9 – 11 October	Chillventa 2012	Nuremberg, Germany	www.chillventa.de/en/
9 – 11 October	Finnbuild 2012	Helsinki, Finland	www.finnbuild.fi
17 – 18 October	CEP® Clean Energy & Passive House Expo	Budapest, Hungary	www.cep-expo.hu

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Search level	Criteria
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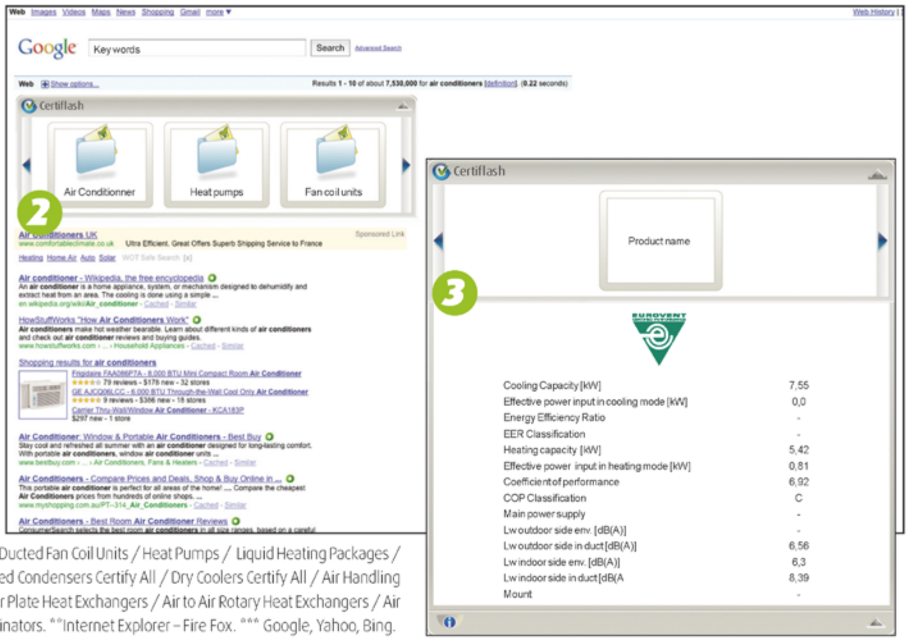
3	Product classification
4	Product range
5	Product reference

3 Click on the reference to display the product characteristics. The technical data sheet appears on the search engine results page.



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