PERFORMANCE OF DEMAND CONTROLLED VENTILATION : CASE STUDY

Anne-Marie Bernard[1], Michaël Blazy[1] and Marie-Claude Lemaire[2]

[1]CETIAT, France
[2]ADEME, France

ABSTRACT

In order to assess the real performances of different demand controlled ventilation systems, two of them were installed in meeting rooms of an office building.

The first system is controlled by movement detection on terminal units and has been installed in a small meeting room (10 persons) which is regularly used.
The second system is controlled by CO_2 detection and frequency variation on fan. It has been installed in a large meeting room (30 persons seated, up to 50 persons standing).
Occupancies rates, airflows, CO_2, humidity and temperature (inside and outside) have been monitored during 3 months for both rooms. System reaction as well as comparison between measured values and expected ones have been studied.

The systems have proved to be energy saving (up to 85%) with correct CO_2 levels. Meeting rooms have low occupation rate due to the fact there are generally less people in meetings than the maximum allowed. Simulations have also been run considering full office buildings to estimate the variation of savings for different occupation rates.

KEYWORDS
Ventilation rate – Control – Energy conservation – Air Quality – Air change rate.

INTRODUCTION

Demand controlled ventilation (DCV) is an important solution for energy conservation in buildings due to the importance of Air change losses. Various systems are available on the market. After a bibliographic review on DCV, the aim of the study was to experiment two different systems on site, in order to assess their real performances.

METHODS

We have installed two meeting rooms, one with CO_2 controlled and one with movement detection DCV. The size and the occupation of these rooms are strongly different.
Each meeting room was monitored during three months on several parameters: airflow, absorbed fan power as well as CO_2 levels and outside temperatures and humidity both inside and outside.
As measurements were taken every 10 seconds, polynomial regression and average values are used for results presentation.

RESULTS

Movement detection controlled ventilation

The system was installed in a small meeting room for 10 persons. The room is largely occupied. It was occupied during 19 meetings lasting 1 to 3 hours in the monitoring period of 11 working days. Yet the occupation rate, including the number of occupants as well as the time of occupation, happens to be only of 15% during this period. The movement detection system integrates movement on a detection lens during a period of 3 minutes and correlates it to the number of occupants.
This information is processed to determine opening or closing of the Air Terminal Device's damper which position (5 positions are possible) is visualized by LED.
The full system (detection lens, signal processing, visualization LED, with 5 positions damper) is integrated in each Air Terminal Device. The room was installed with three units covering the total surface and each of them varying from 0 to 75 m3/h.
The ventilation system is a single exhaust one with air inlets on the windows and an extraction fan covering both this meeting room and a set of offices with constant airflow.
Average airflows and CO_2 levels in permanent mode are reported in figures 1 and 2.

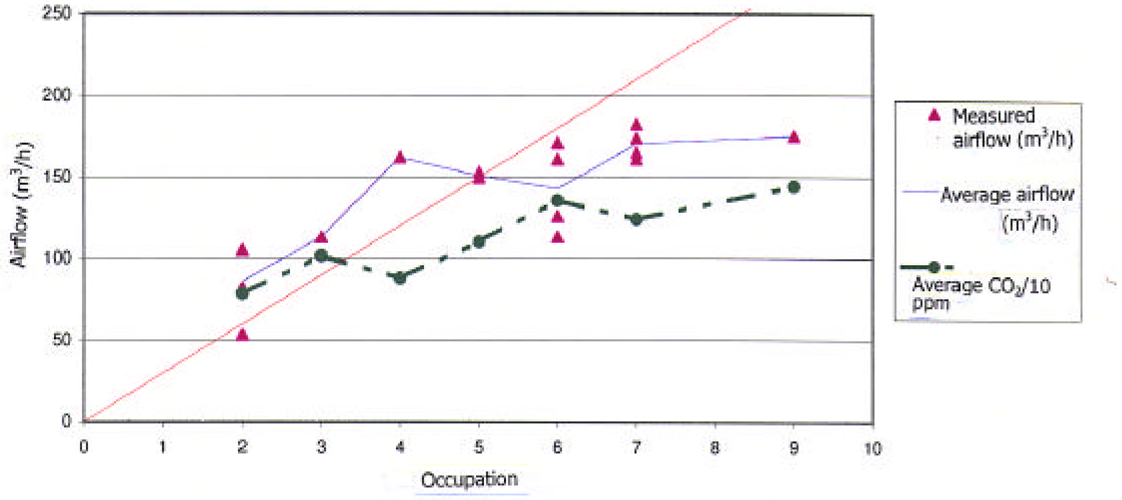

Figure 1 : average airflow depending on occupation

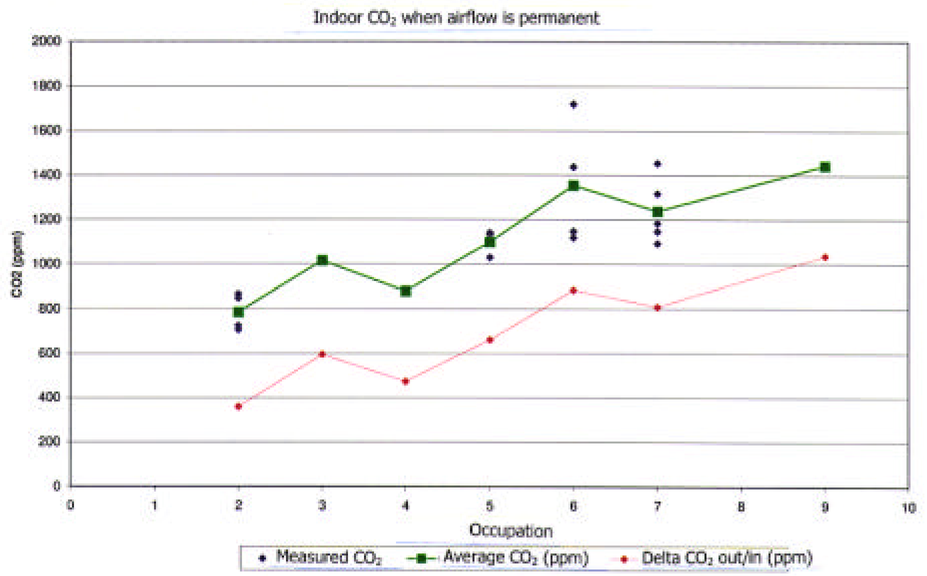

Figure 2 : average CO_2 levels depending on occupation

We can note that the system reacts correctly to the real occupation of the room although position of occupants (the detection cones of the three ATDs cross each other) and their activity have sometimes induced different airflows for the same occupation.
As the controlled airflow in the room (that has varied from 50 to 200 m^3/h) is quite low compared to the permanent airflow coming from offices (585 m^3/h) the fan absorbed power (270 W) varied very little (± 10 W).
French thermal regulation in buildings requires the ventilation stops during non-occupied periods (nights, week-ends…).
The mean airflow obtained on the measuring period of occupation (11 working days of 10 hours occupation) is 46 m^3/h which is to compare to a permanent designed ventilation rate of 300 m^3/h. We can conclude that energy savings are important (85%) due to the fact that even when a room is widely occupied, it is not fully occupied.

Health regulation in France requires a maximum level of CO_2 of 1000 ppm (± 300 ppm for non smoking rooms). Required airflows per person have been calculated to achieve this value with 300 ppm outdoor CO_2 level. The indoor levels measured are therefore correct and higher values are mainly due to the fact that this building is close to an highway in city environment which induced outdoor rates from 450 to 500 ppm CO_2, and to the measured airflows.

CO_2 controlled ventilation

This second system was installed in a large meeting room (30 persons seated and up to 50 standing). This room is very seldom used and not fully occupied.
Test were made during two periods. The first period of 17 working days was in summer. The room was used 8 times for short meetings (less than two hours). The occupation rate noted was 1.7%. The second period, in September, was more representative of standard room occupation. On 14 working days, the room was used for 5 meetings but on wider periods (2 to 7 hours). Therefore, the occupation rate was of 4.2%.
The CO_2 controlled system is composed of :

- a CO_2 sensor situated in the occupied zone close to the exhaust grill
- a frequency converter to regulate fan speed.

The system is a supply mechanical ventilation designed for 1500 m^3/h. Fan and ducts supply only this meeting room. Although all parameters can be adjusted, the regulation parameters were to have a proportional response starting from 400 ppm indoor CO_2 to the maximum as indicated in figure 3.

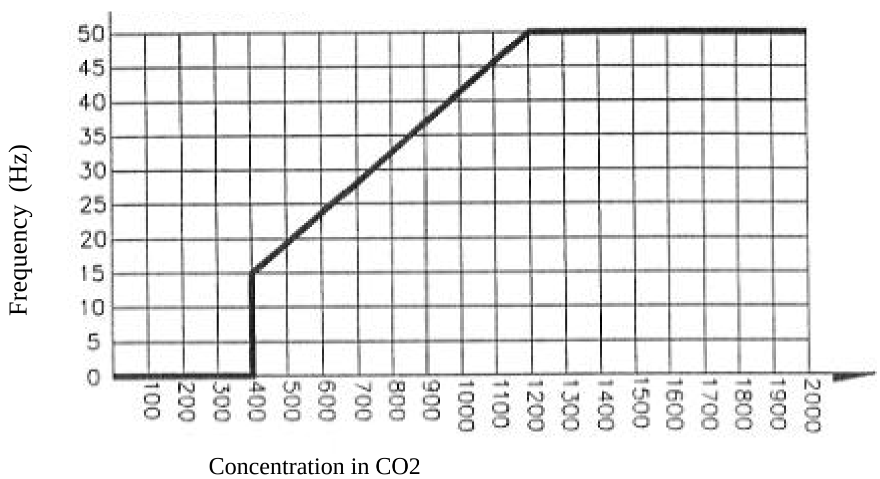

Figure 3 : frequency regulation parameters

Average airflows and CO_2 levels in permanent mode are reported in figures 4 and 5.

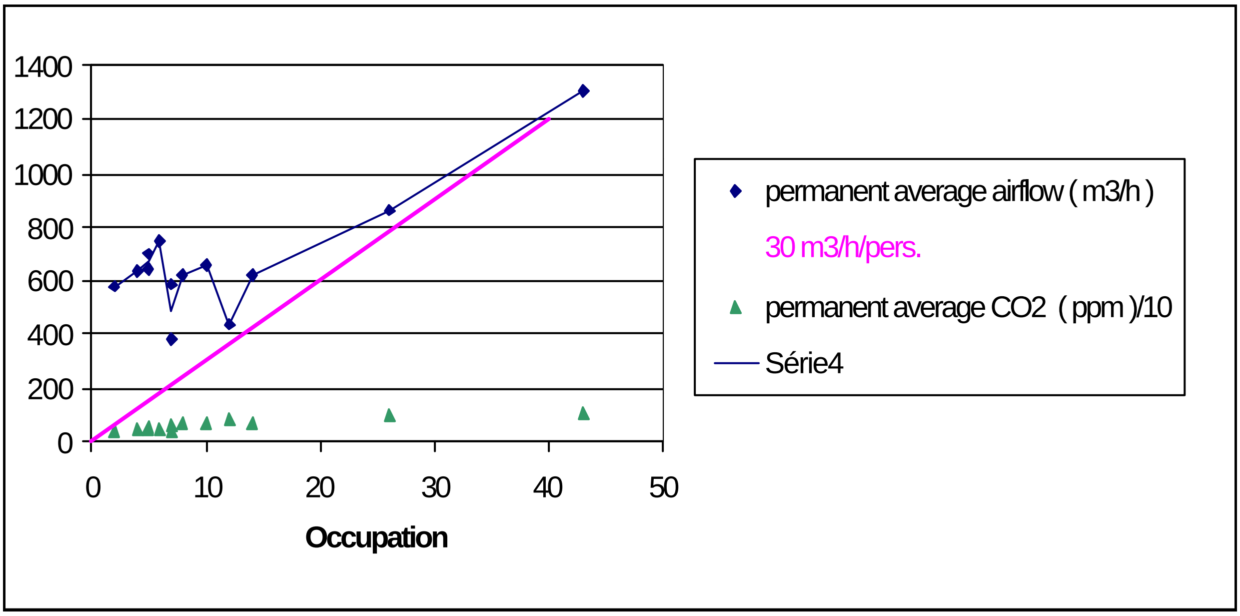

Figure 4 : average airflows depending on occupation

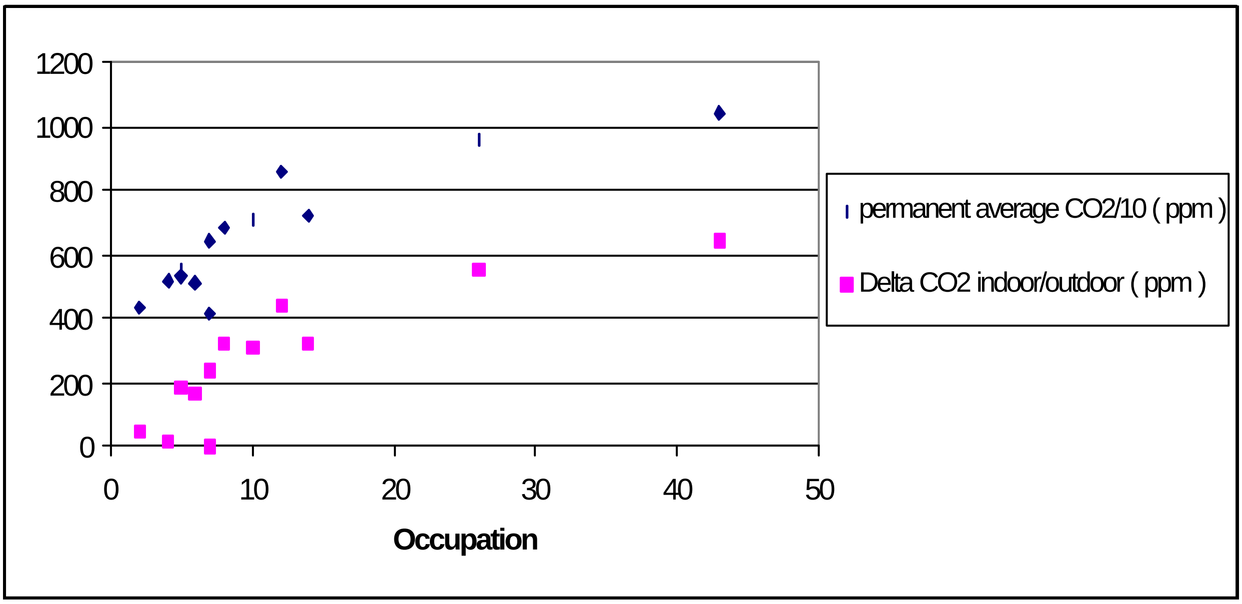

Figure 5 : average CO_2 levels depending on occupation

This system also reacts correctly to real occupation.
We have noted that due to the high outdoor CO_2 levels (340 to 500 ppm), even at night, the airflow very seldom came back to zero (in average, zero was reached only 12% of scrutation time).

Figure 6 reports the fan mean absorbed power versus occupation of the room. When airflow was zero, a residual power of 17 W was measured due to the frequency converter.

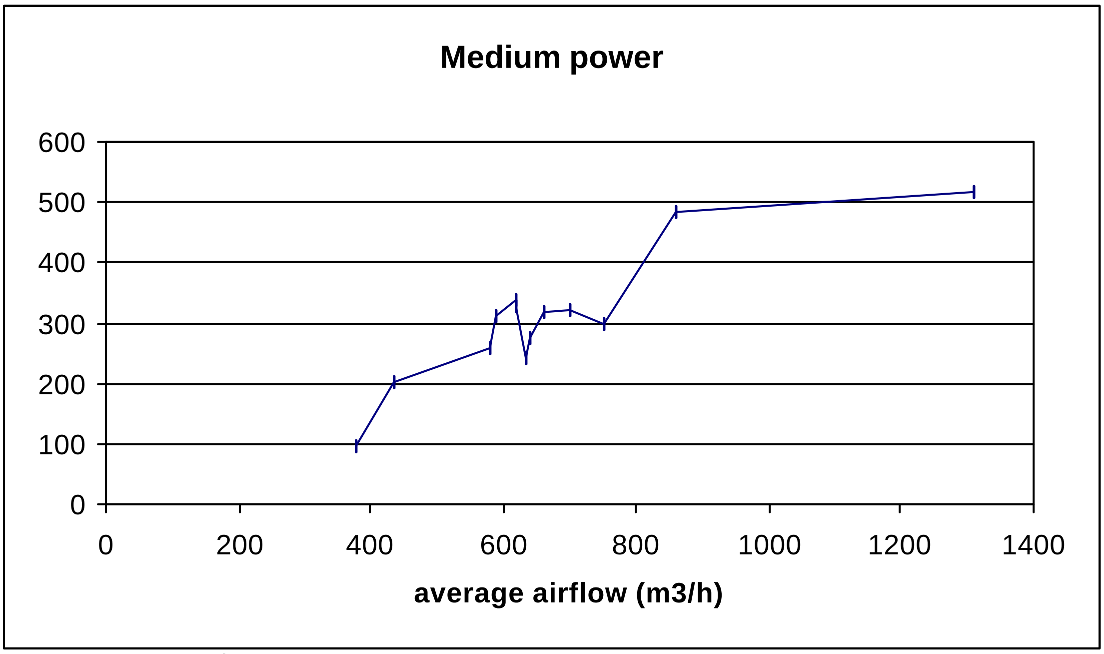

Figure 6 : mean fan absorbed power depending on occupation

Energy savings can be calculated on both periods. During the summer period, the ventilation run during 16 hours with an average airflow of 580 m^3/h.In September, it ran 18.30 hours with an average airflow of 670 m^3/h. The energy savings due to the CO_2 controlled ventilation were of 75%.

CO2 levels simulations

The CO_2 indoor level can be easily calculated from mass conservation equation knowing ventilation rate, outdoor level and assuming an average production rate of 16.2 l/h/person. These calculations have been made for the 19 meetings of the first measurement campaign. Generally, a very good correlation was found between calculations and measurements as indicated, for example, in figure 7.

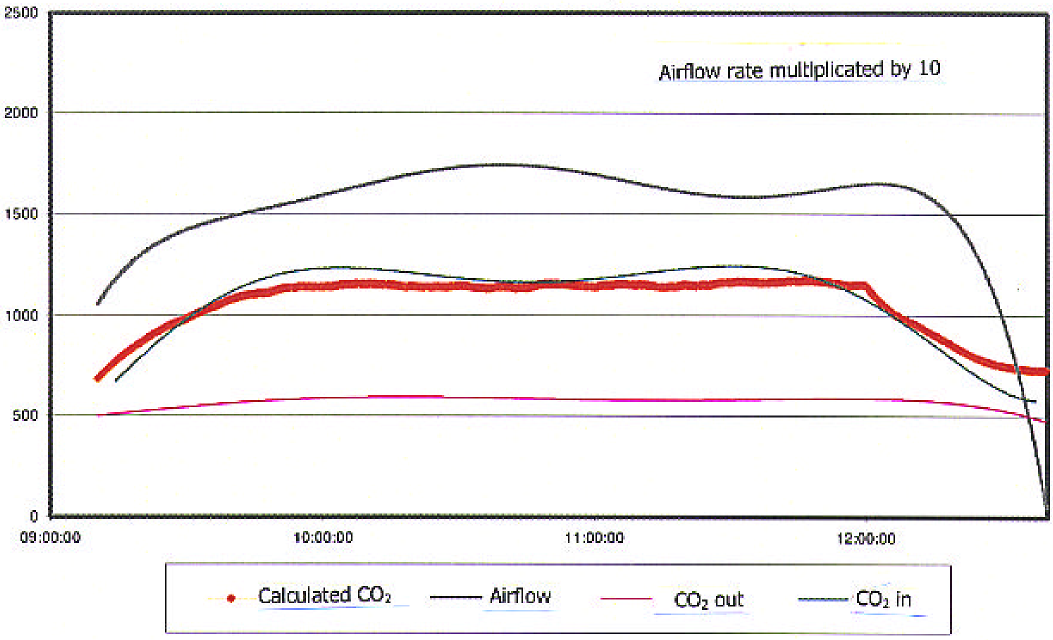

Figure 7 : example of correlation measurement / simulation on indoor CO_2 level

Yet, in 6 cases out of 19 the correlation was not found. Measurements could be explained only by a double production of CO_2. Although bibliography reports variation of CO_2 production on persons and activity, it is quite unlikely that these variations would only be noted as doubled of the average values. Other explanations such as door opening on corridor also remains unsatisfactory and these divergences have not been explained.

DISCUSSION

DCV systems appear to be really interesting for energy savings (75 to 85% savings) in intermittent occupation rooms while maintaining correct CO_2 levels. Different systems exist [1,2] and can be employed. This study is now continuing on energy simulations of air systems in a full office building during heating season and on a practical guide for owners on how to realise a correct DCV system.

ACKNOWLEDGEMENTS

This study was sponsored by ADEME (French Agency for Environment and Energy Management), ABB VIM, ALDES and CETIAT members Companies.

REFERENCES

1. W.J. Fisk, A.T. De Almeida, Sensor-based demand-controlled ventilation : a review, Energy and buildings, 29, p. 35 - 45, 1998.
2. S.J. Emmerich, A.K. Persily, Literature review on CO_2 -based demand-controlled ventilation, ASHRAE Transactions : Research, p. 229 - 243, 1997.