DG XVII Report 'Natural ventilation systems and components'

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1. introduction

This document deals with various aspects in relation to natural ventilation systems and components. In the first part, the need for ventilation is discussed and various types of ventilation systems are presented. Also an overview of components is made.

In the second part, various critical aspects of natural ventilation systems are discussed. Finally, a number of possible actions are proposed.

2. Survey

2.1 Need for ventilation

Good building design includes the achievement of good indoor climate conditions. In order to achieve good indoor climate conditions, the following performances have to be realised (figure 1):

- good thermal comfort, as well during the heating season as during summer periods (avoidance of overheating);
- good indoor air quality (IAQ);
- acoustical comfort;
- visual comfort.

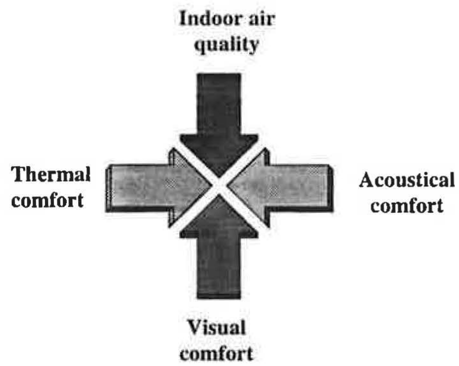

figure 1 : Essential aspects of indoor climate

In nearly all European climates, it is at least during a part of the year necessary to make use of appliances for achieving these conditions : heating systems, ventilation systems, lighting appliances and in some cases cooling appliances.

Most of these appliances require energy for operation. Within a context of energy efficiency, it is therefore very important to make use of energy efficiency concepts.

The achievement of good indoor air quality conditions is not evident since there are many sources of pollution. The following list gives an indication of the range of potential sources :

- body odour
- emission of building materials
- water vapour;
- open combustion appliances;
- radon;
- outdoor pollution (traffic, industry,...)

In the past, the major sources for pollution were body odour and water vapour. Also open combustion appliances were common but connected to chimneys. The airtightness of buildings was often very poor and, as a result, the indoor air quality was perceived as acceptable. Moreover, the outdoor environment (noise, risk of burglary) was experienced as less aggressive than nowadays and window opening was frequently used. As a result, no specific ventilation previsions were required.

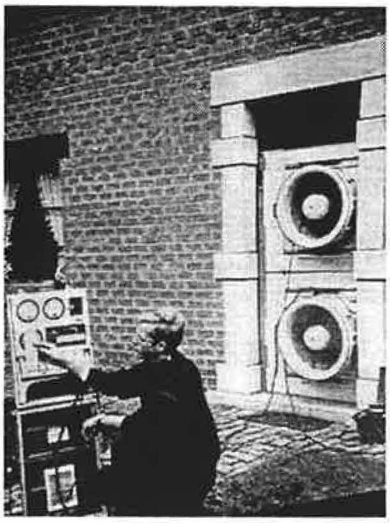

figure 2 : airtightness measurement

This situation has substantially changed for most situations :

- the airtightness of buildings (figure 2) has in most countries and for most buildings types substantially been improved. So-called pressurisation measurements have been carried out in most EU countries and indicate that many recent buildings have a very good airtightness or at least that a number of rooms are very airtight;
- the type of pollutant sources is extended : some of the new building materials (certain paints, certain carpets,...) emit, especially during the period following production and installation, high concentrations of vol.. organic compounds (VOC)
- the perception of the users has been changed. Occupants have become more aware and the requirements/expectations are today much higher than in the past. Moreover, openable windows (figure 3) as a means for ventilation in occupied spaces are less accepted than in the past.

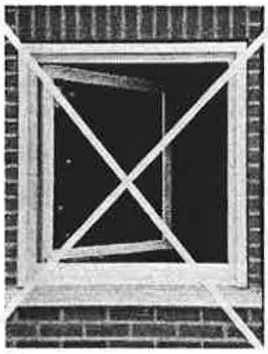

figure 3 : openable windows for IAQ control

- As a result, it is today generally recognised that it is not possible to achieve good indoor air quality in occupied buildings without the prevision of purpose provided ventilation devices. This can be by natural means (buoyancy driven and/or wind effect), by mechanical means (ductwork in combination with fans,..) or by a mixing of natural and mechanical ventilation.
- It is clear that the lack of appropriate ventilation possibilities has caused a lot of condensation and mould growth problems. Research carried out at the end of the eighties in the context of the International Energy Agency has clearly shown that ...10...20...% of the social dwellings in Belgium, the Netherlands and the UK suffered from serious condensation or mould growth problems. The main reasons for these problems were on the one hand insufficient and/or incorrect thermal insulation and on the other hand no possibilities for a correct ventilation.

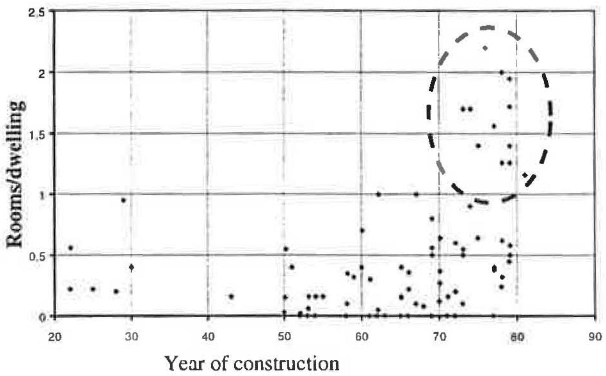

figure 4 : Number of rooms per dwelling with serious condensation/mould growth problems (100 social housing estates)

In figure 4, results are presented from a study carried out in Belgium. Hundred social housing estates were analysed (on average 23 dwellings per housing estate) and an inventory of rooms with serious condensation and mould growth problems was made. The average number of rooms per dwelling was calculated for each housing estate and figure 4 shows this average value as function of the year of construction of the housing estate. One can notice that there were at that time not many housing estates without serious condensation and mould growth problems. Moreover, the 10 housing estates with the highest frequency of problems (indicated by the ellipse) were all rather recently constructed housing estates.

This document is not focusing on the ventilation of technical rooms (heating boiler, garages,...). It is clear that in all rooms with open combustion appliances, a correct ventilation is very important. Specific guidelines, standards and requirements exist for such applications.

2.2 Ventilation requirements

2.2.1 Ventilation for occupants

Until a decade ago, the occupants were considered as by far the most important source of air pollution and the ventilation requirements were expressed per person. Already in 1937, Yaglou considered the impact of occupants on odour.

It is clear that the higher the air flow rates per person, the better the air quality. However, there is no optimum. During the heating season, increasing the air flow rates means an increase in energy demand for ventilation (heating of the air and fan energy in case of mechanical ventilation). Therefore some compromise is necessary. This situation (figure 5, left side) is very different when compared with the thermal comfort in winter time. The optimum is situated in a narrow range (figure 5, right side) and there is little discussion about the set points to be achieved.

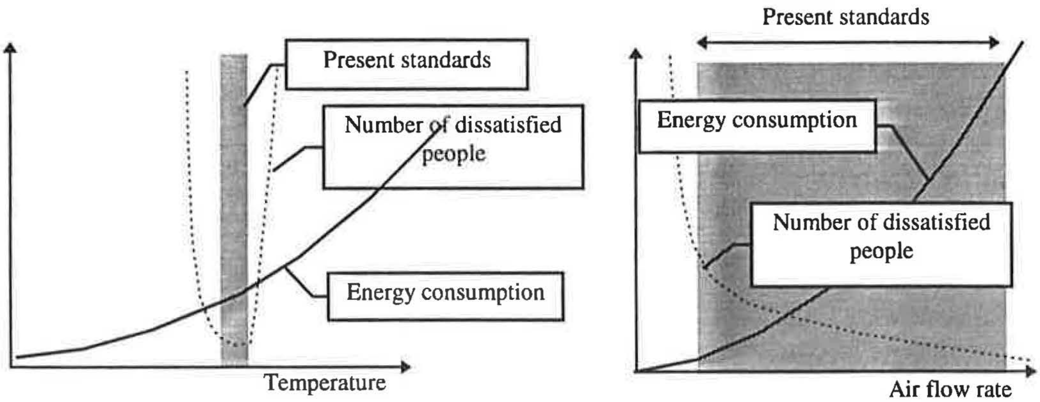

figure 5 : comparison between 'thermal comfort versus energy' and 'IAQ versus energy'

With respect to ventilation and indoor air quality, the requirements for air flow rates are determined by the relative importance given to the energy aspect versus the indoor air quality aspect. This can be clearly illustrated by the variations in air flow requirements in the American ASHRAE standard 62 . The version of 1981 basically required 2.5 l/s,person (9 m³/h,person) and this low value must be seen in relation to the high importance given to energy conservation around 1980. In the 1989 version, the requirements were increased to 7.5 l/s,person (27 m³/h,person). This very large increase can be explained by on the one hand the strong reduction in energy prices at that time and the bad experiences in many buildings designed to the 1981 standard. Such tremendous variation in the requirements is impossible with respect to thermal comfort.

In many standards, one finds air flow rates expressed per m² of floor area. These values assume a certain density of occupation and a related air flow rate per person. The values in the 1996 draft proposal for prENV 1752 (proposal for European standard) are given in table 1 as an illustration.

Building	Occupancy (Pers/m²)	Category	Mean air velocity (cm/s)	Required ventilation l/s,m²	Extra for smoking[1] l/s,m²
Single office	0.1	A	18/15	2.0	-
		B	22/18	1.4	-
		C	25/21	0.8	-
Landscaped office	0.07	A	same values	1.7	0.7
		B		1.2	0.5
		C		0.7	0.3
Conference room	0.5	A	same values	6.0	5.0
		B		4.3	3.6
		C		2.4	2.0
Auditorium	1.5	A	same values	16.0[2]	-
		B		11.0	-
		C		6.4	-
Cafeteria Restaurant	0.7	A	16/13	8.0	-
		B	20/16	5.7	5.0
		C	24/19	3.2	2.8

table 1 : Design criteria for spaces in different types of buildings. This table applies for low-polluting building materials and furnishing, for the occupancy listed in the table and for a ventilation efficiency of one

2.2.2 Ventilation for various sources

Since the end of the eighties, evidence has been given that in certain buildings and especially in non-domestic buildings, body odour from occupants are not the primary source for pollution. Smoking, emission from building materials and even pollution by the ventilation system and the fact of polluted outdoor air are recognised as an important source for pollution. As a result, a number of standards and legislation's do not longer base the ventilation requirements on the (expected) number of persons but also on other sources. Unfortunately, it is not evident to come to sound procedures for quantifying the other sources of pollution and the required air flow rates. To illustrate the difficulties to come to agreement, the discussions in CEN TC 156 on ventilation requirements are already lasting several years and it seems not evident to come to procedures which can satisfy all the member countries.

It is evident that the ventilation requirements are room type dependent. This is illustrated by the values in table 1.

For dwellings, the ventilation requirements are not the same for all spaces. Differences in air flow rates are therefore logical. The 'ideal' system would be air supply to each room and air exhaust from each room. This has a number of disadvantages : very complex and expensive systems and a very high energy use.

More intelligent is to have combined systems. In most standards and building regulations , a distinction is made between the following types of rooms :

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[1] Additional ventilation required for comfort when 20% of the occupants are smokers. The health risk of passive smoking should be considered separately.

[2] It may be difficult to meet the Category A draught criteria

- the so-called 'dry' spaces : living and dining room, bedrooms, offices,... . In this type of rooms, air supply previsions are in most cases required;
- to so-called 'humid' rooms : kitchen, bathroom and WC. Because of the pollution sources, air exhaust is preferably;
- the other rooms as corridors. Most standards and building regulations require for these spaces transfer openings allowing the air which enters the 'dry' rooms to flow to the 'wet' rooms.

As an illustration, the air flow requirements as given in the Belgian standard NBN D50-001 are given in table 2.

General requirement :	1 l/s.m² floor area(3.6 m³/h.m²)	
Additional requirements:	*Minimum*	*May be limited to...*
Living room	21 l/s (75 m^3/h)	42 l/s (150 m^3/h)
Bedroom, study room,...	7 l/s (25 m^3/h)	10 l/s (36 m^3/h.persoon)
Bathroom, closed kitchen, wash place,...	14 l/s (50 m^3/h)	21 l/s (75 m^3/h)
Open kitchen	21 l/s (75 m^3/h)	----
Toilet	7 l/s (25 m^3/h)	----

table 2 : requirements in NBN D50-001

2.2.3 Natural ventilation for temperature control

Natural ventilation can also be used as a means for increasing thermal comfort in summer conditions. It can be applied as well at daytime as at night-time :

- at daytime, it can bring in outdoor air at high air flow rates. If the outdoor temperature is not above the acceptable comfort conditions, the thermal comfort can substantially be improved. Moreover, one often obtains relatively high air velocities which gives an additional improvement of the thermal comfort sensation;
- at night-time, the outdoor air is nearly always cooler than the upper comfort limits and bringing in this air into the building has nearly always a positive impact on the thermal comfort. In order to realise such intensive ventilation for summer comfort control, a whole range of boundary conditions must be realised. They are briefly summarised in figure 6. These various potential 'barriers' for a successful application of natural ventilation for summer comfort are studied in detail in the Project 'AIOLOS' of the EC Altener programme.

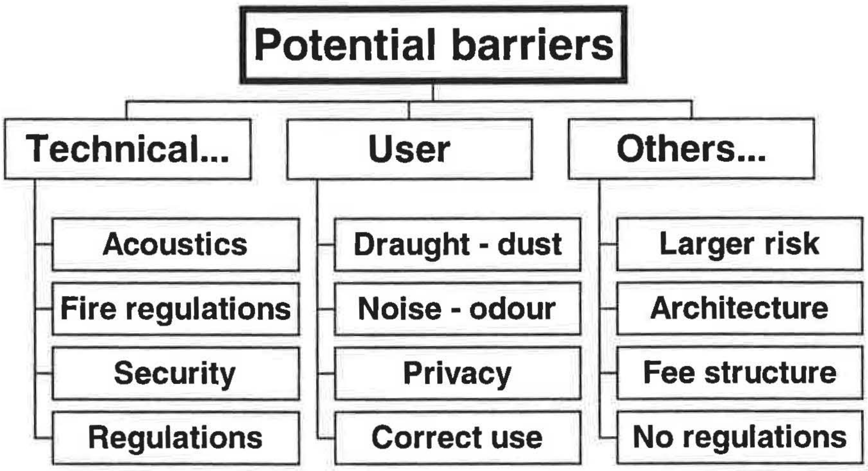


figure 6 : Overview of important boundary conditions/possible barriers with respect to night ventilation for summer comfort

The design of the PLEIADE dwelling (architect Ph. Jaspard) (figure 7 and figure 8) is largely based on he use of night time natural ventilation in summer for achieving thermal comfort whereas mechanical ventilation with heat recovery is used for IAQ purposes. Air flow rates obtained with night ventilation are presented in figure 9.

figure 7 : The PLEIADE dwelling (arch. Ph. Jaspard)

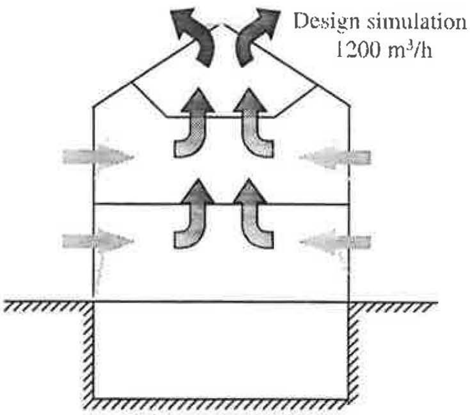


figure 8 : night ventilation in PLEIADE dwelling

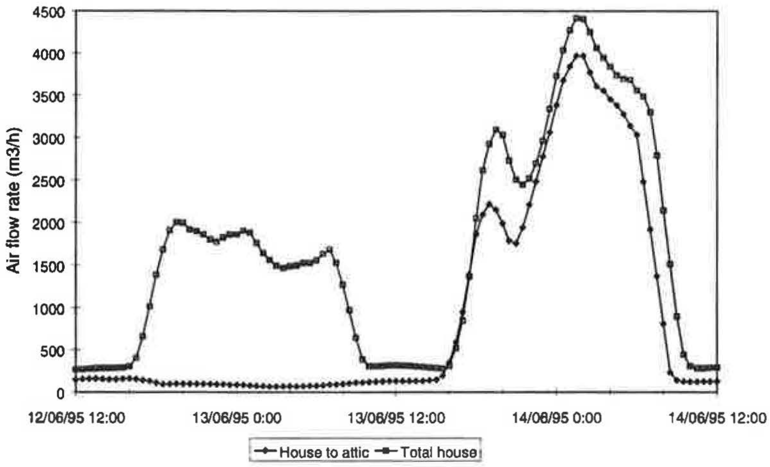


figure 9 : Measured air flow rates in PLEIADE dwelling

An example of a non-residential building is the Canning Crescent Health Centre in London (architect xxx) (figure 10).

In this building, natural ventilation is used for IAQ control as well as for thermal comfort control in summer. Some interesting features of this design are on the one hand no air intake at street side because of the intensive traffic (noise, air pollution) but through underground ductwork air intake at the side of the courtyard and on the other hand the array of chimneys for the natural ventilation exhaust.

2.3 Types of ventilation systems and definitions

Standards in relation to ventilation exist in most countries. In distinction is often made between different types of ventilation needs (figure 11):

- previsions for the standard ventilation in normally occupied rooms : living room, bedrooms, kitchen,...
- ventilation previsions in special rooms : basement, attic, storage rooms,...
- provisions to be used for exceptional purposes allowing/requiring intensive ventilation

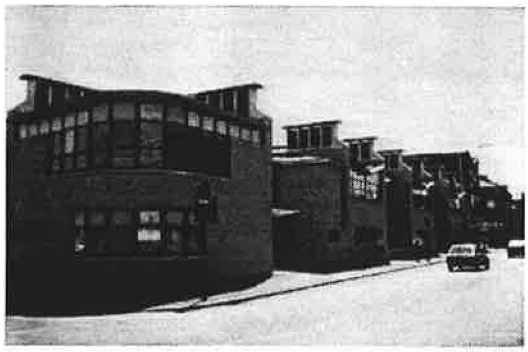


figure 10: Canning Crescent Centre (arch. xxx)

In the framework of this document, natural ventilation systems are defined as those systems which don't make use of electrical fans with the exception of fan assisted extraction. In the case of dwellings, it is common to make a distinction between 4 types of ventilation systems (table 3):

- system A : natural supply and exhaust
- system B : mechanical supply and natural exhaust
- system C : natural supply and mechanical exhaust
- system D : mechanical supply and exhaust

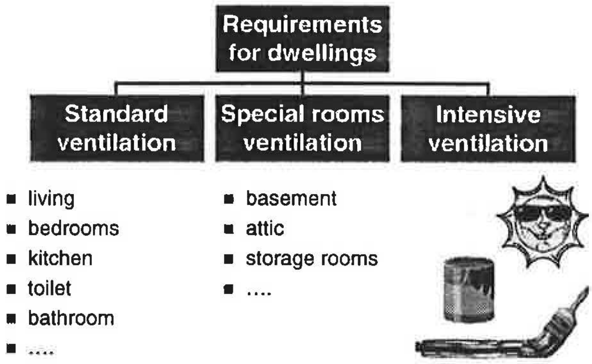


figure 11 :various types of ventilation requirements

Exhaust	Supply	
	Natural	Mechanical
Natural	System A	System B
Mechanical	System C	System D

table 3: Classification of ventilation systems

acoustical insulated supply grill is given in figure 13. At present, the building regulations in France and the Netherlands require for many applications the use of such acoustical insulated supply grills. These regulations are a important driving force for product development and substantially improve the performances in practice.

This model is made for the Dutch and Belgian market and one clearly sees the knob for manual opening and closing.

One of the weak points of classical supply grills is the strong dependency of the air flow rate as function of the climatic conditions. A number of techniques have been developed for reducing the dependency of climatic conditions.

- Pressure sensitive vents

One approach is to have self-regulating devices as function of pressure difference. Such devices are on the French market for more than 10 years (and installed in substantial part of the French dwellings) and allow to have a limited dependency of pressure difference in the range of 20 to 100 Pa. At lower pressure differences, they work as classical devices. Recently, a pressure sensitive vent has become on the market in the Netherlands which is self-regulating for pressure differences as low as 1 Pa. The Dutch standard NEN 1087 specifies requirements for pressure sensitive vents and the requirements assume such self-regulation for pressure differences of 1 Pa.

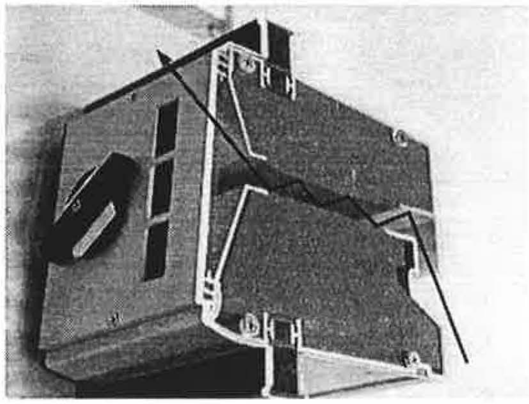


figure 13 : example acoustical insulated supply grill

- Humidity sensitive vents

A further improvement (partly financed in the framework of EC DG XVII) has been to built in a humidity control. This allow to adapt the ventilation rates as function of building use and it also allows to partly compensate for the increased stack effect during cold periods. In the Netherlands, efforts are concentrated on developing self regulation devices at very low pressures. The Dutch standards requires that so-called constant air flow devices regulate already at a pressure difference of 1 Pa. Since about 1 year, a device is on the market which meets these requirements.

- It is important that the supply openings are correctly used. This is illustrated in figure 14, which shows measurement results in the PLEIADE dwelling. The mechanical exhaust is in operation. However, the supply openings not being open, there is clearly a lack of fresh air in the bedrooms and the monitored CO2-levels are substantially above the limit values

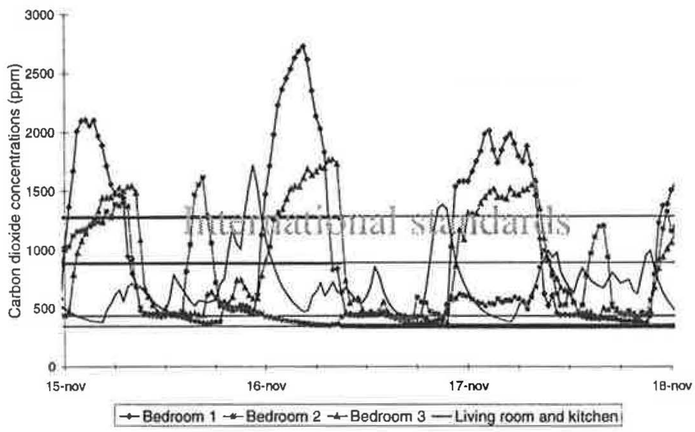


figure 14 : CO2 levels in PLEIADE dwelling if supply closed

2.4 Requirements in relation to systems A, B and C

In the case of natural supply and exhaust (system A) , it is clear that the air flow rates through ordinary natural ventilation devices are not constant over time because of variations in wind speed, temperature difference and use of building. Only with so-called self regulation devices, this dependency can become rather small. As such, it is not possible to meet the air flow rate requirements in all circumstances. At certain periods, higher air flow rates will occur whereas lower values will be observed at other times. In the case of mechanical exhaust (system C) or mechanical supply (system B), the air flow rate through the natural ventilation devices will be more stable, especially if the building is very airtight.

For dimensioning purposes, it is necessary to define the conditions for which the air flow requirements must be met. One possibility is to define the section of the opening. This method was used in the older versions of the Dutch standard NEN 1087 and is still used in the UK Building regulations part F. However, this method is not evident to use for more complex ventilation devices. Another and more performance oriented approach is to define the corresponding pressure difference. This method is at present used in several standards :

- Belgium : NBN D50-001 : air flow rates to be realised for pressure difference of 2 Pa
- Netherlands : NEN 1087: air flow rates to be realised for pressure difference of 1 Pa
- French regulations : air flow rates to be realised for pressure difference of 10/20 Pa

It is clear that the reference pressure varies substantially : from 1 Pa up to 20 Pa. Another important difference in philosophy concerns the controllability: certain regulations (Belgium, Netherlands,...) require that the natural ventilation devices can be controlled by the occupants and that it must be possible to close them whereas in France the opposite is required : the ventilation devices MUST be non closable. The reason for this fundamental difference in approach lies in the fact that the assumed role of the user is totally different in both approaches: in the first case (Belgium, the Netherlands,...) priority is given to the consideration that users will close the devices if there are problems of draught, if they believe that the specific weather conditions require to close the devices,... whereas in the latter case (France) priority is given to the believe that the users are unable to control the ventilation devices correctly and that therefore they must be non-closable.

2.5 Components

2.5.1 Supply

For the basic ventilation, one has normally relatively small devices which are installed in or around the windows or in the external walls. The section is of the order of 20...200 cm² for bedrooms (depending on the requirements in the standards and regulations). In the UK, these devices are called trickle-ventilators.

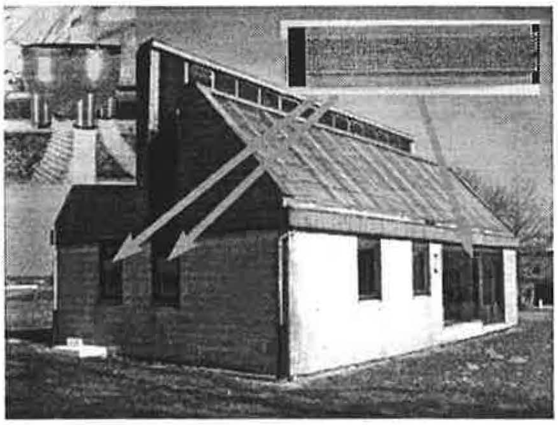


figure 12 : placement of supply grills in living and bedrooms and mechanical extraction

The classical supply openings for natural ventilation represent serious acoustical leaks in the facade. If a good acoustical performance of the facade is required, special precautions are needed. An example of an mentioned in various international standards (area indicated in grey).

2.5.2 Exhaust

In order to have exhaust under all weather conditions, it is not possible to have exhaust openings in the facade. The requirement is to have the outlets at roof level. As an illustration, in Belgium is it required that for flat roofs, the chimney is at least 50 cm higher than the roof level and for inclined roofs of more than 23°, the chimneys must be more or less at the summit of the roof.

2.5.3 Transfer openings

It is important that the air entering the 'dry' spaces (living room, bedrooms,...) can flow to the wet rooms without too high air flow resistance's. Inner doors are often rather airtight and will not allow such an air flow pattern. In order to guarantee a correct functioning of the natural ventilation concept, it is important that there are sufficient openings in the inner doors or walls. These openings are called transfer openings. The requirements for these transfer openings varies from country to country.

2.5.4 Performance approach

The basic function of natural ventilation devices is to deliver the required air flow rates . In practice, a whole range of performances must be realised in order to have systems which satisfy the users and which are well performing. In order to stimulate the development of better products, it is important to clearly define the relevant performances and the way to determine them. Such approach is used in several countries, e.g. in Belgium and the Netherlands. An example of such approach is given in table 4. It is expected that all manufacturers will in the future express the performances of their products in line with the agreed procedures. In table 4 are the following information given :

- 'Value' : the performance can be characterised by the measured value (e.g. for performance 1 : 23 dm^3/s at 2 Pa)
- 'Classes' : the performance is given by a class (e.g. for performance 11 are several classes defined)
- 'Measur.' : the performance must be determined by means of a standardised procedure.

Performance	Performance			Device		
	Value	Classes	Measur.	Supply	Transfer	Exhaust
1. Relation pressure - flow open position	●	●	●	X	X	X
2. Relation pressure - flow closed position		●	●	X	-	X
3. Acoustical insulation open position	●		●	X	X	(X)
4. Acoustical insulation closed position	●		●	(X)	-	(X)
5. Thermal insulation closed position	●		●	X	-	-
6. Condensation risk closed position		●	●	X	-	-
7. Controllability by user		●		X	-	X
8. Self regulation		●	●	(X)	-	(X)
9. Draught risk		●●	●●	X	(X)	-
10. Water tightness open position		●●	●●	X	-	-
11. Water tightness closed position		●	●	X	-	-
12. Protection against insects,...				X	-	(X)
13. Material characteristics				X	X	X
14. Security, strength and stiffness				(X)	(X)	(X)
15. Geometrical characteristics	●		●	(X)	(X)	(X)
16. Maintenance related aspects		●		X	X	X
17. Types of control		●		X	-	X
18. Manuals (installation, maintenance)		●		X	X	X
19. Cleanliness???				X	X	X
20. Noise production				X		(X)

table 4 : overview of performances as defined by Belgian Building Research Institute and ventilation industry

x : The performance determination is relevant for this type of device

(x) : The performance determination is relevant for certain models of this type of device

- : It is not relevant to determine the performance for this type of device

● : An agreed procedure for measurement is available

●● : A procedure is under development in the framework of CEN TC 156 and it is proposed not to determine the performance until the CEN procedure is adopted.

3. Questions

3.1 Problems related to the considered technology

The ideal ventilation system should allow to achieve good indoor air quality conditions under all circumstances and at a minimum energy cost. Natural ventilation systems have a number of advantages[AIVC Guide] :

- suitable for many types of buildings in mild or moderate climates;
- the 'open window' environment associated with natural ventilation is often popular, especially in pleasant locations and mild climates;
- natural ventilation is usually inexpensive when compared to the capital, operational and maintenance costs of mechanical systems;
- High air flow rates for cooling and purging are possible if there are plenty of openings;
- No plant room space is needed;
- Minimum maintenance.

The disadvantages of natural ventilation systems include[AIVC Guide] :

- inadequate control over ventilation rate could lead to indoor air quality problems and excessive heat loss. Air flow rates and the pattern of air flow are not constant;
- Fresh air delivery and air distribution in large, deep plan and multi-roomed buildings may not be possible (in non-residential buildings);
- High heat gains may mean that mechanical cooling and air handling will prevent the use of natural ventilation (in non-residential buildings);
- natural ventilation is less evident to noisy and polluted locations;
- Some designs (especially for summer cooling) may present a security risk;
- Heat recovery from exhaust air is technically feasible but not generally practicable;
- Natural ventilation may not be suitable in severe climatic regions;
- Occupants must normally adjust openings to suit prevailing demand;
- Filtration or cleaning of incoming air is not usually practicable;
- Ducted systems (mainly exhaust) require large diameter ducts and restrictions in routing.

The further development and use of self-regulating natural ventilation devices can surely improve the energy efficiency of natural ventilation. With respect to other aspects as air pollution, heat recovery,... , research is carried out in the framework of the EC DG XII JOULE project 'NATVENT'.

3.2 Obstacles to its dissemination

Natural ventilation devices are to a large extent used in a number of countries with mild climate. The market use is very strongly guided by the local standards and building regulations. As such, there are no major obstacles to its dissemination.

However, there is a tendency to use the cheapest products which meet the requirements in the standards and regulations. It is not evident to sell better products (acoustical insulation, thermal insulation, self regulation with better energy efficiency,...) if the standards and regulations are not requiring the use of such devices. Therefore, an essential element for the dissemination of improved products are standards and building regulations which have higher demands. The best approach is clearly a performance oriented approach and not a descriptive approach. In the latter case, the requirements are too much expressed under the form of solutions and represent a barrier for the development of innovative products.

3.3 Dissemination potential

As already mentioned in 3.2, the market is in principle vary large. Many owner probably prefer natural ventilation if there is enough confidence that natural ventilation devices can be used without specific problems. At present, improvements in especially the supply devices are possible and such improvements can lead to a much better image and therefore a much wider dissemination potential.

3.4 Environmental impact

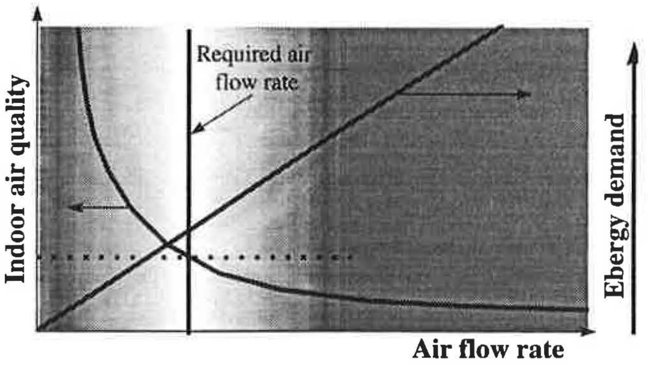


figure 15 : relation between air flow rate, indoor air quality and energy demand

Ventilation will cause during the heating season an increase in the energy demand of the building. As such, natural ventilation systems will increase the energy demand and the environmental pollution. However, it is generally accepted that a good indoor air quality is important and that ventilation is needed. An important advantage of natural ventilation is the fact that no electricity is needed for fans (or relatively small amounts in case of fan assisted extraction). An important disadvantage of most natural ventilation systems is the limited control of the air flow rates. The key challenge for natural ventilation is to realise air flow rates which are as close as possible to the required air flow rates (figure 15). Too low air flow rates will mean poor indoor air quality whereas too high air flow rates mean a too high energy penalty. As mentioned in 2.5.1, there are a number of so-called pressure sensitive vents but it clear that a number of these vents only control at relatively high pressure differences and that those vents which works at very low pressure differences have until now a very marginal market penetration.

It is not evident to precisely quantify the potential environmental gains by a better control of the air flow rates. Classical vents are controlled by the users and such use is not standardised. If one assumes that the users don't close the vents during the heating season and if one assumes an average pressure difference on a facade of 4 Pa, one will find for the vents dimensioned according the Dutch regulations that the average air flow rate is more or less the double of the required air flow rate. With an average nominal air change rate of around 0.75 h^{-1} ,assuming a dwelling volume of 300 m^3 and 1500 degree-days, this means an additional energy demand of 9.9 GJ/dwelling, year or 2.700 kWh/dwelling, year or some 350 m^3/dwelling, year of natural gas. A simple representation of the relation between air flow rate, power and energy demand is given in

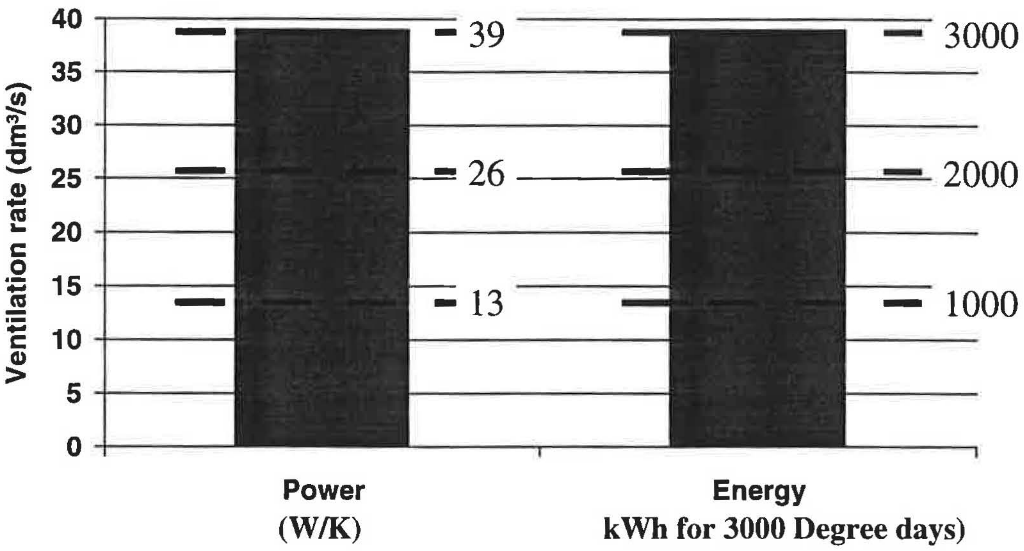


figure 16 : heating power and energy demand for various air flow rates

3.5 Economic impact

Given the wide potential market for natural ventilation, it is clear that the economic impact can be important. In a number of countries, the ventilation provisions are not yet adopted at a wide scale and the implementation of ventilation provisions (whether mechanical or natural) will on the one hand increase the building cost and on the other hand create additional employment in the building sector.

3.6 Sociological impact (employment)

It is not evident to give precise figures about the expected impact on employment.

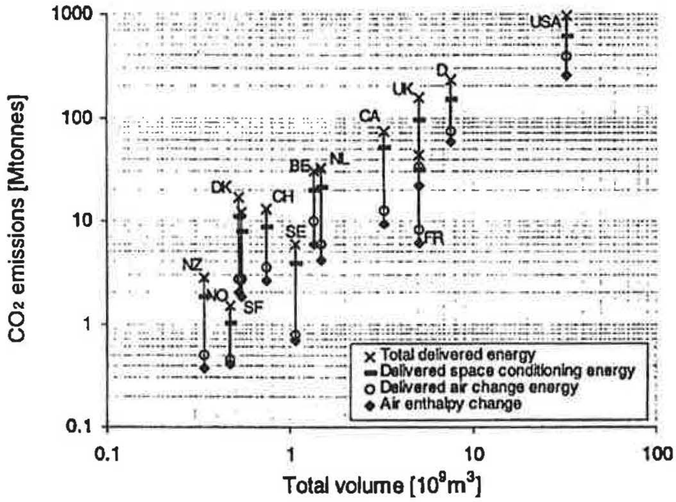
3.7 Level of market penetration

The market situation with respect to natural ventilation can be characterised as follows :

- in a number of countries (Belgium, France, Netherlands, UK,...) , natural supply openings for dwelling applications(in living room, bedrooms,...) are very common and its use is described in national standards and regulations. However, the technical prescriptions are quite different :
  - In Belgium, the supply openings are dimensioned for a pressure difference of 2 Pa and they should be closable;
  - in France, the supply openings are dimensioned for a pressure difference of 10 or 20 Pa and they may not be closable;
  - in the Netherlands, the required air flow rates are similar as in Belgium, but the supply openings are dimensioned for a pressure difference of 1 Pa;
  - in the UK, the requirements are expressed in mm^2 : 4000...8000 mm^2.

3.8 Saving potential by building sector

The International Energy Agency has done a number of studies with respect to the energy consumption in relation to ventilation in buildings. Figure shows the estimated CO2 production for dwellings for the member countries of the Air Infiltration and Ventilation Centre (AIVC).



3.9 Regulations, legislation's

As indicated in the previous paragraphs, there are several regulations containing specifications with respect to natural ventilation. The prescriptions are not at all similar. Moreover, they are in most cases of a descriptive nature and do not stimulate the development of innovative and energy efficient technologies. It is clear that some specific actions could substantially improve the situation.

Because of the diversity in the approach used in the standards and the philosophical differences in the various countries, it seems at present not possible for the European Standardisation Organisation (CEN) to come with a unique approach. Therefore, the work in Technical Committee (TC) 156 is concentrated on testing procedures and ways for expressing the performances but no specific actions are foreseen for a more performance oriented approach of natural ventilation.

4. Proposed actions

Actions are proposed in the following domains :

1. Product development
2. Support of performance approach at level of standardisation and legislation
3. Demonstration projects

4.1 Product development

As indicated in this report, there are still important improvements possible at the level of the components. Especially the air supply can be substantially improved. Among the major improvements can be mentioned :

– **pressure sensitive vents at low pressure and cost**

There is clearly a very large market for pressure sensitive vents which operate at low pressure difference (starting at 1...2 Pa). Supporting more developments by industry in this area is clearly a priority since the market acceptance in case of success will be very high.

– **low pressure loss air cleaning techniques**

Since more and more people live in urban areas and because of the problems of outdoor air quality, supply devices with some air cleaning performances clearly have a large potential. At present, such devices are not yet on the market. An important boundary condition is to develop air cleaning devices which are small and which have a very low pressure loss (less than 1 Pa at nominal air flow rate). Electrostatic cleaning devices are probably relevant options but the cost implications may be too high.

– **demand controlled supply vents**

The emission of pollution in buildings vary in time. As such, there is no need to realise the nominal air flow rates at all circumstances. The development of demand controlled supply vents can result in important energy savings while maintaining a good indoor air quality. Besides the existing possibilities (humidity control for devices dimensioned at 10...20 Pa), there are probably interesting possibilities for humidity controlled devices working at low pressure difference, devices which are controlled by presence (infrared) detectors,...

– **energy autonomous systems**

Improving the controllability of natural supply vents is much easier if there is a minimum of electrical energy available for the control devices. However, connecting to the grid is not evident because of all the wiring problems and the need of transformers. To built in small and cheap energy providers is therefore an interesting option. One possibility which looks quite promising is the integration of small Photovoltaic (PV) elements in combination with small batteries.

– **Domotic and immotic systems**

Controllability is a key issue for natural ventilation. If one can realise intelligent energy supply, it is probably a realistic step to move to a domotic systems allowing central control of the devices. The ongoing developments in the area of domotics and immotics justify such approach. This can than allow a whole range of control strategies :

Besides improvements of the supply devices, it is also important to improve the natural exhaust devices. Automatic control seems also very relevant here.

Remark :

> *As mentioned earlier in the text, the development of low pressure air cleaning is studied in the framework of the JOULE project NATVENT. Also the development of pressure sensitive vents is studied in the framework of NATVENT as well as the development of heat recovery systems for natural ventilation. It is important to mention that these developments are focused on office type buildings and that the residential sector is not considered in this study.*

4.2 Support of performance approach at level of standardisation and legislation

Several countries have already some type of performance approach but it is clear that there is room for optimisation and that many countries/regions don't have yet such performance approach. This is clearly an important barrier for a wider dissemination of new technologies and they clearly don't motivate industry to develop interesting technologies. EC support in this area seems very relevant and in line with the philosophy of subsidiarity.

A project in the context of e.g. the SAVE programme seem very appropriate. In such project would it be interesting to bring together representative organisations from those countries with a (potential) market for natural ventilation. The project could include an inventory of the existing approaches in the different countries (including the reasons/philosophy) for these approaches, the possibilities for a more performance oriented approach and practical suggestions for a new approach. It is evident that industry should be involved in such project, e.g. by means of a number of workshops. Also evident is the involvement of organisations which have experience with standardisation and building regulations.

4.3 Demonstration projects

In order to gain experience with new technologies (allowing product optimisation), and also to convince the market of the advantages and potential of these technologies, demonstration projects in the framework of e.g. the THERMIE programme are very relevant. Specific attention should be given to retrofitting projects since this is clearly a very important market for the future. Moreover, it is especially in the case of retrofitting often not evident to make use of mechanical ventilation : difficulties for installing ductwork, existing ducts for natural ventilation are often not airtight enough for use in mechanical ventilation systems,...

The following criteria are important for the selection of demonstration projects:

- To what extent is a performance oriented approach envisaged?

  It is important that the intended performances with respect to the indoor climate (acoustics, thermal comfort, indoor air quality), the air flow rates and the performances of the components and system (airtightness, energy use, maintainability,...) are clearly described

- What is the degree of innovation in the demonstration project?

  Given the fact that a substantial part of the existing systems have in practice shortcomings with respect to the indoor climate and/or energy performances, specific attention should be given to projects with innovative concepts.

- Is there a coherent monitoring programme in which the performances are evaluated?

It is important that the intended performances are correctly evaluated.

5. Literature

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