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VENTILATION REQUIREMENTS IN NON-DOMESTIC BUILDINGS AND ENERGY EFFICIENCY

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1. Introduction

This paper focuses on the importance of the level of ventilation requirements on the energy demand of non-domestic buildings At present, one observes a tremendous difference in the ventilation requirements in various countries as well as at the European level. Variation of a factor 10 of the ventilation rate requirement can be found in the proposal for European standard CEN prENV 1752 depending on the boundary conditions (cleanness of the building, outdoor air pollution, etc.).

The present paper develops these problems and makes a comparison with the situation in other areas like thermal comfort and lighting requirements. Results of a practical case study are included.

2. Importance of ventilation in overall energy demand

It is a fact that the transmission losses through opaque and transparent parts of the building envelope have substantially been reduced thanks to an improved thermal insulation of these components. High thermal insulation levels are common technologies in many countries, especially in Scandinavian countries. Further improvements are under development, e.g. transparent insulating materials, etc.

With respect to the ventilation losses, the situation is far different :

- whereas in the past, providing sufficient ventilation was not a key element in the design considerations, there now is a growing interest in providing good indoor air quality through adequate ventilation of the occupied spaces;
- there were no spectacular achievements allowing to reduce the energy requirements for a similar comfort level as it is the case in the area of thermal insulation.

As a result, one observes a growing part of the ventilation losses in the overall losses of a building. In modern office buildings ventilation losses are of similar or even greater importance then the transmission losses. Therefore, ventilation related energy consumption is crucial in the context of energy efficiency.

3. Comparison of various comfort aspects

When trying to improve the energy efficiency of a building, one often focuses the efforts on ameliorating the technologies needed for meeting a certain demand, e.g. a certain thermal comfort level, a certain visual comfort level. In some cases, the required comfort level influences substantially the energy needs while in some other ones it has a minor impact. In this paragraph, an effort is made to compare the situation for thermal comfort, visual comfort and indoor air quality.

3.1 Thermal comfort

As far as thermal comfort in winter conditions is concerned, only very small variation exist between the various standards with respect to the required comfort conditions in buildings. For the summer situation, there is substantially more discussion, especially about the acceptable temperature levels during warm periods. The outcome of these discussions is important when designing without active cooling. In case of active cooling, it may also lead to a substantial discussion about the cooling needs. The situation is illustrated in figure 2.

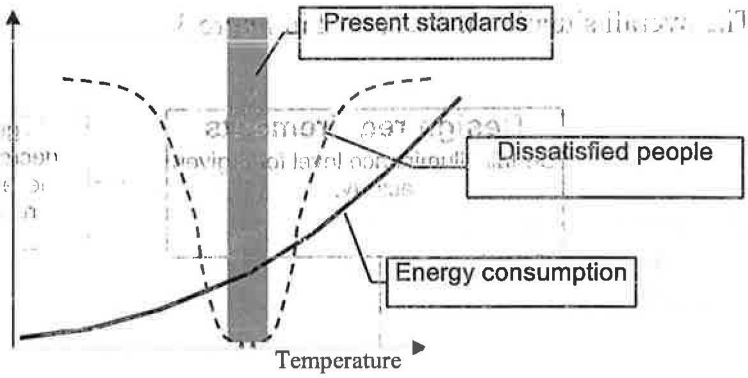

Figure 1 - Thermal comfort criteria (winter) and energy

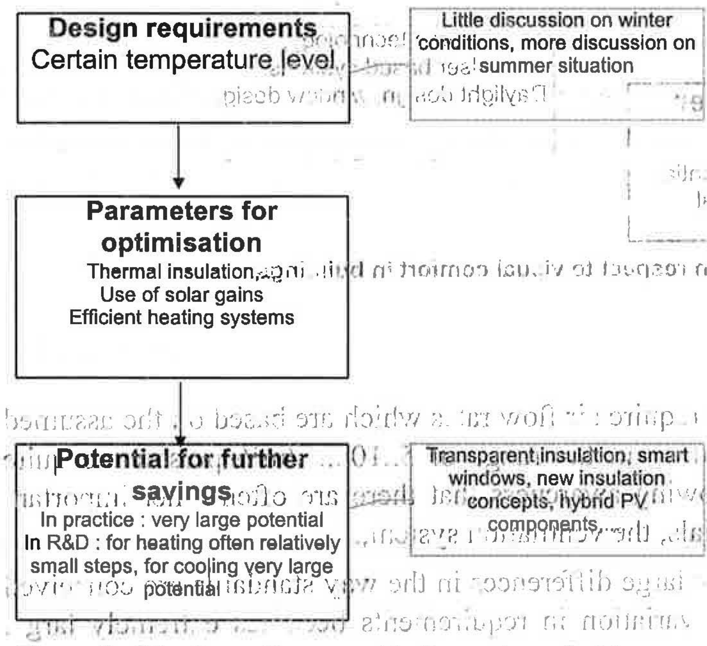

Figure 2 - Situation with respect to thermal comfort in buildings

Energy efficiency in the area of thermal comfort in winter conditions should focuses on the means for reducing the energy demand: good building design, components with high performances, passive solar design, etc.

In the case of summer comfort, there is a need for some further research on the comfort needs. But also here, there is a very large potential for improved energy efficiency by a better overall building design, good solar protection,... In case cooling is needed, innovative low energy cooling systems should surely be promoted. Probability criteria with respect to the thermal comfort in buildings, as e.g. used in the

Netherlands, may be a good approach (ref. 3).

3.2 Visual comfort

With respect to visual comfort, the following elements have to be mentioned :

- in general there is a tendency to decrease the required illuminance levels in comparison with the values used in the seventies and eighties;
- in the case of office buildings, there is also a tendency for a combination of local lighting with general lighting;
- there is an increased interest in natural lighting, allowing to reduce the need for artificial lighting as well as the need and the level of active cooling.

The overall situation is illustrated in figure 3.

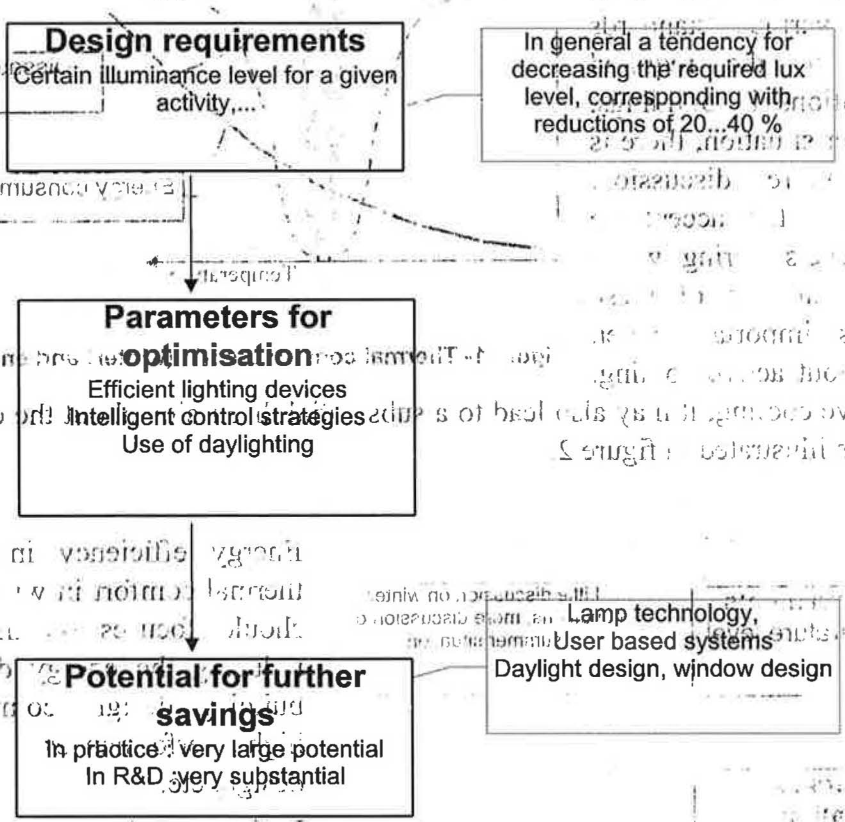

Figure 3 - Situation with respect to visual comfort in buildings

3.3 Indoor Air Quality

At present, nearly all existing standards require air flow rates which are based on the assumed odour emissions by the occupants. Values in the range of 5..10,... dm³/s,person are quite common. The last years, there is a growing awareness that there are often other important sources of pollution: the building materials, the ventilation system,...

As a result, one observes at present very large differences in the way standards are conceived and, more important, the fact that the variation in requirements becomes extremely large. Some examples are given in section 4.

In any case, the present tendency is towards an increase in the required air flow rates. Such increase is in some cases not of the order of 10...50% but may be a multiplication by 2, 3 or more. Therefore, the impact on the energy demand is extremely important.

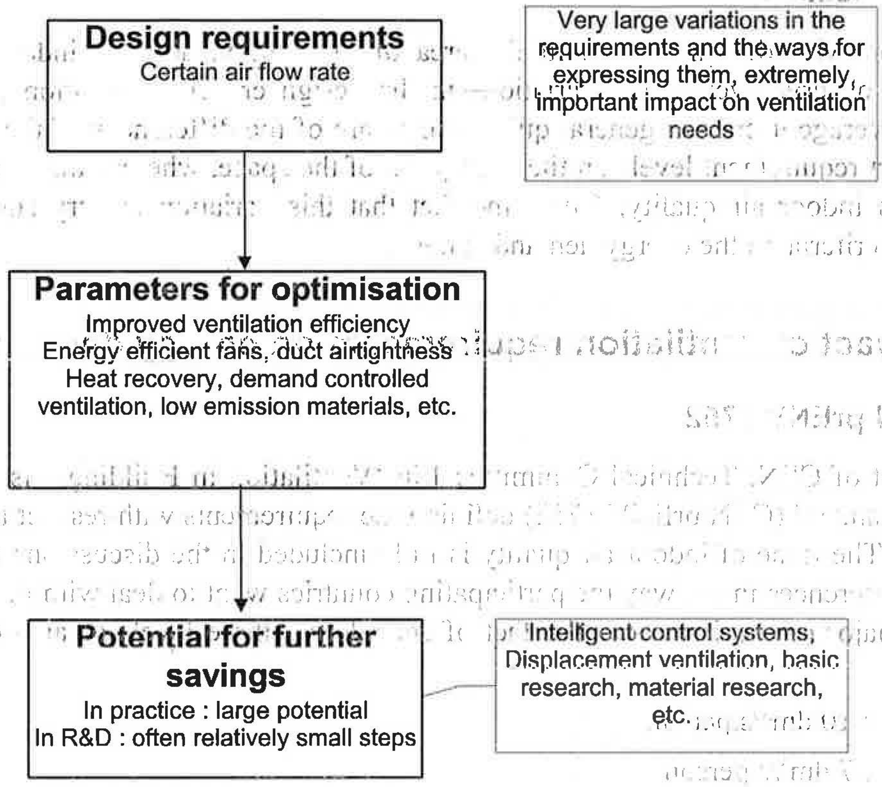

Figure 4 - Situation with respect to indoor air quality and ventilation

Although the ventilation related energy demand is becoming more and more important, it seems that this tendency is not confirmed by the available means for research and development. At present, there is relatively little funding in relation to indoor air quality and ventilation. This may be due to a lack of understanding of the importance of ventilation related energy needs in buildings.

It is important for decision makers to be aware of the fundamental difference between the situation with respect to indoor air quality and e.g. thermal comfort in winter conditions. Likewise, they should understand the importance of the requirements in the case of ventilation. This is illustrated in figure 5.

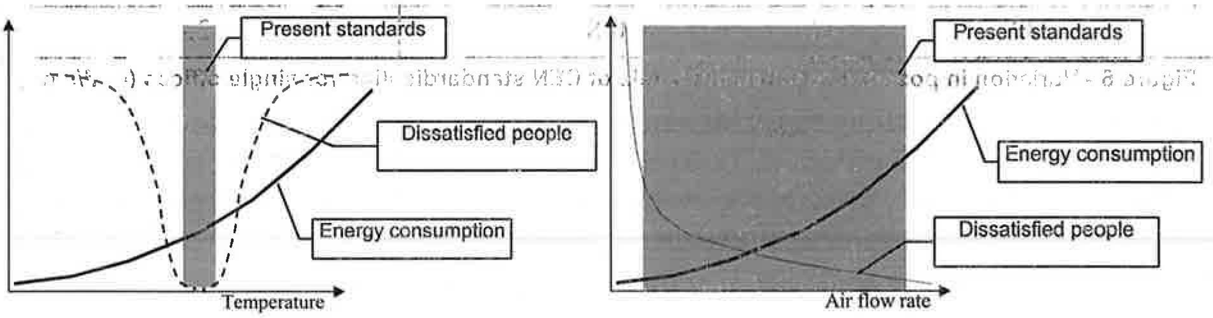

Figure 5 - Comparison between 'thermal comfort versus energy' and 'IAQ versus energy'

3.4 Synthesis

In comparison with design criteria in the area of thermal, visual and indoor air quality comfort, one observes very large variations in the design criteria in relation to indoor air quality. An average user is in general quite well aware of the differences of the thermal and visual comfort requirement levels on the perception of the space, whereas this is not so much the case with indoor air quality. Given the fact that this variation is very substantial, the impact of the criteria on the energy demand is huge.

4. Impact of ventilation requirements on energy demand

4.1 CEN prENV 1752

In the context of CEN, Technical Committee 156 'Ventilation in Buildings' is in charge of preparing a standard (CEN prENV 1752) defining the requirements with respect to ventilation in buildings. The issue of indoor air quality is fully included in the discussions but there are substantial differences in the way the participating countries want to deal with it. In any case, there is no major discussion about the fact of considering three levels of air flow rates per person :

- Class A : 10 dm^3/s,person
- Class B : 7 dm^3/s,person
- Class C : 4 dm^3/s,person

The ventilation requirements can substantially increase by including the emission of building materials, HVAC systems, etc. Table 1 compares requirements on air flow rates for individual offices for the 3 classes and for 2 situations : on the one hand, assuming no emission of the building (as is the assumption in many existing standards) and, on the other hand, assuming an average pollution level as was measured in a range of buildings over the last 5 years. One observes a variation in the requirements with a factor of about 10.

Class	Desirable design conditions	Mean conditions[1]
A	3.3	8.2
B	1.4	5.2
C	0.8	2.6

Figure 6 - Variation in possible requirement levels of CEN standardisation for single offices ($dm^3/s,m^2$)

[1]These values are based on mean pollution load (from ECA report 1992) and a ventilation efficiency of 0.7 and are under discussion.

4.2 Analysis of impact ventilation requirements on energy demand

4.2.1 General

The impact of ventilation requirements has been studied for an office type building in Belgium. The study was done for 2 levels of requirements:

- Class C, clean building (the present requirements in the Walloon region) => 0.8 l/s,m²
- Class A, building with average pollution level => 8.2 l/s,m²

4.2.2 Assumptions for the calculations

The assumptions used for the calculations are summarised in Table 1. The test reference climate of Uccle was used for both cases. The simulations were made with the CAPSOL software (ref. 4). The aim of the simulations was to study the savings that can be obtained by using a demand controlled ventilation (presence detection, CO_2 control,...) that would result in a 50% reduction of the air change rate.

Case 1	Case 2
High expectations Outdoor : 0.3 decipol Inside : 1.0 decipol Building : 0.3 olf/m² 0.1 person/m² vent efficiency = 0.7	Moderate expectations Outdoor : 0.0 decipol Inside : 2.5 decipol Building : 0.1 olf/m² 0.1 person/m² vent efficiency = 1.0
Common assumptions for both cases	
– 20 stories – 20 * 20 m² – 30% glazed area – 20°C (heating)/ 22°C (cooling) during working hours (8-18 hours) – ventilation :6-19 hours – Infiltration :0.2 l/s.m²	– Insulation : – facade : 0.4 W/m²K – window : 1.5 W/m²K – roof : 0.3 W/m²K – floor : 0.4 W/m²K – Internal gains : 35 W/m²

Table 1: assumptions used for the calculations

4.2.3 Results of the simulations

The simulation results are presented in Figure 8. Study 1 predicts a energy saving (on total heating energy demand for transmission and ventilation losses) of some 13% whereas study 2 predicts 45%.

The difference becomes even much larger when looking to the absolute savings which can be achieved. Study 1 predicts a saving of some 70 MWh whereas study 2 shows savings of the order of 1.200 MWh. The differences are tremendous. Moreover, the choice of the required air flow rates is completely overruling the effect of all other energy conservation measures.

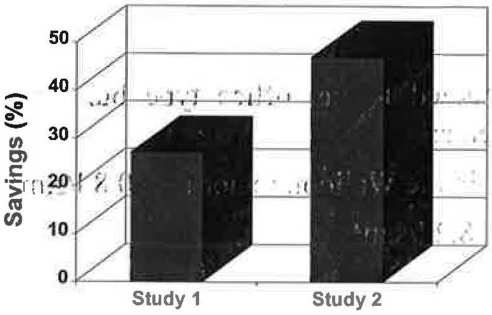

Figure 7: predicted relative savings by applying demand control

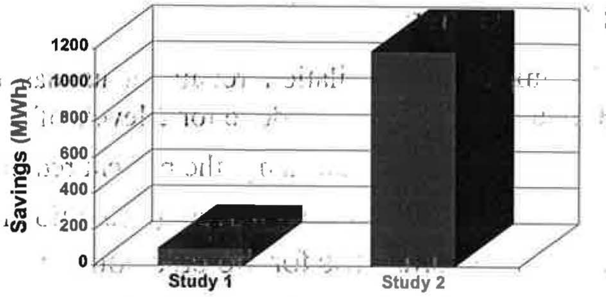

Figure 8 : predicted savings in energy demand by using DCV with an efficiency of 50%

Conclusions

1. Whereas the thermal comfort requirement in winter time are in a quite small range and not under discussion, there is a tendency for more flexible thermal comfort requirements in summer. More flexible thermal comfort conditions are especially requested by the countries with a relatively hot climate. The extent to what active air-conditioning can be avoided is strongly influenced by the type and level of thermal comfort requirements. As far as visual comfort is concerned, there is a tendency for reducing the illuminance levels.
2. With respect to the ventilation requirements, several countries plan a substantial increase in the required air flow rates
3. The relative importance of the ventilation needs in the overall energy balance is increasing. This is on the one hand due to the continuous reduction of the transmission losses and on the other hand due to the tendency for increasing the ventilation requirements in buildings.
4. The reduction of the emission of pollution from building materials, ventilation systems,... is an important priority for the future.
5. Decision makers (research managers, politicians,...) should become better aware that the human being spends a very large portion of his time indoors, that there are serious concerns about the indoor air quality and that there is a very clear link with the energy efficiency of buildings. They should understand that indoor air quality should receive similar attention as outdoor air quality issues.
6. Decision makers (research managers, politicians,...) should become better aware of the tremendous importance of a correct definition of the IAQ and ventilation needs since the impact on the overall energy demand is enormous. This awareness should then be translated in a substantial increase of the available means for research and development in the area of IAQ and ventilation related issues.

References

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