RESHYVENT

Cluster Project on Demand Controlled Hybrid Ventilation in Residential Buildings with Specific Emphasis on the Integration of Renewables

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WP 4: Standards and Regulations support unit

Report Title:

Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems

Standards and regulations concerning Energy Performance of Buildings

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Disclaimer

The authors of this report have made their best efforts to get reliable information. The authors are not responsible for the use which might be made of the information contained in this report.
In particular, it must be noticed that this report has been prepared at the very beginning of the RESHYVENT project. Since that, standards and regulations may have changed.

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1. Introduction

This report constitutes the third WP4 report.

The main goal of the RESHYVENT Working Package WP4 "Standards and regulations support unit" was to identify barriers (to hybrid ventilation) related to standard and regulations and to make proposals for better standards and regulations. In order to achieve this goal, several reports were written:

- A first report named 'Opportunities, barriers and challenges in relation to the application of standards and regulations on hybrid ventilation systems – General considerations' has described general principles about standards and regulations.

- The second and third reports aim to specifically analyse the possible barriers to the development of hybrid ventilation systems in residential buildings. The second report addresses standards and regulations related to indoor air quality (IAQ) and thermal comfort. The third report addresses standards and regulations related to Energy Performance of Buildings (EPB).
  Both these two documents are structured around two levels:
  1. The first level is focusing on the international level. European standards will be treated at this level.
  2. The second level is focussing on national situation. A country specific analyse is realised in order to evaluate the different existing national standards and regulations.

The reports have been written to help the RESHYVENT industrial consortia to develop their hybrid ventilation system, but are dedicated to other ventilation industries or to any one who is interested to have a quick overview of the standards and regulations dealing with ventilation in dwellings in Europe.

Remark:
It must be mentioned an extensive surveys of national regulations related to EPB has been carried out previously in the frame of the SAVE ENPER-TEBUC project (www.enper.org), and is therefore considered as part of "state-of-the-art".
For this present report, contributors were asked to focus on specific aspects that could be barriers for hybrid ventilation.

2. Documents applying at international level

2.1 European regulation: Directive on the Energy Performance of Buildings

At the European level, one of the most relevant documents is the new Directive on the Energy Performance of Buildings[1]. This document does not contain technical details but set the general framework of the Energy Performance Regulations across Europe.

The main features of this new directive are described in article 1 :
"This Directive lays down requirements as regards:
(a) the general framework for a methodology of calculation of the integrated energy performance of buildings;
(b) the application of minimum requirements[2] on the energy performance of new buildings;
(c) the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
(d) energy certification of building; and
(e) regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old."

The Article 2 defines the energy performance of a building as "the amount of energy actually consumed or estimated to be necessary to meet the different needs associated with a standardised use of the building, which may[3] include inter alia heating, hot water heating, cooling, **ventilation** and lighting".

Some of the justifications of this Directive are the need to manage energy demand in order to influence the global energy market and the security of energy supply, and the need to reduce CO_2 emissions (Kyoto Protocol).

The text of this Directive can be downloaded from http://www.europa.eu.int/eur-lex/ or from e.g. http://www.kyotobuildings.net/doc/directive/liste.htm

2.2 European standards

Until now, there are no European standards that provide procedures to evaluate the energy performance of a (residential) building. However, some countries apply methods derived from EN832. Therefore, EN832 (restricted to residential building) will be described below, as well as prEN ISO 13790 (for non-residential building too).

[1] Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings (16 December 2002)
[2] It is recalled that under Article 176 Member States may maintain or introduce more stringent protective measures. Such measures must be compatible with this Treaty.
[3] If the Article 2 states that the EP "**may** include (…) ventilation", the Annex explicitly states "The methodology of calculation of energy performances of buildings **shall include** at least the following aspects : (…) d) ventilation"

EN 832
Thermal performance of buildings – Calculation of energy use for heating – Residential buildings

This standard provides a calculation method to evaluate heat losses, including these due to ventilation.

The total heat loss is defined as:

$$Q_L = H(\theta_i - \theta_e)t$$

where H is the heat loss coefficient, due to transmission and ventilation $(H = H_T + H_V)$,
θ_i is the indoor temperature and θ_e is the outdoor temperature,
t is the duration of the calculation period,
$H_V \approx 0.34\ \dot{V}$ is the ventilation heat loss coefficient
$\dot{V}$ is the airflow rate through the building, including through unheated space and infiltration

The annex gives a way to evaluate $\dot{V}$, according to the ventilation strategy. Two strategies are defined: natural and mechanical ventilation.

For *natural ventilation*,

$$\dot{V} = \max(\dot{V}_{\min}, \dot{V}_{design})$$

where $\dot{V}_{\min} = 0.5\ V$ [m³/h] with V = the ventilated volume (for dwellings),
$\dot{V}_{design}$ is the design ventilation rate.

For *mechanical ventilation*,

$$\dot{V} = \dot{V}_f, + \dot{V}_x$$

where $\dot{V}_f$ is the maximum of mechanical supply and extract airflows
$\dot{V}_x$ is an additional airflow rate induced by wind and stack through ventilation openings and cracks.

$\dot{V}$ can be reduced if heat recovery is used.

Moreover, the standard takes into account systems that switch from one strategy to the other:

$$\dot{V} = (\dot{V}_o, + \dot{V}_x')(1-\beta) + (\dot{V}_f, + \dot{V}_x')\beta$$

where $\dot{V}_o$ is the airflow rate with natural ventilation, including through ducts of mechanical system,
$\dot{V}_x'$ is an additional airflow rate with fans off, induced by wind and stack,
β is the fraction of time period with fans on.

The standard is a calculation procedure only, and it considers hybrid ventilation in some extent. In conclusion, EN 832 is not regarded as a barrier for hybrid ventilation.

prEN ISO 13790 **Thermal performance of buildings – Calculation of energy use for heating**
This standard project is very similar to EN832, but is also applicable to non-residential building. The main difference concerning ventilation is that $\dot{V}_{min} = 0.3\ V$ (instead of 0.5V). Therefore, prEN ISO 13790 is not regarded as a barrier for hybrid ventilation.

3. Documents applying at a national level

In the scope of the RESHYVENT project, representative of 10 countries are involved in the project (* indicates non EU-15 members, ** indicates a new EU-25 member):

- Belgium / Czech Republic** / Denmark / France / Greece / Norway* / Portugal / Sweden / Switzerland* / The Netherlands

The next EC countries are not represented by scientific partners in the project:

- Austria / Finland / Germany / Ireland / Italy / Luxembourg / Spain / United Kingdom

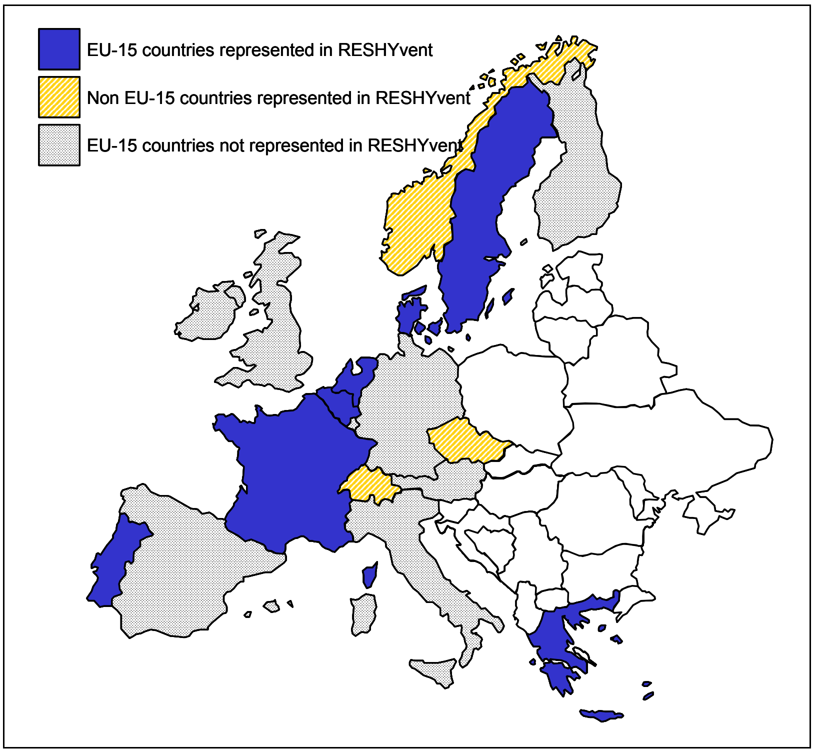
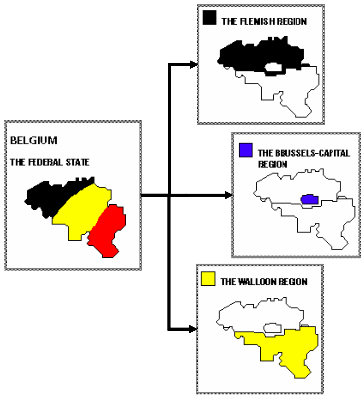


Figure 1: Countries represented in the RESHYVENT project (Situation in 2002)

3.1 Belgium

Contribution from Nicolas Heijmans (Belgian Building Research Institute)

3.1.1 The current energy regulation in Belgium



Belgium is a federal state composed of three regions: the Flemish region, the Walloon region and the Brussels Capital Region. Each region is competent to establish thermal regulation of buildings.

The situation in August 2004 in the three regions relative to the thermal regulation applied to Buildings is summarized in the next table. A distinction is made in the requirements between new buildings and refurbished building with a change of function[4]. Information about offices and school buildings are also included even if less relevant in the context of the RESHYVENT project.

	New buildings		Refurbished buildings with change of function	
	Residential buildings	School and office buildings	Residential buildings (3)	School and office buildings (4)
Brussels Region	K55	K65	55 + 10.At/s (1)	60 + 10.At/s (1)
Flemish Region	K55	-	-	-
Walloon Region	K55 ou be_{max} (2)	K65	K65	K70

(1) At (m²) = thermal losses building area, calculated according to NBN B 62-301.
s (m²) = area of all the refurbished walls.

(2) Another method, called be_{max}, can be used. This method is a step further in the direction of the EPB assessment, but is usually not applied.

(3) Only applicable if the existing building is transformed into a residential building. If there's no change of function, no requirement apply.

(4) Only applicable if the existing building is transformed into a school or an office building. If there is no change of function, no requirement apply.

The K level described into this table is the global insulation level of the building calculated according to the Belgian Standard NBN B62-301. For building with a compactness (V/A ratio) lower than 1m, the K-level is equal to 100 * Um, with Um equal to the average U value of all the external building walls. A K55-level means in this case an average U-value lower than 0.55 W/m²K. Requirements are also imposed on the maximum U-values of the different external building walls.

In the Walloon Region, it is also possible to comply with the regulation by having a Net Energy Needs (be_{max}) calculated according a specific calculation procedure lower than a given value. The net energy needs are considering not only transmission losses but also ventilation losses, internal and solar gains and the influence of the building thermal mass. It has to be

[4] For example, an old factory transformed into residential building

mentioned that the ventilation losses taken into account in the calculation procedure are based on fixed values and that it doesn't take the specificities of the ventilation system into account.

As a first conclusion, the current energy regulations are only taking into account transmission losses excepted in the Walloon region where compliance may also be shown via a criteria based on the Net Energy Needs . With the present regulations, hybrid ventilation systems, as well as a lot of other techniques, are not considered in none of the thermal regulations of the three regions.

This current situation will change in the near future due to the European EPB directive. A decree of the Flemish Region approved in April 2004 introduces an energy Performance Regulation applying on all buildings intended for human occupancy. This regulation will enter into force in January 2006. The two other Regions will have to develop their own regulation conform to the EPBD requirements. For the Belgian Building market, it would be much preferable to be confronted with only one calculation procedure valid in all regions of the country.

3.1.2 Specificities of the Flemish Energy Performance Regulation

The energy performance regulation set requirements on the overall building energy consumption and not only on the transmission losses. The next elements enclosed into the Energy Performance Regulation applying on residential buildings in the Flemish region, the so-called EPW procedure[5], are described more in detail in the next paragraphs:

- Energy required for ventilation
- Energy required for fans
- Way the summer comfort aspects are taken into account

These elements can have an impact on the way hybrid ventilation system could be assessed.

3.1.2.1 Energy required for ventilation

The regulation [1] considers three energy flows related to ventilation:

- in/exfiltration due to a lack of building airtightness,
- ventilation for IAQ,
- overventilation for heat pump for hot water[6].

$$H_V = 0.34\left[\dot{V}_{in/exfilt} + r_{preh}\dot{V}_{dedic} + \dot{V}_{over}\right]$$

Where :

- $\dot{V}_{in/exfilt}$ will usually correspond to a building airtightness of $n_{50} = 12\ h^{-1}$ for a building that has a compactness of 1 m. The presented n_{50} value is the default value, but it can also be measured,
- $\dot{V}_{dedic}$ is the intentional hygienic ventilation,

[5] EPW = Energie Prestatie Woongebouwen, "Energy Performance for Dwellings" in Dutch.

[6] According to the EPW, the building has to be divided in different zones if the HVAC systems differ from one zone to the other. As this is not very important for the present document, the equations presented here are simplified and suppose that the building consists of a single zone only.

- $\dot{V}_{over}$ is a function of the building volume and the airflow of the heat pump,
- r_{preh} is a reduction factor for preheating, that will be ≤ 1.0 (1.0 when no preheating).

The calculation procedure establishes a link between the size of the dwelling and the nominal airflow used to determine the heat losses (V_{dedic}). The hygienic airflow is a function of the volume of the dwelling and of a correction factor (coefficient m). This correction factor integrates the characteristics of the ventilation system and the quality of realization of it (air tightness of ducting, pressure controlled inlets, etc…):

$$\dot{V}_{dedic} = (0.2 + 0.5\,\exp(-V/500)).m\,.V$$

According to the EPW procedure, in order to reduce the energy for ventilation:
- the building should be airtight,
- natural supply air inlets should be self-regulating and tested according to EN 13141-1,
- ducts should be airtight and tested according to prEN 14134,
- mechanical inlets and extracts should be correctly regulated in every room,
- heat recovery or preheating in an unheated space (like a veranda) should be used.

The standard calculation procedure doesn't foresees the possibility to reduce the airflows in a dwelling, for instance because of a better ventilation efficiency of a given system.

3.1.2.2 Energy required for fans

The calculation has to be done on a monthly basis. Two types of fan are considered:

- the fans for the hygienic ventilation,
- the fans for air heating systems.

$$W_{aux,fans,m} = W_{aux,fans,vent,m} + W_{aux,fans,heat,m}$$

<u>Fans for ventilation:</u>

$$W_{aux,fans,vent,m} = t_m \left(\sum_i \Phi_{fans,vent,i} \right) \Big/ 3.6$$

Where:

t_m is the length of the month in[Ms].

$\Phi_{fans,vent,i}$ is the electric power of the fan i in [W] that can be a default value, a value given by the supplier or established in-situ.

<u>Fans for air heating system:</u>

$$W_{aux,fans,heat,m} = t_m \sum_j \left(f_{heat,m,j} \Phi_{fans,heat,j} + f_{vent,m,j} \Phi_{fans,vent,j} \right) \Big/ 3.6$$

Where:

$f_{heat,m,j}$, $f_{vent,m,j}$ are the fractions of the time that the fan i is running for heating/ventilation purpose (if the fan can run for both purposes, $f_{vent,m,j} = 1 - f_{heat,m,j}$, otherwise $f_{vent,m,j} = 0$).

$\Phi_{heat,vent,i}$ is the electric power of the fan i in [W] that can a by default values or a value given by the supplier.

3.1.2.3 Summer comfort

Summer comfort is taken into account by the EPW procedure. A simplified calculation procedure estimates the risk of overheating at the building[6] scale; the overheating in a specific room is not evaluated, so there is still a possibility of overheating in a room.

It is generally assumed that the chance of overheating is proportional to the excess gains. The smaller these are, the better the design in terms of overheating.

The calculation of the excess gains is done for each month:

$$Q_{excess,seci,m} = \max\left[0; \left(1 - \eta_{util,summer,m}\right) \cdot Q_{g,summer,m} - 2V\right] \quad \text{[MJ]}$$

Where:

$\eta_{util,summer,m}$ the utilisation factor on a monthly gains;
$Q_{g,summer,m}$ the monthly gains by solar and internal heat production.

Taking the sum for all months, and dividing by the volume of the sector, must give a value that has to be lower than 9MJ/m³. If the result is higher than 9MJ/m³, the design should be reconsidered. One must repeat till the value is smaller than 9MJ/m³. Improvements can be: lowering the glazing surface, using blinds, increasing the thermal mass, etc.

3.1.3 How are hybrid ventilation systems considered?

Hybrid ventilation systems, as well as a lot of other techniques, are not taken into account in the current thermal regulations since they are mainly based on transmission losses.

In the future EPW procedure that will be applied in the Flemish Region, Hybrid ventilation is not considered in the standard procedure. The principle of equivalence shall be necessary to evaluate the performances of such a system.

3.1.4 Summary of possible barriers and proposed solutions to solve them

The current regulations in the three Belgian Regions are mainly focusing on transmission losses and are not paying attention to ventilation. An alternative calculation procedure valid in the Walloon region takes ventilation into account but without considering the specificities of the installed ventilation system. Hybrid ventilation, as well as a lot of other techniques, are not considered in none of the regional regulations and are thus not stimulated.

The EPBD imposes to the regions to adopt regulations based on the overall building energy consumption.

Such a regulation is ready in the Flemish region [1] and will enter into force in January 2006. It is not possible at the level of the basis procedure to take into account systems (as for instance hybrid ventilation systems) allowing a reduction of the hygienic airflow with a constant Indoor Air Quality. This kind of system has to be treated via the principle of equivalence. There are also no bonuses for systems allowing the realization of a better IAQ in the dwelling.

At the moment to write this report, the concept of the Principe of equivalence is legally foreseen in the Flemish Energy Performance Regulation. Neither there's nor legal or technical framework implementing in practice the realization of study of systems according to the principle of equivalence. It is impossible for producer of such systems to get an idea of the benefit their system could have in EPR terms. This is a major barrier for the development, optimization and the application of such smart ventilation systems (when this regulation will be in force). The development of the framework to assess innovative system will be developed in Belgium in the coming years. The objective is trying to benefit of the existing experience in other countries (France, The Netherlands about the application of this principle of equivalence).

3.1.5 Details of the calculation procedure in the Flemish Region

This paragraph gives details about the EPW calculation procedure, and is dedicated to readers who want to know more about the Flemish regulation that is intended to be implemented. The calculation procedure enclosed here is those valid when the report was written. It is recommended to consult the original document of the regulation to have the very last version of these texts.

$$H_V = 0.34\left[\dot{V}_{in/exfilt} + r_{preh}\dot{V}_{dedic} + \dot{V}_{over}\right]$$

<u>In/exfiltration</u> : $\dot{V}_{in/exfilt} = 0.04 \times \dot{v}_{50} \times A_T$

Where:

A_T is the surface of the building envelope, expressed in [m²].

$\dot{v}_{50}$ is the leakage airflow at 50 Pa for a envelope surface of 1 m², in [(m³/h)/m²]. It can be determined with a pressurization test (according to NBN EN ISO 13829). If a test result is not available, the default value is 12 (m³/h)/m².

→ In/exfiltration can be measured after construction or can be taken as the default value. It is supposed that (at least during the first years after the implementation of the legislation) airtightness measurements will be seldom carried out and that the default value will be generally applied.

<u>Ventilation for IAQ</u> ($r_{preh}\dot{V}_{dedic}$ **)**

r_{preh} is a correction factor for preheating due to heat recovery or airflow passing through an unheated zone (however in that case, r_{preh} must be evaluated with the Principle of Equivalence). It will be ≤ 1.0 (1.0 default value and when no preheating is applied).

$$\dot{V}_{dedic} = (0.2 + 0.5\ \exp(-V/500)).m\ .V$$

Where:

m is a correction factor that depends on the ventilation strategy and that takes into account the presence of self-regulating inlet for natural supply, the lack of airtightness of extract ducts, imperfections of mechanical supply and/or extract. It varies between 1.0 and 1.5 (default value).

- <u>System A : natural ventilation</u>

$$m = 1.0 + 0.5\left(\frac{r_{\text{nat.supply}} + r_{\text{nat.exh}} + r_{\text{leak,stack}}}{r_{\text{nat.supply,def}} + r_{\text{nat.exh,def}} + r_{\text{leak,stack,def}}}\right)$$

Where:
$r_{\text{nat.supply}}$ is a correction factor for the self-regulating inlets and varies between 0.02 and 0.2, according to the class P given by a test according to prEN 13141-1. The default value $r_{\text{nat.supply,def}}$ is 0.2.

$r_{\text{nat.exh}}$ is a correction factor for the self-regulating outlets. The way to determine it has not yet been fixed, so that the default value must be used: $r_{\text{nat.exh,def}} = 0.2$.

$r_{\text{leak,stack}}$ is the ratio between the leaks in the natural exhaust ducts and the required airflow. The leaks have to be measured according to prEN 14134. If no measurement is available, the default value must be used: $r_{\text{leak,stack,def}} = 0.025$.

- System B: mechanical supply, natural exhaust

$$m = 1.0 + 0.5\left(\frac{r_{\text{mech.supply}} + r_{\text{nat.exh}} + r_{\text{leak,stack}}}{r_{\text{mech.supply,def}} + r_{\text{nat.exh,def}} + r_{\text{leak,stack,def}}}\right)$$

As system B is not really applied in Belgium, it will not be discussed here. See the other systems for a discussion of each of the terms.

- System C: natural supply, mechanical exhaust

$$m = 1.0 + 0.5\left(\frac{r_{\text{nat.supply}} + r_{\text{mech.extr}}}{r_{\text{nat.supply, def}} + r_{\text{mech.extr, def}}}\right)$$

System C is commonly applied in Belgium (when a ventilation system is applied at all!) For $r_{\text{nat.supply}}$ and $r_{\text{nat.supply,def}}$, see system A. The evaluation of $r_{\text{mech.extr}}$ requires to measure the actual airflow of all mechanical exhausts and the leakages of all exhaust ducts. Therefore, it is expected that the procedure will not be widely applied during the first years.

- System D: mechanical ventilation

$$m = 1.0 + 0.5\left(\frac{r_{\text{nat.supply}} + r_{\text{mech.extr}}}{r_{\text{nat.supply},zone\,z} + r_{\text{mech.extr},zone\,z}}\right)$$

The evaluation of m requires to measure the actual airflow of every inlet and exhaust and the leakages of all ducts. Therefore, it is expected that the procedure will not be widely applied during the first years.

→ In the first years of the implementation of the EPW regulation, it is probable that only self-regulating inlets will be used to reduce the m value, if data are made available by the industries.

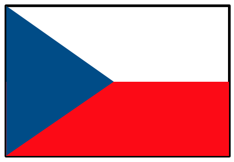
Class RTO	System A	System C
P0	1.50	1.50
P1	1.48	1.48
P2	1.43	1.45
P3	1.36	1.40
P4	1.29	1.34

3.1.6 References

[1] 'Calculation procedure of the characteristics primary annual energy consumption of residential buildings' - Annex 1 of the energy performance decree of the Flemish Region – (available on http://energiesparen.be/energieprestatie/ - in Dutch)

3.2 Czech republic

Contribution from Miroslav Jicha (Brno University of Technology)



The Czech Republic shall harmonize its legislation with the legislative standards of the EU as well as with the principles of the International Energy Agency, of the Energy Charter Treaty and its Protocol on Energy Efficiency and Related Environmental Aspects. Currently, Czech energy agency (CEA) is coordinating a national program, that aims at facilitating and accelerating the introduction of energy conservation and use of environmentally sustainable technologies in sustainable housing and to analyse compatibility of Czech legislation on energy efficiency with the new Directive on Energy Performance of Buildings, 2002/91, and thereby to support the energy efficiency in buildings in the Czech Republic.

Within the program, CEA is focused on the reduction of energy consumption and on developing the use of renewable and secondary energy sources. In order to achieve the goals fixed in the National Energy Policy in the field of energy use, CEA initiates different individual projects addressed to accomplishing high efficiency of energy consumption. Consequently, CEA disseminates the results achieved and make the public aware of the procedures, technologies and materials used. The results of these activities depend on the introduction of the latest legislation and technical standards.

The key Czech legislation in the field of energy use is the **Energy Management Act No. 406/2000 Coll**. This act determines which thermo-technical parameters of buildings and constructions must be evaluated in order to accomplish the corresponding effective energy use. The Decree No. 291/2001 Coll. issued according to this act, determines the particular criteria to be met. However, this principle is valid for construction and modernisation of buildings with consumption of heat higher than 1500 GJ/year if they are financed by public financial means. The whole construction and modernisation of apartment houses and public buildings must then only observe the National Technical Standard. In all cases however, only the thermal input for heating is being evaluated.

The main purpose of the national program is reinforcement of **Energy Management Act** in the area of relevant regulations and technical standards to achieve higher quality of new buildings and improve quality of existing buildings through higher thermal insulation and using of the potential of energy savings. Enforcement of professional knowledge and skills of local experts, technicians and investors brings higher effectiveness in the utilisation of new energy efficiency technologies and renewable and non-traditional sources of energy and minimise negative environmental impacts of energy use.

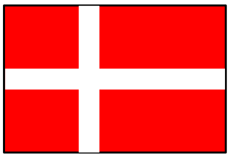
The **Energy Management Act** and the **Decree no. 291/2001 Coll**. of the Ministry of Industry and Trade introducing details with respect to energy audit requirements set the obligation to realise energy audits by all applicants for the state subsidy within the National Programme for Economical Energy Management and Use of Renewable and Secondary Energy Sources and by the state organisation units, regional and municipal organisation units including bodies entirely or partly financed from the national budget with the annual energy consumption higher than 1500 GJ and by other individuals and legal entities with the annual energy consumption higher than 35 000 GJ.

Energy Management Act requires submitting in annex the presentation of written document – energy passport of building –, which verifies and defines all characteristic parameters of energy effective consumption of heat for heating.

Concerning private buildings sector, which is out of the rules of Energy management Act and Decree no. 291/2001 Coll, there is necessary to proceed according to the National technical standard CSN 73 05 40. This standard gives the content and form of the Energy Passport of Building and the method of approaches in creation of the definition of energy demand of buildings.

The possibility of combined production of electricity and heat (CHP) is evaluated by existing legislation in the case of installation of new source or change of existing sources at the sum output higher than 5 MWt or 10MWe, in the case of utilisation of gas turbines with the output higher than 2 MWe and combustion engines higher than 0,8 MWe.

3.3 Denmark



Contribution from Signe Antvorskov (Esbensen consulting engineers ltd)

3.3.1 Regulations

The Danish Building Regulations 1995 and the Danish building Regulations 1998 for small dwellings state that buildings shall be provided with thermal insulation to avoid unnecessary fuel and power consumption and achieve a healthy indoor climate.

The energy effect of thermal bridges and edge losses must be taken into account in calculating the thermal transmittance for the various construction elements. U-values and edge losses shall be calculated in accordance with Danish Standard 418: Rules for calculation of heat loss from buildings.

The Danish building Regulations also states that the total area of windows and outer doors, glazed curtain walls and hatches in contact with the outside air, must not exceed 22 percent of the buildings heated floor area.

However, the regulation provides two possible alternatives to the above mentioned rules:

1. The Energy Frame
2. The Heat Loss Frame

The **Energy Frame** states the maximum permissible heat demand. This means that the U-values and edge losses may be changed and the areas of windows etc. may be increased provided the buildings total net thermal energy, required for space heating and ventilation per m^2 of heated floor area, does not exceed the maximum permissible heat demand. The maximum permissible heat demand is calculated as; 160 MJ/m^2 per year plus 110 MJ/m^2 per year divided by the number of floors in the building. However, the individual construction elements shall at least be insulated corresponding to a stated minimum of U -values and edge-losses.

The **Heat Loss Frame** states the maximum of permissible heat loss. This means that the U-values and edge losses may be changed and the areas of windows etc. may be increased provided that the total heat loss from the building does not exceed the heat loss as if the general requirements were met. However, the individual construction elements shall at least be insulated corresponding to a stated minimum of U -values and edge- losses.

3.3.2 Energy required for preheating

In single family houses, it is allowed to have natural ventilation, mechanical exhaust or mechanical ventilation. In multi-storey houses, only mechanical exhaust or mechanical ventilation is allowed. For mechanical ventilation it is required to have an efficient heat recovery unit; however no specific heat recovery efficiency is required.

In general the ventilation system must be designed to ensure a good indoor climate which includes the assurance of no draught, i.e. generally the rule of thumb is a maximum temperature difference between inlet air and room temperature of 6 degrees. Also it is recommended that the air velocity in habitable rooms does not exceed 0.15 m/s.

3.3.3 Energy required for fans

In accordance with the Danish Building Regulations 1995 it is required that the electricity consumption for air transport does not exceed 2.5 kJ/m³ external air in CAV systems (Constant Air Volume) and for VAV systems (Variable Air Volume) the energy consumption must not exceed 3.2 kJ/m³ external air.

3.3.4 Summer comfort

The Danish Building Regulations of 1995 specify that cooling of ventilation air only is permitted when all other options has been used and found insufficient e.g. solar shading, removal of heat produces by equipment, lighting etc. A more specific requirement is expected in the new standard of 2005, which is currently under development.

3.3.5 How are hybrid ventilation systems considered?

Currently no Danish regulation or standard considers hybrid ventilation.

3.3.6 Summary of possible barriers and proposed solutions to solve them

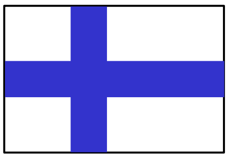
In multi-storey houses, only mechanical exhaust or mechanical ventilation is allowed. This represents a barrier for pure natural ventilation, but should not be a barrier for hybrid ventilation.
At present, no formal procedures for assessing innovative systems (e.g. hybrid ventilation) by calculation or laboratory testing exist. In practise, the building authorities are fairly flexible in the acceptance of innovative systems, if the designer can make probable that the system will result in an acceptable IAQ and the system will have the energy efficiency assumed in the calculation of the annual energy consumption.

The target outlined in the Danish Government's action plan for energy, Energy 21, is to introduce new energy requirements in the Danish Building Regulations by the year 2005. The goal is to reduce heat demand in new buildings by a further 33 % and to reduce electricity consumption for ventilation and lighting as well.
It is expected that the coming energy frame will also include efficiency of boilers, solar hot water production and electricity for ventilation and cooling purpose. It is also to be expected that the requirements to the electricity consumption for air transport in ventilation plants will be tightened. New requirements to heat recovery units in mechanical ventilation systems including specific minimum requirements to heat recover efficiency will probably be introduced. **These requirements will only benefit hybrid ventilation.**
The philosophy will probably be to have very tight direct energy requirements to thermal insulation, heat recovery and electricity consumption and to have the energy frame as an obvious alternative to full fill the requirements in most cases.

3.3.7 References

[1] Danish Building Regulations for Small Dwellings 1998. Danish Ministry of Housing and Urban Affairs.
[2] Danish Building Regulations 1995. Danish Ministry of Housing.
[3] DS 447: Code of Practice for Ventilation Installations. 1981.
[4] DS 418: Rules for calculation of heat loss from buildings. 2001

3.4 Finland



Contribution from Jorma Heikkinen (VTT Technical Research Centre of Finland) – **Written in the scope of the HYBVENT project**

3.4.1 Standards and regulations related to Energy Performance

The National Building Code of Finland contains binding requirements and non-binding guidelines how to meet these requirements. The present building code for thermal insulation came into effect 1985 [1]. The building code applies to dwellings, offices and schools as well.

No target values are given for the building energy consumption but the building code sets the requirements for the maximum U-values of the walls (0.28 W/(m^2.K)), floors and ceilings (0.22 W/(m^2.K)) and windows (2.1 W/(m^2.K)).
The energy consumption for ventilation must be minimised without sacrificing the indoor air quality. According to the official guidelines, the heat recovery has usually to be installed but it can be left out if the airflow is less than 3600 m^3/h or the operation hours are short. The minimum fan efficiency is given in the guidelines, depending on the fan power.

A new proposal of the National Building Code of Finland was circulated for comments in May 2001. The information given here is based on the proposal and must be taken with reservation because the final form of the new code will be different. The aim of the new regulations and guidelines is to save energy taking the good indoor environment into account.
The present compensation principle of the U-values will be extended to concern the yearly energy consumption of the building. It makes possible for example to replace the heat recovery with better U-values of the building envelope. There will however be no regulations concerning the energy consumption of the whole building but the wider compensation principle is a step towards the energy performance regulations in the future.

The U-values in the new proposal are about 30% lower than before but the change in reality is smaller because the new U-values are close to the present building practise.
Heat recovery is now required but it can be left out if compensated by other energy saving means. The specific fan power is required to be lower than 2.5 kW/(m^3/s) in balanced ventilation and lower than 1.0 kW/(m^3/s) in exhaust ventilation.

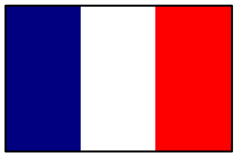
The yearly heating energy consumption for compensation purposes can be calculated using the procedure given in the building code [2]. The procedure is based on monthly weather data and takes into account heat recovery, air infiltration, solar radiation and internal heat gains. The airflow rates and air infiltration are given as input and therefore more sophisticated airflow models are sometimes needed to produce the input. It is also possible to make the energy calculations using a relevant European standard.
The diversity of energy calculation methods was one reason to leave out the yearly energy consumption from the building code at this stage. The other reason was that the local authorities were not regarded to be ready to judge the energy calculations.

3.4.2 References

[1] National building code of Finland, part C3, thermal insulation. Regulations 1985. Ministry of the Environment, Helsinki.

[2] National building code of Finland, part D5, calculation of energy and power for heating of buildings. Guidelines 1985. Ministry of the Environment, Helsinki.

3.5 France



Contribution from Jean-Robert MILLET and Jean Georges VILLENAVE
(Centre Scientifique et Technique du Bâtiment)

3.5.1 RT2000

The new regulation RT 2000 has been introduced in 2001 and aims to improve the energy efficiency and the summer comfort of all new buildings (except swimming pool and skating rink).

It is based on following items:
• The respect of minimum values for buildings and components characteristics.
• The Conventional consumption of energy (C) for heating, ventilation, cooling, hot water and lighting must be less or equal to a C_{ref} coefficient.
The calculation of C coefficient is made by month for one year, with conventional climatic data (3 zones). C_{ref} is obtained by replacing in the building under consideration the planned components by reference components. These reference components are defined in the law.
C and C_{ref} coefficients are calculated according to the Th-C calculation method.
• The calculation of the maximum operative temperature in summer for a reference day (T_{ic}).
• The calculation of reference U-value and C-value.

Ventilation plays an important role in the RT 2000 regulation.

The algorithms are based on an implicit method (as EN 13465) extended to non-residential buildings. Mechanical system and passive duct systems are taken into account (additional window airing is also considered).

The main input parameters are:

- ventilation components characteristics (as inlets, outlets, cowls, heat exchanger …),
- airtightness of the building envelope,
- airtightness of the ducts ,
- heat losses through ducts for balanced system,
- air preheating,
- fan energy consumption and impact on air heating
- control of the ventilation system (as clock, humidity, CO_2, presence…),

For each situation of climate and system behaviour, the implicit method calculates the different airflows through the ventilation system and the building envelope in a first step and the energy impact in a second step. This energy impact is divided in 3 parts:

- the main one is the ventilation losses (H_v in W/K) is added to the static heat losses of the building for the calculation of the heat need,
- the air heating due to fans is considered as an internal gain, as it is not related to outdoor temperature. An utilisation factor is furthermore applied, which lowers the effective heat gain,
- the third one is the fan energy.

These 3 values are input data for each phase of heating in the global C calculation method.
The hybrid systems are taken into account but with a limited range of possibilities.

3.5.2 How are hybrid ventilation systems considered?

Different possibilities take into account innovation concerning the product characteristics.

If the new product or system with available standard characterisation or with possible characterisation corresponds to an input to the Th-C or Th-E method, the insulation characterisation can be incorporated in the product database and used in the C calculation. However in the second case, new products or systems are evaluated in t**he framework of a technical assessment**.

If a new product or system is not considered in the calculation method, it is possible to ask for a special agreement decided by a national commission. This procedure concerns the case where the user wants to consider a particular building and the case when the user wants the new components or systems to be valid for many buildings.
A high energy efficiency and a very high efficiency quality mark will be attributed to buildings with a global performance higher than required (8% and 15%). The first level will be reached through good design and available products and methods. The second one will be obtained through innovative design and use of new products and methods.

3.5.3 Summary of possible barriers and proposed solutions to solve them

In France, both IAQ and thermal regulations allows the use of hybrid or/and controlled ventilation systems.
However, it is not always easy to prove in practice the compliance of a given system.
For energy / comfort regulation:
The hybrid systems are taken into account but only for some predefined ones. For system that are not taken into account in the calculation methods Th C or Th E, it is possible to ask for the application of an equivalence principle (described in the titre V of the law [4]), by proposing (and proving) some adaptation of the calculation method.

3.5.4 References

These documents are only available in French:

[1] Arrêté du 24 mars 1982 (urbanisme, logement, énergie, santé) modifié - dispositions relatives à l'aération des logements
[2] Arrêté interministériel du 2 août 1977 (Intérieur, Equipement, Agriculture, Industrie, Santé) modifié - règles techniques et de sécurité applicables aux installations de gaz combustible ou d'hydrocarbures liquéfiés situées situées à l'intérieur des bâtiments d'habitation et de leurs dépendances
[3] Arrêté du 31 janvier 1986 (intérieur et décentralisation, urbanisme, logement et transport) modifié, relatif à la protection contre l'incendie des bâtiments d'habitation
[4] RT 2000 : Arrêté du 29 novembre 2000 (équipement, transport et logement) relatif aux caractéristiques thermiques des bâtiments nouveaux et des parties nouvelles de bâtiments
[5] RT 2000 : Règles de calcul Th-C Th-E
[6] Modalités d'instruction des Avis Techniques sur les systèmes de ventilation asservis
[7] www.rt2000.net

3.6 Germany

Contribution from Uwe Meinhold (Dresden University of Technology)
– **Written in the scope of the HYBVENT project**

3.6.1 EnEV2002

The EnEV2002 (New German regulation of energy saving for buildings, valid since 01.02.2002) specifies a yearly heat requirement that should not be exceeded. It is valid for buildings with normal room temperatures (dwellings, schools, hospitals, offices,...). The heat requirement for the whole year is for normal buildings proportional to the relation of external surface and volume in a wide range, see Figure 2.
This regulation is not only a standard; it is a law in Germany.
It has to be proved by a calculation procedure that the heat requirement of the building lies below the possible maximum. Within the calculation procedure, heat losses by ventilation can be reduced if a ventilation system is applied (simple ventilation systems 5%, with heat recovery 20%, depending on the efficiency of the system).
There is no standard for saving electrical energy for necessary apparatuses (fans, pumps...).

The new energy saving regulation (EnEV2002) replaced the old WSVO 95. Compared to the old regulation the influences of the technical equipment of the buildings have been included. The energy consumption which is limited is no longer the yearly heat requirement but the yearly heating energy consumption (that is converted to the primary energy consumption). Therefore in future, both the technical equipment of the building and construction criteria will be considered (integration of heat insulation and technical equipment).
The calculation of the heat requirement consumption will be done by using monthly balancing method, according the standard DIN EN 832.
A limitation of cooling energy was not included into the new regulation.

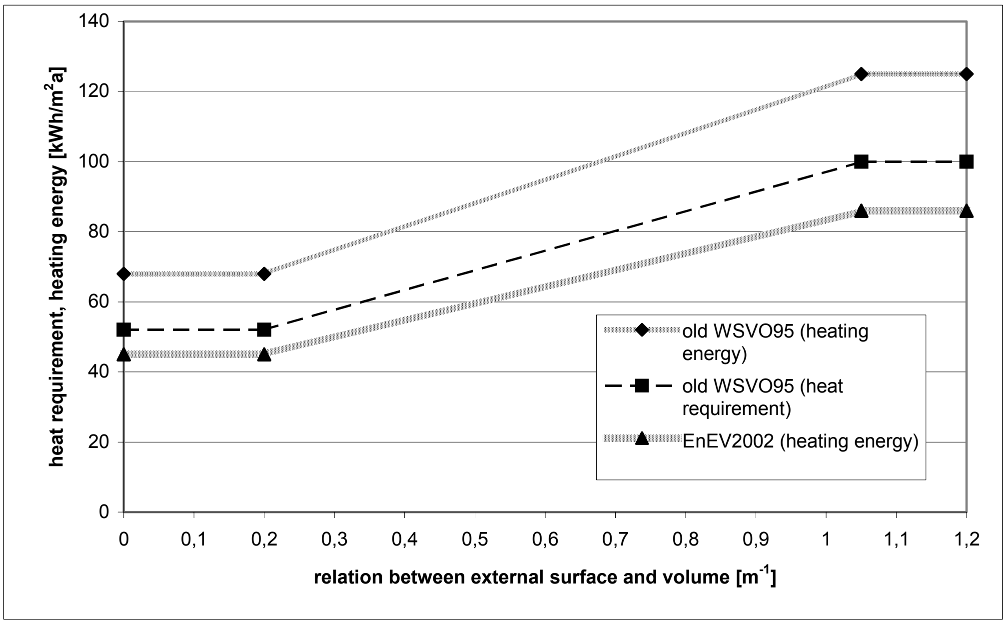


Figure 2: Required yearly heating energy consumption per floor space

3.6.2 Handling of innovative systems

There are regulations and standards for natural and mechanical ventilation, but nothing for hybrid ventilation. In most cases, the demands on a mechanical system are met, but the operation of the system takes place in a hybrid mode.
In general, it is necessary to bring a special certificate if an innovative system does not fit into the existing standards and regulations.

3.6.3 References

[1] DIN 1946 DIN 1946 Ventilation and air conditioning (VDI ventilation rules), Beuth Verlag Berlin, 1998

[2] VDI 2088 Ventilation systems in dwellings Beuth Verlag Berlin

[3] VDMA 24773 Guideline of the VDMA (Association of German Machinery Manufacturers) www.vdma.de

[4] AMEV Guideline (Arbeitskreis Maschinen- und Elektrotechnik staatlicher und kommunaler Verwaltung), Raumlufttechnische Anlagen für öffentliche Gebäude, Druckhaus Bernhard GmbH, Wermelskirchen, 1993

[5] DIN EN 832 Thermal insulation of buildings Calculation of energy use for buildings, Beuth Verlag Berlin, 1998

[6] CR 1752 Ventilation for buildings - Design criteria for the indoor environment, CEN Brussels 1998

3.7 Greece

Contribution from Katerina Niachou and Mat Santamouris
(National and Kapodestrian University of Athens)

3.7.1 Regulations in Greece related to energy performance and ventilation

The major Greek legislative sources concerning energy performance and ventilation of buildings are:

- **Building Structure Regulation**
- **Technical Guide of the Technical Chamber of Greece, 2425/1986:** "Installations in buildings: Calculation for air-conditioning loads in building"
- **Technical Guide of the Technical Chamber of Greece, 2423/1986:** "Installations in buildings: Air conditioning in buildings"
- **The new standard for Thermal Performance and Energy Conservation**, which has been proposed but it is still under development.

The terminology for the definition of energy and ventilation requirements of buildings is adopted for the air-conditioned buildings and it is expressed in constant values. In the new standard for Thermal Performance and Energy Conservation, two evaluation phases are proposed: a) design phase and b) post-construction phase.

The new standard will impose conditions and limits on use and size of air-conditioning and ventilation requirements. Post-construction phase will include Post-construction assessments and a Rating scheme (Certification) based on normalized energy consumption will be attributed to each building. Measurements to assess energy consumption and ventilation performance will be mandatory (monitoring protocol in preparation) in large buildings. Refurbishment is possibly next on the agenda after “new built” legislation is passed.

3.7.2 Ventilation Requirements

In the new standard for Thermal Performance and Energy Conservation [1] a minimum requirement of 0.6 ACH in order to avoid overheating is mentioned. A new methodology is proposed for the estimation of natural ventilation in buildings. The estimated ventilation rates refer to airflow through large and small openings.

The Technical Guide of the Technical Chamber of Greece [7] mentions three criteria for the estimation of the ventilation rate in occupied spaces:

- size of the space
- the number of occupants
- the quality of the internal air

i) Hourly fresh air changes in a space

This criterion is usually applied in simple air-conditioning installations. The recommended empirical values of air changes for different use spaces are summarized in Tables [7]. The required quantity of fresh air in the space is given as:

$$Q=ACH*V \quad (m^3/h)$$

Where V = volume of the ventilated space (m^3).
The magnitude of the fresh air required in a space is not only dependent on the size of the ventilated space but also on the number of people that occupy the space and the quality of the internal air.

ii) Required fresh air per person

This criterion gives satisfactory values for ventilation of internal spaces and it is more appropriate for large spaces. The required quantity of fresh air in the space is given as:

$$Q=N*q \qquad (m^3/h)$$

Where N = number of people in the space
Q= the recommended quantity of air per person (m^3/h per person).

In case the number of people in the space is not known, some values are recommended in Table 1 together with the expected number of people per 100m^2 of floor area. In cases that return internal air is used after subjected to a process the above required quantities of fresh air can be reduced to the 33% of the total supplies air in the space. Additionally, when the indoor air is extracted in order to achieve removal of odours and other pollutants and the supplied air before entering to the space, is treated with special filters, then the required quantity of fresh air can be reduced up to 15% of the supplied air to the space. But in any case, the minimum required quantity of fresh air per person, 8.5 m^3/h, should be ensured. In case of residential building the minimum and recommended quantity of fresh air is presented in Table 1:

SPACE	Estimated people per 100m² of floor area	Demanded Ventilation (m^3/h per person)	
		Minimum	Recommended
Detached houses			
Sitting rooms-bedrooms	5	8.5	12-17
Bathrooms-kitchens	-	34	50-85
Block of flats			
Sitting rooms-bedrooms	7	8.5	12-17
Bathrooms-kitchens	-	34	50-85

Table 1: Minimum and recommended quantity of fresh air per person for different spaces [7].

ii) Required fresh air according to internal pollution

This estimation is applied in specific places, like garages, dying-rooms, where the production rate of pollutants is known. The recommended estimation aims to derive values of supplied fresh air in the space in order to ensure air quality.

The demanded quantity of fresh air is given by:

$$Q = \frac{K}{M - ka}$$

where K = the produced quantity of pollutant (m^3/h)
ka = quantity of pollutant air in the supplied air in the space (m^3 pollutant per m^3 of supplied air)
M = maximum allowable concentration of pollutant in the space (m^3 pollutant per m^3 of air)

3.7.3 Energy required for fans

The existing Greek Legislative Framework does not mention any regulations concerning fan power.

3.7.4 Summer comfort

The second chapter of the Technical Guide of the Technical Chamber of Greece [7] defines the recommended summer thermal comfort conditions for the indoor spaces. Their definition is necessary for the calculation of the cooling loads. These conditions are defined considering a pair of values of two magnitudes: either the dry bulb temperature with the relative humidity or the dry bulb temperature with the wet bulb temperature.

For general air-conditioning applications, dry bulb temperature of 25.5°C is recommended. Table 2 gives the recommended design conditions for air-conditioning spaces during summertime period.

SPACE	**TEMPERATURE (°C)**	**RELATIVE HUMIDITY (%)**
Residences	25-26	40-50
Offices	25-26	40-50
Libraries-Museums	22	40-55
Restaurants-Clubs	23-26	50-60
Educational facilities	26	45-60
Hospitals		
Wards	24	45-50
Surgeries	20-24	50-60
Recovery wards	24	50-60

Table 2: Recommended design temperatures for air conditioned spaces during summer period [7].

3.7.5 How are hybrid ventilation systems considered?

Hybrid ventilation systems are considered only in the new Building code for Thermal Performance and Energy conservation in Buildings [1]. The term of hybrid ventilation is introduced for a first time together with new alternative techniques of natural ventilation:

- Hybrid ventilation with the use of ceiling fans
- Wind Towers
- Solar chimneys
- Ventilated building envelopes

However, this is just a proposal, which is not yet accompanied with any regulations or standards concerning the performance of these systems.

3.7.6 Summary of possible barriers and proposed solutions to solve them

- The use of air-conditioning systems should be restricted in buildings with a cooling load above the critical value.
- The terminology for the definition of the ventilation requirements of buildings is adopted by the air-conditioned buildings and it is expressed in constant values of air changes per hour. **This is not applicable in hybrid ventilated buildings, as the number of air changes is depended on the indoor air quality and thermal comfort requirements.** A new definition for the ventilation requirements of hybrid ventilated buildings should be introduced in the new legislative texts.
- Stricter standards for energy consumption should be adopted in the legislative frameworks.
- Introduction in the national legislative texts of a methodology for the evaluation of fan power.

3.7.7 References

[1] "A new standard for Thermal Performance and Energy Conservation", Center of Renewable Energy Sources (CRES), 2002.

[2] European Prestandard, prENV 1752, "Ventilation for buildings - Design criteria for the indoor environment".

[3] European Standard, prEN 68, "Workplace atmospheres - Guidance for the assessment of exposure to chemical agents for comparison with limit values and measurement strategy".

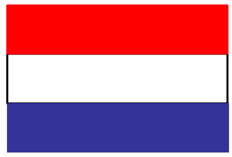
[4] General Constuction Regulation (Law Number 1577/1985, modified by the law No 1647/1986, 1722/1988, 1892/1990).

[5] "Source book of Legislation on passive solar energy and energy conservation: Europe-Greece-Italy", Energy Conservation in Buildings, CIENE, EC DGXVII.

[6] Technical Guide of the Technical Chamber of Greece, 2423/1986: "Installations in Buildings: Air-conditioning of buildings".

[7] Technical Guide of the Technical Chamber of Greece, 2425/1986: "Installations in Buildings: Calculation of air-conditioning load in buildings".

3.8 Netherlands



Contribution from Willem de Gids
(TNO Building and Construction Research)

3.8.1 General framework

In the Netherlands, the Buildings regulations is a complex combination of Law, Decrees, Standards and sometimes other relating documents such as Quality assurance declaration, Codes of Practices etc. The requirements are given by the Ministry of Housing in the Building Decree. The Building Decree is connected to the Building Act. Some modifications on the Building Decree and deviations from standards are specified in a Ministerial Decree. The determination methods are specified in standards. The requirements are in most cases performance oriented. That means on the highest possible performance and Building level. Figure 3 gives schematically the situation.

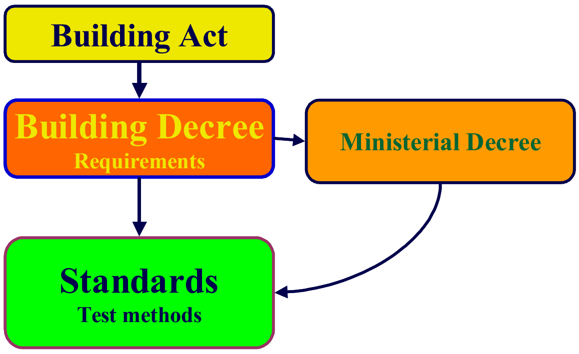


Figure 3: The relation between building act, building decree and standards

The building permits are given by the municipalities on the basis of written information such as calculations and drawings. They should do the final checking on test methods from standards. The responsible for the Building permit has to build according to the Building Regulations. In case he has not done so, he is responsible for the consequences. Apart form standards there may be also Codes of Practice in which solutions are specified from which one may expect that they are fulfilling the requirements. Contrary to other countries there is no “dossier as built” principle.

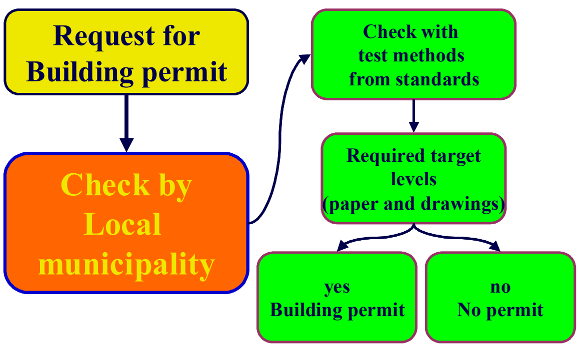


Figure 4: A scheme on checks for the building permit

In case a system or product cannot be tested according to the applied standard or that it cannot fulfil the requirements, the equivalence principle can be applied to show that the performances of the system or component is the same than those of a system that fulfils the requirement. The municipality concerned may accept a declaration of conformity made by any person. Normally, these declarations are given by well known scientific institutes.

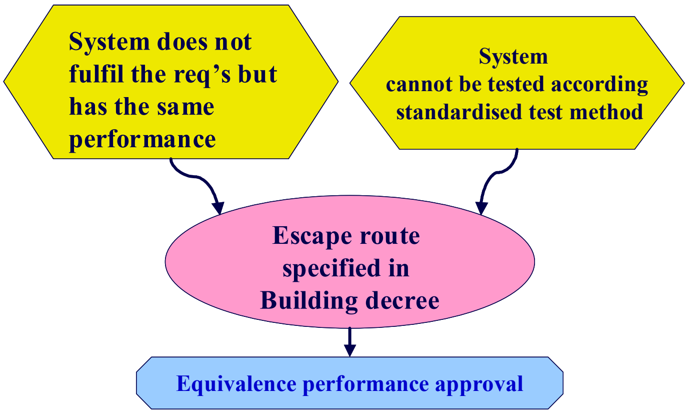


Figure 5: The principle of the equivalence performance approval

For new dwellings the energy performance standard NEN 5128 is valid.
It requires information on:

- Heating
- Lighting
- Cooling
- Humidification
- Domestic hot water
- Use of passive sun
- Internal load
- Ventilation
- Fans
- Heat recovery

The energy performance is expressed as a ratio between the calculated energy according to the method specified in the standard and a reference energy use of a standard dwelling.

In the paragraphs below more specific information is given for ventilation.

3.8.2 Energy required for ventilation

The energy required for ventilation and infiltration is calculated with:

$$H_{vent} = 1.2\ q_v$$

where:

H_{vent} specific heat loss due to ventilation and infiltration of the heating zone in the building [W/K]

q_v airflow rate for ventilation and infiltration of the heating zone in the building [dm³/s]

The ventilation and infiltration has to be specified according to a generic equation which in independent of the ventilation system:

$$q_v = 0.47\ A_g + 0.13\ q_{v10}$$

where:

q_v airflow rate for ventilation and infiltration of the heating zone in the building [dm³/s]

A_g useable ground floor area of the heating zone in the building in [m²]

q_{v10} air leakage of the of the building [dm³/s]

These equations and constants are based on multi-zones reference case studies.

3.8.3 Energy required for fans

The energy used by fans gives two possibilities:

1. a fixed value: $Q_{prim} = 3.6 * Q_{vent} / \eta$
2. based on the installed power of the fans: $Q_{prim} = 32 * P_{eff} / \eta$

where:

Q_{prim} primary energy use for fans [MJ]

Q_{vent} yearly energy use according to a certain table [kWh]

P_{eff} effective fan power in W

η efficiency of the electricity power station [-]

3.8.4 Summer comfort

In the existing standard NEN 5128 passive cooling is not taken into account. The new version of the standard which is in preparation takes excessive ventilation or night cooling through ventilation into consideration.

3.8.5 How are hybrid ventilation systems considered?

Hybrid ventilation systems can only be handled along the lines of the equivalence principle route. There are two systems existing that have equivalence approvals.

3.8.6 Summary of possible barriers and proposed solutions to solve them

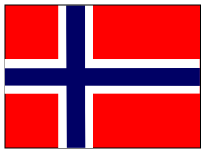
The main barrier is still the fact that hybrid systems cannot be tested along the same lines as natural or standard mechanical systems. The way to investigate the performance of a hybrid system along the lines of the equivalence principle is a barrier. The cost and time for an investigation to reach the status of conformity is considerable. Nevertheless, Dutch manufacturers have gone all the way for their systems. A solution is not available. It will be normal practice that in case an innovative solution comes on the market, standards and regulations will only follow after some years.

3.8.7 References

[1] Dutch Building Decree, Staatsblad 410, 7 augustus 2001

[2] NEN 5128 Energy performance of dwellings and residential buildings, NNI, Delft, December 1998

3.9 Norway



Contribution from Peter G. Schild
(Norwegian Building Research Institute)

3.9.1 Regulations & standards in Norway related to energy consumption.

Though Norway is not presently an EU state, it is paradoxically more assiduous than most EU states in adopting EU directives and standards.

Norway has a Planning and Building Act (*Plan- og bygningsloven* [1]). Of the many regulations that are implemented under this act, the most important is the Technical Regulations (*Teknisk forskrift til plan- og bygningsloven* (*TEK*) [2], also available in English). This regulation has an accompanying guidebook (*Ren veiledning til teknisk forskrift* [3]), which describes quantitatively how the performance criteria given in TEK can be satisfied, by describing pre-accepted design solutions. This guidebook simply presents an interpretation of the law and its regulations, and is not statutory. Nevertheless, the advice in the guidebook has a very strong bearing on practice in the building industry in Norway.

The greatest concern is to limit energy consumption for heating during winter. The technical regulations [[2]] give a choice of three alternative requirements, of which new buildings must comply with at least one:

1. Specified levels of insulation
2. Heat loss through walls limit (*varmetapsramme*)
3. Energy consumption limit (*energiramme*) [true EPR]

The first two alternatives are quite simple in application but represent a loophole or opt-out with respect to EPR, and therefore disappear in January 2006.

The third alternative is the most flexible and forward-looking one, as it gives the building designer an almost unrestricted opportunity to (*a*) take into account any reasonable energy-saving solutions, and (*b*) to the trade between different elements of the building.

Generally EN 832 is used in the EPR calculation; however the regulations permit any reasonable method or software to be used, so long as it is equivalent to, or better than EN 832. (This should change in January 2006, due to the EPD). Thus, when using advanced software, there is practically no limit to the exploitation of energy-efficient features.

3.9.2 Energy required for ventilation preheating

The Norwegian EPR takes into account infiltration and mechanical ventilation heat loss (≡ preheating) and heat recovery efficiency.

3.9.3 Energy required for fans

The building regulations do not presently give limits to fan power, nor do they explicitly require that fan energy consumption be included in the EPR. NBRI would like to see it introduced in the next regulations.

During the heating season, the energy consumption of a supply fan provides beneficial space heating, and should be accounted as such. The remaining fan energy (supply fans in summer, and exhaust fans all year) constitutes a loss. With heat recovery equipment, the picture becomes more convoluted because the fraction of fan power that provides useful heating depends on (*a*) the locations of the supply and exhaust fans, (*b*) heat recovery efficiency, and (*c*) the building's balance point temperature. The most practical way of taking account of fan power is thus to include it as a system loss reducing the ventilation system's effective annual heat recovery efficiency. This approach has recently been put forward by NBI in a new proposed Nordtest method [5][7]. We hope that this practical approach will eventually be adopted in pan-European standards.

3.9.4 Summer comfort

Norway is in the process of adapting CEN CR 1752 [4] as a national standard.

The national building regulations do not set any limits on energy consumption for cooling in summer. Paradoxically, despite Norway's subarctic climate, it is not unknown for office buildings to have a higher power demand in summer than in winter, due to air conditioning.

3.9.5 How are hybrid ventilation systems considered?

The national building regulations do not present any hindrance for the exploitation of hybrid ventilation.

Compared to a conventional ventilation system, the reduction in fan energy in a hybrid ventilation system is predominantly attributed to the reduction in friction losses in the air distribution system (e.g. duct system with very low pressure drop). Exploiting natural driving forces (which can for example be 10 Pa on average for a 2-storey building) enables a further reduction in fan power. The savings in fan energy attributed to exploiting the natural driving forces is generally much smaller than the savings attributed to reducing duct friction losses in the air distribution system. Hybrid ventilation strategies are usually demand controlled strategies, which constitutes also a large potential reduction in fan power. All this does not mean that one should not bother exploiting natural driving forces; it is sensible try to exploit its full potential as long as it makes sense economically and environmentally.
Similarly, exploitation of natural driving forces does not reduce energy consumption for ventilation preheating or space conditioning — it is other measures, such as demand control, heat recovery and exploitation of thermal mass for thermal cooling, that provide a significant reduction in energy for preheating/conditioning.

3.9.6 Summary of possible barriers and proposed solutions to solve them

- The EPR energy consumption limit should be made stricter.
- The EPR should explicitly include fan power in the calculations.

[7] The Nordtest method NT VVS 130 should be released in the beginning of 2005.

- The two alternatives to the EPR, namely (2) specified level of insulation, and (3) heat loss limit, represent a possible loophole, and should be removed.
- There should be more financial incentives for energy efficient technologies in buildings.

3.9.7 References

[1] Plan- og bygningsloven. (http://www.be.no/) Miljøverndepartementet, ved lov av 14. juni 1985 nr. 77. Last changed by law 16th April 1999.

[2] Tekniske forskrifter til plan- og bygningsloven (Forskrift om krav til byggverk og produkter til byggverk). (http://www.be.no/) Kommunal- og regionaldepartementet, og Miljøverndepartementet, by law 22nd January 1997. English translation available on http://www.be.no/

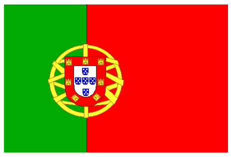
[3] Ren veiledning til teknisk forskrift til plan- og bygningsloven. (http://www.be.no/) Statens bygningstekniske etat, 2.utgave, april 1999

[4] CEN Technical Report CR 1752. Design criteria for the indoor environment. 1997

[5] Peter G. Schild. Nasjonal undersøkelse av boligventilasjon med varmegjenvinning. Norwegian Building Research Institute (NBI), Project report 341-2003. (in Norwegian). http://www.byggforsk.no/default.aspx?DokumentID=936&innholdsID=58

3.10 Portugal

Contribution from Eduardo Maldonado (IDMEC)



3.10.1 The current energy regulation in Portugal

The first set of Thermal Regulations for Building Envelopes (RCCTE), with requirements for energy efficiency in both winter and summer, was published [1]. It became law on January 1, 1991.

The envelope regulations impose a maximum allowable amount of energy that would be needed to heat and cool a building under nominal conditions (constant thermostatic control during the whole heating - 18°C - or cooling seasons - 25°C). These two separate limits, one for the winter heating season (Ni) and another for the summer cooling season (Nv), are established by simple formulas on the basis of reference building envelopes with characteristics that are dependent on climate [2]. For this purpose, the country was divided into three distinct winter and summer zones, depending on their severity. The buildings are not penalized for a high surface to volume ratio.

These regulations only establish target values, i.e., they do not mandate specific levels of insulation or envelope tightness. Designers are free to use any combination of solutions they may wish, better or worse than the reference solutions, as long as the overall nominal energy needs (Nic or Nvc) do not exceed the established maximum (Ni or Nv). There is also a credit for solar gains in winter, allowing for reduced levels of insulation, for example, when solar gains have a useful contribution to winter heating needs. There are, however, maximum levels of the heat transfer coefficient of individual envelope components (walls, roofs and pavements) that cannot be exceeded.

The formula for calculation of the target value of the heating requirements is shown in Figure 6. As clearly seen, the only pertinent values are the heat transmission characteristics of the walls (K). Ventilation is included in the formula, but the air change rate is fixed at a constant 1 ACH, independently of any building characteristics: $0.34\ \dot{V}$ is the ventilation heat loss coefficient (with $\dot{V} = h.\ Ap$).

These regulations were revised in 2002-2003, and the new version is expected to come into force in 2005. Their structure is, in essence, the same, but the reference values for the envelope transmissivity, now renamed U values in line with EN ISO 13790, are reduced by 50%. Reference heating and cooling needs for ventilation are also calculated with 0.6 ACH rather than 1 ACH in the existing regulations, to better match the performance of the building stock. There is, though, a major change regarding the way that ventilation is dealt with: the ventilation rate of the building is calculated as a function of several variables, namely:

- The type of ventilation (natural or mechanical);
- The type of window frames, in terms of their leakage characteristics;
- The degree of exposure, in terms of height and location of the building;
- The amount of windows (windows in excess of 15% of floor area are penalized);
- The use of self-regulated inlets (nominal ACH is reduced);
- The air-tightness characteristics of doors (with airtight doors, the nominal ACH is reduced).

NOMINAL HEATING NEEDS

$$N_i = \left(\frac{1.3 K_{fr} A_f + K_{hr} A_h + K_w A_w}{A_p} + 0.34h \right) (0.024) DD$$

where:

A_f - Area of vertical opaque walls (m^2)
A_h - Area of horizontal opaque roof and external pavement (m^2)
A_w - Area of glazings (m^2) - Maximum: 15% of useful floor area
A_p - Useful floor area (m^2)
K_{fr} - Reference heat transfer coefficient for walls ($W/m^2.°C$)
K_{hr} - Reference heat transfer coefficient for roofs and pavements ($W/m^2.°C$)
K_{fr} - Reference heat transfer coefficient for windows ($W/m^2.°C$)
h - Ceiling to floor height (m)
DD- Degree-days (°C.day)

Figure 6: Maximum Allowable Heating needs (1990 Regulations)

This calculation methodology is closely following the specifications of EN ISO 13790, explained in more detail in § 2.2 of this report. Table 3 lists some of the specifications that have been developed for the new Portuguese regulations, to promote better window frames and design of the ventilation system. The exposure limits are defined in Table 4.

Exposure	Inlet device in façade?	Air-tightness of windows (EN 12207)								In compliance with NP 1037-1
		Not rated		Class 1		Class 2		Class 3		
		Roller-shade?		Roller-shade?		Roller-shade?		Roller-shade?		
		yes	no	yes	no	yes	no	yes	no	
Exp. 1	yes	0,90	0,80	0,85	0,75	0,80	0,70	0,75	0,65	0,60
	no	1,00	0,90	0,95	0,85	0,90	0,80	0,85	0,75	
Exp. 2	yes	0,95	0,85	0,90	0,80	0,85	0,75	0,80	0,70	
	no	1,05	0,95	1,00	0,90	0,95	0,85	0,90	0,80	
Exp. 3	yes	1,00	0,90	0,95	0,85	0,90	0,80	0,85	0,75	
	no	1,10	1,00	1,05	0,95	1,00	0,90	0,95	0,85	
Exp. 4	yes	1,05	0,95	1,00	0,90	0,95	0,85	0,90	0,80	
	no	1,15	1,05	1,10	1,00	1,05	0,95	1,00	0,90	

Table 3: Nominal ACH values (h^{-1}) in naturally-ventilated buildings (2005 Regulations)

Height above ground	Location		
	Urban	Suburban	Rural
< 10 m	Exp. 1	Exp. 2	Exp. 3
10 m to 18 m	Exp. 1	Exp. 2	Exp. 3
18 m to 28 m	Exp. 2	Exp. 3	Exp. 4
>28 m	Exp. 3	Exp. 4	Exp. 4

Remark: Near the coast, some types are higher

Table 4: Exposure type

3.10.2 Mechanical ventilation systems

In the new regulations, energy needs for ventilation in buildings with mechanical ventilation systems are calculated on the basis of the methodology defined by EN ISO 13790. The nominal flow rate is defined as:

$$\dot{V} = \dot{V}_f + \dot{V}_x$$

where $\dot{V}_f$ is the maximum of mechanical supply and extract airflows

$\dot{V}_x$ is an additional airflow rate induced by wind and stack through ventilation openings and cracks, being set at zero if an adequate amount of under or overpressure is achieved in the ventilation system, as recommended.

The minimum air exchange is set at 0.5 ACH, even if real airflows are lower, to ensure an adequate level or indoor air quality. Heating needs are correspondingly reduced if heat recovery is used, as a function of the airflow rates and recovery efficiencies.

Fan power is accounted for, assuming that fans operate 24 hours a day, as required by the regulations.

3.10.3 Summer comfort

In the new regulations, ventilation in summer is accounted using the exact same methodology as described for winter. As the cooling needs are calculated on the basis of a simplified dynamic simulation tool (Figure 7), the free-cooling effect is taken into account during most of the summer. The regulations recommend higher ventilation rates when free-cooling is possible, though this feature is not required.

3.10.4 How are hybrid ventilation systems considered?

The regulations specifically indicate that ventilation can be provided by natural, mechanical or hybrid ventilation systems. No model is however provided for hybrid systems. Operating details to be used must be demonstrated by the user with data provided by the manufacturer, and accepted by the licensing authorities.

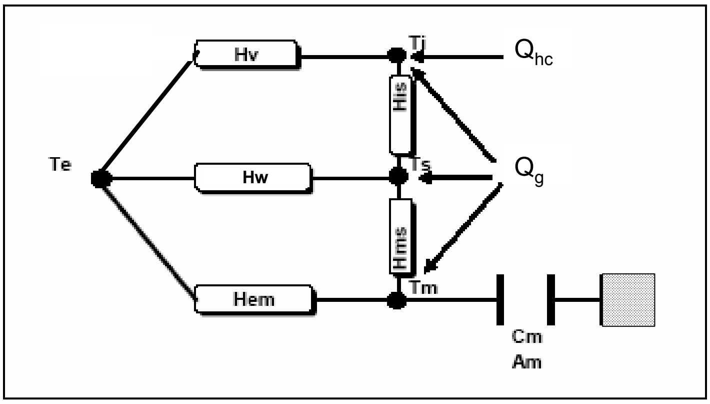


Figure 7: Simplified dynamic model for calculation of summer cooling needs (Based on a figure from [3])

3.10.5 Summary of possible barriers and proposed solutions to solve them

The new regulations that are expected to come into force in 2005 specifically list hybrid ventilation as a possible alternative for residential buildings. However, as hybrid systems are unique and non-standard, no specific method is included in the calculation methodology. An equivalence clause specifies that these types of systems must show that their performance is indeed equivalent to the performance of the more common natural and mechanical ventilation systems, with certification by a recognized independent third party. This is, no doubt, a major barrier for innovative systems, but a necessary one until there are standardized hybrid systems in the market.

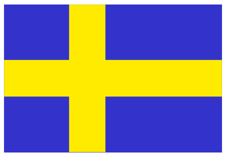
The new regulations are a strong step forward towards better ventilation in buildings. There are clear incentives for using better window frames, to use self-regulated inlets and to use heat recovery in mechanical ventilation systems. Better systems are rewarded with an improved energy rating and, in some cases, an efficient ventilation system will be essential to keep a building within the maximum heating and cooling allowance, a requirement for obtaining a building license.

Ventilation is thus treated in an equal footing as envelope losses (in winter) and gains (in summer). Designers will have to pay attention to ventilation design, under penalty of important consequences for the energy rating of the building or, in limiting cases, even as a necessary step to obtain a building permit. The door is open to hybrid ventilation systems, though still only through a more complex procedure involving performance certification by the manufacturer.

3.10.6 References

[1] Regulamento das Características de Comportamento Térmico de Edifícios. Official Journal, Decreto-Lei 40/90, 1 February 1990.
[2] E. Maldonado. "Thermal Characteristics of Building Envelopes in Portugal". Proc. of the Seminar "Building Shell and Energy Efficiency", FAST, Milan, September 1992, pp. 23-35.
[3] TC 89/WG4 WI EPBD WI 14 - GTR WI 100, Energy performance of buildings — Calculation of energy use for space heating and cooling, 2004.

3.11 Sweden



Contribution from Åke Blomsterberg (J&W Consulting Engineers)

3.11.1 Energy required for heating

A maximum average U-value of the building envelope and a maximum air tightness of the building envelope are required. The maximum average U-value is calculated as a function of the area of the building envelope and the window area. The value for a typical single-family house is 0.23 W/(m².K) (BBR 94).

Heat recovery on the ventilating air is required if the energy demand for heating of the ventilating air exceeds 2 MWh/year and if the heat energy requirement is substantially supplied by oil, coal, gas or peat, or is wholly or partly supplied by electricity during the period November to March inclusive (BBR 94).

The national board of housing, building and planning are currently studying and developing a system for energy labelling of apartment buildings. These activities will have an influence on the energy efficiency requirements, which are likely to be more performance oriented and to consider the total energy use of a building and the use of electricity. The climate goals of the government are also important in this context. The EU development concerning energy efficiency requirements is being followed.

3.11.2 Energy required for fans

The building services engineering installations, which use electricity, shall be designed so that power demand is limited and the use of electricity efficient (BBR 94).

In most building projects, VVS AMA 98 is used. The VVS AMA air tightness requirements on ventilation ducts are often applied. Thereby innovation is encouraged and performance assessment enforced of a component contributing to energy efficiency.

In some building projects, recommendations on specific fan power are enforced (SIKI R2).

3.11.3 Summer comfort

The operative temperature should not for longer periods exceed + 26 °C and should not exceed + 28 °C for more than short periods. The average airspeed should not exceed 0.15 meters per second at + 20-24 °C operative temperature. During the summer, higher air speed can be accepted. (SoS AR1988:2: Indoor Thermal Comfort. General Advice, nr 1988:2, from the Swedish Social Welfare Board).

3.11.4 How are hybrid ventilation systems considered?

The Swedish national Building Regulations (BBR 94) apply to the construction of all kinds of new buildings and to the alteration of buildings when relevant. Innovation as the efficient use of electricity is also encouraged by the Swedish building regulations. **The requirement on**

heat recovery does not really encourage innovation. This aspect can cause problems as to obtaining approval for hybrid ventilation systems. However, it is possible to apply for an exception from heat recovery, which is usually done at the city or municipality level i.e. the local building committee. The procedure is to be able to prove by calculations that other energy saving measures compensate for the lack of heat recovery. **During the nineties, some 100 passive stack (mostly hybrid) ventilated schools were built in Sweden, most of them without heat recovery.**

3.11.5 Summary of possible barriers and proposed solutions to solve them

The required heat recovery on the ventilating air is hard to fulfil since there is often no connection between incoming and ventilating air and a heat recovery system will often increase the pressure drops in the duct system. The energy use for ventilation can be lowered through demand controlled ventilation.

During the construction phase, developers will usually carry out performance tests e.g. air tightness of ducts, performance of dampers. In the contract documents, there is usually a plan and descriptions of the different tests to be carried out. At the final inspection by the developer or shortly before e.g. airflows are measured, **which is not always easy to perform in a hybrid ventilation system**. At times, very seldom, some of the performance testing is repeated a couple of months after the building have been occupied. This to ensure that the building functions when occupied.

3.11.6 References

[4] BBR 94, Building Regulations 94. Mandatory provisions and general advisory notes. (in Swedish), The Swedish National Board of Housing, Building and Planning (Boverket), 2002.

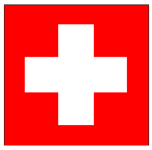
[5] SIKI: R2 Classified air distribution systems - Guidelines and specifications (in Swedish), Swedish indoor climate institute, 1991.

[6] VVS AMA 98, Universal material and job descriptions for HVAC technical installations (in Swedish). Swedish Building Office, 1998.

[7] Indoor Thermal Comfort - General advice (in Swedish), the Swedish Social Welfare Board, 1988:2, 1988.

3.12 Switzerland

Contribution from Andreas Weber / Viktor Dorer (EMPA)



3.12.1 Introduction

Standardisation and especially regulation is quiet complex in Switzerland. Public law and regulations are issued on federal, state and municipality level and show a wide spread from national to very local approaches. There is a national harmonisation effort for energy legislation. Standards are mostly developed and issued by publicly acknowledged or authorised associations (e.g SIA, Swiss engineers and architects association) and commissions, on behalf of the Swiss standards association, and apply throughout the country. There is a long tradition for energy standards and regulations, but IAQ is much less covered.

In recent years, **innovation in residential ventilation has been pushed by the introduction of low energy certificates for buildings**. The MINERGIE certificate [7] has been introduced in order to distinguish buildings with a very high standard concerning energy performance and comfort. The newly introduced MINERGIE-P [8] label goes even beyond this level and is equivalent to the German "Passivhaus" certificate, but compliance has to be assessed according the method defined in the Swiss standard SIA 380/1 Energy use of buildings [1].

3.12.2 Energy required for ventilation

With the combination of a good building construction and an optimized ventilation system, the requirement of energy has to be as low as possible. This is a general requirement of the standard SIA 382/1 [3]. To achieve this, many recommendations are given in SIA 382/3 [5], here is only a selection:

- Maximum outdoor air flow rate of 30 m^3/pers if smoking is not permitted and 70 m^3/person if smoking is permitted (less stringent requirements: 25 and 50 m^3/person respectively)
- Source control by capturing heat, humidity and pollutant loads directly at their sources if possible
- Utilize possibilities of free cooling
- Utilize waste heat
- Ventilation system with individual operation of rooms with different requirements and different occupation times.
- Total pressure difference in the air distribution system as low as possible (sum of supply and exhaust: max. 1200 Pa incl. filter and heat recovery; (stricter requirements: 900 Pa))
- Fan efficiency as high as possible
- Ventilation system with heat recovery
- Humidification only as much as necessary and together with humidity recovery
- Simultaneous heating and cooling per zone is allowed only for dehumidification
- Temperature and humidity may free float in a certain band width
- Variable air flow rates
- Demand controlled ventilation

The Swiss standard for thermal energy use in buildings SIA 380/1 [1] applies the calculation method according to EN 832 with monthly energy balances. Therefore the monthly averaged values of the outdoor air flow have to be used to calculate the ventilation energy loss. In buildings with mechanical ventilation systems, the highest value of the supply and exhaust volume flow has to be taken during operating hours. If a heat recovery exists, the thermally active volume flow is calculated using the heat recovery efficiency η_V. The outdoor airflow due to the leakages during operating time $\dot{V}_x$ is added and outside the operating hours the infiltration air flow $\dot{V}_0$ is taken:

$$\dot{V}th = [\{ (\max (\dot{V}sup, \dot{V}ex) \bullet (1 - \eta V) + \dot{V}x) \bullet \beta \}] + [\dot{V}0 \bullet (1 - \beta)]$$

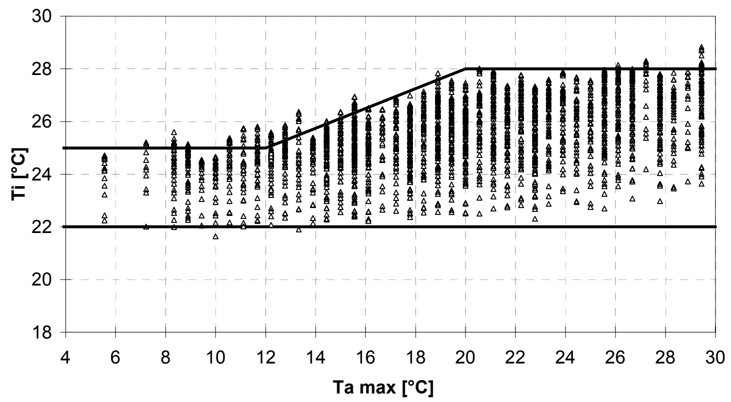
β is the fraction of time period with fans on.

3.12.3 Energy required for fans

According SIA 380/4 [2], the specific energy required for fans per net floor area can be calculated with the specific fan power per net floor area and the operating time of the ventilation system. General and stricter reference values for this specific fan power are given for smoking permitted and smoking not permitted zones, depending on the specific floor area per person or depending on the specific air flow per floor area. For the general reference values a pressure difference of 1200 Pa, a fan efficiency of 55 % and an outdoor air flow of 70 m^3/person for smoking permitted and 30 m^3/person for smoking not permitted is assumed. For the stricter values a pressure difference of 900 Pa, a fan efficiency of 60 % and an outdoor air flow of 50 respectively 25m^3/person is assumed. Values for the operating time are given for different applications but not for residential buildings.

3.12.4 Summer comfort

The need for room air cooling has to be proved according to [5]. Mechanical cooling is only allowed if the room air temperature exceeds the upper limit of the allowed temperature range for operation (Figure 8) during the occupied hours for more than 30 Kh per year. Hot days, with higher than 30 °C maximum 1h-mean outside temperatures, may not be considered. The air temperature evolution in the room without cooling has to be predicted using a dynamical building simulation tool. Boundary conditions for the simulation, such as solar protection, minimal thermal building mass, window airing during unoccupied time and standard internal loads, are defined in the standard. A detailed description of the simulation method is given in [6].



upper limit of the operation range

lower limit of the operation range

Ti: 1h mean value of the room air temperature during occupied time
Ta max: maximum 1h mean value of the outside air temperature of the day

Figure 8: Summer comfort

3.12.5 How are hybrid ventilation systems considered?

Hybrid ventilation systems are not explicitly mentioned or treated in the Swiss ventilation and energy standards. Hybrid systems can very well be considered in summer comfort evaluations, where dynamic simulations are requested. For space heat calculations, hybrid systems have to be considered on the basis of actual operation times of the different ventilation modes. Approaches can be quite similar to the ones established for demand controlled ventilation.

3.12.6 Summary of possible barriers and proposed solutions to solve them

In regard to energy requirements, no barriers to the application of hybrid ventilation systems have been identified. **On the contrary, many of the recommendations in [4] actually promote such solutions.**

In regard to changing thermal comfort conditions, no procedures are established for the time dependent evaluation of thermal comfort and the evaluation of temperature or draft risk exceedings or undershots.

3.12.7 References

[1] SIA 380/1, Thermal energy use of buildings, 2001

[2] SIA 380/4, Electrical energy use of buildings, 1995

[3] SIA 382/1, Performance and technical requirements for ventilation systems, 1992

[4] SIA 382/2, Cooling power demand of buildings, 1992

[5] SIA 382/3, Determination of the demand of ventilation equipments, 1992

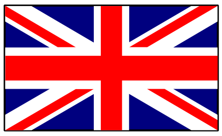
[6] SWKI Guideline 95-3, Yearly energy demand of ventilation equipment

[7] Minergie Standard, issued by the Minergie association (see www.minergie.ch)

[8] Minergie-P Standard issued by the Minergie association (see www.minergie.ch)

3.13 United Kingdom

Contribution from Shawn Galliers and Andrew Martin (BSRIA Ltd)



Remark: The ventilation and energy regulations are currently being revised. It is anticipated that they will be completed by the end of 2005.

3.13.1 National Standards

The primary legislation in the UK is The Building Act 1984. A number of regulations are implemented under this Act, the latest edition of which is The Building Regulations 2002. In practice the Building Regulations are applied through a series of Approved Documents, which provide detailed guidance to allow the specific regulations to be met. While there is no obligation to adopt any particular solution contained in an Approved Document, any alleged contravention of a specific requirement (of the Regulations) will require evidence to demonstrate that the Regulation has been satisfied. In the vast majority of cases, compliance with the regulations is based on meeting the requirements of the Approved Documents.

The Building Regulations, and associated Approved Documents, are administered by the Office of the Deputy Prime Minister (ODPM). Practical enforcement of the Regulations is carried out by the Building Control Officers of the Local Authority or the Fire Officer if the issue concerns fire precautions.

The Approved Documents of the Building Regulations frequently refer to Standards, which in the UK are published by the British Standards Institution (BSI). BSI publishes British, European and ISO Standards. Current British standards tend mainly to be generic in their approach and are not tailored to specific building types. Exceptions to this include highly specialised applications such as clean rooms. Approved Documents also make reference to industry guidance produced by organisations such as the Chartered Institution of Building Services Engineers (CIBSE) and the Building Services Research and Information Association (BSRIA).

Separate Building Regulations apply for England and Wales, Scotland and Northern Ireland. The information contained here relates to the Regulations in England and Wales.

3.13.2 Overview of Legislation

The following briefly outlines the legislation and standards relating to ventilation in dwellings.

Directly applicable standards:

- Approved document F1: Means of Ventilation
- BS 5720:1979 Code of practice for mechanical ventilation and air conditioning in buildings
- BS 5925:1991 Code of practice for ventilation principles and designing for natural ventilation

Indirectly applicable standards:

- Approved document L1: Conservation of Fuel and Power in Dwellings
- BS 5250:1989 Code of practice for control of condensation in buildings

Associated standards:

- BS 7671: Requirements for electrical installations

There are also numerous performance and testing standards related to ventilation systems and components.

3.13.3 Energy efficiency considerations

Approved document L1 states that:

Reasonable provision shall be made for the conservation of fuel and power in buildings by:

- *Limiting the heat loss:*
    - *through the fabric of the building*
    - *from hot water pipes and hot air ducts used for space heating*
    - *from hot water vessels*
- *Providing space heating and hot water systems which are energy efficient*
- *Providing lighting systems with appropriate lamps and sufficient controls so that energy can be used efficiently*
- *Providing sufficient information with the heating and hot water services so that building occupiers can operate and maintain the services in such a manner as to use no more energy than is reasonable in the circumstances.*

The requirement for sufficient controls in requirement L1(c) applies only to external lighting systems fixed to the building.

Approved Document L1 focuses mainly on thermal insulation (fabric and services) and control system requirements for space heating and domestic hot water. Compliance with Approved Document L1 can be met by using one of the following assessment methods:

- The Elemental method: The requirement is met if thermal performance of construction elements conform with those tabulated in the approved document
- The Target U-value method: The requirement is met if the average U-values do not exceed the targets laid out in the approved document
- The Carbon Index method: this is a calculation using the Government's Standard Assessment Procedure. The procedure takes account of ventilation rate, fabric losses, water heating requirements, internal heat gains and solar gains. The requirement is met if the SAP Energy rating is not less than that tabulated in the approved document.

The SAP method takes into account estimates of heat loss due to infiltration and ventilation for both natural and mechanical based ventilation. Mechanical systems designed with heat recovery result in a higher SAP rating compared to those without.

General notes applicable to LI for dwellings:

- Basic guidance, along with sources of further guidance, is provided on limiting air leakage. The approved document references CIBSE Technical Memorandum 23:2000 as a guide for dwelling permeability (this relates to new construction).
- The requirements for control equipment are limited to space heating controls (zone, timing and boiler interlocks) and hot water storage systems (timer and thermostat). No requirements exist for the control of mechanical ventilation systems. The exception to this is the requirement for ducted warm air systems to have a thermostat. (These systems do not generally provide ventilation - they tend to re-circulate room air.)

- Insulation of ducts is required unless heat loss from the duct contributes heat to an occupancy area. Cross-reference is made to BS 5422: 1990 Methods for specifying thermal insulation materials on pipes, ductwork and equipment.

3.13.4 References/Further information

[1] The Building Regulations 2000 (SI 2531), The Stationary Office.

[2] BS 5720:1979 Code of practice for mechanical ventilation and air conditioning in buildings. BSI.

[3] BS 5925:1991 Code of practice for ventilation principles and designing for natural ventilation, BSI.

[4] BS 5250:1989 Code of practice for control of condensation in buildings, BSI.

[5] BS 7671: Requirements for electrical installations, BSI.

[6] BRE Digest 398 Continuous mechanical ventilation in dwellings: design, installation and operation, BRE.

[7] CIBSE TM 23:2000 Testing of buildings for air leakage, CIBSE.

[8] The Stationary Office Online: http://www.hmso.gov.uk

[9] British Standards Institute Online: http://bsonline.techindex.co.uk

[10] Chartered Institution of Building Services Engineers (CIBSE): http://www.cibse.org

[11] Building Services Research and Information Association (BSRIA): http://www.bsria.co.uk

[12] Building Research Establishment (BRE): http://www.bre.co.uk (BRE is an organisation that provides guidance on i.e. ventilation related aspects, see [6]).

4. Comparison of specific aspects

ENPER Contribution of Peter Blom (Norwegian Building Research Institute) – **Written in the frame of the ENPER project** (http://www.enper.org/)[8]

The following table shows the number of countries (out of 15) that consider parameters related to ventilation.

Ventilation		15
Air flow rate		15
Heat recovery		10
Infiltration		10
Flow control		8
Fan Power		5
Duct airtightness		3
Nearly all	± ½ of them	$^{1}/_{3}$ or less

Table 5 : Number of countries (out of 15) which considered this parameter (source: ENPER)

4.1 Aspects treated in the basic calculation procedure

4.1.1 Overview of calculation procedures

The European countries calculate ventilation heat loss in very different ways in their energy performance calculation procedures:

- In France, there is developed a relatively advanced physical model for calculating ventilation air flow based on prEN13465[9] of TC156 (an implicit method which must be solved using computer);
- In the Netherlands, the calculation of ventilation air flow are to a large extent based on correlation factors that are developed from ventilation measurements and calculations with a detailed model;
- Other countries, like Austria, Switzerland and Greece use standard CEN methods (EN832 Thermal performance of buildings);
- Some countries, like Portugal and Spain, do not actually consider ventilation air flows at all.

[8] The information provided in this paragraph was valid at the time it was written (2001), but changes in regulations could have occurred since then.
[9] Published as EN 13465 in February 2004.

Table 6 describes, in general terms, the calculation method, the output from the ventilation calculation, and whether the energy use of a reference building is calculated. The calculation procedures are described in more detail in the synthesis on global philosophy in EPC.
France is the only country that has developed an EPC procedure that calculates the air flow in natural ventilation systems.

	Unit for ventilation heat loss	Calculation of air flows/ventilation heat loss in EP
Austria	W/K	EN832
Flanders-Belgium	KWh	Always sum of 2 terms: infiltration flow and intentional ventilation flow. The intentional ventilation flow is either a fixed value with correction factors (for dwellings), or the design flow rate (for offices and schools).
Denmark	KWh	DS418
Finland	KWh	Ventilation rate: national regulation and guide D2, EP: national calculation method D5 or approved method (e.g. EN 13790)
France	W/K	Air flows are calculated from physically based algorithms using prEN13465 implicit method
Germany	W/K	Simplified method for residential buildings: $\dot{V}$ = 0.19V, or 0.163V if n50 is below 3 ach. (V = volume of building)
Greece	W/K	In residential buildings, procedures in EN 832 are used. In other buildings, any recognised simulation program can be used.
Ireland	W/K	Calculation procedure is a part of Heat Energy Rating procedure
Italy	W/K	EN 832/prEN13790
Netherlands	W/K	Flow rate in Dwellings (l/s): qv = 0.47 Afloor + 0.13 qv @ 10 Pa with threshold (qv_{min})
Norway	KWh	EN 832 or national method NS 3031 for reference building, any simulation method can be used for actual building
Portugal	W	A certain amount of air flow is assumed, depending on the type of building and person activity
Spain		EP is not calculated
Sweden		Any recognised simulation program can be used to calculate air flow
Switzerland	W/K	EN832
UK		In residential buildings, air flow is derived from pressure test (L50/20) or from building characteristics. For other buildings, any recognised simulation program can be used.

Table 6: Calculation of air flows in EPC and ventilation heat loss (source: ENPER)

4.1.2 Intermittent and demand controlled ventilation

Table 7 shows how the EPC procedures handle intermittent ventilation and demand-controlled ventilation (DCV), which is of first importance for hybrid ventilation.

Most countries use actual values regarding demand-controlled ventilation and intermittent ventilation.

	EPC reference building		**EPC actual building**	
	Intermittent ventilation	Demand-controlled ventilation	Intermittent ventilation	Demand-controlled ventilation
Austria			Default values	-
Flanders-Belgium			Default values	Principle of equivalence
Denmark			Actual values	Actual values
Finland	Reference values/minimum performance	Default values/minimum performance	Actual values	Actual values
France	Reference values/minimum performance	Default values/minimum performance	Actual values	Actual values
Germany			Default values	-
Greece			Actual values	Actual values
Ireland			-	-
Italy			Actual values	Actual values
Netherlands			Default values	-
Norway	-	-	Actual values	Actual values
Portugal	-	-	-	-
Spain			-	-
Sweden	Reference values	-	Actual values	Actual values
Switzerland			Actual values	Actual values
UK			Actual values	Actual values

Table 7: Input for intermittent ventilation (e.g. operating hours ventilation system) and demand-controlled ventilation in EPC (source: ENPER)

4.1.3 Infiltration

Estimation of infiltration (unintentional air) into the buildings is crucial for the correct calculation of total air flow rate. This is handled quite differently in the various countries, see Table 8.

	Minimum performance required		Infiltration air flow calculated from pressure test data	Default value in/exfiltration flow in EPC	Comment
	Resi-dential	Other			
Austria	-	-	-	EN832	-
Flanders-Belgium	-	-	$\dot{V}_{in/exfilt} = 0.04 \times \dot{v}_{50} \times A_T$	$\dot{v}_{50}$ = 12 m³/h/m² envelope area	Default values are used if no pressure test data are available
Denmark	-	-	-	DS 418	Air tightness can be determined from default factors and from building type
Finland	-	-	-	0.1 / 0.2 ach	Uninhabited and inhabited buildings respectively
France	-	-	$\dot{V}_{env}$ @ 4 Pa	0.22 – 0.69 l/s per m^2 envelope area	Reference values ranging from detached houses to industrial buildings. Default values are 0.14 l/s per m² higher
Germany	-	-	-	EN832	
Greece	-	-	-	EN832	
Ireland	-	-	-		Infiltration rates dependent on building characteristics
Italy	-	-	-	EN832	
Netherlands	Yes	Yes	Yes		See Table 6
Norway	Yes	Yes	-	NS3031/EN 832	Default rate dependant on geographical location and shielding
Portugal	-	-	-	1 ach	Default value for reference building
Spain	Yes	Yes	-	-	Minimum tightness of windows and doors. Three levels, function of climatic area
Sweden	0.8 l/s m^2 @ 50 Pa	1.6 l/s m^2 @ 50 Pa	-	-	Ex/infiltration rate dependent on choice of calculation method

	Minimum performance required		Infiltration air flow calculated from pressure test data	Default value in/exfiltration flow in EPC	Comment
	Resi-dential	Other			
Switzerland	0.14 –0.42 l/s per m^2 envelope area @ 4 Pa		-	EN832 prEN 13790	Values for maximum air permeability is for new, mechanically ventilated buildings and for retrofitted, naturally ventilated buildings, respectively. An intermediate value is given for new, naturally ventilated buildings
UK	No	Yes	$\dot{V}_{env}$ @ 50 Pa /20		A pressure test should be conducted in buildings over 1000 m².

Table 8: Infiltration minimum performance required, ventilation air flow calculated from leakage test data (EN 13829) and default values for infiltration air flow in EPC (source: ENPER)

4.1.4 Duct airtightness

Table 9 shows how the different countries handle duct air tightness. Until now, only a few countries included duct airtightness in EPC.

	Minimum performance required	Included in EPC	Comment
Austria	-	-	
Flanders-Belgium		Yes	Included in EPC in dwellings only: Proportional increase of the set time averaged ventilation flow rate, dependent on duct tightness.
Denmark	Yes	-	DS447
Finland	Yes	-	Three air tightness classes, five classes from 2003
France	-	Yes	EPC includes impact of duct airtightness. Reference values corresponds to class A. Actual value is taken into account for the actual building, with a default value corresponding to 2.5 * class A
Germany	-	-	
Greece	-	Yes	Air leakage coefficient specified (> 0.22)
Ireland	-	-	
Italy	-	-	
Netherlands	-	-	
Norway	Yes	-	General recommendations-requirements not specified
Portugal	-	-	
Spain	-	-	
Sweden	Yes	-	Three airtightness classes (A,B,C)
Switzerland	-	-	
UK	-	-	

Table 9: Air tightness in ducts, minimum performance required and whether duct tightness is included in the Energy Performance Calculation (source: ENPER)

4.1.5 Heat recovery

Table 10 shows how the different countries handle heat recovery. Most countries consider heat recovery in the EPC-procedure.

	Minimum performance required	Source for efficiency data/ measurement method	Included in EPC	Comment
Austria	-	-	Yes	
Flanders-Belgium	-	EN308	Yes	Penalisation factor 0.85 of C.O.P if no continuous balancing of air flows
Denmark	Yes	Manufacturer	Yes	Heat recovery may be skipped if the exhaust air cannot be expediently utilized in profitable way.
Finland	-	Default efficiency/ manufacturer	Yes	The heat recovery is demanded with the utilization factor 50% or trade off with envelope must be used from the year 2003
France	-	Manufacturer	Yes	
Germany	-	Manufacturer	Yes	
Greece	Yes	Manufacturer	-	Dwellings: Verify that the energy consumed by the recovery system is lower than the energy gains.
Ireland	-	-	-	
Italy	Yes	Manufacturer	Yes	
Netherlands		Default efficiency/ type approval	Yes	National standard to measure unit efficiency, specifically adapted as EPC input
Norway	-	Default efficiency/ manufacturer.	Yes	Heat recovery recommended in buildings with a mechanical ventilation system
Portugal	Yes	-	-	Heat recovery is mandatory for the heating season, min. c.o.p. 50 % if rejected thermal power > 80 kW
Spain	Yes	-	-	45 % heat recovery with flow rates greater than 3,000 l/s and more than 1000 hours of operation yearly.
Sweden	Yes	Type approval	Yes	50 % heat recovery if annual ventilation heat demand exceeds 2 MWh
Switzerland	-		Yes	
UK	-	-	-	

Table 10: Heat recovery: minimum performance required, source for efficiency factor for the heat recovery unit and whether EPC includes heat recovery (source: ENPER)

4.1.6 Fan power

Table 11 shows how the different countries handle fan power. There is a trend to include fan power in the EPC-procedure.

	Minimum performance required	Included in EPC	Comment
Austria	-	-	
Flanders-Belgium	-	Yes	Total input power consumed by fan
Denmark	Yes	-	Specific fan power requirement
Finland	Yes	-	Total input power consumed by fan
France	-	Yes	Reference values for total input power given in regulations
Germany	-	-	
Greece	Yes	-	Maximum fan power (W) for large buildings and when the total fan power is higher than 20 kW
Ireland	-	-	
Italy	-	-	
Netherlands	-	Yes	Including default values differentiated for AC and DC driven fans to promote the latter
Norway	-	-	
Portugal	-	-	
Spain	-	-	
Sweden	-	Yes	
Switzerland	-	-	
UK		Yes	Non-domestic buildings

Table 11: Fan power, minimum performance required and whether EPC includes fan power (source: ENPER)

4.1.7 Conclusions

There is a trend in European countries to calculate design minimum ventilation rates in buildings both from the number of occupants and from the floor area. The idea is that both persons and building materials pollute the indoor air, and that both air flows need to be dealt with separately. This calculation method is now required in four countries (no, be.-fl, dk, se). The method seems to imply an increase in the ventilation air flows in buildings.

Four European countries (ch, gr, at, it) calculate ventilation heat loss as described in EN 832. Two countries (dk, no) use national methods based on a calculation method similar to EN 832. The other countries have developed different national methods, or let the user freely choose a well-recognised calculation method. In France, quite an advanced physical model has been developed for calculating ventilation air flow (implicit method based on EN 13465). This method also calculates the air flow in natural ventilation systems.

Regarding demand-controlled ventilation and intermittent ventilation, most countries use actual values instead of default values.

Estimation of the unintentional air infiltration into the buildings is crucial for a correct calculation of the total air flow rate. Six countries (nl, no, es, se, ch, uk) require minimum performance of building air tightness. Four countries (be.-fl, fr, nl, uk) have developed simple expressions to calculate ventilation air flow rates from pressure test data. If pressure test data is unavailable, eleven countries use default data. One country (uk) requires that air tightness tests shall be conducted in buildings over 1000 m^2.

Similarly, three countries (dk, fi, se) require minimum performance of ventilation duct air tightness. But only three countries (be.-fl, fr, gr) include duct air tightness in the EPC procedure.

Heat recovery is required in seven countries (dk, gr, no, pt, es, se, it), and in Finland from 2003, provided that the ventilation heat loss is above specified limits. All countries that have an EPC procedure consider heat recovery in the calculation method.

Three countries (dk, fi, gr) require minimum performance for fan efficiency. Five countries (be.-fl, fr, nl, se, uk) include fan power in their EPC procedure.

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4.2 Handling of innovative systems

ENPER **Enquiry carried out in the frame of the ENPER project** (http://www.enper.org/)

In the framework of the project ENPER-TEBUC, 2 questionnaires dealt with the issue of innovation:

- the general enquiry held in May-June 2001 whereby some questions concerned the issue of innovation
- a specific enquiry on innovation

The result of the general enquiry are given below.

1. *Describe if there is a general philosophy in your country with respect to the handling of innovative systems.*
2. *How is it used in daily practice?*

Country	Yes/no	Use in daily practice	Comment
Austria			
Belgium	Yes	Not implemented	
Denmark	No		
Finland	Yes	No daily practice	
France	Yes	Not systematically	The energy performance calculation procedure is regularly updated
Germany	Yes	Industry is very hesitating to apply new products	If you use innovative systems at one component, an other component can be less isolating
Great Britain	Yes	It is unusual	Authorisation to get a relaxation of the rules
Greece	Yes		They have to be recognised by certify laboratories
Ireland	Yes	The Irish Agreement Board oversee the assessment	
Israel	Yes		
The Netherlands	Yes	Decided by the municipality	Principle of equivalency
Norway	No		
Portugal			
Spain	yes	There isn't a well stabilised methodology	Freedom to develop whatever measure or system
Sweden	Yes	For most innovative concepts	
Switzerland	Yes	Yes	Only use for very innovative system

Table 12 : Is there a general philosophy concerning the handling of innovation and how is it done in practice? Results from general enquiry in June 2001 (source: ENPER)

3. *Is there a reference framework that allows comparing the standard solutions with innovative solutions?*
4. *Who can carry out the investigations:*
    - *A few organisations?*
    - *A large number of organisations?*
    - *Is there some kind of accreditation?*
5. *Who can approve a study of equivalence?*
6. *Is it at national level? Is it the communes?*

	General framework to compare innovative solutions	A few organisations	A large number of organisation	Approval at national level	Approval at local level	Kind of accreditation
Austria						
Belgium	Yes	Not defined yet				
Denmark	No					
Finland	No	X				It depends of the needs
France	Yes	X		X		yes
Germany	DIN V4108 / DIN V4701		X		X	
Great Britain	Not in formal sense	X		X		
Greece		X				
Ireland	Yes	X				
Israel	No. The performance criteria are the yardstick, and not an existing non-relevant prescriptive standard.	NBRI		X		
The Netherlands	Yes		X		X	Anyone can
Norway	No	X			X	no
Portugal						
Spain	No					No
Sweden	Yes		X			
Switzerland	Yes	State energy delegate			X	
	Number of states:	**7**	**3**	**2**	**4**	

Table 13 : General enquiry: information in relation to innovation (source: ENPER)

5. Conclusions

According to the authors who have contributed to the national review, the present regulations regarding the energy performance of (residential) buildings do not present themselves major barriers to the application of innovative hybrid ventilation systems. The main difficulties are caused by the "Principle of Equivalence", which in almost every country can be used if the performance of such systems cannot be assessed by the standard regulation. This aspect is mentioned by Belgium, France and Netherlands (it must be noticed that France and Netherlands are among those who have the most developed EPR regulations) and will be discussed in another report [6]. Even if some regulation doesn't constitute barriers to the application of hybrid ventilation system, they don't always promote such systems. The improving of the IAQ due to such system for a given energy consumption is most of the time not rewarded by regulations.

The lack of efficient procedure allowing the assessment of innovative system constitutes a major barrier to the development, optimization and application of innovative systems in general and of hybrid ventilation systems in particular.

Some of the barriers that have been identified are summarised below.

- *It should be possible to provide higher airflow rate than the nominal airflow rate (foreseen by standards and regulations), in order to reduce overheating risk and to increase indoor air quality.*

This implies that if the airflow rate provided by the system is higher than the nominal airflow rate, the amount of energy that is authorised to use increases. This is e.g. foreseen by the proposed EPR regulation for Belgium (Flemish region) for non-residential buildings (but not for residential buildings).

- *A system that reduces the risk of overheating during summer should receive a benefit.*

This implies that a procedure to correctly but easily evaluate the overheating risk reduction must be developed, and that boundary conditions must be defined.

6. References

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