MARKET OPPORTUNIIES FOR ADVANCED VENTILATION TECHNOLOGY

22ND ANNUAL, AIVC CONFERENCE
BATH, UNITED KINGDOM, 11–14 SEPTEMBER 2001

Evaluation and development of innovative and energy efficient ventilation strategies

Alireza Afshari
Niels C. Bergsoe

Danish Building and Urban Research
Energy and Indoor Climate Division
PO Box 119
DK-2970 Horsholm
DENMARK

SYNOPSIS
A potential conflict may exist between energy saving and good indoor climate. The present project is phase 2 of a 5-year research programme consisting of four phases, the objective of which was to develop energy efficient ventilation strategies that will provide both healthy and comfortable indoor climate and reduced energy consumption when compared to present standard. Results of simulations from phase 1 and measurements from this phase 2 indicated that on average the basic ventilation in a typical apartment under normal use could be reduced by 20-30 percent without compromising the indoor climate.

1. INTRODUCTION

In recent years, much attention has been paid to the moisture content of the room air. Excess moisture indoors promotes house dust mites, mould growth and premature degrading of building components [1, 2, 3]. Therefore, humidity can be a relevant parameter for demand-controlled ventilation. Basically, the ventilation strategies will be founded on a general reduction of the continuous basic ventilation and possibilities for individual increase of the ventilation to the actual needs within each dwelling and room. Danish Building and Urban Research has initiated a 5-year research programme consisting of four phases. The main purpose of the programme is to develop energy efficient ventilation strategies that will provide both healthy and comfortable indoor climate and reduced energy consumption when compared to present standard. Results of the first phase of the research programme were presented at the AIVC conference 2000 in The Hague [4]. Based on the evaluation of ventilation needs in dwellings and simulated moisture balance in the room air, the author concluded that the basic ventilation in a typical apartment under normal use could be reduced by 20-30 percent without compromising indoor air quality. Phase 2 of the research programme, detailed in this report, covers development and testing in the lab of selected ventilation strategies.

2. VENTILATION STRATEGIES

The selected ventilation strategies for phase 2 show below. Four scenarios will be investigated as follows:

Scenario 1:
- Constant mechanical extraction of 35 l/s (20 + 15 l/s from kitchen and bathroom respectively).
- Permanent open outdoor air inlets in living room and bedroom.
- Moisture and pollution loads according to timetable, shown in Table 1.

Scenario 2:
- Basic mechanical extraction of 20 l/s (10+10 l/s from kitchen and bathroom respectively).
- Increased ventilation to 70 l/s in the morning and the early evening.
- Permanent open outdoor air inlets in living room and bedroom.
- Moisture and pollution loads according to timetable, shown in Table 1.

- ***Scenario 3:***
- Demand-controlled (moisture) extraction from bathroom (basic ventilation 5 l/s and forced ventilation 20 l/s).
- Manually controlled extraction from kitchen (basic ventilation 15 l/s and forced ventilation 50 l/s).
- Supply air is delivered primarily to occupied room.
- Humidity sensors in living room, bedroom and bathroom.
- Moisture and pollution loads according to timetable, shown in Table 1.

Scenario 4:
- Demand-controlled (moisture) extraction from bath (basic ventilation 10 l/s and forced ventilation 20 l/s).
- Demand-controlled (moisture) extraction from kitchen (basic ventilation 10 l/s and forced ventilation 50 l/s).
- Supply air is delivered primarily to occupied room.
- Moisture and pollution loads according to timetable, shown in Table 1.

3. EXPERIMENTS

Scenario 1 was performed full scale in a test apartment in the laboratory, located in a large test hall, at the Department of Built Environment, University of Gävle. Figure 1 shows the test apartment. The volume of the apartment was approximately 175 m^3 and the total free floor area was approximately 70 m^2.

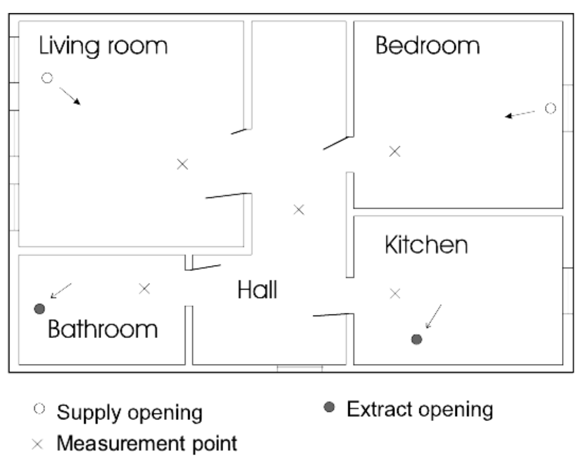

Figure 1 Test apartment.

The apartment was provided with two separate mechanical extract fans from kitchen and bathroom, respectively. The exhaust airflow rate was 20 l/s from kitchen and 15 l/s from the bath. Supply air was taken from the laboratory hall through openings in the ceiling of the living room and bedroom. The measurement period was 72 hours (3 days and nights). The test included two contaminant sources. One was CO_2 simulating occupants and one was simulating contaminant emission from building products and furnishings. Tracer gas, N_2O was supplied continuously and at a constant rate to the living room.

Time	Bedroom	Living room	Hall, kitchen, bathroom
00:00-01:00	15 gH_2O/h	2 persons: 50 $gH_2O/h/person$ 20 l $CO_2/h/person$ 60 $gH_2O/h/person$ 15 gH_2O/h Contaminant emission	**Hall:** 15 gH_2O/h
01:00-07:00	2 persons: 25 $gH_2O/h/person$ 12 l $CO_2/h/person$ 15 gH_2O/h	15 gH_2O/h Contaminant emission	**Hall:** 15 gH_2O/h
07:00-08:00	15 gH_2O/h	15 gH_2O/h Contaminant emission	**Hall:** 15 gH_2O/h **Kitchen:** 2 persons: 20 l $CO_2/h/person$ cooking 200 gH_2O/h **Bathroom:** 2 pers., 2 x 15 min: 20 l $CO_2/h/person$ bathing: 2000 gH_2O/h
08:00-18:00	15 gH_2O/h	15 gH_2O/h Contaminant emission	**Hall:** 15 gH_2O/h
18:00-19:00	15 gH_2O/h	15 gH_2O/h Contaminant emission	**Hall:** 15 gH_2O/h **Kitchen:** 2 persons: 20 l $CO_2/h/person$ cooking: 200 gH_2O/h
19:00-24:00	15 gH_2O/h	2 persons: 50 $gH_2O/h/person$ 20 l $CO_2/h/person$ 60 $gH_2O/h/person$ 15 gH_2O/h Contaminant emission	**Hall:** 15 gH_2O/h

Table 1 The diurnal moisture and pollution loads.

Five custom-built humidifiers were used to simulate the generation of water vapour in the apartment (occupants and their activities, i.e. bathing, showering, cooking, clothes washing and drying, floor washing and plants.). These were placed in the living room, the entrance and the bedroom. The humidifiers consist of a tank connected to a spiral tube for regulation of water and a hotplate for evaporation. Boiling water generated moisture in the kitchen and the bathroom. Table 1 presents the diurnal moisture and pollution load in the apartment.

4. RESULTS

Figure 2 shows as an example the result of the measurements of H_2O in all rooms. The results indicated that the level of moisture increases in all rooms during the occupants' showers. The moisture took several hours to decay before it reached normal level.

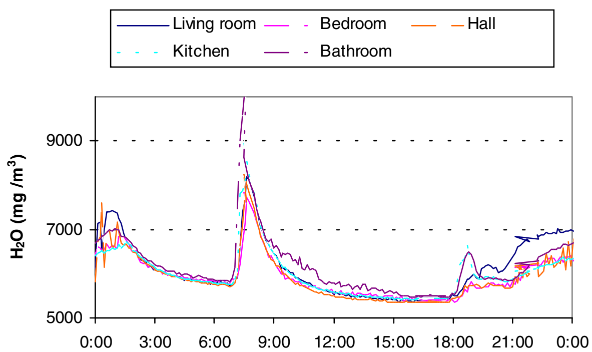

Figure 2 Moisture content of room air during the study of Scenario 1.

5. CONCLUSIONS

The results obtained from the experimental study and the calculations from phase 1 were compared. The measured moisture content in the experiment showed the same pattern of variation as the mathematical simulation. In addition, the CO_2 concentration also showed similar results as the moisture content. It was found that the moisture content and CO_2 concentration in the apartment air decay in a similar way as simulation. Practical difficulties arose during the experiments and difficulties were also encountered in regulating the water and the hotplate for evaporation of water.

Agreements between experiment results and simulations justify continuation of the project. Scenarios 2, 3 and 4 will start in the fall of 2001. Phase 3 is full scale testing in demonstration buildings and phase 4 is measurements and evaluations of the tests in the demonstration buildings. Phases 3 and 4 will carried out before 2005.

6. ACKNOWLEDGEMENTS

The present study was been carried out as part of the Energy Research Programme (ERP/EFP) administered by The Danish Energy Agency, and Agency under the Danish Ministry of Environment and Energy.

7. LITTERATURE

[1] Lars Gunnarsen, A. Afshari: Occurrence of fungi and house dust mites in Danish apartments. Proceedings of Healthy Buildings 2000, Vol. 3, pp. 353- 358.

[2] A. Nevalainen, A. Hyvärinen, A-L. Pasanen and T. Reponen: Fungi and bacteria in normal and mouldy buildings. Air quality monographs – V2 – Health implications of fungi in indoor environments. Elsevier, 1994.

[3] J. Korsgaard: House dust mites and absolute indoor humidity, Allergy, V 38, pp. 85-92. 1983.

[4] Niels C. Bergsøe: Innovations in ventilation technology. Proceedings of the 21st annual AIVC conference. The Hague, Netherlands, 2000.