

RESHYVENT

## **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 indoor air quality and summer comfort***

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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.

# Table of contents

ACKNOWLEDGMENTS .....	2
DISCLAIMER.....	2
TABLE OF CONTENTS.....	2
1. INTRODUCTION.....	2
2. DOCUMENTS APPLYING AT INTERNATIONAL LEVEL .....	2
2.1 European standards - Technical committee 156 'Ventilation for buildings' .....	2
2.2 Other documents.....	2
3. DOCUMENTS APPLYING AT A NATIONAL LEVEL .....	2
3.1 Belgium .....	2
3.2 Czech republic .....	2
3.3 Denmark.....	2
3.4 Finland.....	2
3.5 France .....	2
3.6 Germany.....	2
3.7 Greece.....	2
3.8 Italy.....	2
3.9 Netherlands .....	2
3.10 Norway .....	2
3.11 Portugal .....	2
3.12 Sweden .....	2
3.13 Switzerland.....	2
3.14 United Kingdom.....	2
4. CHECKING OF PROPOSED CONCEPTS OF HYBRID VENTILATION SYSTEMS .....	2
4.1 Cold Climate hybrid ventilation system .....	2
4.2 Moderate climate hybrid ventilation system .....	2
4.3 Mild and warm climate hybrid ventilation system.....	2
4.4 Severe cold climate hybrid ventilation system .....	2
5. CONCLUSIONS .....	2
6. REFERENCES.....	2

# 1. Introduction

This report constitutes the second 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 that two extensive surveys of national standards and regulations have been carried out previously, and are therefore considered as part of “state-of-the-art”:

1. A first survey was carried out in the frame of the European TIP-Vent project. The full report can be found on the TIP-Vent CD-ROM: “Impact of Standards and regulations on the performance of ventilation systems” (Task\_3 Final report) by Ch. Filleux and P. Hardegger (2000). Standards and regulations from Belgium, France, Netherlands, Portugal, Sweden, Switzerland and United Kingdom were analysed.
2. A second survey can be found in the AIVC Technical note 55 “A review of International Ventilation, Airtightness, Thermal Insulation and Indoor Air Quality Criteria” by Mark J. Limb (2002). Standards and regulations from Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States of America were analysed.

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

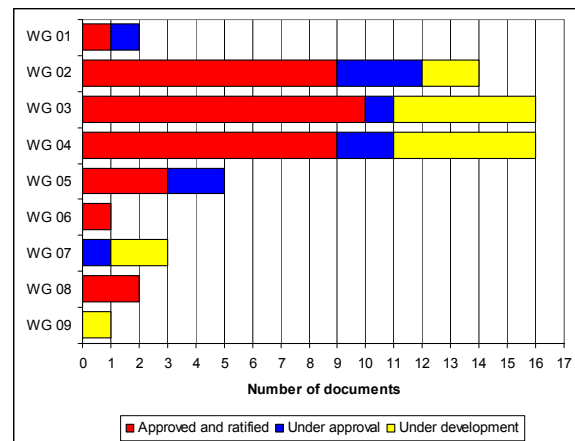
### 2.1 European standards - Technical committee 156 'Ventilation for buildings'

#### 2.1.1 Introduction

Within the European Union, standards related to ventilation for buildings are prepared by the Technical Committee 156 of the CEN (European Committee for Standardisation).

CEN/TC 156 is organized in nine working groups:

1. Terminology
2. Residential ventilation
3. Ductwork
4. Terminal devices
5. Air handling units
6. Indoor climate
7. System performance
8. Installation
9. Fire protection of air distribution systems



**Figure 1: Number of documents approved (or ratified), under approval and under development for each working group (15-12-2003)**

Some documents produced by the working groups are already published as standards or technical reports (22), some have been ratified but not yet published (13), some are under approval (10) and some are under development (15). Some documents are revision of documents already published as standards.

The following tables give an overview of these documents.

#### Remarks:

- For documents that have already received one, the reference number (e.g. EN 12220) is given. Otherwise, the working item number (e.g. 156029 which means WI 029 of TC 156) is given.
- It is important to pay also attention to other standardisation committees, e.g. TC 89.



Updated lists of the documents under development, under approval or already published can be found on the CEN web site (available in English):  
<http://www.cenorm.be/cenorm/index.htm> > Standards and drafts > Finding draft standards > select "CEN/TC 156 Ventilation for buildings"  
> Standard under development  
> Published standards

## 2.1.2 Published documents (15-12-2003)

Reference number	WG	Document title
CR 1752:1998	6	Ventilation for buildings - Design criteria for the indoor environment
CR 12792:1997	1	Ventilation for buildings – Symbols and terminology
CR 14378:2002	3	Ventilation for buildings - Experimental determination of mechanical energy loss coefficients of air handling components
ENV 12097:1997	3	Ventilation for buildings - Ductwork - Requirements for ductwork components to facilitate maintenance of ductwork systems
EN 1505:1997	3	Ventilation for buildings - Sheet metal air ducts and fittings with rectangular cross section - Dimensions
EN 1506:1997	3	Ventilation for buildings - Sheet metal air ducts and fittings with circular cross-section - Dimensions
EN 1751:1998	4	Ventilation for buildings - Air terminal devices - Aerodynamic testing of dampers and valves
EN 1886:1998	5	Ventilation for buildings - Air handling units - Mechanical performance
EN 12220:1998	3	Ventilation for buildings - Ductwork - Dimensions of circular flanges for general ventilation
EN 12236:2002	3	Ventilation for buildings - Ductwork hangers and supports - Requirements for strength
EN 12237:2003	3	Ventilation for buildings - Ductwork - Strength and leakage of circular sheet metal ducts
EN 12238:2001	4	Ventilation for buildings - Air terminal devices - Aerodynamic testing and rating for mixed flow application
EN 12239:2001	4	Ventilation for buildings - Air terminal devices - Aerodynamic testing and rating for displacement flow applications
EN 12589:2001	4	Ventilation for buildings - Air terminal units - Aerodynamic testing and rating of constant and variable rate terminal units
EN 12599:2000	8	Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems
EN 13030:2001	4	Ventilation for buildings - Terminals - Performance testing of louvres subjected to simulated rain
EN 13053:2001	5	Ventilation for buildings - Air handling units - Ratings and performance for units, components and sections
EN 13180:2001	3	Ventilation for buildings - Ductwork - Dimensions and mechanical requirements for flexible ducts
EN 13181:2001	4	Ventilation for buildings - Terminals - Performance testing of louvres - Performance testing of louvres subject to simulated sand
EN 13182:2002	4	Ventilation for buildings - Instrumentation requirements for air velocity measurements in ventilated spaces
EN 13264:2001	4	Ventilation for buildings - Floor mounted air terminal devices - Tests for structural classification
EN 13403:2003	3	Ventilation for buildings - Non-metallic ducts - Ductwork made from insulation ductboards

## 2.1.3 Ratified documents (15-12-2003)

Reference number	WG	Document title
EN 12599:2000/prAC	8	Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems
EN 13053:2001/prAC	5	Ventilation for buildings - Air handling units - Ratings and performance for units, components and sections
prEN 13141-1	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 1: Externally and internally mounted air transfer devices

prEN 13141-2	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 2: Exhaust and supply air terminal devices
prEN 13141-3	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 3: Range hoods for residential use
prEN 13141-4	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 4: Fans used in residential ventilation systems
prEN 13141-6	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 6: Exhaust ventilation system packages used in a single dwelling
prEN 13141-7	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings
prEN 13142	2	Ventilation for buildings - Components/products for residential ventilation - Required and optional performance characteristics
prEN 13465	2	Ventilation for buildings - Calculation methods for the determination of air flow rates in dwellings
prEN 14134	2	Ventilation for buildings - Performance testing and installation checks of residential ventilation systems
prEN 14239	3	Ventilation for buildings - Ductwork - Measurement of ductwork surface area
prEN 14240	4	Ventilation for buildings - Chilled ceilings - Testing and rating

#### 2.1.4 Under approval documents (15-12-2003)

Reference number	WG	Document title
prEN 1507	3	Ventilation for buildings - Ductwork - Rectangular sheet metal air ducts - Requirements for testing strength and leakage
prEN 1886:1998 rev	5	Ventilation for buildings – Air handling units – Mechanical Performance
prEN 12792 rev	1	Ventilation for buildings - Symbols, terminology and graphical symbols
prEN 13053:2001 rev	5	Ventilation for buildings - Air handling units - Ratings and performance for units, components and sections
prEN 13141-5	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 5: Cowls and roof outlet terminal devices
prEN 13141-8	2	Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 8: Performance testing of inducted mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for a single room
prEN 13779	7	Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems
prEN 14277	4	Ventilation for buildings - Air terminal devices - Method for airflow measurement by calibrated sensors in ATD/Plenum boxes
prEN 14518	4	Ventilation for buildings - Chilled beams - Testing and rating of passive chilled beams
prEN 14788	2	Ventilation for buildings - Design and dimensioning of residential ventilation systems

## 2.1.5 Under development documents (15-12-2003)

Reference number	WG	Document title
156051	4	Ventilation for buildings - Terminals - Comfort criteria
156058	7	Ventilation for buildings - Cooling load
156073	9	Ventilation for buildings - Fire precautions for air distribution systems in buildings
156077	7	Ventilation for buildings - Calculation methods for air flow rates in commercial buildings
156078	2	Ventilation for buildings - Calculation methods for energy losses due to ventilation and infiltration in commercial buildings
156079	2	Ventilation for buildings - Calculation methods for energy losses due to ventilation and infiltration in dwellings
156080	4	Ventilation for buildings - Air terminal devices - Aerodynamic testing and rating for mixed flow applications for non-isothermal testing
156083	4	Testing and rating of active chilled ceilings
156084	3	Ventilation for buildings - Flat oval ductwork - Dimensions, strength and leakage
156085	3	Ventilation for buildings - Material specification of surface treatment for ductwork
prEN 12097 rev	3	Ventilation for buildings - Ductwork - Requirements for ductwork components to facilitate maintenance of ductwork systems
prEN 1506 rev	3	Ventilation for buildings - Sheet metal air ducts and fittings with circular cross-section – Dimensions
00156091	3	Ventilation for buildings - Flat oval ductwork - Leakage and strength
00156092	4	Ventilation for buildings - Air terminal devices - Aerodynamic testing and rating for mixed flow applications for non-isothermal testing - Part 2: Hot jets
00156093	4	Technical Report (TR) on basic data used to produce prEN 14240 'Ventilation for buildings- chilled ceilings- Testing and rating' and WI 00156082 'Ventilation for buildings chilled beams - Testing and rating of passive chilled beams'
00156095		Air flow measurements in ventilation systems

### Remark:

**EN** means European Standard. This is a standard developed by CEN (for ventilation at least) and that should be adopted by all Member States within 6 months after his publication. Conflicting national standards have to be withdrawn in the meanwhile.

**prEN** means Draft of European Standard. This document might become an European Standard if it is approved by the CEN members.

**ENV** is old denomination that has been replaced by TS (Technical Specifications). It was a European Standard that Member States were not forced to adopt. Moreover, conflicting national standards could be maintained. After a few years, ENV were supposed to become EN or to be withdrawn.

**CR** means CEN Report. This denomination has been replaced by TR (CEN Technical Report). It could be a document intended to be a standard (EN) but that did not pass the approval procedure.

BBRI has tried to make an overview of standards produced by CEN/TC 156 (approved or under approval) in order to identify possible barriers for hybrid ventilation.



means that the standard applies to residential buildings (even if, in some cases, not very relevant).



means that the standard does not apply to residential buildings.

## 2.1.6 WP 01: Terminology

### **CR 12792:1997** **Ventilation for buildings – Symbols and terminology**



This technical report is a **list of symbols and terminology** to be used in all European Standards produced by TC 156 "Ventilation for buildings".

## 2.1.7 WP 02: Residential ventilation

### **prEN 13141-1** **Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 1: Externally and internally mounted air transfer devices**



This European standard specifies laboratory methods for testing externally and internally mounted air transfer devices operating under pressure differences. It applies to devices located between two spaces (between one room and outside, or between two rooms) of the following types: devices with fixed opening(s), devices with manually adjustable opening(s), devices with pressure difference controlled opening(s), window openings specifically designed to act as an air transfer device.

It describes tests intended to characterise the following: flowrate/pressure, non-reverse flow ability, 'air tightness when closed' (for closeable externally mounted air transfer device), geometrical free area, air diffusion in the occupied zone, sound insulation and water tightness.

This standard does not apply to evaluation of air filtration, condensation risk and noise production.

### **prEN 13141-2** **Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 2: Exhaust and supply air terminal devices**



This European standard specifies laboratory methods for testing exhaust and supply air terminal devices operating under pressure differences. It applies to devices used in mechanical and natural powered residential ventilation systems, of the following types: device with a manually adjustable opening, device with a fixed opening and pressure difference controlled device.

It describes tests intended to characterize: flowrate/pressure, air diffusion characteristics (for supply air terminal devices), noise production for components of systems, insertion loss of component of systems and sound insulation.

**prEN 13141-3****Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 3: Range hoods for residential use**

This European standard specifies methods for measuring the main performance characteristics of range hoods for residential use. It applies to recirculating range hoods, air extraction range hoods incorporating a fan and air extraction range hoods without fan.

This standard does not specify values for performance characteristics.

**prEN 13141-4 Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 4: Fans used in residential ventilation systems**

This European standard specifies aerodynamic, acoustic and energy consumption performance test methods for fans used in residential ventilation. These methods primarily concern: ventilation fans installed on a wall or in a window without any duct, ventilation fans installed in the downstream of a duct, ventilation fans installed in the upstream of a duct, ventilation fans installed in a duct and encased ventilation fans having several inlets.

For acoustic performance testing, one of the following methods can be used: in duct method, reverberant field method, or free field or semi-reverberant method.

**prEN 13141-5****Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 5: Cowls and roof outlet terminal devices**

This European standard specifies methods for measuring the aerodynamic and acoustic characteristics of cowls and roof outlets used in both natural and mechanical ventilation. Only those cowls and roof outlets fitted onto ducts which project above the roof surface are covered by the present standard.

Regarding the assisted cowls, only the fan assisted cowls are covered by the present standard, other types (such as injection assisted cowls) being too recent to be adequately considered for the time being.

The performance testing of the "assistance" provided by the auxiliary fan of an assisted cowl is excluded for the scope of this standard.

**prEN 13141-6****Ventilation for buildings - Performance testing of components/products for residential ventilation - Part 6: Exhaust ventilation system packages used in a single dwelling**

This European standard specifies laboratory methods for measuring the aerodynamic and acoustic performance characteristics and energy consumption of assembled exhaust ventilation system packages for a single dwelling.

The object of this standard is to provide tested characteristics for a system package in worst case conditions so that the user be confident that better values will be achieved on site when the system package is installed in accordance with the manufacturer's instruction and within these limits of the test conditions.

**prEN 13141-7****Ventilation for buildings - Performance testing of mechanical supply and exhaust units (including heat recovery) for mechanical ventilation systems intended for single family dwellings**

This standard specifies the laboratory test methods and test requirements for the testing of aerodynamic, thermal and acoustic performance, and the electrical power of a mechanical supply and exhaust ventilation unit used in a single dwelling.

In general such a unit contains: supply and exhaust air fans, air filters, -air to air heat exchanger with/without air to air heat pump for exhaust air heat recovery and control system.

This standard does not deal with non-ducted units.

**prEN 13142****Ventilation for buildings - Components/products for residential ventilation - Required and optional performance characteristics**

This standard specifies performance characteristics which shall be measured and presented according to relevant test methods, and other performance characteristics which are optional but which may be required, e.g. to comply with local or national regulations.

This standard applies to the following components/products: externally mounted air transfer devices, internally mounted air transfer devices, exhaust and supply air terminal devices, - range hoods, fans, cowls and roof outlets, and residential exhaust ventilation system packages. It mainly refers to the series prEN 13141.

**prEN 13465****Ventilation for buildings - Calculation methods for the determination of air flow rates in dwellings**

This Standard specifies methods to calculate basic whole house air flow rates for single family houses and individual apartments up to the size of approximately 1 000 m<sup>3</sup>, may be used for applications such as energy loss calculations, heat load calculations and indoor air quality evaluations.

The same basic method applies for these different applications, the input parameter values being selected according to the requirements of the specific application.

This standard covers natural, mechanical extract and balanced ventilation systems. Flows due to window opening are also considered, but only as a single sided effect (i.e. no cross ventilation).

**prEN 14134**

**Ventilation for buildings – Performance testing and installation checks of residential ventilation systems**



This standard specifies **checks and test methods** to verify the fitness for purpose of installed systems in dwellings. It can be applied to commissioning of new systems and performance testing of existing systems. Three steps are described:

- a) **completeness checks** to verify if the ventilation system is well documented, conform with all regulations and requirements, safe to use, "reasonably clean", correctly fitted, ...;
- b) **functional checks** to prove the ability of the system to operate according to the specifications;
- c) **functional measurements** to prove that the system actually operates according to the specifications (mainly airflow rates and direction of flows, control and running time).

The standard describes the way to check the system, but does not contain any requirements on the system performances.

#### 2.1.8 WP 03: Ductwork

**CR 14378:2002**

**Ventilation for buildings - Experimental determination of mechanical energy loss coefficients of air handling components**



This Technical report specifies unified **test procedures** and conditions for the experimental determination of mechanical energy loss coefficients for ductwork components such as ducts, bends, diffusers, converging junctions and diverging junctions.

**ENV 12097:1997**

**Ventilation for buildings - Ductwork - Requirements for ductwork components to facilitate maintenance of ductwork systems**



This pre-standard applies to ductwork in buildings subject to human occupancy. It specifies requirements for dimensions, shape and location for openings, access and inspection covers and access doors for cleaning and service in supply and exhaust air ducts. These requirements are valid for any type of ventilation system which includes ductwork; it does not present barriers specific to hybrid ventilation. A revision of this pre-standard is under development.

**EN 1505:1997**

**Ventilation for buildings - Sheet metal air ducts and fittings with rectangular cross section - Dimensions**



This standard specifies the **dimensions** of the rectangular sheet ducts and their accessories. It applies to the networks of ducts used in the ventilation systems and air conditioning of buildings designed for human occupation. The thickness of the ducts and the accessories is not specified in the present standard. Resistance and the sealing are treated in prEN 1507.

**EN 1506:1997**

**Ventilation for buildings - Sheet metal air ducts and fittings with circular cross-section - Dimensions**



This standard is similar as EN 1505, but for circular ducts.

**prEN 1507**

**Ventilation for buildings - Ductwork - Rectangular sheet metal air ducts - Requirements for testing strength and leakage**



This European Standard specifies requirements and methods for the strength and leakage testing of rectangular ducts, including joints. It applies to ductwork used in ventilating and air conditioning systems in buildings, subject to human occupancy. The standard is primarily applicable to steel sheet ducts, but it also applies to rigid ducts manufactured from other metals, such as aluminium and copper. The standard does not take into account the method of duct installation and support.

**EN 12220:1998**

**Ventilation for buildings - Ductworks - Dimensions of circular flanges for general ventilation**



This standard specifies the dimensions of circular flanges for general ventilation.

**EN 12236:2002**

**Ventilation for buildings - Ductwork hangers and supports - Requirements for strength**



This standard provides guideline information for the construction and application of supports and hangers for sheet metal ductwork systems, and air distribution components within those systems. The standard applies only to ductwork (rectangular and oval) and components used in air conditioning and ventilation systems.

**EN 12237:2003**

**Ventilation for buildings - Ductwork - Strength and leakage of circular sheet metal ducts**



This standard specifies requirements and test methods for strength and air leakage of circular ductwork used in air conditioning and ventilation systems in buildings. The requirements and methods are applicable also to rectangular ductwork in respect of air leakage.

**EN 13180:2001**  
**Ventilation for buildings - Ductwork - Dimensions and mechanical requirements for flexible ducts**



This standard specifies requirements and test methods for the technical characteristics of flexible ducts used in ventilation and air conditioning installations in buildings for human occupancy. This standard identifies the following parameters which shall be tested or inspected: - dimensions and tolerances; - mechanical resistance (including airtightness). Acoustic, thermal, fire and pressure loss properties of flexible ducts are not covered in this standard.

**EN 13403:2003**  
**Ventilation for buildings - Non-metallic ducts - Ductwork made from insulation ductboards**



This standard specifies the basic requirements and characteristics for ductwork made of insulation ductboards and used in ventilation and air conditioning systems of buildings subject to human occupancy.

**prEN 14239**  
**Ventilation for buildings - Ductwork - Measurement of ductwork surface area**



This standard specifies a method for the measurement and calculation of the surface area of ductwork and ductwork components.

## 2.1.9 WP 04: Terminal devices

**EN 1751:1998**  
**Ventilation for buildings - Air terminal devices - Aerodynamic testing of dampers and valves**



This standard specifies the **testing methods** and the classification of registers and valves used in the air distribution systems with pressure differences up to 2000 Pa.

The tests included are: a) leakage through a register or a valve closed; b) sealing of the envelope; c) characteristics of the regulations airflow-pressure; d) couples; e) thermal transfer.

The acoustic tests of registers and valves are not included.

**EN 12238:2001**  
**Ventilation for buildings - Air terminal devices - Aerodynamic testing and rating for mixed flow application**



This standard specifies method for the laboratory aerodynamic testing and rating of air terminal devices for mixed flow applications, including the specification of suitable test facilities and measurement techniques. The standard gives only tests for the assessment of characteristics of the air terminal devices under isothermal conditions.

**EN 12239:2001****Ventilation for buildings - Air terminal devices - Aerodynamic testing and rating for displacement flow applications**

This standard specifies methods for the laboratory aerodynamic testing and rating of low velocity air terminal devices for displacement flow applications, including the specification of suitable test facilities and measurement techniques. The standard gives only tests for the assessment of characteristics of the air terminal devices under isothermal conditions. This standard applies to Class IV air terminal devices as defined, the European standard for the aerodynamic testing and rating of air terminal devices for mixed flow applications.

**EN 12589:2001****Ventilation for buildings - Air terminal units - Aerodynamic testing and rating of constant and variable rate terminal units**

This standard specifies methods for the aerodynamic testing and rating of constant and variable flow rate terminal units suitable for use with air distribution systems. The terminal units considered are: - Single and dual duct.- Induction. - Fan assisted induction (parallel and series). - Single duct with integral diffuser.

**EN 13030:2001****Ventilation for buildings - Terminals - Performance testing of louvres subjected to simulated rain**

This standard specifies a **test method** for measuring the water rejection performance of louvres subject to simulated rain and wind pressures, both with and without air flow through the louvre under test.

The standard gives a classification for penetration efficiency.

Class	A	B	C	D
Efficiency	≥ 0.99	0.95 – 0.989	0.80 – 0.949	< 0.80

**EN 13181:2001****Ventilation for buildings - Terminals - Performance testing of louvres - Performance testing of louvres subject to simulated sand**

This standard specifies a **test method** for measuring the sand rejection efficiency of sand trap louvres subject to simulated sand and with air flow through the louvre under test.

**EN 13182:2002****Ventilation for buildings - Instrumentation requirements for air velocity measurements in ventilated spaces**

This standard specifies the main characteristics of air velocity measuring devices. This includes requirements for velocity probes, recalibration and the signal processing of measurements in a ventilated space, including those in the air jet and in the occupied zone.

(\*): This standard applies not the ventilation components but to measuring devices (devices that can be used by standards applying to components for ventilation systems in residential buildings).

**EN 13264:2001**

**Ventilation for buildings - Floor mounted air terminal devices - Tests for structural classification**



This standard specifies structural classification for floor mounted Air Terminal Devices (ATDs) in respect of their possible applications and the following related **structural test** methods: a) Static test methods; b) Impact test methods c) Dynamic test methods.

**prEN 14240**

**Ventilation for buildings - Chilled ceilings - Testing and rating**



This standard specifies test conditions and methods for the determination of the cooling capacity of chilled ceilings and other extended chilled surfaces.

**prEN 14277**

**Ventilation for buildings - Air terminal devices - Method for airflow measurement by calibrated sensors in ATD/Plenum boxes**



This standard specifies methods for the laboratory aerodynamic testing and rating of the air flow rate measurement accuracy of fixed air flow rate measurement devices, including supply and exhaust air terminal devices (ATD) and in-duct measurement stations (IMS) and the sensitivity of such devices to flow disturbance.

**prEN 14518**

**Ventilation for buildings - Chilled beams - Testing and rating of passive chilled beams**



This standard specifies test conditions and methods for the determination of the cooling capacity of chilled beams or other similar systems with free convection, i.e. without forced air flows, as well as the local air velocity and temperature below the beam.

#### 2.1.10 WP05: Air handling units

**EN 1886:1998**

**Ventilation for buildings - Air handling units - Mechanical performances**



This standard specifies the mechanical performances of air handling units (AHU).

**EN 13053:2001**

**Ventilation for buildings - Air handling units - Ratings and performance for units, components and sections**



This standard specifies requirements and testing of ratings and performance of air handling units as a whole. It also specifies requirements, classification and testing of specific components and sections of air handling units. It is however not applicable to air handling units for residential buildings.

#### 2.1.11 WP06: Indoor climate

**CR 1752:1998**

**Ventilation for buildings - Design criteria for the indoor environment**



This Technical Report specifies the requirements for, and methods of expressing the quality of the indoor environment for the design, commissioning, operation and control of ventilation and air-conditioning systems. This Technical Report covers indoor environments where the major concern is the human occupation but excludes dwellings.

#### 2.1.12 WP07: System performance

**prEN 13779**

**Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems**



As it is mentioned in the title and in the § 1 (scope), the standards “applies to the design of ventilation and room-conditioning systems for non-residential buildings subject to human occupancy”. This text can therefore not be a barrier for hybrid ventilation in residential buildings.

#### 2.1.13 WP08: Installation

**EN 12599:2000**

**Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems**



This standard specifies checks, test methods and measuring instruments in order to verify the fitness for purpose of the installed systems at the stage of handing over. According to § 1 (scope), “the standards applies to ventilation and air conditioning systems designed for the maintenance of comfort conditions for building **excluding dwellings**.”

#### 2.1.14 WP09: Fire protection of air distribution systems

No document approved or under approval yet.

### 2.1.15 Discussions

Nowadays, standards and regulations have very different roles<sup>1</sup>:

- a *standard* is a document that specifies a procedure to evaluate the performance of a product or a system, and possibly classify them into classes according to the evaluated performances;
- a *regulation* is a document which gives the (minimal) performances that are required ; it should make references to appropriate standards.

Example: *EN 13030:2001* gives the procedure to evaluate the protection against rain provided by ventilation louvres and defines four classes (A to D) according to the efficiency. A *national regulation* could require ventilation louvres to present a protection of class B, according to EN 13030.

Therefore, the general impression of BBRI is that the CEN standards and technical reports do not present barriers for hybrid ventilation systems by themselves. Of course, they can however have an impact on the design of components for hybrid ventilation. Therefore, every manufacturer should carefully read them. Especially, the following standards should be kept in mind when designing a new product/system:

- The series *prEN 13141*, which specifies test methods for components like those developed in the frame of the RESHYVENT project (e.g. flowrate/pressure relationship, airtightness when closed, acoustical performances, ...). Especially *prEN 13141-5:2002*, which specifies methods for measuring the suction effect of cowls and roof outlets. The suction effect is measured for the least favourable horizontal wind approach angle, and four height vertical wind approach angles.
- *ENV 12097:1997*, which emphasises the importance of the maintenance.
- *EN 13030:2001*, which emphasises that louvres should not allow rain to enter in a building. This can be very important for e.g. intensive night cooling (IC3).

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<sup>1</sup> This is only a theoretical situation. Standards will always include some requirements and regulations some procedures to evaluate product or system performances.

## 2.2 Other documents

Other documents that might be relevant are listed below:

- *EN 779:2002*, written by CEN TC 89, can also be relevant for RESHYVENT.

### **EN 779:2002**

#### **Particulate air filters for general ventilation - Requirements, testing, marking**



This standard specifies tests to determine a filter's fractional particle efficiency. The revised method provides greater knowledge about a filter's performance characteristics, making it possible to:

- evaluate filter performance properties in relation to IAQ requirements and process demands;
- find better agreement between lab test results and filter performance in real operating conditions;
- obtain a faster, simpler test method that is also easier to understand.

- *ISO 5136:2003 Acoustics -- Determination of sound power radiated into a duct by fans and other air-moving devices -- In-duct method*
- *ISO 6944:1985 Fire resistance tests -- Ventilation ducts*

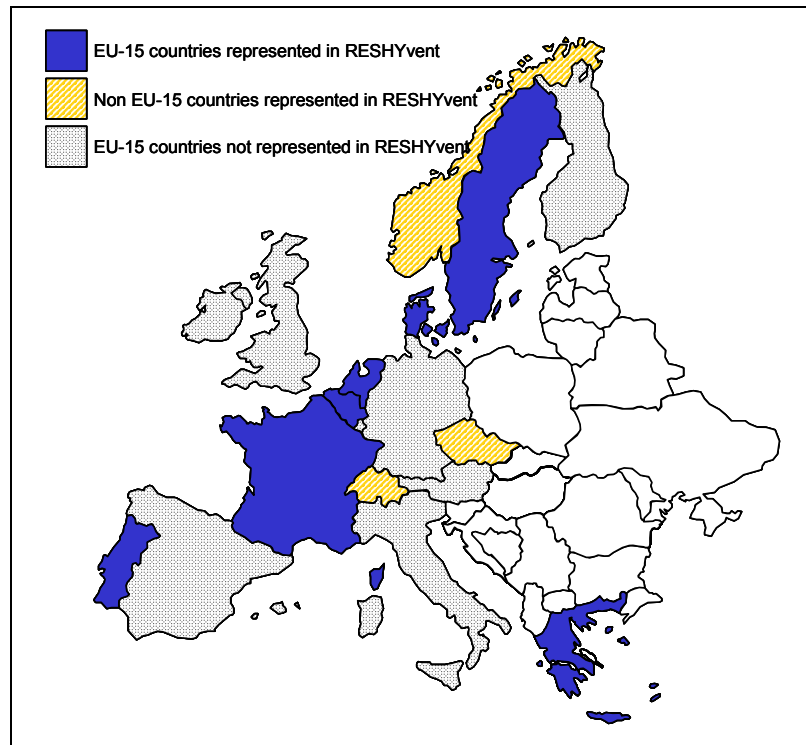
### 3. Documents applying at a national level

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 2: Countries represented in the RESHYVENT project  
(Situation in 2002)**

## 3.1 Belgium

Contribution from Xavier Loncour ([Belgian Building Research Institute](#))



### 3.1.1 Situation in relation to IAQ

#### 3.1.1.1 National standard

In Belgium, one national standard describes the requirement in terms of ventilation of residential buildings (NBN D50-001).

This standard, published in 1991, is written in descriptive terms rather than in performance terms. It describes the different acceptable technical solutions, but also requirements for the ventilation systems, for instance requirements in terms of air flows rates.

The descriptive character of this standard could be a barrier for hybrid ventilation, which is a trend that did not exist when the standard was developed.

#### ➤ Assumptions and definitions

The basic assumption of the standard is that the quality of the outdoor air is good enough to be used as ventilation air. The airflows described in the standard are adapted to occupancy pollutants only and don't take into account any particular risks related to building emission.

The next definitions have to be mentioned:

- Natural ventilation: Natural ventilation is the air exchange resulting from wind speed or from temperature difference between indoor and outdoor environment.
- Mechanical ventilation: Mechanical ventilation is the air exchange resulting from a motorised fan. Mechanical ventilation may be realised via one or several fans.

The description of the simplified ventilation systems (see next §) states that mechanical ventilation must be permanent.

- Permanent ventilation: mechanical air supply or exhaust that cannot be interrupted by manual or automated devices being a part of the system.

In principle, this last definition could be a problem for the application of hybrid ventilation system in Belgium. The system (supply or exhaust) must be based on one principle (natural or mechanical ventilation). In case of mechanical ventilation the fan may not be interrupted. In practice, no barrier exists to dimension the system (supply or exhaust) as a fan-assisted natural ventilation system.

#### ➤ Basic requirements – air flow rates

The basic requirements of the standard are dealing with the air flow rates to realise in the different rooms of the dwelling. The basic rule is to deliver 1 l/s.m<sup>2</sup> with minimum and maximum airflow rates according to the destination of the room.

Type of room	Supply/ Exhaust	Airflow	Minimum airflow rates	Maximum airflow rates
Living rooms	Supply	1 l/s.m <sup>2</sup>	75 m <sup>3</sup> /h	May be limited to 150 m <sup>3</sup> /h
Bedrooms, studies, play rooms	Supply	1 l/s.m <sup>2</sup>	25 m <sup>3</sup> /h	May be limited to 36 m <sup>3</sup> /h per person
Kitchens, bathrooms, laundries	Exhaust	1 l/s.m <sup>2</sup>	50 m <sup>3</sup> /h	May be limited to 75 m <sup>3</sup> /h
WC	Exhaust	25 m <sup>3</sup> /h		

**Table 1: Required airflows according to NBN D 50-001**

The natural ventilation air inlets must be dimensioned for a pressure difference of 2 Pa. The natural ventilation air inlets must be closable and adjustable (continuous or at least 3 different positions between fully open and fully closed). The exhaust ducts for natural ventilation must be mainly vertical and come out of the roof. There is a formula to determine the height above the roof but it is at least 50 cm. The cross section of the ducts is at least 1 m<sup>2</sup> per m<sup>3</sup>/s.

➤ Ventilation systems allowed:

The reference ventilation system is a system where mechanical supply and exhaust occurs in each room of a dwelling. Since application of this kind of system is unrealistic, the standard proposes 4 simplified ventilation systems.

		Air exhaust	
		Natural	Mechanical
Air supply	Natural	A	C
	Mechanical	B	D

**Table 2: Simplified systems**

The application of one of these simplified systems correctly dimensioned according to the rules defined in the standard implies that the requirements of the standard are supposed to be fulfilled.

➤ Application of hybrid ventilation systems in Belgium

The only way a hybrid ventilation system can comply with the requirements of the standard is by dimensioning the whole ventilation system as a full natural ventilation system (A system). This is in general the common way to proceed with this kind of ventilation system. Assistance fans may be installed on this kind of systems. The particular requirements about the way the fan is working, allow to adapt the conception of the exhaust systems by softening the requirements in terms of verticality of the exhaust ducts.

Although the Belgian ventilation standard is written in descriptive terms instead of performance terms, it represents no barriers to the application of hybrid ventilation systems in Belgium. It has to be noted that the standard doesn't give any encouragement to apply hybrid ventilation system.

Such systems have therefore to be considered as fan-assisted natural ventilation systems. All components of the system (air inlets, air exhaust grilles, exhaust ducts, roof outlets) have to be dimensioned as components of a natural ventilation system. The additional requirements on the ventilation system also apply to the hybrid ventilation systems.

### 3.1.1.2 National regulations and requirements

In Belgium, the standards are made at national level by the Belgian Standardisation Institute (BIN-IBN).

The federal or the regional governments can impose requirements, as function of their competencies. Energy efficiency in buildings and ventilation comes under the responsibilities of the Regions (Flemish, Walloon, Brussels). If Belgian standards are available, they should make reference to these standards. Otherwise, they can include the procedure in their regulation.

The next regulations apply in the different Belgian Regions:

- At present, only the Walloon Region imposes to install a ventilation system in new dwellings. To a certain extend, it is also obligatory for retrofitted dwellings.  
*Reference : Walloon Decision of 15-02-1996 "Thermal insulation and ventilation of buildings in the Walloon Region"*  
The Walloon legislation related to ventilation of buildings is quite simple and imposes the respect of the Belgian standard NBN D 50-001.
- The Flemish Region is preparing a new legislation including the ventilation of the new dwellings (also based on NBN D 50-001).
- The Brussels Region does not impose ventilation of buildings.

It has to be noted that standards in Belgium are considered as rule of good workmanship. Even if not required by any regulation, standards should in theory always be applied.

The requirements and the application problems related to the ventilation standard are treated in the next website: <http://www.bbri.be/webcontrole>

### 3.1.2 Situation in relation to the summer comfort

The only reference to the summer comfort in the standard requires the possibility to realise intensive ventilation. The standard requires openable windows in the rooms (. The size of the openable areas must be at least 6.4 % of the floor surface of the room (openings in only 1 façade) or 3.2% (openings in 2 different façades).

No requirements are currently existing in the national regulation in terms of summer comfort. The EPR in preparation in the Flemish Region will consider this aspect in the general evaluation of the energy efficiency of the residential buildings.

### 3.1.3 Summary of possible barriers and proposed solutions to solve them

In Belgium, no barriers to the application of the hybrid ventilation systems have been identified neither in national standards nor in the national regulation. In a certain way, the fact that in some regions of the country no requirements exist concerning the installation of

ventilation systems in residential buildings could be considered as a barrier to the development of ventilation systems in general and to hybrid ventilation systems in particular. Although the standard on residential ventilation has been written in descriptive terms, a way to apply hybrid ventilation system by staying conform to the standard exists.

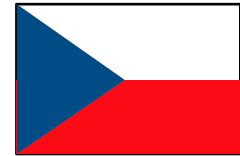
No barrier exists but encouragements to apply such systems are also missing. Writing standards and requirements in more descriptive terms could create incentive to apply this kind of system.

#### 3.1.4 Standard references

- [1] IBN, NBN D50-001 – Ventilation systems for housings, first edition, October 1991 (only available in French and Dutch)

## 3.2 Czech republic

Contribution from Miroslav Jicha ([Brno University of Technology](#))



### 3.2.1 National standards and regulations - comments

Currently in the Czech republic, there is no standard or regulation specifically dealing with ventilation in residential buildings. All requirements on the subject have to be found in standards that deal with construction of houses. The same applies for indoor air quality in residential buildings. Such regulations exist however for to work environment.

As a basis for planning and design of ventilation, either general rules for construction of buildings are applied or appropriate rules for work environment. Moreover, there is no barrier to apply foreign standards and regulations.

Currently, a harmonisation of the Czech standards with EU standards is under way. As a basis, EN 14449 is employed. The Czech standard is supposed to calculate the required amount of the air for ventilation purposes based on both the health requirements and IAQ. The higher value from both is then selected. From the point of health, the WHO permitted concentrations are taken into account, from the point of the comfort the sensorial load defined in Olf and perceived quality of air in dpol. The sensorial load is ranked into 3 categories: A - where only 10% dissatisfied people are acceptable, B - 20% dissatisfied, C - 30% dissatisfied.

Except CSN 730540, according which the thermal stability in rooms has to be fulfilled, the Czech standard does not solve the summer comfort. The comfort is left on the contract between investor and contractor.

### 3.2.2 Overview of the Czech standards.

- *CSN 734301 - Residential buildings.* The standard is valid but currently under revision. This standard sets the basic requirements on ventilation of apartments and how to reach them.
- *CSN 730540 - Thermal protection of buildings, Part 2: functional requirement.* The standard is valid but currently under revision. Among others, the standard contains requirements on thermal stability in winter and summer taking into account heating systems. The standard contains also the minimum requirements set for air change by infiltration and mechanical exchange of air for individual types of buildings.
- *Circular of the Czech Ministry for regional development 137/1998.* The circular sets general requirements for building construction. Namely, requirements for ventilation of rooms (§23), openings fills (§37) and ventilation systems (§48).

### 3.2.3 Basis requirements set by CSN 734301 in relation to ventilation

There are requirements set mainly for residential houses. Single family houses are mostly only on the basis of recommendations.

Habitable rooms must have direct ventilation by windows. Windows with adjustable position should be used, either window wings or vents.

Kitchens in residential houses must be ventilated mechanically. In single family houses, kitchens are recommended to be ventilated naturally or by other efficient means.

Window or an opening to the outside of the house must ventilate bathrooms and WC.

Common airducts can be used for individual apartments, except kitchens, bathroom, WC and rooms of different apartments on one floor.

Ventilation ducts in natural ventilation are allowed to be connected with ventilation stack only in the next upper floor.

Apartments and common spaces must not be connected into one ventilation stack.

### 3.2.4 Basis requirements set by CSN 730540

Air change by infiltration is set for the following types of buildings in Table 3.

Habitable rooms	0.50 ach
Civil buildings (office, schools, libraries, etc.) and other rooms in residential houses	0.35 ach
Other buildings	0.25 ach

**Table 3: Required air change for typical spaces**

From the aforementioned standards and regulations, the following limits are recommended (see Table 4).

Type of room	Minimum extracted airflow [m <sup>3</sup> /hour]	Air change	Additional conditions
Living rooms Bedrooms	3 m <sup>3</sup> /hour.m <sup>2</sup>	0.5	Must be a direct ventilation by opening window or vent
Kitchens with range	100 - 120	3	Must be a direct ventilation by opening window or vent
Kitchens with gas stove	150	>3	Must be a direct ventilation by opening window or vent
Bathroom	60	3-5	Vacuum exhaust
WC	25	3	Vacuum exhaust
Food store, closet		1	
Laundry		3-5	

**Table 4: Required airflows according to CSN 734301 and CSN 730540**

### 3.2.5 Situation in relation to summer comfort

There is no special standard in relation to summer comfort. The standard *CSN 730540 - Thermal protection of buildings, Part 2: functional requirement* sets basic requirements that concern the allowable increase of diurnal temperature in a room. For residential buildings, the increase makes 5K or 7.3K against design temperature depending on the thermal region A or B. The regions are specified in the standard CSN 730540-3.

### 3.2.6 Summary of possible barriers and proposed solutions to solve them

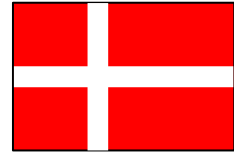
Hybrid ventilation is an unknown system in the Czech republic. There are no barriers in application of hybrid ventilation for residential houses to the extent that the requirements set by current standards are fulfilled. As the standards are under development and in the process of harmonisation with EU standards, it is difficult to specify whether the revised standards will impose any barriers. Opinion of experts is that hybrid ventilation must be first installed on an experimental basis, tested for a long-term performance and after that could be recommended for practical use.

### 3.2.7 Standard references

- [1] CSN 734301 - Residential buildings, issued 1.1.1989, harmonised 1997, currently under revision, (only in Czech)
- [2] CSN 730540 - Thermal protection of buildings, Part 2: functional requirement, issued 1.6.1994, harmonized 1999, currently in fundamental revision that will take into account ventilation of rooms, (only in Czech)
- [3] CSN 060210 - Calculation of thermal losses of buildings for central heating systems, (only in Czech)
- [4] Circular of the Czech Ministry for regional development 137/1998, (only in Czech)

### 3.3 Denmark

Contribution from Line O. Bushby ([Esbensen consulting engineers ltd](#))



#### 3.3.1 Situation in relation to IAQ

##### Dwellings

The requirements to indoor air quality in dwellings are in the Danish Building Regulations for Small Dwellings 1998 (for single family houses) and in the Danish Building Regulations 1995 (for multi-storey houses). The requirements are given as minimum ventilation rates. 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 are allowed.

The regulations require that each habitable room and the entire dwelling shall at least have a total air exchange rate of  $0.5 \text{ h}^{-1}$ . In dwellings with natural ventilation, minimum opening areas are required. In dwellings with mechanical exhaust or mechanical ventilation, minimum exhaust flows are required from kitchen and bathroom. The exhaust shall be continuously operated. In small flats with mechanical exhaust, the air exchange rate can be up till  $1.0 \text{ h}^{-1}$ . The regulations also requires that building materials must not emit gases, vapours, particles or ionising radiation that can cause an unhealthy indoor climate. Reference is given in the guide section to the Danish Indoor Climate Labelling of Building Products. There are no direct requirements to the indoor air quality in dwellings.

##### Offices

There are no requirements in the Danish Building Regulations related to ventilation rate in offices. The guide section says that natural ventilation will suffice in offices for one or a few people and that mechanical ventilation may be needed in offices for a large number of people and in assembly rooms. Reference is given in the guide section to DS 447. DS 447 only requires that the minimum external supply airflow should be specified in the project. If smoking is not allowed, the guide section of DS 447 proposes between 4 and 10 l/(s.person), according to the room volume per person. If smoking is allowed, the guide section of DS 447 proposes 10 l/(s.person) independent of the room volume per person. Most HVAC designers are aware that this minimum requirement is often too low if smoking is allowed and specifies a higher ventilation rate. The Danish Working Environment codes specifies that 1000 ppm  $\text{CO}_2$  is acceptable in the working environment and that improvements has to be made if the  $\text{CO}_2$  goes beyond 2000 ppm.

##### Schools

The Danish Building Regulations requires mechanical ventilation in classrooms. At least 5 l/(s.person) plus  $0.4 \text{ l/(s.m}^2)$  must be supplied and extracted in each class. If special building measures are used, e.g. larger room volumes per person and provision of several possibilities for airing rooms, including possibilities for cross-ventilation, the requirement of mechanical ventilation may be waived provided a healthy indoor climate can be maintained. There are no direct requirements to the indoor air quality in schools.

#### 3.3.2 Situation in relation to the summer comfort

The Danish Building Regulation for Small Dwellings 1998 (BR-S 98) and the Danish Building Regulations 1995 (for multi-storey houses, offices, schools etc. called BR95) both states, that 'buildings shall be so constructed as to ensure a satisfactory indoor climate with respect to health and safety in normal use'.

There is no direct reference to summer temperatures in BR-S 98.

Section 11.5 in BR95 deals with indoor temperatures and say that 'buildings shall be so constructed the healthy temperatures can be maintained in room occupied for prolonged periods of time during normal use of buildings, having regard to the human activity in the rooms'. For functional requirements and methods for specification, verification and inspection and testing of thermal indoor climate BR95 refers to Danish Standard DS 474: Code for indoor thermal climate.

DS 474 deals with a range of issues related to indoor thermal climate mainly based on the work of Fanger and similar researchers. In terms of general temperatures it is advised to maintain the operative temperature in a range from 20°C to 24°C (1.0 clo) yet during summer from 23°C to 26°C (0.5 clo).

It is allowed periodically to exceed the normal temperature ranges under which comfortable indoors conditions occur, if the outdoor temperature or other conditions is extreme. Thus it is advised that the operative temperature maximum exceeds 26°C and 27°C in 100 hours and 25 hours during a typical year (during warm days with light summer close and low physical activity level of the concerned people).

### 3.3.3 Summary of possible barriers and proposed solutions to solve them

At present, no formal procedures for assessing innovative systems by calculation or laboratory testing exist. In practise, the building authorities are fairly flexible in the acceptance of innovative systems in offices and schools if the designer can make probable that the system will result in an acceptable IAQ.

#### Dwellings

Hopefully demand controlled ventilation will be allowed in dwellings in future regulations. Research is ongoing to prove that demand control can be satisfactory to the indoor climate.

#### Offices and schools

No changes are to be foreseen.

### 3.3.4 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.

### 3.4 Finland

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



#### 3.4.1 Situation in relation to IAQ

The National Building Code of Finland contains binding requirements and non-binding guidelines how to meet these requirements. The present building code for indoor climate and ventilation came into effect in 1988 [1].

More instructions are given in a voluntary classification of indoor climate [2] which is generally referred to in construction contracts. The lowest classification level out of three corresponds to the building code. Both the building code and the classification are applied to dwellings, offices and schools as well.

##### Indoor air quality related aspects

The binding indoor air quality requirements in the building code are verbal but the actual performance numbers in the official guidelines are in practise regarded almost as mandatory.

The minimum air change rate is generally  $0.5 \text{ h}^{-1}$  but higher air flow rates in the guidelines for specific spaces are usually applied. For example the minimum air flow rate in office rooms is  $3.6 \text{ m}^3/\text{h}/\text{m}^2$  and in classrooms  $11 \text{ m}^3/\text{h}/\text{m}^2$ .

To give an idea of the voluntary indoor climate classification system the  $\text{CO}_2$  concentrations of the three levels are 1200, 900 and 700 ppm, from the lowest to the highest level. The corresponding air flow rates per person are 22, 29 and  $43 \text{ m}^3/\text{h}/\text{person}$ .

A new proposal of the National Building Code of Finland is in preparation. The new proposal sets higher demands for indoor air quality. The maximum  $\text{CO}_2$  concentration 1000 ppm is now included as a binding regulation and the air flow rates in the guidelines are changed correspondingly. The air flow rate per person is now  $29 \text{ m}^3/\text{h}/\text{person}$  in dwellings, offices and schools as well. The proposal includes also minimum air change rate  $0.2 \text{ h}^{-1}$  for non-occupied hours. An important technical aspect for natural or hybrid ventilation is that the supply air filter is now compulsory.

Natural or hybrid ventilation is not well described in the guidelines and therefore it is up to the designer to prove the performance of the design to the local authorities. There are no standard calculation procedures which means that the evaluation of the system is difficult and the decisions are variable.

#### 3.4.2 Situation in relation to the summer comfort

Such guidelines do not concern dwellings.

#### 3.4.3 References

- [1] National building code of Finland, part D2, indoor climate and ventilation. Regulations and guidelines 1987. Ministry of the Environment, Helsinki.
- [2] Säteri, J., Hahkala, H. New target values for IAQ and climate in Finland. Proceedings of Healthy Buildings 2000 conference. Espoo, 6 - 10 Aug. 2000, Vol. 4. 511 – 522.

### 3.5 France

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



#### 3.5.1 Situation in relation to IAQ

*The 1982 national regulation [1].*

##### System

The ventilation system can use natural forces (passive stack ventilation) or mechanical forces. Collective ducts can be used.

##### Airflow

The ventilation was required to continuously provide air change in each habitable room. It had to supply fresh air to the habitable rooms and to exhaust stale air from the service rooms. The extract flow rate are given versus the number of habitable rooms as follow:

Number of habitable rooms	Extract flow (m <sup>3</sup> /h)				
	Kitchen	Bathroom or shower-room	Other water-room	Toilets	
				single	multiple
1	75	15	15	15	15
2	90	15	15	15	15
3	105	30	15	15	15
4	120	30	15	30	15
5 en more	135	30	15	30	15

These flows can be reduced subject to respect the following values:

	number of habitable rooms						
	1	2	3	4	5	6	7
Minimal flow in kitchen (m <sup>3</sup> /h)	35	60	75	90	105	120	135
Minimal flow for all the dwelling (m <sup>3</sup> /h)	105	120	150	165	210	210	210

In case of controlled system which adjust automatically the extract flows the values given here above can be reduced in the occupant's absence:

	number of habitable rooms						
	1	2	3	4	5	6	7
Minimal flow for all the dwelling (m <sup>3</sup> /h)	10	10	15	20	25	30	35

### 3.5.2 Situation in relation to the summer comfort

The RT 2000 takes into account summer comfort through an approach equivalent to the energy one. For non cooled buildings, the basic requirement is that the maximum temperature for a reference warm day Tic (calculated as the average operative temperature for the 3 consecutive warmest hours) must be less or equal to a reference one Ticref calculated by applying reference solar protections. These Tic values are calculated with a dynamic calculation method (Th E) according to CE standard.

It is also imposed that the window opening ratio must be at least 30 % in each habitable room.

Use of night cooling is also possible to improve summer comfort, but the calculation method Th E does not include many possibilities for that for the moment.

### 3.5.3 Summary of possible barriers

In France, both IAQ and thermal regulations allow 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 IAQ:

- the regulation stipulates that the air flows must be reached in winter average conditions. For passive stack system, this requires the definition of such conditions, and associated calculation method. Such documents/method are not available today. Designers are therefore reluctant to propose such system, having few bases to prove their compliance.
- for automatically controlled system, it stipulates that the air flow reduction must not lead to health impact, and that condensation should not occur but for limited period. The technical agreement group for humidity controlled system had therefore developed an equivalence methodology, based on yearly simulations (whose results are also used for energy requirements). [6]

Some other limitations have also to be taken into account:

- the inlets can be adjustable, but not closable, [1]
- in case of gas appliances the inlets have to have a minimal area, [2]
- if several fans are used in a same dwelling they have to run simultaneously [1],
- it is not possible to connect a fan (e.g. a kitchen hood) to a collective installation of extract flow [1] and [3].

### 3.5.4 References

These documents are only available in French:

- [3] Arrêté du 24 mars 1982 (urbanisme, logement, énergie, santé) modifié - dispositions relatives à l'aération des logements
- [4] 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 à l'intérieur des bâtiments d'habitation et de leurs dépendances
- [5] Arrêté du 31 janvier 1986 (intérieur et décentralisation, urbanisme, logement et transport) modifié, relatif à la protection contre l'incendie des bâtiments d'habitation

- [6] RT 2000 : Arrêté du 29 novembre 2000 (équipement, transport et logement) relatif aux caractéristiques thermiques des bâtiments nouveaux et des parties nouvelles de bâtiments
- [7] RT 2000 : Règles de calcul Th-C Th-E
- [8] Modalités d'instruction des Avis Techniques sur les systèmes de ventilation asservis

## 3.6 Germany

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



### 3.6.1 Situation in relation to IAQ

Basis of every implemented ventilation system is the German industrial norm DIN 1946. In part 2 the requirements concerning health and hygiene are specified. This is done by general demands on the indoor climate (operative temperature, air quality, air moisture, velocity, pollution and ventilation efficiency). The guidelines are verbally performed and refer to special regulations.

#### Indoor air quality related aspects

In terms of the CO<sub>2</sub> concentration it is recommended to keep the level below 1500 ppm. Furthermore for variably used rooms different air change rates are specified (referring to areas and persons, see table below). But there is no instruction how to meet the demands of air change.

By the way, it is stated within the introduction of the norm that air quality and thermal comfort could not be always guaranteed by using natural ventilation.

In addition to the basic norm DIN 1946 there are some special regulations and guidelines concerning ventilation systems in dwellings (VDI 2088), demand controlled ventilation (VDMA 24773), ...

If the building is a public one there is a regulation to keep that is called AMEV which is nearly equivalent to DIN 1946 but more detailed concerning the type of building.

Area of the flat [m <sup>2</sup> ]	Planned occupancy [persons]	Planned outdoor air change rate	
		Natural ventilation [m <sup>3</sup> /h]	Mech. Ventilation [m <sup>3</sup> /h]
< 50	up to 2	60	60
50 ...80	up to 4	90	120
> 80	up to 6	120	180

**Table 5: Airflows in dwellings according to DIN 1946 part 6**

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.

### 3.6.2 Situation in relation to the summer comfort

In general the norm DIN EN ISO 7730 is used for summer comfort.

The design criteria are described in the CR 1752 (ventilation for buildings – design criteria for the indoor environment).

(Simply said the German industrial norm DIN 1946 part 2 recommends that the indoor temperature should not exceed 27°C.)

### 3.7 Greece

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



#### 3.7.1 Situation in relation to IAQ

##### National regulations and requirements

The legislative sources concerning the indoor air quality are:

- **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 Technical Guide of the Technical Chamber of Greece, 2423/1986 deals with the air-conditioning of buildings. It has been ratified by the Ministerial decision 4395 and has the validity of a law.

The air quality issue is dealt in the Technical Guide of the Technical Chamber of Greece, 2425/1986: "Installations in buildings: Calculation of air-conditioning loads in buildings", where the quantity of the required ventilation air in an occupied space is estimated in order to ensure removal of the pollutants from the occupied spaces. The ventilated air needed to remove the pollutants is given by the formula:

$$V = \frac{K}{MAC - K_a} (\text{m}^3 / \text{h})$$

where

- K = quantity of pollutant harmful to the health ( $\text{m}^3 / \text{h}$ )
- $K_a$  = ratio of the harmful pollutant in the incoming air ( $\text{m}^3$  of pollutant /  $\text{m}^3$  of incoming air)
- MAC = maximum allowable concentration of harmful pollutants in the space ( $\text{m}^3$  of pollutant /  $\text{m}^3$  air)

This estimation is usually applied at places with heavy production of pollutants, where the rate of pollutants production is known.

#### 3.7.2 Situation in relation to the summer comfort

The major legislative source that concerns thermal comfort is:

- **Technical Guide of the Technical Chamber of Greece, 2425/1986:**  
"Installations in buildings: Calculation for air-conditioning loads in building"

The second chapter of the Technical Guide of the Technical Chamber of Greece defines the thermal comfort conditions. In this chapter the recommended design temperatures for heating and the design air temperature and humidity for air-conditioned spaces for different use spaces are given.

Also the recommended summer conditions for the indoor spaces are presented. The thermal comfort of each person is dependent on heat exchange between its body and the outdoor

environment and on its activity as well. This heat exchange is a relationship many parameters, like the outdoor ambient temperature and humidity, the air movement, the person's clothes other parameters related to the exchange of thermal radiation between the person and the outdoor environment.

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 25.5oC is recommended. Table 1 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 6: Recommended design temperatures for air conditioned spaces during summer period [1].**

### 3.7.3 Summary of possible barriers and proposed solutions to solve them

The Greek national legislations, as far as indoor air quality and thermal comfort aspects are concerned, are referred mainly to air conditioning buildings. Standards or regulations concerning naturally and hybrid ventilated buildings have not yet been introduced in the existing legislative framework. Nevertheless, it could be said that on one hand the existing legislative sources don't act as a barrier on the performance of hybrid ventilation systems but on the other hand do not promote the application of these systems in the residential buildings.

Namely the following proposals should be taken into account for the future implementation of hybrid ventilation systems in the residential sector on a national basis:

- ✓ Air quality is very elementary treated in the existing national Regulations and it is only mentioned as being one of the conditions that should be fulfilled in a building. The Technical Guides of the Technical Chamber of Greece are referred to air quality for the case of air-conditioned buildings. An existing methodology is missing for the case of naturally ventilated buildings and furthermore for hybrid ventilated buildings.
- ✓ The air quality of the air inside buildings is related to the external air quality. The introduction in the national legislative texts of a methodology for the evaluation of the air quality in the interior of buildings with regard to the outdoor pollutant levels should be adopted in case of the performance of either natural or hybrid ventilation systems in existing Greek building stock.

- ✓ Stricter standards of air quality of the external environment in urban areas will contribute to better quality of air in the interior of buildings.
- ✓ A flexible methodology for the definition of thermal comfort conditions of naturally and hybrid ventilated buildings based on the outdoor meteorological conditions should be adopted in the new legislative texts. The existing one is introduced for air conditioned buildings, where the indoor environment can be controlled and is not subjected directly to the outdoor conditions. A more tolerant definition of the indoor comfort conditions – ranging within realistic limits – should be more appropriate in case of hybrid ventilation buildings.

#### 3.7.4 References

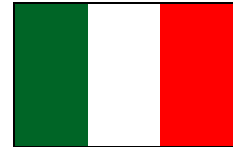
- [1] Installations in Buildings: Calculation of air-conditioning loads in buildings, Technical Guide, Technical Chamber of Greece, 2425/86.
- [2] Installations in Buildings: Air-conditioning of buildings, Technical Guide, Technical Chamber of Greece, 2423/86.
- [3] Source book of Legislation on passive solar energy and energy conservation: Europe-Greece-Italy, Energy Conservation in Buildings, CIENE, EC DGXVII.

## 3.8 Italy

Contribution from Marco Citterio et al.

(Italian National Agency for New Technology, Energy and Environment)

– Written in the scope of the HYBVENT project



### 3.8.1 Situation in relation to IAQ

Ventilation systems in Italy have to be compliant to the standard UNI 10339 “Air-conditioning systems for thermal comfort in buildings - General, classification and requirements - Offer, order and supply specifications”. Systems with no mechanical intake of outdoor air are out of the sphere of application of the above said standard.

Therefore, systems in which hybrid ventilation is used (i.e. in which ventilation is partially natural and partially mechanical) should be influenced directly from UNI 10339 to the extent of the part of outdoor air mechanically supplied.

UNI 10339 Standard on clause 9 indicates some requirements which have to be satisfied by ventilation systems. These requirements should be necessarily considered to be aimed at hybrid ventilation systems too. In fact it is obvious that the adoption of a hybrid ventilation system takes place only when at least the following conditions are satisfied:

1. the saving of energy and therefore of money obtainable avoiding the thermal-hygrometric treatment and the mechanical movement of part of the outdoor air is higher than the extra cost due to plant design complications deriving from having two coupled systems of different kind with their adjustment and control devices;
2. the goals in terms of thermal-hygrometric comfort and of indoor air quality (IAQ) which are reached by means of purely natural or mechanical ventilation systems can be equally achieved.

While the first condition is based on purely economic considerations (and it is not a restriction by itself), the second one relies on the protection of the occupants’ health and comfort. This is the reason why the second condition is subject to constraints like in the UNI 10339 Standard.

The air conditioning system must ensure:

I) **thermal-hygrometric** conditions according to the prescriptions;

II) **IAQ and air motion** conditions according to the prescriptions and more precisely:

1. outdoor air supply equal or higher than the minimum values of number of air changes as a function of:
  - a. use of the air-conditioned space;
  - b. occupancy of the space;
  - c. floor surface (plant) of the space;
  - d. volume of the space;
2. filtration of the outdoor and recirculated air above a certain minimum grade;
3. constraint on the motion of the air (i.e. on air velocities) inside the conventional volume occupied.

The condition I) is satisfied by imposing lower and higher limits to the temperature and the relative humidity (for both winter and summer operation). When hybrid ventilation is used the calculation may be more delicate and difficult than in the case where temperature and relative humidity of a controlled ventilating air flow are imposed. Nevertheless, by means of an adequate strategy which establishes the fraction of natural ventilation to be used, it is possible to satisfy, in theory, whatever need could arise in function of indoor (i.e. of the room inside of which it is necessary to control the temperature and the relative humidity) and outdoor conditions.

The condition II) implies the adoption of the three sub-conditions which should allow to obtain a satisfactory IAQ. The procedure as it is planned could result effective in the case in which:

1. the concentrations of every pollutant taken into consideration and present in the outdoor air are lower than the limits as shown in Table 7;
2. the room does not change its use;
3. unusual (i.e. not considered during the project phase) contaminants are not introduced into the space;
4. unusually strong sources of specific contaminants are not introduced into the space.

It is possible that the above four conditions are not respected.

Contaminant	Long term			Short term		
	Concentration averaging			Concentration averaging		
	$\mu\text{g}/\text{m}^3$	ppm	period	$\mu\text{g}/\text{m}^3$	ppm	period
Sulfur dioxide (SO <sub>2</sub> )	80	0,03	1 year	365	0,14	24 h
Total Particulate	75 <sup>a</sup>	-	1 year	260	-	24 h
Carbon monoxide (CO)	-	-	-	40000	35	1 h
Carbon monoxide (CO)	-	-	-	10000	9	8 h
Oxidants (ozone, O <sub>3</sub> )	-	-	-	235	0.12	1 h
Nitrogen dioxide (NO <sub>2</sub> )	100	0,055	1 year	-	-	-
Lead	1.5	-	3 months	-	-	-

a- arithmetic mean

**Table 7 : Acceptable quality outdoor air pollutants (from ASHRAE Standard 62 - 1989)**

### 3.8.2 Summary of possible barriers and proposed solutions to solve them

As inside UNI 10339 Standard the “Indoor Air Quality Procedure” approach (ASHRAE Standard 62 - 1989) is not considered, i.e. the acceptable IAQ is achieved within the space by controlling known and specifiable contaminants, it is possible that the adoption of hybrid ventilation systems leads to unwanted and harmful concentrations of contaminants. This fact can be considered and obstacle to the adoption of a hybrid ventilation system.

In order to come over this obstacle it could be necessary to measure and at least to evaluate by calculations during the project phase the quality of the air inside the space to be ventilated in this way.

### 3.9 Netherlands

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



#### 3.9.1 Introduction

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.

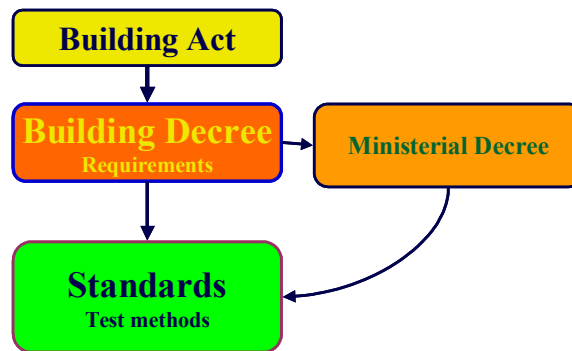


Figure 3: The relation between building act, building decree and standards

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 from 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.

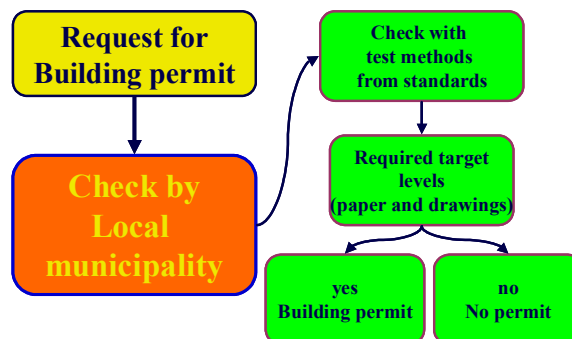
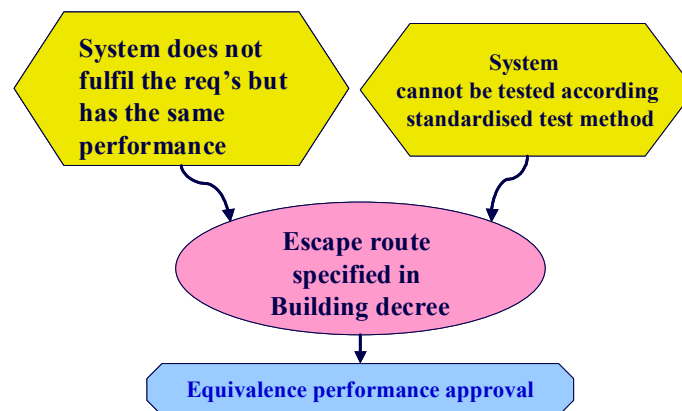


Figure 4: A scheme on checks for the building permit

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 and existing dwellings the requirements are given in the Building Decree and the determination method in NEN 1087 Ventilation of buildings for newly built estates and NEN 8087 Ventilation of buildings for existing estates.

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

### 3.9.2 Ventilation

An occupant must have ventilation provisions to realise the required airflow rates, as described in Table 8. Supplies to occupation areas such as living and bedrooms must be controllable. These areas may have overflow provisions as extract. Some special rules are valid in this case. The total flow rate required for the whole dwelling is depending on the largest occupation area in the building but is normally not less than 42 dm<sup>3</sup>/s, which is the sum of the extract flows for kitchen, bathroom and toilet. The direction of flow is also required and a determination method is described in the standard NEN 1087.

Type of room	Capacity of flow rate required	Remarks
Occupation areas	0.9 dm <sup>3</sup> /s per m <sup>2</sup> floor area min. 7 dm <sup>3</sup> /s	– min. 50% from outside – controllable – draught requirement 0.2 m/s at ΔT=20 K
Kitchen	21 dm <sup>3</sup> /s	Extract direct to outside
Bathroom	14 dm <sup>3</sup> /s	Extract direct to outside
Toilet	7 dm <sup>3</sup> /s	Extract direct to outside

**Table 8: Requirements for newly built dwellings**

The requirements for existing dwellings are only absolute minima. All existing dwellings should fulfil the requirements existing during their construction.

The main difference for existing dwelling is 0.7 dm<sup>3</sup>/s in stead of 0.9 dm<sup>3</sup>/s. Furthermore, there are no requirements on comfort, controllability and flow direction.

Type of room	Capacity of flow rate required	Remarks
Occupation areas	0.7 dm <sup>3</sup> /s per m <sup>2</sup> floor area min. 7 dm <sup>3</sup> /s	– min. 50% from outside – no control required – no comfort requirements
Kitchen	21 dm <sup>3</sup> /s	Extract direct to outside
Bathroom	14 dm <sup>3</sup> /s	Extract direct to outside
Toilet	7 dm <sup>3</sup> /s	Extract direct to outside

**Table 9: Requirements for existing dwellings**

### 3.9.3 Airtightness

The requirements of the building airtightness are given in the building decree. The airtightness is expressed as a flow rate at a pressure difference of 10 Pa ( $q_{v10}$  : air leakage of the of the building dm<sup>3</sup>/s).

In brief, for dwellings up to 500 m<sup>3</sup>, the airtightness should be lower than 200 dm<sup>3</sup>/s @ 10 Pa (which approximately corresponds to  $n_{50} \cong 8 \text{ h}^{-1}$ ). For dwellings larger than 500 m<sup>3</sup>, an equal amount of airtightness may be applied according to the volume.

### 3.9.4 Example of barriers (for system developed by IC2)

In case of natural ventilation, the Dutch standard gives the height above which the roof cowl must be placed. For a hybrid system, which can sometimes operate in natural mode, this requirement could be considered as a barrier as it is not required. Indeed, the aim of this requirement is to be sure that the roof cowl is in negative pressure, so that air is actually extracted. An innovative system like the one developed by IC2 measures the actual airflow. If the airflow is too low, a fan is turned on. So, there is no reason anymore to have this requirement.

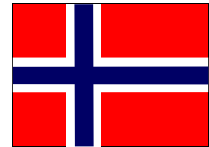
The “principle of equivalence” can be used to demonstrate that the performances of the system are the same or better than the performances required by the standards and regulations. The principle of equivalence is a very open procedure. Anyone can produce a report; the report must be accepted by the municipality. In the case mentioned here above, a description of the control strategy could possibly be enough to prove that the requirement is fulfilled, even if the cowl is placed under the requested height. In other cases, extensive simulations could be necessary to prove the performances.

### 3.9.5 References

- [1] Dutch Building Decree, Staatsblad 410, 7 augustus 2001
- [2] NEN 1087 Ventilation of buildings, Determination methods for newly built estates, NNI, Delft, December 2001
- [3] NEN 8087 Ventilation of buildings, Determination methods existing estates, NNI, Delft, December 2001
- [4] NEN 2686 Air tightness of buildings, Determination method, NNI, Delft, December 2001

### 3.10 Norway

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



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 functional requirements given in TEK can be satisfied, by describing pre-accepted design solutions. These documents are administered by the National Office of Building Technology and Administration in Oslo (*Statens Byggtekniske Etat*). The law and its regulations are statutory, whilst the guidebook simply presents an interpretation of the law and its regulations, and is not statutory itself. The law and its regulations give predominantly *functional requirements* as opposed to specific design details, thus the regulations can be interpreted in ways that give other acceptable designs than those that are recommended in the guidebook, but such alternative designs should be founded on sufficient documented analysis. So, although the guidebook does not give statutory requirements for design execution or performance, in practice the advice in the guidebook has a very strong bearing on practice in the building industry in Norway.

Since the building regulations are functional-requirement based, they do not explicitly condone natural ventilation in dwellings. Indeed, the guidebook attempts to give guidelines for minimum dimensions of passive stacks in dwellings. However, conventional natural ventilation (e.g. passive stack) has proved to be generally inadequate in modern Nordic dwellings, so about 98% of new housing in Norway has mechanical ventilation, about half balanced and half exhaust ventilation.

Below is a summary of the most important points in the regulations and its guidebook, that have a bearing on the indoor environment and ventilation solutions in dwellings. **A commentary giving NBI's own opinions and experiences is given in lighter-coloured text.**

- *Energy consumption and peak demand for a building:* Here, the greatest concern is to limit energy consumption for heating during winter. One of the three following alternatives can be chosen:
  - Energy consumption limit (*energiramme*) based on calculations with EN 832
  - Specified levels of insulation
  - Heat loss limit (*varmetapsramme*)
- *Airtightness:* The building envelope's airtightness for detached and terraced housing: recommended maximum  $n_{50}=4$  ach at 50 Pa.
- *Air quality:*
  - The air quality in a building shall be acceptable. The indoor air shall not contain pollutants in known damaging concentrations with respect to health or irritation.
  - If the outdoor air quality is not satisfactory (e.g. due to traffic, industry) then it shall be filtered before it is supplied to the building. The filter should be at least F7. **(In Norway, dwellings with mechanical exhaust ventilation generally do not have a proper filter [fresh air vents are often integrated in the windows], but balanced ventilation systems are often installed with effective EU7 filters.)**
- *Pollutants:* Dwellings with a radon risk should have a ventilation system that creates minimal negative pressure. The annual mean radon concentration indoors should not exceed 200 Bq/m<sup>3</sup> indoor air.
- *Ventilation:*

- Basal ventilation of at least 0.5 air changes per hour [ach] in dwellings, even when the dwelling is not occupied. (NBI believes that the air change rate can be reduced to 0.15  $\ell/s$  pr  $m^2$  useful floor area [0.25 ach] when the dwelling is unoccupied for longer than 24 hours, to reduce the ventilation heat loss without detriment to the air quality, since infiltration contributes in addition to basal ventilation. Moisture production is reduced when the occupants leave the building for longer periods. The basal ventilation shall then just hinder moisture damage and remove emissions from materials. Infiltration in dwellings with balanced ventilation is bigger than for dwellings with mechanical extract. NBI believes that one can consider the infiltration as part of the useful ventilation flow rate in dwellings with balanced ventilation—in which case the useful contribution shall not be considered to be greater than 0.10~0.15 ach. Here we mean infiltration through leaks, which occurs all year, and excludes periodic purposeful airing with windows or doors. Though the regulations do not explicitly mention features such as demand-control, cascade-flow, displacement ventilation etc., in NBI’s opinion it is acceptable to be able to reduce design flow rates within reasonable limits on the basis of these.)
- An additional recommended requirement of *at least 7  $\ell/s$*  fresh air per person in occupied bedrooms. This requirement was removed from the guide in 1999, but will very likely reappear in the next edition. Bedroom ventilation is an issue, and is used by manufacturers as an argument for balanced ventilation, since extract ventilation can not guarantee 7  $\ell/s$  at all times (with closed windows).
- Supply of 42-84  $\ell/s$  to wood-burning stoves etc., which equates to a total fresh air vent opening area of at least 300  $cm^2$ , either well distributed in the room or as a fresh air duct direct to the fireplace.
- Specified extract flow rate from wet-rooms, as shown below:

	Minimum [ $\ell/s$ ]	Boosted [ $\ell/s$ ]	
Kitchen	10	30	Boosted from fan-powered extract hood
Bathroom	15	30	No requirement for boosted exhaust if there is an openable window
WC	10	-	
Washroom / drying room	10	20	No requirement is open connection to kitchen. No requirement for boosted exhaust if there is an openable window. Extract to outside for tumble dryer without condenser.

- The ventilation system’s fresh air intake shall be located to give the best possible indoor air quality.
- *Protection against noise from building services:* For limit values for acceptable total sound pressure level ( $L_{p,max}$ ) from technical installations (ventilation, lifts, heating, cooling, plumbing etc.) in the same building or adjacent building, including sources such as garages and communal car parking, which can not be controlled by the affected occupant, the building regulations refer to Norwegian Standard NS-8175 sound level class C [4]; summarized in the table below. If one can control the ventilation unit in one’s own dwelling, then these are recommended limit values, not statutory requirements. **These regulations do not necessarily guarantee satisfactory comfort, so NBI recommends that the maximum sound levels should be about 5 dB(A) lower, particularly for occupied rooms.**

Room type	Building regulations (NS-8175)	NBI's stricter recommendations
	(L <sub>max</sub> )	(L <sub>max</sub> )
Bedroom	32 dB(A), 47 dB(C)	27 dB(A)
Kitchen	37 dB(A)	33 dB(A), max 45 dB(A) when boosted
Living room etc.	32 dB(A), 47 dB(C)	27 dB(A)
Bathroom / WC	37 dB(A)	33 dB(A)
Outdoor space, and outside windows at night	35 dB(A)	-

- *Thermal indoor climate:* Recommended requirements for thermal comfort are given in CEN CR 1752 [5], which is in the process of being published as a Norwegian Standard. The table below gives requirements for class B, though the building regulations do not explicitly state which class is required.

	Thermal comfort for body as a whole	Local thermal discomfort (parts of body)						
		Draught	Vertical temperature difference (head/feet)	Floor temperature	Radiation asymmetry			
					Cold wall	Warm wall	Cold ceiling	Warm ceiling
Requirement (% dissatisfied)	-0.5<PMV<+0.5 (< 10%)	DR < 20% (< 20%)	< 3°C (< 5%)	19 - 29°C (< 10%)	<10°C	<23°C	<14°C	<5°C (< 5%)

- *Operation, maintenance and cleaning:* Technical installations shall be arranged for effective operation, and simple and effective maintenance and cleaning
- *Technical requirements for ventilation systems:* Here are specified requirements for, among other things, airtightness and fire safety of air ducts and air handling units.
  - It is recommended to use round ducts of galvanized steel. These are advantageous with respect to air quality, cleaning, durability, maintenance and fire. For fitting ducts to air terminal devices, short lengths of flexible aluminium ducts can be used, within the same fire cell. Beyond this, flexible ducts should not be used.
  - For technical requirements to the actual ventilation unit, NBI has developed a report suggested list of requirements, which could in future be used for technical approval of balanced ventilation units [6].

### 3.10.1 Summary of possible barriers and proposed solutions to solve them

In summary, Norway's predominantly performance-oriented building regulations are largely accommodative to innovative ventilation systems, so long as they fulfil all the normal criteria for healthy indoor environment etc. The main statutory barrier is that the regulations do not overtly encourage innovative solutions - i.e. by not having a more stringent energy consumption limit, and simply by not mentioning their benefits, such as the fact that total fresh air flow rates can be reduced with demand-control, displacement and cascade ventilation. It is not difficult to get planning approval for buildings with hybrid ventilation technologies.

The state housing bank has financial incentives for features such as heat pumps and heat recovery. About 48% of new small houses have heat recovery. Nevertheless, the most dominating barrier to innovative technologies is still cost and market forces. Housing is built mostly by large property developers concerned almost only with capital costs, not LCC, and who try to just meet minimum regulatory requirements. This is the greatest challenge facing the product that the Norwegian consortium is developing. The stiff competition in the

housing market is in part a result of the buying habits and attitudes of the general public. In order to sell new technology to home-buyers, it must be competitive with other investment priorities, such as larger floor area, so it must be attractive with respect to their conceived concerns on comfort, health and safety as well as running costs and investment return when they move house. Having said that, new housing in Norway is generally more energy-efficient, with a higher level of comfort, than housing further south in Europe.

### 3.10.2 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] Standard NS 8175. Lydforhold i bygninger : Lydklasser for ulike bygninger. 1996
- [5] CEN Technical Report CR 1752. Design criteria for the indoor environment. 1997
- [6] NBI Teknisk Godkjenning av boligventilasjonsaggregater med varmegjenvinning. Norwegian Building Research Institute (NBI), project N-9752, report 3, 2002-09-12.

## 3.11 Portugal

Contribution from Eduardo Maldonado (IDMEC)



### 3.11.1 Situation in relation to IAQ

#### 3.11.1.1 National standard

In Portugal, there is only one national standard describing the requirements in terms of natural ventilation of residential buildings (NP 1037-1).

This standard, published in 2002, prescribes the model to calculate the characteristics of the permanent window openings (self-regulated registers), diameters and locations of chimneys, as well as airtightness of window frames (as a function of window exposure to wind) and doors that are needed to ensure a 0.6 ACH air exchange rate in residential apartment buildings. It is a rather complex performance standard that is very difficult to implement in practice. Other parts of the standard, for mechanical ventilated buildings and single-family residences, are under preparation, but no schedule is foreseen for their availability.

In practice, by being simply a natural ventilation standard and not addressing even the cases when there is fan-assisted exhaust in toilets, bathrooms and kitchens, the most commonly used ventilation system in Portuguese apartment buildings for more than 20 years, its applicability is quite small. A demonstration project has been made in a few buildings in low-cost housing in Northern Portugal.

#### 3.11.1.2 National regulations and requirements

Building regulations for Portugal, up to 2003, have no requirement regarding neither ventilation rates nor indoor air quality. They do state indicative, or recommended air exchange rates (around 30-35 m<sup>3</sup>/h.person as the reference ventilation rate for most typical spaces) that designers should adopt, but there is neither verification nor any penalty for not doing so.

In 2002-2003, a new set of regulations, expected to come into force in 2005, drastically changed this situation. The most important requirements of the new regulations are as follows:

- Buildings are allowed to have natural, mechanical or hybrid ventilation systems, at the choice of the designer.
- Buildings resorting to natural ventilation alone will have to fully obey NP 1037-1.
- Residential buildings must have at least 0.5 ACH and prove that the design is able to satisfy this objective.
- Non-residential buildings will have to undergo periodic IAQ audits (every 2 or 3 years, depending on building type) and prove that the indoor concentration of selected pollutants (among others, CO, CO<sub>2</sub>, formaldehyde, VOC's, particulates, and, in certain cases, bacterial or viral concentrations) do not exceed certain preset maximum levels - if any of these are exceeded, corrective measures must be implemented, including appropriate changes in the ventilation rates.
- The designs of HVAC systems in new buildings will have to be checked by an independent third party and certified to conform to the requirements of the regulations

in terms of mandatory minimum ventilation rates, of the same order of magnitude of the previous regulations (30-35 m<sup>3</sup>/h.person) - the requirement is in terms of minimum capacity of air exchange, but actual rates can be lower if the limits indicated in the previous bullet are not exceeded, at the discretion of the building supervisor.

- Ventilation rates must be effective, i.e., ventilation efficiency within each room must be taken into account during design.
- There is a "technology innovation clause" that allows new systems to be able to prove that they satisfy the performance requirements of the regulations and become immediately in compliance with the regulations.

### 3.11.2 Situation in relation to the summer comfort

The regulations require accounting of cooling needs in summer. Ventilation at large rate for free cooling is encouraged and accounted for in calculations whenever outdoor temperature is below internal temperature and there are cooling needs. All windows must be openable, according to general building regulations, except where it might be advisable not to do so but, in such case, proof of suitable ventilation arrangements are a precondition to licensing. All windows with an area of more than 5% of the floor area of the room they serve must be shaded, except those in the North quadrant.

### 3.11.3 Summary of possible barriers and proposed solutions to solve them

Hybrid ventilation systems are specifically indicated in the national regulations as one of the options designers can use to meet the ventilation requirements.

No barrier exists but encouragements to apply such systems are also missing.

### 3.12 Sweden

Contribution from Åke Blomsterberg (J&W Consulting Engineers)



#### 3.12.1 Situation in relation to IAQ

##### Indoor air quality related aspects

According to the Swedish building regulations (BBR 94) the ventilation systems of buildings shall be designed in such a way that the required quantity of outside air is supplied to the building and contaminants from activities, respiration, products from persons and airborne emissions from building materials, as well as moisture, bad smell and substances hazardous to health are removed. The effectiveness of ventilation shall be satisfactory. The air change efficiency is recommended to be not less than 40 %.

Rooms shall have continuous air change when they are in use. The outside air flow rate shall not be less than 0.35 l/s per m<sup>2</sup> of floor area. When rooms are not in use the air flow rate may be reduced but not to such an extent that health risks arise or so that there is a risk of damage to the building or its services. Such a reduction may be effected continuously, in several stages or in the form of intermittent operation.

For bedrooms the advice (an example of one way that the requirements can be fulfilled) is that the outdoor air flow should be 4 l/s.person. There is also advice given, applicable to mechanical ventilation systems, for air flow rates from kitchen, bathrooms and common rooms in apartment buildings. However in 1994 a handbook on passive stack ventilation was issued as an elucidation of the Swedish building regulations. The foreword of the handbook states that “there are no regulation barriers to equip buildings with simple ventilation systems such as passive stack”. The handbook gives a simple approach for dimensioning a passive stack system, which fulfils the above requirements for all conditions but extreme weather. There are a couple of prerequisites e.g. bathrooms must have windows for airing and excessive ventilation must automatically be prevented.

The levels of the requirements are expected to be revised in the future, depending upon new findings. New parameters on which requirements can be based might be introduced. The new governmental environment proposition emphasises radon and Legionella. The difficult question is still, which parameters are of importance for the indoor air quality. The outdoor air quality should be taken into consideration. To use the CO<sub>2</sub>-level as an IAQ requirement is not very satisfying. Technical requirements do not cover all aspects of IAQ. The perceived IAQ is also of importance.

#### 3.12.2 Situation in relation to the summer comfort

The operative temperature should not for longer periods exceed + 26 °C and should not exceed + 28 °C for more than short periods (SoS AR1988:2: Indoor Thermal Comfort. General Advice, nr 1988:2, from the Swedish Social Welfare Board). If these requirements are not fulfilled the building can be condemned, which has most likely never happened, as the summers in Sweden very rarely are hot.

#### 3.12.3 Summary of possible barriers and proposed solutions to solve them

The Swedish building regulations are to some extent performance oriented as to indoor air quality, but do require a minimum ventilation rate and not directly a certain specified level of IAQ. The development of innovative ventilation systems is to some extent encouraged. Innovative systems like hybrid ventilation systems can be implemented, although they are not

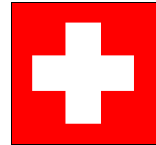
really covered by the procedures in the current regulations and standards. For a hybrid ventilation system, it has to be proven to the local building committee that the indoor quality and/or air flows are likely to fulfil the requirements. This can be done in different ways e.g. simple calculations or that if necessary the fans alone can fulfil the requirements. More work is likely to be required to get approval for a hybrid ventilation system than for a mechanical one. Consequently as to indoor air quality the Swedish building regulations should be more performance oriented in the future.

#### 3.12.4 References

- [1] BBR 94, Building Regulations 94. Mandatory provisions and general advisory notes. (in Swedish), The Swedish National Board of Housing, Building and Planning (Boverket), 1998.
- [2] AFS 2000:42, Design of the workplace - Directions concerning design of the workplace and general advice concerning application of the directions, (in Swedish), National Swedish Board of Occupational Safety and Health, 2000.
- [3] SIKI: R2 Classified air distribution systems - Guidelines and specifications (in Swedish), Swedish indoor climate institute, 1991.
- [4] SIKI: R1 Classified Indoor Climate Systems - Guidelines and specifications (in Swedish), Swedish indoor climate institute, 1991.
- [5] VVS AMA 98, Universal material and job descriptions for HVAC technical installations (in Swedish). Swedish Building Office, 1998.
- [6] Indoor Thermal Comfort - General advice (in Swedish), the Swedish Social Welfare Board, 1988:2, 1988.
- [7] Performance checks of ventilation systems, Swedish Code of Statutes, SFS 1991:1273, 1991.
- [8] Passive stack ventilation – handbook (in Swedish), The Swedish National Board of Housing, Building and Planning (Boverket), 1994.

### 3.13 Switzerland

Contribution from Andreas Weber / Viktor Dorer (EMPA)



#### 3.13.1 Introduction

Standardisation and especially regulation is quite 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 recognised 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. Most standards are in the process to be adapted to CEN standards. The SIA standard for mechanical ventilation systems [4] is in review process. The aim is to establish a general standard for ventilation with specific chapters for specific applications, like residential ventilation. The prEN 13779 and several CEN standards on residential ventilation will be implemented.

In recent years, innovation in residential ventilation has been pushed by the introduction of low energy certificates for buildings. The MINERGIE certificate [6] has been introduced in order to distinguish buildings with a very high standard concerning energy performance and comfort. The newly introduced MINERGIE-P label goes even beyond this level and is equivalent to the German "Passivhaus" certificate, but compliance has to be assessed according to the method defined in the Swiss standard SIA 380/1 Energy use of buildings [2].

#### 3.13.2 Situation in relation to IAQ

##### 3.13.2.1 National standards

The SIA 180 standard for heat and moisture protection in buildings [1] requires an airtight building envelope. A ventilation concept for the renewal of room air, for pollutants removal and cooling loads dissipation has to be established by the architect or HVAC planner. A natural ventilation system with windows or other openings, possibly reinforced with passive shafts or fan assistance is possible. Natural systems may be operated manually only if the operation is guaranteed during the whole life time of the building. Automatically regulated openings (e.g. humidity controlled) are recommended. Mechanical ventilation may be realised with supply and exhaust systems, with a heat recovery whenever possible, or with exhaust systems. Minimum required airflow rates are determined by the maximum allowed steady state pollutants or humidity concentration threshold and the respective source strengths. The highest value of the air flow rates determined for each pollutant has to be considered. In rooms where smoking is not allowed and with an allowed threshold for the CO<sub>2</sub> concentration of 1500 ppm, an air flow rate of 12 - 15 m<sup>3</sup>/h.person is required. In rooms where smoking is allowed, an air flow rate of 30 - 70 m<sup>3</sup>/h.person is required.

In the SIA 382 standard for mechanical ventilation systems [4] the essential requirements in relation to IAQ are: no impairment of health and well-being of the occupants, and no damages to the building structure. In addition to the air flow rate requirements given in SIA 180, an air change rate of 0.3/h is recommended in unoccupied rooms. A mechanical ventilation system has to be installed if the required outside conditions concerning pollutant concentration and noise are not fulfilled or if the room has no window.

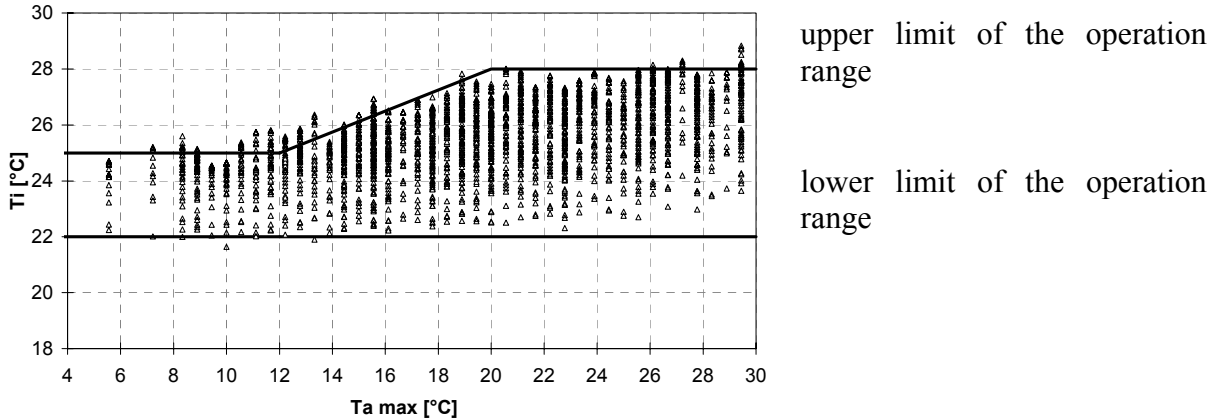
The MINERGIE certificate [6] requires at least some control of the ventilation. Manually operated natural ventilation is not allowed. Outdoor air has to be filtered if possible and indoor pollutants have to be removed continuously. If possible a heat recovery should be installed. For the MINERGIE-P certificate [7] a mechanical ventilation system with heat recovery is required.

**3.13.2.2 National regulations and requirements**

Only very few national regulation concerning IAQ in residential buildings exist, e.g. on formaldehyde and asbestos concentrations. Recent initiatives to explicitly consider indoor air pollutants or indoor air quality in general in the national regulations, were not successful. Often the regulation requires a demand controlled mechanical extract in blind wet rooms. This actually translates in many cases into a simple hybrid ventilation system.

**3.13.3 Situation in relation to the summer comfort**

The need for room air cooling has to be proved according to [4]. Mechanical cooling is only allowed if the room air temperature exceeds the upper limit of the operation range (Figure 6) during the occupied hours more than 30 Kh per year. Hot days with higher than 30 °C maximum outside temperatures may not be considered. The air temperature in the room without cooling has to be predicted using a dynamical building simulation tool. Boundary conditions for the simulation, such as sun 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 [5].



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 6: Operation range**

**3.13.4 Summary of possible barriers and proposed solutions to solve them**

No barriers to the application of hybrid ventilation systems in residential buildings have been identified. While transient room situations are covered in terms of summer comfort (temperature exceedence), no standard covers the respective issues for winter situations (temperature undershoot) and in terms of indoor air quality.

### 3.13.5 References

- [1] SIA 180, Heat and moisture protection in buildings, 1999
- [2] SIA 380/1, Energy use of buildings, 2001
- [3] SIA 380/4, Electrical energy use of buildings, 1995
- [4] SIA 382, Technical requirements to ventilation equipment, 1992
- [5] SWKI Guideline 95-3, Yearly energy demand of ventilation equipment
- [6] Minergie Certificate, Minergie association, Bern
- [7] Minergie-P Standard, Minergie association, Bern

### 3.14 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.*

#### 3.14.1 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.

#### 3.14.2 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.

### 3.14.3 Requirements

Approved document F1 states that:

*‘There shall be adequate means of ventilation provided for people in the building’.*

Approved Document F1 is split into two main parts: ‘Dwellings’ and ‘Buildings other than dwellings’. Only dwellings are covered here.

Required ventilation arrangements are outlined below:

Ventilation of rooms containing openable windows (i.e. located on an external wall)

Room	Rapid ventilation (e.g. opening windows)	Background ventilation	Extract ventilation fan rates or passive stack
Habitable room	1/20 <sup>th</sup> of floor area	8000 mm <sup>2</sup>	-
Kitchen	opening window (no minimum size)	4000 mm <sup>2</sup>	30 l/s adjacent to a hob or 60 l/s elsewhere or PSV
Utility room	opening window (no minimum size)	4000 mm <sup>2</sup>	30 l/s or PSV
Bathroom	opening window (no minimum size)	4000 mm <sup>2</sup>	15 l/s or PSV
Sanitary accommodation (separate from bathroom)	1/20 <sup>th</sup> of floor area or mechanical extract of 6 l/s	4000 mm <sup>2</sup>	-

**Figure 7: Figures for Rapid ventilation and background ventilation refer to area of opening.**

Extract ventilation can be provided either by:

- Mechanical extract ventilation operated manually and/or automatically by a sensor or controller
- Passive stack ventilation operated manually and/or automatically by a sensor or controller
- An appropriate open-flued heating appliance.

Additional requirements are provided for rooms that do not have openable windows.

As an alternative to the above approaches, the requirement is deemed to be satisfied by following a number of referenced sources of guidance. These are:

- BS 5925: 1991 Code of practice for ventilation principles and designing natural ventilation.
- BS 5720: 1979 Code of practice for mechanical ventilation and air-conditioning in buildings.
- BS 5250: 1989 Code of practice for the control of condensation in buildings
- BRE Digest 398 Continuous mechanical ventilation in dwellings: design, installation and operation.

#### Referenced sources of guidance:

BS 5925:1991 Code of practice for ventilation principles and designing natural ventilation:

This Code of Practice provides guidance regarding general principles of ventilation along with detailed guidance for natural ventilation. Information relating to general principles includes:

- Provision for human respiration.

Reference is made to further information concerning metabolic rates in:

- Dilution and removal of airborne pollutants, including odours and tobacco smoke
- Control of humidity
- Provision of air for fuel-burning appliances
- Control of thermal comfort
- Clearance of smoke resulting from an accidental fire.

Specific design data provided includes:

- Fresh air requirement values for respiration
- Moisture generation rates
- Ventilation required to reduce the risk of surface condensation.
- Carbon dioxide production rates and air supply rates

Detailed information regarding recommended ventilation rates is also included.

Guidance specifically for the design of natural ventilation includes the following:

- Flow characteristics (includes  $k$  values for windows along with equivalent area of ventilation openings)
- Generation of pressure differences (includes typical magnitudes of pressure created by wind and temperature difference)
- Meteorological variables
- Flow equations for wind only, temperature difference only and wind and temperature difference together.

Appendices provide guidance on the following:

- Further sources of information
- Calculation of contaminant concentration
- Calculation of ventilation rates to reduce the risk of surface condensation under steady state conditions
- Determination of ventilation requirements
- Calculation of reference wind speed
- Calculation of natural ventilation rates for a simple building.

#### BS 5720:1979 Code of practice for Mechanical ventilation and air conditioning in buildings

This Code of Practice deals with the work involved in the design, installation, commissioning, operation and maintenance of mechanical ventilation and air-conditioning systems. Recommended minimum outdoor air supply rates for a range of buildings are provided. The Code recommends that the quantity and distribution of introduced outside air should take into account the natural infiltration of the building.

Information is provided regarding the importance of air movement, however, no quantification of design requirements is provided. Guidance for air purity and filtration suggests that air inlets and extracts are positioned to avoid cross contamination. (This includes pollutants from other buildings and sources such as vehicles.)

Design considerations are supplied for:

- Ventilation systems:

- Mechanical extract/natural supply
- Mechanical supply/natural extract
- Combined mechanical supply/extract

- Air-conditioning systems:

- Constant volume
- Variable volume
- Fan coil systems
- Induction systems
- Single units
- Multiple units
- ‘Special system’ for subsystems

- General design guidance is provided for the following areas:

- Ductwork.

#### 3.14.4 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. Checking of proposed concepts of hybrid ventilation systems

National standards and regulations about ventilation are so country-specific (e.g. about the airflow to realise, nominal pressure) that ventilation systems developed for one country may generally not be exported to another one without adaptations. The check of the possibility applying one ventilation system into different countries will show that the system doesn't comply with the different national requirements. This has nothing to do with the hybrid character of the considered systems but with requirements applying on every ventilation system. The possibility to apply the concept of hybrid system on itself has been considered in the §3 of this report. We analyse in the scope of this report which specific elements have been considered for systems developed in the scope of the Reshyvent project in order to comply with the national requirements of the country where the system was designed for.

### 4.1 Cold Climate hybrid ventilation system

#### 4.1.1 Description of the concept

Hybrid ventilation in a cold climate means a ventilation system with low pressure drops, which result in a minimisation of the mechanical energy for ventilation, and that natural driving forces can play an important role.

The ventilation concept is based on an exhaust air system with low pressures drops and a separate fan for each apartment. The fan has a built-in control system for a, according to desire adjustable, constant exhaust air flow independent of the boundary conditions. The desired air flow can be set according to the number of occupiers from a panel in the apartment, but is also automatically controlled by humidity and outdoor air temperature. The outdoor air is preheated by a supply convector. Each apartment has individual control of indoor climate and individual metering of energy use. The system will result in a similar level of energy use for space heating as for a system with balanced ventilation with traditional heat recovery, but lower use of electricity, more user-friendly and improved indoor air quality.

The system was mainly developed for installation in new apartments, but can also be used for refurbishment.

The main characteristics of the prototype system are the following:

#### General

- individual co-ordinated control of heating, indoor temperature and ventilation i.e. for each apartment
- individual metering of energy use, ventilation and indoor temperature, to motivate the users to operate their apartment in an energy efficient manner
- LON-based BEMS, enabling improved operations monitoring
- low pressure drops in ventilation system, to contribute to low use of electricity for ventilation
- control of humidity in bathrooms in order to avoid moisture damage to the building
- passive stack and wind (wind catcher) assisted exhaust fan ventilation, where the fan can be turned off e.g. when no one is at home.

#### Ventilation in apartments

- one self regulated flow constant volume flow EC fan per apartment

- exhaust air terminal devices in bathroom, lavatory and kitchen
- outdoor air inlets with back flow damper, in façade of bedroom and living room
- pre-adjusted normal ventilation as a function of number of persons, the number can be set by the user
- high efficiency cooker hood with manually forced ventilation with timer
- lowered ventilation when no one at home, manual or automatic (controlled by burglar lock of entrance door or pre-set timer) control. The fan can be turned off.
- lowered ventilation at night in living room, manual or automatic (pre-set timer) control
- relative humidity controlled ventilation in bathroom i.e. preventing lowered ventilation if high humidity level and no one at home.

#### Ventilation of common areas

- demand controlled ventilation of common areas like stairwell, bicycle storeroom, apartment storerooms, laundry room, technical rooms or central air-to-air heat recovery from exhaust air to supply air (to some of the common rooms)

#### Space heating apartments

- supply air to bedrooms pre-heated by supply air radiator
- bedrooms heated by radiator
- supply air to living room pre-heated to 18 °C by special convector with back draft damper
- living room heated by radiator and convector
- indoor temperature 19 °C – 23 °C
- the radiators are controlled as a function of outdoor and indoor temperature (thermostat)

#### 4.1.2 Specific question to this system in relation with the Swedish regulation

The specific air flow rate (l/s,m<sup>2</sup>) in the concept is occupancy dependent. This may lead to low specific air flow rates in flats with few occupants relative to the floor area i.e. lower than the required 0.35 l/s,m<sup>2</sup>, without decreasing indoor air quality. This is formally not allowed, and had to be discussed with the authorities (National Board)

## 4.2 Moderate climate hybrid ventilation system

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

### 4.2.1 Description of the concept

The Dutch system is developed for moderate climates and consists of self-regulating inlets and vents, round 225 mm ductwork, a DC fan and an optimized roof outlet. A CO<sub>2</sub> sensor based control system will adjust the ventilation to required air flows with respect to indoor air quality. Target fan power is lower than 2 W (SFP < 0.04 kW/(m<sup>3</sup>/s)). This means an enormous reduction of auxiliary energy use. At this moment most of the Dutch domestic ventilation systems have natural supply with mechanical exhaust with a typical fan power of 30 to 40 W (Specific Fan Power 0.7 – 1.0 kW/(m<sup>3</sup>/s)). In the EU TIP-VENT project improvements on ductwork and fan have resulted in a fan power of 7 W (SFP 0.17 kW/(m<sup>3</sup>/s)). The pressure drop over the fan unit decreased from about 50 to 30 Pa. In RESHYVENT a further reduction to 2 W is established.

The next figure gives an overview of the system. A single-family house is shown, with the living room and the kitchen at the ground floor and the bathroom and the bedrooms at the first floor. To reduce the flow resistance the exhaust is lined up under the roof outlet.

The ventilation flow is demand controlled. For the living room and the bedrooms CO<sub>2</sub> sensors are foreseen. Also other sensors to detect the presence of persons like infrared (IR) can be used. A central control unit receives information from these sensors and gives set points to the self-regulating inlets and vents and, if necessary, starts and controls the fan. The nominal total flow rate is 56 dm<sup>3</sup>/s. However the maximum flow rate is foreseen at 100 dm<sup>3</sup>/s, which can be used during cooking, showering and for passive cooling.

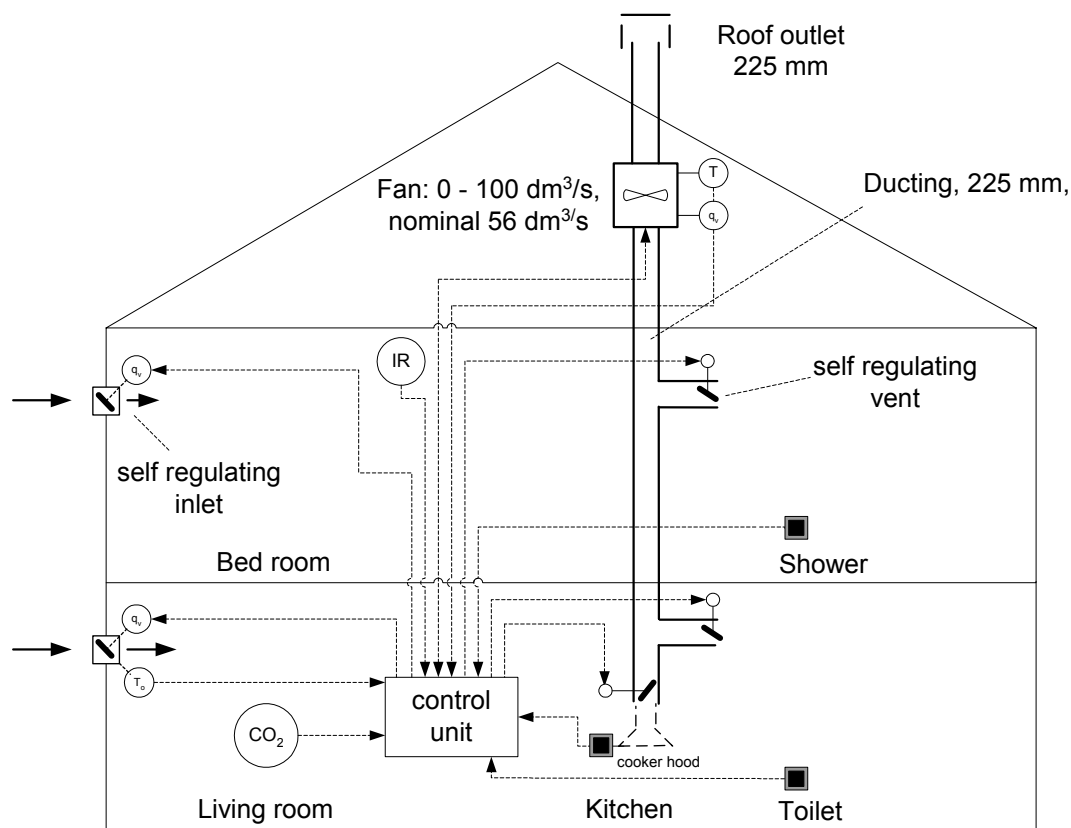


Figure 8: Principle of the Dutch demand controlled hybrid ventilation system in a family house.

The supply inlets are self-regulating inlets with building leakage compensation, placed in the top of a window frame. To optimise thermal comfort the inlets have draught correction and possibility for passive cooling in summer through extra fixed inlet with larger geometric aperture.

The distribution components are designed to limit the pressure drop at 56 dm<sup>3</sup>/s to maximal 2 Pa. To achieve this the ducting is substantially larger than in conventional systems (round maximum 225 mm). Ductwork also features improved coupling fittings, limited noise propagation (cross transmission of noise) especially with regard to fan. Self-regulating vents are applied with controllable flow rate at approximate 5 Pa pressure difference.

Energy consumption fan is 1 to 2 W at 56 dm<sup>3</sup>/s and 10 Pa (nominal flow) and 20 W at 100 dm<sup>3</sup>/s and 40 Pa.

The roof outlet is optimized for wind conditions with a maximal static pressure of 1Pa.

The system has a user-friendly interface for control by inhabitant with a possibility for overruling. Indoor Air Quality is controllable at several levels of CO<sub>2</sub> concentration. There is temperature control (passive cooling) by outside temperature through self-regulating inlets and inside temperature through sensor at fan system.

#### 4.2.2 Specific question to this system in relation with the Dutch regulation

The Dutch Standard for the determination of the energy performance of dwellings has an equation for ventilation  $q_v = 0.47 A_g + 0.13 q_{v10}$ .

This equation is based on a fixed use of the ventilation provisions by the inhabitants. In case of demand controlled ventilation on the basis of CO<sub>2</sub> sensing the actual flow in the heating season may differ from the one calculated by the equation from the standard. So the determination method in the standard for energy performance does not suite this innovative system. The specific question for the application of the principle of equivalence was:

How should the equation  $q_v = 0.47 A_g + 0.13 q_{v10}$  be changed to fit for the innovative demand controlled system? In terms of indoor air quality the system fulfils the requirements for ventilation as stated in the Dutch Building Decree.

### 4.3 Mild and warm climate hybrid ventilation system

#### 4.3.1 Description of the concept

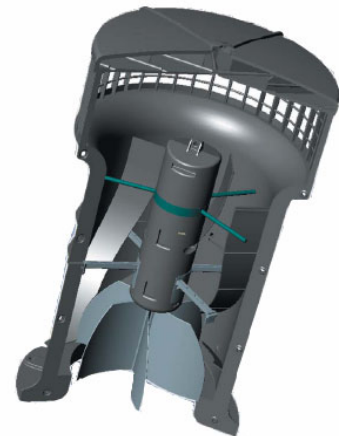
This concept, developed for mild and moderate climates, is a demand controlled ventilation system based on sensors for presence detection, relative humidity and temperature. The summer comfort issue is specially handled by the integration of intensive ventilation devices into the system. A first version of this system has been developed during the EU SAVE project Photovent. This system was not yet a two mode system at that time and the aspect of summer comfort was not yet integrated. It has been further developed into an hybrid system during the reshyvent project, among other thanks to the development of the fan.

All the ventilation devices such as air inlets, outlets and intensive ventilation device are motorised and these devices as the fan are piloted by a central control unit, determining the airflow in each room, speed of the fan and the opening of some windows. The balance between supply and exhaust is continuously guaranteed by the central control unit who makes the needed adjustment to the system.

Air supply is provided by naturally dimensioned motorised inlets. Air exhaust is provided by naturally dimensioned motorised outlets. The exhaust is a low resistance air duct (160 mm square duct) equipped with low resistance connection fittings, fan-assisted. The airflows in the kitchen and bathroom are regulated by relative humidity controlled devices when no

presence is detected and by the presence detection otherwise. The airflow in the dry rooms (living room, bedrooms) is controlled by presence detection. Minimal airflows are realised when no presence is detected.

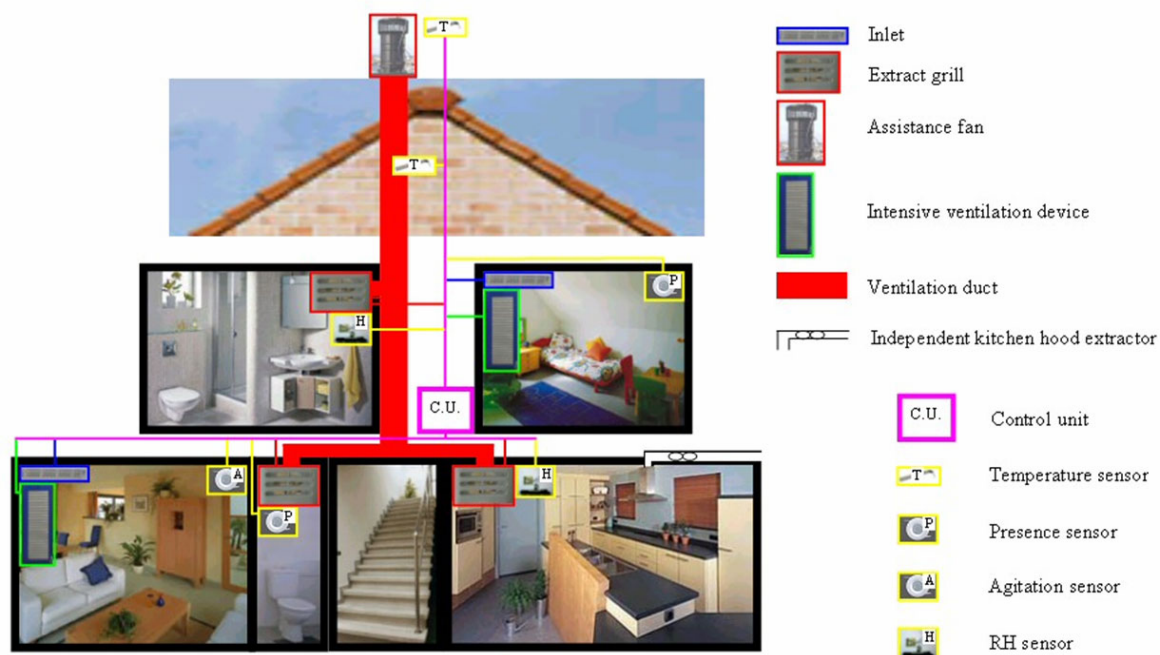
A crucial part of the system is the fan. It has been specially developed to allow natural ventilation when it is switched off. The development of this fan is described in the proceedings of the 2001 AIVC conference. The pressure losses due to the fan are lower than 1Pa for airflows of 70dm<sup>3</sup>/s. The fan, placed on the roof, has also been optimised (a.o. via wind tunnel testing) to act as roof cowl to benefit of the wind effect. The energy consumption of the fan is 2W at 6Pa or 70dm<sup>3</sup>/s. Prototype of PV-supply of the fan is now available.



The hybrid character of the system comes from the facts that the fan is switched off when the outdoor conditions are favourable which makes this system a two-mode system and not a low-consuming mechanical system.

The communication between the components of the system can occur via wires or via a wireless solution. The wireless solution (433 Mhz radio-commanded) make this system particularly convenient for refurbishment applications.

The system has been optimised to insure a good thermal comfort during summer conditions. Motorised windows equipped with intensive natural ventilation grilles are part of the system. These grilles allow the application of night cooling strategies in the building.



**Figure 9: IC3 concept**

#### 4.3.2 Specific questions to this system in relation with the Belgian regulation

This system complies with all the existing requirements in Belgium if all the ventilation components are dimensioned as components of a natural ventilation system. This system is considered according to the standard NBN D50-001 as a fan-assisted natural ventilation system. This system could not be applied if the components were developed as parts of a mechanical ventilation system. Among other because the Belgian regulation about ventilation

doesn't allow stopping the fan of a mechanical ventilation system (for other reasons than maintenance reasons).

#### 4.4 Severe cold climate hybrid ventilation system

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

##### 4.4.1 Description of the concept

The economic benefit of heat recovery in very cold climates is very significant, dwarfing the cost of the fan energy. Over 60% of new Norwegian dwellings now have balanced ventilation with air-to-air heat recovery. The suggested tightening of the energy performance requirements in the Norwegian building regulations in 2006, requiring 60% net heat recovery efficiency, will in practice mean that none of systems IC1, IC2 and IC3 would meet the Norwegian regulations (unless the builder compensates by increasing insulation), as none of them have heat recovery.

The IC4 concept is an attempt to unite the benefits of heat recovery with very low pressure drop systems. It has the following features:

- Balanced ventilation with a modular packaged air handling unit (AHU) with minimal air flow resistance, and the following components: 2 efficient axial fans with EC motors, air-to-air heat exchanger (rotary), electrostatic air filter (washable metal filter).
- Natural ventilation assistance with a roof-mounted wind cowl (integrated inlet and exhaust cowl). The concept system is dimensioned such that the system can operate on full natural ventilation when the building is unoccupied, since the required flow rate can be allowed to drop from 0.5 air changes per hour to approx 0.2 air changes per hour when the building is unoccupied. The system is dimensioned such that the system pressure drop is 5 Pa at 0.2 air changes, which is the same as the available natural driving forces.
- Demand-controlled ventilation:
  - The ventilation flow rate is controlled according to a CO<sub>2</sub> or RH sensor (or both) placed in the exhaust air side of the ventilation unit. The air flow rate is controlled to keep the concentration below a certain value (PI-controller). When the building is normally occupied, the fan power is 25 W (an additional 5 W is provided by natural driving forces). When the building is unoccupied over long periods, the fan power can drop to 0 W, since the natural driving forces alone are sufficient for the required 5 Pa.
  - A motorized damper is placed in the air supply duct to the living room. The damper is controlled by an IR-sensor in the living room. When the living room is vacated, more of the supply air is diverted to the bedrooms.
- All components are designed for low pressure losses: Shorter wider ducts that permit easier inspection and cleaning, low velocity air supply/exhaust terminals (thus low noise generation, the low velocity promoting displacement ventilation in bedrooms).

##### 4.4.2 Specific question to this system in relation with the Norwegian regulation

The IC4 concept system complies with the Norwegian building regulations, so long as it functions as intended.

## 5. Conclusions

Standards and regulations apply on ventilation systems. Standards should specify test procedures or calculation methods and not deal with requirements. It is clear that they can have an impact on the conception of components of the hybrid ventilation systems as on every ventilation component. The review of European standard realised in this report has not shown barriers to hybrid ventilation systems.

Regulations should specify requirements based on standardised calculation methods applying to every ventilation system. Problems may occur for specific systems when these documents are descriptive instead of being performance-oriented.

The country-related situation has been established via contributions collected in the scope of the RESHYVENT project as by using already available analyses (e.g. in the scope of the HYBVENT project). According to the authors who have contributed to the national review, the present regulations regarding the indoor air quality and summer comfort (if any) in residential buildings do not present major barriers to the application of innovative hybrid ventilation systems. However, four countries (Belgium, Greece, Norway, Portugal) have mentioned that if the regulations related to IAS do not present barriers, they do not promote innovative systems; Sweden is an exception as innovative systems are “to some extent encouraged”. There is consequently no rewarding of a potential improve of the indoor air quality due to such efficient systems.

**Belgium** mentioned that there is no barrier, if hybrid ventilation systems are designed as natural ventilation systems.

**Greece** mentioned that a flexible methodology for the definition of thermal comfort conditions based on the outdoor conditions should be adopted, as it is for example the case in e.g. The Netherlands for office buildings (maximum 5% of office hours above 25.5°C and maximum 1% above 28°C).

**Norway** mentioned that the main barriers are not to be found in the regulations, but in the market itself, which is very sensitive to the price. This is probably valid for most of the countries. This aspect has been analysed by Work Package 2.

**Sweden** mentioned that regulations should be more performance oriented (e.g. achieve a minimum IAQ level) than prescriptive (e.g. airflow rate to provide). This is probably also the case in other countries, like in **Belgium**.

The fact that the regulations varies from country to country can be considered as a problem for the development of new systems (for instance, the required flow rates vary from country to country, as shown on Figure 10). The system developed in a country will probably not fulfil the regulations in another country. This point has however nothing to do with hybrid ventilation system but is valid for all ventilation systems.

It is important to remember that this report has focused to standards and regulations related to indoor air quality

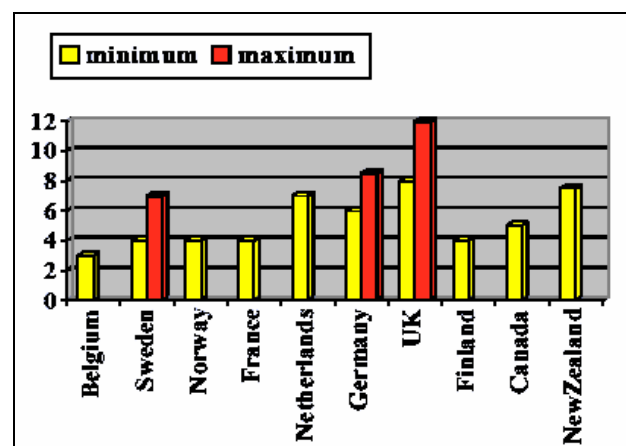


Figure 10: Required flow rates per person for dwellings [dm<sup>3</sup>/s] (Source: TIP-Vent report)

and summer comfort. In the future, the innovative (ventilation) systems will be influenced by standards and regulations related to the Energy Performances of Building Directive (EPBD). Those have been analysed in the third WP4 report [2].

## 6. References

- [1] IEA ECBCS Annex 35, Technical Report n°9 - Performance assessment of advanced ventilation systems in the framework of energy and IAQ regulations - Critical issues, challenges and recommendations, Hybrid Ventilation Centre, Aalborg University (Denmark), 2002
- [2] Wouters P., Heijmans N., Loncour X., Delmotte Ch. 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, RESHYVENT WP4 D4.3 report, 2005.