Ventilation for Energy Efficiency and Optimum Indoor Air Quality
13th AIVC Conference, Nice, France
15-18 September 1992

Paper 16

Occupants' Behaviour with Respect to Window Opening: A Technical and Sociological Study.

B. Fleury and C. Nicolas

EDF DER DAE, Les Renardières, Route de Sens, 77250 Moret sur Loing, France
1.0 Synopsis

The occupant's behavior with respect to window opening may greatly affect the ventilation system, the energy consumption or the indoor air quality. In order to quantify the magnitude of opening times, many surveys have focused on climatic parameters and concluded to the temporal correlation between the timelength of opening and the outside temperature or the solar irradiation. In this paper, we study the influence of sociological and technical parameters on the average time of opening during the winter. The research is based on a sociological survey and a two year monitoring of thirty houses with recording sensors on every window.

The wife at home or not, the size and age distribution of the family are key variables in the kitchen, bathroom, children's bedroom. The orientation of the living room related to the sun explains the occupant's behavior in this room. For the parent's bedroom, none of the selected parameters emerges, the distribution and frequency of opening time are so erratic. The type of ventilation systems, natural versus mechanical, is not the main explainable variable, as well as the degree of equipment of the family.

2.0 Introduction

In the past years, research has focused on understanding air infiltration and improving ventilation systems. Building construction techniques and ventilation products have now reached a high quality standard. However, we still face some claims for a better indoor environment. Satisfying this demand implies a clear identification of occupants' wishes and behavior. In this paper, we analyse the technical and sociological parameters impacting occupants' behavior with respect to window opening during winters. We will not present the influence of the weather data on their behavior.

3.0 Methods

Given the complexity of understanding the occupants' behavior with respect to window opening, we used different approaches to examine this issue:
- a two year monitoring on 30 individual electrically heated houses, recording duration and number of openings on each window /1/
- a questionnaire survey on 60 households including the 30 monitored one /2/
- 3 household interviews.

3.1 Building group

The studies were conducted in the same geographical area near Lyon (France) with houses built between 1982 et 1985. In the measurement group, 10 dwellings were equipped with humidity controlled ventilation (numbered 1 to 10), 5 with natural ventilation system (numbered 11 to 15) and 15 with mechanical exhaust ventilation systems (numbered 16 to 30).
3.2 Recorded parameters

Instead of an automatic monitoring of the entire house, we decided to develop miniature sensors with an periodical inspection. Every two or three weeks, the following data were recorded:
- duration of opening of each window
- number of opening of each window
- energy consumption (day and night)
- functioning time of the ventilation.

During the visit, the agent noted:
- temperature and humidity in the living-room
- flow rate in exhaust rooms
- angle of opening of opened windows if any
- cleanliness of exhaust valves
- temperature and humidity in the parents' bedroom.

At the local weather station, the following data were recorded:
- global solar irradiation (MJ/m2)  
- diffuse solar irradiation (MJ/m2)
- number of hours of sun (h)  
- water precipitation (mm)
- wind speed (m/s).

For analysis, all the previous data were converted to a daily basis.

3.3 Characteristics of the households

For each instrumented houses, we have identified:
- number of persons
- number of babies (not at school)
- number of children at school
- number of smokers,
- women at home
- men working during nights
- number and type of pets
- ventilation system,
- equipment of the house (dishwasher, microwave, cooker hood,...),
- orientation of the living room window (north or other).

4.1 Recorded duration of opening

Table 1 is the synthesis of two winters. Winter in 90 was more severe than in 89, (average temperature 2°C less). Consequently, the durations were slightly different but the same order of magnitude is respected.

If we compared with foreign experiences, the figures are different but the building techniques and HVAC systems also differ significantly. However, the parents' bedroom is also the room where the window is often opened.
Table 1: Duration of opening in every room

<table>
<thead>
<tr>
<th>Room</th>
<th>Present Experiment</th>
<th>Netherlands /3/</th>
<th>Belgium /4/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>30 mn</td>
<td>1h45</td>
<td>1h</td>
</tr>
<tr>
<td>Living room</td>
<td>50 mn</td>
<td>1h</td>
<td>30 mn</td>
</tr>
<tr>
<td>Bathroom</td>
<td>45 mn</td>
<td></td>
<td>1h30</td>
</tr>
<tr>
<td>Parents' bedroom</td>
<td>2h30</td>
<td>5h</td>
<td>4h</td>
</tr>
<tr>
<td>Children's bedroom</td>
<td>1h</td>
<td>1h45</td>
<td>2h30</td>
</tr>
</tbody>
</table>

Table 2: % of people under, over or correctly (+/- 10 mn) estimating the duration of opening

<table>
<thead>
<tr>
<th>Room</th>
<th>Overestimation</th>
<th>Underestimation</th>
<th>Right estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>26</td>
<td>43</td>
<td>30</td>
</tr>
<tr>
<td>Living room</td>
<td>13</td>
<td>57</td>
<td>30</td>
</tr>
<tr>
<td>Bathroom</td>
<td>10</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>Parents' bedroom</td>
<td>7</td>
<td>73</td>
<td>20</td>
</tr>
<tr>
<td>Children's bedroom</td>
<td>14</td>
<td>57</td>
<td>29</td>
</tr>
</tbody>
</table>

4.3 Multivariable analysis

4.3.1 Method

The sociological survey identified explanatory parameters of the occupants' behavior and a kind of hierarchy. Using the Morgan and Sonquist method, we have tried to identify the main explanatory variables of the recorded duration of window opening. The segmentation criteria is based on the variable which is going to maximize:

\[ W = \sum P_j (M_j - M) \]

Where \( M \) is the average of the duration of opening

\( M_j \) is the average of the duration of opening of the state of the explanatory variable

\( P_j \) is a weighting values.

Repeating the segmentation criteria at different levels, we can build a segmentation tree with a hierarchy for the explanatory variables. This method is really attractive but presents some risks. When no variable
represents a strong segmentation criteria, the segmentation tree can be unrealistic because a bifurcation was not pertinent. This fact should lead to a comparative analysis of W for the various explanatory variable. Because of the limited number in the sample, we will consider only the first levels of the segmentation tree.

4.3.2 Kitchen

The wife working full time, part-time or at home is the main variable for the kitchen. The time available for cooking activities explains the difference between the various households. As we will notice for other rooms, the larger the family is, the less the window is opened. Finally, we notice a shorter duration of opening in a house equipped with a mechanical exhaust ventilation system. In a naturally ventilated house, the wife may need to open the window to exhaust the pollutions.

4.3.3 Living-room

The orientation of the living-room is the key variable: occupants open widely their windows by sunny days. The presence of smokers induces a longer duration of opening, babies within the family lead to the opposite.

4.3.4 Bathroom

The households without children leave the window open for a long time. The presence of babies in the family leads a short duration of opening.

4.3.5 Children's bedroom

When the bedroom is occasionnally used, the window is opened for large period of time. In fact, this room can be used for other activities and is largely ventilated before the welcome of a guess. When the wife is working full time, this room is rarely opened.

4.3.6 Parents' bedroom

No explanatory variable emerges from the statistical analysis. None of the listed parameters can correlate the opening. In fact, we notice a difference behavior in any class. From a few minutes to hours, the entiere spectrum was recorded.

4.3.7 Conclusions

The wife working or not, the presence and the age of children are the key variables explaining the occupants' behavior. However, usually another specific variable emerges in any room. The type of ventilation systems is not fundamental in the occupants' behavior except in the kitchen where the natural ventilation system is not sufficient to exhaust pollutions. These results are in agreement with the sociological survey and illustrate the major role of the household with respect to the window opening and the ventilation system.
4.4 **Energy consumption**

This study has identified a large spectrum of behavior with respect to window opening. The act of opening is usually combined with the switch of the electric radiator and we did not point out a correlation between the time of opening and the energy consumption.

5.0 **Conclusions**

This study illustrates the crucial role of sociological parameters regarding to the occupants' behavior with respect to window opening. Even if the conclusions are limited to this reduced sample, this research points out that the specifications and the operation of a HVAC system should better integrate the occupants' behavior. An excellent system from a theoretical and technical approach can be a failure if it does not include, in the design approach, the occupants.

6.0 **References**

/1/ B. Fleury, P. Niard
Comportement des occupants vis à vis de l'ouverture des fenêtres, Rapport EDF HE 12 W 3065, Nov 90.

/2/ J. Rivoire
Les habitants et leurs fenêtres, Rapport EDF, Jan 90.

/3/ J. E.F. Van Dongen
Inhabitants'behavior with respect to ventilation 7th AlVC Conference, Stratford, UK, Oct 86.

/4/ P. Wouters, D. de Baets
A detailed statistical analysis of window use and its effect on the ventilation rate in 2400 Belgium social houses, 7th AlVC Conference, Stratford, UK, Oct 86.
Figure 1: Duration of opening for the window of the kitchen
Figure 2: Duration of opening for the window in the living room
Figure 3: Duration of opening for the window of the bathroom
Figure 4: Duration of opening for the window of the children's bedroom