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OVERVIEW AND SYNTHESIS OF THE MONITORING ACTIVITIES CARRIED OUT IN THE FRAMEWORK OF THE NATVENT EC JOULE PROJECT

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ABSTRACT

Since the beginning of this decade, natural ventilation in office buildings is receiving specific interest. There are two sorts of application. Natural ventilation can be a strategy for indoor air quality control. Besides it can be used as night ventilation during warm or hot periods. In this case the objective is to cool down the thermal mass and improve the thermal summer comfort. The EC JOULE NatVent project wanted to identify the barriers to the application of natural ventilation in office-type buildings in moderate and cold climates and to provide solutions. In the framework of the NatVent project 19 naturally ventilated buildings in Belgium, Denmark, Great Britain, the Netherlands, Norway, Sweden and Switzerland were monitored. This paper briefly presents the monitored buildings and the major findings.

KEYWORDS
natural ventilation, office buildings, monitoring, measurements, case studies, indoor air quality, summer comfort, night cooling, NatVent, EC JOULE

THE NATVENT PROJECT

The NatVent project is a seven-nation EC JOULE project. The objective of the project is to overcome the barriers that prevent the application of natural ventilation in office-type buildings. It is intended for countries with low winter and moderate summer temperatures, where summer overheating from solar and internal gains can be significantly reduced by natural ventilation.

THE MONITORED BUILDINGS
In the framework of Task 2 of the NatVent project 19 naturally ventilated buildings in seven countries - Belgium, Denmark, Great Britain, the Netherlands, Norway, Sweden and Switzerland – were selected for detailed monitoring. The selected buildings are very diverse. Both existing as well as renovated and new buildings were studied. The objective of the monitoring was to identify the advantages and shortcomings of natural ventilation in ad-hoc buildings. The selected buildings were monitored during one winter and one summer period. Parameters such as temperature, humidity and ventilation rates were measured to identify the efficacy of the ventilation strategies.

The results of the monitoring campaigns and an interactive presentation of each building, as well as all the other final products of NatVent are collected on the NatVent CD-rom. The major findings of the monitoring campaigns are given below in eight key messages:

BE1: PROBE building	DK2: BRF Kredit headquarters	NO2: Pfizer building
BE2: Keppekouter building	DK3: WindowMaster building office	NL1: European patent office
BE3: Renson headquarters	GB1: BRE Energy Efficient Office	NL2: Town Hall of Zevenhuizen-M.
CH1: VELUX building	GB2: Canning Crescent Centre	NL3: Tax office of Enschede
CH2: EWZ building	GB3: Portland Street building	SE1: Tage Møller building
CH3: Basler Versicherungen building	NO1: Ulleval administration building	SE2: Technical Office of Varberg
DK1: E.Pihl & Son AS headquarters		

Figure 1: List of the 19 monitored buildings

KEY MESSAGES AND CONCLUSIONS

The key challenge is to achieve comfortable buildings that in addition are energy efficient

The indoor air quality in most of the 19 buildings is acceptable. The measured CO_2 levels are below the limits, which are generally accepted. On the contrary, many buildings suffer from serious overheating problems. Too high internal temperatures is the most common user complaint in the 19 buildings.

It is clear that indoor comfort should be the starting point of each building design. Due to the oil crisis in the seventies and the environmental concern nowadays, top priority is often incorrectly given to energy efficiency. This leads to energy efficient buildings with too high temperatures in summer, acoustical problems, poor indoor air quality, etc.

Priorities have to be reversed. The main objective is a good indoor climate: thermal comfort, indoor air quality, visual comfort and acoustical comfort.

Because of large internal gains thermal summer comfort is for most office-type buildings the main challenge. A comfortable indoor climate must be achieved by good building design and energy efficient installations. Furthermore it is crucial that the users are able to understand the concept of the building and are able to finance the required investments and running costs.

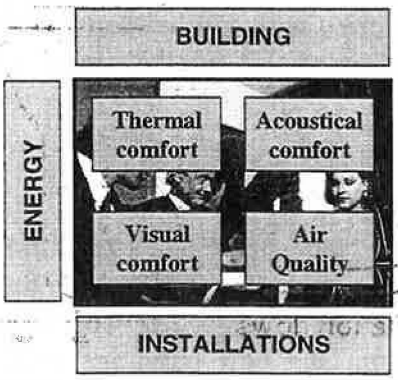

Figure 2: Global context for energy efficient buildings with good indoor climate

It is essential to understand the different meanings of natural ventilation

All 19 selected buildings were designated as 'naturally ventilated' buildings. However it was not always clear what was meant by 'naturally ventilated'. This leads to confusion, which is probably not good for the reputation of natural ventilation and which may also indirectly lead to poor design concepts. Therefore, it is essential to clearly identify the meaning of 'naturally ventilated building'.

Basically, there are 3 different understandings and concepts of natural ventilation:

- A design in which the air is assumed to enter and leave the building through unintentional leakages (infiltration). In the framework of the NatVent project, this type of air flow is not considered.
- A design in which the air quality is determined by a concept of supply and exhaust openings. Wind pressures and the stack effect are the driving forces for ventilation. This concept is called 'natural ventilation for Indoor Air Quality (IAQ) control'.
- A design in which during the summer a cooling effect is created by intensive ventilation with outside air. This concept is called 'natural ventilation for summer comfort'. Given the low temperatures at night time, intensive night ventilation is very interesting in moderate and cold climates.

Ventilation for IAQ is an optimisation of IAQ and energy efficiency

When applying natural ventilation during the heating season to control the IAQ, one has to avoid too large ventilation flows. Large ventilation flows mean large energy losses. The energy impact can be considerable, especially in very well insulated office buildings.

Several of the monitored projects (DK2, NO2, etc...) where natural ventilation is used for IAQ control, have no advanced control strategy for the air flow rates. Although an acceptable indoor air quality is achieved, air flow rates are often substantially above the required air flow rates leading to unnecessary ventilation losses.

In a number of projects (BE1, BE2, BE3), natural ventilation is only used for summer comfort, while mechanical ventilation for IAQ control. It is evident that at present there is a wider offer of products and systems for mechanical ventilation systems to achieve an energy efficient ventilation: good control of the air flow rates, various systems of demand controlled ventilation, heat recovery, etc.

There is a clear need for new components and concepts to optimise and control the air flows in naturally ventilated buildings. In the framework of the NatVent project work was done on pressure controlled air inlets (WP 3.2), heat recovery systems (WP 3.3),...

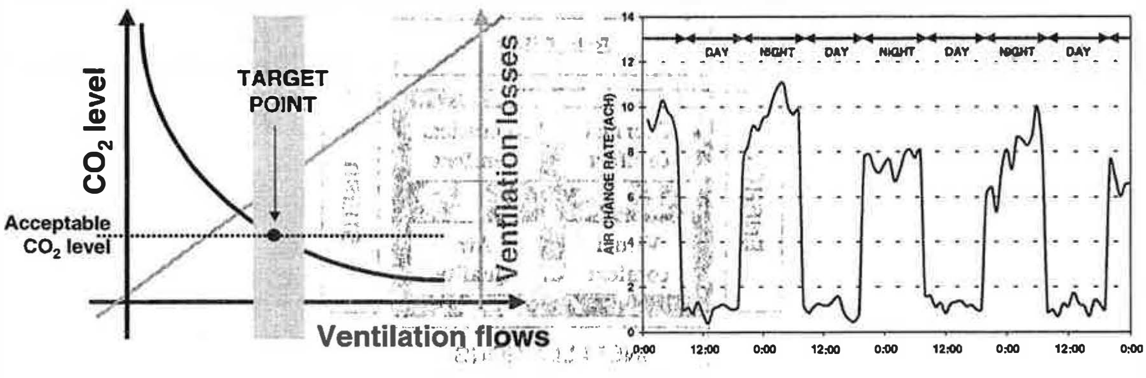

Figure 3a: Optimisation of ventilation flows
Figure 3b: Ventilation flows for summer comfort and IAQ

The required air flow rates for summer comfort are much higher than for IAQ control and the thermal mass of the building must be accessible

The concept of ventilation for summer comfort is based on two indispensable elements: large air flows of cold external air and accessible thermal mass.
A first target is to achieve the highest possible air flow rate without specific problems. Control of the air flow rates for summer comfort is in most cases not so critical as it is for ventilation for IAQ (see before). A possible problem can be a (slight) subcooling during the early morning hours leading to complaints by some of the building users. Automatic (central) control is in principle not required. An advantage of automatic control is the possibility of optimising the opening and closing of the intensive ventilation provisions (e.g.: only open when outdoor temperature is lower than indoor temperature). In case of automatic control, it is preferable that the users can during most part of the time overrule the automatic control.
As already indicated before, most of the monitored case studies have no explicit splitting between devices aimed for IAQ control and others for summer comfort. In some cases, the designer made a clear separation between both strategies (e.g. in GB2). However, the monitoring results indicate that the control strategy is not clear to the users with the result that the required performances are not achieved.
The second target is to bring the cold external air in contact with the thermal mass. The optimal situation is a building with exposed heavy ceiling, floor and walls. In many cases this is not possible for reasons of cabling and flexibility. However less optimal solutions like only an exposed ceiling or an open false ceiling give acceptable results. The experience of several case studies has learnt that the accessibility of the thermal mass has a major influence on the building design in a very early stage. Furthermore it is often a barrier to the application of ventilation for summer comfort in existing buildings.

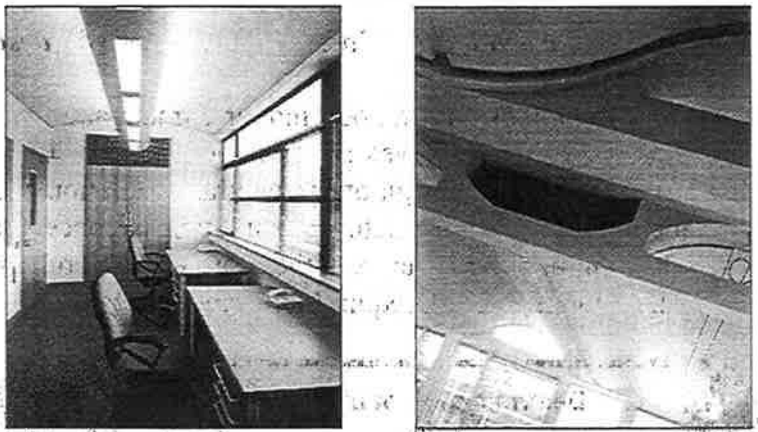

Figure 4: Exposed false ceilings (Canning Crescent Centre – The Environmental Building)

Summer comfort requires much more than intensive ventilation

Intensive ventilation for summer comfort can only be a successful strategy if also the other elements of the building are designed for summer comfort. An intelligent choice of glazing type, glazing areas, orientation and shading devices must control the direct solar gains through transparent surfaces. A high insulation level can limit the indirect solar gains through opaque surfaces. Energy efficient and well-controlled lighting systems minimise the internal gains. It is possible that under certain conditions (e.g. heavy internal loads or limited accessibility of thermal mass) the indoor temperatures are still too high. In this case limited active cooling by hygienic ventilation (also called 'top-cooling') can be an interesting solution.
Thermal simulations are an indispensable tool for the design of buildings with this global strategy. During the pre-design a simple, user-friendly tool (e.g. NiteCool, the Natvent program, etc...) must give an estimation of the overall effect of the different measures. In a later stage more elaborated simulations and powerful simulation programs (e.g. ESP-r, Capsol, etc...) can be used.

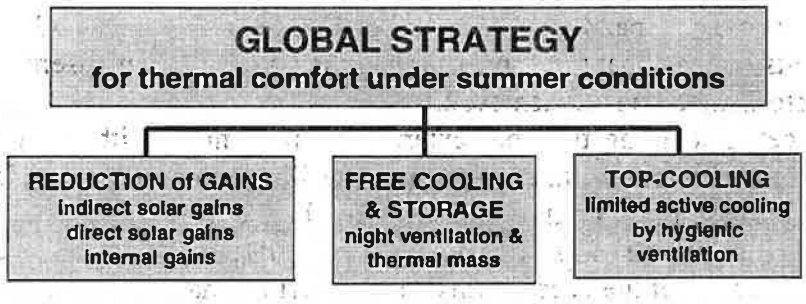

Figure 5: Thermal summer comfort – global strategy

Estimating the air flow rates is a small part of achieving a successful design

The real target is to realise buildings with a good indoor climate and a low energy use. This comprises the design of the building envelope and the installations. In case of natural ventilated buildings, it is clear that the design of the natural ventilation is only a small part of the overall design challenge. As far as the natural ventilation is concerned, it is evident that one should have a good sizing in order to achieve the required level of ventilation but a good design requires that a whole range of other requirements are achieved.

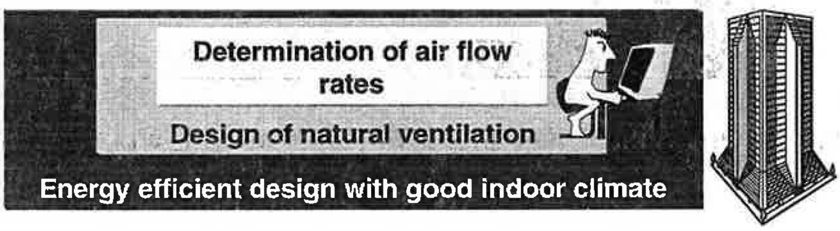

Figure 6: Natural ventilation - the overall context

A successful design can only be achieved if a number of potential barriers are taken. In some of the 19 studied buildings, the natural ventilation is operating bunsatisfactorily due to incorrect sizing. However multiple are the problems due to other reasons. As illustrated in Figure 6, there is a whole range of potential barriers for applying intensive night ventilation. Some of them are of a more technical nature (e.g. the local fire regulations require separation of the various parts of the building, acoustical requirements for buildings used at night time, etc..., other are more linked to the user (e.g. internal doors are closed at night for reasons of privacy, dust entering the offices at night,...). It is also possible that non-technical reasons are an important barrier for application (the designer has to take a larger risk, the impact on the architecture is considered unacceptable, the fee structure for the consultants is not stimulating such kind of studies,...).

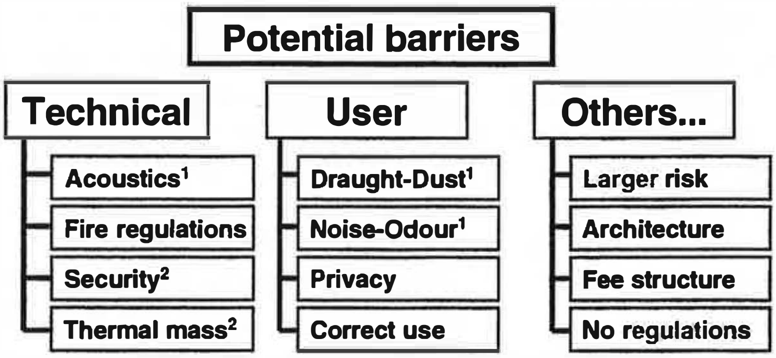

Figure 7: Overview of potential barriers for the application of natural ventilation for indoor air quality[1] and summer comfort[2]

The creation of an attractive environment for innovation is extremely important

A number of innovative and/or high performance products and systems relating to natural ventilation of office-type buildings are available on the market or are expected to come on the market during the next years. However, experience from other technological areas clearly shows that innovative and interesting technologies are not necessarily adopted by the decision makers (architects, building owners,...). Lack of awareness is one possible reason, another reason is the fact that the decision maker is not able to correctly interprete the performances of such system and/or has doubts about the advantages of the technology. Such an evolution can only be avoided by large dissemination of the knowledge on natural ventilation and by performance-based standards for natural ventilation components, respectively.

Natural ventilation can be an attractive option, NOT the only option

It is clear that many of the monitored buildings would perform better with a well-designed mechanical ventilation system. Heat recovery and demand controlled air flows are some of the extra possibilities of mechanical ventilation.
However, a well-designed natural ventilation system could also lead to good performances. The NatVent project activities in WP 3 aimed primarily at indicating possible ways for optimisation of natural ventilation strategies. Air inlets with high acoustical performances, with constant air flow and with intelligent control as well as hybrid concepts with low-energy fans and heat recovery broaden the possibilities and the application area of natural ventilation.

Natural ventilation is not by definition the best option. Energy efficient designs with good indoor climate is the challenge, one should try to take the best of all available options.