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Federation of European Heating, Ventilation and Air-conditioning Associations

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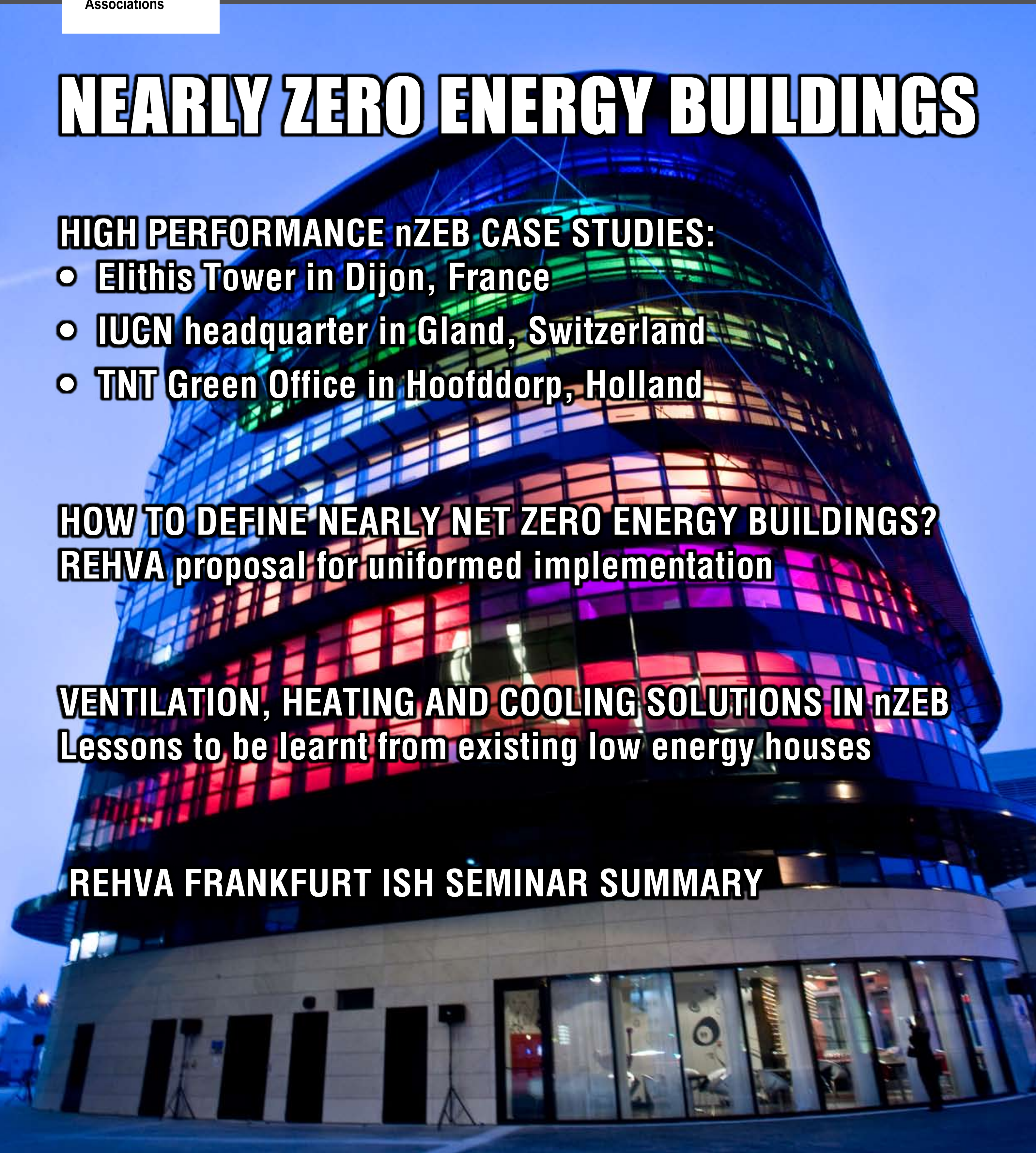
# NEARLY ZERO ENERGY BUILDINGS



## HIGH PERFORMANCE nZEB CASE STUDIES:

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### IN THE NEXT ISSUE OF REHVA JOURNAL
The theme of the August issue (4/2011) of REHVA Journal is
***Heat pumps and use of renewable energy sources*** - Articles due 23.6.2011.
The Guest Editor of issue 4/2011 is **Dr. Signhild Gehlin** from Sweden: gehlin@emtf.se

Jarek Kurnitski
GUEST EDITOR

# Nearly zero energy buildings nZEB

We are still far from common understanding of nearly zero energy buildings, but there is also some time left, about 7-9 years, before all new buildings are expected to be nZEB. No need to start from the beginning, because EPBD has already established a common methodology and today energy performance is expressed in primary energy in most of member states. This is however not enough for nZEB, needing much more specific definitions to be understood in uniform fashion.

As currently not defined exactly, there already exist advertisements about nZEB buildings, which in reality are not nZEB and can cause major confusion. Quite common buildings can be manipulated to look like nearly zero energy, if all energy flows are not taken into account and poor appliances considered. An apartment building with couple of PV panels and high internal loads used in the calculations becomes easily nZEB if electricity of the households is not accounted. In such a building, there is a little of other electricity use, appliances are enough for heating on monthly bases and cooling can be intentionally excluded.

REHVA has an important role in nZEB implementation. REHVA Task Force has resulted in the proposal, how national nZEB definitions can be uniformly established and at the same time national conditions taken into account. Now it is up to REHVA members to make this proposal available for relevant national bodies. Everybody understands that 27 different national definitions will make no sense.

Definitions are important, but how to construct nZEB? Case studies of high performance nZEB office buildings, reported in this issue, prove that nZEB can be built with reasonable technical solution, and even net zero energy office buildings are reachable in near future. "Reasonable" means in this context an additional construction cost of 10%, mainly due to on site energy generation like PV panels. As this is already in many countries compensated with feed in tariffs, and other technical solutions needed are mostly cost effective, one can believe that nZEB buildings will be cost optimal, at least from the viewpoint of society. In residential buildings, nZEB is technically less complicated, thus there is really not many technological barriers.

For the engineering, there is indeed a lot of challenge. Not all projects can be flagship projects. Should one use less or more complicated solutions, more control and automation or utilization of self controlling features? How to ensure that mixed mode systems are operated by users as expected in design? There are no simple answers. Evidently we need improved performance, meaning improved performance of components and systems, but also system integration for utilization of passive means and integrated design for the whole building performance. At the same time, advanced systems and solutions are needed, but overkill complexity is to be avoided, because somebody has to able to install, balance, operate and maintain the systems and buildings. There are promising examples available, showing that careful design and optimization can lead to simple and reliable solutions, couple of such reported in this issue.

Lessons are to be learnt from low energy buildings such as passive houses and similar mistakes be avoided in nZEB. Overheating is reported very commonly, insufficient heating is also reported… Even a simple nZEB detached house is so complicated thermal system with internal gain utilizations needing a dynamic simulation to be relevantly solved for achieving comfortable indoor climate. Obviously engineers have not enough capacity as well as nonprofessional construction clients are not willing to pay for detailed design of every house. Standardized solutions for larger deliveries are probably only way to overcome the problem.

It is good question, who has to take the responsibility? It looks like a good chance for contractors, manufactures and engineering companies to raise the profile and utilize partnership based business models. At the end of the day, clients, both professional and nonprofessional expect the performance: comfortable buildings meeting energy and indoor climate specifications. How many service providers are ready to deliver multiple systems and take responsibility not only for the systems performance but also for energy and indoor climate? How many main contractors have procedures for performance contracting? nZEB performance delivery is creating challenge for the whole supply chain of construction and manufacturing industry, however positive examples with controlled process and delivery can be found, and not only in pilot projects. 3E


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# How to define nearly net zero energy buildings nZEB

## – REHVA proposal for uniformed national implementation of EPBD recast

*Jarek Kurnitski, Francis Allard, Derrick Braham, Guillaume Goeders, Per Heiselberg, Lennart Jagemar, Risto Kosonen, Jean Lebrun, Livio Mazzarella, Jorma Railio, Olli Seppänen, Michael Schmidt, Maija Virta*

**Summary**

This REHVA Task Force proposes a technical definition for nearly zero energy buildings required in the implementation of the Energy performance of buildings directive recast. Energy calculation framework and system boundaries associated with the definition are provided to specify which energy flows in which way are taken into account in the energy performance assessment. The intention of the Task Force is to help the experts in the Member States in defining the nearly zero energy buildings in a uniform way.

The directive requires nearly zero energy buildings, but since it does not give minimum or maximum harmonized requirements as well as details of energy performance calculation framework, it will be up to the Member States to define what these for them exactly constitute. In the definition local conditions are to be obviously taken into account, but the uniform methodology can be used in all Member States.

The directive defines nearly zero energy building as a building that has a very high energy performance and requires the calculation of primary energy indicator. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

Based on the directive's definition, nearly zero energy building is technically defined through the net zero energy building, which is a building using 0 kWh/(m² a) primary energy. Following the cost-optimality principle of the directive, nearly net zero energy building definition is proposed as **national cost optimal energy use of > 0 kWh/(m² a) primary energy**. In order to end up with proposed general definition, it was needed to clarify which energy flows shall be included in energy performance assessment and how the primary energy factors should be used for primary energy indicator calculation. For the uniform methodology, a general system boundary definition was established with inclusion of active solar and wind energy, as well as the guidance for technical meaning of "nearby" in the directive.

### 1. Background

The Energy performance of buildings directive recast (EPBD recast) came into force on 9 July 2010. Member States shall adopt and publish, by 9 July 2012 at the latest, the laws, regulations and administrative provisions necessary to comply with most of the articles. According to the Directive the Member States shall ensure that by 31 December 2020, all new buildings are nearly zero- energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

National roadmaps towards nearly zero energy buildings are needed for all member states. Member States shall draw up national plans for increasing the number of nearly zero-energy buildings. The national plans shall include, inter alia, the following elements:

(a) the Member State's detailed application in practice of the definition of nearly zero-energy buildings, reflecting their national, regional or local conditions, and including a numerical indicator of primary energy use expressed in kWh/m² per year. Primary energy factors used for the determination of the primary energy use may be based on national or regional yearly average values and may take into account relevant European standards;

(b) intermediate targets for improving the energy performance of new buildings, by 2015,

(c) information on the policies and financial or other measures adopted in the context of for the promotion of nearly zero-energy buildings.

## Terms and definitions

**net zero energy building (nZEB)**
energy use of 0 kWh/(m² a) primary energy

**NOTE 1.** A nZEB is typically a grid connected building with very high energy performance. nZEB balances its primary energy use so that the primary energy feed-in to the grid or other energy network equals to the primary energy delivered to nZEB from energy networks. Annual balance of 0 kWh/(m² a) primary energy use typically leads to the situation where significant amount of the on-site energy generation will be exchanged with the grid. Therefore a nZEB produces energy when conditions are suitable, and uses delivered energy during rest of the time.

**nearly net zero energy building (nnZEB)**
national cost optimal energy use of > 0 kWh/(m² a) primary energy

**NOTE 1.** The Commission shall establish by 30 June 2011 a comparative methodology framework for calculation of cost-optimal levels (EPBD recast).

**NOTE 2.** Not all renewable energy technologies needed for nearly zero energy building have to be cost-effective, if appropriate financial incentives are not available.

**energy performance of the building (EN 15316-1:2007)**
calculated or measured amount of energy delivered and exported actually used or estimated to meet the different needs associated with a standardized use of the building, which may include, inter alia, energy used for heating, cooling, ventilation, domestic hot water, lighting and appliances.

**NOTE 1.** According to EPBD, the energy performance of a building shall be expressed with a numeric indicator of primary energy use, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on- site production.

**NOTE 2.** Appliances (households and outlets) are added to the original definition of EN 15316-1:2007.

**delivered energy (EN 15603:2008)**
energy, expressed per energy carrier, supplied to the technical building systems through the system boundary, to satisfy the uses taken into account (e.g. heating, cooling, ventilation, domestic hot water, lighting, appliances etc.) or to produce electricity

**exported energy (EN 15603:2008)**
energy, expressed per energy carrier, delivered by the technical building systems through the system boundary and used outside the system boundary

**net delivered energy (EN 15603:2008)**
delivered minus exported energy, both expressed per energy carrier

**NOTE 1.** net delivered energy values are expressed separately for each energy carrier, i.e. for electricity, fuels, district heat, etc.

**primary energy (EPBD recast)**
energy from renewable and non-renewable sources which has not undergone any conversion or transformation process

**$CO_2$ emission coefficient (EN 15603:2008)**
for a given energy carrier, quantity of $CO_2$ emitted to atmosphere per unit of delivered energy

**NOTE 1.** The $CO_2$ emission coefficient can also include the equivalent emissions of other greenhouse gases (e.g. methane).

**system boundary (EN 15603:2008)**
boundary that includes within it all areas associated with the building (both inside and outside of the building) where energy is used or produced

**NOTE 1.** all areas associated with the building typically refers to footprint of the building site.

A recent benchmarking study on implementation on EPBD 2002 by REHVA (Seppänen & Goeders 2010) revealed a large variation in the technical regulations of the different countries. These differences in regulations have a significant effect on the building industry, and complicate manufacturing, sales, installation, construction and design of buildings in the common market area.

REHVA experts have realized the problem various definition of nearly zero energy building may cause in Europe. An important issue is how to define the various energy flows and how to establish the energy boundaries on the building. This paper reports the results of REHVA Task Force "Nearly Zero Energy Buildings". REHVA hopes that this report that focuses on definitions and energy boundaries will help the experts in the member states in defining the nearly zero energy buildings in a uniform way. This would help in understanding the policy options and in exchanging information of most energy efficient technical solutions for buildings.

## 2. Proposed general definition format for nearly net zero energy buildings

The following general definition format is proposed to clarify the exact technical meaning of EPBD recast requirements in order to support national implementation. EPBD recast requires nearly nZEB buildings, but since it does not give minimum or maximum harmonized requirements as well as details of energy performance calculation framework, it will be up to the Member States to define what these for them exactly constitute. The following proposal includes energy calculation framework specifying how to define the various energy flows and how to establish the energy boundaries on the building, affecting the performance levels of nnZEB building definitions. This guidance will help the experts in the member states in defining the nearly zero energy buildings in a uniform way.

Nearly net zero energy building definition shall be based on delivered and exported energy according to EPBD recast and EN 15603:2008. The net delivered energy, which is delivered minus exported energy per energy carrier, is shown in **Figure 1** and described with detailed system boundary definition in Ch. 3, **Figure 3**. This system boundary definition is a general form modified from the one of EN 15603:2008. Suggesting the inclusion of energy use of appliances (households and outlets), the system boundary proposes that all energy used in buildings will be accounted in net delivered energy as well as in nearly net zero energy building definition. According to that, energy use in the buildings includes inter alia, energy used for heating, cooling, ventilation, hot water, lighting and appliances. The last one is an amendment compared to EPBD recast definition shown in Ch. 3.

From net delivered energy, numeric indicator of primary energy can be calculated and used to define the performance level of nearly net zero energy building. Primary energy indicator (called often also as primary energy rating) sums up all delivered and exported energy (electricity, district heat/cooling, fuels) into a single indicator with primary energy factors. In a similar fashion, numeric indicator of $CO_2$ emission may be calculated with $CO_2$ emission coefficients. $CO_2$ indicator provides additional information about the consequences of energy use, in the terms of $CO_2$ emitted to atmosphere.

$$E = \sum_i \left(E_{del,i} - E_{\exp,i}\right) f_i$$

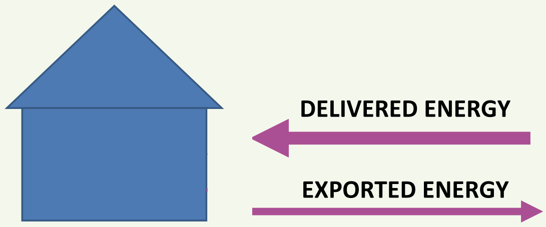


**Figure 1.** System boundary for nearly net zero energy building definition, connecting a building to energy networks. Net delivered energy is delivered $E_{del,i}$ minus exported energy $E_{exp,i}$ accounted separately for each energy carrier *i*. Primary energy *E* is calculated with primary energy factors $f_i$ (the same factors are assumed for delivered and exported energy carriers in the figure, see Equation 1 for more details).

In order to be a sound definition, nearly net zero energy building defined through primary energy indicator, shall refer to specified energy calculation framework, including:

- system boundary of net delivered energy (EN 15603:2008 and Ch. 4);
- standard energy calculation input data (EN 15251:2007);
- test reference year to be used in energy calculations (ISO 15927-4:2005);
- primary energy factors for energy carriers (EN 15603:2008);
- energy calculation rules and methods for energy need and system calculations, covered in relevant EPBD standards;

which all affect calculated or measured primary energy indicator.

Net zero energy requirement has exact performance level of 0 kWh/(m² a) primary energy. The performance level of "nearly" net zero energy use is a subject of national decision taking into account:

- cost optimal and technically reasonably achievable level of primary energy use
- how many % of the primary energy is covered by renewable sources
- ambition level of the definition

The following definitions are proposed:

**net zero energy building (nZEB)**
energy use of 0 kWh/(m² a) primary energy

**nearly net zero energy building (nnZEB)**
national cost optimal energy use of > 0 kWh/(m² a) primary energy

Primary energy can be calculated with **Equation 1** as:

$$E = \sum_i \left(E_{del,i} f_{del,i}\right) - \sum_i \left(E_{exp,i} f_{exp,i}\right) \qquad \textbf{(1)}$$

where

$E_{del,i}$ is the delivered energy for energy carrier $i$;
$E_{exp,i}$ is the exported energy for energy carrier $i$;
$f_{del,i}$ is the primary energy factor for the delivered energy carrier $i$;
$f_{exp,i}$ is the primary energy factor for the exported energy carrier $i$, which may or may not be equal to the factor of the delivered energy, depending on national definition;

For the national definition of nearly net zero energy buildings, the performance levels of E-values should be specified for each building type, at least for those listed in EPBD recast.

### 3. Proposed system boundary for net delivered energy

For any low energy or zero energy building definition or indicator, it would be necessary to specify which energy flows are included in the definition and which ones not. Either all energy used in the buildings may be taken into account, or some energy flows, such as electrical energy use of occupant appliances may be excluded. Such energy flow specification is called as system boundary and it provides a general framework for energy indicators. According to EPBD recast, energy performance is defined as (article 2):

> *'energy performance of a building' means the calculated or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia,* ***energy used for heating, cooling, ventilation, hot water and lighting***

This energy performance definition helps to understand the EPBD recast definition for nearly zero-energy building (nZEB):

> *'nearly zero-energy building' means a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby*

According to these EPBD recast definitions, electricity for households and outlets are not mandatory to be included. All other major energy flows are mandatory to be included.

EPBD recast, Annex I states common general framework for the calculation of energy performance of buildings. In this framework, it is said that:

> *The energy performance of a building shall be expressed in a transparent manner and shall include an* ***energy performance indicator and a numeric indicator of primary energy use****, based on primary energy factors per energy carrier, which may be based on national or regional annual weighted averages or a specific value for on- site production.*

This definition means that energy performance indicator may be based on primary energy. But it is let open to use some other indicator for energy performance together with primary energy, meaning that energy performance requirements may also be based on this other indicator. There is no guidance for this "other" energy performance indicator, expect that is given in energy performance definition (energy used for heating, cooling, ventilation, hot water and lighting). In the Annex, it is also referred to the use of relevant European standards:

> *The methodology for calculating the energy performance of buildings should take into account European standards and shall be consistent with relevant Union legislation, including Directive 2009/28/EC.*

EN 15603:2008 discusses energy flows to be included in the energy ratings, **Figure 2**. It is upon national decision to take into account electricity for households and outlets or not.

For the energy boundary specification, the guidance is provided in EN 15603:2008. This is mainly general guidance, and again, exact specification is let for national bodies. Inside the boundary the system losses are to be taken into account explicitly, outside they are taken into account in the conversion factor (=primary energy factor). Technical building systems located partly outside of the building envelope are considered to be inside the system boundary. It is also clearly stated that the assessment can be made for a group of buildings serviced by the same technical systems.

EN 15603:2008 states that for active solar and wind systems only the energy delivered by the generation devices and auxiliary energy are taken into account in the energy balance (i.e. kinetic energy of wind is not). It is to be decided on the national level, if this energy is part or not of the delivered energy (Definitions, 3.3.4). Actually this will conflict with EPBD recast, if renewable energy produced on site is considered as delivered energy (meaning that there is no difference between on site solar electricity and grid electricity, and on site solar electricity is not reducing the amount of delivered grid electricity). In this case, there is conflict with EPBD recast, Annex I, that states that the positive influence of active solar and other renewables are to be taken into account. Thus, this national decision seems not any more relevant and EPBD recast has caused a revision need for EN 15603:2008.

Proposed energy boundary is modified from EN 15603:2008 and as stated in EPBD recast, renewable energy produced on site is not considered as part of delivered energy, i.e. the positive influence of it is taken into account, **Figure 3**.

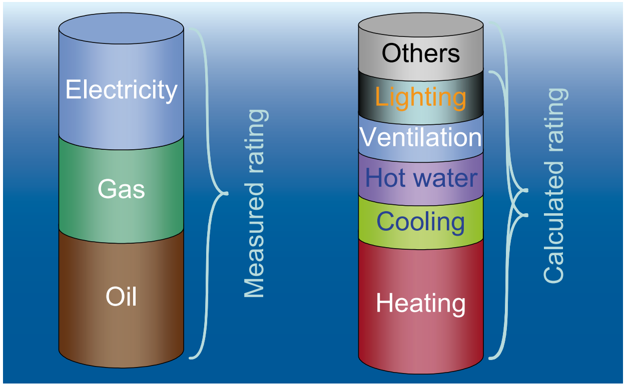


**Figure 2.** In the measured ratings typically all energy flows are included as measured. In the calculated energy ratings electricity for households and outlets ("others") may or may not be included.

Energy need represents energy need in a building for heating, cooling, ventilation, domestic hot water, lighting and appliances (if appliances are included in the system boundary as proposed). Energy need for heating is caused by heat losses and is reduced by solar and inter-

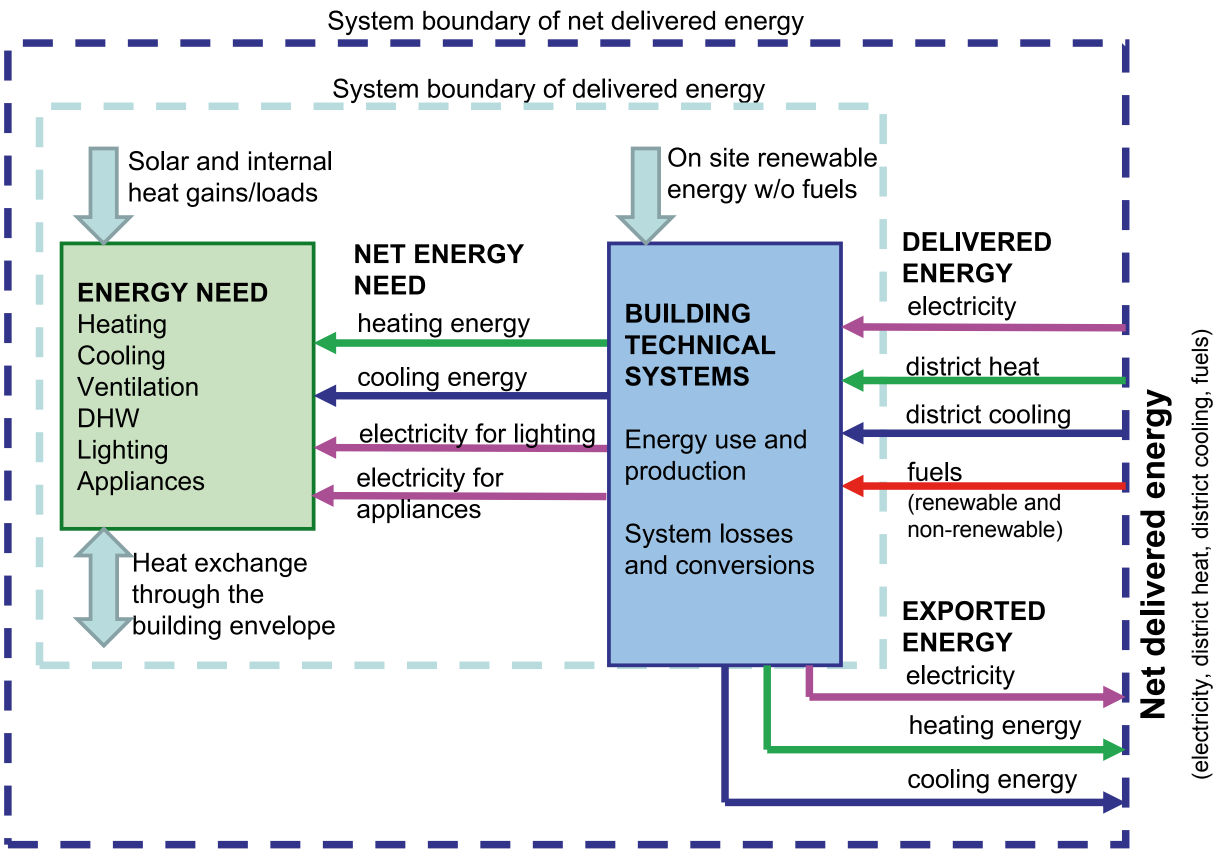


**Figure 3.** Energy boundary of net delivered energy and how it forms from energy need, energy use of technical building systems, on site renewable energy production, delivered energy and exported energy. The box of "Energy need" refers to rooms in a building and both system boundary lines may be interpreted as the building site boundary.

nal heat gains. Net energy need is the energy need minus heat gains, i.e. thermal energy without any system losses needed to maintain indoor climate conditions. For the lighting and appliances electrical energy is needed.

Building technical systems supply the amount of net energy needs of heating, cooling and electrical energy. To supply these net energy needs, building technical systems use energy and have typically some system losses and energy conversion in some systems (i.e. heat pumps, fuel cells). The energy used by the building technical systems is from delivered energy to the building or from on site renewable energy (without fuels).

Delivered energy to the building is grid electricity, district heat and cooling, renewable and non-renewable fuels. On site renewable energy without fuels is energy produced from active solar and wind (and from hydro if available). Renewable fuels are not included in this term, because they are treated as delivered energy to the building, i.e. off-site renewables. Energy from heat sources of heat pumps (air, ground, water) is also renewable energy, but this information is not needed for heat pump system and delivered energy calculations which are based on COP data of heat pumps. (However, energy taken from heat sources of heat pumps is needed for calculation of the share of renewable energy, which is additional information).

On site renewable energy production systems may supply other technical building systems, thus reducing the need for the delivered energy to building, or may be directly exported to energy networks. This is taken into account in the net delivered energy balance. Net delivered energy is delivered minus exported energy, both expressed per energy carrier.

Primary energy use is calculated from net delivered energy, per energy carrier, as product of primary energy factor and net delivered energy of that energy carrier.

## 4. An example of energy flow calculation

Consider an nnZEB office building located in Paris with following annual net energy needs (all values are specific values in kWh/(m² a)):

- 3.8 kWh/(m² a) net energy need for heating (including ventilation and DHW)
- 11.9 kWh/(m² a) net energy need for cooling
- 21.5 kWh/(m² a) electricity for appliances
- 10.0 kWh/(m² a) electricity for lighting

Breakdown of the net energy need is shown in **Figure 4**.

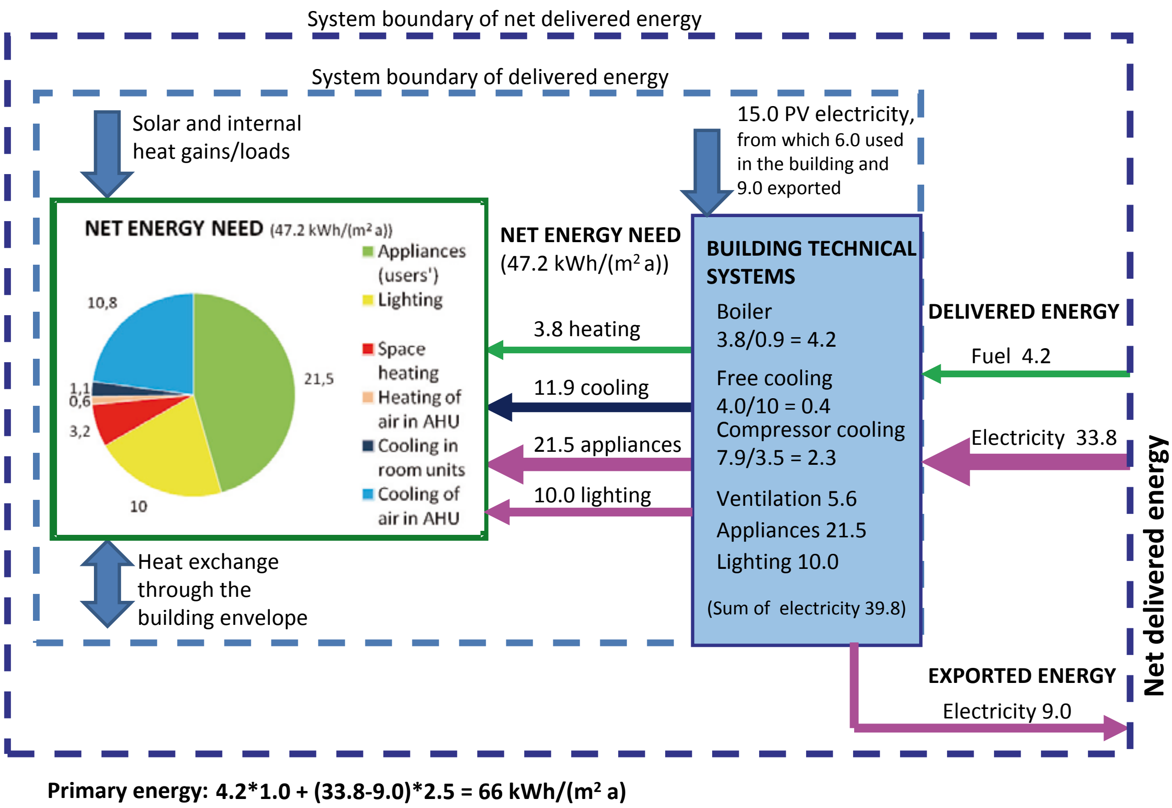


**Figure 4.** Calculation example of the energy flows in nnZEB office building.

The building has a gas boiler for heating with seasonal efficiency of 90%. For the cooling, free cooling from boreholes (about 1/3 of the need) is used and the rest is covered with mechanical cooling. For borehole cooling, seasonal energy efficiency ratio of 10 is used and for mechanical cooling 3.5. Ventilation system with specific fan power of 1.2 kW/($m^3$/s) will use 5.6 kWh/($m^2$ a) fan energy. There is installed a solar PV system providing 15.0 kWh/($m^2$ a), from which 6.0 is utilized in the building and 9.0 is exported to the grid.

Energy calculation results are shown in **Figure 4**, in the building technical systems box. Gas boiler with 90% efficiency results in 4.2 kWh/($m^2$ a) fuel energy. Electricity use of the cooling system is calculated with seasonal energy efficiency ratios 10 and 3.5 respectively. Electricity use of free cooling, mechanical cooling, ventilation, lighting and appliances is 39.8 kWh/($m^2$ a). Solar electricity of 15.0 kWh/($m^2$ a) reduces the net delivered electricity to 24.8 kWh/($m^2$ a). Net delivered fuel energy (caloric value of delivered natural gas) is 4.2 kWh/($m^2$ a). From these two net delivered energy flows, primary energy is calculated with the result of 66 kWh/($m^2$ a).

## 5. Conclusions

In this paper a technical definition for nearly net zero energy buildings is proposed. This definition is needed in the member states for the implementation of EPBD recast. In order to propose a general definition, it was needed to clarify:

- which energy flows shall be included
- the use of primary energy factors for primary energy indicator
- system boundary definition with inclusion of active solar and wind
- the technical meaning of "nearby" in EPBD recast so that it may mean existing district heating or cooling network or any other technical system serving a group of buildings

Energy performance definition of EPBD recast was followed so that appliances (households and outlets) were included, i.e. all energy used in buildings would be accounted. For the system boundary definition, a general form modified from the one of EN 15603:2008 is proposed. It is proposed to the Member States to use the system boundary shown in **Figure 3** and primary energy definition given by **Equation 1** in defining the performance levels of nearly net zero energy buildings.

Net zero energy requirement has exact performance level of 0 kWh/($m^2$ a) primary energy use. The performance level of "nearly" net zero energy use depends on national conditions and decisions. The following definitions were proposed:

**net zero energy building (nZEB)**
energy use of 0 kWh/($m^2$ a) primary energy

**nearly net zero energy building (nnZEB)**
national cost optimal energy use of > 0 kWh/($m^2$ a) primary energy

In order to be a sound definition, nearly net zero energy building defined through primary energy indicator, shall refer to specified energy calculation framework, including:

- system boundary of net delivered energy (EN 15603:2008 and **Figure 3**);
- standard energy calculation input data (EN 15251:2007);
- test reference year to be used in energy calculations (ISO 15927-4:2005);
- primary energy factors for energy carriers (EN 15603:2008 and Equation 1);
- energy calculation rules and methods for energy need and system calculations, covered in relevant EPBD standards;

which all affect calculated or measured primary energy indicator. The performance levels shall be specified for each building type, at least for those listed in EPBD recast.

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- EN 15603:2008 Energy performance of buildings – Overall energy use and definition of energy ratings.
- EN 15251:2007 Indoor environment input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.
- ISO 15927-4:2005 Hygrothermal performance of buildings – Calculation and presentation of climatic data – Part 4: Hourly data for assessing the annual energy use for heating and cooling.
- EN 15316-1:2007 Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies – Part 1: General
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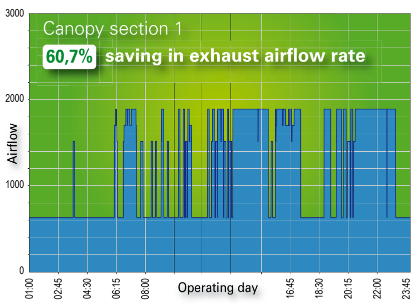
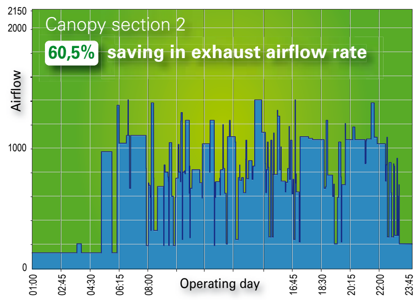
The kitchen ventilation has typically worked at 100% of the exhaust air flow rate during operation, but Halton M.A.R.V.E.L. changes this logic. An innovative Demand-Controlled Ventilation system, it adjusts every canopy according to the actual activity of the kitchen equipment. This means an average of 50% savings in energy consumption, which increases profitability. The history-steeped Le Meurice Hotel now gains advantage from this modern innovation.

The results of the real-time monitoring carried out at the hotel are as promised. The combination of the Capture Jet™ and M.A.R.V.E.L. technologies provides a nearly **61% reduction in exhaust air flow rates, corresponding to about 50% lower total energy consumption**.






Halton

# Towards nZEB – some examples of national requirements and roadmaps

Lennart Jagemar, Michael Schmidt, Francis Allard, Per Heiselberg and Jarek Kurnitski

A recent benchmarking study on implementation on EPBD 2002 by REHVA (Seppänen & Goeders 2010) revealed a large variation in the energy performance regulations of the different countries. Not only the performance levels are different, but even the units, in which the performance is measured are different. Primary energy, delivered energy, various energy frames and even $CO_2$ emissions are used. Such differences in regulations have a significant effect on the building industry, and complicate manufacturing, sales, installation, construction and design of buildings in the common market area. The experience learned from the actions taken by CEN from the year 2002 to help the implementation of EPBD showed that technical development work takes time. However, it can be seen that EPBD is establishing a common methodology, as majority of the countries already use or are moving to use primary energy in the definition of energy performance in [kWh/m²,a]. Many countries have prepared long term roadmaps with detailed targets, **Figure 1**. Such roadmaps help the industry to be prepared and committed to the targets. For example, in Norway, zero energy buildings are expected in 2027, but in UK carbon neutral buildings already in 2017.

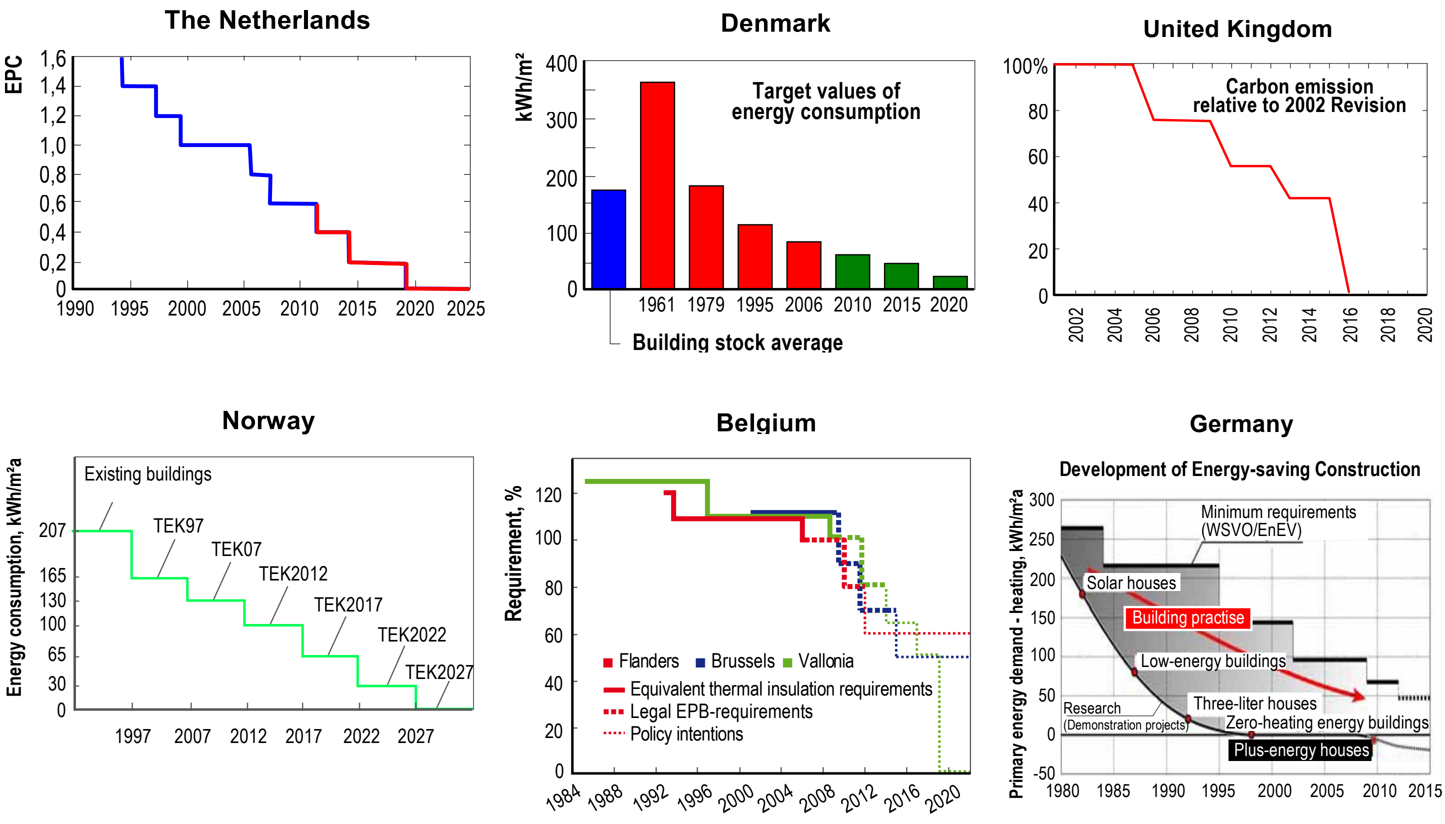



**Figure 1.** Roadmap of some countries towards nearly zero energy buildings to improve the energy performance of new buildings.

| Summary Table of Incentives | | | DE | IT | FR | Hu | BE | SE |
|---|---|---|---|---|---|---|---|---|
| | YEAR | | 2009 | 2009 | 2009 | 2009 | 2009 | 2009 |
| FINANCIAL | Direct Funding of Energy Repairs | | Yes | Yes | Yes | Yes | Yes | Stopped |
| FINANCIAL | Financial Help for Low-Income Households | | Yes | Yes | Yes | No | Yes | No |
| FINANCIAL | Green Loans / Soft Loans | | Yes | Yes | Yes | Yes | Yes | No |
| FINANCIAL | Third Party Financing | | Yes | Yes | Yes | Yes | Yes | No |
| TAXES | Tax Deduction | | Stopped (2009) | Yes | Yes | No | Yes | Yes |
| TAXES | Lower VAT on Labour and Materials | | Stopping | Materials | Labour & Material | No | Labour | n.a. |
| TECHNOLOGY SPECIFIC | Subsidies on Sustainable Energy Devices | | Yes | Yes | Yes | Yes | Yes | Yes |
| TECHNOLOGY SPECIFIC | Feed-in Tariffs | per kWh (€/kWh) | Yes | Yes | Yes | Yes | No | n.a. |
| TECHNOLOGY SPECIFIC | Feed-in Tariffs | Green Certificates | No | Yes | Yes | Yes | Yes | n.a. |
| OTHERS | Rent Indexation (Owner-Renter Balance)[1] | | n.a. | n.a. | n.a. | No | n.a. | No |

**Figure 2.** Available incentives in selected countries. Data shown in the figure was valid in 2009; changes are possible because incentive programs are typically revised with rather short intervals.

Most countries apply for major renovations both code requirements, which will become mandatory for all countries according to the recast of EPBD, as well as comprehensive incentive packages. This shows that improvement of existing building stock is taken seriously, **Figure 2**.

At the moment there are no official definitions of nearly nZEBs available, but the work with the national plans for nZEBs is ongoing and few results have been published. In the following the developments in the energy performance requirements in five Central European and Nordic countries are reported.

### Denmark

In the Danish Building Code (BR10), a class 2015 is defined, which fulfils the future energy performance requirements in 2015.

The total primary energy use in the energy frame consists of heating, ventilation, cooling, domestic/service hot water, and lighting (except in residences). Tenants' or users' electricity is excluded. Heating (natural gas, oil or district heating) has a primary energy factor of 1, but a factor of 0.8 can be used for district heating for buildings fulfilling class 2015. Electricity has a primary energy factor of 2.5. The floor area, A, used is the gross floor area measured outside the external walls. As a small country, there is only one climate zone.

**Table 1.** Primary energy frames for new buildings in Denmark 2008, 2010 and 2015.

| | Energy frame [kWh/(m² a)] | Energy frame [kWh/(m² a)] | Energy frame [kWh/(m² a)] |
|---|---|---|---|
| Building Code | BR08 | BR10 | BR10 - Class 2015 |
| Residential | 70 + 2200/A | 52,5 + 1650/A | 30 + 1000/A |
| Non-residential | 95 + 2200/A | 71,3 + 1650/A | 41 + 1000/A |

### France

The new French regulation (RT2012) issued on October 26th 2010, addresses low energy buildings targets for residential buildings, office buildings, school buildings, kinder gardens etc.

The total primary energy consumption is defined for heating, cooling, hot water production, lighting, ventilation and any auxiliary systems used for these domains. It is given by an overall coefficient Cep kWh/(m² a) using the net floor area of the building defined by the French building code.

The target maximum value of Cep, Cepmax is fixed to 50 kWh/(m² a) with various correction coefficients depending on the climatic zone, the altitude, the total area of the building and the type of energy used.

Furthermore, in order to ensure a good quality of the design of the envelope, another constraint is added. A new parameter Bbio is added in order to check the "bioclimatic" quality of the design. This Bbio parameter measures the energy need of the building for heating, cooling and lighting for a whole year. It has no dimension and is evaluated by a certain number of points. It has to be lower to Bbio max defined in the new regulation as a function of the location, altitude, type of building etc.

Finally, the air tightness of the building is also imposed to a maximum value depending of the building type, and in summer, a limit for indoor summer temperature has to be checked if no cooling is used.

### Germany

The current requirements (EnEV2009) for new residential buildings are calculated depending to a so called reference building. For the reference building there are standard U-values for the bottom floor, walls, windows and the roof and standard installation engineering given in the EnEV. The energy demand for residential buildings could be calculated with two different standards. On the one hand with DIN V 18599, on the other hand with a combination of DIN V 4108-6 : 2003-06 and DIN V 4701-10 : 2003-08. The primary energy demand of the new building must be below or equal to the energy demand of the reference building. Also a limit value for the specific transmission heat loss must be reached. A weighting factor for electricity consumption of 2.7 is being used.

Official definitions concerning the public subsidies for (residential) Low Energy Buildings are subject of the programs run by the (state-owned) Kreditanstalt für Wiederaufbau Frankfurt (KfW). These programs are mainly fed by public sources. The current requirements are KfW 70, KfW 55 and KfW 40. The primary energy demand of these buildings has to be 70%, 55% and 40% of the reference building. In addition, there is also a subsidy program for "Passiv-Häuser", which is defined in accordance with the Passiv-Haus-Institute as "KfW-40-buildings with an annual heat demand lower than 15 kWh/m²".This figure can 't be directly compared with the low energy classes from the other countries as passive houses only have requirement to energy for heating combined with a requirement to the overall use of primary energy to be maximal 120 kWh/m² including energy for appliances.

Next step of enforced requirements in 2012 will be another 30% reduction for both residential and non-residential buildings. In 2020 new buildings shall be "climate friendly" with less primary energy demand.

### Norway

A Low Energy Commission delivered a number of suggestions for increased energy efficiency of all sectors in Norway in the summer of 2009. The thick report also included suggestions of future net energy frame values for new buildings as well as for major renovations. The Norwegian Building Code, TEK is proposed to be sharpened every fifth year. TEK 07 was published in 1 February 2007 and is fully enforced from 1 September 2009. This building code was the first in Norway with an energy performance approach. The net energy use in the energy frame consists of heating, ventilation, cooling, domestic/service hot water, as well as tenants' or users' electricity. The net energy includes cooling supplied to air-cooling coils or fan coils in the rooms.

**Table 2.** Proposed future net energy frames for new buildings in Norway.

| | Energy frame [kWh/(m² a)] | | | | |
|---|---|---|---|---|---|
| **Building Code** | **TEK07** | **TEK12** | **TEK17** | **TEK22** | **TEK27** |
| Residential | 130 | 100 | 65 | 30 | 0 |
| Non-residential | 155 | 110 | 70 | 40 | 0 |

The floor area used is the heated floor area measured inside the external walls. Norway has a number of climate zones. The values given below are valid for the "standard" climate zone around Oslo, which is in the south-eastern part of the country. The annual energy use of the proposed building is first modelled for the actual climate zone and then for the "standard" climate zone. The results for the standard climate zone must fulfill the energy frame. The current energy frames are specified for one-family houses, multi-family houses and eleven types of non-residential buildings.

## Sweden

A report of the draft Swedish plan for nZEBs was delivered by the Swedish Energy Agency to the Ministry of Enterprise, Energy and Communications on 18 October 2010. The report wants to keep the energy performance values, expressed as delivered energy per heated floor area, since the property owner cannot control how the delivered energy is "produced". Primary energy factors are typically policy based and may be changed over time and a future report is suggested to define Swedish primary energy factors. These are mainly proposed to be used for official purposes, such as reporting to the European Commission.

The proposed maximum values for annual delivered energy per heated floor area are goals for the year 2020. They are more or less half the values in the current Building Code from 1 February 2009. The report also contains values for major renovations in 2020. The first such values in Sweden will be found in the coming Building Code of 2011. The Building Code from 2006 was the first in Sweden with an energy performance approach.

**Table 3.** Proposed energy performance numbers for new buildings in Sweden in 2020.

| Maximum energy performance [kWh/(m² a)] | Climate Zone | | |
|---|---|---|---|
| | Zone I North | Zone II Middle | Zone III South |
| Residential (non-electric heating) | 75 | 65 | 55 |
| Residential (electric heating) | 50 | 40 | 30 |
| Non-residential (non-electric heating) | 70 to 105 | 60 to 90 | 50 to 75 |
| Non-residential (electric heating) | 50 to 75 | 40 to 60 | 30 to 45 |

The midterm goal for 2015 is that at least 25% of the floor area of all erected buildings in 2015 should fulfill the energy requirements for the year 2020. For new buildings owned or used by the state the requirements are for the year 2019 and the portion in 2015 that should fulfill them is at least 50%. The delivered energy in the energy performance value consists of heating, ventilation, cooling, and domestic/service hot water. Electricity for technical building systems is also included. Tenants' or users' electricity is excluded. Electricity to chillers in non-electrically heated buildings shall be multiplied with the factor 3 in order to make possible comparisons with district cooling. Electric heated buildings are defined as having an installed electric power for heating of at least 10 W/m². For non-residential buildings the energy performance value is depending on the average outdoor airflow rate during the heating season. The floor area used is the heated floor area ($A_{temp}$) measured inside the external walls. Sweden has three climate zones. About 80% of the population lives in southern climate zone and less than 10% lives in the northern climate zone.

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# Ventilation with heat recovery is a necessity in "nearly zero" energy buildings

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With between 30% and 40% of the EU's annual energy consumption caused by the building sector, we appreciate that the target laid down in the Energy Performance of Buildings Directive (EPBD) to install a "Nearly Zero Energy Building" is a must for the coming years.

Although this type of building is not yet completely defined, we can be sure that the first priority is to reduce energy demand, whilst the second is to increase renewable energy in buildings.

However, the basic objective of a building is not to save energy, but rather to provide the right balance between heating and cooling, to provide good indoor air quality, and to achieve these objectives at acceptable standards and in an efficient manner to proved high user productivity.

We all know that in new buildings the thermal insulation and air tightness of buildings has reached high levels in the northern EU Member States, and further improvements will only bring few benefits at a high cost.

This reality will soon also be valid in the other Member States. That means that the issue of energy demand in terms of ventilation is increasingly occupying the minds of building designers. In principle, there are two ways to reduce energy demand for ventilation:

- Lower the ventilation rate; and/or
- Recover the energy from ventilation.

On the other hand, there are three emission sources in buildings which have to be considered:

- Human emissions ($CO_2$, humidity, odours);
- Emissions created by humans (water in kitchen, bathrooms etc.); and
- Emissions of buildings (pollutants, solvents, odours, VOC etc).

This means that, depending on the use of the building, different emissions sources will have greater prominence. This also means that the ventilation rate cannot be lowered under a certain limit, because this will cause several problems with the building (e.g. the potential deterioration of the material) or the user (e.g. bad air quality). Demand-controlled ventilation is a strategy to detect the ventilation need and to reduce "needless" ventilation (see Rehva March 2011, Mari-Liis Maripuu), but in the end there is a need for a certain ventilation rate depending on the individual and the building needs in order to prevent the building from being damaged by insufficient ventilation and to ensure the provision of good indoor air quality with a high level of comfort. This ventilation rate has to be heated up in Winter and cooled down in Summer. There is no other means to save this thermal energy than by introducing heat recovery in the ventilation system.

### Heat recovery in ventilation systems

This means that in the near future the heat demand for ventilation will achieve a dominant percentage of the energy requirements for residential and non-resi-

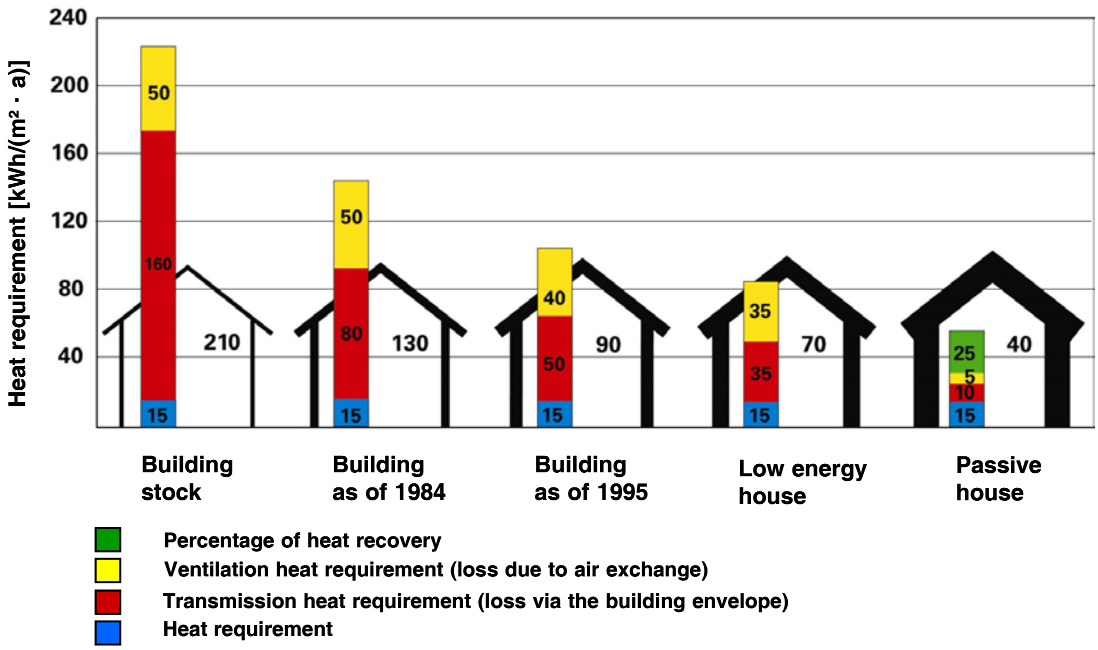


**Figure 1.** Percentage of ventilation heat demand of residential buildings in Germany.

dential buildings due to the high thermal insulation standards.

In low energy and passive houses, at least 50% of the thermal heat is caused by the ventilation. The example of passive houses shows that the thermal heat requirement can only be significantly reduced by using heat recovery in ventilation systems (**Figure 1**).

Coming back to the "Nearly Zero Energy Building", we have to discuss first the definition of heat recovery. The reduction of energy is commonly understood to be characterized by passive systems such as thermal insulation, building tightness, sun protection, among others, and to make up the rest a building should use renewable energies for heating and cooling systems. Ventilation does not fit strictly into this, because theoretically it can be realized in many cases, and, in the opinion of many people, without a machine, and we have to compare a passive system (such as window airing) with an active system (ventilation with heat recovery). This leads to the question: does heat recovery reduce energy demand or when used in ventilation is it a renewable energy source?

Initially it is not straightforward to answer, and it is always a matter of chosen boundaries (e.g., energy balance boundaries). The following points can, however, be stated:

1. The heating source of outside air is usually to be seen as a renewable energy source (for example, an outside air heating pump for heating).

   Thus the outside air is energy from an environmental source, and the exhaust air of a ventilation system becomes outside air once it leaves the building. The use of exhaust air as a heat source is, due to the higher temperature, more efficient than the use of outside air.

2. A large part of the internal heating sources in buildings comes from renewable sources:

   a. Passive solar gains via windows (100% renewable);

   b. Persons (100% renewable);

   c. The renewable percentage of the power electricity from the grid (currently approximately 10%, and increasing); and

   d. The renewable part of the space heating, for example, biomass, geothermal energies, and environmental energies (currently approximately 10% and increasing).

Therefore the ventilation heating losses of up to approximately 40% come from renewable sources. With heat recovery, this heat can be almost completely recycled. In addition, the heat recovery can once again make the energy available that the heat recovery system has already retrieved and conveyed into the building.

So heat recovery is a revolving process and keeps the energy in the building, and we need at least a machine, a heat recovery unit, to realize this. So the conclusion is:

**Heat recovery in ventilation systems is a renewable energy source** in analogy with a heat pump.

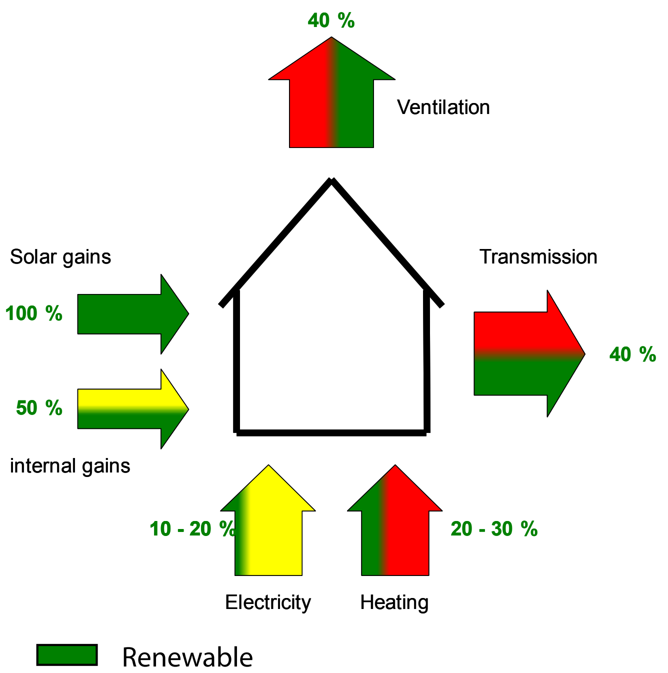


**Figure 2.** Regenerative percentage of the heat recovery.

Looking at the market for heat recovery systems, we need to divide up the different segments into residential buildings, non-residential buildings, and industrial systems.

### Heat recovery in Non-Residential Buildings

Sometimes, it is hard for an expert to understand why efficient heat recovery is not generally accepted and used in ventilation systems of non residential buildings, because the cost efficiency of heat recovery is in most cases outstanding.

**Table 1** shows the impact of legal and normative aspects in the energy efficiency of buildings and the result on heat recovery systems.

Before 2007 no legal aspect defined minimum heat recovery in non-residential buildings in Germany. As a result fewer than 50% of units had heat recovery. The impact of EPBP and its target to reduce the energy demand of technical building systems in EnEV 2007 and 2009 by 2010 gave rise to a significant increase in heat recovery units.

**Table 1.** Heat recovery in Non-Residential Buildings [2].

| Year | Turnover Mio € | Export Mio € | Percentage | Units | With heat recovery | Percentage |
|---|---|---|---|---|---|---|
| 2008 | 431 | 111 | 25,8% | 42.236 | 15.569 | 46% |
| 2009 | 379 | 97 | 25,5% | 33.476 | 15.148 | 55% |
| 2010 | 390 | 103 | 26,4% | 36.476 | 19.791 | 67% |

If we look into the near future and the target of a "Nearly Zero Energy Building", we cannot see any possibility other than efficient heat recovery. This does not mean that the temperature ratio or the humidity ratio of a heat recovery unit must have the maximum possible values. Depending on the use, the climate, and the thermal loads of a building, a detailed yearly calculation of an optimized efficiency is necessary.

Heat recovery offers some other opportunities which help to reduce energy demand for cooling in Summer. Firstly, heat recovery in Summer during the cooling period reduces the chiller capacity and the chiller consumption in the same manner as in the heating period.

In most European climate zones, the energy recovered in Summer will be relatively small in relation to the possibilities in winter, but heat recovery systems can be upgraded with indirect humidification systems in the exhaust air stream.

### Indirect evaporative cooling

In connection with efficient heat recovery, the cooling effect of evaporated water can be used for cooling the supply air in the central air-handling-unit (AHU). The cooling effect is mainly used indirectly in European climate zones, thereby ensuring that the supply air does not increase the humidity in the rooms. A basic need is to improve thermal conditions.

### Indirect evaporation cooling with exhaust air

The **exhaust air** is cooled down as much as possible by being sprayed with water depending on exhaust air conditions. With an efficient heat recovery system the "cold" is then transferred to the supply air side. These systems are highly suitable when, after evaporation, the exhaust air temperature is, in cooling mode, lower than the outside air temperature. For example, when rooms in a building remain relatively cool via the storage or additional room cooling systems, and the humidity load is low.

### Indirect evaporation cooling with outside air

For these systems, the **outside air** is cooled as much as possible by being sprayed with water. The "cold" is then transferred to the supply air or to recirculation air.

**Table 2.** Ventilations rates in Residential Buildings EN 15251 [4].

| Category | Total air exchange rate house | | Air exchange rate habitable rooms (living, bedrooms, study) | | Related exhaust airflow from wet rooms | | |
|---|---|---|---|---|---|---|---|
| | Per m² dwelling 1 [l/s/m²] | Ach (at ceiling height of 2,5m) | Per person 2 [l/s/pp] | Per m² 3 [l/s/m²] | Kitchen 4a [l/s] | Bathroom 4b [l/s] | Toilet 4c [l/s] |
| I | 0,49 | 0,7 | 10 | 1,4 | 28 | 20 | 14 |
| II | 0,42 | 0,6 | 7 | 1,0 | 20 | 15 | 10 |
| III | 0,35 | 0,5 | 4 | 0,6 | 14 | 10 | 7 |

These systems are highly suitable when in cooling mode after the evaporation the outside air temperature is lower than the room temperature. For example, when the thermal room load is relatively high in a building (i.e., in industry).

These examples show that a heat recovery system is more than a simple unit to reduce energy demands. Instead, it can be a kind of energy generator providing renewable energy.

## Heat recovery in Residential Buildings

In general we can state that the same principles for non residential buildings are also valid for residential buildings. There is however some differences that must be taken into account:

- Fewer people per square meter
- Lower thermal loads
- Higher water emissions
  - o Risk of mould
- Multiple use (living rooms, bedrooms, kitchen, bathroom) with different ventilation demands in small systems
- Typical ventilation systems are different:
  - o Balanced systems with heat recovery
  - o Exhaust systems
  - o Positive ventilation systems
- Relative small air-change rate compared to other buildings (**Table 2**)
- Predesigned systems with serial ventilation units
- Significant interaction with the tightness of the building envelope.

We also need to note that inhabitants are used to opening windows for airing, with the result that in some cases the ventilation rate is too high (resulting in high energy losses) or too low (resulting in a risk of mould), depending on the individual. So in all cases we have to compare window airing with fan assisted systems.

The supplementary study on Ecodesign Lot 10 shows the possible energy savings of ventilation systems with heat recovery [3]. Although the typical design criteria for residential ventilation are different within the EU Member States, the resulting ventilation air change rates are rather similar at an average rate of approximately 1.3 m³/(h m²).

This results in a total EU-average amount of 369 TWh per year of thermal energy in the heating season for the ventilation rate needed. These high values show that a focus on electrical energy for fans is completely misleading and that this thermal energy can only be recovered with heat recovery systems. If we consider that heat recovery is widely installed in EU Member States, nearly 80% of this energy can be saved.

A scenario made in Germany for Residential Ventilation show the potential of energy savings if we consider, that up to 2020 HRV will be present in 10, 20 or 30% of the building stock (**Figure 3**). This will result in a $CO_2$-Savings potential of approx 6 Mio to/year. If we expand these values on EU 27, we can expect a $CO_2$-Savings potential of approx 18 Mio to/year or 3% of the total 20-20-20 target of Europe. A significant value.

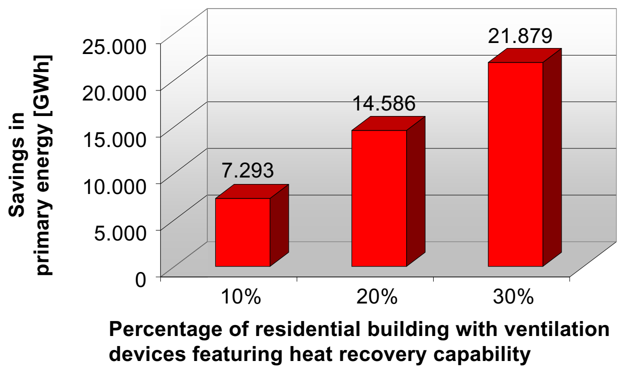


**Figure 3.** Primary energy savings potential by using ventilation systems with heat recovery in residential buildings.

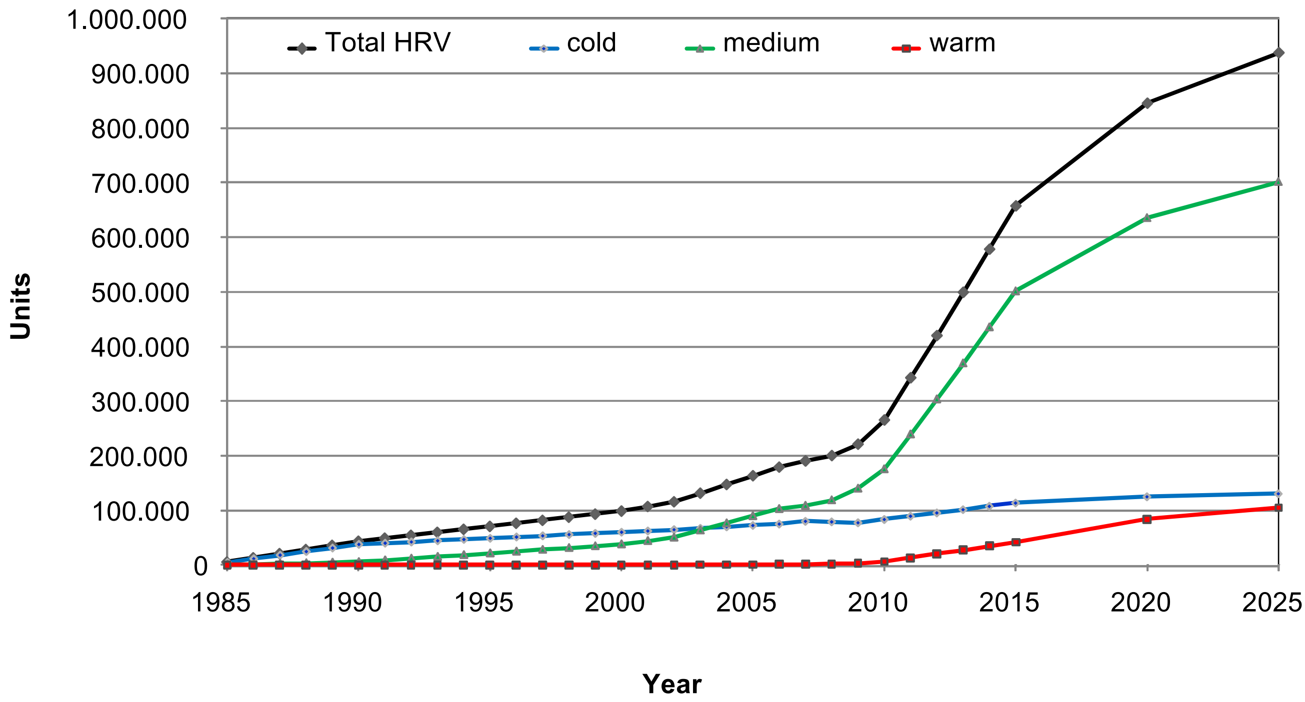


**Figure 4.** Estimated market for single dwelling ventilation units with heat recovery [3] and EVIA.

In Non-Residential Buildings we can expect the same amount of $CO_2$-Savings, so in total we talk about reaching 6% of the EU targets.

If we review the European market, we can see that the market for HRV started in the 1980s in the Scandinavian and Dutch markets, dominating them until 2000. This is a direct result of regulation and the climate impact.

From 1995, the market in medium climate countries began developing in the bigger countries such as Germany, the UK, and France, and we are currently seeing a dramatic rise in all the medium climate countries with their high populations and a degree of saturation in the cold climates. This results from the energy discussions and a changing perception from the building owners with regard to energy, health & comfort, and special promotion programs.

Countries in warmer climates do not yet have any significant markets for HRV. Up to now, heat recovery systems have not been mandatory in most of the EU Member States. This must change, because otherwise the energy targets for 2020 will not be reachable.

The mission of EVIA is to be a thought-leader on ventilation issues, helping to profile it in the political discussion, taking into account the significant impact of ventilation on energy, hygiene, health, and comfort. It is important to learn from the countries with considerable experience in ventilation systems and solutions to avoid mistakes made elsewhere in the past.

EVIA supports the goals of Ecodesign to establish a transparent European market for ventilation units with heat recovery without artificial barriers.

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# 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?

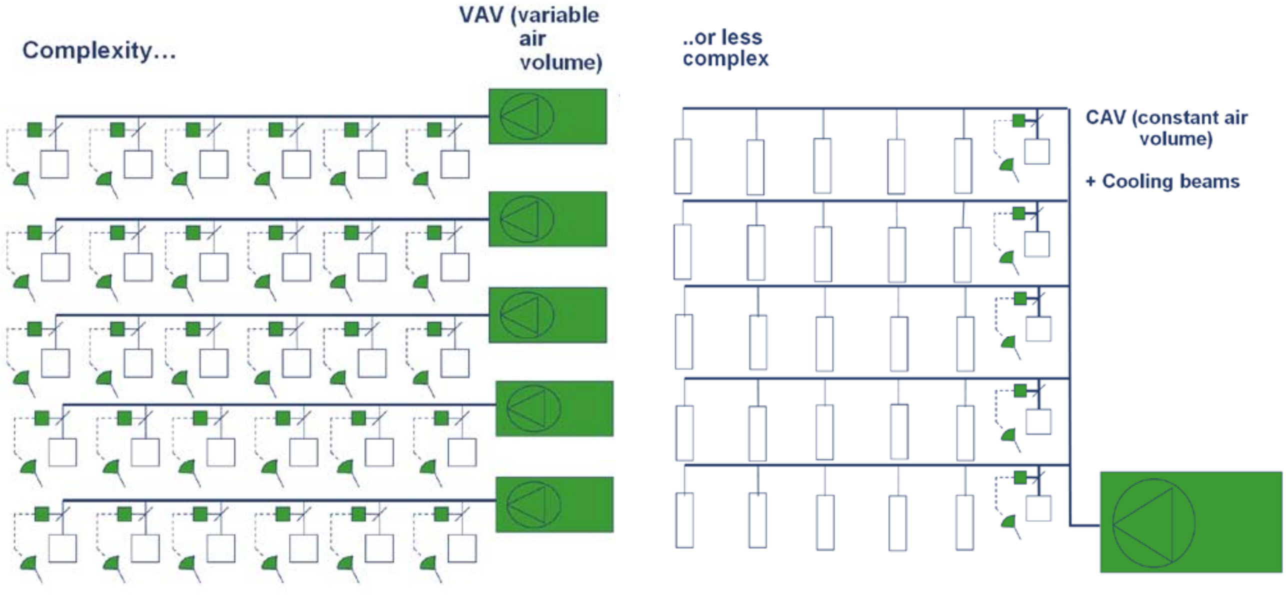



**Figure 1.** Complex solution vs. less complex solution. Left figure shows VAV system with motorized supply air diffusers for all office modules. In the right figure, dampers are used only to control air flows in the meeting rooms. Balancing, commissioning and maintenance are easier in more robust CAV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

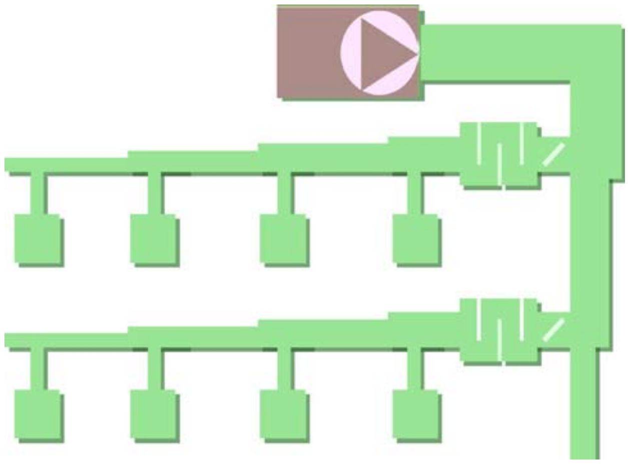
We have overcome this problem by using untraditional design, sizing for final pressure drop. The maximum speed in ducts are limited to 5 m/s in vertical duct in shafts and static pressure to 120 Pa, and the maximum speed 3 m/s in distribution duct on the office floors and static pressure to 100 Pa. The 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**

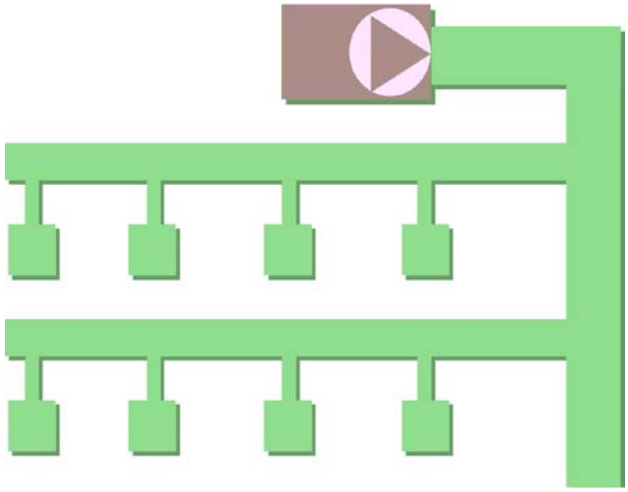


**Figure 2.** Traditional ductwork with dampers, silencers and decreasing diameters compared to final pressure drop ductwork with constant diameter and less components.

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. $\eta_t$, % | 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. $\eta_t$, % | 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. $\eta_t$, % | 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.

# Saving Energy and Improving IAQ through Application of Advanced Air Cleaning Technologies



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## Introduction

In the future, we may be able use air cleaning systems and reduce rates of ventilation (i.e., reduce rates of outdoor air supply) to save energy, with indoor air quality (IAQ) remaining constant or even improved. The opportunity is greatest for commercial buildings because they usually have a narrower range of indoor pollutant sources than homes. This article describes the types of air cleaning systems that will be needed in commercial buildings.

## Benefits and Costs of Outdoor Air Ventilation

Energy costs are incurred to heat, cool, and dehumidify ventilation air. In U.S. commercial buildings, an estimated 6.5% of site-consumed energy is used for conditioning mechanically-supplied ventilation, and approximately another 3% of site energy may be used to condition air from uncontrolled infiltration (Benne et al. 2009). The primary benefit of ventilation is its role in maintaining acceptable IAQ by exhausting polluted indoor air to outdoors and bringing in outdoor air free of indoor-generated pollutants. However, as detailed in **Table 1**, ventilation is marginally effectively in controlling our exposures to some types of indoor pollutants and ventilation is often unnecessary for control of combustion pollutants because many commercial buildings have no significant sources of combustion pollutants. Ventilation also brings outdoor-air pollutants into buildings. Commercial building ventilation is most helpful in reducing our exposures to indoor-generated volatile organic compounds (VOCs) such as formaldehyde from manufactured wood products and odorous gaseous bioeffuents. Ventilation can also help reduce our exposures to indoor-generated particles, although in commercial buildings we typically must filter the supplied outdoor and recirculated-indoor air to protect equipment and people from particles.

## Criteria for Air Cleaning

Reducing ventilation rates to save energy, with no countermeasures, will increase indoor concentrations of indoor-generated VOCs and small particles by an amount that may degrade perceived air quality or pose health risks. If we reduce the ventilation rate by an amount $\Delta Q_v$ the pollutant removal rate $R$ is diminished by the amount $\Delta Q_v \cdot C$, where $C$ is the indoor air pollutant concentration. From a mass balance, to prevent IAQ from being degraded, we need to add an air cleaning system that provides the same or higher pollutant removal rate.

**Table 1.** IAQ impacts of ventilation (outdoor air supply) in commercial buildings.

| Pollutant type | Exposures changes when ventilation rates are reduced | Explanation |
|---|---|---|
| Outdoor air pollutants | No change or decrease | Reduced ventilation sometime reduces our exposures to outdoor pollutants |
| Indoor generated VOCs | Increased | Ventilation flushes these pollutants out of buildings. |
| Indoor generated airborne particles | Small increase for indoor-generated particles and decrease for outdoor-air particles | Reduced ventilation will increase indoor concentrations but the impact of ventilation is small when indoor air is recirculated through efficient particle filters. |
| Indoor combustion –produced gaseous pollutants (e.g., CO, $NO_x$) | Increase, but generally not applicable | In most commercial buildings, there are no indoor sources or only very small sources. In buildings with combustion-based cooking, sources may be significant. |
| Radon | Increase, but generally not applicable | In most commercial buildings, radon levels are low |
| Semi-volatile organic compounds (e.g., plasticizers, flame retardants) | Not much change | These pollutants are mostly on indoor surfaces. Much of the airborne fraction is adsorbed on airborne particles. For some of these compounds, ingestion or dermal contact with surfaces are key routes of exposure. |

For an air cleaner,

$$R = Q_{AC}\varepsilon\, C$$

where
$Q_{AC}$ is the rate of air flow through the air cleaner, and
$\varepsilon$ is the efficiency of pollutant removal by the air cleaner.

Thus, to maintain IAQ when the ventilation rate is decreased, the following must apply

$$Q_{AC}\varepsilon \geq \Delta Q_v$$

for the range of indoor-generated VOCs and particles that pose health risks or degrade perceived air quality. The product of $Q_{AC}$ and $\varepsilon$ is an effective flow rate sometimes called the clean air delivery rate. To save energy when we reduce ventilation in combination with air cleaning, the energy consumed per unit of clean air delivery for air cleaning must be less than the energy required per unit of outside air supply. Also, to be economically attractive the total cost per unit of clean air supply for air cleaning must be less than or equal to the total cost per unit air supply for ventilation. The criteria given above, assure that indoor concentrations of indoor-generated pollutants are not increased. Effective air cleaning will provide additional IAQ benefits by reducing indoor concentrations of VOCs and particles from outdoor air.

### Availability of Air Cleaning Technologies meeting the Criteria

Assume that to save energy, we reduce the ventilation rate in a building by an amount $\Delta Q_v$ which is 50% of the normal minimum ventilation rate. Do we have the air cleaning technologies that meet our criteria for maintaining IAQ, saving energy, and being cost competitive? For particles, the answer is clearly yes. We already have effective, and low cost air cleaning technologies for particles, with fibrous filters being the most common. A filter with a MERV rating of 14 (EU rating of F7 or F8) is approximately 75% to 85% efficient in removing particles in the 0.35 to 0.64 micrometer range, thus, high efficiency particulate air filters are not necessary. There is only a modest incremental cost for filtration when we reduce ventilation and add particle filtration of recirculated indoor air. We avoid filtering a ventilation airflow of $\Delta Q_v$, but to keep indoor airborne concentrations of small indoor-generated particles from increasing we must add filtered recirculated indoor air with a flow rate of

$$\frac{1}{\varepsilon_f}\Delta Q_v$$

where $\varepsilon_f$ is the particle removal efficiency of the filter.

For our example MERV 14 filter with an $\varepsilon_f$ of 0.75 for small particles, we must filter $1.3\Delta Q_v$ of recirculated indoor air, as opposed to filtering $\Delta Q_v$ of ventilation air for our base case. The costs of filtration are low. In U.S. buildings which typically filter a supply air stream with a flow rate of four times the total ventilation airflow (or eight times $\Delta Q_v$ in our example scenario), the total monthly filtration cost has been estimated at less than $2 per person per month for a MERV 14 filter (Fisk et al. 2002). Since particle filtration costs will scale approximately with the flow rate of air filtered, the incremental cost for filtering the extra $0.3\Delta Q_v$ of airflow is about $1 per person per year. From analyses of the results of modeling of the U.S. office building stock, we estimate that average energy cost just of heating ventilation air with natural gas is $3.1 per person per year, and the cost is higher in most other types of commercial buildings. Except in mild climates, filtration will be far more energy efficient and cost effective than ventilation for controlling concentrations of indoor-generated particles.

For VOCs, the answer is less clear, but the future is promising. The most mature VOC air cleaning technologies are granular activated carbon (GAC) for reversible adsorption of higher molecular weight VOCs and granular chemisorbents for removal, by permanent chemical reaction, of lower molecular weight easily-oxidized VOCs such as formaldehyde. The granular media are normally installed in trays placed in the supply airstream and disposed of when expended. While these granular media can be highly effective in removing a broad range of VOCs from air, they are costly, can impose a high airflow resistance, and have an uncertain lifetime in indoor air applications (Fisk 2007). Consequently, trays of granular media are not typically used in buildings unless there is a special need for VOC control. Another option is the use of fibrous particle filters that contain activated carbon grains within the fibrous media. Many major particle filter suppliers now offer such products. However, the amount of carbon in these filters may be too small to reliably adsorb VOCs for the duration of filter deployment, and the result of limited field testing of the VOC control capabilities of these filters is not encouraging (Fisk 2007).

We believe that emerging technologies show greater promise in meeting our criteria. One emerging technology that has received much attention is photocatalytic oxidation (PCO) air cleaning in which the air passes over a surface coated with a titanium dioxide catalyst irradiated with ultraviolet light. The system creates hydroxyl radicals and other reactive species that break down VOCs, ideally to carbon dioxide and water. A few issues must be resolved before PCO systems prove practical for our application. Many PCO systems fail to fully breakdown all VOCs to carbon dioxide and water vapor, and the products of incomplete VOC decomposition can pose health risks. Also, the catalyst can be deactivated or partially deactivated by common indoor air pollutants. There has been progress in addressing both of these issues, but the energy cost to operate the UV lamps and the initial and replacement cost of the UV lamps also remain barriers. Two emerging technologies that show promise are activated carbon fiber (ACF) systems, and metal-oxide catalysts that can destroy some pollutants at room temperature. ACF is available as a woven cloth-like media made of activated carbon. Like GAC, ACF adsorbs a broad range of VOCs. Unlike GAC, ACF can easily be regenerated in place. Periodically, e.g., each night, heated air can be passed through ACF cloth at a low flow rate for a short period to drive the previously adsorbed VOCs off the ACF media. These desorbed VOCs are then vented outdoors, making the ACF again ready to serve as an air cleaner. Advantages of ACF compared to GAC include a greatly smaller mass of carbon media, lower pressure drops, and potentially longer life and much lower costs. We have studied ACF system performance with mixtures of VOCs, with VOC properties ranging from those of formaldehyde (molecular weight 30, boiling point –21°C) to undecane (molecular weight 156, boiling point 196°C). The research results as shown in **Figure 1** suggest that an ACF system coupled with a 50% reduction in ventilation rate will substantially improve IAQ, and that the energy required is only about 10% of the energy typically required in the U.S. for ventilation (Sidheswaran et al. 2011a). A metal-oxide catalyst showing great promise in breaking down formaldehyde and other easily oxidizable compounds is manganese oxide ($MnO_x$). Various deployment options for this catalyst are being evaluated including inside wallboards (Sekine and Nishamura 2001) and on surfaces placed in airstreams. In our research, we are applying this catalyst to the fibrous media of typical particle filters and removing formaldehyde, at room temperature, with 80% efficiency (Sidheswaran et al. 2011b). The material costs are low and the catalyst synthesis is not complex. With these new air cleaning technologies, or others, the potential is high for ventilation energy savings with IAQ maintained unchanged or improved.

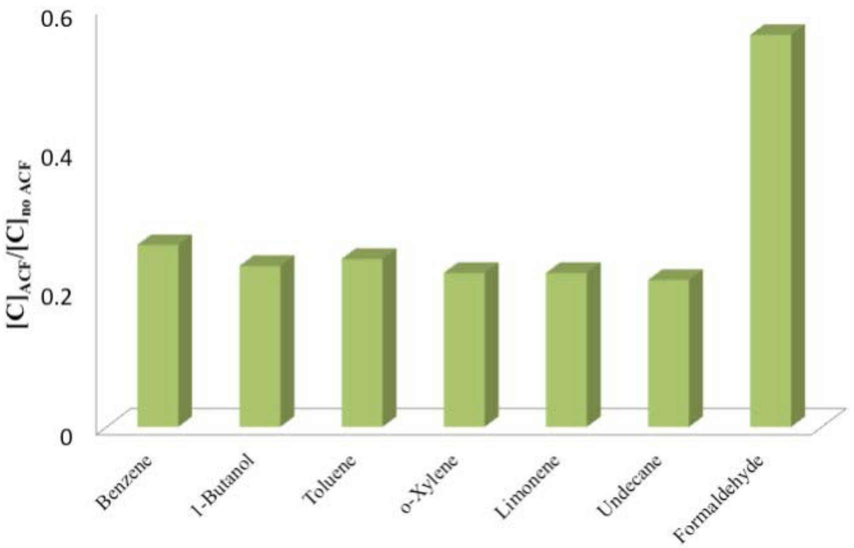


**Figure 1.** Ratio of Concentration of Common Pollutants during Air-Cleaning with 50% Reduction in Ventilation to Concentration of Common Pollutants with no Air-Cleaning. Air exchange rate was assumed to be 1/h (Sidheswaran et al., 2011a)

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# Comfort ventilation - a key factor of the comfortable, energy-efficient building

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Ruedi Kriesi is the owner of the Kriesi-Energie GmbH, vice-president and head of strategic group of Minergie association and technology-consultant of Zehnder Group. Until 2000 he was head of the energy office of Zurich Canton. In this function, he developed concept and brand Minergie with the economist Heinz Uebersax. Until 2010 he was head of Technology at Zehnder Group, where he introduced the comfort ventilation business. For 12 years he was member of the Swiss Commission for Energy Research and he is a single member of the Swiss Academy of Technical Sciences. Since 1990 he lives in Wädenswil in a zero heating energy dwelling, which he built with the architect Ruedi Fraefel.

## 1. Introduction

Passivhaus in Germany and Austria, MINERGIE® in Switzerland, Klimahaus in Italy – for all these brands heat recovery ventilation is mandatory thanks to its positive effect on energy consumption. Thus, these brands are important drivers for the introduction of this new technology. Whereas Passivhaus has reached just a few percent of the total new-build volume in Germany, about 25% of the total new-build volume in Switzerland is certified by MINERGIE®, creating a very important market for all energy efficient technologies.

In Holland, heat recovery ventilation is a cost effective means to fulfill the building code both for ventilation and energy efficiency. But whereas in Germany and Switzerland the image of heat recovery ventilation is good and improving further thanks to its broad promotion with its user benefits, its reputation is clearly inferior in Holland, where investors often apply the technology without approval by the users. The positive perception becomes clearly visible with its denomination in Switzerland, where it is called Comfort Ventilation.

Houses are built more and more tightly for air infiltration, in order to reduce energy needs for heating and cooling and to increase their effect as barriers to external noise. This means, however, that interior air quality requires additional attention – by frequent manual operation of windows during short periods or by installation of an automatic air exchange system.

## 2. User benefits of comfort ventilation - driver for its fast introduction

The main driver for comfort ventilation is the improvement of indoor climate:

- Many people suffer from increasing traffic noise - the automatic air exchange allows keeping the windows closed most of the time, maintaining their function as effective noise barriers, especially at night, when the inhabitants are asleep and manual operation of windows is not possible (**Figure 1**).
- Thanks to the automatic air exchange, no bad odours can accumulate and no mould can build up in a cold climate, even with users who are often absent for work or vacation with no possibility to

**1 plane with window closed:**
**30 dBA in room.**

**1 plane with window inclined:**
**45 dBA in room.**
**Equal to 32 planes with window closed!**

**Figure 1.** Fresh air with windows closed - noise-absorbing windows can properly perform only when closed.

regularly operate the windows for humidity control, or with tenants who don't care about air quality and keep windows continuously closed.
- Comfort ventilation also protects against dust through open windows. For people with hay fever it can even be equipped with pollen filters.

For the user, these advantages are clearly more important than the reduced energy consumption. Thanks to the increased comfort the value of an apartment may be increased by 10%, amounting to 1 000 €/a at an annual rent of 10 000 €, whereas the effect on the energy consumption for space heating thanks to the heat recovery amounts to about 25% or 400 kg oil/a and is worth about 300 €/a only at today's oil cost of -.75 €/kg.

Besides higher rents the investors can benefit from a higher long-term value of their building. Since it is equipped with the latest technology, which will become standard equipment within only a couple of years, the building will provide a modern standard for a longer period of time.

Comfort ventilation increases the benefit of a noisy construction site, because the building can be operated with closed windows most of the time. And again, the higher value of the site in many places outweighs the extra investment for the better technology.

## 3. Reduced energy consumption thanks to comfort ventilation

Reducing energy consumption by thermal insulation and heat recovery ventilation costs much less than providing renewable energy for space heating, down to very low consumptions. This experience was made with the Wädenswil zero-heating dwellings, built by the author with the architect Ruedi Fraefel as early as 1990, where the author has lived ever since.

With the improvement of thermal insulation of buildings the proportion of air exchange on the energy consumption has continuously increased. In the 70's, it may have counted for 10% of total demand for space heating of a single-family home, while it has risen to 35% today and up to 70% in apartment buildings.

Comfort ventilation reduces energy consumption by transferring heat from the return air to the fresh supply air. This is done by a heat exchanger, in which thin membranes made of plastics or aluminium separate the two airflows. About 85% of the heat contained in the return air is recovered, heating the cold supply air. In addition, the automatic ventilation helps to reduce the air exchange in the apartment, because the fresh air is supplied to the bedrooms and reused in the hallway, in many cases also in the living room and finally in the bathrooms and kitchen, from where it is returned to the ventilation unit. If manual ventilation through windows is the only way to get fresh air, the windows often remain open during long periods, increasing the air exchange far above an optimum value.

To move the two air streams, two small fans are operated, consuming electricity. To assess the energetic quality of comfort ventilation, the amount of heat recovered must be compared to the electricity consumed by these fans, as is common to qualify heat pumps. For heat pumps, an annual or seasonal performance index (API or SPF) is defined as the ratio of the annually delivered amount of heat and the annual consumption of electricity, reaching 3 to 5 for modern installations. An equal index can be defined for comfort ventilation systems, by comparing the annually recovered amount of heat with the annual electricity consumption. Table 1 shows that the corresponding values of Comfort Ventilation are much better.

Obviously, if the unit is operated all year round, the resulting annual performance index, API, is inferior to a resulting seasonal performance index, SPF, for seasonal use. Indeed, most users operate the units all year round to profit from improved protection against outside noise, dust, pollen and pests such as spiders, insects or snails, also in spring and fall, when temperatures outside and inside are very similar.

As shown in **Table 1**, exhaust ventilation reduces the heat demand of a flat with good performance indices as well, but to a much smaller degree than heat recovery ventilation. This technology extracts air from bathrooms and kitchen by a central fan. Fresh air is pulled into the bedrooms through openings in the window-frames by the slight under-pressure created by the fan. This reliably avoids mould in most cases, but it does not offer a good barrier against outside noise and no effective filter can be placed in the window openings. Additionally, wind will often create larger pressure differences around the house, resulting in very different air supply rates or even negative air flow directions in the bedrooms and living room.

## 4. Early home market in Switzerland with MINERGIE®

The standards for MINERGIE®-buildings all require an automatic air exchange. Since a very low consumption of non-renewable energy is required at the same time and all forms of renewable energies tend to be expen-

**Table 1.** Energy gain of Comfort Ventilation (or Heat Recovery Ventilation, HRV) compared to ventilation through windows and by exhaust fans.

| | | Window ventilation | Exhaust ventilation | HRV, 85% recovery | Gain compared to window vent. | |
|---|---|---|---|---|---|---|
| | | | | | Exhaust v. | HRV |
| Air exchange rate | $m^3/h – h^{-1}$ | 190 – 0.5 | 135 – 0.35 | 135 – 0.35 | | |
| Energy demand for heating air exchange: | | | | | | |
| - Zurich (3400 HDD) | kWh/a | 5170 | 3670 | 550 | 1500 | 4620 |
| - Milano (2200 HDD) | kWh/a | 3340 | 2370 | 360 | 970 | 2980 |
| Energy demand fans | | | (15W) | (30W) | | |
| - Year round operation | kWh/a | – | 130 | 260 | -130 | -260 |
| - Seasonal operation (4 500 h/a) | kWh/a | – | 62 | 135 | -62 | -135 |
| Performance Indices API/SPF Zurich | – | | | | 11/24 | 18/34 |
| Performance Indices API/SPF Milano | – | | | | 7/15 | 11/22 |
| Net energy gain | | | | | | |
| - annual/seasonal oper. Zurich | kWh/a* | | | | 1240/1380 | 4100/4350 |
| - annual/seasonal oper. Milano | kWh/a* | | | | 710/850 | 2460/2710 |

* 1 $kWh_{el}$ = 2 $kWh_{therm}$

**Figure 2.** Two blue mounting plates (top) are nailed to the wooden formwork and connected to the ComfoTube ducts, later covered by liquid concrete. Once the formwork is dismounted, the distribution casings can be bolted to the mounting plates, then visible on the ceiling. Below right both the distribution casings for fresh and return air can be seen, connected to the sound absorbers in front of them.

sive, 97% of all MINERGIE®-buildings are equipped with Comfort Ventilation. Thanks to the 20 000 certified MINERGIE®-buildings existing today, the brand therefore offers a perfect platform for the continuous improvement of ventilation systems.

Zehnder entered the Comfort Ventilation business by buying the ComfoHome-concept from UC Uebersax Consulting in the year 2000 and only two years later the Dutch manufacturer of heat recovery ventilators Storkair. Consequently, Zehnder was the first company to offer complete standardized home ventilation systems with its own products (**figures 2 to 4**). These systems can be combined with all types of heating systems, such as with gas boilers, wood stoves or wood boilers or heat pumps.

Its central component are the 90% efficient ComfoAir heat recovery units for the application in homes, manufactured by Storkair since 1995. Another key component is the flexible, double wall, all plastic ComfoTube duct, which has become the dominant way of air distribution for home ventilation first in Switzerland, later in Germany and Italy. This is thanks to the good air tightness of the required small duct diameters and the easy installation of the low-weight ducts. With ComfoHome Zehnder also introduced central air distribution casings, from which all ducts supply the air to the rooms in parallel. This results in small differences between the air flows, even without any adjustments, and in a good noise barrier between connected rooms. Zehnder also became the first to apply a standardized soil heat exchanger, ComfoFond, to avoid freezing of the heat exchangers at very low outside temperatures, using renewable energy. In the mean time, Zehnder has patented a soil heat exchanger on the basis of an anti freeze loop, heating the supply air of the ventilator unit with a traditional brine to air heat exchanger. This concept avoids frequent mistakes with the buried air ducts.

Kitchen hoods normally evacuate additional exhaust air over the hood. Since houses with Comfort Ventilation are normally very air tight, a special air supply duct must provide additional air when the hood is in operation, or a window must be opened. In both cases a lot of cold air will make the kitchen uncomfortable during hood operation. Types with active charcoal filters avoid cold air, but the filters must be replaced frequently, since the coal also absorbs humidity, abundantly available above the cooker. Zehnder has developed a third solution in cooperation with V-Zug, leading Swiss manufacturer of white wear. The hood is optimized for minimal use of return air, so that it can be coupled to the heat recovery ventilator. This results in a very low noise level of the hood, no cold intake air and infinite use of the same filter, which can be cleaned in the dishwasher.

### 5. Some myths on Comfort Ventilation

As all new technologies, Comfort Ventilation is opposed by traditionalists with experience from bad installations but often also with entirely incorrect arguments:

a) In homes with Comfort Ventilation it is not possible to open windows: Balanced ventilation applies two independent fans for the air in and out. Hence open windows do not affect it. Obviously the energy requirement of the building will increase with open windows. In a good installation, bad air quality will occur very rarely. Hence the desire to open windows will be rare as well. But if the air is bad or if there are other reasons for opening windows, such as listening to outside noise or dumping something to the garden, it is always possible.

b) Air ducts are unhygienic and microbes will develop: The air distribution system is positioned within the thermal envelope of the building. Therefore it is as warm as the rooms and the air in the system cannot condense any water. In dry ducts, no microbes can develop. Additionally, correctly built systems use filters both in the supply duct and in the vents of the return air, and the systems must be accessible for cleaning according to German and Swiss regulations. Tests on many installations have shown lower concentrations of microbes in the supply air than in the air intake, because a part will remain in the filter. The only source of microbes can be a dirty filter in the air intake, ahead of the heat recovery unit, where the air is still as cold and humid as outside, for example in autumn.

**Figure 3.** Each country has its own construction principles. Whereas in Switzerland and Austria most concrete ceilings are poured on site onto site built wooden formwork, in which round ComfoTube ducts can be mounted, prefab hollow ceiling-elements are applied in Northern Germany, on which flat ComfoTubes are positioned in the layer of the impact noise insulation.

c) The systems are noisy: Correctly dimensioned systems apply very low air velocities in the distribution system to keep pressure drops low. Thus the fans will run at low speed, creating little noise. This remaining noise must be lowered to the severe maximum limit of 25dBA by noise absorbers, according to German and Swiss regulation.

d) The system will create unpleasant draft: Comfort Ventilation in a dwelling for 3 to 5 people or 100

**Figure 4.** Comfortable energy efficient homes often are equipped with standardized combined units: A Zehnder ComfoBox provides not only heat recovery ventilation to the building on the left, but also space heating, space cooling and domestic hot water by an energy efficient soil to water heat pump, reducing cost for planning and installation.

to 200 m² moves 100 to 200 m³/h only, since it has to remove bad odours and excess humidity only and it is not used for heating or cooling purposes. Thus airflows are so low that it can only be sensed by holding the hand in front of a grill or close to a passage under a door, but never in the room at some distance from grills and passages.

e) Comfort Ventilation means air heating with dry hot air near air vents: The great majority of homes with home ventilation apply water systems for the distribution of heat, hence radiators or floor heating. The ventilation system is used for hygienic purposes only and the fresh supply air is heated by heat recovery only. Hence the temperature of the supply air always remains slightly below room temperature when it is cold outside and slightly above, when it is hot. Only traditional smaller Passivhouses apply air heating in order to keep cost low.

f) Comfort Ventilation means dry air: The systems will always reuse the supplied air in several rooms, thus reducing the amount of air required for a given level of air quality. Fresh air is brought into the bedrooms. It is then lead through the hallway and often through living rooms as well before it is returned from bathrooms and kitchen to the heat recovery unit. Since less air is required, the apartment is less dehumidified by dry outside air in winter. If houses with correctly dimensioned Comfort Ventilation still are too dry, it is due to a leaky envelope or to insufficient or entirely missing source of water vapor in the apartment. Enthalpy recovery exchangers, returning not only heat from the exhaust air but also humidity, can reduce the problem in many situations. However, a relative humidity inside of 35% at temperatures below freezing is sufficient. High indoor humidity favours mite growth and increases the risk of mould close to heat bridges of the thermal insulation.

g) Comfort Ventilation leads to bad air quality: The automatic and continuous air exchange leads to better air quality than with manually operated windows. However, Comfort Ventilation cannot solve the problem of hazardous emissions from building materials, such as formaldehydes from glues or paint. Many such gasses are harmful or just annoying in concentrations over several orders of magnitude. Comfort Ventilation can constantly reduce the level of all gasses a bit, but it would be very costly and most uncomfortable to increase the air exchange rate to such an extent. Gas emissions from materials must be avoided at the source; there is no other solution to this.

## 6. Conclusion

Comfort ventilation is an effective technology not only to increase indoor comfort but also to reduce the energy consumption for space heating and cooling of buildings. This double advantage is recognized in a growing number of countries. The only reason its application is not spreading even faster is the traditional thinking of both planners and users – air has always come into the buildings through windows, why should this be changed? But also wooden wheels had been used for centuries and resistance to these "modern rubber tyres" on horse trailers had been intensive. 3E

## MINERGIE® - brand that created a large market for comfortable, energy-efficient buildings

The first 200 buildings were certified according to the MINERGIE®-standard in 1998 in Zurich. In 2010, about 25% of the total new-build market in Switzerland and a total of 20'000 buildings with close to 20 mill. m² of heated floor area were certified by this brand, lifting it within 15 years to the by far cheapest and most effective instrument for energy policy in the country.

This huge success was possible thanks to a pragmatic technical approach and to promotion on the basis of the user-benefits:

- MINERGIE®-technology: With the zero heating-energy dwellings built in Wädenswil in 1990, it was shown that an air tight and well insulated building envelope, combined with heat recovery ventilation can reduce the energy demand for space heating to a very low level at reasonable cost. At this low level, it doesn't really matter, if still fossil fuels are used and, if more expensive renewable energies are applied, they can be afforded thanks to the low requirement.
- MINERGIE®-promotion: Traditional promotion for energy saving measures in all industrialized countries asked for contributions from users and investors to reduce the countries' energy dependency. But when an individual investor spends a lot of money in a new home, he cannot afford any risk and he would invest in a proven concept only, hence in a traditional home with high energy consumption.

  This learnt with long lasting fruitless efforts, MINERGIE®-promotion was based on user benefits, also learnt with the Wädenswil zero energy dwellings: The airtight and well-insulated building envelope protects the user from external noise. Thanks to Comfort Ventilation, the windows can remain closed most of the time, keeping dust and pests outside and avoiding any risk of mould.

  For the investor, these advantages of the energy efficient building actually are worth more than the energy savings. Once the building industry had understood that the investors would listen to this kind of promotion, planners, installers and system suppliers copied the arguments and sent them to the market with their means of communication.

Accordingly, MINERGIE® was defined as the combination of increased quality of life, increased competitiveness and reduction of non-renewable energy to a sustainable low level. This new philosophy has entirely changed the image of energy efficiency in Switzerland. Whereas it was a subject reserved for the green corner of society before, it now is accepted by all parties and by all types of investors in the country.

MINERGIE® was developed by the author, who at that time was the head of the Zurich canton energy office, together with Heinz Uebersax, a marketing consultant who was the initial owner of the brand and who developed it privately at first. Today the brand is owned and managed by the MINERGIE® association, with all the Swiss cantons, the federal government, system manufacturers, planners and professional building investors as the main members. A strong position is held by the cantons, which are responsible for the building regulations in the country. The fact that their information to the market is supporting the MINERGIE® philosophy has accelerated the acceptance of the brand.

Another important early support for the brand was provided by the bank of the canton of Zurich: In 1998 already they offered a special mortgage rate for MINERGIE®-buildings with the arguments, that these houses would maintain their value better thanks to their high comfort and that they would not be affected by a sudden increase in energy price, hence that they present a smaller risk for the bank. In the meantime, it has been shown by the University of Zurich, that the resale value of MINERGIE®-homes indeed is higher than of comparable buildings.

The brand is applied on a broad scale in Switzerland and Liechtenstein. There is a licensee in France. In 2011, it is planned to create an organization for the export of the brand and the related knowledge for any organization who wants to install a similar brand in its home country.

**For more information:** www.minergie.ch

# Overheating and insufficient heating problems in low energy houses up to now call for improvements in future

Requirements for improved energy performance have shifted major focus on energy calculations in the design process. Experience from a Danish research project on low energy homes built today, shows that more attention has to be paid on indoor climate and specially temperature control issues to ensure comfortable living conditions in future houses.

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Energy savings in the residential area are essential in order to achieve the overall goal for energy savings outlined in the 2008 Danish energy political agreement. The residential area is responsible for approx. 30% of the combined energy consumption in Denmark, and, therefore, holds great potential. In recent years, this has resulted in several experimental buildings and development projects with focus on developing low energy houses in a Danish context.

Unfortunately, not all experiences from these low energy houses have given positive feedback, and problems with indoor climate in the houses, have been in focus. However, it is important to point out that some of the problems with low energy houses also existed in previous constructions. For instance, the problem with overheating is well-known, but the problem is more distinct with low energy houses as the houses heat up very quickly, so even though many details and good solutions in the houses have been considered, problems can still arise. The objective of the work is to analyze these problems and evaluate how the problems can be removed in the future or be heavily reduced in future houses in order to ensure that future low energy houses in Denmark will be healthy houses with good indoor climate.

**Keep the sun outside!**

Previous experience from houses built as low energy constructions has shown that very high temperatures and consequent discomfort arises quickly in some houses. The high temperatures occur partly due to the several south facing window sections, which in many cases are poorly shaded from solar radiation, and partly due to lack of ventilation or free cooling options.

An analysis of the problems with overheating shows that implementing the option of active use of window airing in our houses combined with external solar shading is essential in the future. It is of great importance, that the solar shading is chosen as an external solution, since this type of shading is the most effective solution. Many technical solutions are available. **Figure 1** shows four different solutions. Illustration a. shows an automated solution where blinds run up behind the facade cladding when not in use. In the illustrations b. and c. solutions with fixed overhangs above the windows are shown. In such cases it is essential to make a careful calculation, that happens when the sun drops below the shading device causing direct radiation into the house. In Illustration c. louvers fixed on rails are

**a.** **b.** **c.** **d.**

**Figure 1.** Examples of external solar shading.

seen. These can manually be run in front of the windows when needed. At the house in Illustration d. it is planned to grow deciduous vegetation (not yet planted in this photo) over the rooftop, which, during the summer will provide shade on the windows around the terrace, but during the winter will allow the sun to come into the house.

Combined with solar shading, active use of window airing/night ventilative cooling will help cool down the house. During the day, when the house is empty or at night, it should be possible to ventilate and utilize free cooling effect that can simply be provided by opening windows. In order to make this possible, the openings in the house must be incorporated during the beginning of the design phase, so that the house is designed with the possibility of ventilative cooling, since it can be difficult to create this option after the house has been built.

Another question is the utilization of thermal mass, i.e. could heavy materials affect the indoor temperatures in the house in either a positive or negative manner. The conclusion is that the thermal mass only has a positive effect as long as it is possible to cool down the construction during the night, i.e. the use of thermal mass only works when it is possible to provide a suitable air change during the night. If this is not attained, the thermal mass can even enhance the problems with overheating in the house instead.

### Control of the indoor temperature during summer

During the design process the main attention is drawn to the expected energy consumption of the house. This often includes large window areas in the southern room in order to increase the solar gain, and thereby reduce the heating need. The thermal conditions in these southern rooms often become critical, due to focusing only on energy needs. In order to avoid this, the temperatures in such critical south facing rooms need to be analyzed in order to determine whether the rooms have a risk of too high temperatures.

Today, the energy demand is calculated in Denmark with Be10 program, which is a simple energy calculation program, based on the single zone monthly calculation. The program has a very simple control of the indoor climate in the form of a built-in "over temperature penalty", but this is a very uncertain control since the program treats the building as a single zone and will, thereby, often not reveal problems in e.g. south facing rooms with large amounts of solar radiation. Here the problems typically occur, when the occupants have closed the doors to the northern part of the house and thereby reduced the volume. It is important to understand that the indoor climate cannot be controlled by an energy calculation program, but must be analyzed with tools suited for indoor climate.

One way to control indoor climate could be via a simple calculation of the daily average and maximum temperature on a summer day. Calculation can be done in app. one hour, as many of the necessary parameters already are defined in connection to the energy calculation (window sizes, solar shading, U-values). To illustrate how this is done, a calculation of the daily average and maximum temperatures are made for a south-facing room, where, in two successive summers, very high temperatures in the finished house were recorded. Measurements from the living room are shown in **Figure 2**.

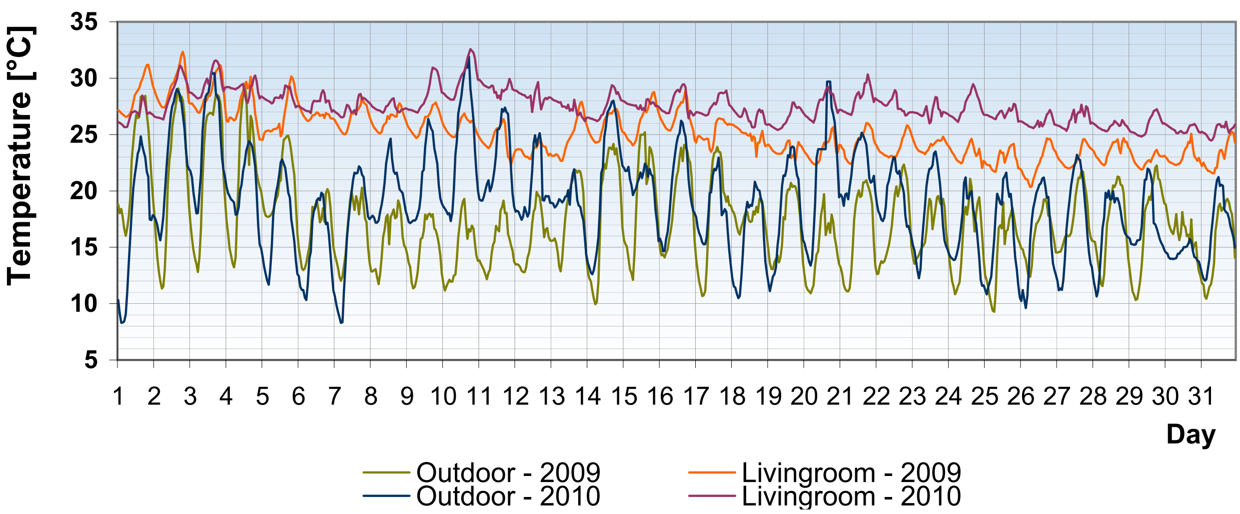


**Figure 2.** Outdoor temperatures and room temperatures measured i July 2009 and 2010. (Results from the white one-storey house in Skibet.)

In the method, calculations have been made both for an occupied house (L1) and an empty house (L2). Also the ventilation rates are varied. (V1) is calculated for the ventilation rate specified in the energy calculations. (V2) are made for increased use of window airing. All calculations are done with weather data for June. The results of calculation shown in **Table 1**.

**Table 1.** Results for the daily average temperature and the daily maximum temperature in July.

| | Case A | Case B | Case C | Case D |
|---|---|---|---|---|
| **Person load + lighting** | L1 | L1 | L2 | L2 |
| **Natural ventilation** | V1 | V2 | V1 | V2 |
| **Daily average temperature** | 35.4°C | 30.4°C | 34.5°C | 29.8°C |
| **Daily maximum temperature** | 38.6°C | 33.8°C | 37.6°C | 33.1°C |

From the table it is seen that in all cases temperatures reached well above comfort temperature. This calculation indicates that the house will have problems with overheating in the summer, just as it was found from the measurements in the house. Increased solar shading, reduction in window area or more ventilative cooling could have been the solution to the problems, but unfortunately the temperatures were not checked during the design process for this house and therefore the problems were not shown before the occupants moved in.

### Insufficient heating during winter

In low energy houses, it is quite often very small amounts of energy that has to be added to the house in order to heat it up during winter. If the heat outputs are sized so that internal heat gains are considered to be always present and the average heat loss per floor area instead of room specific losses are used, the house will easily experience situations with insufficient capacity in the building as soon as the present conditions in the house deviate from the calculation prerequisites. For example, it happens in situations where the outdoor temperature is lower than -12°C (Danish design value) and you want to keep the room temperature higher than 20°C, or if the house is not as airtight as assumed in the calculations. It is therefore recommended to use careful room by room sizing with full heat losses and some capacity margin in order to avoid this situation.

Another issue that needs to be highlighted is the reduced or missing option of using individual control of the room temperature in the air heating systems used. While typically under floor heating was used in wet rooms, other rooms were equipped with centrally controlled ventilation air heating, where supply air was distributed both from floor or ceiling level and no recirculation air was used. Such ventilation air heating can, among other things, result in cold corner rooms in a house, an example is shown in **Figure 3**. Insufficient heating in some rooms with simultaneous overheating in some other rooms was also reported by Minergie® Agentur Bau in their study for houses with ventilation air heating. They concluded that the disadvantages with this type of air heating are too great compared to the

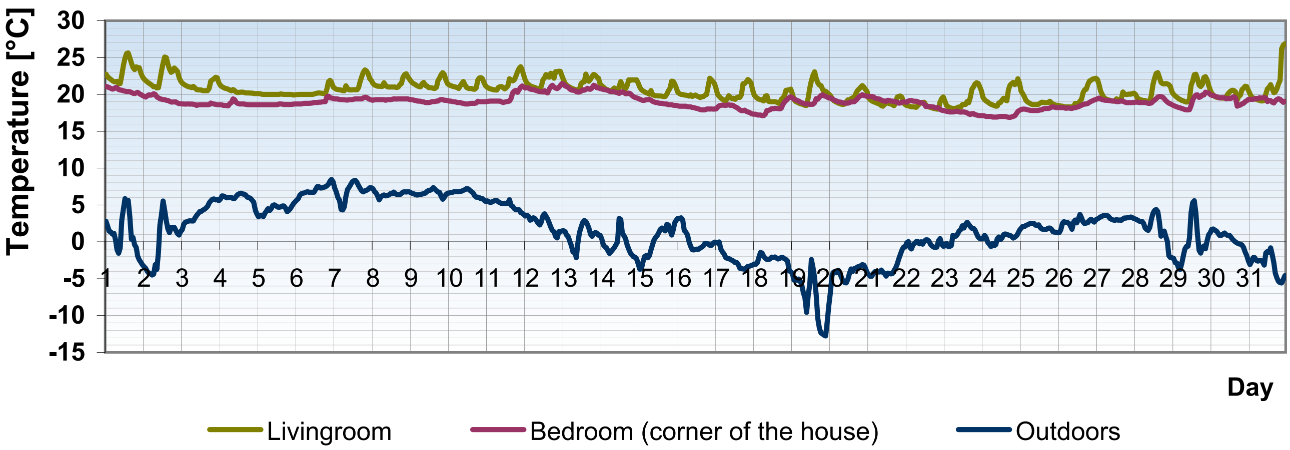


**Figure 3.** Outdoor temperatures and room temperatures measured in December 2009. (Results from the white one-storey house in Skibet.)

savings achievable by not using a hydronic distribution system [Minergie® Agentur Bau, 2007]. If the house has a poor distribution of heat between rooms (e.g. due to soundproofing in walls between each room), an individually controlled heat supply in each room would be able to increase the temperature in the room if so required as long as the capacity is available in the system. The problem with the uneven heat distribution between the rooms also underlines the necessity of calculating several temperature zones of the house where heat loss and heat supply are different from zone to zone.

Finally, it is to be pointed out that the air tightness is an essential parameter when sizing heat outputs and calculating energy use, which is illustrated in **Figure 4**. If the construction is leaky, the infiltration will cause infiltration, which has to be heated. If heat outputs have been sized with a small or no safety margin already, an increased infiltration will quickly result in heating problems.

### Demand controlled ventilation

Indications show that future houses will be larger and larger and at the same time we will be fewer people in the houses. This means that we will have a greater amount of $m^2$ per. person, which also leads to a reduction in the need for fresh air per $m^2$ of the house – at least when the temperature, $CO_2$ and relative humidity are evaluated. Whether or not the same applies to other parameters such as radon and formaldehyde is not evaluated in this analysis, but must be concluded before a final appraisal of the demand controlled ventilation in houses can be completed.

Different solutions for demand controlled ventilation are today available at the market. Most of the systems are operated automatically via measurements of relative humidity (RH) but some solutions also include RH combined with measurements of $CO_2$-levels. These solutions ensure a robust ventilation method in the house where fluctuation on the internal loads is taken into account, but the solution with measurement of both RH and $CO_2$ will provide the most reliable solution. However, $CO_2$ with an air change of 0.5 $h^{-1}$ will often only be a problem in short periods with guests in the house, but if air change rates of less than 0.5 $h^{-1}$ are allowed in the future, it is debatable whether or not the additional investment is necessary as the analyses in the project do not show any problems with high RH but rather the opposite. It is, however, important to point out that small rooms with high, internal loads must have higher air change rates. These are typically bedrooms and children's rooms where there is internal load all night. The children's rooms are in some cases extra critical as there is also activity during the day in these rooms and pollution added to the room air from many plastic toys etc.

Another important parameter is evaluation of the energy efficiency in the ventilation systems, i.e. the SFP value. There is a large fluctuation in the SFP value despite the fact that all of the investigated systems have been installed within the last 2-3 years. A high SFP value can ruin even the best of intentions of creating an effective and energy-friendly ventilation system, so it is, therefore, important that the SFP value as a standard procedure is documented at the delivery of the construction based on measurements of the installed system.

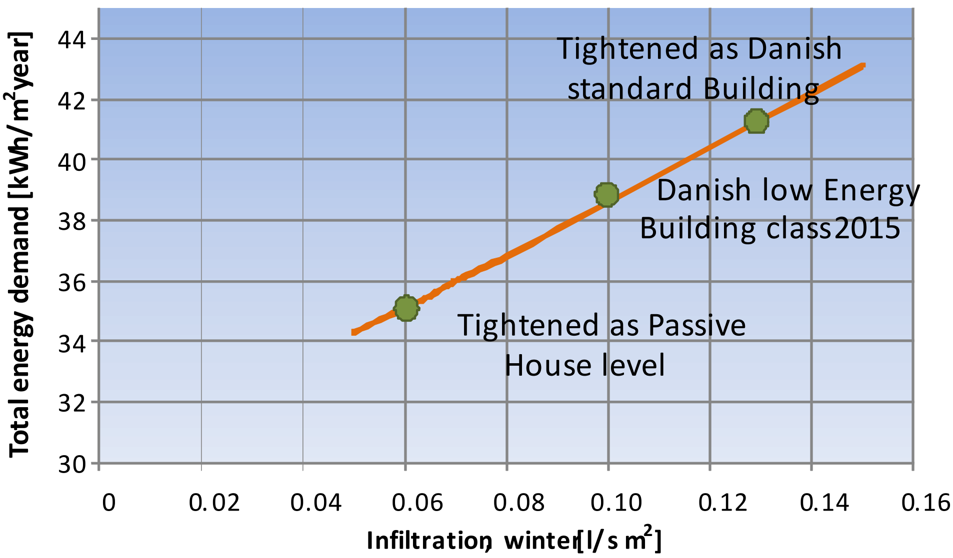


**Figure 4.** Energy use for heating, domestic hot water, fans and pumps as a function of infiltration – a case study.

### Using previous experiences - and build on them

To ensure a healthy and comfortable environment in future low-energy housing we must make demands for the indoor environment in our homes on an equal basis with demands for the energy use. At the same time the engineer and architect needs to be better at working together from project start so that the architecture is optimized for the requirements for low energy, which will be

- a passive house of 141/169 (net/gross) m² from the Comfort House project in Skibet near Vejle, Denmark
- heat source: ground source heat pump combined with air/water heat pump
- heating system: underfloor heating in bathrooms and ventilation air heating in other rooms
- ventilation: heat recovery mechanical supply and exhaust ventilation, demand controlled (RH)
- U-value of ext walls 0.085 W/(m²K) and windows 0.66 W/(m²K)
- fixed solar shading on southern and partly eastern and western windows

- a passive house of 154/198 (net/gross) m² from the Comfort House project in Skibet near Vejle, Denmark
- heat source: ground source heat pump combined with air/water heat pump
- heating system: underfloor heating in bathrooms and ventilation air heating in other rooms
- ventilation: heat recovery mechanical supply and exhaust ventilation, demand controlled (RH)
- U-value of ext walls 0.087 W/(m²K) and windows 1.02 W/(m²K)

- a house build in 1974 renovated in 2010 to low energy class 1 (energy for heating, hot water and building electricity app 40 kWh/(m²-gross a)). 176 m² from Tilst near Aarhus, Denmark
- heat source: low temperature district heating
- heating system: underfloor heating and radiators
- ventilation: heat recovery mechanical supply and exhaust ventilation, demand controlled (RH and $CO_2$)
- U-value of ext walls 0.12 W/(m²K) and windows 0.96 W/(m²K)
- combined use of mechanical ventilation during the winter and natural ventilation during the summer.

found in optimized shape of the building, integrated solar protection, proper orientation, use of passive measures, etc.

Furthermore, it is important to involve the experiences already available from the low-energy buildings that are built today. It requires that we become better at sharing both the good experiences, but also the bad experiences we've already got. One can learn a lot by making mistakes and it is therefore important that errors are not hidden away, but used to improve the buildings ahead.

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# Heating and cooling challenge in nZEB

Experiences from built houses and detailed building simulations calls for a careful and integrated approach when designing heating and cooling systems for nearly zero energy buildings

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## Introduction

Building codes are presently moving towards new low energy standards with annual primary energy rates gradually approaching net zero energy levels. One can rightly ask what implications this has for the design and layout of heating and cooling systems. There is clearly a need to adapt our current systems in such a way that they optimise both energy use and comfort requirements in low energy construction. Even nearly zero energy buildings require some energy input to maintain an acceptable indoor climate, and the task is to ensure that the supplied energy is utilised for an optimal indoor environment.

## Legislation and building labelling

The EPBD recast of May 2010 introduced nearly zero energy buildings (nZEBs) requiring that all new buildings in member states shall be nZEB from 31 December 2020 – and that public buildings shall lead the way and be nZEB from 31 December 2018. A zero energy building is most often defined as a building with zero net energy use on annual basis or zero

"Trelleborg huse" in Denmark. An example of newly designed mass produced low energy houses specified with radiant under floor heating and cooling controlled by a dynamic energy management principle. The house has mechanically-balanced ventilation with heat recovery, a double heat pump (ground heat and hot water with solar connection). Active summertime floor cooling is applied using the ground heat loops. (Source: Trelleborg and Uponor).

net carbon emissions, but different definitions exist and different approaches will be taken and adapted in national building codes. Very low energy demand buildings or even positive energy buildings are already being constructed in significant numbers throughout Europe.

In addition to the official national building regulations, a number of voluntary labelling schemes exist in the European markets, such as MINERGIE® and passive house standards. The passive house concept has proven successful in providing single family houses with very low net energy need for space and ventilation heating meeting a threshold typically around 15 kWh/m², but with remaining issues to be resolved for user comfort, indoor climate and energy optimisation. Meanwhile, the concept is being challenged by different active house concepts that aim at optimising the balance between indoor climate, energy and environment, with the most known example of MINERGIE®. Some active houses even produce more energy than they use and therefore become net energy suppliers to the public electricity grid and possibly also heating networks.

As the overall energy use is lowered, it is evident that the overall energy efficiency becomes a more important issue. We need a more integrated building design and more attention should be given to the integration of the building in its environment. In other words, the engineering focus is shifting from energy savings to energy optimisation.

This article describes heating and cooling needs in typical low energy houses which are built to adhere to the climatic conditions in Nordic countries. In particular we have simulated the performance of low energy houses build in accordance with the current definition of low energy buildings in the Danish building code (BR 2010).

The Danish building code operates with maximum primary energy use for space, ventilation and hot water heating as well as HVAC-electricity based on a fixed element plus a variable element depending on the heated space. The Standard Regulation 2010 stipulates a maximum primary energy use of (52.5 + 1650/A) kWh/m² per year and the Low Energy Class 2015 stipulates a maximum primary energy use of (30 + 1000/A) kWh/m² per year, where A is the heated space in m²-gross.

The Danish Low Energy Class for 2020 is in preparation and is expected to be ready in spring 2011. The final requirements have not be settled and decided on yet, but the working definition stipulates a primary energy frame defined as (15+500/A) kWh/m² per year in 2020.

### Engineering challenges – for all seasons

Designing for a proper indoor climate in nZEBs implies a number of challenges. There is a great need to adapt building services to low energy standards as even passive buildings need a small amount of energy to remain inhabitable with an adequate indoor environment year round. Ventilation, heating and cooling strategies need to be planned in order to maximise the use of renewable sources and thus limit the environmental impact. The required energy must be supplied utilising the lowest cost and most environmentally-friendly energy sources possible.

The heating system must meet the heat need with the lowest possible use of primary energy. In well-insulated buildings equipped with heat recovery, the heating system must operate on the basis of a very low average heat need while remaining reliable and energy efficient during peak load periods. The improved thermal envelope will shorten the annual operation time, but peak load situations need to be designed very carefully in order to ensure adequate system capacity.

Another challenge is to optimise the thermal envelope and architecture in such way that the summer cooling loads are minimised. In principle the energy use for heating and cooling should be optimised during building design. Clearly passive measures like solar shading, geometry and building orientation should of course always be exploited to a maximum, but much evidence still points to severe overheating problems in well insulated buildings. Often overheating is not even limited to the hot summer months.

Typically large heat gains from the sun can start to heat up a building already in March and April, with a similar pattern in autumn. The heat gains entering the house as solar radiation through the windows can be several hundred W/m², largely exceeding the dimensioning heat power. The heat gains from the sun combined with the internal heat gains create a need for cooling, even in the colder seasons.

### End user experiences

Experiences from low energy houses that have already been built show that several issues regarding comfort and energy performance remain unsolved. According to the indoor climate comfort criteria, thermal comfort for inhabitants requires an indoor temperature of between 20 and 26°C when occupied, but there is often a significant difference between what is calculated in the design phase and what is really experienced by the end user.

Residents typically suffer discomfort from overheating in the summer and cold due to low temperatures outside the comfort range in the winter. This often translates into missed heating and cooling capacity and an expressed wish to have more direct user influence on the technical heating and cooling systems.

In addition, people with heat pump installations often experience their electricity bills being much higher than the design expectations. This is most likely a result of heat pump installations running at none-optimal supply levels and in none-optimal operating schemes.

**Table1.** Input data for building envelope, ventilation and infiltration for a Danish low energy case study.

| | U-values [W/m²K] | |
|---|---|---|
| | **Standard** | **Low energy** |
| External walls | 0.23 | 0.18 |
| Roof | 0.13 | 0.10 |
| Ground floor | 0.10 | 0.09 |
| Windows | 1.56 | 1.09 |
| Doors | 1.56 | 1.09 |
| Ventilation max efficiency | 85% | 85% |
| Infiltration | 0.13 l/(s m²) | 0.06 l/(s m²) |

## Case studies

In order to adapt heating, cooling and ventilation system design to low energy standards, Uponor has carried out extensive simulations of low energy buildings located in different locations throughout Europe. The simulations were made for annual net energy need for space and ventilation heating within the range of 10 to 25 kWh/m² per year with heating power needs within the range of 20 to 40 W/m². The building simulations were carried out using the building simulation software IDA-ICE Indoor climate and Energy 4.0.

The simulations were made for building geometries corresponding to the current national building codes based on real buildings currently being constructed by local house builders.

**Table 1** specifies input data for a Danish case study. Weather data from a Danish reference year is used, and most findings would be applicable in similar climatic conditions in Northern Europe. All employed data such as U-values, loads, ventilation and infiltration rates were specified according to the Danish building regulation BR2010. Internal heat gains with a total maximum of 5 W/m² (persons 1.5 W/m² and equipment and lights 3.5W/m²) were specified according to a detailed occupancy schedule. The "standard" input data corresponds to the minimum requirements in the current building codes, whereas the "low energy" input data corresponds to the insulation and tightness requirement stipulated in the Low Energy Class 2015.

## Heating season and peak loads

Exposing the test house to the Danish reference year shows that the heating season for the standard house adds up to about 4500 hours while the low energy insulation and tightness measures reduce the heating season to about 4000 hours. The low energy building standards typically reduced the annual net energy need by 30% or more while the peak loads only typically reduced by 15%.

The heating peak loads have been calculated excluding the internal heat gains and solar heat gains. Transmission loss, infiltration and ventilation losses are calculated when the outdoor temperature is -12°C and room the temperature is 20°C. The peaks for the space heating power need are calculated for an air change rate at 0.5 ach supplied at temperature of minimum 18°C.

For the low energy house, average peak loads above 14 W/m² (total 2000 W) only occur for a very limited time period of about 70 hours per year. It is nevertheless crucial to take the extreme peak into consideration when designing the capacity of the heating system, in order to meet the indoor comfort requirements. There is a large peak load variation between rooms and peak loads of up to 22 W/m² (south facing rooms) and 32 W/m² (north facing rooms) can be observed during the standard Danish reference year. Relying on average values for capacity design will most certainly lead to discomfort.

The large variation in heating power needs between rooms supports the need for individual room controls. Furthermore, it is of course important that central heating systems are properly commissioned and controlled in order to prevent improperly balanced water flows in the system.

A typical design misconception is that the free heat contributions from solar and internal heat gains are equally distributed over time. As seen in **Figure 1** this is far from being the case. Nevertheless, capacity dimensioning is in many cases done with average values, assuming an average contribution from the sun and an internal heat gains based on a standard number of people using the house. This is a simple explanation for many insufficient heating problems in practice.

## Need for Cooling

Several tendencies indicate that the need for cooling in residential buildings is generally increasing. This is partly because we experience more extreme weather types with warmer summers, because people's requirements for indoor comfort are rising and last but not least because of low energy building codes with stricter requirements for tightness and insulation have brought about significant cooling loads during the warmer seasons.

This trend is confirmed by the building simulation, which identifies significant cooling loads that of course depend on applied solar shading. Peak loads of more than 60 W/m² are identified, in particular in rooms exposed to the south and south-west. In addition, for the cooling loads a very high variation occurs, mainly due to the room orientation, so one has to be careful when using average building values for design purposes. Direct sunshine has the most significant influence on the cooling loads and therefore the cooling peak loads don't necessarily occur on the "warmest day". Instead they are dependent on the building geometry and its orientation.

If there is no cooling at all in the building, the temperature will be outside the comfort range (20-26°C) for about 20% of the time for a standard house and about 30% of the time in a low energy house.

As can be seen in **Figure 2**, shadings can reduce the cooling loads to some extent, but not fully eliminate them. The applied external shadings have an 86% shading factor and the in-between shadings have a 50% shading factor. The shadings are applied in the period from 1 March to 30 September and only during the daytime between 8am and 5pm, when it is assumed that the house is not going to be occupied. Weekend occupancy patterns are assumed to be similar to weekdays.

The calculated cooling loads excluded the part being covered by the ventilation system. The inlet air of the

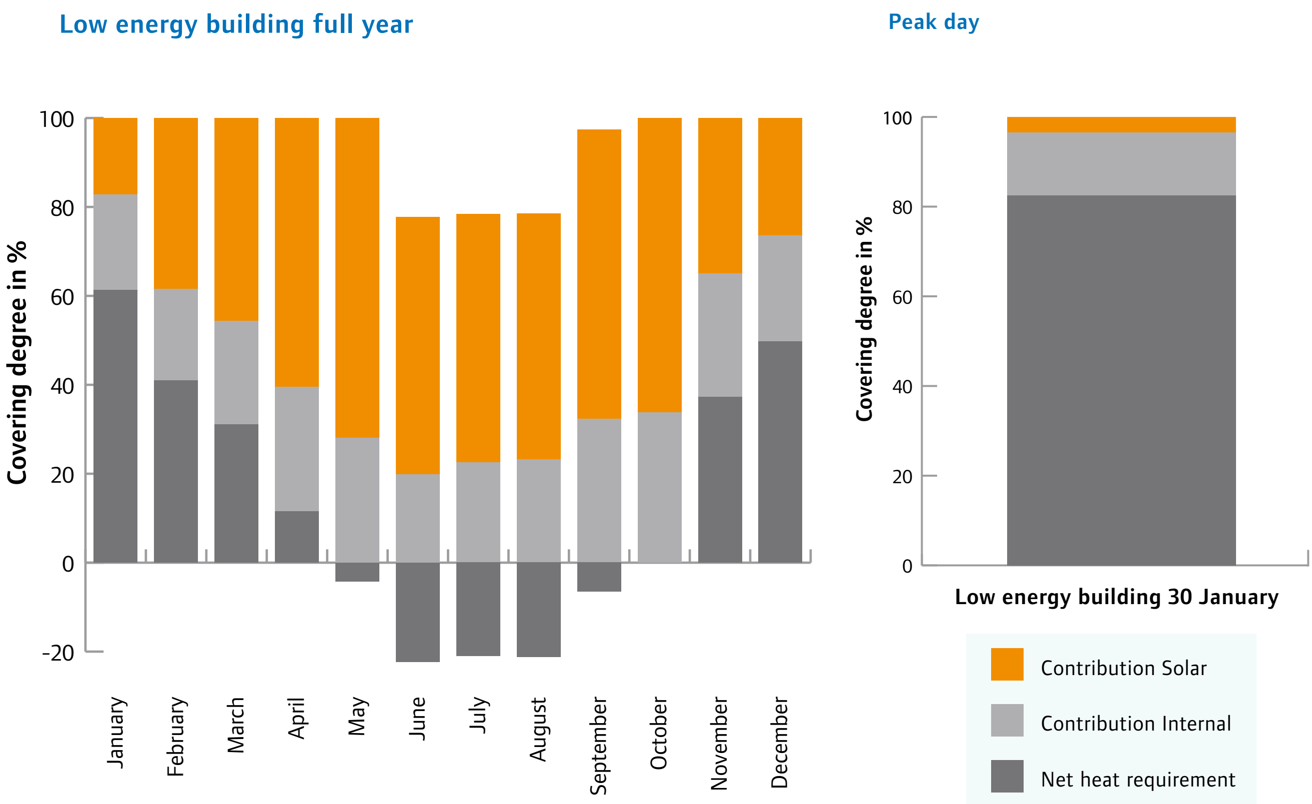


**Figure 1.** During the coldest month (January) solar gains and internal heat gains nearly cover 40% of the heat power need on an average basis. On the coldest day, however, the free contribution is less than 20%.

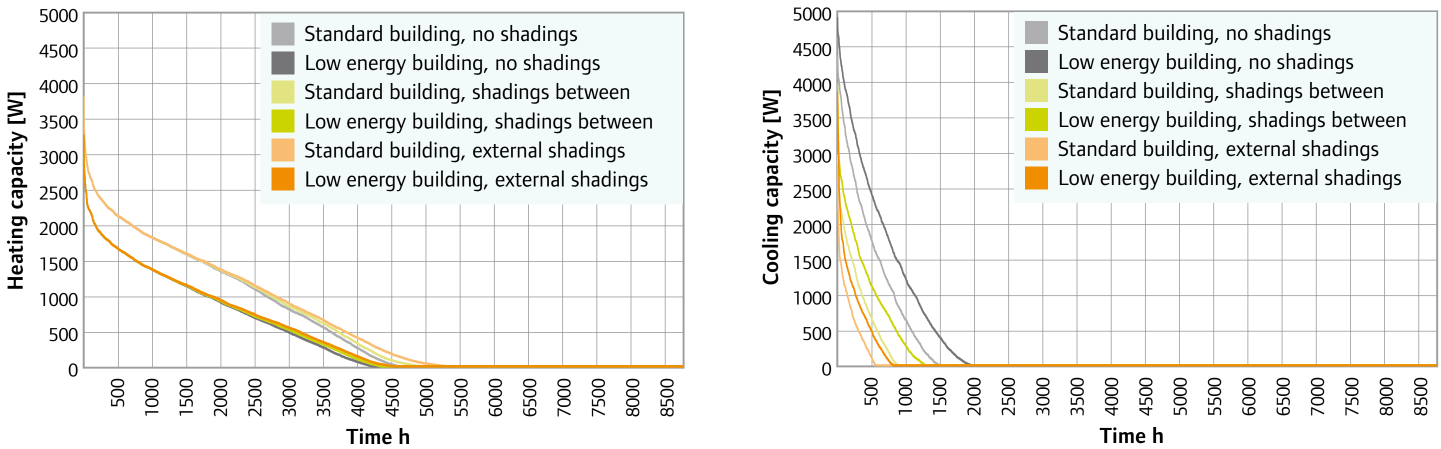


**Figure 2.** Duration curves for heating and cooling needs (Danish test house).

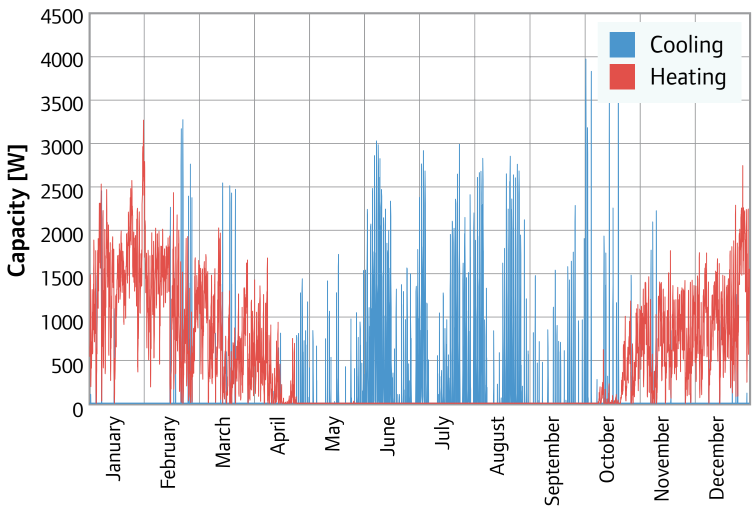


**Figure 3.** Cooling loads are present in summertime as well as throughout the intermediate seasons. Applying shadings can reduce the building average cooling peak loads to around 25 W/m².

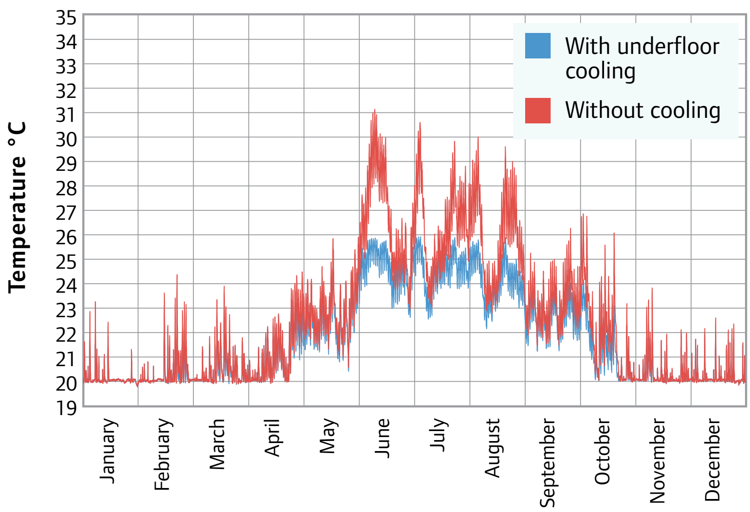


**Figure 4.** An under floor cooling system designed with supply water temperature at 14°C, return temperature 17°C and thermostat set point at 24°C yields a cooling output of 30 W/m², sufficient to maintain the room temperature at levels below 26°C.

ventilation system was supplied with a temperature of 18°C at an applied air change rate of 0.5 ach for the total volume of the building. During the summer period there was a by-pass for the HRV unit when the outdoor temperature exceeded 18°C. As long as the outdoor temperature is lower than the indoor temperature it is possible to allow the cooler outdoor air to enter the room and reduce any overheating effect.

Proper use of shading of the windows from direct sun radiation and other passive measures should always be the first steps taken to reduce cooling loads. In the simulated case this can reduce cooling peak loads to 25 W/m². The remaining part of the cooling loads need to be removed by active or passive cooling. Using electricity (compressor cooling) for active cooling by the ventilation system, will in most cases not be possible within the nZEB energy frames. Instead, by using a combined under floor heating and cooling system, the cooling need can be met by using floor cooling 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 use, for example via free cooling from the ground or with a ground coupled heat pump.

## Primary energy use

Heat pump technology is widely used in low energy houses and is an important way to reduce the primary energy use. The overall efficiency of heat pumps strongly depends on the supply temperature in the heating system. The lower the supply temperature, the higher the efficiency. A rule of thumb suggests that lowering the supply temperature in the heating system by 1°C will yield a reduction in annual heat pump electricity use up to approximately 2%.

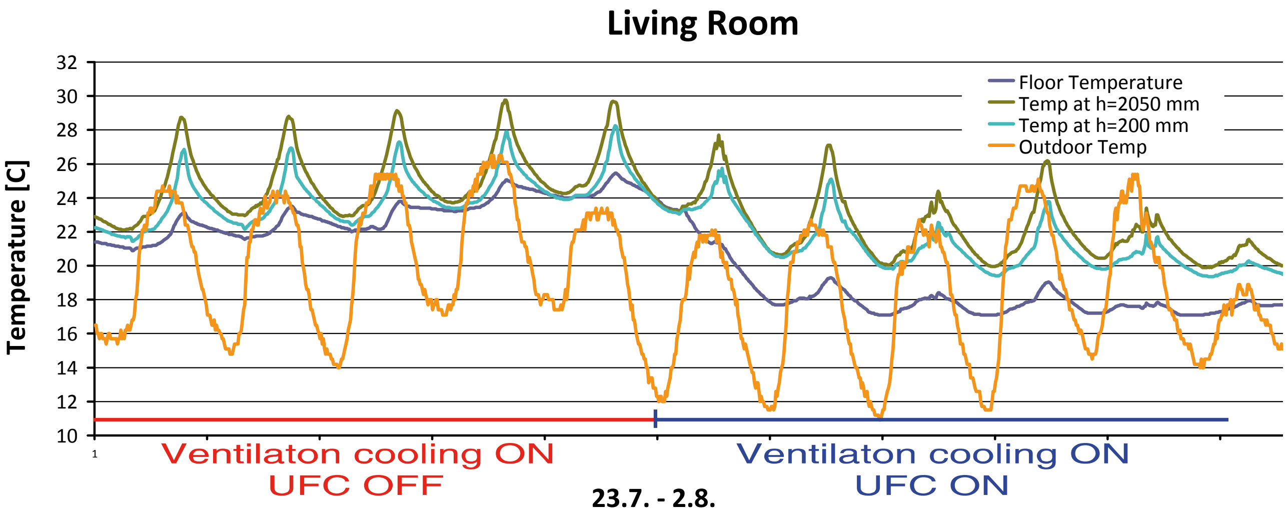


**Figure 5.** Example of applied radiant under floor cooling in a Finnish single family house (source: Uponor).

A low supply water temperature requires that the heat transmission takes place over relatively large surfaces as applied in under floor heating systems, for example. The favourable temperature levels make it possible to operate heat pumps at a favourable seasonal performance factor.

As an example, when using a brine water heat pump, if the heating system is designed with low temperature heating operating at a supply temperature of 30°C instead of a conventional system with a supply temperature of 50°C, this will yield an annual saving of about 20% to the electricity bill, depending of course on the heat pump type and other parameters (see **Figure 6**).

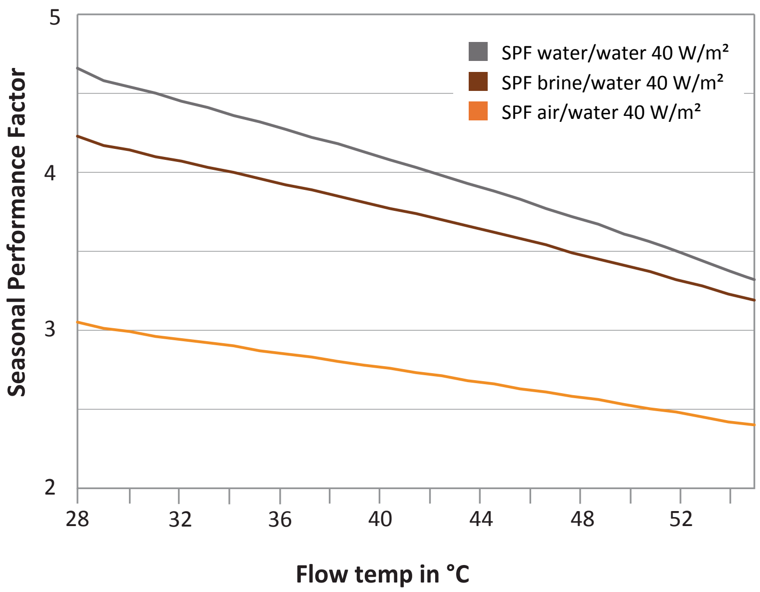


**Figure 6.** The influence of the supply temperature on the seasonal performance factor (SPF) for different types of heat pumps installed in a low energy single-family house. The SPF is calculated based on a 6 kW heat pump model using VDI4650.

## Summary and perspectives

Nearly zero energy buildings are already being constructed and inhabited in significant numbers throughout Europe. Reducing the net energy need for space heating has proven to be successful, when applying passive measures such as improved insulation and building tightness. Various aspects of comfort, energy efficiency and optimised use of primary energy calls for an integrated design approach for building architecture and building services.

If the focus is only on the reduction of the required heating energy, there is a risk that the comfort of the occupants is neglected. It is important to design the building geometry in such a way that periods with temperatures outside the thermal comfort criteria are minimised. It is equally important to design the heating, cooling and ventilation systems in such a way that the cooling loads can be removed efficiently with minimum extra energy consumption, preferably using free or renewable cooling sources.

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.

At the end of the day, marketable solutions which potential house owners are actually likely to be willing to invest in are the joint responsibility of the different parties involved in the design and construction of nearly zero energy buildings.

# A market overview of erected low-energy buildings in Sweden

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## Introduction

The recently revised directive on the energy performance of buildings (2010/31/EU) contains requirements that all new-build public buildings must meet the requirements for *"near zero-energy buildings"* by 1st January 2019, and that the same will apply to all buildings with effect from 1st January 2021. The definition of exactly what *"near zero-energy buildings"* means is left to each member state to decide for its buildings. If this performance is to be achieved, it will require a number of support measures and a tightening up of regulations relating to new building work and renovation work. Developing a strategy for near zero-energy buildings and deciding which and where resources should be set in requires updated information on the present market status of low-energy buildings.

The LÅGAN programme *(name derived from the Swedish for buildings with very low energy use)* is one of the national initiatives that assist improvement of energy use in buildings. Its objective is to increase the rate of construction of low-energy buildings. Two market surveys of low-energy buildings in Sweden have been performed as part of the work of LÅGAN. The first is a web-based market overview (www.laganbygg.se), for which detailed data on about 50 buildings has been collected and quality-assessed. The second survey, described in this article, aims to provide an overview of various categories of low-energy buildings that have been built in Sweden, and does not go into details of the technologies used or similar aspects. It has been performed partly in the form of a search of the literature and partly by direct contact with persons involved in the sector, in the form of an e-mail enquiry to which over 70 persons in the sector responded. The information that they gave in respect of energy performance, costs, energy classifications etc. has been used without further checking, which means that the results from this investigation must therefore be regarded only as an overview.

The overview contains information on erected buildings having an energy use that is at least 25% less than the requirements in the applicable building regulations. It does not include information on buildings that are at the design stage.

## The Swedish building regulations

The most recent edition of the building regulations published by the National Board of Housing, Building and Planning dates from 2006. It sets out the requirements for energy performance of buildings. Further restrictions for electrically heated buildings were published in 2009. The requirements specify not only maximum permitted energy use per square meter, but also the permitted installed electric power for heating, and a mean coefficient of thermal transmittance of the building envelope. In addition, the new building code specifies that energy performance must be verified by measurements within 24 months of completion of the building.

The requirements are described in terms of specific energy use (kWh/m² $A_{temp}$), and are shown in **Table 1**. $A_{temp}$, the temperature area, is defined as the area bounded by the inside of the building envelope, on all floors, that is supposed to be heated to more than 10°C.

The building's energy use is defined as the energy that needs to be delivered to the building *(often called "purchased energy")*, in normal use and during a normal year, for heating, comfort cooling, domestic hot water, and electricity for operation of the building's services systems. This means that the delivered electricity for buildings heated with heat pumps is included while the heat from ground sources are not. Electricity for domestic purposes or business activities is not included.

## Construction of low-energy residential buildings beats all records

The market for low-energy buildings initially grew only very slowly, but has begun to take off in recent years. In total, over 100 detached houses and over 3200 apartments (in 72 apartment buildings) have been built as low-energy buildings. Over 60% of them have been built in the

**Table 1.** Requirements for specific energy use in the national building code (kWh/m² $A_{temp}$).

| Type of building | Climate zone | | |
|---|---|---|---|
| | I (north Sweden) | II (middle Sweden) | III (south Sweden) |
| Residential buildings with heating systems other than electric heating | 150 | 130 | 110 |
| Residential buildings with electric heating | 95 | 75 | 55 |
| Commercial and similar premises with heating systems other than electric heating | $140 + 110 \cdot (q–0,35)$ | $120 + 95 \cdot (q–0,35)$ | $100 + 70 \cdot (q–0,35)$ |
| Commercial and similar premises with electric heating | $95 + 65 \cdot (q – 0,35)$ | $75 + 55 \cdot (q–0,35)$ | $55 + 45 \cdot (q–0,35)$ |

*q* is the average specific outdoor air ventilation flow rate during the heating season (l/(s,m²) and is an addition that must be included when the outdoor air flow exceeds 0.35 l/(s,m²) in order to maintain required hygienic air quality in temperature-controlled areas. Its maximum permissible value is 1.00 l/(s, m²).

last two years (**Figure 1**). Most of them have been built in Climate Zone 3, distributed as follows: western Sweden 54%, Småland 18%, Greater Stockholm 11%, and southern Sweden 9%.

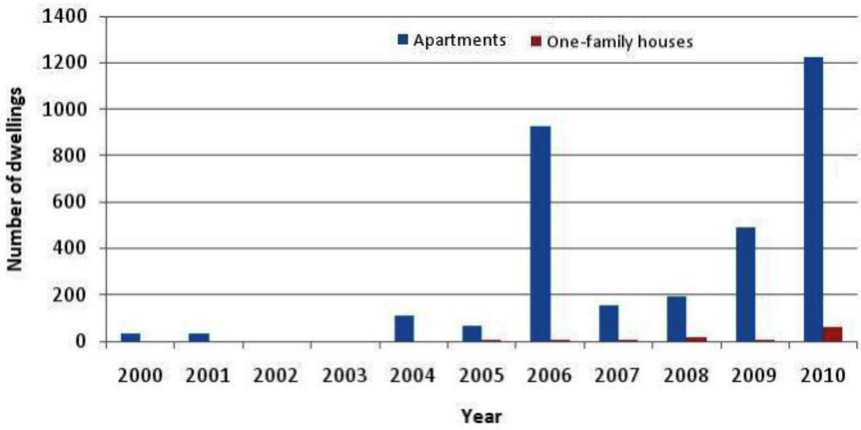


**Figure 1.** Numbers of residential dwelling units constructed per year.

Numbers beat all records in 2010, when the proportion of low-energy apartments accounted for 11.2% of total apartment new-build numbers, and the proportion of detached houses amounted to about 1%.

The large number of buildings that were built in 2006 are mostly "electrically heated", complying with the building regulations of the time, which did not impose particular requirements on electrically heated buildings, and giving a total of 523 apartments. They cannot be classed as low-energy buildings under the present building regulations requirements for "electrically heated" buildings.

**Table 2** shows the spread of energy performance in residential buildings for those of them that fall into the "heating other than by electricity" category. Where possible, the metered energy use is shown: if this is not available, then the expected *(i.e. as expected in the design work)* energy use is shown. It has been assumed that buildings with heat pumps fall into the "electrically heated" category , while other buildings fall into the "heating other than by electricity" category.

$E_{BBR}$ is the requirement in accordance with the current building regulations (January 2011). $E_{use}$ is the building's

**Table 2.** Energy performance for residential buildings in the "heating other than by electricity" category.

| Energy use, $E_{use}$, (kWh/m² $A_{temp}$) | No. of det. houses | Proportion (%) of detached houses | No. of apartments | Proportion (%) of apartments |
|---|---|---|---|---|
| $E_{use} < E_{BBR}$ | - | - | 80 | 4 |
| $E_{use} \leq 0.75 \cdot E_{BBR}$ | 17 | 22 | 1012 | 52 |
| $E_{use} \leq 0.5 \cdot E_{BBR}$ | 37 | 47 | 800 | 41 |
| $E_{use} \leq 0.25 \cdot E_{BBR}$ | 24 | 31 | 68 | 3 |

metered or expected energy use (excluding energy for domestic purposes). The 80 apartments having an energy use higher than 75% of that specified in the current building regulations have design values that are less than 75% of the building regulations values, but did not achieve this performance during the first year of metering.

Five detached houses and 658 apartments use heat pumps for heating, and are therefore classified as electrically heated, they are not included in **Table 2**. Under present-day building regulations, many of them fail the classification of low-energy buildings as their energy consumptions are well over 75% of permissible values in the applicable building regulations. However, it must be pointed out that they were built in accordance with the building regulations at the time, which did not include special requirements for electrically heated buildings. Their energy use values lie in the range of 41-75% of the energy requirements for buildings with heating systems other than electric heating.

## Energy performance of commercial and similar premises improving, too

The market for low-energy buildings in the commercial and similar premises sector is similar to the residential buildings market. Development has been very slow, and has started to improve only during the last few years. A total of 700 000 m² of commercial and similar premises has been built as low-energy buildings, in 78 construction projects.

Most of the low-energy commercial and similar premises have been built in the last three years: **Figure 2**. As with residential buildings, most of them have been built in Climate Zone 3, with the distribution as follows: western Sweden, 36%; Greater Stockholm, 31%; southern Sweden, 12%; and northern central Sweden, 8%. Over 400 000 m² of office premises have been built, with half of them being in Greater Stockholm.

2009 and 2010 beat all records, with the proportion of commercial and similar premises built as low-energy premises amounting to 8% of the total area.

76% of these buildings have an energy performance that is 25-50% better than required by the current building regulations, while 20% are 50% better than required by the regulations.

## Much more extensive valuation data needed

As by far the majority of the buildings have been built in the last two years, there are no high-quality post-construction measurements or assessments. Several such follow-up projects are in progress, but many more are needed. In the residential buildings, less than half of them have had their energy performance measured. More extensive measurements of airtightness of the building envelope, and follow-up in the form of questionnaires to occupants or interviews asking about the indoor climate have been carried out in a quarter of the apartments and in only three detached houses.

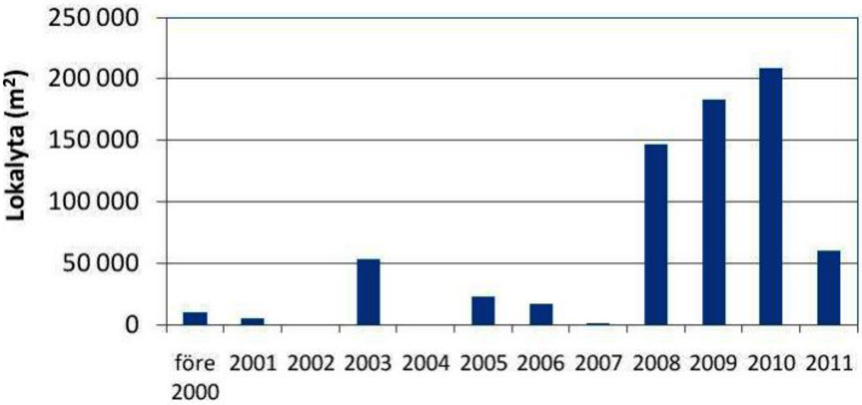


**Figure 2.** Low-energy commercial and similar premises, construction per year.

**Table 3.** Energy performance in new commercial and similar premises.

| Energy use, $E_{use}$, (kWh/m² $A_{temp}$) | Infant schools | Schools | Universities | Office | Care services, hotels | Sport, industry | Retail | Total number | Proportion (%) |
|---|---|---|---|---|---|---|---|---|---|
| $E_{use} < E_{BBR}$ | 1 | | 1 | | 1 | 0 | 0 | 3 | 4 |
| $E_{use} \le 0.75 \cdot E_{BBR}$ | 12 | 6 | 5 | 27 | 3 | 2 | 4 | 59 | 76 |
| $E_{use} \le 0.5 \cdot E_{BBR}$ | 7 | 3 | | 2 | 1 | 1 | 1 | 15 | 19 |
| $E_{use} \le 0.25 \cdot E_{BBR}$ | | 1 | | | 0 | 0 | 0 | 1 | 1 |
| **Total** | **20** | **10** | **6** | **29** | **5** | **3** | **5** | **78** | |


**Hamnhuset, a residential low energy building by Älvstranden Utveckling in Göteborg.** The tenants moved in 2008.

Among the commercial and similar premises, follow-up of energy use and evaluation of other properties and characteristics of the buildings is even more deficient than for the residential sector. Support for monitoring their performance will be important for many years into the future, in order to collect experience and develop the necessary appropriate technical design and system improvements.

The Swedish building code requires that energy performance must be verified by measurements within 24 months of completion of the building and the building´s energy certificate will normally be based on the monitored energy performance. Exceptions are if the building is sold within the first 24 months. In that case the energy certificate will be based on calculated energy performance.

### Voluntary initiatives

Changes can be seen in the construction and property sectors, with several developers, contractors and local authorities already having clearly enunciated targets for constructing buildings having lower energy use than as specified in the applicable building regulations.

Interviews have shown that several of the parties have their own high performance requirements for all future work – and this in a sector that has previously been regarded as conservative. Project development company JM AB has, for example, decided to build only residential buildings with an annual energy use not exceeding 75 kWh/m² in Climate Zone 3, or 45 kWh/m² for electrically heated buildings. Contractors Skanska Residential Development Nordic and NCC Boende Sverige have also set the requirement of 75 kWh/m² in Climate Zone 3.

Public property owners are also setting performance requirements for new buildings. Göteborg Property Department, which builds schools, infant schools and residential property for the elderly, has set its performance requirement for maximum permissible energy use as 45 kWh/m². Västfastigheter, which builds health care premises, has set its maximum permissible annual energy use level at 100 kWh/m², including electricity for operational requirements.

Developers Skanska Commercial Development Nordic and NCC Property Development have committed themselves to ensuring that, in all projects where they have some form of purchasing role, and are therefore in a position to influence energy performance, such performance shall be at least 25% lower as required by the applicable regulations.

Since 2009, Göteborg has applied stricter requirements than in the Building Regulations when granting planning permission for buildings. For apartment buildings, the city requires a maximum heating energy not exceeding 60 kWh/m² (or 45 kWh/m² for 'electrically heated' buildings). For detached houses, the figures are 55 kWh/m² (or 40 kWh/m² for 'electrically heated' buildings) respectively. In December 2010, Stockholm City Council announced that all residential buildings and commercial and similar premises to be built on the city's land must be passive buildings.

Växjö, Malmö, Jönköping, Västerås and Linköping also set stricter standards as a condition for planning permission, ranging between 70 and 85 kWh/m², year. However, the setting of specific local energy requirements can make industrial-scale building and renovation more difficult.

### Driving forces

The Västra Götaland region in particular has favourable experience of construction of apartment buildings as low-energy buildings, with the proportion of low-energy apartments being as high as 24% of total new building in 2010. This is of course due to a range of factors. The region has had several proponents of such development, who have pushed development, while the Environmental Department has supported a multi-year programme for energy-efficient buildings, under which such developments as the passive house sector in Alingsås have been carried out. Another contributory reason can be that there is a tradition of interdepartmental cooperation in the region between land use planning, purchasers, administrators, contractors, energy utilities etc.

The purpose of energy labelling certification schemes is to support development. In the commercial and similar premises sector, almost half of the buildings have obtained GreenBuilding certification, which indicates that this labelling has provided an important impetus. This is particularly noticeable for development in the Stockholm area, which has accelerated since establishment of the GreenBuilding scheme.

The establishment of performance specifications for passive houses may also be one of the factors that has assisted development of most of the residential properties, with an energy use less than half that of the applicable building regulations.


**A new low energy office built by Husvärden in Göteborg, Sweden.** The consultant company Bengt Dahlgren moved in December 2010.

### Investment costs

Information on additional costs is very difficult to estimate, with what they are based on being dependent on who has prepared the cost estimates and what system solution has been taken as the comparison case for a building designed and constructed in accordance with the relevant building regulations. The additional costs given are for the particular building or project concerned, which is often the first energy-efficient building that the organisation has built. This means that the additional cost probably includes an element of learning costs which, in a more efficient construction process with greater volumes and numbers, could be expected to fall as the number of buildings increases.

**Stadsskogen in Alingsås built 2008.**
A kindergarten built with passive house technique.

Based on information from ten detached houses investment costs amount to SEK 19 500/m² on average. Data for three of them indicates that the additional investment for energy efficiency is about 10%. Based on information from 34 of the apartment buildings investment costs amount to SEK 17 000/m² on average. The average additional investment for energy efficiency is stated as about 7%, but varies between 0 - 17%.

Based on information from 13 infant schools investment costs amount to SEK 27 000/m² on average. The additional investment for energy efficiency is stated as about 3% on average, but varies between 0-10%. Based on information from seven schools investment costs amount to SEK 23 000/m² on average. The additional investment for energy efficiency is stated as about 2% on average, but varies between 0-5%.

Cost information is available for seven of the newly built offices. The average investment cost amounts to SEK 22 000/m². The average additional cost for energy has been given for only one building, for which it is stated to be "negligible".

### Are the target levels of the NNE strategy reasonable?

During 2010, the Swedish Energy Agency has been working on preparation of a strategy to implement the requirements for *"near zero-energy buildings"*. The preliminary strategy proposes halving the maximum specific energy use allowed in the present building regulations in the "heating other than electric heating" category by 2020.

This review identifies a relatively large number of residential buildings that have shown that it is technically possible to meet a performance requirement of only 50% of the energy use specified in the applicable building regulations. Practice from calculation of profitability shows that it is not viable to build low-energy apartment buildings if the additional investment cost exceeds 7%. Viability requires the process to be improved so that the additional cost at least go halves.

For infant schools and primary schools, it is technically possible to construct buildings having an energy use of only 50% of that given in the applicable building regulations, but that several empirical follow-ups are needed to measure both energy performance and other technical parameters and properties.

Practice from calculation of profitability shows that it may be viable to build low-energy infant schools and schools if the additional investment cost is of the order of 2-3%, i.e. these energy efficiency improvement measures can already be viable.

This review shows that it is today technically possible to build office premises having an energy use 25% less than in the applicable building regulations. The additional cost for higher energy efficiency is stated as being negligible for an office, but was also without exception regarded as negligible in interviews with a number of contractors.

At present there are not sufficient material available from existing and monitored buildings that clearly shows the technical and economic potentials for low-energy buildings in each category of building. However, for commercial and similar buildings as a common group, there is an indication that it is technically possible to produce buildings having energy use 25% less than as given in the applicable building regulations. 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 m$^2$ (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.

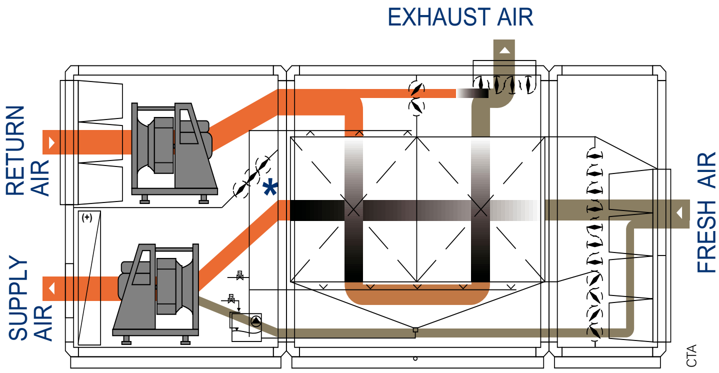
| | |
|---|---|
| Building type | Office |
| Net floor area | 4 500 m$^2$ |
| Gross floor area | 5 000 m$^2$ |
| Gross volume | 16 7500 m$^3$ |
| Mean occupant density | 15 m$^2$/person (overall average) |
| Occupied hours | 2 450 h |

**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.

## 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

A photo of the façade intake.

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.

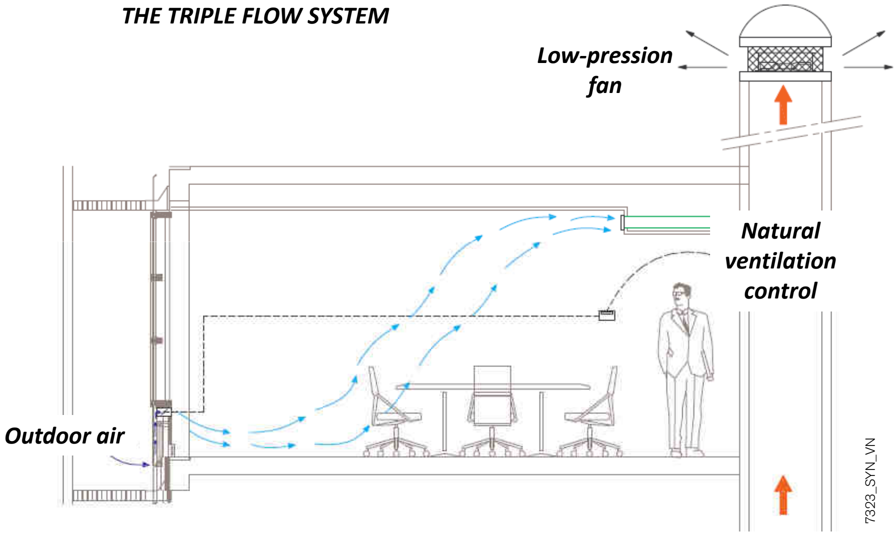
The third operation mode is the free cooling. Air handling units are stopped and atrium exhaust used in order to ventilate the building in night summer time. In this mode, the building can be ventilated with low pressure central atrium exhaust ventilation. The 32 air valves are opened in order to ventilate 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/(m² a) | **Primary energy factor** - | **Primary energy use** kWh/(m² a) | **Primary energy use** kWh/(m² 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/(m² a) per net floor area, 57 kWh/(m² a) per gross floor area as calculated according to French standard, which is 33 kWh/(m² 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/(m² 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

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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.

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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.

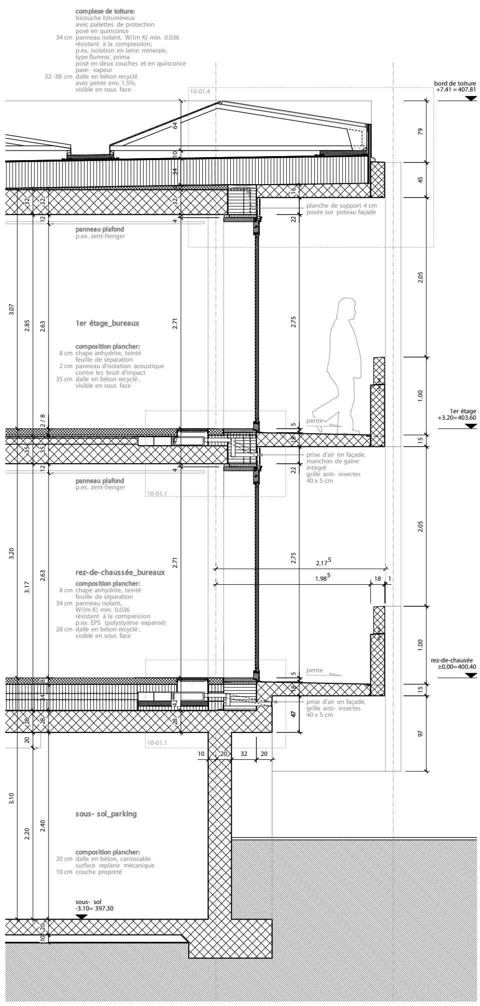

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**Figure 1.** Principle section.

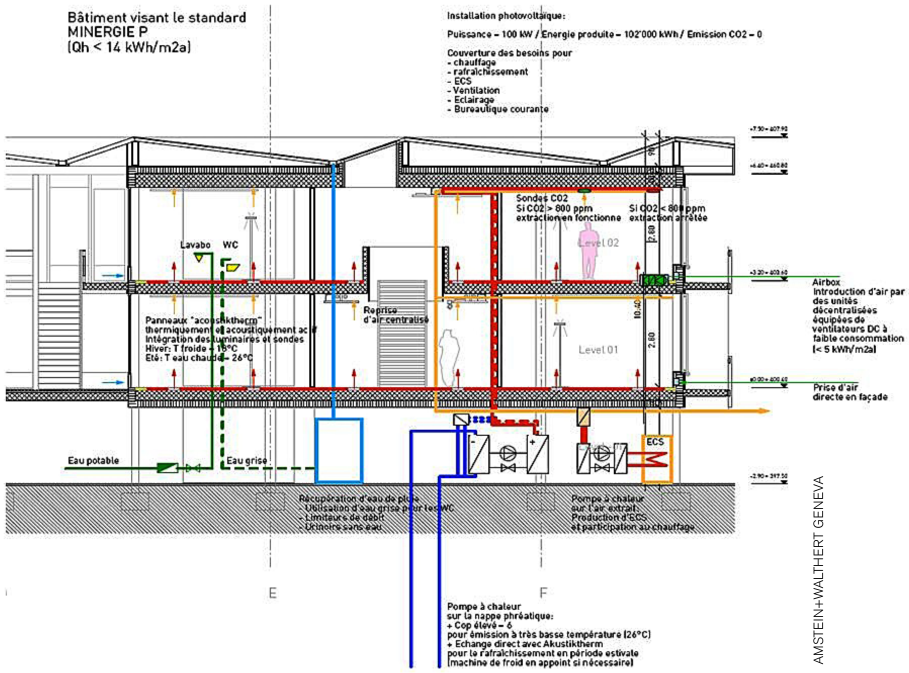


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**Figure 2.** HVACS diagram.

## 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

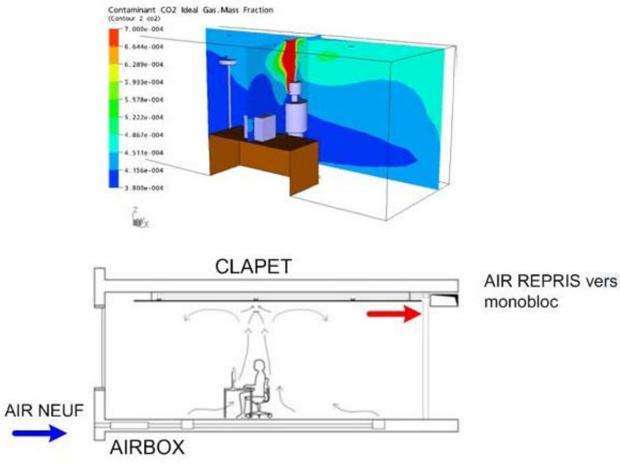


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**Figure 3.** Ventilation, heating and cooling concept.

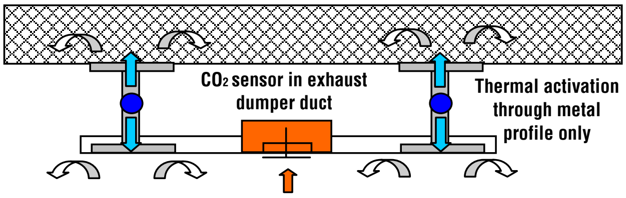


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**Figure 4.** Ceiling panel for heating and cooling, with integrated extract air terminal and lighting.

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**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.

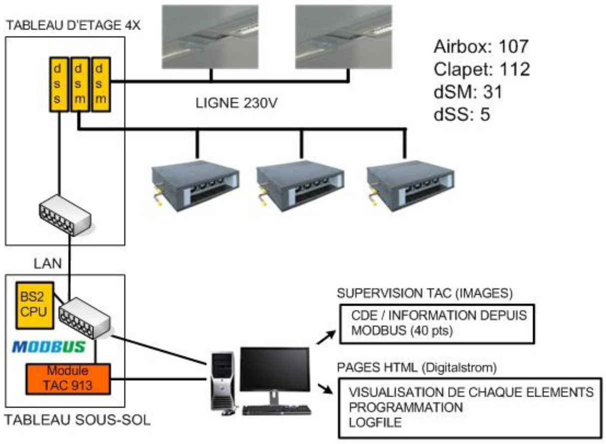


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**Figure 6.** Digitalstrom typology.

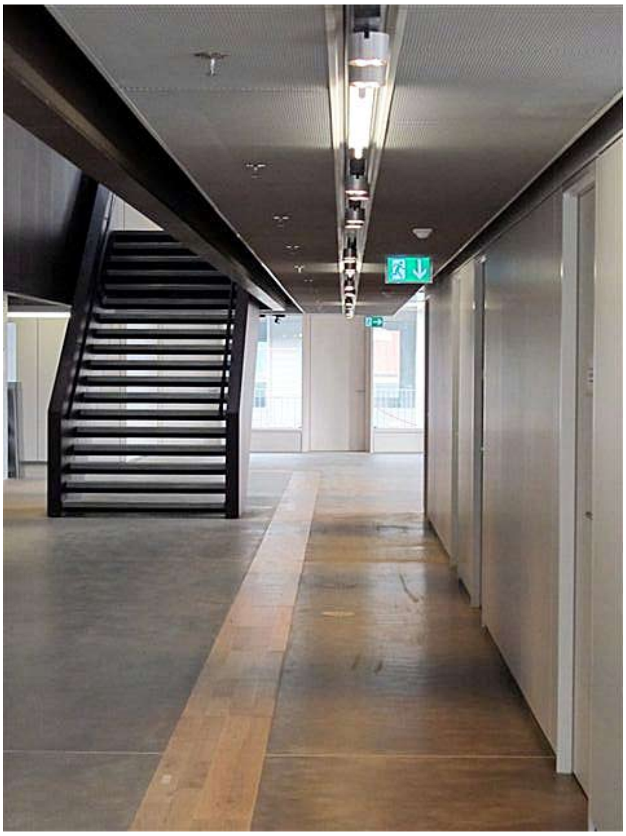

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**Figure 7.** View from inside the building.

## 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 $m^2$ 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 $W/m^2$. 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 $m^3$. 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-

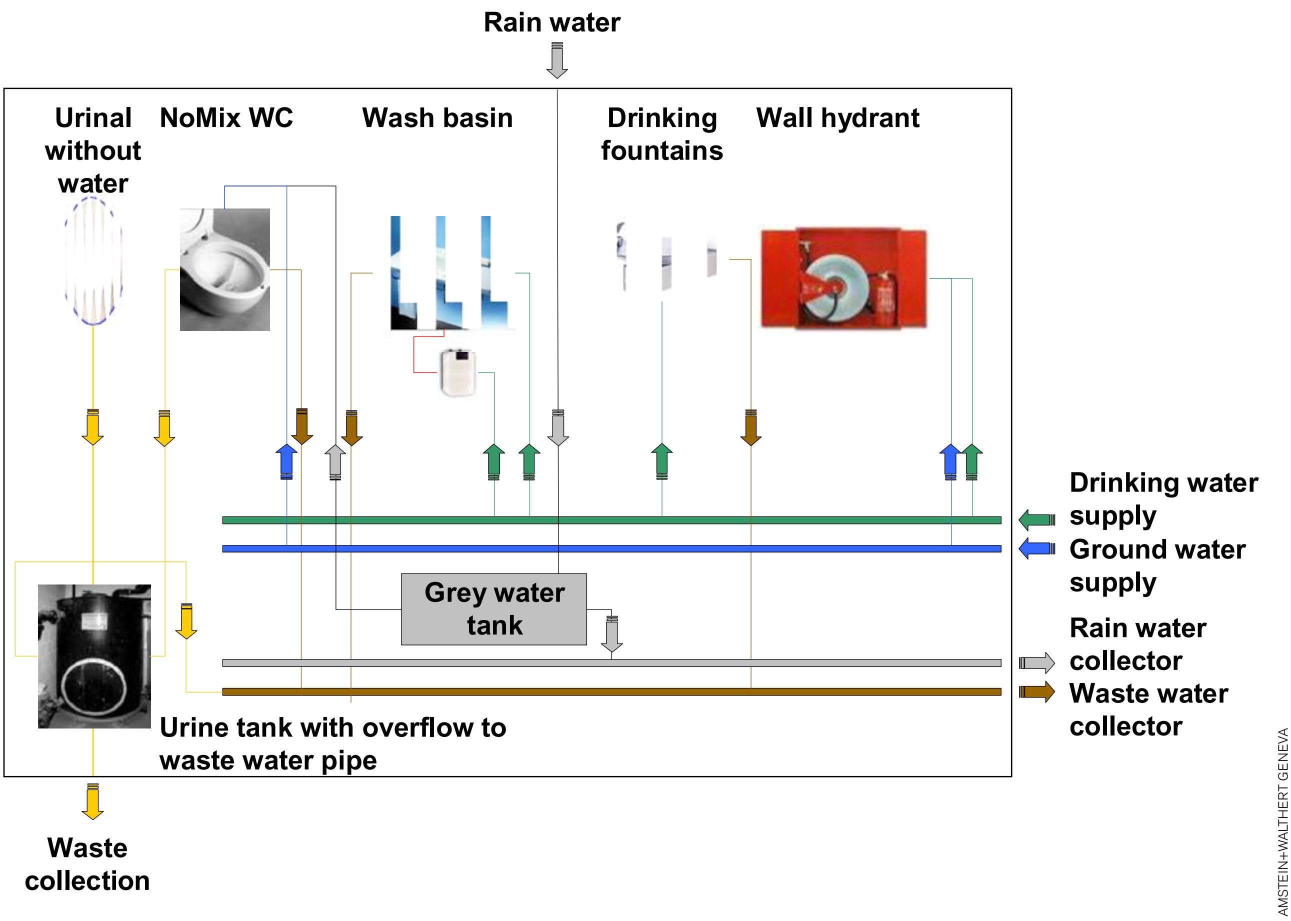


**Figure 8.** Principle of water management.

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.

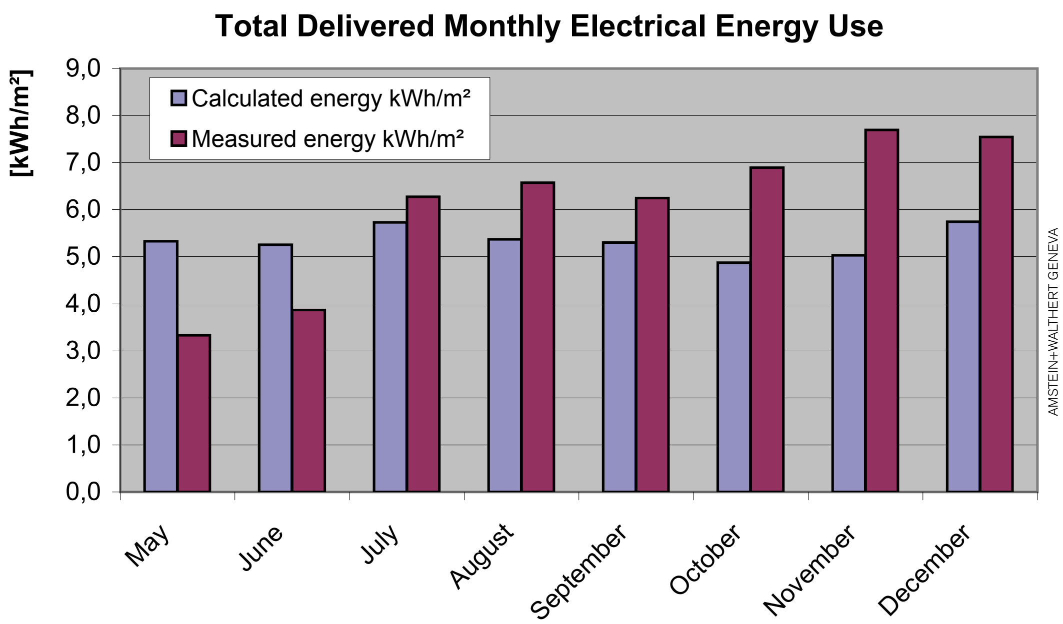


**Figure 9.** Comparison of calculated and measured delivered energy use.

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 |

# UKP NESK: TNT Green Office in Hoofddorp, Holland

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Strong fluctuating and rising energy prices, depletion of fossil fuel and growing awareness of global warming led to planned actions to reduce carbon dioxide emissions. As the built environment is responsible for nearly 40% of $CO_2$ emissions new approaches are necessary. In July 2009 the G8, the 8 most important industrial countries, agreed on 80% $CO_2$ reduction by 2050. In the Netherlands stakeholders agreed with the government to increase gradually to 0-energy new houses over 25% $CO_2$ reduction in 2012, and 50% $CO_2$ reduction in 2016.

Recent literature review indicates that there is wide diversity among ZEB definitions [Torcellini et al 2006, Marszal and Heiselberg 2009, Kilkis 2010, Kang et al 2010, Ritter 2010]. In current practice ZEB use the electricity grid both as a source and a sink of electricity to avoid expensive on-site electric storage systems [Hernandez & Kenny 2010].

In 2009 the Dutch government started the so called UKP NESK program to stimulate innovation for energy neutral buildings. UKP means unique chances projects and NESK means 'Towards energy neutral schools and offices' (Naar Energieneutrale Scholen en Kantoren). This program of the Dutch government gave in 2010 funding to projects which show exceptional innovation in the area of energy conservation, sustainability or organization within the building industry, see **Table 1**. Innovation is needed in the construction sector in order to make the transition to energy neutral building. The Ministry of Housing, Spatial Planning and the Environment is therefore giving support to fifteen innovative projects in the commercial and industrial sector. The aim of the NESK scheme is to learn by experience with building for extreme energy efficiency in order to build energy neutral buildings in 2020 and to stimulate innovation. Agentschap NL will take care of supervising the projects, monitoring and evaluation, setting up a Community of Practice, master classes for leading figures and communication.

The Ministry presented NESK certificates to the initiators of offices and schools that are acquiring experience in energy neutral commercial and industrial buildings. These projects are very innovative projects that already meet the energy requirements for 2020. These projects

**Table 1.** UKP NESK office projects.

| | Project | Type | Location | Year | Special features of project |
|---|---|---|---|---|---|
|  | TNT Green Office | New office | Hoofddorp | 2010 | Cooperation between principle and project developer, bio heat power combination, heat pump, aquifer |
|  | Villa Flora | New office | Venlo | 2011 | Technology from green houses applied |
|  | CBW-Mitex | New office | Zeist | 2011 | Performance contracting by Kropman and Octalix for a guaranteed energy neutral office building. |
|  | Zeswegen | New office | Heerlen | 2012 | Heatpump uses mijnwater as heat and cold source. |

and organizations play as inspiring examples an important part in stimulating other leading figures and the mainstream in commercial and industrial building in The Netherlands.

This article presents one of the current nZEB (Net Zero Energy Building) offices planned and built in the last year. It shows that already an important step can be made from Low energy offices towards nZEB.

**TNT Green Office**

The TNT Group, a global express delivery service headquartered in the Netherlands, recently announced to move its operations to newly to be developed green office buildings [Eichholtz et al 2009]. TNT Green Office project shows how important it is that a client has a strong and clear vision about the sustainability goals he wants to achieve in their housing. Despite the driving trends sustainable office development is still far from being main stream. One of the causes is the circle of blame; a vicious circle in which the stakeholders blame each other for not initiating the demand or supply of sustainable buildings [Vink 2009]. Breaking this circle of blame was one of the intentions of TNT. The office building of TNT in Hoofddorp (NL) is their first Green Office. Green Offices is part of the ambitious Planet-Me program, by which TNT wants to prove its ambition to become the first emission-free mail and express delivery company in the world. The most important key success factors for sustainable office buildings are [Vink 2009]: 'commitment to sustainability from the involved persons', 'willingness of the end-user to invest in sustainability', 'focus on long term value creation', 'early involvement of all stakeholders in the project' and 'clear definition of sustainability goals'. All these requirements were met within the new Green Office in Hoofddorp, as it should meet the highest standards regarding sustainability: $CO_2$ emission free, the design should also achieve more than 1000 points under the Dutch green building certification GreenCalc+ and LEED Platinum certified.

The development of GreenCalc started in 1997. The Greencalc+ assessment method is a questionnaire which allows you to estimate how much land it takes to run and maintain your office. It that can be used to calculate what the developers call the environment index of a building. This is done by calculating the environmental impact of the buildings by Life Cycle Analysis (LCA). The GreenCalc+ software consists of four modules, each representing a different aspect of the building characteristics; mobility, materials, water and energy. The input values for this program are divided in the following four groups: Materials: Energy: Water: Travel to and from work.

LEED (Leadership in Energy & Environmental Design) is an American methodology for assessing the sustainability qualities of a building and was developed by the US Green Building Council (USGBC) for the US Department of Energy. The pilot version (LEED 1.0) for new construction was first launched at the USGBC Membership Summit in August 1998 [Lee and Burnett 2007]. The current LEED reference Guide presents detailed information on how to achieve the credits which are divided in the following six groups [Fowler and Rauch 2006]: Sustainable site: Water efficiency: Energy & Atmosphere: Materials & resources: Indoor Environmental Quality: Innovation & Design process.

To guarantee this, TNT entered into cooperation with an experienced consortium in the field of sustainability: Triodos Bank and OVG Development. The sustainability ambition is an essential part of the contract between TNT and the consortium which had not only to develop the building but also had to own the office for 10 years. TNT Real Estate has made an innovative form of contract similar to a DBFMO (Design-Build-Finance-Maintain-Operate) contract with the consortium [OVG 2010]. TNT Real Estate has a contract for 10 years, with a fixed price for water, electricity, heating and cooling. This gives TNT as the consortium's principal hard guarantees in the areas of energy and other sustainability performances. The consortium and end-user TNT are both encouraged to reduce energy consumption throughout the lease period of the building. The consortium acts as an Energy Service Company (Esco) for the tenant and all investments in additional sustainability measures are taken within a ten-year payback period [OVG 2010].

Architect Paul de Ruiter is responsible for the design of the Green Office. He has a clear vision about sustainability and architecture [de Ruiter 2010];

> *"After the release of Al Gore's An Inconvenient Truth, Dutch politicians are prepared to put the environment on the political agenda. However, the Dutch government primarily views sustainable construction in terms of energy-efficient construction, and to this end has decided to implement a more stringent Energy Performance Norm, without giving much thought to the architectural quality, let alone the quality of the building's interior. The results of this approach are smaller windows, more isolation and a balanced ventilation – resulting in, for example, airtight homes and schools that are actually very unhealthy for their users. Not enough oxygen; ex-*

*cessive $CO_2$ levels; insufficient daylight and restricted views; buildings that are too ugly: this can hardly be what was intended. The quality norms relating to comfortable homes, a healthy life and a properly functioning professional and residential environment are far more important than mere energy efficiency. It makes far more sense to base the theme of sustainability on the viewpoint of the end user. Architecture needs to develop a radical service attitude. In other words, it should not only satisfy the demands of the client, but actually exceed them, delivering added value as a result. We can only achieve real improvements by radically addressing the actual needs of the end users, clients and their environment. Only this way, we can create an obligation to really get to grips with innovative solutions that work and as a result have a tangible impact on the world of tomorrow." [de Ruiter 2010]*

The design of the TNT Green Office is characterized by sustainability, transparency and connectivity. First a volume study was done to test different volumes regarding criteria like compactness, flexibility, daylight factor, view, building costs and the highest LEED results. The design consists of two rectangular parallel volumes, each six stories high. On the Westside (the Geniedijk) the lower three stories of these two volumes are connected by terrace-like volumes and the upper three stories by connective bridges [OVG 2010]. These connections offer great meeting places for the employees as well. On the Eastside both volumes are connected by a third 'floating' volume. For the TNT headquarters, 16-meterlong concrete floor slabs were used that were made out of recycled rubble and granulate. Due to the long span, fewer supports were needed, which saves material and generates spaces that can be divided up freely [OVG 2010].

### Sustainability

The atrium has been designed in such a way that as many daylight as possible can enter and it offers the employees a beautiful view. The atrium and the entrance are clearly connected, and the terrace-like volumes encourage employees to take the stairs instead of the elevator, thereby serving both a health and social purpose [de Ruiter 2011, OVG 2010].

The presence of daylight in living and working areas is of crucial importance to the wellbeing of the working and living environment and also for the health of the user. Daylight gives energy, generates happiness and stimulates productivity [de Ruiter 2010]. Smart window awnings keep out the heat of the sun while letting more than enough daylight enter the building. This way, less cooling and less artificial light is needed. Smart awnings help reduce energy use and increase wellbeing at the workplace. Daylight was the leitmotif in the design of the building, which has a completely glazed north façade. In addition to an optimum interior climate, daylight incidence was at the center of Paul de Ruiter's sustainability philosophy, which goes beyond purely technical aspects: "It has to be about the people who work in the building. You can erect a building that saves energy, yet is still bad for employees. That's not sustainable" [Schueco 2010]. The Schüco mullion-transom FW 50+ was used as a façade system, offering a very narrow profile face widths and large module widths, as well as excellent sound and thermal insulation. Due to their narrow face widths, the window systems AWS 102 and AWS 65 (Aluminum window system) allow for a large amount of glazing. U-value of the glazing units is 1.4 W/(m² K) and the solar heat gain coefficient *g* is 0.27 or 0.33, depending on façade, corresponding to visible transmittance of 0.5 and

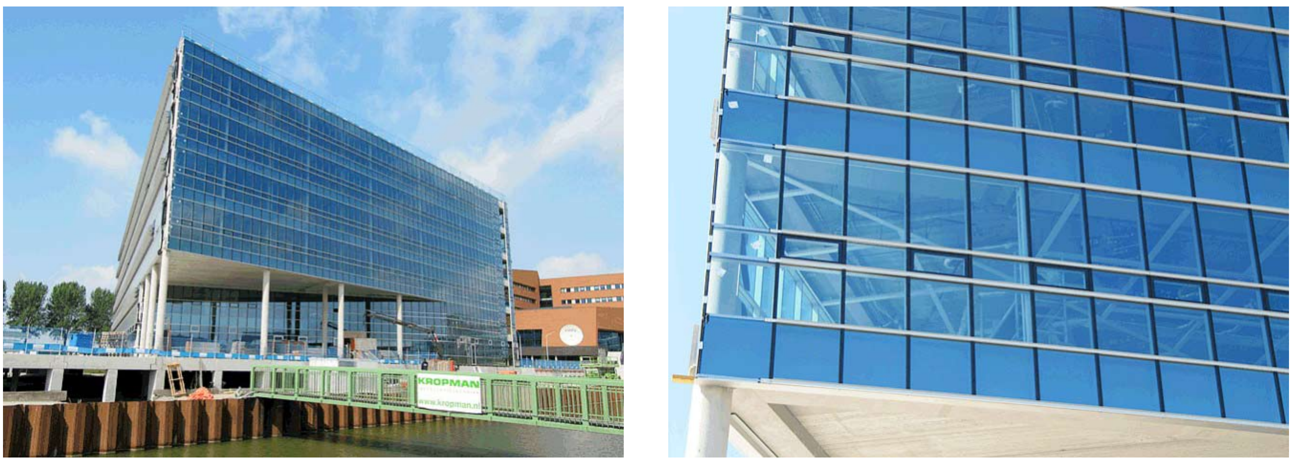


**Figure 1.** Facade of the TNT Green office building Hoofddorp.

**Figure 2.** Roof and area of the atrium.

0.6 respectively. Intelligent solar shading louvers were installed on the façade.

### Heat load

Goal was to minimize the heating load as much as economical possible made sense, high levels of insulation were applied, see **Table 2**. Also the internal heat gains were reduced as much as possible to reduce the cooling load in summer.

The different equipment types included in the calculation of miscellaneous equipment are: PC's, mLCD monitors, printers/copiers/scanners, communication and A/V, and kitchen en restaurant equipment. The Datacenter equipment comprises the computer server equipment located in the Main Equipment Room and Satellite Equipment rooms, spread throughout the building. This led to the following results: Office rooms 28 W/m², from which persons and equipment 20 W/m² and lighting 8 W/m², total energy use office appliances 19.2 kWh/(m² a) and total energy use of data center equipment 24.0 kWh/(m² a). The breakdown of energy use is shown **Table 3**.

### Space heating and cooling energy use

All the measures to reduce the heat and cooling load resulted in a low energy consumption; the proposed design space heating energy use is 9.8 kWh/(m² a) and that for cooling 3.3 kWh/(m² a), which both are electric energy use of heat pumps.

### Ventilation

The overall ventilation for the building is done by 4 central air handling units, all equipped with heat recovery systems, see **Figure 3**. HVAC total supply air volume is 111.091 m³/h, static fan pressure 944 Pa for supply air fan and 688 Pa for extract fan, with total fan energy use of 16.8 kWh/(m² a).

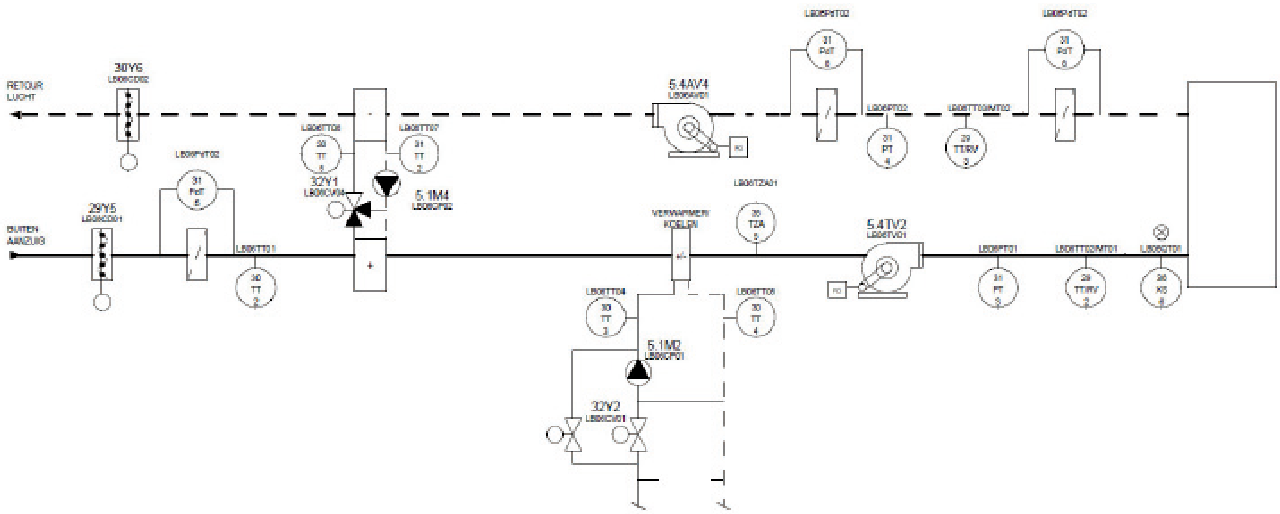


**Figure 3.** Process and information diagram of central air handling units.

**Table 2.** Applied levels of insulation.

| Construction | Description | U-Factor (W/m²-°C) | HC (kJ/m²-K) |
|---|---|---|---|
| Roof | Roof TNT Green office | 0,240 | 39,8 |
| Ceiling | Gyp. bd. ceiling, radiant barrier | 4,229 | 10,6 |
| Floor | Floor on ground | 0,240 | 190,8 |
| Int. Floor | Floor above garage | 0,320 | 300,5 |
| Interior Wall | CMU Partition | 3,282 | 381,6 |

**Table 3.** Simulated energy performance of the building. All specific values are per net floor area. The data center electricity use and heat rejection of bioCHP coolers are not included in the building energy balance.

| | **Net delivered energy use** kWh/(m² a) | **Primary energy factor** - | **Primary energy use** kWh/(m² a) |
|---|---|---|---|
| Heating, electricity to heat pumps | 9,8 | 2 | 19,6 |
| Hot water, electric boiler | 3,5 | 2 | 7,1 |
| Cooling, electricity to heat pumps | 3,3 | 2 | 6,6 |
| Fans | 16,8 | 2 | 33,7 |
| Pumps | 0,7 | 2 | 1,5 |
| Elevators | 0,8 | 2 | 1,5 |
| Lighting (interior) | 21,1 | 2 | 42,2 |
| Lighting (exterior) | 0,8 | 2 | 1,6 |
| Appliances (plug loads) | 19,2 | 2 | 38,3 |
| BioCHP electricity generation | -73,8 | 2 | -148 |
| BioCHP fuel consumption | 184 | 0,5 | 92,2 |
| Heating energy exported to other buildings (estimated value) | -50 | 0,5 | -25 |
| **Total** | **137** | | **72** |
| *Not included in the building energy balance* | | | |
| Data center electricity | 24,0 | 2 | 48,0 |
| Heat rejection of BioCHP coolers (electricity) | 10,0 | 2 | 20,0 |

**Maximum heating need**
Air handling ...............28.6 W/m²
Transmission .............14.2 W/m²
Infiltration ..................... 8.5 W/m²
**Total ..........................51 W/m²**

**Maximum cooling need**
Air handling ...............13.1 W/m²
Cooling load...............41.8 W/m²
**Total .........................55 W/m²**

### Divers sustainable measures

Several sustainable techniques are applied: intelligent awning, hybrid ventilation (natural if possible, mechanical if necessary), heat recovery from the extract air, energy-saving equipment and lighting, long term cold/heat storage in the aquifer, on site generation of electricity through the use of bio-CHP (Green Machine) and an advanced building management system. Kropman and Schneider Electric worked together in full transparency, not only on specific components but on the total solution for the energy distribution, building management solution as well as energy management and maintenance. The whole process control management system is based on process control LON FT10IP, bit rate 10Mbs.

### Long Term Energy Storage

The surplus heat of heat pumps in the summer and the surplus of cold in the winter are stored below ground level in the aquifer. The stored heat is used through heat pumps to warm the building in the winter, and the stored cold to cool it down in the summer. The electricity for the two heat pumps of 332 kW is delivered by the bioCHP.

### BioCHP

All electricity for the Green Office (on yearly basis) is generated on site in a sustainable way using a bioCHP. For the remainder of the peak demand, green electricity is purchased. This way, the TNT Green Office operates completely $CO_2$ emission free. The produced heat of bioCHP is supplied to nearby (yet to be realised) office buildings. During the periods when bioCPH heat production cannot be fully utilized, the excess heat is rejected with roof placed coolers.

**Figure 4.** Ceiling of concrete core activation for heating and cooling, with integrated air diffusers in the ceiling panels..

The bio-CHP installed is a Cummins KTA 19 bioCHP unit of electric power 300 kW with a Stamford HCI 534C generator, which should generate 1.200 MWh/a (73.8 kWh/(m² a)). The bioCHP unit that generates electricity for the building uses biolone as fuel, which is oil produced from slaughter house waste. The electrical efficiency of bioCHP plant is 40% and the total fuel efficiency with heat production 86%.

### Solar hot water heater

A solar hot water heating system has been added to the building. The system includes two solar collectors with size of 2.4 m² each. The system contributes heat toward the DHW system. 0.25 kWh/(m² a) of heat is collected on average each year. Since the DHW system comprises electric boilers, the energy contribution of the solar collectors displaces electric energy.

### Results GreenCalc+ and LEED

Based on the design and the actual relalisation the Milieu Index Gebouw has been calculated for the TNT Green office [DGMR 2008], the building will have an Environmental Index of at least 1,000 points in accordance with the GreenCalc methodology. This is more than 1.5 times better than the current building with the highest Building Environmental Index [Volker Wessels 2011]. This index is determined on the basis of the materials and the quantities used. During the design and preparation for the construction of the building continuous attention is devoted to assessing whether the choice of materials is the most environmentally friendly and whether the quantities remain within estimates so as to guarantee that the building achieves an ultimate index of at least 1,000 [Volker Wessels 2011]. Not only materials count towards this goal, also how water and energy are treated contribute to a higher index. The TNT Green Office has a bioCHP (combined heat and power production from biofuel) for the purpose of generating power. The high score for energy is due to the compensation effect of applying the bioCHP, without that the score for energy would have been around 220. This would lead to a GreenCalc+ score of 481, still among the best, par example one of the most environmental friendly office buildings in the Netherlands, the 2004 Rijkswaterstaat building in Terneuzen, has a score of 323 [Greencalc 2011].

| | Material cost a year | | |
|---|---|---|---|
| | design | reference | MIG |
| Materials | € 28.473 | € 38.352 | 135 |
| Energy | € 0 | € 264.958 | ∞ / 200 |
| Water | € 1.138 | € 1.663 | 146 |
| Total | € 29.610 | € 304.973 | 1030 / 481 |

The LEED assessment takes place in the area of design, implementation, the ultimate use and management. This is tracked in five categories: materials, energy consumption, efficient water use, interior environment and the environment. By way of example: the location is important, therefore including the proximity of the building to the public transportation network [Volker Wessels 2011]. The methodology even extends to the need for documenting the specific properties of the paints used. These may not contain more harmful substances than prescribed by LEED. In addition, a prescribed minimum quantity of recycled materials must be used and a large percentage of the materials used must be 'regional' [Volker Wessels 2011]. The highest certificate that can be issued under this methodology is the LEED Platinum Certificate and this will indeed be the certificate awarded to the building [olker Wessels 2011].

**List of basic information:**

| | |
|---|---|
| Clients | Triodos Bank and OVG Development, Green Office B.1 |
| User | TNT |
| Address | Taurusavenue 111, 2132 LS Hoofddorp, The Netherlands |
| Net floor area of the building | **16.136 m²** |
| Gross floor area building | 17.956 m² |
| Floor area parking garage | 7.207 m² |
| Number of floors | 6 |
| Building Occupants | 873 |
| Program | Emission free office building with parking garage |
| Start design | June 2007 |
| Start construction | 2009 |
| Delivery | 2011 |
| Design | Architectenbureau Paul de Ruiter b.v. |
| Building physics consultant | DGMR |
| Structoral consultant | Van Rossum Raadgevende Adviseurs |
| Building Services consultant | Deerns, Rijswijk |
| Consultant LEED | B en R Adviseurs voor duurzaamheid |
| Building company | Boele & van Eesteren |
| Facade | De Groot & Visser |
| Building Services contractor | Kropman |
| Process control | Schneider Electric |
| EPC value | 0,67 |
| GPR result | 8,7 |
| LEED | Platinum certificate |

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# Saving water and energy with modern tap wear technology without reducing comfort of living

*Domestic hot water heating accounts for 14% of total EU-27 households' energy use at residential homes.*

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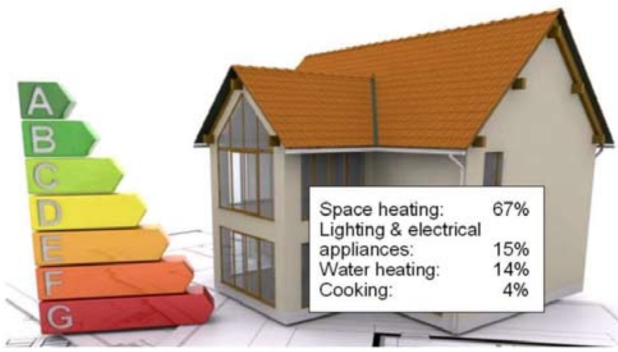



Source: Odyssee indicators, www.buildup.eu

**EU-27 households' energy consumption** at residential homes, %.

It is well known that a large energy saving potentials have remained untapped, although a technology exists; and water saving is one of easiest ways for hot water heating energy savings. In addition to heating energy, the water is extremely crucial natural resource, so the water saving has much wider meaning. Water efficiency is well recognized in green building sustainable construction certification systems such as LEED, BREEAM, DGNB and others, where reduced water flow rates are required among other issues for better ratings. This article introduces modern tap wear technology solutions and products already available today by Oras for effective water use.

## Single lever faucets with flow and temperature limit button

The choosing of single lever faucet instead of two handle faucet is the first step to reduce water consumption in all premises. Modern single lever faucet offers more possibilities to avoid unnecessary water consumption; an integrated eco-button will cut maximum flow so that the water flows from the faucet with 75–90% of the maximum flow, depending on the place of consumption. The eco-button does not restrict one from taking the maximum flow, if needed. The same eco-button is used with washbasin faucets and shower faucets to limit the mixed water temperature.

Stylishly integrated eco-button:

- To get maximum flow, you have to press the button.
- To get really hot water, you have to push the button – safe for small children.

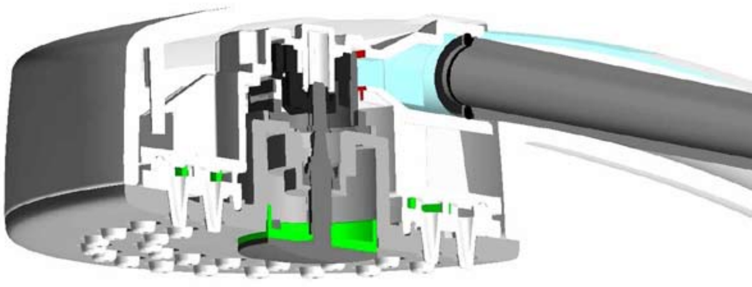
**Eco-button: safety and water/energy saving function.**

**A small limiting screw** in the lever axel is turned to adjust maximum water flow. Adjustment can be made individually, based by the user's needs or to fulfill flow demands.

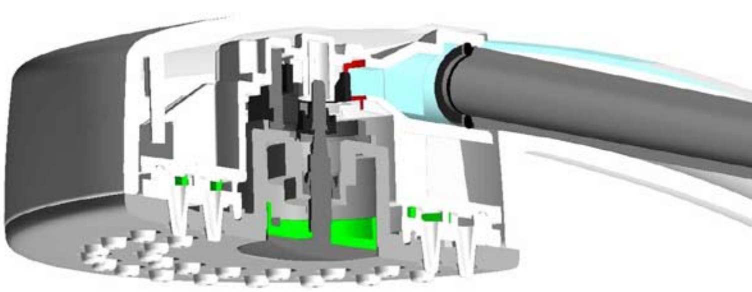

All Oras single lever faucets are manufactured with multifunction cartridge. The unique construction of Oras cartridge allows the restriction to maximum water flow.

The Oras cartridge together with restricted aerator keeps the usage of the faucet comfortable. Water flow limitation with only low flow aerator causes risk of cross flow to pipe system in the building. Cross flow is harmful when hot water enters cold water side. Oras single lever faucet with restricted aerator and synchronized cartridge meets most of the green building demands of water saving flow rates e.g. LEED requirements.

Showering with 38°C water all the time is possible with thermostatic faucet, Oras Optima. Unnecessary adjusting of temperature saves water every time a person is taking a shower. The thermostatic cartridge reacts in supply water's temperature changes and maintains the mixed water temperature at wanted level. Eco-button eases the saving of water; it limits the water flow about 60% of maximum flow. By pressing the eco-button the handle can be turned to full flow, if needed.



A



B

When **eco-button** is used, green indicator ring is visible and water supply channel to strainer is partly blocked (**A**). When eco-button is in normal position, the supply channel is fully open (**B**).

### Showers with down to 5.5 l/min flow rate

Oras Natura ecological hand showers revolutionary eco-button cuts water consumption to 50% with a single, simple click. It is proved that without compromising showering pleasure: Oras Natura still provides an enjoyable and relaxing shower experience as claimed in idé-nyt-magazine test, where Oras Natura was announced as sovereign winner (see the full article at www.idenyt.dk).

The design of strainer is the key issue in nice water flow perception even with less amount. The water flow stays wide and the water is spread evenly to every nozzle by carefully designed water paths inside the hand shower. Nozzles are designed to spray a stream, not drops which user can't enjoy. For green building flow requirements, Oras thermostatic faucet is equipped with flow regulators. Then together with Oras Natura shower, it can reach as low as 5,5 l/min at 300 kPa eco-button clicked on and 7,5 l/min at 300 kPa eco-button clicked off.

| Testing place | Faucet model | Water consumption litres / person / cycle | | | Saving-% | Saving-% |
|---|---|---|---|---|---|---|
| | | Cold | Hot | Total | Water | Energy |
| Airport | Single lever | 0,58 | 0,60 | 1,18 | | |
| | Electra | 0,33 | 0,38 | 0,71 | 40 | 37 |
| 24 h Service station | Single lever | 0,37 | 0,62 | 0,99 | | |
| | Electra | 0,34 | 0,35 | 0,69 | 30 | 44 |
| Hotel | Single lever | 0,56 | 0,63 | 1,19 | | |
| | Electra | 0,45 | 0,36 | 0,81 | 31 | 43 |
| Kinder garden | Single lever | 0,76 | 0,63 | 1,39 | | |
| | Electra | 0,34 | 0,38 | 0,72 | 48 | 40 |
| Hospital surgery | Single lever | 0,77 | 0,85 | 1,62 | | |
| | Electra | 0,50 | 0,40 | 0,90 | 44 | 53 |
| Public toilet | Two handle faucet | 0,71 | 0,79 | 1,50 | | |
| | Electra | 0,31 | 0,47 | 0,78 | 48 | 41 |

### Prevent wasting of water in public premises

A significant part of water consumption involves waste-running of water and/or turning off the faucet for the time of washing when water usage is not necessary. Due to laziness, or just an old habit this appears to require an effort. In public places the consumption of water is not a personal cost; on the contrary typically unlimited amount of water can be used. The correct choice of faucet can prevent such wasting.

Oras Electra technology offers faucets and showers to minimize waste-running of water and are thus especially suitable for these points of water consumption. In washbasin models water flows only when hands are washed. In showers, the faucet closes when the user leaves shower. Oras Electra cannot be left on, not in purpose or by mistake. Additional water and energy saving innovation is the fixed flow rate. As standard; Oras Electra's maximum washbasin flow is 6 l/min and in Oras Electra showers 12 l/min. For project demands, Oras Electra washbasin with maximum flow 4 l/min and showers with 6 l/min or 9 l/min are available.

The impact of Oras Electra on water consumption was measured in four different locations. In places located in the cities of Helsinki, Vantaa, Turku and Forssa, single lever faucets were replaced with Oras Electra models. The consumption of water was measured for a month before and after the replacement. The results of water and energy savings are convincing: water saving accounted for 31-51% and the energy used for heating the water, 37–53% per each time of use.

### Private households

For private use Oras Electra is a simple solution for saving water and energy. Water runs only when it is needed, like automatic stop and start function in a modern, ecological car. Fixed water flow is set to 6 l/min.

Combined faucets are an excellent example of modern technology for private houses. Touchless part of the faucet gives the user an easy hand wash with lukewarm water and traditional part helps with cooking.

For green building requirements Oras Electra is suitable also as a metering faucet. Maximum flow is 0,56 l per 8 seconds cycle.

Il Bagno Alessi One by Oras, touchless washbasin faucets designed by Stefano Giovannoni.

High spout provides nicely room for pots and pans. Separate hot and cold handles give easily water for you needs (cold water is mainly used for cooking).

In private toilets, the touhcless function preserves excellent hygiene for hand washing and saves water by preventing unnecessary water usage. Single lever part provides different temperatures for washing face, brushing teeth and using the bidetta hand shower.

### How to change old habits?

Technology can help, but cannot do everything. To use water only when one needs it, in the shower it is needed to turn the faucet off, when one applies soap and washes hair. When brushing your teeth or shaving, the faucet can be off. Oras Electra faucet shuts off automatically when hands are removed from under it. In the kitchen, rinsing dishes under running water consumes a great deal of water. With best available products and solutions, saving of water does not mean compromising on personal hygiene or comfort.

In the shower, Oras Eterna helps one to achieve the ideal water consumption. Easily start up the water flow by pressing the EcoLed -press pad. When closing the shower within two minutes a **green** signal light rewards you for taking an ecological shower. When closing the shower after two minutes, a **red** signal light blinks reminding you of water consumption. When reaching three minutes, the **red** signal light starts to blink continuously, reminding you of water consumption. After showering for four minutes, the water flow stops automatically. One can easily close or restart the water flow at anytime by pressing the EcoLed -press pad once. ϶Ɛ

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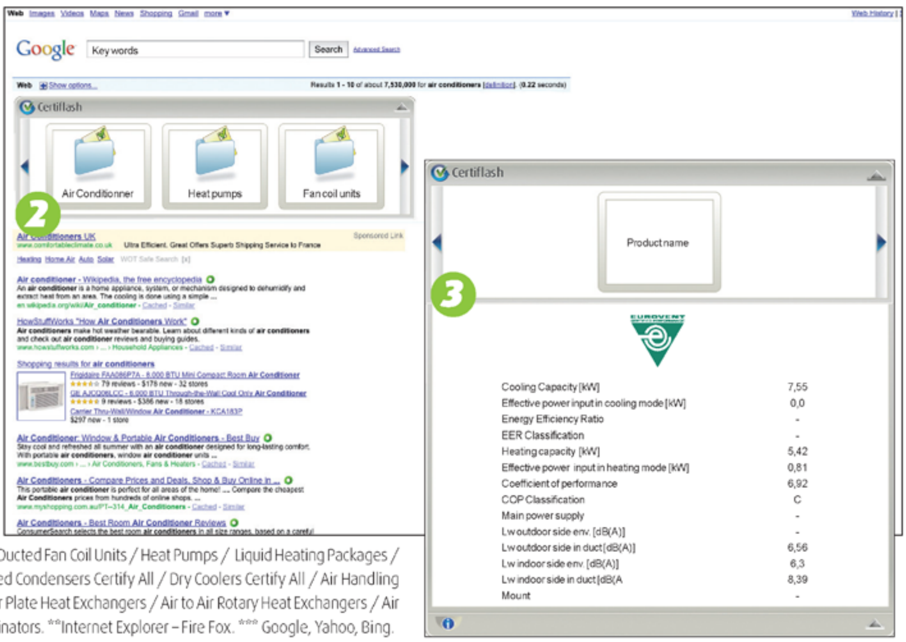


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# Accumulating fireplace integrated with a water-based central heating system

## A domestic fireplace of soft-stone construction and integrated heat exchanger for thermal storage

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Tulikivi is the world's largest manufacturer of accumulating fireplaces, with net sales of EUR 60 million and 500 employees.

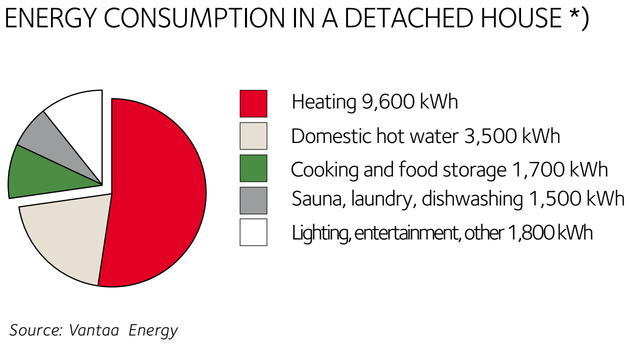


**Figure 1.** Typical delivered energy use in a household of four persons in an electrically heated detached house of 120 m² in southern Finland. Total delivered energy use is 18 300 kWh/year, from which the heating energy use is 13 100 kWh/year.

Space and domestic hot water heating account for about 80% of energy use in European households. Using an accumulating fireplace with integrated heat exchangers and a water-based heating system, a substantial proportion of the heat produced by the fireplace can be used for space and hot water heating. Such fireplaces can easily pay itself back in terms of reduced delivered energy use.

### Wood heating – a workable alternative?

New building regulations mean more energy-efficient homes requiring less energy for heating. In low-energy and passive homes, the fireplace and integrated water-heating system can supply a substantial proportion of a household's heating energy needs. The energy generated by a highly efficient (80–85%) accumulating fireplace can be used for heating different areas of the home or for heating of domestic hot water. By having heat exchangers integrated with the massive fireplace, one can make the fireplace part of the heating system, which means fewer overlapping investments. This includes also other important benefits of the fireplace, as it enhances comfort in the home, is an attractive design feature and provides a backup of heating system that is independent of other energy sources in any crisis situation.

### For new or renovated homes

An accumulating Tulikivi fireplace with integrated heat exchangers can be used as the heart of the new water-based heating system. Heating energy is transferred from the fireplace to the circulating water, which can then be stored in a hot water tank. The system can be installed in new or renovated homes. In a renovation project, the customer can make use of an existing water tank and the water-circulation heating system. The system is particularly well suited for use in hybrid systems involving a solar collector or a heat pump in buildings where a low-temperature heating system, such as floor heating, is used.

### Conventional massive fireplace

To fully heat the fireplace, normally requires about 2 to 3 hours, which means it can be lit in the evening after work, for example. The energy released by the combustion of the wood is storage in the soapstone of the fireplace. The soapstone mass of the heat-storing fireplace is typically 1 000–2 000 kg, which means that the amount of energy stored in the structure from burning at full load of wood can be as much as 30–70 kWh. The energy storage in the soapstone is released gradually over a period of 18–36 hours to the room the fireplace is located. The heat output is in the range of 1–3 kW, as the surface temperature of the fireplace increases during heating and then drops as energy is released. During the time of year when heating is needed, the fireplace should be heated once a day, or even twice on the coldest days.

### Fireplace with heat exchangers

In an accumulating fireplace equipped with heat exchangers, between 25 to 50% of the energy stored in the fireplace soapstone is transferred to the water system using an heat exchanger system and then carried

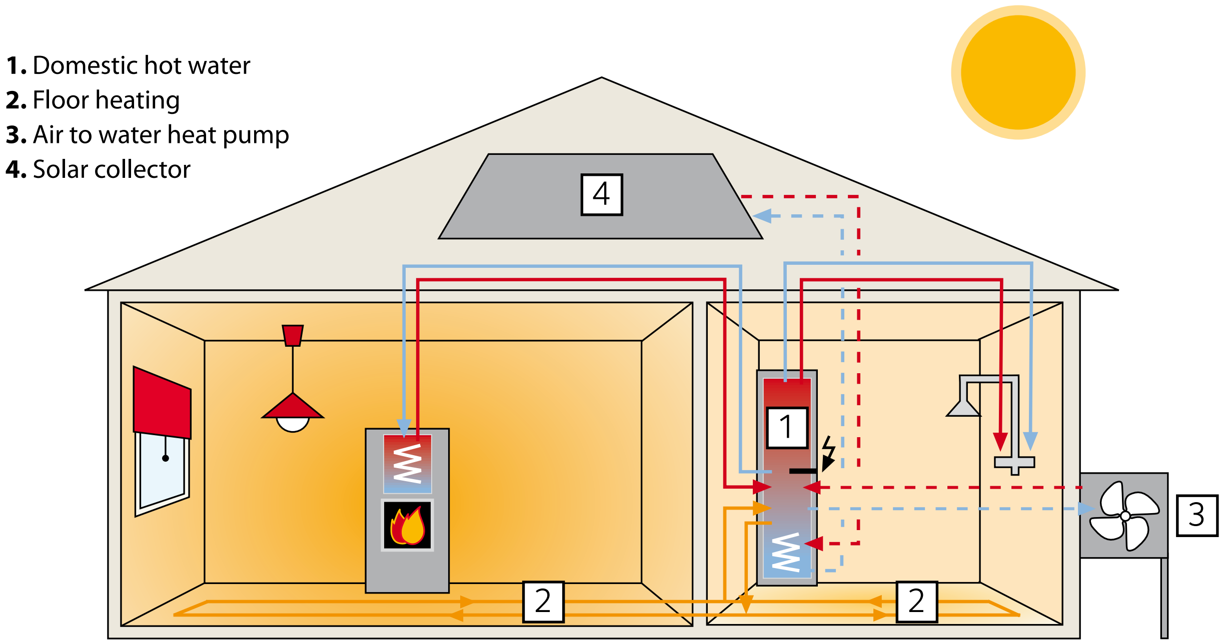


**Figure 2.** A fireplace with heat exchangers integrated into water-based heating systems.

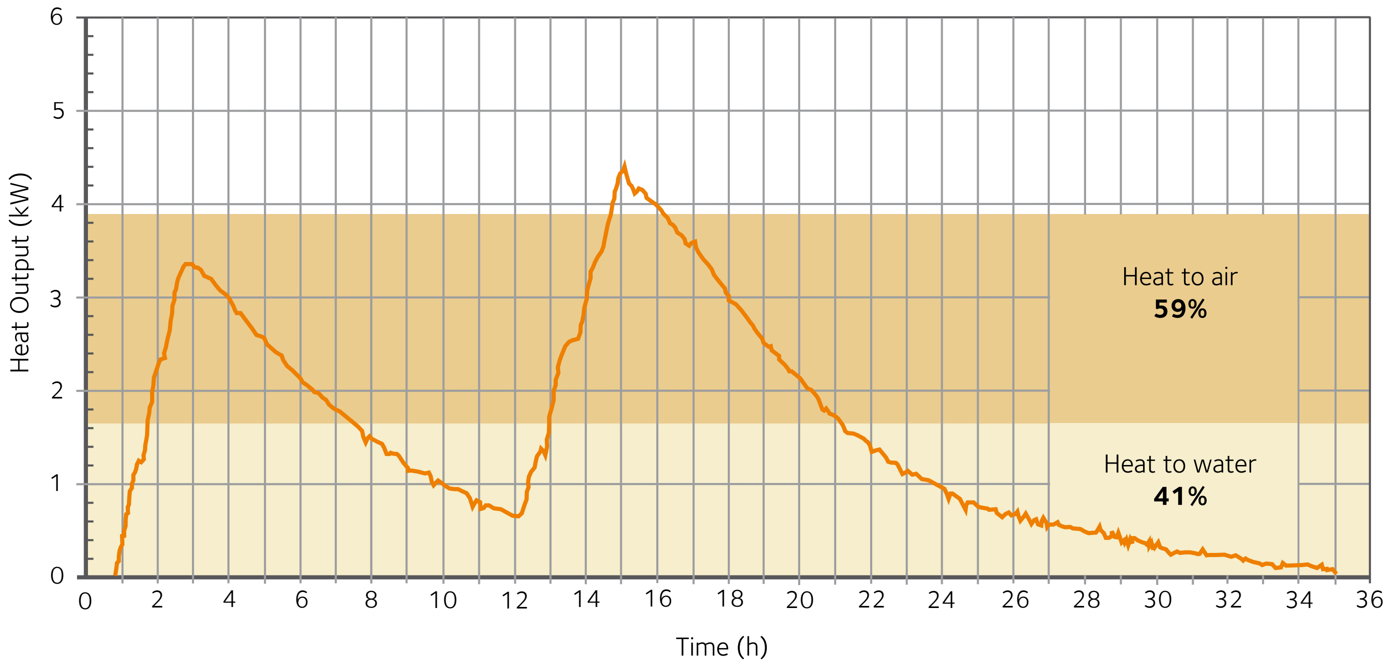


**Figure 3.** Functioning of an accumulating fireplace with integrated heat exchangers.

by the water for use in the home's heating system. Heat stored in the fireplace during the heating is thus gradually transferred to the hot water tank with the heat output of 1–2 kW. Some of the heat will radiate through the fireplace structure, heating the room. This system does not change the manner in which the fireplace is heated, so one can still use the fireplace as set out in the operating manual. If more heat is needed, the heat output can be increased by heating the fireplace twice a day. This means that one can achieve substantial savings in energy bills as there is no need to purchase energy to cover peak heating needs.

The curve in **Figure 3** shows how an accumulating fireplace with integrated heat exchangers functions in a normal situation. A fireplace with a mass of 2 000 kg has been heated with 2 x 20 kg of wood. The measurement was carried out during a period of 36 hours. The amount of energy gained from the wood is 141 kWh ($\eta$=85%). Of this total, 57.5 kWh (41%) was transferred to the hot water tank using the heat exchangers (curve). The remaining energy output of 84 kWh (59%) was provided to the room as radiated from the surfaces of the fireplace. In average, energy was transferred to the water with 1.5 kW power, while the total average heat output of the fireplace (to the water and directly to the room) was 4 kW.

### Easy to use and reliable

The Tulikivi Green W10 water-heating system consists of a double-walled Tulikivi fireplace and a heat exchanger package specifically designed for it. The system can be incorporated in an existing heating system already equipped with a solar collector and/or an air to water heat pump. The heating system should be sized in accordance with the energy needs. The following factors should be taken into account in the design of the heating system: the annual net energy need for space heating and domestic hot water; how much of this need should be met by wood heating; and will the system be used as the main heating system or a backup system.

### Safe and maintenance-free

The heat exchangers should be installed on both sides and at the back of the fireplace. If necessary, they can also be installed on the top of structure and on the front side above the door. As the heat exchangers are installed between the inner and outer walls of the fireplace, they do not have any impact on the combustion process. The heat exchangers do not at any stage get into contact with flue gases. The heat is transferred to the heat exchanger elements directly from the soapstone mass storing and transferring the heat. As the heat exchangers lower the surface temperature of the fireplace, the fireplace can also be installed in spaces that are smaller than those typically recommended. One does not need to clean or service the heat exchangers, and because of their simple construction, they can be used for many years.

**WOOD AND SOLAR HEATING – RENEWABLE ENERGY ALL YEAR ROUND**

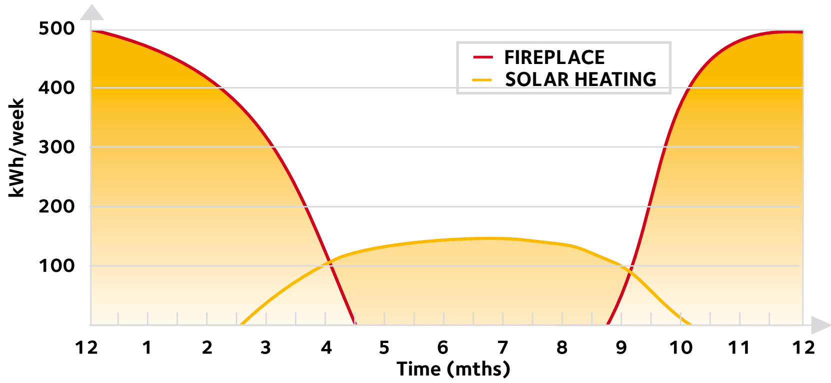


**Figure 4.** Solar heating and heating generated with a fireplace can complement one another. Regular heating of the fireplace is the natural alternative during the winter months, when the need for heating energy is highest. Solar heating is the most effective in early spring and in summer when the heating energy produced can be used for floor heating in wet rooms and for domestic hot water. Such combination will minimise the delivered electricity use.

**Figure 5.** The Sonka accumulating soapstone fireplace equipped with heat exchangers.

### Accumulating fireplace extends the use of conventional fireplace

Equipping a fireplace with heat exchangers will allow you to extend the period in which the fireplace is used each year, because the combined structure can heat both the room and the water. Using the fireplace will ensure that room temperatures remain at comfortable levels. Such fireplace has a low surface temperature and is safe to use. It also provides a backup system during power failures.

# New hybrid solution for energy efficient cooling, heating and ventilation – chilled beam integrated with radiant panels

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Halton introduces new hybrid solution for energy efficient cooling and heating in office environment. The chilled beam integrated with radiant panels aims to combine the benefits of chilled beams and radiant panels. The room unit is shown in the **Figure 1**. The chilled beam is located inside and top of the unit, and radiant panels on the bottom surface. Radiant panels can be equipped with acoustic material or replaced with acoustic panels.

Combining chilled beam with radiant panels, the conductance of the unit can be increased. It means higher cooling/heating power per room unit, and is the same as increasing the induction rate of the chilled beam, but now the increase has been done with integrated radiant panel. This is more favourable solution for thermal conditions point of view, because higher air circulation can increase the risk of draft. The room unit also provides

**Figure 1.** The chilled beams integrated with radiant panels (red colouring).

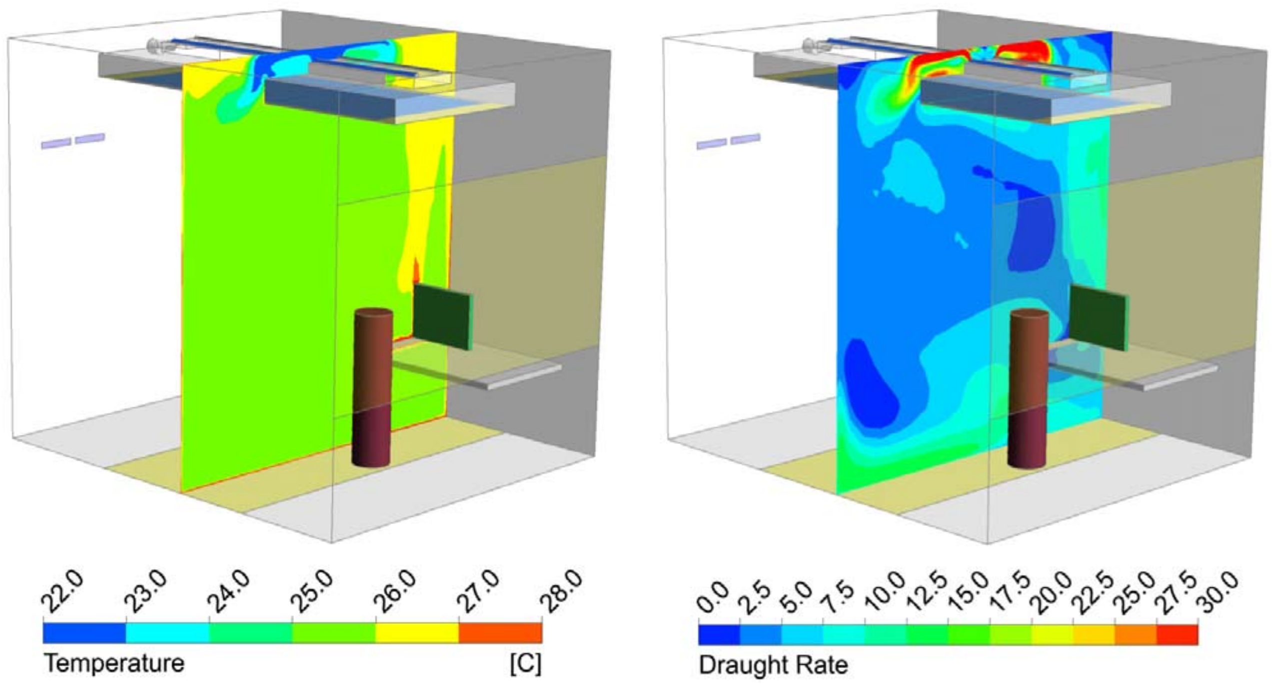


**Figure 2.** Temperature (left) and draught rate (right) distribution in CFD-simulation of office room with room unit integrating chilled beam with radiant panels.

effective radiant heating or cooling when the ventilation is turned off.

Other advantage is in the energy efficiency of the whole HVAC system, as the room unit with high conductance can operate efficiently in high temperature cooling and in low temperature heating system. This means higher COP for the chilled water system and possibility to use free cooling longer time as well as good possibilities to use renewable energy sources.

In the case study shown below, new chilled beam solution with integrated radiant panels was studied in cooling conditions with computational fluid dynamics (CFD) modelling and in heating conditions with dynamic thermal modelling (DTM).

The case study consisting of one person office room is simulated with CFD in cooling conditions. The cooling need is 50 $W/m^2_{floor}$ consisting of occupant 70 W, computer 150 W, lighting 112 W, window load 140 W and direct solar load 50 W. Supply air flow rate is 18 $l/s/m^2_{floor}$ at 18°C. One three meters long unit is installed into room perpendicular to the window façade. Radiant panels are located to the bottom surface and air is supplied from the top part of the unit. Cooling water inlet temperature is 20°C and return 23°C.

Temperature and draught rate distribution in the room is shown in the **Figure 2**. Average room temperature is 25°C and the draught rate is at very low level especially in the most sensitive head region, as being below the strictest criterion of 10%.

In heating conditions, chilled beam integrated with radiant panels enables heating operation without the need of supply air. Temperature stratification will be lower because heating power of radiant panels is mostly based on radiant heat transfer in heating case. DTM was used to calculate the conditions and energy consumption for similar office room simulated with CFD, with Stockholm weather data during heating season. Compared to the situation, where air handling unit is used one hour longer for heating up with traditional beam system, in addition to the normal ventilation schedule, it caused 9% increase in the fan electricity consumption during the heating season. This can be avoided with integrated system.

# EU plans to reduce GHG emissions with 80% by 2050

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The European continent has not only embraced renewable energy, but it is determined to exceed all emissions goals it is faced with. Not content with decimating its 2012 targets and being on track to more than meet its 2020 goals, the EU is now aiming to cut total emissions by 80% by 2050. The European Commission has developed a roadmap on 8 March 2011, which sets out key elements that should shape the EU's climate action helping the EU become a competitive low carbon economy by 2050. Although the continent is aiming to reduce emissions by 80%, this is actually just their minimum aim — the roadmap lays out plans to cut greenhouse gas emissions by up to 95%.

Scientific evidence indicates that global warming needs to be limited to less than 2°C above the temperature in pre-industrial times. Without firm global action to limit climate change, temperatures could increase by 2°C or more by 2050 and 4°C or more by 2100. To stay below 2°C every country will have to reduce its greenhouse gas emissions (GHGs), but developed countries will need to take the lead by targeting a cut of 80-95% below 1990 levels by 2050. The European Council and the European Parliament have endorsed this target range as an EU objective in the context of developed countries as a group making the reductions needed.

The EU with little more than 10% of global emissions will not be able to tackle climate change on its own. Progress internationally is the only way to solve the problem of climate change, and the EU must continue to engage its partners. Today, countries representing more than 80% of global emissions have pledged domestic targets under the Copenhagen Accord and the Cancun agreements. For some countries, delivering on these pledges will require stronger action than currently envisaged. The main target is to globalize climate change policies.

Achieving these deep emission cuts will require a transition to a climate-friendly, low carbon economy. The analysis on which the Roadmap is based shows that the most cost-efficient pathway to an 80% domestic reduction in 2050 requires a 25% cut in 2020 through domestic measures alone. The analysis also shows that this can be achieved if the EU delivers on its existing commitment to improve energy efficiency 20% by 2020. The Roadmap provides guidance on how this transition can be achieved in the most cost-effective way. It gives insights into what type of technologies and actions need to be implemented and what types of policies the EU will need to develop over the next 10 years and beyond. The Commission has carried out an extensive modelling analysis with several possible scenarios showing how this could be done. This analysis of different scenarios shows that domestic emission reductions of the order of 40% and 60% below 1990 levels would be the cost-effective pathway by 2030 and 2040, respectively. In this context, it also shows reductions of 25% in 2020. This is illustrated in **Figure 1**. Such a pathway would result in annual reductions compared to

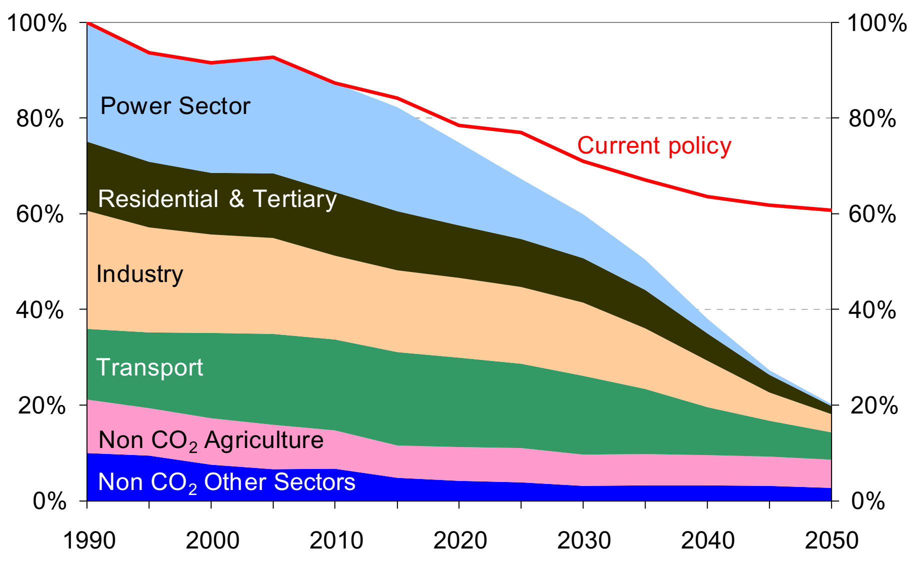


**Figure1.** EU GHG emissions towards an 80% domestic reduction (100%=1990). [1]

**Table 1.** Sectoral reductions. [1]

| GHG reductions compared to 1990 | 2005 | 2030 | 2050 |
|---|---|---|---|
| Total | -7% | -40 to -44% | -79 to -82% |
| Sectors | | | |
| Power ($CO_2$) | -7% | -54 to -68% | -93 to -99% |
| Industry ($CO_2$) | -20% | -34 to -40% | -83 to -87% |
| Transport (incl. CO2 aviation, excl. maritime) | +30% | +20 to -9% | -54 to -67% |
| Residential and services ($CO_2$) | -12% | -37 to -53% | -88 to-91% |
| Agriculture (non-$CO_2$) | -20% | -36 to -37% | -42 to -49% |
| Other non-$CO_2$ emissions | -30% | -72 to -73% | -70 to -78% |

1990 of roughly 1% in the first decade until 2020, 1.5% in the second decade from 2020 until 2030, and 2 % in the last two decades until 2050. The effort would become greater over time as a wider set of cost effective technologies becomes available.

Figure 1 illustrates the pathway towards an 80% reduction by 2050, shown in 5 year steps. The upper "reference" projection shows how domestic greenhouse gas emissions would develop under current policies. A scenario consistent with an 80% domestic reduction then shows how overall and sectoral emissions could evolve, if additional policies are put in place, taking into account technological options available over time.

Based on the cost-effectiveness analysis undertaken, the Roadmap gives ranges for emission reductions to be achieved in key sectors by 2030 and 2050 (see **Table 1**). The greatest emission reductions can be made in power generation, which will be almost completely decarbonised by 2050. A wide range of existing technologies will need to be widely deployed, including more advanced technologies, such as photovoltaics, that will continue to become cheaper and thus more competitive over time.

Above-average contributions in the medium and long term can also be achieved by the residential and services sector. Industry would decarbonise slightly less than the overall economy in the medium term, but would be able to achieve significant further reductions by 2050, in particular due to the mainstream application after 2030 of carbon capture and storage technology – CCS – to industrial process emissions that cannot be reduced in other ways. As solutions are sector-specific, the Commission sees a need to develop specific Roadmaps in cooperation with the sectors concerned.

R&D, demonstration and early deployment of technologies, such as various forms of low carbon energy sources, carbon capture and storage, smart grids and hybrid and electric vehicle technology, are of paramount importance to ensure their cost-effective and large-scale penetration later on. In addition, increasing resource efficiency through, for instance, waste recycling, better waste management and behavioural change, as well as enhancing the resilience of ecosystems, can play an important role. Also, continued effort to strengthen research on climate mitigation and adaptation technologies will be required.

Beyond the reductions in greenhouse gas emissions, which are the key benefits of the shift to the low carbon economy, this transition will bring a number of other essential benefits, such as new jobs, savings on fossil fuel imports, improvements in air quality and public health, increasing capital investments

The Commission invites the other European institutions, Member States, candidate countries as well as potential candidates, and stakeholders to take this Roadmap into account in the further development of EU, national and regional policies for achieving the low carbon economy by 2050. Internationally, the Commission will present the 2050 Energy Roadmap to its global partners in order to stimulate international negotiations working towards global action, and will foster cooperation with countries in the EU's neighbourhood on measures to promote a resilient low carbon economy.

During its term of EU Presidency, Hungary is responsible for coordinating the adoption of a common EU position and common thinking in major strategic matters; and for representing the European Union at international negotiations. The Hungarian Presidency wants Europe to take on new dimensions in the field of energy policy, and to open the way to clean energy, which is affordable and available in the long run. Energy policy has to contribute to economic growth, the fight against climate change, and the reduction of dependence on outside energy resources. The most pressing task, is to create Europe's internal energy market and reduce the fragmentation of Europe's energy infrastructure.

An Energy Dialogue conference was held in Budapest on April 1, where Mechthild Wörsröder, European Commission Head of Energy Department announced that the European Commission will publish the 2050 Energy Road Map by autumn. The Hungarian Presidency is ambitious, to see the energy strategy and infrastructure objectives. The Energy Roadmap 2050, will be discussed by an informal ministerial meeting in May, while the New EU Energy Savings Plan, can be adopted by the European Council's meeting in June. In order to prepare the legislative proposal on financing energy infrastructures, it needs to be-submitted by the Commission, in the second half of 2011, Budapest will host a high-profile conference in the subject.

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# 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**).

**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<br>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 |
| | Energy transformation | (3) Making power generation and distribution more efficient |
| • Information & support programs | Transport | (4) Achieving fuel efficiency of cars |
| | HORIZONTAL ISSUES | |
| • Voluntary actions | 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<br>(9) Energy efficiency in cities |
| | International partnerships | (10) Foster energy efficiency worldwide |

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 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.

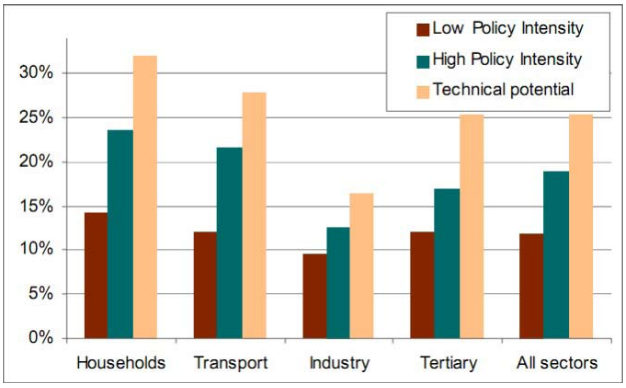


**Figure 1.**
Final energy savings potential in EU 27 in 2020. [6]

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.

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.

**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) |

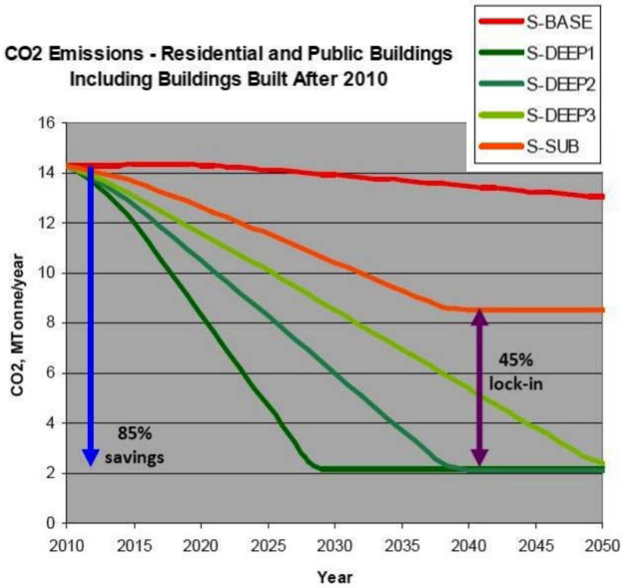


**Figure 2.**
$CO_2$ emission reductions of the Hungarian building stock for all scenarios considered in the study. [13]

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# The Construction Products Directive revised

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matti.j.virtanen@ymparisto.fi

Mr. Virtanen has been the Head of the Finnish Delegation to the Standing Committee on Construction since 1995. He explains why the Construction Product Directive has revised, the content of the revision and the meaning of the Construction Products Regulation.

## Internal market of construction products does not function properly

One of the main goals of the European Union is the Internal Market for products and services. Construction Products Directive (CPD) was adapted already in 1988. The CPD aims to remove technical barriers to trade in the field of construction products in order to enhance their free movement in the internal market. The real implementation of the CPD will happen according to harmonised product standards. The first harmonised product standard was published in 2001. Nowadays, over 400 harmonised product standards have been published.

However, we are far from the proper functioning of the internal market for construction products. There are still a lot of technical barriers to trade. In 2008 the Commission made a proposal how to revise the CPD. The target is still to remove technical barriers to trade.

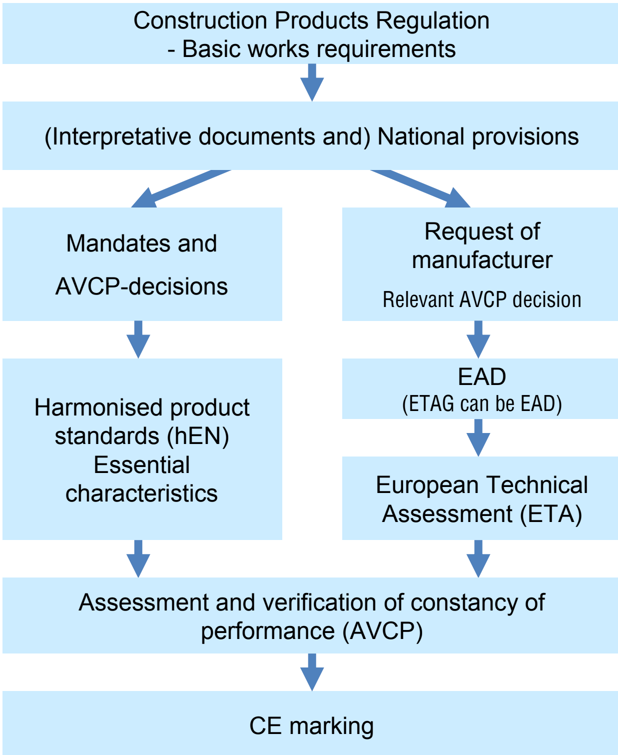
## Agreed new Regulation

Construction Products Regulation (CPR) was published in the Official Journal of the EU in 4$^{th}$ of April 2011 after nearly three years work in the European Parliament, in the Council (Member States) and in the Commission. The regulation will partly enter into force on the 20$^{th}$ day following its publication. Most of the articles of the regulation shall apply from 1$^{st}$ of July 2013.

The status of the regulation is different compared with the directive. The regulation will enter into force as such. There is no need to implement it into national legislations. This is very good for industry because it will mean identical application of the rules how to place construction products or make them available on the market. It clarifies also duties and tasks of the manufacturers and distributors which are the same in every Member State.

## Content of the CPR

CPR is much longer (68 articles and 5 annexes) compared with the CPD (24 articles and 4 annexes). The main route to CE-marking is still the harmonised product standards. In order to allow a manufacturer to enter into the internal market with a construction product not covered or not fully covered by a harmonised product standard, it is necessary to provide a European Technical Assessment (ETA). In the CPD this route was called a European Technical Approval (ETA). The huge investment of industry on standardization and on ETAs which has been done under the CPD can also be used under the CPR.




The Commission and the Member States have agreed on many Guidance Papers in the meetings of the Standing Committee on Construction. The Guidance Papers are not legally binding but followed by standardization writers. The CPR has adopted some items from these Guidance Papers thus providing a legal basis on existing practice.

The CPD has six attestation of conformity systems. The CPR has the same systems without number 2. They are called systems of assessment and verification of constancy of performance.


The CPD has six essential requirements for construction works in its Annex I. The CPR has the same requirements on construction works except number 3 and 4 which has been refined. The CPR has also a new one which is called 'sustainable use of natural resources'. These essential requirements are renamed 'basic works requirements' and can be found from Annex I of the CPR.

The CPD demands a declaration of conformity. It is replaced by a declaration of performance which manufacturers have to draw up. When a construction product is covered by a harmonised product standard or conforms to a European Assessment which has been issued for it, the manufacturer shall draw up a declaration of performance when such a product is placed on the market. This is the obligation even if some Member States have no requirements for the product.

By way of derogation and in the absence of Union or national provisions requiring the declaration of essential characteristics where the construction products are intended to be used, a manufacturer may refrain from drawing up a declaration of performance when placing a construction product covered by a harmonized product standard on the market where:

a) the construction product is individually manufactured or custom-made in non-series process in response to a specific order and installed by a manufacturer
b) the construction product is manufactured on the construction site
c) the construction product is manufactured in a traditional manner or in a manner appropriate to heritage conservation as part of a designated environment or because of their architectural or historic merit

The Commission in consultation with the Standing Committee on Construction should establish the interpretative framework for the definition of 'non-series process'.

The CE marking shall be affixed to those construction products for which the manufacturer has drawn up a declaration of performance.

Anyway, it is not probable that many construction products covered by harmonised product standards are able to derogate from the main rule (mandatory CE-marking and declaration of performance).

The content of the declaration of performance has been explained in Annex III of the CPR. The declaration of performance will give information on characteristics and intended uses of the construction product.

The CPR sets up requirements on quality of harmonised product standards e.g. to determine the applicable factory production control rules in harmonised product standards. Manufacturers shall draw up technical documentation describing all the relevant elements related to the required system of assessment and verification of constancy of performance. Manufacturers shall keep the technical documentation and declaration of performance for a period of 10 years after the construction product has been placed on the market.

The CPR will force Member States to increase resources of market surveillance authorities. Nowadays, market surveillance resources are very limited in some Member States. The reliable control system needs reliable market surveillance.

Member States shall designate Product Contact Points also for Construction products. This Point shall provide information on the provisions of construction products in its territory. Manufacturers can ask free of charge on rules which are used in the Member States.

CPD is not giving rules to the economic operators but CPR clarifies the obligations of manufacturers, authorized representatives, importers and distributors. The meaning is to guarantee the information related to the declaration of performance and the CE-marking to pass through the whole supply chain to the users of the construction products.

## The meaning of the CPR

The CPR will improve the functioning of internal market for construction products. But it does not remove all the problems. It will bring mandatory CE-marking to Finland, Sweden, UK, Ireland and Norway. In these countries the impact of the CPR will be greater than in countries where CE-marking has already been mandatory.

The removal of technical barriers to trade means an opportunity to increase competition. Increased competition means better and/or cheaper products. It has said that internal market is useful only for big manufacturers. However the same system to "approve" products is useful also for small manufacturers because they can export to foreign markets without any additional approval costs.

The CPR will help reinforce a level of playing field. Designers and purchasers can compare products in a reliable way. Characteristics of products are tested or calculated, assessed and verified in the same way and values of characteristics are declared according to harmonised product standards or ETAs i.e. using so called European common technical language. Results of research and development work can be used in other EU countries. There will be computer programmes which can be used in whole European Economic Area.

A comprehensive set of European standards will help also to determine and monitor the technical quality of construction works. This is one of the main advantages being specially an advantage to small Member States having limited resources to develop their construction regulations.

European standards are not used only in European Economic Area. Applicant countries of the EU are eager to adapt legislation, systems and standards of the EU. Ex-colonies are using standards of their ex-parent countries. Now they have to choose if they start to use European standards because e.g. British standards do not exist any more. EU is keen to promote European standards in third countries. In the long run only USA and the EU have enough resources to develop a comprehensive set of standards for the construction sector. Wider use of European standards is a huge advantage to the European construction industry and consulting companies.

## Future development

The main criterion for the success of the CPR is how well it will remove other mandatory or voluntary (de facto mandatory) marks which have more or less the same meaning than the CE-marking. In many cases these other marks are called application marks.

One of the main problems is that Member States are not willing or able to amend their provisions which should be based on harmonised product standards. There is also lack of knowledge how to amend national provisions. There is also a need for national research work to setup requirement levels based on European test methods.

Commission has to be more active against Member States which do not follow the rules. There are a lot of complaints from manufacturers concerning illegal provisions of some Member States.

There are not only harmonised product standards with test-, calculation and classification standards which will be used. There will be more and more design and execution standards. A good example is standards for structural design called Eurocodes. They are replacing national design codes and standards. In the near future structural design can be carried out according to the Eurocodes everywhere in European Economic Area.

CEN has elaborated under the 'Energy Performance in Buildings Directive' a set of standards how calculate total energy consumption of buildings. These EPBD-standards are under revision and it is assumed that the revised versions of these standards will be used in the same way as the Eurocodes.

Political decision makers (European Parliament and Council) have expressed their will in the recital of the CPR: "Wherever possible, uniform European methods should be laid down for establishing compliance with the basic requirements set out in Annex I " (of the CPR). This will help national building authorities to take care of their duties because they can rely more and more on European standards.

If more and more European standards can be elaborated as expressed in the recital of the CPR it will mean a huge advantage to European industry. A lot of resources which are now used to improve the national requirements could be used on European level to further develop standards.

## Few observations on HVAC-sector

There is no standardization mandate to many ventilation products. Only few HVAC products have harmonised product standard under the CPD. However there exist national requirements on these products and systems. It would be an advantage to HVAC-industry to have under the CPR harmonised product standards covering also requirements of eco-design and energy efficiency labeling directives.

For example, CE marking is mandatory for air handling units by machinery and low voltage directives, proofing safety of AHUs, but not telling anything about air moving capacity. Eurovent certification focuses on performance characteristics not covered by CE marking.

Is there any protectionism slowing down product standards development? National certification bodies seem to want to keep their own national systems. National certificates and type approvals will cause additional costs to manufacturers and will prevent competition.

# Finland launched new building regulation – primary energy requirements and calculation with dynamic simulation tools coming into force from July 1st 2012

New regulation, part D3 2012 in the building code, was launched on March 30th 2011. Changes are historic as almost everything is new in the energy performance calculation procedure and requirements. A new test reference year for energy calculation has been prepared according to ISO standard. The new code includes well specified input data for energy calculation, describing standard use of major building types as well as indoor climate parameters required to be used in the calculation. Energy performance requirements are given as annual primary energy use in kWh per net floor area for 9 major building types including residential, commercial, educational buildings, hospitals and sport halls. In detached houses, the requirement depends on the net floor area of the building, being less tight for small buildings. Primary energy requirement accounts for all use of energy in the buildings, including lighting and household electricity in residences and plug loads in offices.

Finland launched the second lowest primary energy factor for the grid electricity in EU. Finnish value of 1.7 is almost as low as 1.5 used in Estonia; typical values being around 2.5 in other countries. Other factors are 0.7 for district heat, 0.4 for district cooling, 1.0 for fossil fuels and 0.5 for renewable fuels. In the public draft version, the factor for electricity was 2.0 causing major national discussion about the emissions in the electricity generation compared to emissions in district heat production. Due to massive use of hydro and nuclear power, an average specific emission factors for electricity is only slightly higher than that for district heat production. A primary energy based approach, basically required by EPBD, proved to be a weak argument in a climate change mitigation discussion.

Finland has a long tradition of electrical heating that initiated another national debate about the future of direct electrical heating still used in about half of constructed detached houses. This debate led to less strict primary energy requirement for detached houses, compared to the public draft requirement very similar to current Danish primary energy requirement or Swedish requirement for electrically heated houses. At the end of the day, the final primary energy requirements are still reasonably strict for apartment, office and other non-residential buildings, but less strict for detached houses, which are still possible to built with electrical heating, if well insulated and with effective heat recovery ventilation.

Finnish new energy calculation procedure provides detailed calculation rules mandatory to follow. This applies for energy flows not taken into account, such as professional kitchens, external lighting, elevators and some others. On site energy production is treated as inside the system boundary, i.e. reducing the use of delivered energy. Finland has no intention to launch an official calculation method, because a large number of dynamic simulation tools are available in the markets and nearly zero energy buildings are expected to be designed and built in near future. Dynamic simulation is required in all buildings having a cooling system (applies both for mechanical and free cooling) due to heat transfer dynamic phenomenon. Residential buildings without cooling systems can be calculated with monthly calculation methods, for that the guidance is still provided. Summer overheating/room temperatures are to be simulated in all buildings in typical rooms with the exception for detached houses, there the simulation is not required.

With the new regulation, Finland has taken an important step towards zero energy buildings. New test reference year, calculation frame specifying standard input data, as well as calculation rules and the requirement of validated simulation software to be used, will well support the design of zero energy buildings. It is expected, that primary energy requirements will be tighten in couple of steps before 2020 to move to nearly zero energy building performance level. Another issue yet to be solved is the feeding of on site electricity to the grid, which has not yet a common procedure available, but needs negotiating with the local energy provider. This has not been actual because of missing feed in tariffs, but the nearly zero energy buildings are expected to change the situation.

# Estonian government purchases 1 007 Mitsubishi i-MiEV electric cars mainly with emission rights under the Green Investment Scheme

Emission trading system will make Estonia a demo-country of the electric cars, as 1 007 cars and 250 smart-grid-connected electric car fast chargers are expected to be shipped by the end of 2012 to Estonia, a small country having a population of 1.3 million.

Estonian government has approved the sale of 10 million tons of emissions rights to the Japanese Mitsubishi Corporation. The revenues from the trade will be exchanged for 507 new electric cars and a countrywide infrastructure for charging electric cars. The revenues include the subsidy scheme for another 500 cars, i.e. promoting purchasing of electric cars by 500 private consumers with affordable subsided price, by the end of 2012.

Mitsubishi Motors has announced that this scale of i-MiEV provision, 507 units has been the largest inquiry Mitsubishi Motors has ever received since its sales started. It also marks the first case of provision of electric vehicles under the Green Investment Scheme.

The Estonian government expects to utilize i-MiEV for $CO_2$ reductions in the country, thanks to its zero $CO_2$ emission characteristics while driving. Mitsubishi Motors will also provide technical support to the Estonian government in monitoring $CO_2$ reductions effected by introducing i-MiEV. The 507 units will be shipped to Estonia by end of fiscal 2011. These cars are planned for the workers of state-owned social services system, Hoolekandeteenused.

The charging infrastructure to be set up by Elering will involve 250 smart-grid-connected electric car fast chargers, with the capacity to charge 80% of the dead battery in 30 minutes. The Mitsubishi MiV electric cars travel range before recharging is 100 km. Estonia expects the large scale unveiling of electric cars into road traffic to contribute to the target of energy from renewable sources to account for at least 10% in the transport sector by 2020.

As another sale of emission rights, the Estonian government has approved the sale of 5.5 tons of emissions rights to the Japanese Sumitomo Mitsui Banking Corporation. Revenues from the sale will be used for the renovation and improving energy performance in municipal buildings (day care centers, schools, hospitals and others). This is the fourth package directed mainly at local government buildings. The buildings to be renovated were selected so that the investments will lead to highest possible energy savings and emission reductions.

## NEWS FROM REHVA'S CO-OPERATION PARTNERS:

EHI, the Association of the European Heating Industry, is very pleased to announce the appointment of Michael Bennett as its new Secretary General from 1st March 2011.

AREA and EPEE have issued a joint position calling for improvements of Article 5 of the F-Gas Regulation on training and certification. Starting from the experience with the Regulation's implementation and application, the position makes several proposals.

## REHVA Technical Seminar on Recast EPBD and other EU regulations

**in Brussels October 27, 2011**
**for supporters and members**

Please reserve the date.

**More information:** www.rehva.eu

## EUSEW

EU Sustainable Energy Week, was held in April 11-15, 2011.

Stay tuned for updated information and register your interest!

**More information:** www.eusew.eu

# Interview of REHVA board members on nearly zero energy buildings

REHVA journal interviewed the REHVA board members their take on Nearly Zero Energy Buildings in their country. We had three specific questions for our Board members:

**1. What is the biggest challenge to reach 20-20-20 target in EU?**

**2. What is the most important action taken in your country towards Nearly Zero Energy Buildings?**

**3. What is the most important technology to be developed to reach Nearly Zero Energy Buildings?**


**Francis Allard, France:**
REHVA president 2008-2011

**1.** In Europe, building sector represents more than 40% of the energy demand and 30% of the Green House Gas emission. It is obviously the first target of 20-20-20 policy. However, if most of European countries are clearly addressing the issue of new Nearly Zero Energy Buildings, the main challenge remains the refurbishing of the existing building stock. It remains the biggest potential of energy savings and reduction of $CO_2$ emission.

**2.** The main evolution in France in the following months will be the new building energy regulation (RT2012), it has been launched already and it is focusing on low energy buildings. The average target is to limit the energy consumption of new residential buildings to 50 kWh/m$^2$.y of primary energy for the five main end uses: heating, cooling, ventilation, lighting and domestic hot water. It is also addressing the issue of the quality of the building design itself introducing a specific target on the energy needs.

**3.** I am not sure that a specific technology is enough to reach Nearly Zero Energy Buildings. At the contrary, in my opinion the main issue is the design methodology. We absolutely need an integrated design for low energy buildings since the very beginning of the project. Another element which is not sufficiently addressed may be the need for education and training of the various actors of the construction industry; we certainly need to upgrade the qualifications of most of them in order to improve the quality of the final work.

**Michael Schmidt, Germany**
REHVA president elect

**1.** In Germany the biggest challenge to reach the 20-20-20 target is an economic challenge. All targets and requirements are only mandatory if they are cost effective. So the biggest challenge is to get the necessary money and to get harder legally bounds for investments in the 20-20-20 target.

**2.** There are public subsidies for refurbishing residential building to make them Low Energy Buildings, that program is run by the state-owned Kreditanstalt für Wiederaufbau Frankfurt (KfW). The current requirements are KfW 70, KfW 55 and KfW 40. The primary energy demand of these buildings has to be 70%, 55% and 40% of the reference building. In addition, there is also a subsidy program for "Passiv-Häuser", which is defined in accordance with the Passiv-Haus-Institute as "KfW-40-buildings with an annual heat demand lower than 15 kWh/m$^2$". Next step of enforced requirements in 2012 will be another 30% reduction for both residential and non-residential buildings.

**3.** Nearly Zero Energy Buildings are achievable with the existing and available technologies.

**Karel Kabele, Czech Republic**
REHVA vice - president

**1.** To find solution, this will bring better buildings not only in view of energy efficiency but also in view of better indoor environment quality.

**2.** First action is to find such national application of the definition, which will be accepted by professionals and users. Next step is to implement this definition into the legislation and to find cost-effective way to build such buildings.

**3.** To reach nZEB in the Czech Republic, it is necessary to continue in the development of renewable sources, building services systems and of course building envelope. The control systems enabling to achieve real energy efficiency are very important technologies.

**Maija Virta, Finland**
REHVA vice - president

**1.** Biggest challenge to reach 20-20-20 target in Europe is to reduce energy consumption of buildings. It is going to be difficult to find financial resources for refurbishing existing building stock, especially related to thermal insulation and operation of ventilation systems.

**2.** In Finland we have launched the new regulation for energy efficiency of buildings, which will reduce the minimum energy use of our new buildings average by 20% from 2010 regulation level. This means that our residential buildings with electrical heating will use 50% less energy than five years ago. There are also many voluntary actions taken by industry. Most of major construction companies are building today only A-level apartment houses and also several office buildings are built to A-level.

**3.** The most important technology is the integration of building management system, day light control and active solar shading for commercial buildings. In residential buildings the higher efficiency heat recovery systems are needed.

**Donald Leeper, United Kingdom**
REHVA vice - president

**Derrick Braham, United Kingdom**
member of REHVA TRC

Donald Leeper consulted with Derrick Braham before responding the questions.

**1.** The financial cut backs in the annual National Budgets and the lack of significant growth in the National Economies. People do not realise the full energy saving potential of Thermal Insulation improvements. The lack of independent EU wide reporting of measured data plus the inherent delay between financial budget approval and installation, will mean that even current approval given in 2011 for energy saving programs and information won't be credited and publicised until near 2020.

These are some of the biggest challenges to reach 20-20-20 target in EU.

**2.** Successive UK governments have established a roadmap of progressively improving the National Building Regulations, in response to the original EPBD and its recent Recast. This will ensure that all new Buildings will be nearly net Zero Carbon by 2020. In-addition the Government has published a CARBON PLAN which reaffirms the timetable and will require all non-domestic commercial buildings to display their actual, i.e. as measured, energy performance in an annual Display Energy Certificate (DEC). It is also proposed to improve the content, format and quality of the Energy Performance certificate (EPC) required by all new buildings over 500 m² area, before any detail design work commences and then recalculated when the detail work is completed i.e. before the construction work starts on site.

**3.** Light Emitting Diode (LED) technology to replace Fluorescent tubes, metal halide, halogen and high pressure Sodium lighting in all domestic, commercial and industrial lighting applications ( including street lighting ). This is estimated to have the potential to reduce the UK's annual lighting energy consumption by 18 GW hours. In addition the savings in maintenance time due to the 25 times longer operating life will be another financial benefit.

**Zoltan Magyar, Hungary**
REHVA treasurer

**1.** In Hungary the biggest energy saving potential is the renovation of the existing single family houses. In 67% of all the housing stock, the annual energy consumption is higher than 250 kWh/m², a. Some financial support is needed to renovate the single family houses.

**2.** Based on the EPBD recast, the requirements will be changed in 3 steps. From 2020 the requirements will be to fulfil the nearly zero energy buildings. In Hungary the passive house education is on-going, books and software are available. This is the first step to achieve the nZEB's.

**3.** The passive house education is on-going, using better building envelop, heat recovery in the ventilation and the heat pumps. In 2012, only condensing boiler must be used for heating.

The presentations can be downloaded from the REHVA home page in news section: http://www.rehva.eu/

# REHVA organised seminar: HVAC for Net Zero Energy Buildings at ISH Frankfurt March 17, 2011

SUMMARY BY JAREK KURNITSKI

**REHVA seminar HVAC for Net Zero Energy Buildings (nZEB) at ISH Frankfurt March 17, 2011 showed great interest in nZEB-theme. About 150 participants were much more than expected and the room was too small to accommodate all interested visitors. In addition to HVAC experts, we were pleased to see in the seminar many representatives from real estate and construction sector as well as many young participants – deserving a special mentioning, and also REHVA experts.**

## Highlights of the presentations

### Jarek Kurnitski, SITRA:
**Energy boundaries and scientific definition of nZEB based on the results of REHVA Task Force**

Jarek Kurnitski, the chair of the REHVA Task Force "Nearly Zero Energy Buildings" nZEB reported the ongoing work of nZEB definition preparation. See article on page 6 about REHVA proposal for nZEB technical definition and boundaries which will help Member States in defining the nearly zero energy buildings in a uniform way.

**REHVA Task Force "Nearly Zero Energy Buildings" nZEB proposed definitions**

**net zero energy building (nZEB)**

nZEB has exact performance level of 0 kWh/($m^2$ a) primary energy use

energy use of 0 kWh/($m^2$ a) primary energy

NOTE 1 A nZEB is typically a grid connected building with very high energy performance. nZEB balances its primary energy use so that the primary energy feed-in to the grid or other energy network equals to the primary energy delivered to nZEB from energy networks. Annual balance of 0 kWh/($m^2$ a) primary energy use typically leads to the situation where significant amount of the on-site energy generation will be exchanged with the grid. Therefore a nZEB produces energy when conditions are suitable, and uses delivered energy during rest of the time.

**nearly net zero energy building (nnZEB)**

national cost optimal energy use of > 0 kWh/($m^2$ a) primary energy

NOTE 1 The Commission shall establish by 30 June 2011 a comparative methodology framework for calculation of cost-optimal levels (EPBD recast).

nnZEB depends on national conditions

JAREK KURNITSKI, SITRA

The presentations can be downloaded from the REHVA home page in news section: http://www.rehva.eu/

**Risto Kosonen, Halton Group:**
**Indoor air quality and climate considerations in nZEB**

Risto Kosonen discussed in his presentation the meaning of good IAQ and thermal comfort on well being, productivity and health. Economic calculations easily prove that indoor climate cannot be compromised for saving energy. This can lead to enormous losses for companies or organizations occupying the buildings. From the technical point of view there is not necessarily any conflict between energy performance and indoor climate requirements, because many technical solutions exist enabling to satisfy most tight requirements and making it possible to improve indoor climate and energy performance simultaneously.

▼

- EN 15251:2007 is a good tool to control all important indoor climate parameters. It can be concluded that tightening of energy performance requirements provide good opportunity for advanced ventilation and room conditioning systems leading to win-win-win situation for owners in terms of less complaints and energy savings, for occupants as improved comfort and for manufacturers as more advanced system solution with improved performance.

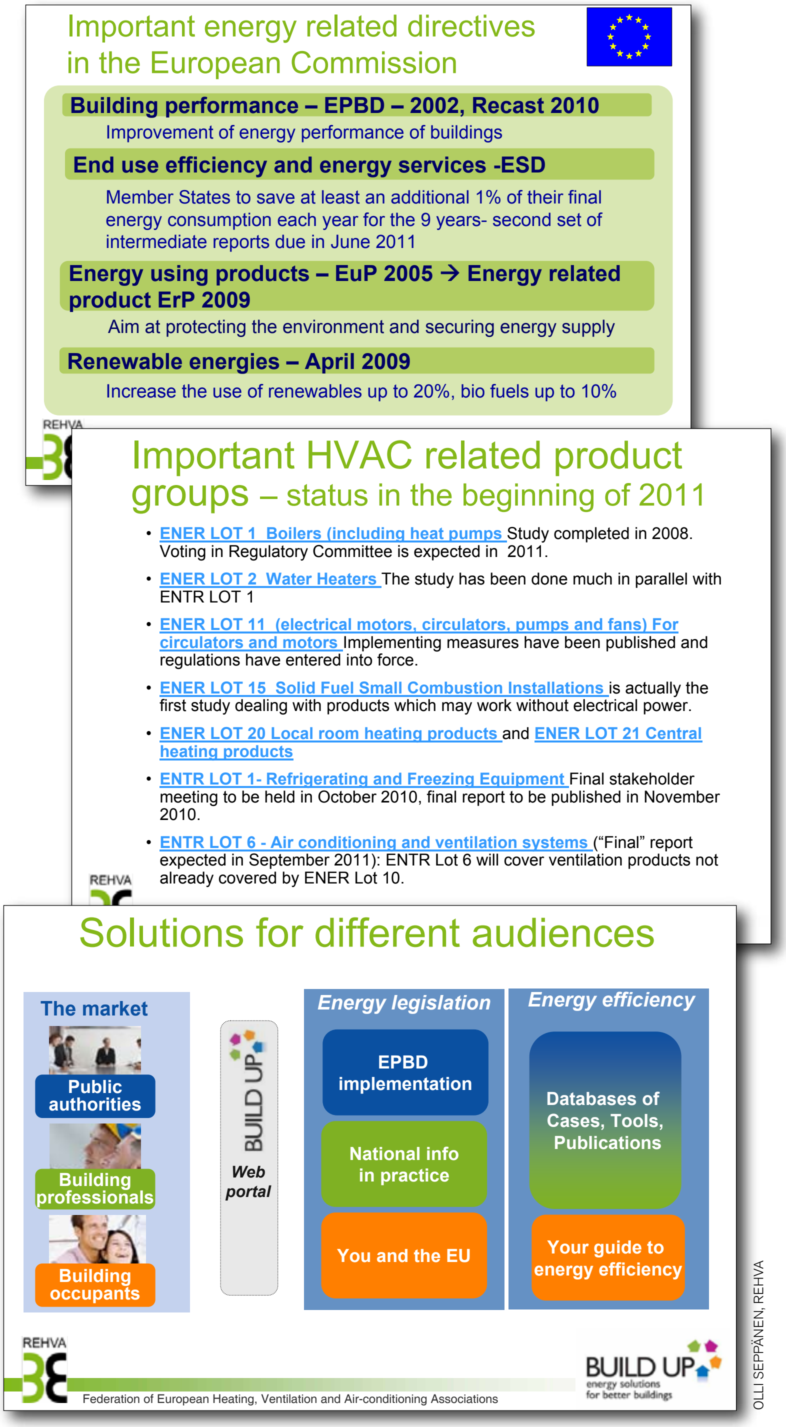

## Olli Seppänen, REHVA:
### News from the European Commission

Olli Seppänen introduced two important policy plans adopted by the European Council: A roadmap for moving to a competitive low carbon economy in 2050 and a new Energy Efficiency Plan 2011. The roadmap reports that EU is on good track to reduce greenhouse gas emissions by 20% due 2020. New milestones, -40% for 2030 and -80% for 2050 are set and considered as cost effective. Both of these refer to domestic (not incl. offsetting) reductions compared to 1990. These targets are also broken down for key sectors. In the energy efficiency, the progress is less good, because only half of the 20% objective of the primary energy reduction is estimated by Commission with current policies. Energy Efficiency Plan 2011 has to be fully implemented to get on track to achieve this target.

The buildings are still the greatest potential and the implementation of EPBD, Ecodesign and RES directives will have major importance. Legally binding national targets for 2020 and legal instruments under whose provisions public authorities will be required to refurbish at least 3% of their buildings by floor area each year – about twice the currently prevailing rate, as well as promotion systems for private sector buildings are some new instruments discussed in Energy efficiency action plan.

EU has provided not only directives but also a large amount of guidance possible to utilize in various levels. A web portal BUILD UP is a good example of an open platform to disseminate energy efficiency related information.

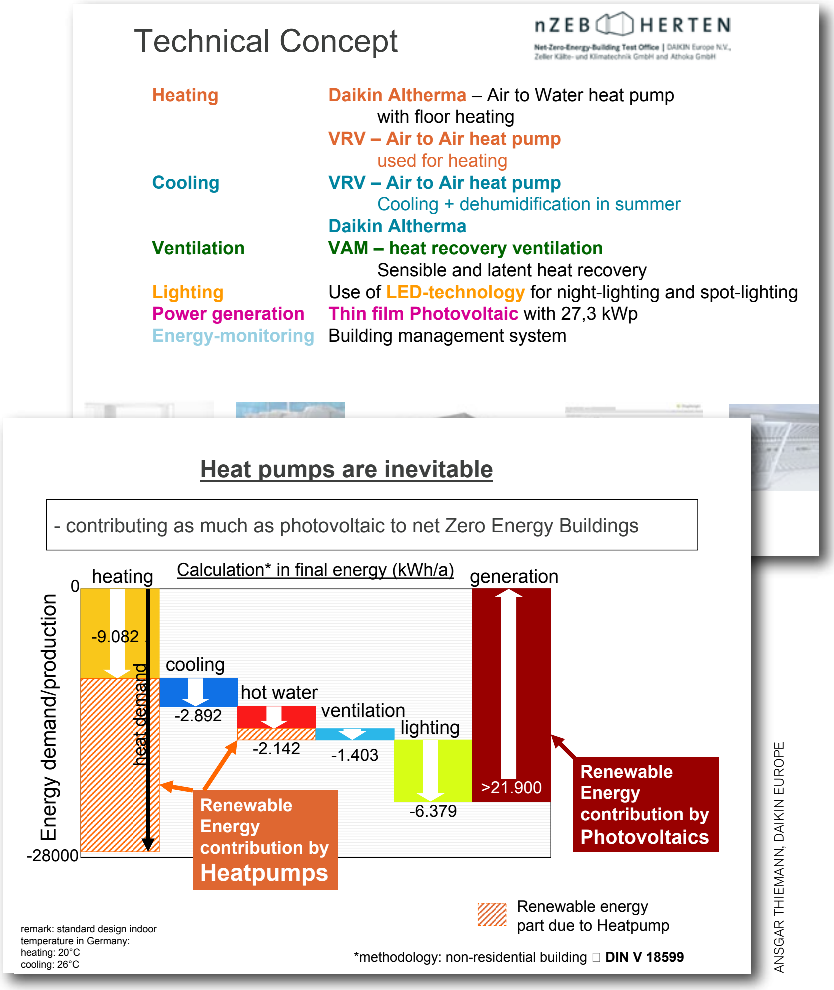
**See:** www.buildup.eu



OLLI SEPPÄNEN, REHVA

## Ansgar Thiemann, Daikin Europe:
### Half year experience from Net Zero Energy Office Building

Ansgar Thiemann introduced technical solutions and results from nZEB office building. The concept is based on combined Daikin Altherma - VRV heat pumps for heating and cooling and VAM heat recovery ventilation supported by photovoltaic power generation.



ANSGAR THIEMANN, DAIKIN EUROPE

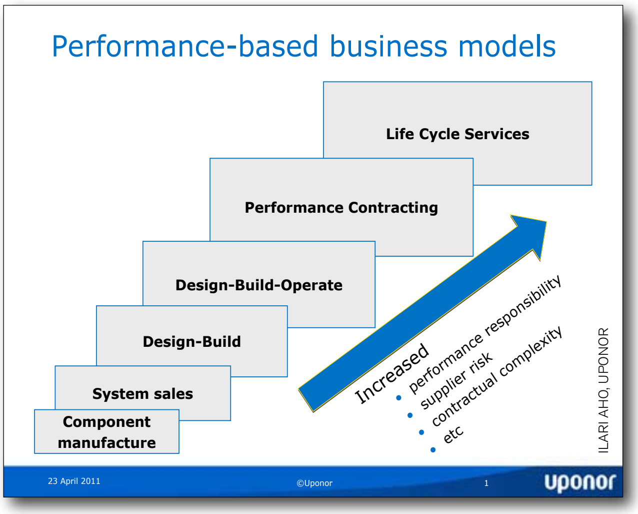
The building is net zero energy building according to calculation with EnEV, but some differences are recorded in reality, suspected to be caused by the limitations of the calculation method. This shows that nZEB requires good calculation methodology, i.e. dynamic simulation, in order to reach net zero energy level in practice.

The project is on good track; the main challenge is that all advanced solutions applied are not yet economically feasible. This applies especially for power generation, as heating, ventilation and cooling solutions are mainly with reasonable payback.

## Ilari Aho, Uponor:
### Heating and cooling business challenges in nZEBs

Ilari Aho raised an important aspect for HVAC industry in nZEB construction process. Subcontractor can deliver only the installation of the technical system, not a performance of the building. nZEB creates challenge for all construction, contracting and manufacturing chain. It is not evident, how nZEB performance can be delivered with existing business models where the focus has been rather in installed components not in performance of the systems and building.

Not only careful commissioning, but utilization of performance based business models are needed to guarantee nZEB operation in practice. For that purpose, development of common, measurable and contractually applicable performance metrics is needed.

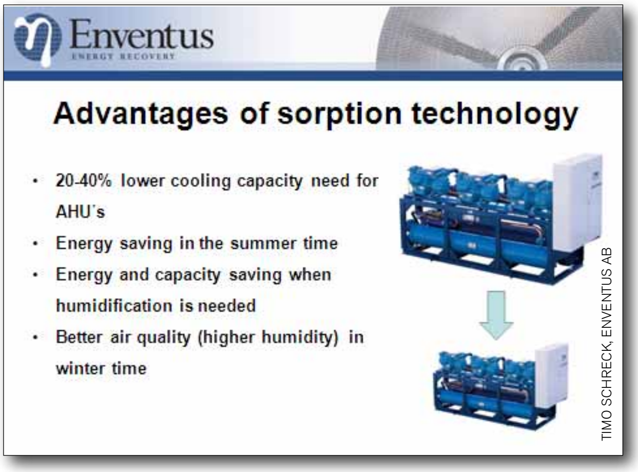



ILARI AHO, UPONOR

## Timo Schreck, Enventus AB:
### Energy efficient ventilation with heat recovery

Timo Schreck introduced sorption technology used in energy recovery rotors still too rarely used in Europe. Sorption rotors provide savings in cooing capacity demand in air handling unit. The savings in cooling capacity investments exceeds the additional costs of sorption treatment making the use of sorption technology highly profitable.

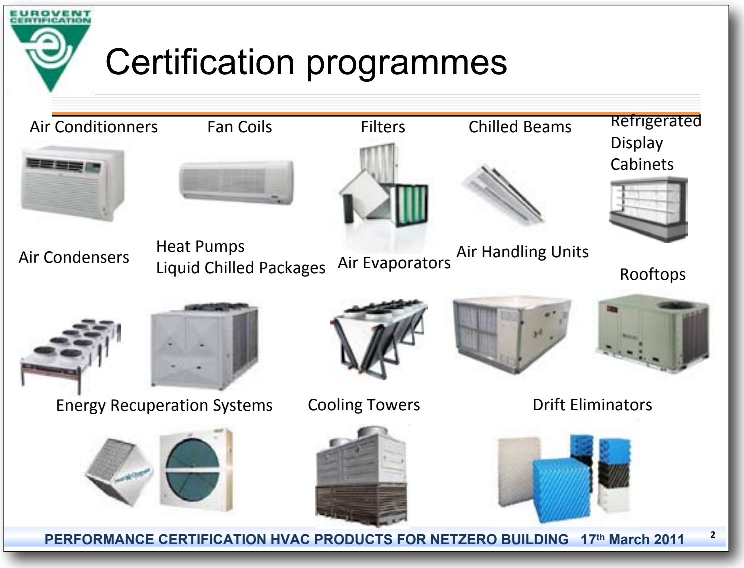
In mild and cold climate, humidity transfer of sorption rotors is beneficial due to cooling capacity savings. The savings in cooling energy are less important due to relatively short cooling period.



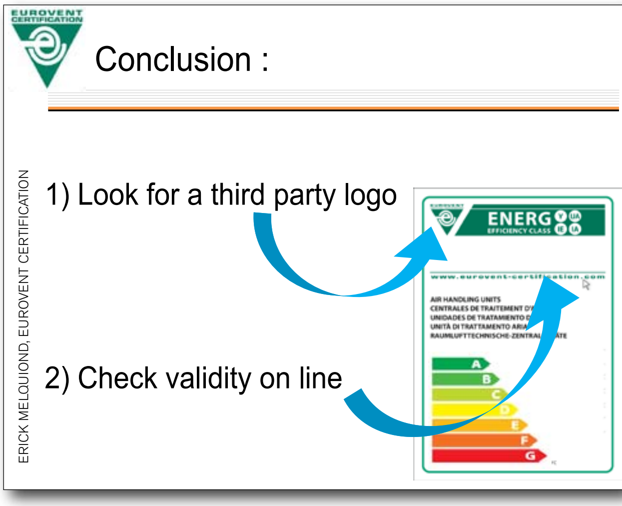

TIMO SCHRECK, ENVENTUS AB

## Erick Melquiond, Eurovent Certification:
### Certified products are needed for Net Zero Energy Buildings

Erick Melquiond provided an overview of a third party certification principle like Eurovent Certification Company. It is important to distinguish efficiency labels and certified efficiency labels. A third party logo and on line check will prove the product performance most effectively. CERTIFLASH downloadable at www.certiflash.com is very convenient to easily google-ized certified performance of more than 50 000 products.




ERICK MELQUIOND, EUROVENT CERTIFICATION

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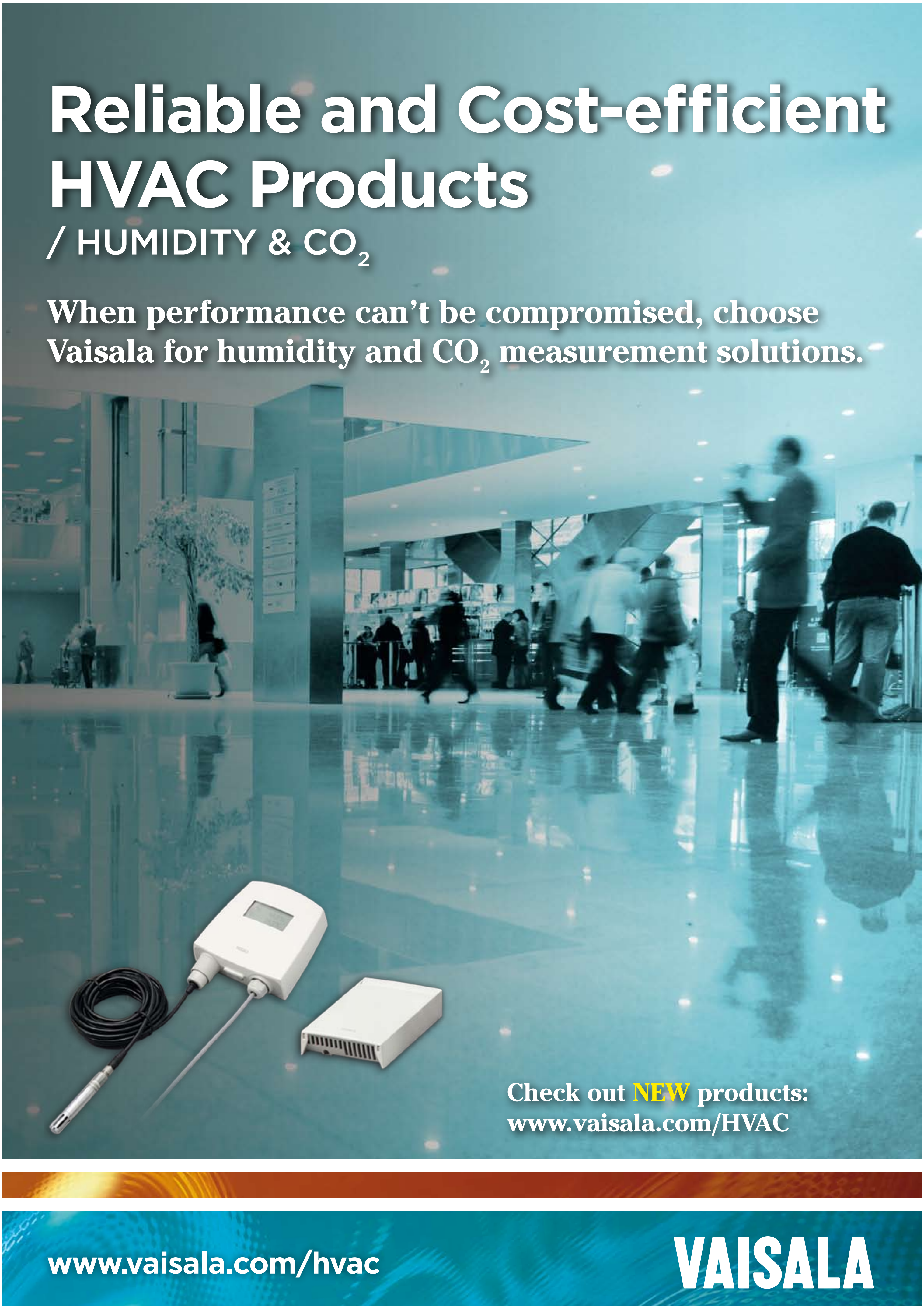
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# EKVÜ – Estonian Society of Heating and Ventilation Engineers – hosts REHVA Annual meeting in Tallinn

**Tiit Kerem**
M.Sc. (Eng.),
EKVÜ President,
CEO of Hevecon OÜ,
working experience of
22 year as consultant

**Aivar Uutar**
M.Sc. (Eng.),
EKVÜ Vice-president,
Construction director in
Clik AS, 14 year in
contracting and lecturer
in Tallinn University of
Applied Sciences

**Peeter Parre**
M.Sc. (Eng.),
EKVÜ Vice-president,
CEO of IB Aksiaal,
worked 35 years as
consultant and 30 years
as lecturer in Tallinn
University of Technology

## History and activities

Professional activities of the engineers of heating and ventilation commenced already in the Soviet period, during the operation of the sanitary technology section of Tallinn University of Technology of the Building Industry of the ESSR as the predecessor of EKVÜ.

In spring 1989, 28 engineers working in the field of heating and ventilation founded the Association of Heating and Ventilation Engineers. The statute of the society was adopted, fixing the objectives of the activities, rules for its membership, organisation of work, main lines of activity as well as rights and obligations of the members.

At the end of 1989 a professional contact was established with the Finnish heating and ventilation engineers SuLVI society in Finland, which inspired and gave rise to the foundation of the Estonian Society of Heating and Ventilation Engineers (EKVÜ) in 1991, when the foundation meeting of EKVÜ was summoned on April 18 with 36 members participating. They elected a 7-member council and a 3-member board committee. In summer 1991, political events called "singing revolution" resulted in restored independent Estonia, as well bureaucratic procedures took a considerable time, and therefore after a small delay the registration certificate issued by the Tallinn City Government bears the date of October 4, 1991.

In 2011, EKVÜ membership has reached already over 225 speciality engineers (while the population of Estonia is 1.3 million people!).

## Courses

EKVÜ started monthly continuing training sessions immediately after its foundation. A demand for such updating education was high, as the design of HVAC systems in 1990es included plenty of new aspects far from common understanding. Contacts with Finnish colleagues were very important at that transitional period, as they did not save time or effort to provide relevant guidance available for Estonian colleagues. The structure of the training plan of EKVÜ has always been similar and mainly targeted to the increase of competency of its members.

## Profession certification

EKVÜ grants profession certification in the field of energy performance of buildings in accordance with the Professions Act. To ensure impartiality in the granting of profession certificates, a 7-member professional qualifications committee has been set up, including the representatives of various experts as well as organisations.

At the moment the following professions are granted:

- Issuer of building label III
- Energy auditor IV
- Energy auditor with a diploma V
- Authorised energy auditor V

Energy auditor is an engineer-advisor of the field of energy performance and energy saving of buildings, who must be able for integrated approach of energy performance of the building. Energy auditors are divided into different levels depending on the complexity of the building.

Energy auditor IV may operate only in the field of dwellings, Energy auditor with a diploma V in the field of dwellings and public buildings, and Authorised energy auditor V also in the field of especially complex (incl. industrial) buildings.

Up to April 2011, the profession of an issuer of building label has been granted to 105 persons and the profession of energy auditor to 95 persons, of whom 6 have received the profession of authorised energy auditor V, 33 the profession of energy auditor with a diploma V and 56 the profession of energy auditor IV.

## Standards and regulation

As the foundation of EKVÜ took place in the period of initial development of the legislation of the restored independent Republic of Estonia, EKVÜ participated from the very beginning in any field requiring the advice of heating and ventilation engineers, and also in the fields, where our advice was not specially expected, but where we considered it necessary ourselves.

When it was decided on national level that the standards of other countries (first and foremost Finland) were not suitable for adoption, we started to draft Estonian national standards (EVS), forming a relevant technical committee TK27. Participating actively in the Council of Building Regulations joining all professional associations, the representation of EKVÜ also helped to develop the standards for other specialities.

In addition to standards we have been participating in legislative activities – our representatives have operated in the working groups for the development of the Building Act as well as various health protection regulations. Hereby EKVÜ has the leading role in the issues of energy performance.

# Danvak Conference on Low Energy Building and Related Issues Successfully Held on 7 April

***Zosia K. Lav***
Communications Manager at Danvak

Danvak – The Danish Society of Heating, Ventilation and Air Conditioning – held its annual conference on HVAC issues on April 7, 2011. Almost 125 people attended the conference, among them exhibitors, academics, professionals from the corporate sector, journalists, architects and students who had all showed up to gain and learn from the latest development of the HVAC field.

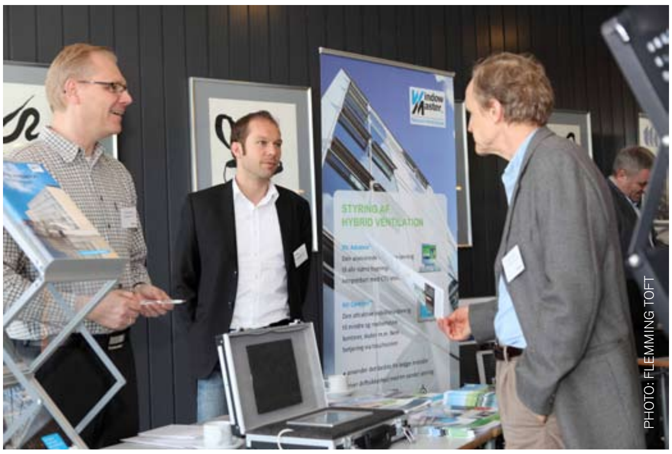
Taking a broad and cross-disciplinary approach to addressing HVAC issues in contemporary society, conference session topics included: Requirements for Energy Efficiency in Hospitals, State of the Art of Low Energy Buildings, Pitfalls of Building Automation Systems, Intelligent Glazed Facades and Refurbishment of Frederik VIII's Palace. Moreover, the conference offered an opportunity to participate in two different panel discussions "Energy Labelling" and "Common or Individual Energy Supply" both of which generated interesting and heated debate.

According to tradition the Professor P.O. Fanger's Award was announced at the closure of the conference. The award was shared between two Ph.d students who had both demonstrated excellence within their particular field of study. Steffen Petersen was nominated by Technical University of Denmark/ALECTIA for his study on *Simulation-based support for integrated design of new low-energy office buildings* and Monika Frontczak was nominated by Technical University of Denmark for her thesis on *Indoor Climate and Quality of Life.* Congratulations!

After a long day of conference sessions, speakers, participants and exhibitors mixed and mingled over a drink. The exhibitors were: Swegon, Schneider Electric, LeanVent, WindowMaster, KNX National Group Denmark, BygErfra, Dansk Ventilation and TT-Coil.


Geo Clausen (center), Associate Professor at Technical University of Denmark and member of the board of trustees together with the two award recipients, Monika Frontczak (left) and Steffen Petersen (right) - both ph.d. students at Technical University of Denmark.


Chairman of Danvak, Mr Jørn Schultz, opening the conference Danvak Dagen 2011




Traffic at the WindowMaster stand

# The Swiss Society of Building Technology-Engineers (SWKI)

**SWKI** Schweizerischer Verein von Gebäudetechnik-Ingenieuren
**SICC** Société suisse des ingénieurs en technique du bâtiment
**SITC** Società svizzera degli ingegneri nella tecnica impiantistica

Affiliated with SIA, ASHRAE and REHVA

The SWKI was founded in 1962 and has emerged from the Swiss section of ASHRAE (the American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Atlanta). The SWKI is affiliated with ASHRAE and linked to REHVA which is the European frame organisation of national societies. Since December 2008, the SWKI is also affiliated to the Swiss Society of Engineers and Architects (SIA).

## The goals

The SWKI wants to support building technology and related fields. Each member is bound to lend his expertise to the society according to his abilities. So that the SWKI treats issues in workgroups and technical task groups according to specific subjects. The focus of SWKI lies on the following three priorities: Development of guidelines, education and training and the support of young talents. Delegates are also nominated to participate in national and international committees of other societies, associations or governmental institutions to help to solve specific HVAC issues.

# VDI- Guidelines published January – March 2011

## January:

**VDI 3551: Electromagnetic compatibility (EMC) in building services**

The guideline provides guidance on how to interconnect individual devices and system components subject to the EMC Act in such a way that the overall installation thus formed does not cause any electromagnetic interference in devices/equipment/installations/systems nearby, and that the functioning of the installation proper is not disturbed by interference from other devices.

**VDI 4708/1: Pressure control, venting, deaeration; Pressure control *(Draft Guideline)***

This guideline applies to the media circulation in heating systems where the interruption of operation or of forced circulation is a regular occurrence (e.g. interruption of heating in summer) during operation. It describes the dimensioning of pressure-maintenance systems and the testing of such systems during operation and maintenance. Pressure relief and safety equipment are not the subject of this guideline. The guideline supplements existing guidelines for the design, manufacture and testing of the pressure-maintenance, deaeration and degassing systems or their system components with respect to thermo-hydraulic integration into the fluid circulation in terms of recommendations and dimensioning guidelines.

**VDI BV/BS 6000/1.1: Provision and installation of sanitary facilities; Generic aspects and systems; Prefabricated sanitary modules (prefabricated sanitary rooms, installation systems) *(Draft Guideline)***

The guideline applies to prefabricated sanitary elements in new construction, in the remodeling of existing buildings, for permanent sanitary facilities in mobile units such as ships, trains and other means of transportation. It does not apply to sanitary containers installed in mobile buildings destined for repeated installation and removal. The guideline applies to wall modules, panels, prefabricated restrooms, installation systems, ready-made toilets. The guideline states requirements to be met by architectural and structural conditions, stability, building physics, building services, transport and storage, installation. General planning of sanitary areas in buildings is not a topic of this guideline. The equipment for various types of buildings is described in VDI 6000 Part 1 through Part 6.

## February:

**VDI 2067/22: Economic efficiency of building installations; Energy effort of benefit transfer for heating potable water**

This guideline applies to all systems for heating potable water (see also DIN 1988) in buildings. It is used to determine the energy, water and auxiliary energy effort for the benefit transfer.

The guideline covers the calculation of the energy effort and the benefit transfer in systems for heating potable water. The calculation processes and reference values contained in this guideline are used in connection with VDI 2067 Part 12 for the property-related calculation of the energy expenditure for usage and benefit transfer. In a cost calculation in accordance with VDI 2067 Part 1, the energy efforts for the (heat) thermal distribution and heat generation must be taken into account.

**VDI 2083/17: Cleanroom technology; Compatibility with required cleanliness class and surface cleanliness *(Draft Guideline)***

The guideline deals with particulate and chemical (molecular) contaminations and electrostatic characteristics of materials and the cleanability of surfaces. Biological and radiological contaminations are not a specific subject of this guideline. The guideline defines the cleanliness compatibility and cleanroom compatibility for materials. Based on this, a classification is made, and procedures are specified for determining the suitability for the intended use in clean production areas.

**VDI 3810/1: Operation and maintenance of building installations; Fundamentals *(Draft Guideline)***

The series of guidelines VDI 3810 gives recommendations for the various building services and trades regarding safe, specified, demand-oriented and sustainable operation. The guidelines describe the prerequisites for fulfilling the operator's obligations, safe operation of installations, economic efficiency and environmental compatibility. Furthermore, they contain practical recommendations for operating and maintaining building-services installations. Installation owners and operators are obliged to operate installations in accordance with the acknowledged rules of technology or state of the art, depending on the object in question.

**VDI 6034: Cooling surfaces for rooms; Planning, installation and operation**

When it comes to the planning, construction and operation of liquid-cooled room cooling surfaces integrated into ceilings, walls and floors, or of systems with cooled massive building components, experts differ about the proper procedures. It is not only the cooling power output but also many other questions of detail that still want a harmonised procedure for planning and execution. For instance, how to deal with the result of a cooling-load calculation when using a room cooling surface? What is the state of the art regarding the selection of materials? What special requirements are to be taken into account in dimensioning the hydraulic system, the room temperature control and fire protection? This guideline is intended to provide more clarity on all these issues and to close a gap, with the aim of improving security in dimensioning the systems, promoting fair competition, and creating more transparency for all those involved in order processing.

## March:

**VDI 2073/2: Hydraulic systems in building services; Hydraulic balancing *(Draft Guideline)***

This guideline applies to the dimensioning of new, and verification, by calculation, of existing, distribution systems for heating and chilling in HVAC installations; its particular aim is the reproducible hydraulic balancing of an installation as planned.

"Hydraulic balance" as stipulated in standards and ordinances is the generic term for a requirement to be met in dimensioning and adjusting of distribution systems, particular in hot-water heating systems. In a stricter sense it means ensuring the intended distribution of flows to handover locations (space-heating surfaces, chilling surfaces, heat exchangers and similar) by selecting proper piping and calculating and adjusting regulating resistances. In addition to ensuring the indispensable function "distribution of intended flows", it is a further aim to minimise the expenditure in heating and cooling energy for handover, and the pumping energy required for water circulation.

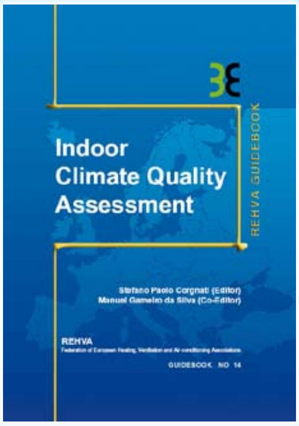
**VDI 4710/3: Meteorological data for the building services; t,x correlations from 1991 to 2005 for 15 climatic zones in Germany**
Since 1979, it has been common practice, particularly in DIN 4710, to compile the basic data of outdoor-air temperature (t) and water vapour content (x) in the form of t-x correlations. Initially, the data from 1951 to 1970 served as the basis for West Germany. When the standard was revised in 2003, in cooperation with the DWD (German Meteorological Service), the data gathered at 15 stations between 1961 and 1990 were published. The concept for the compilation of the correlation tables of air temperature and water vapour content in air, the so-called t-x correlations, so far consisted in using the respective hourly values measured over the 30 years of the currently completed climate normal period, i. e. presently from 1961 to 1990.

Since the end of the nineteen-eighties, the air temperature has kept rising. To give better consideration to the obvious climate change in the air-temperature regime when planning building services, the t-x correlations have been re-calculated, and published in this VDI guideline, for the 15-year period from 1991 to 2005, which corresponds to half of the current climate normal period.

**VDI 6028/6: Assessment criteria for Building Services; Requirements profiles and valuation criteria for the building automation *(Draft Guideline)***
The guideline tries to offer a method allowing an objective and holistic evaluation of offers for building automation. The guideline compiles technical specifications and profiles of requirements for building automation. Based on these, evaluation criteria as per VDI 6028 Part 1 are described. Lists allow to select those criteria for a building project which have to be observed at a given time. These lists can be supplemented by orderers' specifications in all cases. The guideline is addressed to orderers, object and technical planners, executing companies, users and operators. This guideline is only valid in conjunction with VDI 6028 Part 1.

# New REHVA Guidebooks

Both are available from May 2011 at www.rehva.eu or through REHVA National Members

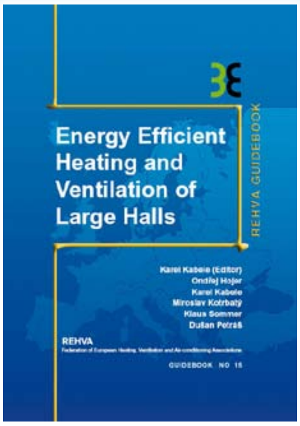



## Indoor Climate Quality Assessment

*Evaluation of indoor thermal and indoor air quality*

**Editor:** Stefano Paolo Corgnati
**Co-Editor:** Manuel Gameiro da Silva

THIS NEW REHVA Guidebook gives building professionals a useful support in the practical measurements and monitoring of the indoor climate in buildings. It is evident that energy consumption in a building is directly influenced by required and maintained indoor comfort level. Wireless technologies for measurement and monitoring have allowed enlarging significantly number of possible applications, especially in existing buildings. The Guidebook illustrates with several cases the instrumentation for the monitoring and assessment of indoor climate.




## Energy efficient heating and ventilation of large halls

**Editor:** Karel Kabele
**Contributing Authors:**
Karel Kabele, Ondřej Hojer, Miroslav Kotrbatý, Klaus Sommer, Dusan Petras

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

# Implementing the Energy Performance of Building Directive (EPBD)


**Editor:**
Eduardo Maldonado
(Coordinator of Concerted Action EPBD)

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Kirsten Thomsen & Kim Wittchen
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Peter Wouters & Andras Zold

Reducing energy consumption and eliminating wastage are among the main goals of the European Union. With 40% of our energy consumed in buildings, the EU has introduced legislation to ensure that they consume less energy. A key part of this legislation is the Energy Performance of Buildings Directive (EPBD) which requires all EU countries to enhance their building regulations and to introduce energy certification schemes for buildings. The introduction of national laws meeting EU requirements is challenging. It is a great opportunity to mobilise energy efficiency in EU buildings, but also a formidable and continuing challenge for many EU countries.

To support EU countries in this task, the Concerted Action EPBD was launched by the European Commission to promote dialogue and exchange of best practice between them. An intensely active forum of national authorities from 29 countries, it focuses on finding common approaches to the most effective implementation of this EU legislation. The Concerted Action EPBD (2007 – 2010) is organized around 5 Core Themes: Certification of Buildings, Inspections of Boilers and AC systems, Training of Experts, Procedures for Characterization of Energy Performance and Information Campaigns. This book contains an extended summary of the main outcomes of these sessions, including conclusions and recommendations, for each of the five main topics. The objective of the reports on the Core Theme activities is to present a snapshot of the concerns and deliberations of the teams dealing with practical implementation of legislation at national level.

The second part of this book features a collection of country reports. These reports will certainly allow the reader to get a good overview of how the directive is being implemented in practice all over Europe, including many points in common amongst the Member States, as well as specific differences between them. In spirit of transparency and in an effort to provide a true portrait of reality, they are straightforward and frank. They convey the reality of the implementation of this challenging Directive in each country as of the end of 2010. Most importantly, these reports show how much progress has been already been achieved all over Europe in the promotion of energy efficiency in buildings as a result of this Directive. Readers are invited to pay special attention to the best practices presented by experts in many of the reports, as they were the inspiration and building blocks for the new upgraded requirements that were adopted in the recast of the directive in 2010. 3E

## Available at www.epbd-ca.eu or contact your national CA-EPBD participant

# Energy efficiency action plan (EEAP) 2011 adopted March 8th by the Council

Background: EU will achieve only half of 20-20-20 targets by 2020 if it continues current policy and actions

Some new actions in the EEAP:

- Exemplary role of the public sector
- Accelerate the refurbishment rate of the building stock
- Public authorities should be required to refurbish at least 3% of their buildings each year
- Energy efficiency criteria to be included in public procurement
- Improve the energy performance of appliances
- Improve the efficiency of power and heat generation
- More smart grids and smart meters

**More information:**

http://ec.europa.eu/energy/efficiency/action_plan

# BUILD UP 2

The Commission has decided to continue developing and updating the BUILD UP portal for building energy efficiency related information at least to the end of 2013. REHVA is one of the organisations updating the information at the portal.

Current status of the portal:

- Over 600 visitors a day
- English is the main language but material in all 23 EU languages accepted (headlines in 22 languages)
- Search by language, theme, topic, keyword, date, country, etc. status in March 2011
- 1 909 publications
- 1 130 links
- 161 cases
- 147 tools
- 49 upcoming events
- 27 communities

**More information:**

http://www.buildup.eu/

BUILD UP energy solutions for better buildings

# Airtightness of buildings and ductwork: The Tightvent Europe Platform

***François Rémi Carrié and Peter Wouters***
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Building and ductwork airtightness represent a key challenge towards very-low energy buildings and therefore towards the ambitious 2020 targets set in the recast of the energy performance of buildings directive. Results of the EU ASIEPI project (www.asiepi.eu, [6]) have shown that for most European climates, leaky envelopes and duct systems have a severe impact on the total energy use of the building, e.g., on the order of 10 kWh per m² of floor area per year for the heating needs in a moderately cold region (2500 degree-days) and 0 to 5 kWh/m²/year for the ducts plus the additional fan energy use [2][10]. Few European countries have taken steps to overcome this challenge, but whether good or bad, their experience is worth sharing to accelerate the market transformation needed on these issues [4][8][9].

This paper gives an overview of the TightVent Europe platform that started in January 2011 and its scheduled activities for year 2011. More information can be found on the TightVent Europe website (www.tightvent.eu).

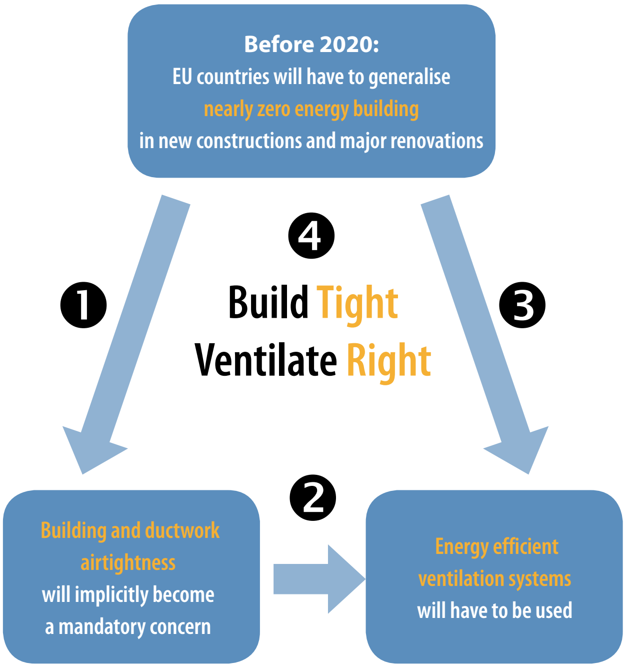


**Figure 1.** Diagram representing interactions between energy targets, ventilation, and airtightness.

### Challenges for nearly-zero energy buildings

The EPBD recast [1] sets ambitious targets for year 2020 including the obligation for EU countries to implement regulations to increase the number of nearly zero-energy buildings (NZEB) in the next few years, and to generalize nearly zero-energy targets in new buildings and major renovations. Therefore, as illustrated in **Figure 1**:

- Because of the demonstrated energy impact of envelope and ductwork leakage, the implementation of the EPBD recast will for most climates automatically lead to specific attention to building airtightness (1);
- As a result of the increased attention for building airtightness, the need for appropriate, energy efficient, ventilation systems (2) will grow. Issues such as correct airflow rates, air quality, acoustics, draught, energy optimisation, economics, etc. will have to be handled. At present, we know that poor ventilation system performance is common in many European countries.
- Indirectly, the move towards nearly zero-energy buildings will lead to a greater need for ventilation systems, whether mechanical, natural or hybrid (3).
- In addition, there are tremendous challenges for the existing building stock. Although there will be in most countries more time for implementation and, in absolute terms, probably less severe targets, in addition to challenges similar to the new stock, there are specificities that considerably complexify the improvement of ventilation and airtightness.

### What is TightVent Europe?

Since there are to a rather large extent similar challenges for the whole of Europe, the TightVent Europe platform aims at meeting the obvious need for a strong and concerted initiative to overcome these challenges. Indeed, sharing experience on practical issues such as specifications, design, execution, control, ... and taking advantage of the lessons learnt from pioneering work will help improve airtightness quality while keeping in mind the need for adequate ventilation.

TightVent Europe has been initiated by INIVE EEIG (International Network for Information on Ventilation and Energy Performance) with at present the financial and/or technical support of the following partners: Building Performance Institute Europe, European Climate Foundation, Eurima, Lindab, Soudal, Tremco-Illbruck, and Wienerberger. All partners are strongly interested in setting up a European wide collaboration and using the knowledge gathered through TightVent Europe for raising the awareness among all building professionals, for developing improved training courses, and for helping professionals in the development of quality management approaches. The partners also believe that there are areas that need further investigation (for example, the durability of seals, the integration of airtightness and ventilation issues in renovation projects, the variability of the energy impact with climate, etc.) where TightVent Europe can play a major role both in terms of research development and dissemination.

The target audience of the TightVent Europe activities is wide and ranges from the research community over designers, practitioners, supply industry to European, national and regional government policy makers. It is clear that awareness raising is key in the starting up phase, whereas in time the emphasis should move to providing the appropriate support tools and getting the knowledge into the market.

## Envisaged deliverables of tightvent europe

### A project-oriented platform involving expert organisations from various countries

One key concept of TightVent Europe is to organize or encourage efforts in a consistent manner around specific topics, e.g., to develop a philosophy on airtightness requirements, to encourage the development of airtightness networks, to improve and encourage quality management. For this, TightVent will make use of its network of reknown specialists around the world and will put forward synergies between national initiatives. For instance, on the subject of airtightness requirements, this might take the form of a project involving a group of experts from various countries with a series of workshops and webinars including lessons learnt from national approaches. The foreseen publications, conferences, webinars, and BUILD UP community described below fall under this project-oriented approach, i.e., they are linked to project deliverables.

### Publications under preparation

A publication on the challenges for building and ductwork airtightness is foreseen in spring 2011. It will include an introductory paper browsing the issues of concern and collect a series of technical documents, namely those produced within the ASIEPI project as well as within the SAVE-DUCT and AIRWAYS projects [1][5].

We are also working on a more extensive publication that will give an overview of envelope airtightness issues and policies to achieve a market transformation. It is primarily targeted at policy markers, but it will include relevant information for building professionals such as project owners or managers or consultants as well, for instance on energy and indoor air quality issues associated with airtightness.

### Two major conferences in Berlin (May 6) and Brussels (October 12-13)

One important aspect of TightVent Europe's strategy is to bring added-value to existing initiatives rather than duplicating efforts. One illustration of this strategy lies in the partnership established with the BUILDAIR conference, which was held in Berlin, May 6. This conference has been for a number of years a major event on airtightness issues in Germany (www.buildair.eu) and has more recently drawn attendees from several European countries. The association with TightVent Europe is expected to bring more visibility of this conference at EU level.

TightVent Europe is also combining forces with the Air Infiltration and Ventilation Centre (AIVC — www.aivc.org), which is the IEA information centre on energy efficient ventilation. In practice, the 32nd AIVC conference, which is *the* major international event on air infiltration and ventilation, is combined with the 1st TightVent conference. The programme includes 2 parallel tracks:

- One track focusing on airtightness related issues;
- The other track addressing ventilation issues in general.

The conference will consist of a mixture of:

- Well-prepared workshops (typical duration 1.5 hours);
- Presentations on invitation;
- Presentations from call for papers.

The deadline for abstract submission is May 15.

### Webinars

Besides the publications, conferences, and BUILDUP community mentioned above, TightVent Europe key activities in 2011 will also include the organization of webinars. Some will be targeted at a specific region (the first webinar will be specifically focused on Romania), some at the specific topic (e.g., sharing national experience on air leakage databases), some at training, some at industry.

### BUILD UP community on airtightness of buildings and ductwork

Today, there is for many issues of interest not a lack of information but, at the same time, it is for most professionals difficult to easily find the information one is looking for. The BUILD UP platform (www.build-up.eu) is the official EU platform on energy efficiency in buildings, and TightVent Europe is actively supporting this through facilitating a community on the "Airtightness of Buildings and Ductwork". Part of the information in BUILD UP can also be accessed on www.tightvent.eu.

## Scientific committee and AIVC collaboration

In order to guarantee high quality deliverables and an unbiased view, the TightVent scientific committee has been set up, with as primary objectives:

- To pay attention to the overall scientific approach of the platform;
- To take care of a correct balance between energy concerns and indoor climate concerns;
- To organise a review process for publications and to give advice to the steering committee.

It is made of internationally re-known individuals in the field of energy efficient ventilation and infiltration. In a concern for efficiency and focus, some of these experts are also members of the Air Infiltration and Ventilation Centre (AIVC).

## Conclusion

The TightVent Europe platform has already initiated a number of activities in its starting up phase since January 2011, ranging from the organization of two international conferences in 2011 to the preparation of publications and webinars, including the dialogue with users and stakeholders. Its ambition is to play a major role in dissemination and research activities on airtightness and ventilation issues, namely by bringing added-value to existing initiatives, gathering experts around common concerns, and producing reference documents. This way it will contribute to the obvious need for international collaboration on building and ductwork airtightness, which is a major challenge for EU countries to reach the 2020 targets. For more information, visit the TightVent Europe website at www.tightvent.eu.

## Acknowledgements

The TightVent Europe platform receives the financial and/or technical support of the following organizations: Building Performance Institute Europe, European Climate Foundation, Eurima, INIVE, Lindab, Soudal, Tremco-Illbruck, and Wienerberger.

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|---|---|---|---|
| 5 – 6 May 2011 | 16th International Conference on Thermal Protection of Buildings 2011 | High Tatras - Štrbské Pleso, Slovakia | |
| 8 – 13 May 2011 | World Renewable Energy Congress 2011 | Linköping, Sweden | http://www.wrec2011.com |
| 10 – 11 May 2011 | Energy services congress | Madrid, Spain | http://www.congresoeses.com |
| 18 – 21 May 2011 | REHVA Conference and Annual Meeting 2011 | Tallinn, Estonia | http://www.ekvy.ee/rehvaam2011 www.rehva.eu |
| 19 – 20 May 2011 | the 30th Edition of the Conference with theme Modern Science and Energy, | Cluj, Romania | |
| 24 – 26 May 2011 | EEDAL 2011 - Energy Efficiency in Domestic Appliances and Lighting | Copenhagen, Denmark | http://www.eedal.dk/ |
| 26 May 2011 | the 3rd Edition of the Conference Energy Performance of Buildings and of Related Building Services | Bucharest Romania | |
| 29 May – 2 June 2011 | NSB 2011 - Nordic Symposium on Building Physic | Tampere, Finland | http://www.tut.fi/nsb2011 |
| 2 – 3 June 2011 | Climamed 2011 - Mediterranean Congress of HVAC | Madrid, Spain | http://www.climamed.org/ |
| 5 – 9 June 2011 | The 6th International Green Energy Conference (IGEC-VI) | Eskisehir, Turkey | http://igec6.anadolu.edu.tr/ |
| 5 – 10 June 2011 | IAQ 2011 - Indoor Air Quality | Austin, Texas, USA | www.lifelong.engr.utexas.edu/2011/ |
| 19 – 22 June 2011 | RoomVent 2011 - 12th International conference on air distribution in rooms | Trondheim, Norway | www.sintef.no/Projectweb/Roomvent-2011 |
| 25 – 29 June 2011 | ASHRAE Annual Meeting | Montreal, Canada | www.ashrae.org |
| 7 – 8 July 2011 | the 21th Edition of the Conference with theme Building Services and Energy Economy | Lasi, Romania | |
| 13 – 15 July 2011 | PLEA 2011 - Passive & Low Energy Architecture | Belgium | http://www.plea2011.be/index.html |
| 11 – 13 August 2011 | 2011 Guangzhou International Refrigeration, Air-condition, Ventilation & Air-improving Fair | Guangzhou, China | http://www.avaichina.com/ |
| 21 – 26 August 2011 | 23th IIR International Congress of Refrigeration – ICR2011 | Prague, Czech Republic | www.icr2011.org |
| 14 -16 September 2011 | International scientific conference CISBAT 11 | Lausanne, Switzerland | http://cisbat.epfl.ch/ |
| 22 -23 September 2011 | 48th AICARR International Conference | Baveno, Italy | www.aicarr.org |
| 1 – 31 October 2011 | Building Simulation 2011 | Wellington, New Zealand | www.ibpsa.org |
| 12 – 13 October 2011 | 32nd AIVC Conference and 1st TightVent Conference | Brussels, Belgium | www.aivc.org |
| 12 – 14 October 2011 | Solar Air-Conditioning - 4th International Conference | Larnaca, Cyprus | http://www.otti.de/ |
| 18 – 21 October 2011 | SB11 Helsinki World Sustainable Building Conference | Helsinki, Finland | http://www.sb11.org/ |
| 20 – 21 October 2011 | ESTEC 2011 - 5th European Solar Thermal Energy Conference | Marseille, France | http://www.estec2011.org, http://www.estif.org/index.php?id=657 |
| 20 – 22 October 2011 | 46th Edition of National Installation Conference with theme installations for the Beginning of 3rd Millenium | Sinaia, Romania | |
| 25 – 28 October 2011 | XXVIII conference and exhibition and XI international symposium | Moscow, Russia | www.abok.ru |
| 6 – 9 November 2011 | ISHVAC 2011 - 7th International Symposium on Heating, Ventilation and Air Conditioning | Shangaï, China | http://www.ishvac2011.org |
| 10 – 12 November 2011 | " Sustainable Energy-CSE " - International Conference | Brasov, Romania | |
| 30 November – 2 Dec. 2011 | 41 th International congress of Heating, Air Conditioning and Refrigeration | Belgrade, Serbia | |

| FAIRS | | | |
|---|---|---|---|
| 5 - 7 May 2011 | RENEXPO 2011 | Budapest, Hungary | www.renexpo.hu |
| 17 - 19 June 2011 | Energy Fair | Custer (WI), USA | www.the-mrea.org/energy_fair.php |
| 10 - 12 August 2011 | 5th Renwable Energy India Expo | New Dehli, India | www.renewableenergyindiaexpo.com |

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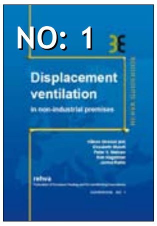
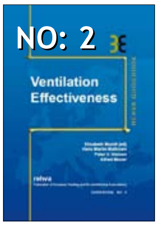
# REHVA GUIDEBOOKS

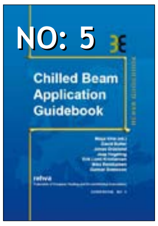
## REHVA Guidebooks are written by teams of international experts



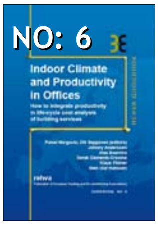

Displacement Ventilation Guidebook serves as a comprehensive and easy-to-understand design manual. It explains the benefits and limitations of displacement in commercial ventilation and outlines where ventilation should be applied. Various case studies are included. The benefits of displacement ventilation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



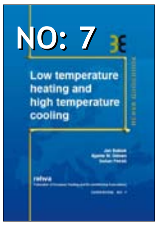

Improving the ventilation effectiveness allows the indoor air quality to be significantly enhanced without the need for higher air changes in the building, thereby avoiding the higher costs and energy consumption associated with increasing the ventilation rates. This Guidebook provides easy-to-understand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



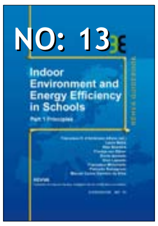

Chilled beam systems are primarily used for cooling and ventilation in spaces, which appreciate good indoor environmental quality and individual space control. Active chilled beams are connected to the ventilation ductwork, high temperature cold water, and when desired, low temperature hot water system.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



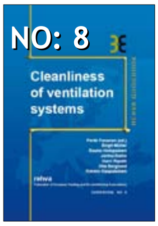

Indoor Climate and Productivity in Offices Guidebook shows how to quantify the effects of indoor environment on office work and also how to include these effects in the calculation of building costs. Such calculations have not been performed previously, because very little data has been available. The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



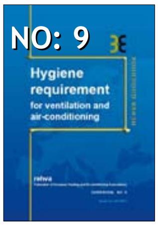

This Guidebook describes the systems that use water as heat-carrier and when the heat exchange within the conditioned space is more than 50% radiant. Embedded systems insulated from the main building structure (floor, wall and ceiling) are used in all types of buildings and work with heat carriers at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



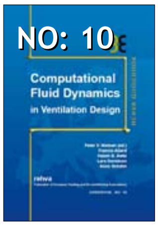

School buildings represent a significant part of the building stock and also a noteworthy part of the total energy use. Indoor Environment and Energy Efficiency in Schools Guidebook describes the optimal design and operation of schools with respect to low energy cost and performance of the students.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



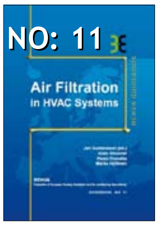

Cleanliness of ventilation systems Guidebook aims to show that indoor environmental conditions substantially influence health and productivity. This Guidebook presents criteria and methods on how to design, install and maintain clean air handling systems for better indoor air quality.



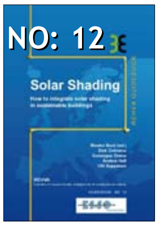

Hygiene requirement is intended to provide a holistic formulation of hygiene-related constructional, technical and organisational requirements to be observed in the planning, manufacture, execution, operation and maintenance of ventilating and air-conditioning systems. These requirements for ventilating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



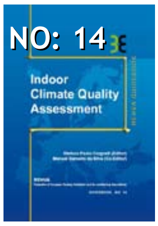

CFD-calculations have been rapidly developed to a powerful tool for the analysis of air pollution distribution in various spaces. However, the user of CFD-calculation should be aware of the basic principles of calculations and specifically the boundary conditions. Computational Fluid Dynamics (CFD) –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



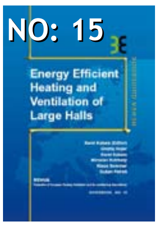

Air filtration Guidebook will help the designer and user to understand the background and criteria for air filtration, how to select air filters and avoid problems associated with hygienic and other conditions at operation of air filters. The selection of air filters is based on external conditions such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




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




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




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



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