# Nat*Vent*™

*Overcoming technical barriers to low-energy natural ventilation in office type buildings in moderate and cold climates*

EC CONTRACT: JOR3-CT95-0022 (DGXII)

# Barriers to Natural Ventilation Design of Office Buildings

## National Report: *Belgium*

*David Ducarme, Peter Wouters*
Belgian Building Research Institute

July 1998

Research part funded by
THE EUROPEAN COMMISION
in the framework of the
Non Nuclear Energy Programme

# Contents

# Introduction

The objective of the study described in this report is to identify barriers restricting the implementation of natural or simple fan assisted ventilation systems in the design of new office type buildings and in the refurbishment of existing such buildings. The perceived barriers are identified in an in-depth study with structured interviews based on questionnaires among leading designers and decision makers. The interviews have focused on general knowledge, viewpoints, experience and perceived problems with natural ventilation in office type buildings and on the decisions actually taken in specific building projects.

Mechanical ventilation systems are often installed in office buildings where good natural ventilation would have been sufficient to obtain comfortable indoor climate and good air quality. It is important to identify the barriers seen by designers and decision makers which restrict the implementation of natural ventilation systems and lead to the decision to install mechanical ventilation plants in office buildings where it is not strictly necessary. Knowing the barriers is the first step in providing solutions to overcome them. To our knowledge it is the first time a study of this type has been performed in Belgium.

The identification of perceived barriers to natural ventilation design of office buildings is the first phase (work package) of the ***NatVent***™ project being carried out under the JOULE programme. The two other work packages in the ***NatVent***™ project are:

- Performance of naturally ventilated buildings.
  The aim is to evaluate the performance of twenty existing buildings designed specifically for natural ventilation.

- 'Smart' technology systems and components.
  The aim is to develop systems, components and solutions to the barriers and shortcomings identified in the first two work packages. This work package includes:
  - Air supply components suitable for high pollution and noise loads
  - Constant (natural) air flow inlets
  - Advanced natural ventilation systems with heat recovery
  - 'Smart' components and 'intelligent' controls for night cooling
  - Integration of ‘smart’ systems for year-round performance

The ***NatVent***™ project is performed by nine organisations in seven central and north European countries. The project is headed by Building Research Establishment, BRE (UK). The other partners are:

1. Centre Scientifique et Technique de la Construction, CSTC (BE)
2. Danish Building Research Institute, SBI (DK)
3. TNO Bouw (NL)
4. AB Jacobsen & Widmark, J&W (SE)
5. Technical University, Delft (NL)
6. Willan Building Group (GB)
7. Norwegian Building Research Institute, NBI (NO)
8. Sulzer Infra Laboratory (CH)

This report is an output from the ***NatVent***™ project which is part funded by the European Commission DGXII within the JOULE programme 1994-1998 and under contract: JOR3-CT95-0022.

This report describes the results of the Belgian interviews. Similar reports giving the results of the interviews in the other countries are also produced.

In addition the main results of the interviews will be published in a common final international report. The final report will summarise the results from the interviews in each country and compare them to identify common problems with the implementation of natural ventilation systems and to gain experience from countries that have solved some of the problems. The final report will also give recommendations on how to overcome the identified barriers.

The *NatVent*™ project team would like to thank all the interviewees: designers and decision makers for the knowledge and experience they have brought to the project and for the time they have spend.

# Method

The perceived barriers to natural ventilation design of office buildings are identified in an in-depth study with structured interviews among leading designers and decision makers: architects, consultant engineers, contractors, developers, owners and the governmental decision maker responsible for regulations and standards.
Interviews with ordinary users of office buildings are not included in this study, because they are not the ones making the decisions in the design phase. The users perception of the indoor climate is part of Work Package 2: 'Performance of naturally ventilated buildings', where physical parameters e.g. ventilation rates, room temperatures and indoor air quality are also measured and compared with the users responses.
The interviews consist of two parts:

- General view on natural ventilation in office buildings.
  This part focus on general knowledge, viewpoints, experience and perceived problems with natural ventilation systems in office type buildings.
- Specific building project.
  This part focus on the decisions actually made during the design or refurbishment of an office type building.

The second part of the interview was performed only with those interviewees that were already experienced with natural ventilation and had already achieved relevant projects.
The interviews were performed among:

7 Architects
3 Consultant engineers
1 Contractors
1 Developers
1 Owners
1 Governmental decision maker

The number of designers and decision makers interviewed are limited due to limited financial resources in the project. The persons interviewed are therefore selected with the intention to also identify the variety in opinions and viewpoints on natural ventilation in office buildings.
The interviews were based on questionnaires. There were two questionnaires to be filled in during an interview. The first questionnaire covers: General view on natural ventilation in office buildings and the second questionnaire covers: Specific building project.
The questionnaires are designed to facilitate the performance of statistics on the viewpoint of the interviewee. The questionnaires are not too tight and there are ample space for additional comments, remarks and viewpoints not included in the questions.
The questionnaires were completed by the interviewee and the interviewer together and the interviewer also if necessary guided the interviewee in understanding the questions. If a question couldn't be answered by the interviewee or is irrelevant to the interviewee it was indicated in the questionnaire.

## *Questionnaire on general view*

The questionnaire concerns general view on natural ventilation in office buildings. The questionnaire comprises 14 subjects:

*1. Interviewee*
Identification of the interviewee

*2. Organisation*
Description of the organisation: type, disciplines, number of employees and building types.

*3. Knowledge*
Knowledge on mechanical ventilation, heat recovery, mechanical cooling, ordinary natural ventilation and special design natural ventilation in offices including special ventilation windows, advanced vents, internal ventilation openings, roof openings etc. The questions were answered by indicating the knowledge on a specific 5 point scale ranking from 'None' to 'Thorough'.

*4. Experience*
Ventilation experience in the organisation focusing on the extension of new and refurbished office buildings designed or owned by the interviewees organisation. Also questions to identify the percentage of buildings with: mechanical ventilation, ordinary natural ventilation and special design natural ventilation in the offices.

*5. Project fee*
Type of project fee received by architects and consultant engineers for the design of office buildings. Questions were asked to identify the percentage of projects with fee paid as: fixed fee, percentage of construction cost, per hour rate or other type of payment for design.

*6. Natural ventilation in cellular offices*
*7. Mechanical ventilation in cellular offices*
*8. Natural ventilation in open plan offices*
*9. Mechanical ventilation in open plan offices*
General views on perceived advantages or problems with either natural or mechanical ventilation in cellular and open plan offices. The questions asked under subjects 6, 7, 8 and 9 are identical and only the ventilation system and the office type differs. The questions concern: design, availability of products, performance in practice, controllability and costs and were answered by checking the same 5 points scale as used in subject 3.

*10. Your source of natural ventilation knowledge*
Possible sources are: standards, guidelines, building studies, experience, own design and other.

*11. Expected future use of natural ventilation in office buildings*
Expected future use of natural ventilation in office buildings designed or owned by the organisation. The question were answered by checking a specific 5 points scale ranking from 'Decreasing' over 'Unchanged' to 'Increasing'. The interviewees were also asked why they have this expectation.

*12. Requirements restricting the use of natural ventilation in offices*
Perceived restriction in the use of natural ventilation in offices from requirements in building codes, norms, standards, working condition codes etc. The question were answered by checking a 5 points scale ranking from 'None' to 'Comprehensive' and by indicating which code, norm or standard that includes the restrictions.

*13. Desirable new design tools for natural ventilation*
Possible new sources and design tools could be source books, guide lines, examples, simple or advanced computer programmes etc.

*14. Desirable new components for natural ventilation*
Possible new components could be air inlets, control systems etc.

## *Questionnaire on specific building project*

The questionnaire concerns one specific building project. The building could be either newly constructed or newly refurbished and could be with either natural or mechanical ventilation. The building were selected by the interviewee to be typical. The questionnaire comprises 5 subjects:

*1. Interviewee*
Identification of the interviewee

*2. Building*
Identification of the building and indication of key figures including building name, address, building type, year of construction, year of refurbishment (if any), site (urban, sub-urban, industrial or rural), $m^2$-floor area, number of storeys, building depth from facade to facade and storey height.

*3. The design*
Description of the actual design of the ventilation system and the building design parameters with influence on the ventilation demand and the ventilation system design. The design were described by checking a row of boxes for each room type in the building: offices, meeting rooms, canteen, corridors, stairways, entrance hall, atria, lavatories and others. The design specification includes:

| | |
|---|---|
| Ventilation system: | Mechanical ventilation, mechanical exhaust, natural ventilation, heat recovery, night time ventilation |
| Mechanical cooling: | In ventilation system, cooled ceilings |
| External openings: | Ordinary windows, special ventilation windows, ordinary vents, advanced vents, stack ducts, ventilation chimneys, roof openings, ducted air supply |
| Internal horizontal flow openings: | Doors, ventilation openings, open connection |
| Internal vertical flow openings: | Ventilation openings, open connection |
| Solar shading: | Internal, between panes, external, protective glazing |
| Ceilings: | High ceiling, false ceiling, exposed heavy structure |
| Floor and walls: | Exposed heavy floor, internal walls, external walls |

*4. Background for the design*

Indication of critical parameters in the ventilation system design and in the relevant parts of the building design. The critical parameters were prioritised for each of the room types on a 5 point specific scale ranking from ‘1. low’ to ‘5. high’. The critical parameters includes:

| | |
|---|---|
| Winter conditions: | Room temperatures, indoor air quality, draught |
| Summer conditions: | Room temperatures, solar loads, internal heat, draught |
| Controllability: | Individual control |
| Noise: | Internal noise, external noise |
| Pollution and odours: | Internal air and external air pollution or odours |
| Safety: | Fire regulations, security |
| Costs: | Construction, operating and maintenance costs |

*5. Biggest influence on chosen design*

Indication of biggest influence on the chosen design. The influence could be from: architect, consultant engineer, contractor, owner, developer, investor, user, the actual building site, requirements in codes, norms, standards or from other. The influence were prioritised on the same 5 point specific scale as used in subject 4 above.

# Results

The main results of the interviews are described in this chapter.

## *The interviewee*

In total, 14 interviews were performed. The interview sample comprises: 3 HVAC consultant engineers, 7 architects, 1 owner, 1 developer, 1 builder and one governmental representative.
The HVAC engineers interviewed represents very well the present practice in Belgium. There is a large consultant office belonging to the biggest engineering company in the country, a medium office and a small office.
Likewise, the architects interviewed represent a good sample of what can be found in Belgium: from leading architects working with 50 collaborators to small architect offices.
It was not too difficult to find designers (architects and HVAC consultants) interested in participating to the enquiry and able to add a value to this enquiry. Our experience is however that builders and developers do not show a gigantic interest for natural ventilation or even for ventilation in itself.
The interviewed builder impersonates the current Belgian practice. The interviewed developer is for himself not very representative of the Belgian practice, he recently took the challenge to build offices with an overheating prevention strategy based on night ventilation. He thinks that in the context of promotion project passive techniques can be interesting.
The interviewed building owner is probably one of the very first in Belgium that decided to construct a low-energy building with a special natural ventilation design (large stack chimneys for night ventilation).
The interviewed governmental representative belongs to the "Régie des bâtiments" and is responsible for special techniques (including ventilation) in public buildings in Belgium. This department of the Public Work Ministry has a strong involvement in the standardisation at both Belgian and European levels.

## *General view*

The results in the figures in this section of the report are the average for each group of professions interviewed. If none of the interviewees in a profession group has answered a question, the result is omitted for that profession group and question. *All* are the average of all groups except the governmental decision maker, with the profession groups weighted equal.

**Knowledge on ventilation**
Figure 1 shows the interviewees perception of own knowledge on the five topics: mechanical ventilation, heat recovery, mechanical cooling, ordinary natural ventilation and special designed natural. A specific 5 point scale ranking from 1: *None* to 5: *Thorough* is used to indicate the level of knowledge.

The interviewee have indicated their level of knowledge on the five topics based on the knowledge necessary to perform their normal task in the design or decision process and relative to their profession. It is therefore not possible to compare the absolute level of knowledge between the professions based on the results. The results can merely be used to compare the relative knowledge on the five subjects group by group.

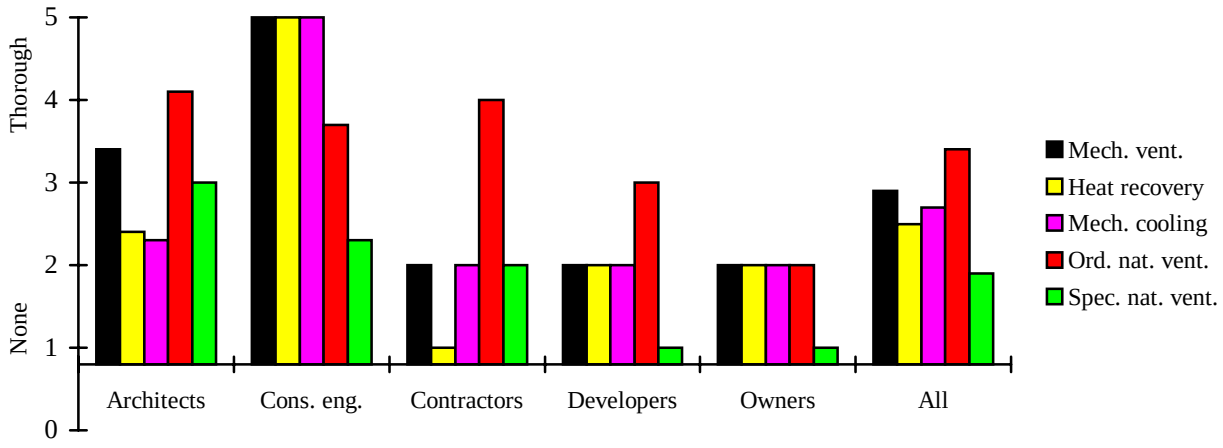


***Figure** Error! Unknown switch argument. **- The interviewees perception of own knowledge. The scale ranks from 1: None to 5: Thorough.***

As it can be seen, the knowledge on ordinary natural ventilation is for most interviewee groups higher than the knowledge on mechanical ventilation with the exception of the consultant engineers (of which of course the main work is to install mechanical ventilation systems). However, a large majority of the interviewees think that natural ventilation does not involve any special devices (window vents, stack chimneys, ventilation louvres, etc.) : a naturally ventilated building is a building where the windows can be opened. Actually, natural ventilation *systems* (with the exception of window opening) are very rarely installed in office buildings in Belgium; in general they are either equipped with mechanical ventilation systems or no system at all. This is confirmed by the low vote given to the knowledge on 'Special Designed Natural Ventilation' in the previous figure.

Briefly put, the fact the natural ventilation gets more points than mechanical ventilation means that ventilation in itself is not well known : it is still often believed in Belgium that openable windows are enough to get a good indoor air quality. This belief is reinforced by the lack of adequate legislation in the Flemish Region and in Brussels for the ventilation of office buildings : the only requirement is that each employee should get 30 $m^3/h$ of fresh air but if the windows are openable no system must be installed. There is a legislation in the Walloon Region which requires that office buildings must be ventilated in a different way that by opening windows but the latter dates only from December 1996 which makes it too early to really evaluate its impact on the Belgian practice.

**Experience**

The interviewees relative experience with mechanical ventilation, ordinary natural ventilation and special designed natural ventilation in new offices is shown in figure 2. Figure 3 shows the interviewees relative experience with mechanical and natural ventilation in refurbished offices. The relative experience is the per cent of mechanical or natural ventilated offices designed, constructed or owned, measured by the floor area or alternatively by the number of office buildings.

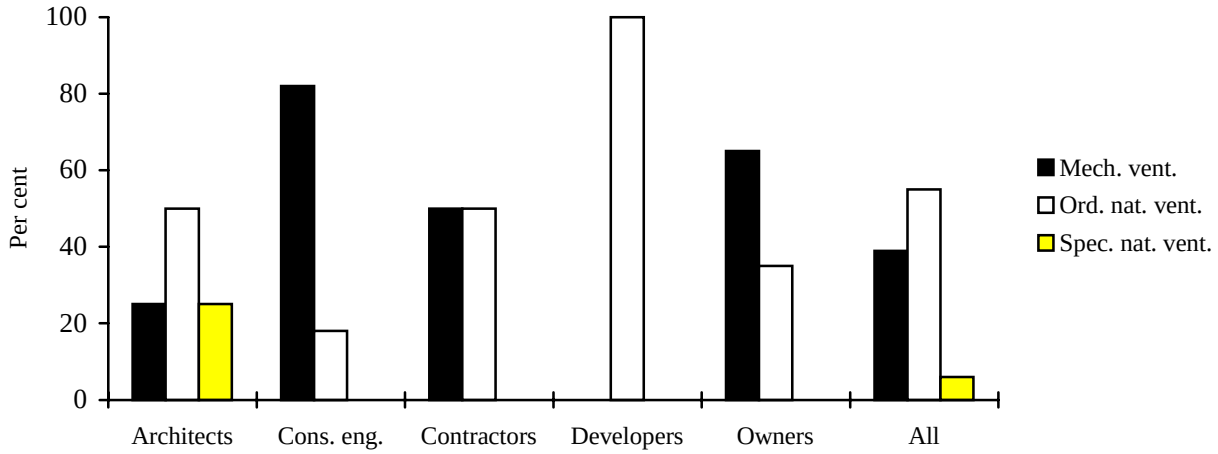


***Figure** Error! Unknown switch argument. **- The interviewees relative experience with mechanical and natural ventilation in new offices. The scale is the per cent of mechanical or natural ventilated new offices designed or owned.***

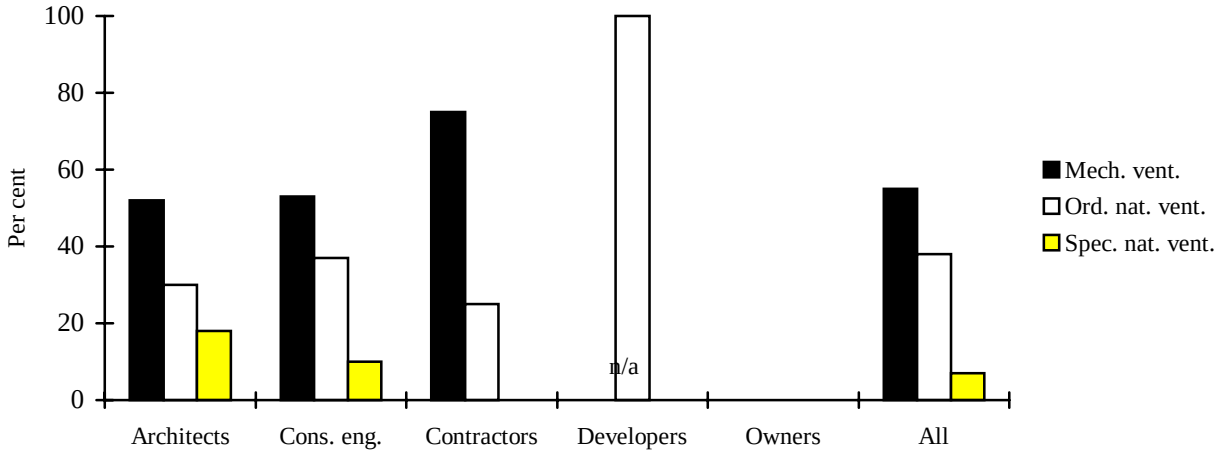


***Figure** Error! Unknown switch argument. **- The interviewees relative experience with mechanical and natural ventilation in refurbished offices. The scale is the per cent of mechanical or natural ventilated refurbished offices designed or owned.***

It is quite difficult to interpret these graphics because a lot of interviewees could not give accurate figures which makes the results not very representative of the exact situation. However, it emerges from the collected data that on average mechanical and ordinary natural ventilation get almost the same points while the experience with special designed natural

ventilation in office buildings is almost not existing. Once again, by ordinary natural ventilation, the interviewees mean openable windows.
The fact that the experience is almost the same for mechanical ventilation and ordinary natural ventilation while the knowledge about natural ventilation is higher is probably due to the fact that HVAC consultants are often subcontracted for designing mechanical ventilation systems whereas ordinary natural ventilation is designed by the architects himself because of their simplicity.

**Project fee**

The type of fee received by the interviewed architects and consultant engineers for the design of office buildings is shown in figure 4. The possible fee types are: Fixed fee, percentage of construction costs and per hour rate.

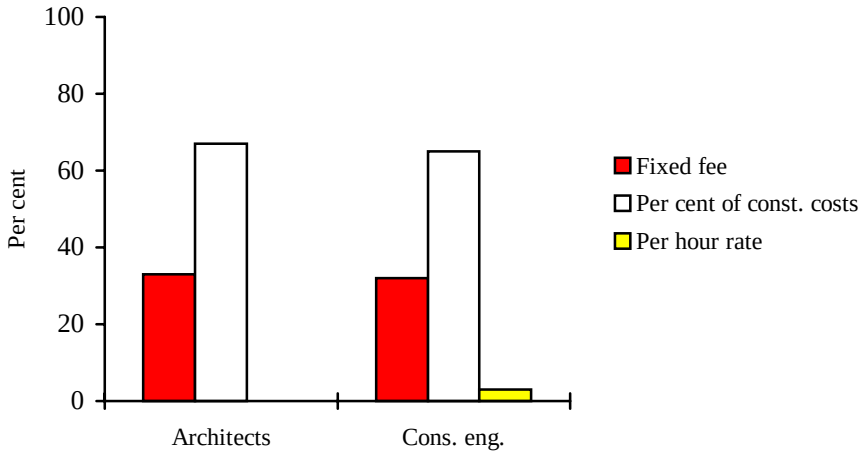


***Figure** Error! Unknown switch argument. - **Type of fee received by the interviewed architects and consultant engineers for the design of office buildings.***

The fee structure which is the most used in Belgium for architects and consultant engineers seems to be the *percentage of the construction costs*. This is a possible barrier against a wider market penetration of low-installation designs (like natural ventilation) since the more systems are installed, the higher the benefit for the consultant engineer.
One of the interviewees (a leading architect very interested in low-energy designs) recently changed from percentage of the construction cost to fixed fee because of several financial problems in low-cost projects.

**Design**

The interviewees perception of the design of natural and mechanical ventilation in cellular and open plan offices regard ease of design, availability of design guidelines and advises, availability of products, flexibility to building use and user satisfaction are shown in figure 5. A specific 5 point scale ranking from 1: *Poor* to 5: *Excellent* is used to indicate the interviewees perception of the design.

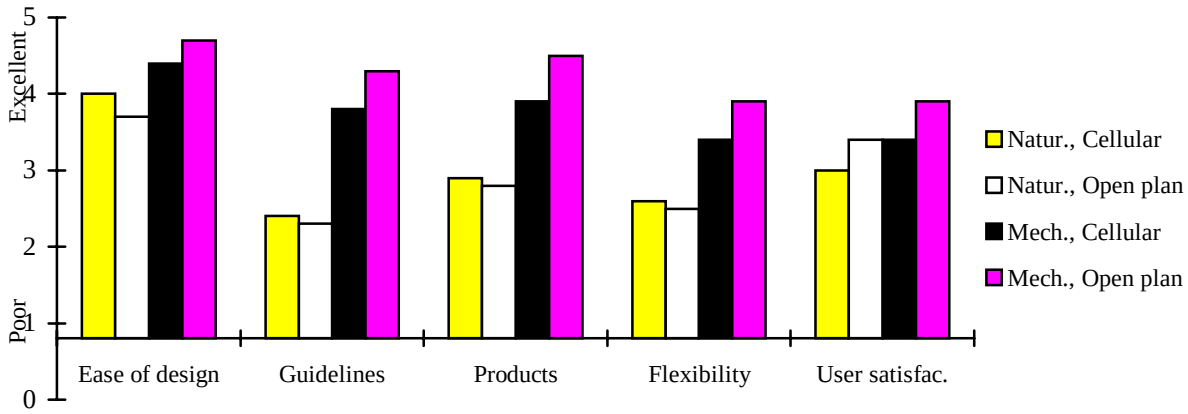


***Figure** Error! Unknown switch argument. - **The interviewees perception of the design of natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Poor to 5: Excellent.***

There are no large difference between the interviewees perception of the *ease of design* in the four cases:

- Natural ventilation in cellular offices
- Natural ventilation in open plan offices
- Mechanical ventilation in cellular offices
- Mechanical ventilation in open plan offices.

Mechanical ventilation gets a slightly better vote but which is probably not statistically significant. The general point of view seems to be that both natural and ventilation systems are quite easy to design. This deserves a comment: it is evident for natural ventilation specialists that special natural ventilation (or low-installation/energy) projects are much more complex to design than ordinary office buildings. The fact that this is not mentioned by the practice is due to the lack of knowledge of the practice about these advanced new techniques.

This is confirmed by the recognition that guidelines for natural ventilation are rather poor while guidelines for mechanical ventilation are very good and available. As well, special natural ventilation products are not found easily in the market compared to classical mechanical ventilation products.

The figures also show that the flexibility of natural ventilation is judged better than the flexibility of natural ventilation. This is indeed a possible barrier against advanced natural ventilation designs. More and more flexibility is wanted from office buildings (moveable partition walls, functions of rooms can change, etc.). Moreover, a lot of buildings are sold by promoters completely empty and the buyers can do whatever he wants with the inside layout. This makes certainly the designs of both natural and mechanical ventilation systems more difficult but, it is probably also true, that special natural ventilation designs with complex air flow patterns within the building can be incompatible with *flexibility*.

It would be dangerous to draw conclusions on the user satisfaction votes because of the small number of interviewees. It is however a general remark from the designers that the users are not always very fair with the ventilation or air-conditioning systems. They are often strongly influenced by other parameters (work atmosphere, etc.).
One can conclude that globally the perception of the sample of interviewees is that the design of mechanical ventilation systems is easier: more guidelines, more products and more flexible.

**Performance in practice**
The interviewees perception of the performance in practice of natural and mechanical ventilation in cellular and open plan offices regard cooling effectiveness, draught minimisation, ability to remove odours and pollutants, ability to prevent ingress of odours and pollutants, insulation against external noise, generation or transmission of internal noise are shown in figure 6. A specific 5 point scale ranking from 1: *Poor* to 5: *Excellent* is used to indicate the interviewees perception of the performance in practice.

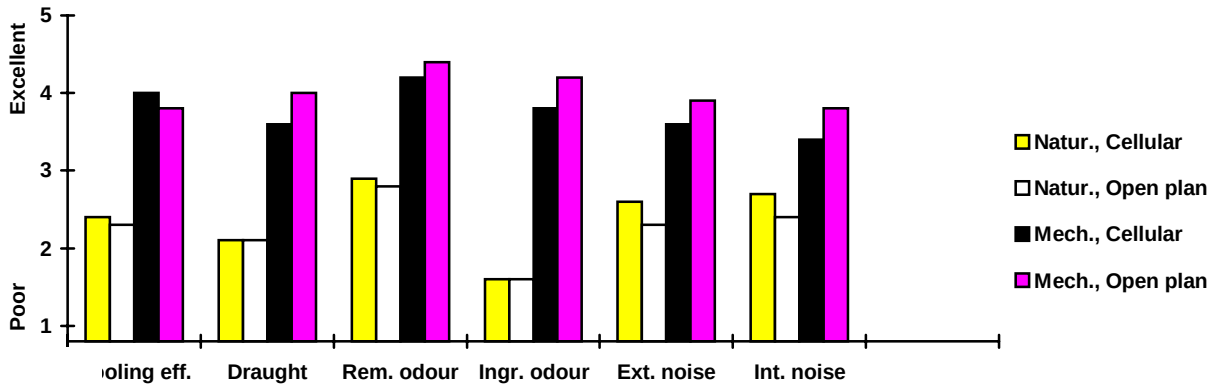


***Figure** Error! Unknown switch argument. **- The interviewees perception of the performance in practice of natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Poor to 5: Excellent.***

The interviewees seem to expect a better performance in practice of mechanical ventilation systems than of natural ventilation systems concerning the cooling effectiveness, draughts, ability to remove of odours and pollutants, ability to prevent ingress of odours and pollutants, insulation of external noise and generation or transmission of internal noise.
This is of course a strong barrier against a wider penetration of low-energy natural ventilation designs.
It was several times mentioned that natural ventilation is not possible in cities because you cannot avoid the penetration of external pollutants and dust from the outside. Moreover, most of office buildings are in cities!
The point on cooling effectiveness for not well understood by the interviewees because the overall design of the building impacts on the possible cooling effect from the ventilation systems.

**Controllability**

The interviewees perception of the controllability of natural and mechanical ventilation in cellular and open plan offices regard central controllability, local controllability (per office) and individual controllability (per person) are shown in figure 7. A specific 5 point scale ranking from 1: *Poor* to 5: *Excellent* is used to indicate the interviewees perception of the controllability.

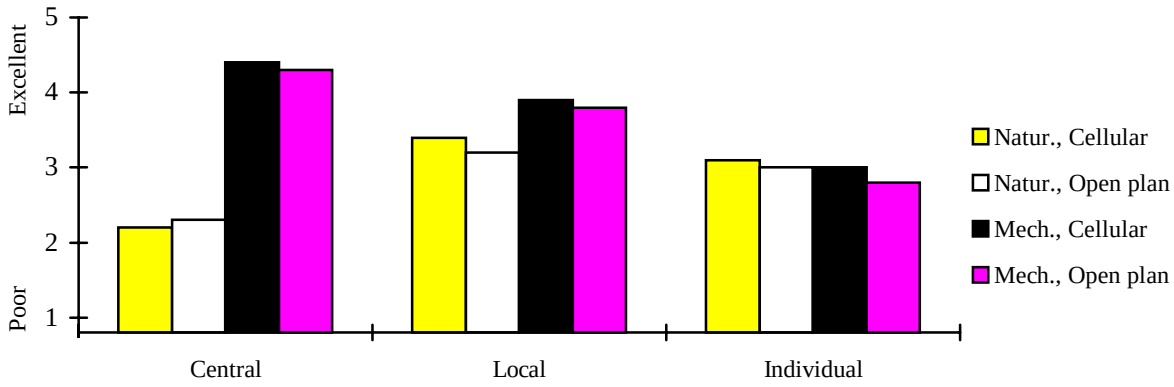


***Figure** Error! Unknown switch argument. **- The interviewees perception of the controllability of natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Poor to 5: Excellent.***

There is no noticeable difference between the controllability in open plan or cellular offices according to the interviewees. This result is a little biased because a lot of interviewees did not find it useful to answer a second time for open plan offices and gave the same answer as for cellular offices.

The interviewees expect a higher central controllability from mechanical ventilation systems than from natural ventilation systems. For the local and individual controllability, no such difference is observed.

One of the interviewed consultant engineers did not answer the parts of the questionnaire on natural ventilation because for him it is not controllable at all and therefore useless.

**Costs**

The interviewees perception of the costs for natural and mechanical ventilation in cellular and open plan offices regard installation costs, running costs and maintenance costs are shown in figure 8. A specific 5 point scale ranking from 1: *Inexpensive* to 5: *Expensive* is used to indicate the interviewees perception of the costs.

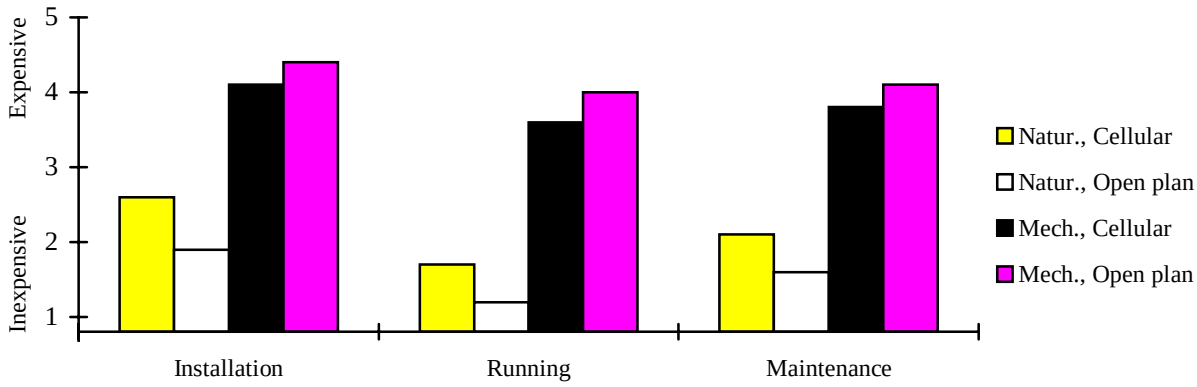


***Figure** Error! Unknown switch argument. - **The interviewees perception of the costs for natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Inexpensive to 5: Expensive.***

The cost aspect turns to the advantage of natural ventilation regarding installation costs, running costs and maintenance costs.

The interviewed promoter, for whom cost aspects are of high importance, mentioned that induced costs of natural ventilation can be very high compared to mechanical ventilation (integration of large ducts in the building, chimneys, etc.). Moreover, such advanced natural ventilation systems can be quite difficult to integrate in a renovation project.

We can illustrate that comment by the following example:

> If a chimney of 1 m² is necessary to ventilate 100 m² floor area of offices, it means that 1% of the usable floor area is lost. This is equivalent to a loss of about 200 ECU/year (if the building is hired) which is enough to pay 1600 kWh/year[1] of cooling energy, that is an average cooling power of 25 W/m² during 1/3 of the yearly working hours (the summer period) or 9 W/m² for the all year round!

[1] Only the cost aspect is taken into account and not the environmental aspect (the price of 1 kWh of cooling energy is assumed to be 0.125 ECU).

**Source to natural ventilation knowledge**

The interviewees sources to natural ventilation knowledge regarding standards, guidelines, building studies, experience, own design and others are shown in figure 9. The scale is the per cent of interviewees using a source type.

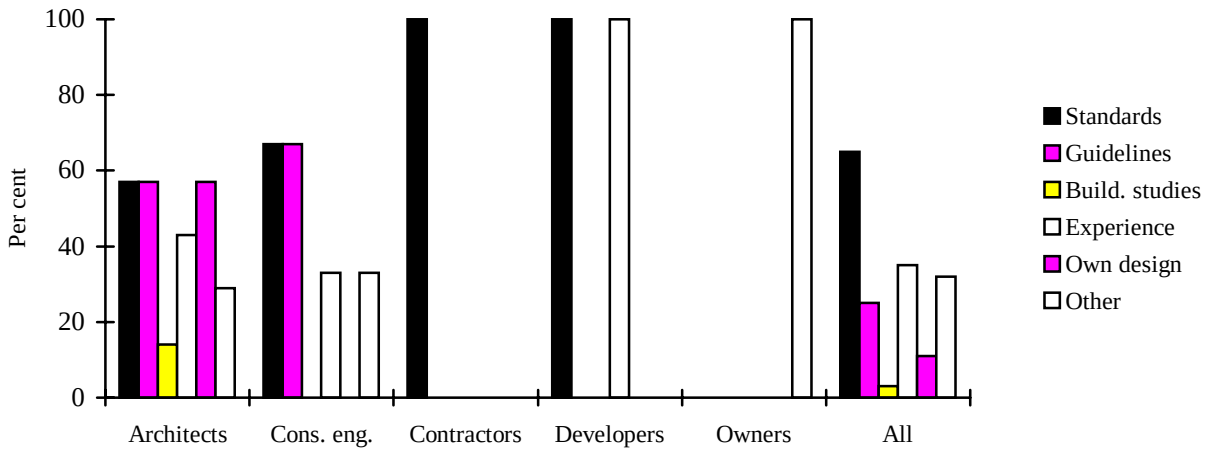


***Figure** Error! Unknown switch argument. **- The interviewees source to natural ventilation knowledge. The scale is the per cent of interviewees using a source type.***

The architects and the consultant engineers (the designers actually) have their knowledge on natural ventilation from different sources: standards, guidelines, own experiences, building studies, etc. The contractors, owners and developers consider only standards and own designs (1 case).

However, the general opinion of interviewees showing an interest in natural ventilation is that there is a lack of good knowledge sources about natural ventilation. With the exception of several prestigious buildings (e.g. the new parliament in London), it is difficult to find good documented case studies.

**Expected future use of natural ventilation**

The interviewees expectations on the future use of natural ventilation in offices are shown in figure 10. The expectation is indicated on a specific 5 points scale ranking from 1: *Significant decreasing* over 3: *Unchanged* to 5: *Significant increasing*.

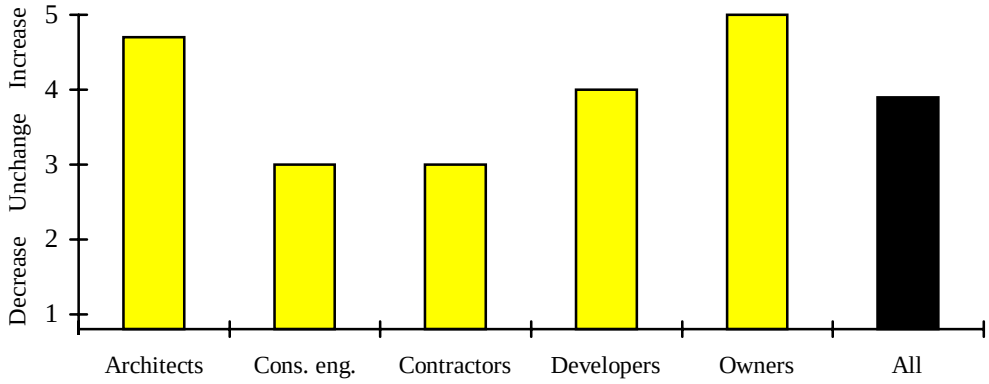


***Figure** Error! Unknown switch argument. **- The interviewees expectations on the future use of natural ventilation in offices.***

*The scale used ranks from 1: Significant decreasing over 3: Unchanged to 5: Significant increasing.*

On average, the interviewees expect an increase of the use of natural ventilation. The architects seem more confident that natural ventilation designs will become more common. Consultant engineers on the contrary think that the situation will remain unchanged (that is almost no natural ventilation designs).

Reasons for an increase of the use of natural ventilation are given hereafter. Comments from the authors of this report are given in *italic*.

- Because it cheaper when systems are simple. *One must be careful with this statement because natural ventilation systems are sometimes much more complex than mechanical ventilation systems.*
- The authorities will have to take care of the pollution problem in cities and take measures to drastically reduce pollutant emissions. This will result in a better outdoor air quality in cities and therefore, one of the major barriers against natural ventilation (impossibility to filter) will fall down.
- The need for comfortable, healthy and low-energy office buildings will become more and more critical.
- The global design of buildings will (hopefully) improve in the future. It is probable that external solar protections will become common, that internal gains will lower, etc. This will open doors to natural ventilation design for thermal comfort.

Reasons for a decrease of the use of natural ventilation in the future:

- Natural ventilation is not controllable, there is no suitable components, users are not disciplined enough.
- It is too risky to design a naturally ventilated building, the owner cannot accept that. There is no demand and no incentive for natural ventilation.
- The pollution problem in cities will increase hence the need for filtering systems which are only possible with mechanical ventilation systems.
- The building sector is so traditional that it takes years and years to change something to the mentalities.
- The internal gains are getting higher and higher.

**Restricting requirements in codes**

The interviewees perception of requirements in building regulations, codes, norms and standards restricting the use of natural ventilation in offices are shown in figure 11.

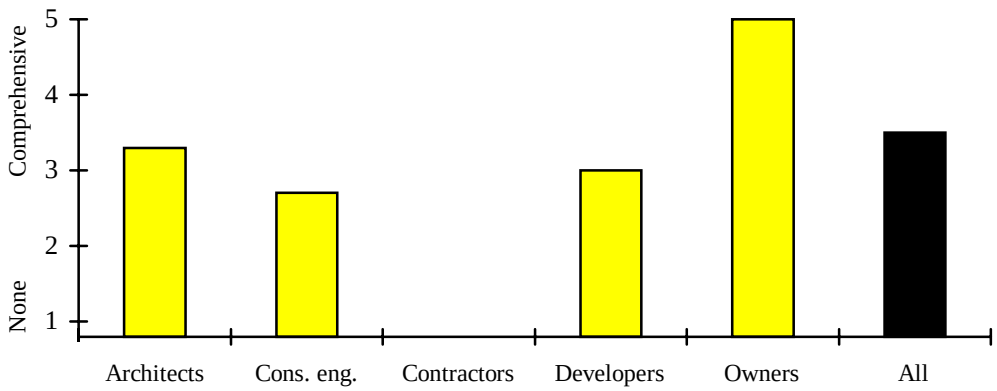


***Figure** Error! Unknown switch argument. **- The interviewees perception of requirements in building regulations, codes, norms and standards restricting the use of natural ventilation in offices. The scale ranks from 1: None to 5: Comprehensive.***

The general impression emerging from the performed interviews is that there are many barriers in standards and regulation which poses problems for the development of natural ventilation. Among others we can mention:

- Fire regulation. These are becoming more and more severe. It for example not allowed to have more than two storeys without a fire-resistant separation between the compartments. This may seriously complicate the natural ventilation design.
- Acoustics requirements. A good acoustical environment is also one of the requirement from the users/investors. This often necessitates to put insulation materials on the walls/ceilings/etc. which can reduce dramatically the accessibility to the thermal mass of the building.
- Standards are generally 'cooking recipes' and not performance oriented. They kill innovation and creativity.

**Desirable new design tools**

Global, the designers (architects and consultant engineers) think that the following design tools are missing:

- Guidelines and rules of thumb to evaluate the possible impact of natural ventilation (for both indoor air quality designs and summer comfort designs).
- User-friendly computer codes allowing to make more accurate estimation of the possibility offered by natural ventilation.
- Well documented case studies presented in attractive way so as to convince designers and investors. They should contain enough details to really understand the design and highlight the pitfalls and problems instead of showing only the successful parts.
- Source books on the theory of natural ventilation.

- Methods to clearly express the risks of exceeding maximal temperature requirements in natural ventilation projects (which reference year to use for the calculation, what is a good comfort criteria, etc.).
- Components that allow a better controllability and which allow a better architectural integration.

## *Specific building project*

8 of the 14 interviewees also filled in the questionnaire on a specific building project. However, among those 8 buildings, only 3 are naturally ventilated office buildings.
The results in the figures in this section of the report are the average of all the buildings included in the interviews.

**The buildings and the designs**

The following buildings were described by the interviewees:

- Three new office buildings with mechanical ventilation for IAQ control and natural (or fan-assisted) night ventilation for summer temperature control. These three buildings can be considered as advanced low-energy projects.
- Four office buildings with mechanical ventilation for IAQ control and air-conditioning or nothing to prevent overheating.
- One residential building with natural ventilation for IAQ control.

**Critical parameters**
The interviewees perception of the critical parameters for the design of the ventilation system in the offices is shown in figure 12. Each interviewee were allowed to point out maximum 5 critical parameters and were ask to prioritise them from 1: *Low* to 5: *High*.

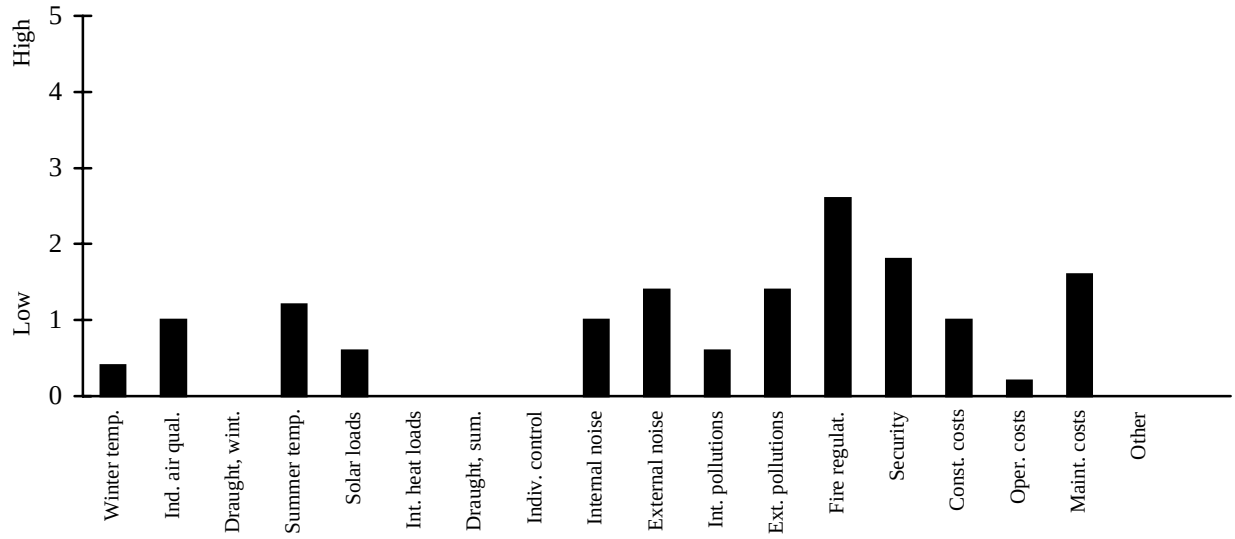


***Figure** Error! Unknown switch argument. **- Critical parameters in the design of the buildings.***

It is interesting to see that compliance with fire regulation is the more critical parameter. This reflect the strong impact that this point can have of the design of a building.
Then comes the security which seems to play a important role at the design stage. The latter can, to a certain extent, form a barrier against natural ventilation.
Maintenance costs and construction costs are also often mentioned as an important aspect to be considered at design stage.
Only after these points come the comfort aspects like summer temperature and pollution or noise.

**Influence**

The interviewees perception of the persons or conditions having the biggest influence on the chosen design is shown in figure 13. Again each interviewee were allowed to point out a maximum of 5 critical parameters and were ask to prioritise them from 1: *Low* to 5: *High*.

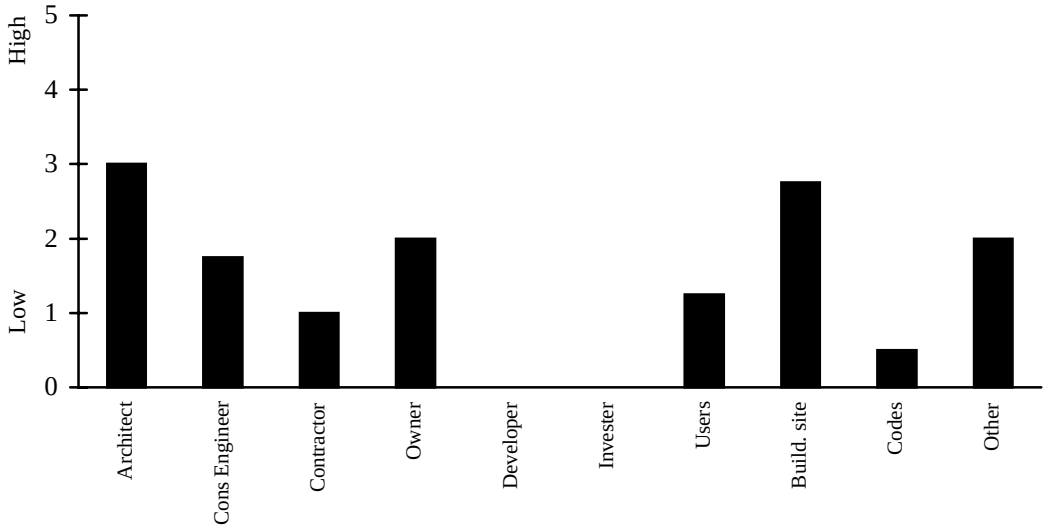


*Figure 13. Influence on the design of the buildings.*

The architects and the owner seem to have the largest influence on the design of the considered buildings. The building, the consultant engineers and the contractor comes only after.
One must be cautious when looking at these results because of the small number of data. For example, it is clear that the developer or the investor can have a big impact in some projects.

# Summary and conclusions

The objective of the study is to identify barriers restricting the implementation of natural or simple fan assisted ventilation systems in the design of new office type buildings and in the refurbishment of existing such buildings. The perceived barriers are identified in an in-depth study with structured interviews based on questionnaires among leading designers and decision makers. The interviews have focused on general knowledge, viewpoints, experience and perceived problems with natural ventilation in office type buildings and on the decisions actually taken in specific building projects. The interviews were performed among: 5 architects, 3 consultant engineers, 2 contractors, 2 developers, 2 owners and a governmental decision maker.

The most significant barriers identified by the interviewees are:

- Natural ventilation design include a certain risk (because it is not controllable, it depends on weather conditions, etc.) that the comfort conditions are not met during certain periods of time. The clients do not want to take risks.
- The offices are in general located in cities where the pollution and the noise are high.
- There is a lack of incentive to create a demand:
  - The energy costs is very low compared to salary costs.
  - There is no strong regulation to oblige people to use rationally energy (e.g. a global energy performance index to be achieved).
  - The investors are not yet ready for ‘green’ or ‘natural’ buildings. The mentality is difficult to change because the construction is a very traditional sector.
- The induced costs of natural ventilation design can be high.
  - Loss of surface.
  - Large impact on the building layout (less flexibility).
- The project fee as a percentage of the installation does not favour low-installation/low-energy projects.
- Consultants engineers do not have the required knowledge for designing naturally ventilated buildings. They do not have time to invest in new advanced techniques because time is money and the economic situation is not brilliant.
- Most of the architects are not interested because their goal is to make money and not to build low-energy buildings. They need a market.
- The owners and the investors are not always aware of the possibilities offered by green designs. It is crucial to educate them.
- Standards can be severe barriers against natural ventilation designs. They should be more performance oriented and less based on system description.

Furthermore, the interviews performed allow to draw the following conclusions:

- There is a very significant **lack of knowledge and experience** on special designed natural ventilation in office buildings compared to the knowledge and experience on mechanical ventilation. A lot of interviewees do not know well natural ventilation and have erroneous idea about it. On average, mechanical ventilation is judged to have better performance than natural ventilation.
- In like manner, there is a **lack of sources to natural ventilation knowledge** in standards, guidelines and building studies and a desire for new design tools on natural ventilation including also rules of thumb and user-friendly computer software. As well, there is a need for **new components** that enhance the controllability and can be more easily architecturally integrated.
- A **driving force is missing**: money, regulation, ecology, etc. Without a driving force there is no market and without a market the knowledge has no reason to build up. The demand need to be stimulated (promotion, demonstration projects, supporting standards, building codes, etc.).
- Interviewed architects expect an **increased interest for natural ventilation** while consultant engineers not with the present technical solutions.

# Annex I: Typical ventilation systems in office buildings

The objective of this annex is to give foreigners some background knowledge on typical ventilation systems in Belgian office buildings and on the Belgian tradition on office ventilation. The description is based on the author's immediate knowledge and must be considered as such and not as a scientific or statistic work.

The indoor air quality of most Belgian office buildings, especially large office buildings, is guaranteed by a mechanical ventilation system.. Smaller office buildings have often only windows that can be opened and mechanical ventilation in specific rooms like canteens, meeting rooms and reproduction rooms. Mechanical exhaust in toilettes is rather common. The amount of office buildings that are really designed for natural ventilation is very limited.

Intensive night ventilation to improve the thermal comfort in summer time is at the moment only applied in demonstration projects.

**Natural ventilation**

If buildings that are ventilated just by opening the windows are not considered as natural ventilated buildings, few Belgian office buildings are naturally ventilated. This present-day situation has several reasons.

One major reason is the fact that office buildings are often situated in an urban environment. Acoustics and outdoor air quality are important barriers to the use of natural ventilation. One however can expect a positive evolution in the future. On the one hand there is an increasing effort to improve the outdoor environment. On the other hand there is an important technological evolution of the natural ventilation devices; acoustical vents, self-regulating vents,…

Another important reason is a lack of knowledge about the principles of natural ventilation. The working of a naturally ventilated system can be quite complex; it depends on several parameters like wind pressure and temperatures. Therefore engineers often prefer mechanical ventilation because of the controllability.

**Mechanical ventilation**

Most existing large Belgian office buildings have a full air-conditioning system. In those climate installations, the ventilation for air quality is just a part of the complete system. There are however quite often several complaints related to this kind of installations: draught problems due to the high air change rates, sick building syndrome due to the problems with recirculation of conditioned air,…

Therefore there is an increasing tendency toward climate installations with a separated system for indoor air quality and thermal comfort. Several recent developments like cooling ceilings and displacement ventilation encourages this tendency.

Another driving force of this evolution is the interest for energy savings and reduction of CO2-emmisssion. The use of a "separated system" implies often an important reduction of energy consumption compared to a full air-conditioning system. At this moment no Belgian legislation restricts the energy use of office buildings. However one can conclude that there is a growing interest of leading architects toward low-energy design of installations.

In the Belgian market of climate installation for office buildings, there is at the moment a clear evolution from full conditioning toward a “separated strategy”. Whether the ventilation for IAQ in the future will be mainly natural or mechanical will depend on several factors like future legislation, the evolution of technology and the knowledge and design tools for natural ventilation. We expect that mechanical ventilation for IAQ control will be dominant.

# Annex II: Requirements in codes related to natural ventilation

This annex gives an overview of requirements in Belgian building regulations, occupational health regulations, standards, codes etc. related to natural ventilation systems or simple fan assisted ventilation systems in office buildings. One of the objectives is to identify requirements possible restricting the implementation of natural ventilation systems or simple fan assisted ventilation systems in office building. Requirements related to mechanical ventilation in office building are included in the overview if they can also be used on natural ventilation systems or simple fan assisted ventilation systems.
A special feature of the Belgian situation is the fact that Belgium is a federal country. There are three regions: Flanders, Walloon and Brussels. As these regions have their own authority in the field of rational energy use, each community has its own energy legislation.
Other matters like labour, public health and security are still elements of the federal authority. Also the Belgian Institute for Standardisation (BIN-NIB) is a federal institute. The standards (NBN + number) published by this institute have no mandatory character, as long as they are not integrated in a regulation of the Belgian government or the government of one of the regions. The Belgian standards are however important as they are considered as general accepted rules.

**Relevant documents**
**Doc.1 - ARAB:** *General Legislation on the labour conditions.* This legislation is a federal law, which determines a large variety of requirements concerning the working place. One of the regulated elements is the climate of the working place: temperature, air quality, lighting, …

**Doc.2 - Walloon Legislation of 15/02/96:** *Decisions concerning the thermal insulation and the ventilation of buildings in the Walloon Region.* This legislation is in force for all new and refurbished dwellings, schools and office buildings in the Walloon Region

**Doc.3 - NBN S 01-400**: Acoustics - Criteria for acoustical insulation. This Belgian standard defines the minimal acoustical performances of internal and external walls in a certain environment. It contains no specific regulations concerning natural ventilation. However it is clear that ventilation devices like vents in the external walls and ventilation ducts through the internal walls can reduce the acoustic performances.

**Doc.4 - NBN S 01-401**: Limit values for the noise levels to avoid a lack of acoustical comfort in buildings. This Belgian standard defines the maximal noise level of each type of room for different environments. To fulfil these requirements all walls have to meet the requirements of NBN S 01-401 and the production of noise from apparatus in the building has to be limited to a certain value.

***Doc.5 – Royal Decision of 19/12/97*** concerning the basic requirements for new buildings to prevent fire and explosion***.*** *This federal legislation applies for all new Belgian buildings. It determines several regulations for high, medium and small buildings. Each building has to be divided in separated fire-zones. This regulation can be a barrier to the application of intensive night ventilation because it requires for large buildings that there are no more than 2 floor levels in each fire compartment. Moreover, it may in the case of renovation works impose to increase the fire resistance of floors. This requirement is often meet by placing an insulation layer on the ceiling due to which the thermal mass is not longer accessible.*

The Belgian legislation and guidelines concerning the ventilation of office buildings is rather limited. There is no specific Belgian standard that treats this item. In the Walloon Region there is a recent legislation (see doc.2), which determines some basic elements (ventilation rates). In the Flemish region there is at the moment no legislation at all.

On the other hand there is a Belgian standard (NBN D50-001, see Doc.A) which deals in detail with the ventilation of dwellings. This standard is also integrated in the Walloon legislation (see Doc.B). Furthermore there are several documents of the BBRI (Belgian Building Research Institute) which comments this norm in detail and give a lot of supplementary guidelines (see.Doc. C & D).

**Doc A. NBN D50-001:** *Ventilation devices in dwellings*

**Doc B. Walloon Legislation of 15/02//96:** *Decisions concerning the thermal insulation and the ventilation of buildings in the Walloon Region.* This legislation is in force for all new and refurbished dwellings and office buildings in the Walloon Region. The legislation for dwellings is based on the Belgian norm NBN D50-001 (see Doc.A)

**Doc. C TV 192:** *Ventilation of dwellings / Part 1: Basic principles*

**Doc. D TV 203:** *Ventilation of dwellings / Part 2: Execution and Performances of ventilation systems*

Furthermore for reasons of public health (smoke) there are special regulations for hotels, restaurants and pubs. The regulations are described in a Royal Decision (federal legislation). Therefore these regulations applies for all Belgian hotels, restaurants and pubs. The content of the Royal Decision is explained in detail in the Horeca-note, a publication of the BBRI. The Royal Decision imposes the use of a mechanical exhaust system. The supply however can be natural (free) or mechanical.

**Doc. E Royal decision of 15/05/90** *concerning the smoking prohibition in public places.*

**Doc. F: Ventilation in the Horeca industry – HORECA-NOTE**

**Requirements**

The text in *'italic between quotation marks'* are quotations from the documents.

| Topic: | Document: | Requirements: |
|---|---|---|
| Ventilation system | **Doc.2** | *Art.2 §7 '.. If the building is higher than 13m, natural ventilation is only allowed when a study guarantees the working of the system.'* |
| Ventilation rates | **Doc.1** | *Art.56 '30m³ air per hour and per person supply of fresh air and exhaust of polluted air must be guaranteed.'* |
| | **Doc.2** | *Art.2 §4: 'For office buildings and the school buildings the following air change rates have to be guaranteed:*<br>• *Individual office: 2,9 m³/h.m²*<br>• *Landscape office: 2,5 m³/h.m²*<br>• *Meeting room: 8,6 m³/h.m²*<br>• *Auditorium: 23,0 m³/h.m²*<br>*The toilets have to be equipped with a mechanical exhaust system that continuously supplies 30m³ per hour per toilet or 60m³ per hour and per toilet when the ventilation is not working continuously….'* |
| Windows | **Doc.1** | *Art.57 'If circumstances permitting, the air of the rooms is changed by opening the windows during the working breaks.'* |
| Relative humidity | **Doc.1** | *Art.57 '…Unless it is not possible due to technological reasons or weather conditions, measures has to be token to ensure a relative humidity between 40 and 70%.".* (This regulation applies to natural and mechanical ventilation.) |
| Room temperatures | **Doc.1** | *Art.64 '…Maximal and minimal limit values are determined for closed working places according to the work effort:*<br>*light work:* $T_{min} = 18°C$ $T_{max} = 30°C$<br>*…..'* |
| Draught | **Doc.1** | *Art.58 4.'When a mechanical ventilation system is used, the air velocity has to be limited to 0,5m/sec, unless higher speed is necessary to ensure a healthy working environment.'* |
| Fire safety | **Doc.5** | *Annex 3 - 2.1 'The building is divided in fire zones. The maximum surface of a fire zone is 2.500m²….. The maximum height of a fire zone is the height of one building layer……The following exceptions are allowed: … a fire zone may contain two building layers if the total surface of the fire zone is less than 2.500m².'* |
| Security | **Doc.2** | *Art.2 §7. '… Natural ventilation is allowed if the ventilation openings are completely burglar-free."* |
| Acoustics | **Doc.4** | *Art.6.2. '…The noise due to sources in the building has to be limited to an exceeding value of 6 dB(A)'* |