EFFECTIVE VENTILATION

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VENTILATION HABITS IN RESIDENTIAL BUILDINGS

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0. SYNOPSIS

Experimental investigations concerning energy savings achieved in buildings with passive solar components (e.g. large south-front windows, sunspaces or Trombe walls) have already been effected under test conditions. Since, however, the influence of occupants' behaviour on energy consumption was generally found to be a very strong one, the main purpose of the present project was to analyze inhabitants' acceptance and use of various components like shading devices, movable heat insulation, manual ventilation, room temperatures, and heating systems. The study is based on extensive measurements performed on 25 occupied single-family houses in Germany. Results concerning the influence of occupants' behaviour will be given.

1. OBJECTIVES

There are still many possibilities to cut down on energy consumption, both in modernizing old buildings and in constructing new ones. In the long run, the heating energy demand for dwellings in the Fed. Rep. of Germany could be reduced to less than a third of today's consumption by consequently applying all of the advanced building concepts and technologies presently available which to date have only been applied with hesitation. It was for these reasons that the German Federal Ministry for Research and Technology decided to give an actual demonstration of the practical implementation by funding the present pilot project.

The demonstration project is aimed at:

- implementing promising solutions for single-family dwellings with low heating energy demand
- proving functionality, efficiency and economical feasibility of the new technologies and building concepts
- pointing out inherent technical problems and contributing to their elimination.

2. SCOPE OF THE PROJECT

In Fig. 1 views and locations of the buildings included in the study are given. At Landstuhl, eight buildings with the same floor plan (namely, that of House no. 8) were measured. In all of the 25 buildings various concepts of low-energy construction methods were realized. Most of the buildings have an excellent thermal insulation.

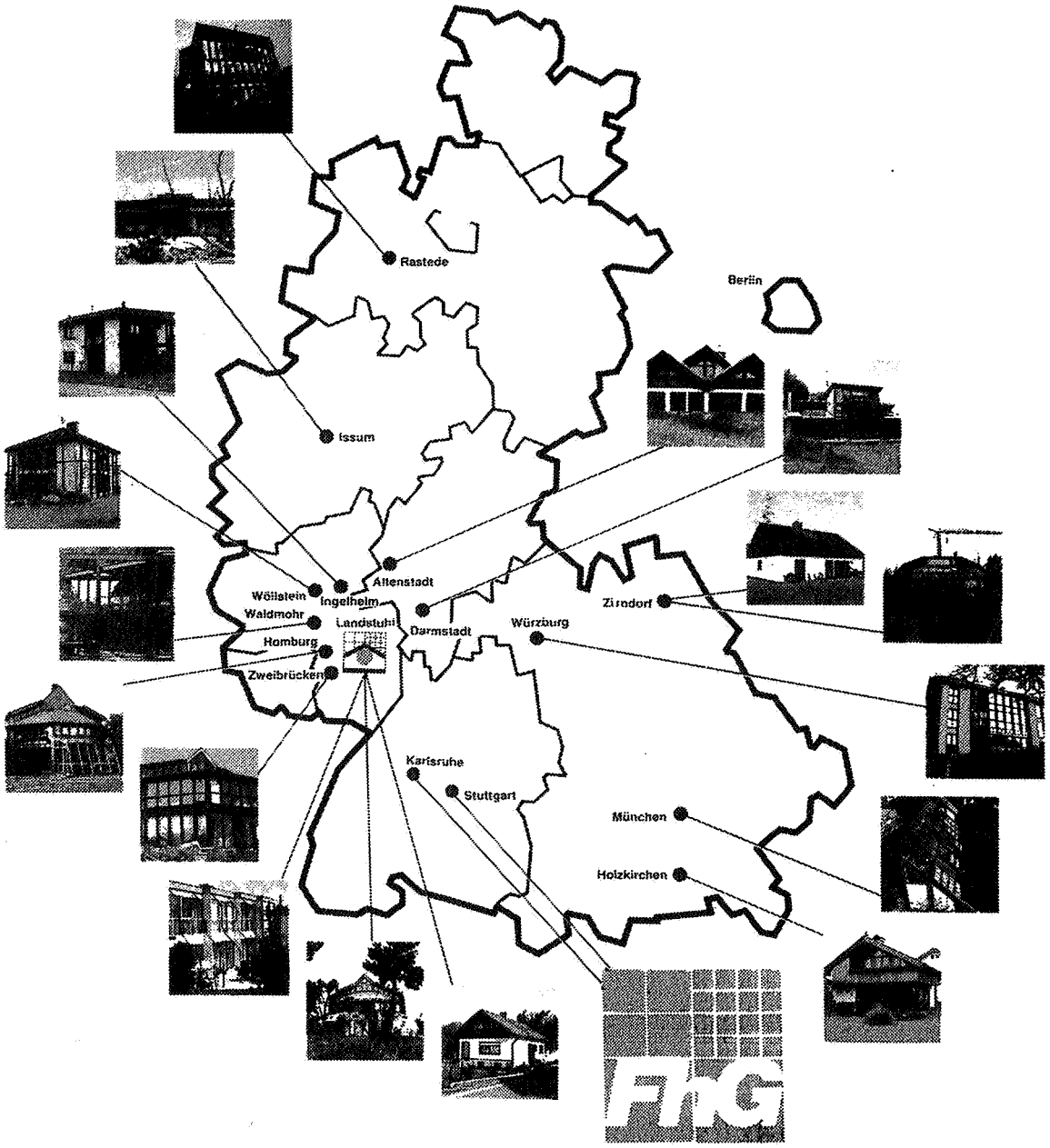

Fig. 1 Views and locations of the buildings included in the study (numbers are related to project participants)

All houses were occupied and provided with a sophisticated measuring equipment. Figure 2 gives a survey of all the values that were continuously recorded for each house. There were also discontinuous tracer gas measurements.

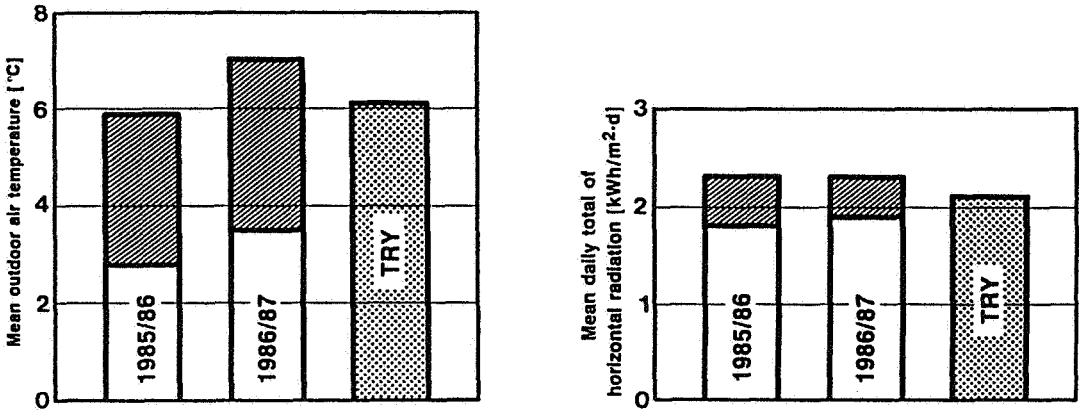

Fig. 2 Measured mean outdoor temperatures and daily totals of global solar radiation during 1985/86 and 1986/87 heating seasons as compared to Test Reference Year (TRY) values for average German climate conditions. The shaded area indicates the range of variation between the building sites.

3. METEOROLOGICAL BOUNDARY CONDITIONS

As the buildings under survey are located in different places all over West Germany, a detailed analysis of climate parameters had to be conducted in order to include also climate-induced effects in the final comparison. Figure 3 presents the mean values of outdoor temperatures and the daily totals of horizontal global solar radiation recorded during the 1985/86 and 1986/87 heating cycles. The shaded area indicates the range of variations between the locations. For comparison, long-term TRY mean values for average German climate conditions are given.

- During both heating cycles, average temperatures fell below Test Reference Year values. The first heating period was the colder one. The differences stated between the locations are significant.
- The mean variation in global solar radiation is low for different locations. On average, it was found not to vary from TRY values.

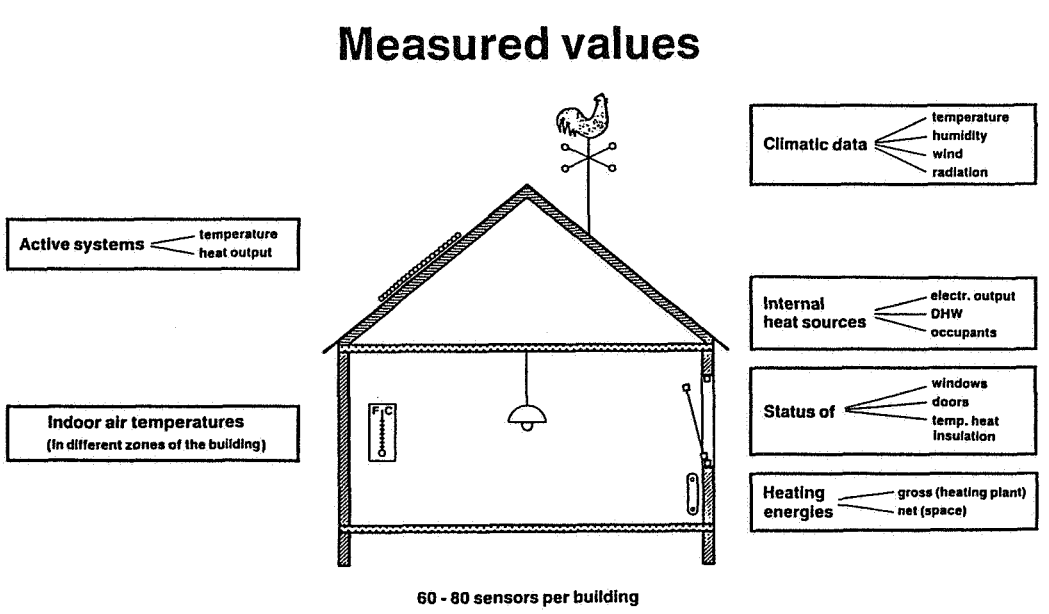

Fig. 3 Instrumentation of the 25 buildings under survey.

4. RESULTS OF THE MEASUREMENT AND INVESTIGATION PROGRAMME

4.1 Investigations concerning occupant behaviour

Among the 25 buildings under survey, 11 buildings were equipped with conventional hot water heating systems (radiators, floor heating) and 14 with warm air heating systems. All of the air heating systems were operated with a partial supply of fresh air; the respective supply rates were at variance. In the following, user-related criteria will be examined separately for the buildings with hot water heating and for those with air heating systems.

4.2 Indoor air temperatures

During the entire monitoring period, all indoor air temperatures were recorded hourly. In Fig. 4 the measured indoor air temperatures are contrasted with the corresponding outdoor air temperatures. The measured values are indicated in the hatched areas. It becomes evident that indoor air temperatures decrease with decreasing outdoor air temperatures. Obviously, there is a tendency for the occupants to accept lower indoor air temperatures more

readily when outside temperatures are low, too, which seems to be a deviation from user patterns during interseasonal heating periods. This tendency proved to be independent of the selected type of heating system. The fluctuation of indoor air temperatures is about the same for all heating systems under study which allows the conclusion that the type of heating system has no part in the user's selection of temperature. User-specified variations in indoor air temperatures are ranging between 4 and 5 K.

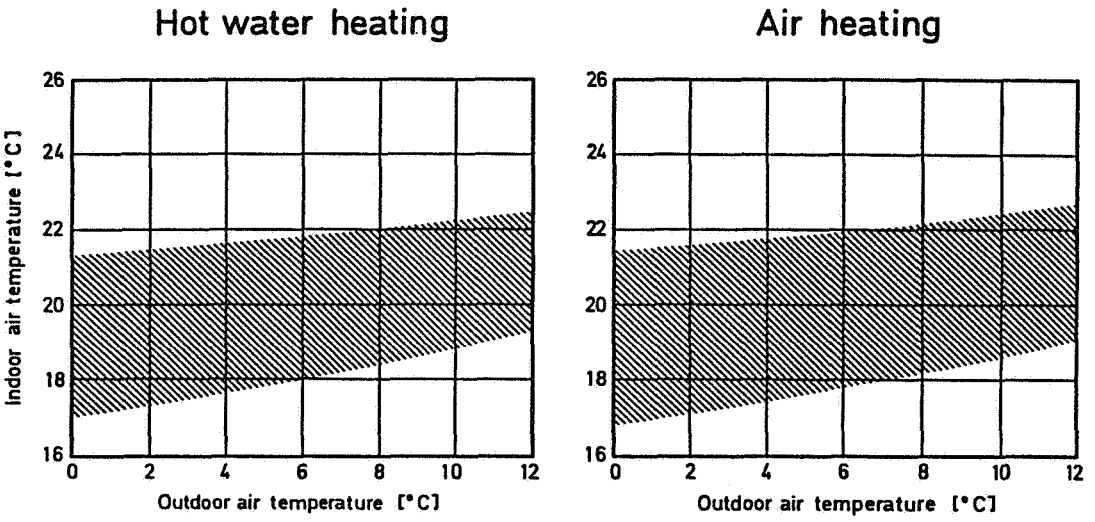

Fig. 4 Measured indoor air temperatures versus outdoor air temperatures for the surveyed buildings with hot water and air heating systems. The range of measured values is hatched.

4.3 Inhabitants' behaviour with regard to opening windows

User patterns that bear relevance to a building's energy performance may not only be described by recording indoor air temperatures but also by examining the occupants' habits and preferences with regard to ventilation. In residential buildings, the occupants' ventilation strategies are characterized by the duration of leaving windows open. In Fig. 5 the measured duration of window ventilation versus outdoor air temperatures is given separately for the buildings with hot water heating and for those with air heating systems. Obviously, the windows were opened significantly less frequently in low outdoor air temperatures than in milder outside air temperatures. While the windows were opened on average for only 2 minutes per hour in low outdoor air temperatures, they were kept open for about 10 minutes on average per hour in milder weather.

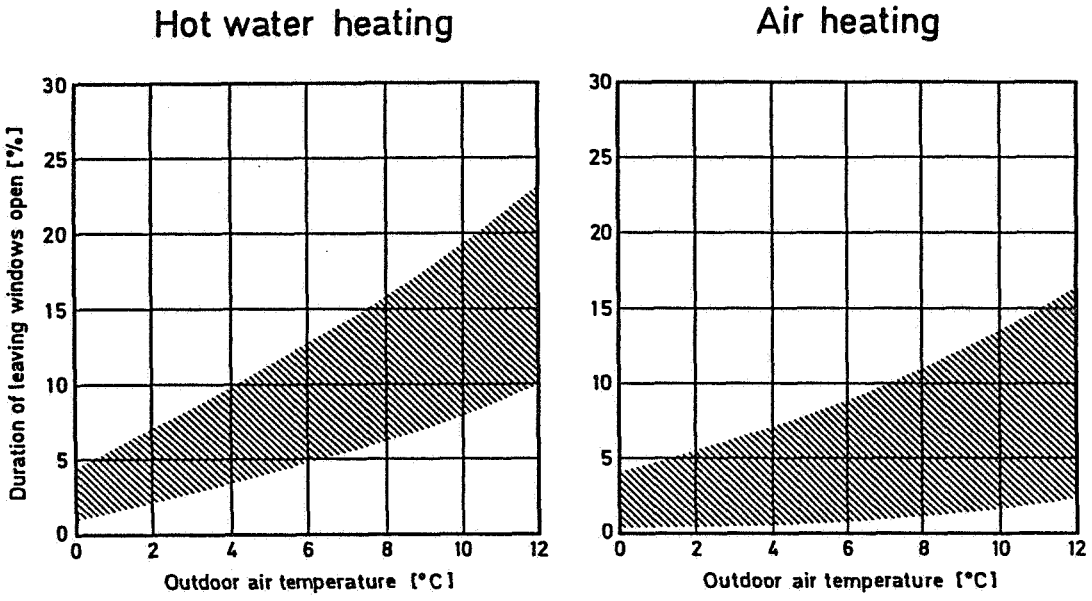

Fig. 5 Measured duration of window ventilation versus outdoor air temperatures for the surveyed buildings with hot water and air heating systems. The range of measured values is hatched.

Considering the duration of window ventilation, pronounced variations are to be observed which are associated with different types of heating systems. In the buildings equipped with hot water heating systems, windows were on average kept open longer than in air-heated buildings, particularly in mild weather. Actually, this tendency was to be expected, since all of the air heating systems were operated with a partial fresh-air supply, i.e. the required air change was already provided via the heating system.

In air-heated dwellings, too, there is a tendency to be observed towards opening windows when outdoor temperatures are rising which may be attributed to psychological rather than physical reasons. In future, this finding which has already been established in [1] for multi-family housing must not be disregarded when planning buildings and installations. As a general rule, windows in residential buildings should be openable and have defined degrees of airtightness when closed. When calculating rates of efficiency and potentials for saving energy by using mechanical ventilation systems in the housing sector, the user-specified "basal air change" resulting from opening windows should always be borne in mind.

When comparing these user habits to those already stated in [1] for multi-family dwellings, occupants of multi-family dwellings are found to open their windows more frequently than occupants of single-family houses (see Fig. 6). This is probably not so much a matter of distinct ventilation strategies characteristic of multi-storey buildings but rather due to the varied number and size of windows depending on the type of construction. This is

why a direct comparison of results is not possible.

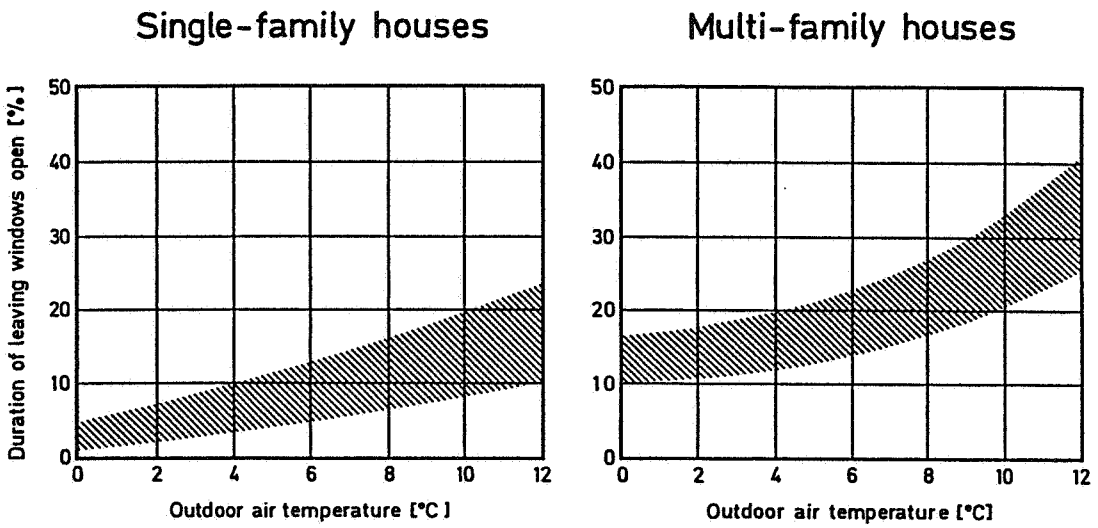

Fig. 6 Measured duration of window ventilation versus outdoor air temperatures for single-family and multi-family buildings acc. to [1], without mechanical ventilation. The range of measured values is hatched.

5. CONCLUSIONS

The study on the energetic performance of occupied single-family houses included monitoring of occupants' behaviour. It was found that there is no significant distinction between buildings with different heating and ventilating systems as regards temperatures. In all of the buildings under survey indoor air temperatures were found to decrease with decreasing outdoor temperatures.

As for ventilation patterns, a direct correlation between the respective type of heating and ventilating system was confirmed. In buildings with air heating systems (all of which were operated with varied portions of fresh air) windows were opened for a significantly shorter period than in buildings with hot water heating and in those without mechanical ventilation. Though, in buildings equipped with mechanical ventilation windows were never found to be absolutely locked. The present findings suggest that a minimum air change via window ventilation is a basic need irrespective of the actual indoor air quality in residential buildings. In future planning, this fact will have to be duly considered.

6. REFERENCES

[1] Erhorn, H.: Influence of the meteorological conditions on the inhabitants' behaviour in dwellings with mechanical ventilation. Proc. 7th AIC Conference, pp. 11.1-11.15, Stratford upon Avon (1986).