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INHABITANTS' BEHAVIOUR WITH REGARD TO VENTILATION. A REPORT OF THE WORK OF THE ANNEX VIII

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SYNOPSIS

If the energy losses due to ventilation have obviously become an important problem since the energy crisis, there is still a lot to be done with respect to the behaviours. Previous research has given results about the share of ventilation losses in the energy balance, and the rational reasons to introduce fresh air into the house.
Annex VIII is specialized in the attitudes of the inhabitants, in their habits with regard to ventilation and even in their apparent irrationality. That should lead to know whether the ventilation behaviour of the inhabitants can be modified and to estimate the amount of energy savings which might result therefrom. To reach these final goals, the Annex VIII foresees three levels. The first one will tempt to describe how people behave with regard to ventilation, the second level will try to find the reasons of such a behaviour, and the third level will estimate the amount of energy loss due to this behaviour.

At the present time, some countries have already carried out one or several steps of the Annex, but it is still too early to go deeply into the conclusions. A behaviour as plain as open a window, but so important with regard to energy still stays partly an unknown.

I. INTRODUCTION

The Annex VIII started officially one year ago, the 24th July 1984, but Switzerland had already proposed to create it in 1978. Unfortunately, although Switzerland made a pilot study, it could not act as operating agent. Nevertheless, the subject had interested other countries and in 1982, Holland, Germany and Belgium presented a project for the Annex VIII to the Executive Comittee with Belgium as operating agent. Since the official starting meeting, the United Kingdom and Switzerland have followed the progress of the Annex as observers, and there is hope that they will join as officially participating countries.

This short history of the Annex shows that the problem of the inhabitants' behaviour with regard to ventilation is not a new one, but has aroused an increasing interest since the energy crisis. Although some researches have already been done on this topic, none has gone as far as to assess whether and how the ventilation behaviour can be modified in order to save energy. The final aim of Annex VIII is to try to answer these questions.

II. BACKGROUND

Why does inhabitants ' behaviour with regard to ventilation become so important for energy policy ?
In order to answer this question, let us briefly examine the energy balance of an occupied residential building as in figure 01.
The energy balance of a residential building gets, on the one hand, as energy inputs, obviously the heat plant and the solar radiation, but also extra inputs from the electric and cooking appliances, the hot water generation and even from the occupants themselves.
On the other hand, the energy losses consist of the transmission losses, the discharge water losses and the infiltration, ventilation and airing losses.

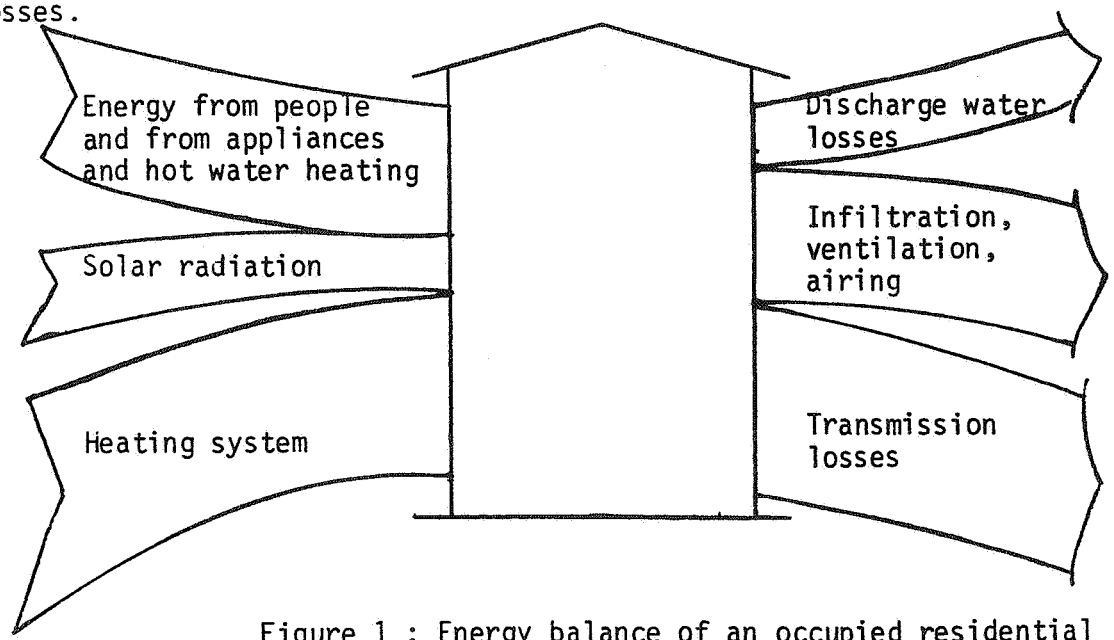

Figure 1 : Energy balance of an occupied residential building.

Homeowners have done a lot since the energy crisis to restrict the transmission losses, by attic insulation for instance, or by side-wall and crawl space insulation. However, they do not appear to get a fair appraisal of the heating and cooling energy load which can be attributed to air infiltration and to ventilation. Yet, it takes a part in the energy consumption that may not be neglected.
For example, one study showed about 35 percent energy loss in a well insulated house under both heating and cooling modes due to air infiltration (1). Another study explained that the recent improvements in fabric insulation make this ventilation factor proportionately more important and can represent 50 % of the total loss (2). Moreover, the major unknown in all the energy consumption patterns is the energy loss due to the ventilation behaviour of the occupants. Indeed, this cannot readily be calculated directly and has to be estimated.

This short review of the energy losses shows that the consumption of the heating energy in residential buildings is not only a question of the heat-insulation of the exterior walls and the efficiency of the heating system, but is also decisively influenced by the ventilation habits of the residents. This leads us to the conclusion that the variety and the causes of inhabitants ' behaviour with regard to ventilation have to be looked into carefully.

There are a lot of good reasons to introduce fresh air into a room. As the figure 2 shows it, one of them is the moisture control (3). The values of 70 % and 40 % relative humidity are the upper and lower limits of relative humidity usually recommended With values higher than 70 %, the risk grows of creating a mould problem inside the house. Values below 40 % are likely to introduce electrostatic shocks when walking on the carpet. These limits depend on the temperature of the room.

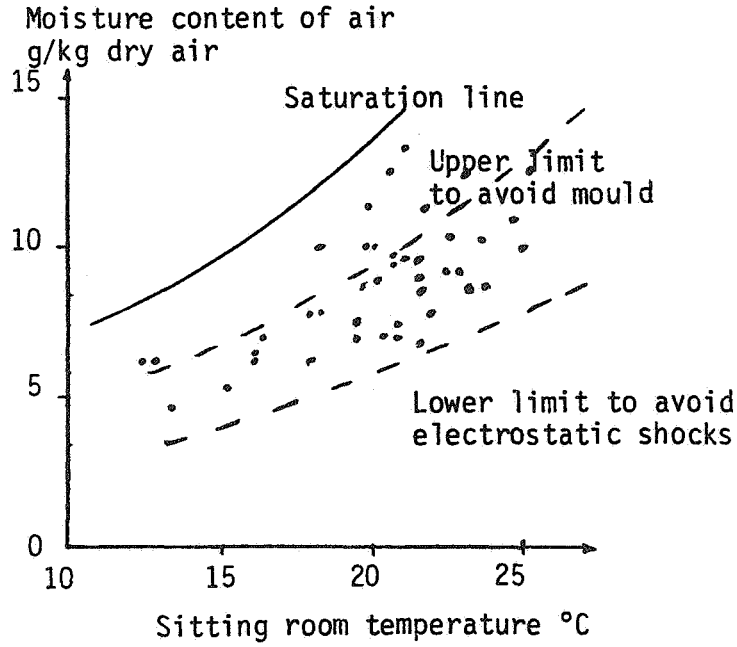

Figure 2 : Moisture level in sitting room according to spot measurements (N = 42). Source : (3)

Another aim of ventilation as illustrated in figure 3 is to provide the necessary oxygen for survival and to dilute the level of contamination to one that is acceptable and safe (3). The contamination can simply be odours coming from the occupants themselves or from the cigarette smokers.

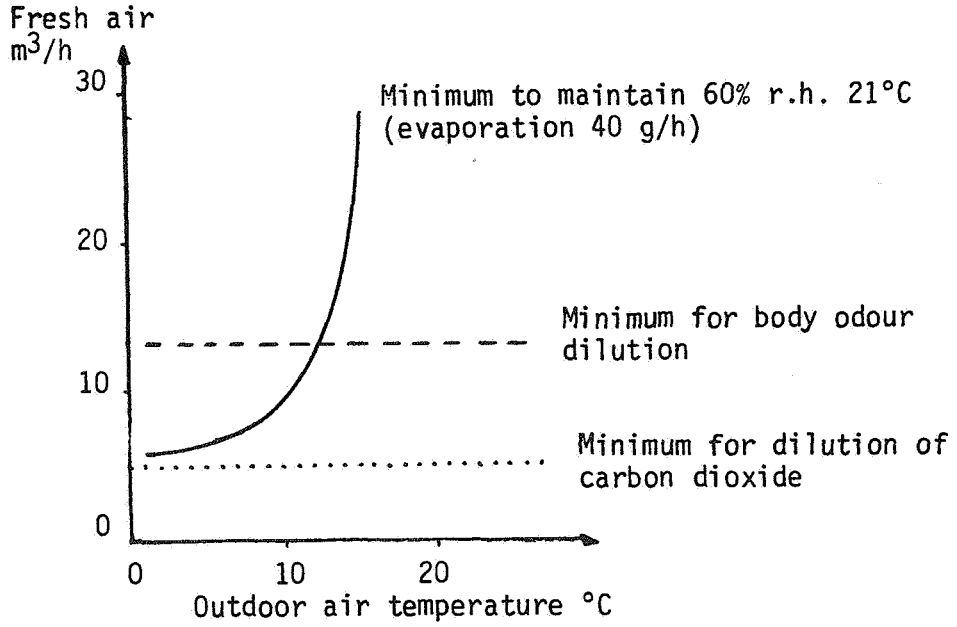

Figure 3 : Ventilation needs for an adult in Britain.
Source : (4).

Last, it may not be forgotten that one of the main objectives of introducing fresh air is the cooling of the house. Indeed, in some well insulated houses with some twenty square meters of south facing windows, the solar gains can easily lead to overheating. Even in winter, ventilation is the easiest way to refresh an overheated room.

So, it is obvious that some ventilation is necessary. In theory it is possible to calculate the needed ventilation rate for each house under any weather conditions. But in practice, the occupants often choose a "wrong behaviour", that is to ventilate less than necessary, or as showed in figure 4, to do it more than useful. The shaded area indicates excess energy consumption due to excess ventilation compared to theoritical consumption with closed windows.

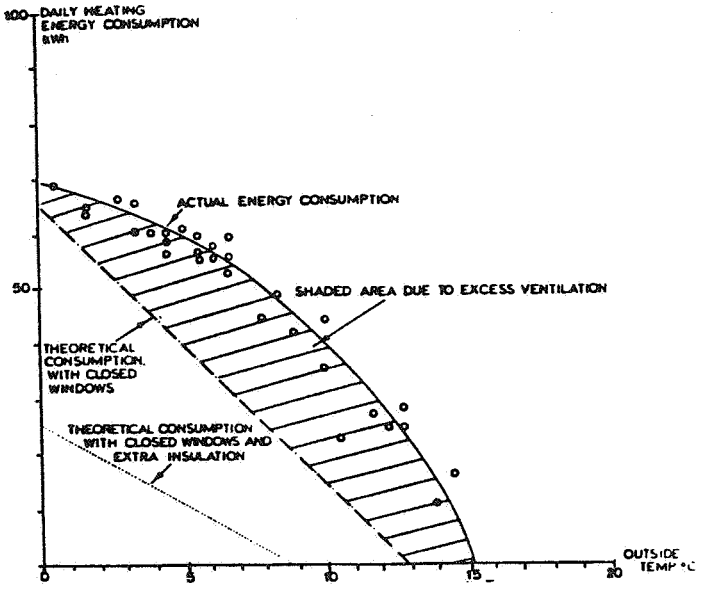

Figure 4 : Actual daily energy consumption for a 4.5 kW terraced house according to ventilation and outside temperature.
Source : (4).

Hypotheses have been expressed concerning the differencies between the expected behaviour and the real behaviour. The "wrong behaviour" that leads to under ventilation should be explained by the motivations of the inhabitants with regard to the energy savings or by a lack of full and accurate informations (5). The overventilation should be due to the attitudes of the occupants with regard to hygiene, health and comfort.
It should also result from the habits of using the windows and from the irrationality of the people who, for instance, forget to shut the casements when they leave their house. These factors are those which are the less well-known whilst they are the only ones that could be modified in the short run by an energy policy, taking the form of a social marketing strategy (6-9).

III. OBJECTIVES

The trick of such a research is, precisely, to distinguish the desirable behaviour from the "wrong behaviour". Previous research has shown, that ventilation patterns change with the climate (sunshine duration, humidity, wind ...), with the different physical features of the house, with the size of the households, and with the house occupancy. But these findings do not give informations about the frequency of the "wrong behaviour", its determinants and the way to change it. These are, in fact, the main questions for the Annex VIII, schematized by figure 5.

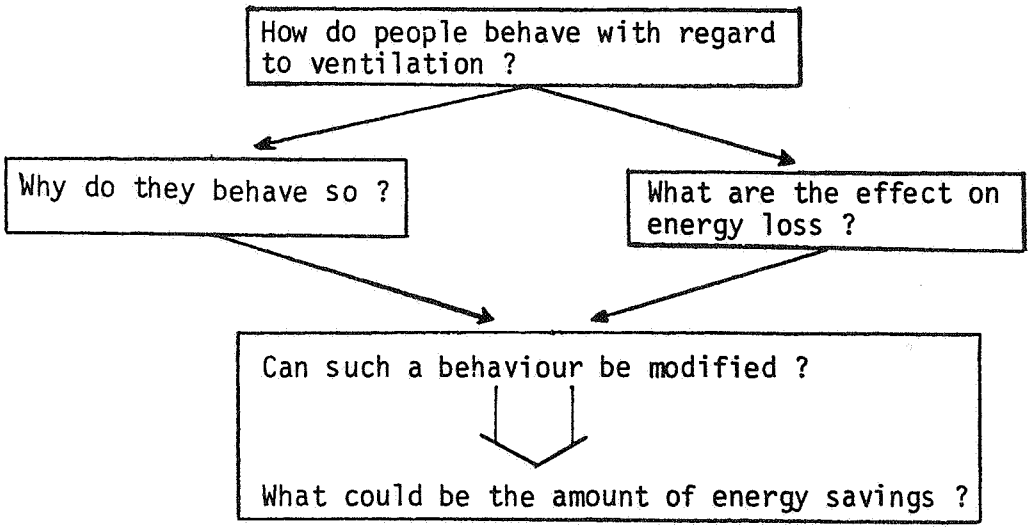

Figure 5 : Objectives of the Annex VIII.

The first objective of the Annex is to determine the actual behaviour of the inhabitants and to correlate it to the outdoor and indoor climate. Indeed, almost every author agrees to assert that the number of open windows is a direct function of outdoor temperature and of the wind speed. For instance, in a study of DICK and THOMAS, it was found that the external temperature alone accounted for over 70 percent of the observed variance in the number of vents and casements open, and a further 10 percent of variance could be attributed to wind speed (10).

The second aim is to estimate the amount of energy loss due to this behaviour. Available analysis suggests that a third of the losses are attributed to ventilation, the remainder through the building fabric (11). This ventilation loss seems equally divided between infiltration and window opening. It is in the range of Annex VIII to calculate

these proportions for different kinds of houses and for different insulation levels.

The third objective is to study the inhabitants ' relevant behaviour motivation. It is now accepted that there are three types of ventilation needs : a physiological one, a dilution of contaminants need and a summer cooling. It is important to know to what extent each type has a great influence on the behaviour, and what has to be devoted to culture, habit or irrationality.

Finally, the last objective is to study whether such a behaviour can be modified, and to estimate the amount of energy savings which might result therefrom.

IV. METHODOLOGY

To reach these objectives, Annex VIII foresees three levels of studies. The first one is an enquiry on at least 500 dwellings to describe the actual behaviour of the householders with regard to ventilation, and to give a first look at their motivations. The sample size and design must ensure statistically valid results. The aim of the second step is to study more precisely the way and the reasons of such behaviours on a sample of 40 dwellers; and finally, each participant will execute elaborate measurements on ventilation patterns in at least 4 dwellings to assess the energy lost due to the ventilation behaviour. The results provided by these steps will allow to define some kinds of actions that can modify the behaviour in order to respect two points of view : the energy consumption and the comfort of the inhabitants. The figure 6 illustrates the methodology followed by the Annex VIII, and the way to execute it.

Questions	Answer by at least	How ?
How do people behave ?	500 dwellings	Questionnaires
Why do people behave ?	40 dwellings	Questionnaires Observations Measurements
What are the possible effects on energy ?	4 dwellings	Elaborate measurements

Figure 6 : The methodology followed by Annex VIII.

To achieve the first level, each country will interview householders with the help of a questionnaire. Its main topics will be the composition of the family, the periods of occupation, the heating system, and, of course, the ventilation pattern. Questions will be aimed at the physical possibilities of ventilation, the frequency, the duration and the reasons for opening and closing the frames. The attitudes of the occupants with regard to energy, comfort, health and hygiene will also be considered. The method of interviews is necessary to provide a lot of informations but there is a problem of reliability. Indeed,people are tempted to explain what they have done only related to the two or three weeks before the interview, and they tend also to adapt their answers to how they think they ought to behave. One solution to control the reliability of the results concerning the ventilation pattern is to observe the fronts of the houses; but this is only possible for a small sample.

This control can be done at the level of the 40 dwellings. There are different methods to observe the casements. The best one is the use of the switches and microswitches fixed on the frames. In theory, there is no feedback on the behaviour and it is a very accurate method. But it is very expensive and it is not always accepted by the inhabitants. Another way is to use observers who will photograph the windows open at different moments during the day. This method has the advantages to be cheap as well as easy to carry out and to have no influence on the behaviour. But it has as drawbacks that the duration of the openings is not known, that all kinds of houses cannot be observed because some windows are invisible and that no observations during the night are possible. At the same time that these observations are made to determine how people behave, a very detailed questionnaire will be administrated to the 40 occupants to know how they say they behave and the reasons they give. From the comparison between the actual observed behaviour and the admitted behaviour, the reliability of selfadministrated questionnaires and the attitudes of the inhabitants with regard to ventilation can be inferred. In addition, measurements will be undertaken to analyze the technical features of the houses. This measurements will be inside and outside temperature measures, humidity level, air leakage or pressurization tests; moreover the climate data that could partly explain the ventilation pattern will be collected.

In the last step, elaborate technical measurements will be undertaken in four dwellings to assess the effect of ventilation behaviour on the energy consumption. The needed data to compute it are supplied by air leakage tests of the building envelope and of the distribution over the envelope, by analysis of the pressure distribution and by indoor and outdoor air temperature. The previous step (40 dwellers) will provide with a ventilation behaviour pattern so that we will be able to introduce this pattern and the measurements data in a model that will compute their effect on energy consumption.

V. STATE OF PROGRESS

Some of the participating countries and of the observers have already carried out one or several steps of the Annex. The results will be compiled and published under a same reporting format.

From the preliminary reports, some results seem interresting to present. The Dutch team found that the frequency and the length of time the windows and the ventilation grilles are used in occupied dwellings are influenced by the following factors. Especially in bedrooms, the airing is correlated with the wind speed, the wind direction, the snow, the rainfall, the sunshine, and the outside temperature. The ventilation behaviour is also higher, in the whole house, when the basic ventilation is lower, when the room is very well insulated, when there is condensation on the glasses, and when the inside temperature is not easy to regulate. The habits of the inhabitants are very important in the way they air their house. Indeed, the dwellers who smoke a lot open more their casements, and the opening of the window in the living room varies with the clothing habits, with the presence of little children, and is often due to the cooking smells. The dwellers who think ventilation is important and who prefer freshness usually use more the ventilation grilles, too.

At this stage, it is still too early to draw general conclusions, but it seems that the results obtained by the research made in each countries will corroborate to some extend the hypotheses coming from the literature. But it is not yet possible to answer to the final questions : "Can the ventilation behaviour be modified ? And what is the amount of energy savings which might result therefrom ?" A first summary report of the surveys which are already finished will be presented by the end of the year. The final publication will synthetize all the investigations and will be available by the end of 1986.

VI. CONCLUSIONS

If the energy losses due to ventilation have obviously become an important problem since the energy crisis, there is still a lot to be done with respect to the behaviours. Previous research has given results about the share of ventilation losses in the energy balance, and the rational reasons to introduce fresh air into the house; in other words, moisture control, oxygen for survival and cooling of the house. Annex VIII is specialized in the attitudes of the inhabitants, in their habits with regard to ventilation and even in their apparent irrationality. That should lead to know whether the ventilation behaviour of the inhabitants can be modified and to estimate the amount of energy savings which might result therefrom. To reach these final goals, the Annex VIII foresees three levels. The first one will tempt to describe how people behave with regard to ventilation on a sample of 500 dwellings at least, the second level will try to find the reasons of such a behaviour on 40 dwellings at least, and the third level will estimate the amount of energy loss due to this behaviour on 4 dwellings.

At the present time, some countries have already carried out one or several steps of the Annex, but it is still too early to go deeply into the conclusions. A behaviour as plain as open a window, but so important with regard to energy still stays partly an unknown.

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