ENERGY EFFICIENT DOMESTIC VENTILATION SYSTEMS FOR ACHIEVING ACCEPTABLE INDOOR AIR QUALITY

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PAPER 8

VENTILATION AND ENERGY CONSUMPTION.
PRACTICAL EXPERIENCE OF PROBLEMS RELATED TO VENTILATION IN SINGLE FAMILY HOUSES.

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1. INTRODUCTION

During the last few years, ventilation has become increasingly important in the total consumption of energy. The rules of the Swedish Building Code (SBN 75) have been made stricter regarding heat loss. Therefore, it has become necessary to build houses that are more airtight and to reduce the air infiltration through elements and the building in general.

These requirements increase the need for mechanical ventilation systems, which would lower the energy consumption during the cold part of the year and, if required, increase the ventilation during the summer.

Basic knowledge seems to be insufficient in the field of building and ventilation technology. The reason for this may be that ventilation in small houses is considered to be far too elementary. There is no total view of the balance of energy and no regard is paid to the interplay between different flows.

2. RATE OF INFILTRATION

Quantitative information about the magnitude of the ventilation losses has been given by, among others, Boman [1], Gustén and Johansson [2]. These analyses indicate that the total ventilation in small houses built between 1960 and 1980 is much lower than previously presumed and amounts to 0.2-0.4 changes per hour. The measurements have been done by the tracer gas method during "normal" climatic conditions in about fifty small prefabricated houses with natural or forced ventilation.

The new building regulations have necessitated considerable construction development aiming at tighter houses. For small houses, the code prescribes that infiltration maximally should be three changes per hour at an average of 50 Pa positive or negative pressure difference. This roughly corresponds to a natural ventilation of 0.1-0.2 changes per hour, as measured by the tracer gas method [2]. Depending on the type of design and the degree of prefabrication, the additional cost for obtaining this level of airtightness varies between 500 and 2,000 Sw. Cr.

3. REGULATIONS FOR VENTILATION ACCORDING TO SBN 75

When determining air-flows in a building, one has to consider regulations both for certain rooms and for the total ventilation, which should be 1.26 $m^3/h/m^2$ of residential floor area. For ordinary types of houses this requirement corresponds to 0.5 changes per hour. According to SBN 75, natural ventilation is still permitted in spite of the risks of hygienic inconveniences.

If a mechanical ventilation system is chosen, the system is to be dimensioned for a total ventilation of 0.5 changes per hour. The contribution from unintentional ventilation is not taken into consideration. It must be possible to reduce the designed air flow rate and, if required, force the flow.

4. CONSUMPTION OF ENERGY

The heat balance is exemplified by a 1½-storey newly-built house in the south of Sweden. The house (figure 1) has a volume of 320 m^3 and is designed in accordance with SBN 75.

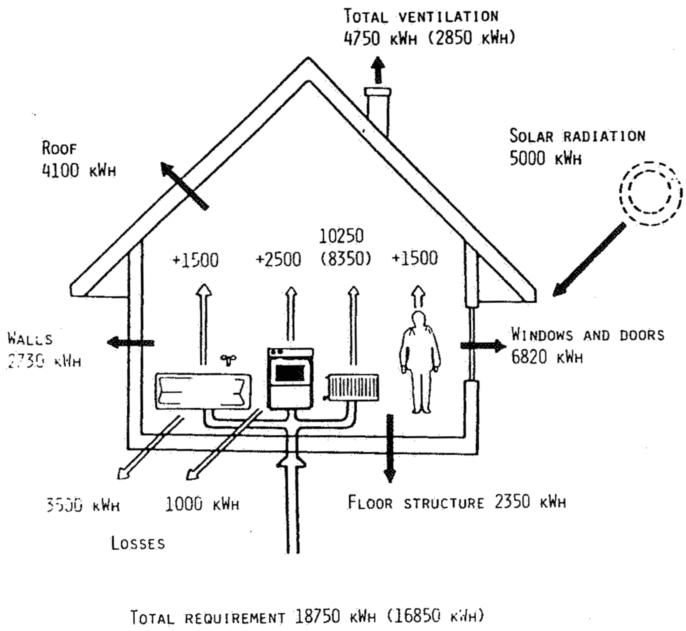

Figure 1. Heat balance at a total ventilation of 0.3 and 0.5 changes per hour. The values within parentheses correspond to 0.3 ach.

The prescribed air change rate - 0.5 changes per hour - gives energy losses of 4750 kWh. In practice, as mentioned before, the air exchange rate will amount to 0.2-0.4 changes per hour. Compared with that of standardized ventilation (0.5 changes per hour), the usual energy losses characterized by 0.3 changes per hour will be 1,900 kWh less. Cooking requires a change rate of 1.0 for one hour per day, resulting in an annual addition of 280 kWh. Smoking and laundry would also increase the necessary change rate.

5. THE NEED FOR VENTILATION

Several factors determine the necessary level of ventilation. Forced ventilation can be the cause of draught and costly losses of energy. Low ventilation can result in:

- Problems with moisture
- Lack of oxygen
- Unpleasant smell
- Problems with CO and CO_2
- Unacceptable content of poisonous gases

Special attention must be given to studies of radioactive gases from different building materials.

At the Department of Structural Design, Chalmers University of Technology, measurements have been done in about fifty timber houses without basements. These investigations indicate that an air change rate of 0.2-0.3 changes per hour is sufficient, provided that the ventilation systems are working and the distribution among different rooms is proper.

Since 1975 roughly 700 houses per year, of the same type as the houses studied, have been produced. The number of complaints is extremely low, and where legitimate, the main reasons are defective workmanship, incorrect adjustment, or insufficient information about how to use the ventilation systems.

The occurrence of radon in dwellings has for some time dominated and to some extent guided the debate on ventilation. The existence of radioactive gases does not mean that the rate of ventilation should be increased generally. The regulations should consider building materials and soil conditions, and the requirements should be less rigid for, e.g., timber houses without basements.

A number of houses that have been built according to SBN 75 have an increase or only a slight decrease in the consumption of energy compared with similar houses built before the oil crisis. The Swedish Parliament's political decision to reduce the consumption of energy by 40% in new houses has not been fulfilled. Therefore, it seems wrong, at least from an energy-conserving point of view, to solve the problems of radon merely with more ventilation. Many years' work to save energy will be frustrated if increased ventilation and airing and in certain cases removal of draught strips are recommended. Instead, the ventilation losses must be limited by means of appropriate building materials in combination with moderate ventilation and air-tightness.

6. CONTROL OF OPERATION AND ADJUSTMENT OF EXHAUST AIR TERMINAL DEVICES

There are some important difficulties in getting even a simple mechanical ventilation system to function properly. Figure 2 shows some differences between the total ventilation for a house and the air flow through the ventilation system.

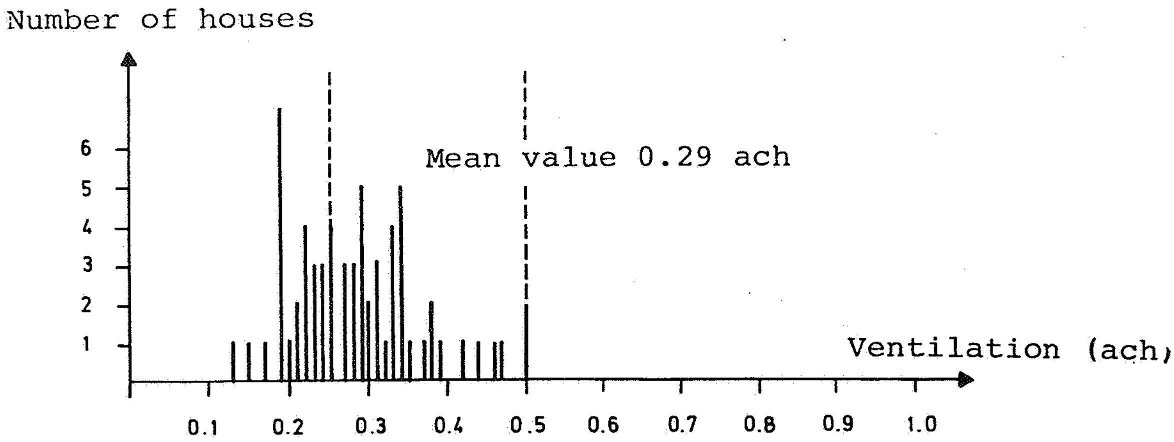

Figure 2A. Measured total ventilation (ach).

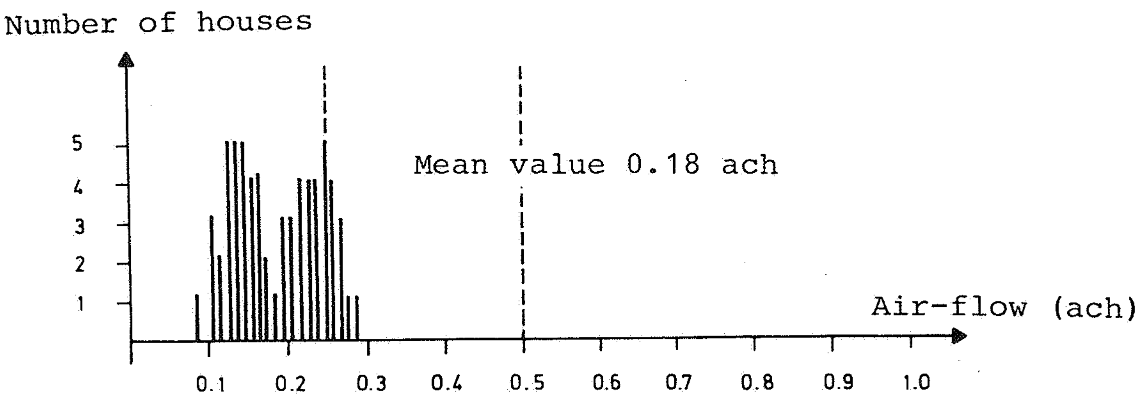

Figure 2B. Measured air-flow through the ventilation system (ach)

The reasons for such differences are careless and defective assembly and lack of knowledge of the system design; in addition, control and inspection often do not occur, figure 3. Consequently, the building industry is not able to meet advertising claims and promises made by the manufacturers of the systems. The equipment must be of good quality and must be installed and tested by competent personnel. Therefore, ventilation systems should be delivered with a guarantee covering adjustment and operation.

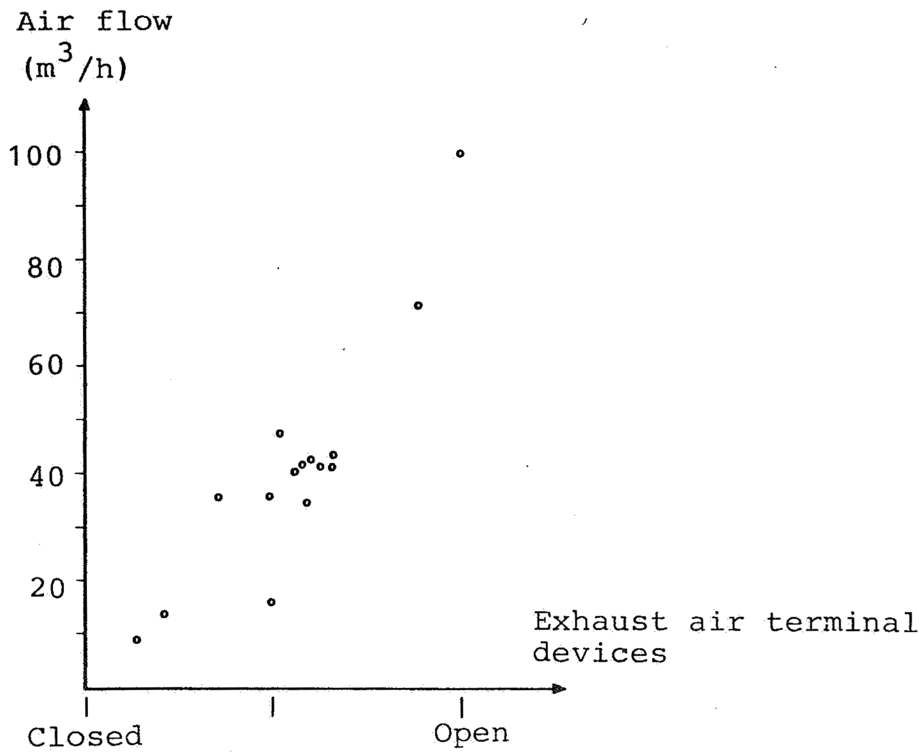

Figure 3. Recorded air-flow and adjustment of exhaust air terminal devices. The devices were presumed to have an air-flow of 50 m^3/h

7. BALANCED VENTILATION WITH HEAT RECOVERY UNITS

Compared with those of mechanical exhaust air systems, the risks of incorrect air flow rate and air-leakage from ducts are in practice considerably larger with balanced ventilation. Balanced ventilation makes severe demands on production and results in a greater amount of work for the builders. It is rather difficult to adjust and measure the air flow rate through supply air terminal devices.

Advantageous loans have to a great extent promoted the sale of balanced ventilation systems with heat recovery units. These systems are expected to give better comfort and recovery of heat. Reduced ventilation losses can lead to a reduced need for heating and to smaller radiator-surfaces.

The proportion of real saving of energy with these kinds of systems has not been determined. When estimating the profitability, one must pay attention to the real airflow rates and the interplay between different flows in newly-built houses.

Heat recovery units belong to those components for saving energy which have not been subjected to any severe criticism. Reasons for this may be that:

- The recovery units make it possible to get favourable loans
- The marketing is effective
- Experience from heat recovery units in industries, offices and stores is applied to small houses, and no attention is paid to the smaller building volume and need for ventilation
- The builders' knowledge about ventilation is insufficient

8. THE EFFICIENCY OF HEAT RECOVERY UNITS

All the producers of heat recovery units show the performance of the exchangers with the so-called temperature efficiency η_t. This quotient is defined as

$$\eta_t = \frac{t_{sa} - t_{sb}}{t_e - t_{sb}}$$

where t_{sa} = supply air temperature after the exchanger
t_{sb} = supply air temperature before the exchanger
t_e = exhaust air temperature.

The temperature efficiency givės a comparison between different types of heat recovery units but can hardly be the basis for forming a judgement of the energy saving (figure 4). Measurements indicate that only 60-80% (i.e., 0.3-0.4 changes per hour) of the total ventilation is guided through the ventilation ducts [2].

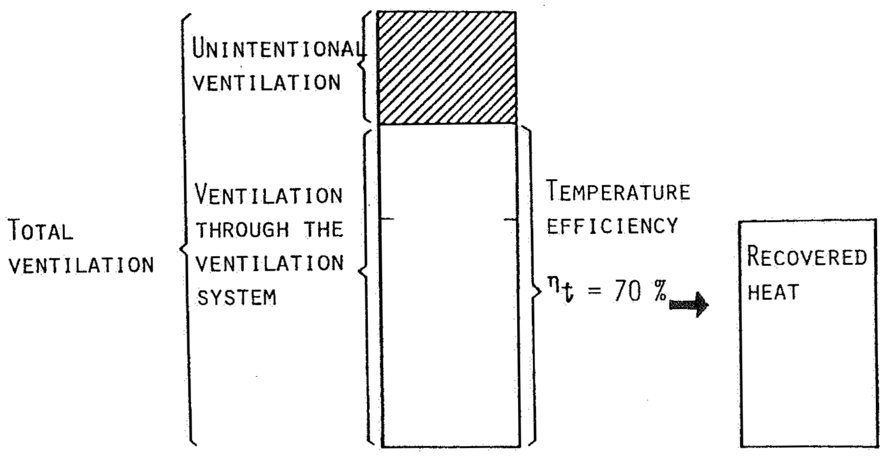

Figure 4. The limitation of the temperature efficiency

9. ARE STRICTER REQUIREMENTS ON AIRTIGHTNESS DESIRABLE?

Of course, heat recovery units become more profitable in extremely airtight houses with more air changes. Balanced ventilation with heat recovery will probably be of interest when houses are tighter than 3 changes per hour at 50 Pa. This value, according to SBN 75, has been attained at a cost of 500 to 2,000 Sw. Cr. Still stricter requirements for air tightness, to one change per hour, will result in an additional cost of between 2,000 and 5,000 Sw. Cr. [3]. Different types of adhesive tape are being used to achieve more airtight houses. The durability of such engineering must be questioned. The consequences of a decision like that must, however, be analysed, particularly since the need for ventilation to reduce radon and moisture has not been determined. Is it - from an economic and practical point of view - sensible to reduce the unintentional ventilation further? What will be the consequences if the mechanical ventilation system ceases to work due to a power failure or for any other reason?

10. RECOMMENDATIONS AND CONCLUSIONS

The purpose of this paper has been to indicate the need for development in the ventilation field. The following recommendations can be given:

- Increased knowledge.
  Because of defective workmanship and lack of information about the quality and function of the ventilation systems, the expected saving of energy has failed to appear, wholly or partially.

- Differentiated requirements on ventilation.
  Differentiated requirements for ventilation, well-documented from radiation research, ought to be introduced in the Swedish Building Code.

- Inspection of systems.
  The authorities must make sure that mechanical ventilation systems always are adjusted.

- Comfort-criteria.
  Comfort-criteria must be defined for different types of ventilation systems and supply air terminal devices.

- Changed conditions for heat recovery.
  Heat recovery can be used only during the heating season. Therefore, heat pumps, which use the heat in exhaust air flows to produce hot water, are good alternatives.

- Well-documented requirements for air-tightness.
  The requirements on air-tightness must be put in relation to the real possibilities of

saving energy. Considering the costs, the regulations must not be made stricter until problems of workmanship, durability and dependability have been solved.

11. ACKNOWLEDGEMENTS

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