ASSESMENT AND DESCRIPTION OF HUMIDITY CONTROLLED SYSTEM IN FRENCH RESIDENTIAL BUILDINGS

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ABSTRACT

In France, ventilation in new residential buildings must be designed and dimensioned according to the Health regulation (Arrêté du 24 mars 1982) which is basically based on required extract air flow rates.
Two points are to be noticed:
1) The extract flow rates have a base level, boost level for local extract, and a minimum level if the dwelling is unoccupied.
2) It is possible to propose automatic controlled systems as for as indoor air quality and avoidance of condensation are maintained.
On an other hand, the energy impact of ventilation is checked by a new thermal regulation (RT 2000).
The humidity controlled ventilation systems are now of common use in France with two main principles:
1) Humidity controlled air outlets with passive air inlets.
2) Humidity controlled air outlets and inlets.
These systems are not easy to assess, as the airflow depends on indoor humidity. Therefore their performances are assessed through a Technical agreement procedure (Avis Technique).
Basically the procedure is as follows:
1) Laboratory testing of the component (for example airflow vs. indoor humidity)
2) Simulation (SIREN Code) in typical dwelling on a complete year providing results on - IAQ (CO^2 level), condensation hazards, energy impact.
The paper describes the principle of the assessment method regarding the respect of the Health and Energy regulation, presents the available technologies, and some examples of results.

KEYWORDS

Indoor Air quality, demand controlled ventilation, energy, simulation,

IAQ AND THERMAL REGULATIONS

The RT2000 energy regulation

This new regulation [4] aims to improve the energy efficiency and the summer comfort of new buildings. It is based basically for winter on the respect of "minimum" values for building and components characteristics (for example a maximum value of U coefficient is stipulated for windows) and the calculation of an energy use a C coefficient.

The C coefficient (primary energy in kWh/year) must be less or equal to a Cref coefficient. C and Cref are calculated with a computer tool. Cref is obtained by replacing in the building under consideration the planned components by reference ones. The C and Cref coefficients are calculated according to the Th C calculation method, which is also part of the law. When a building component has no reference value, the planned characteristic is maintained for the Cref calculation. For some cases, it is possible to apply default values.
For the ventilation side of it, the calculation method aims both to have simple input data and physically based algorithms. The fact that it was chosen to have a computer based approach made

this possible.The algorithms are based on an implicit method as the one developed by TC 156 WG2 (prEN 13465) extended to non-residential buildings. Different ventilation or airing system can be taken, into account, based on the possibilities offered by the hygienic regulation:

- Mechanical system and passive duct systems for residential building (additional window airing is also considered),
- Windows opening, mechanical system in non-residential building (passive duct is also possible but the algorithms focuses on the use for residential buildings).

The different items taken into account can be summarised as follows:

- Building and ducts airtightness,
- Duct heat losses,
- Air inlets and outlets characteristics,
- Fan and cowls airflow characteristics,
- Heat exchanger and air preheating,
- Energy needs for fan,
- Control devices and strategies,

The 1982/83 health regulation

After the energy crisis (1974) research on occupied dwellings came to the conclusion that almost 50 % of dwellings were over ventilated. The 1982/83 regulation [1] defines the flow rate, which depends on the number of habitable rooms.

Table 1 : airflow rate (m3/h) for dwellings

Number of habitable rooms	Kitchen		Bathroom	Other wet rooms	toilets	
	base	boost			If one	If many
1	20	75	15	15	15	15
2	30	90	15	15	15	15
3	45	105	30	15	15	15
4	45	120	30	15	30	15
5 and more	45	135	30	15	30	15

This regulation also enables to reduce the air flow of table 1 if the IAQ is maintained, and if the risks of condensation are not increased. One of the technological consequences was the development of humidity controlled ventilation systems. These systems are always equipped with humidity controlled air outlets. The air inlets can be or not humidity-controlled.

The Technical agreement

The air humidity controlled systems used in dwellings must have a Technical Agreement [5] proving their conformity to the law, and providing their energy impact. A computer model (SIREN 2000) is used to assess these performances

THE ASSESMENT METHODOLOGY

The SIREN computer code

The computer code SIREN ("SImulation du RENouvellement d'air") developed in C.S.T.B is used to calculate the air flow throughout the entire heating season (about seven months) in a dwelling (Figure 1) equipped with a mechanical ventilation system. The code uses hourly

meteorological data (temperature, relative humidity, wind speed and orientation) ; occupancy and pollutants production (CO_2 and H_2O) are defined with an half an hour step. The internal timestep is 3 minutes. This code was also used to develop the IAQ assessment methodology in the frame work of IAE annex 27 "Domestic Ventilation" [1],[2].
Each component (air inlets and air outlets) is characterised by its flow rate curve as a function of the pressure difference and also when relevant, of the temperature or relative humidity.

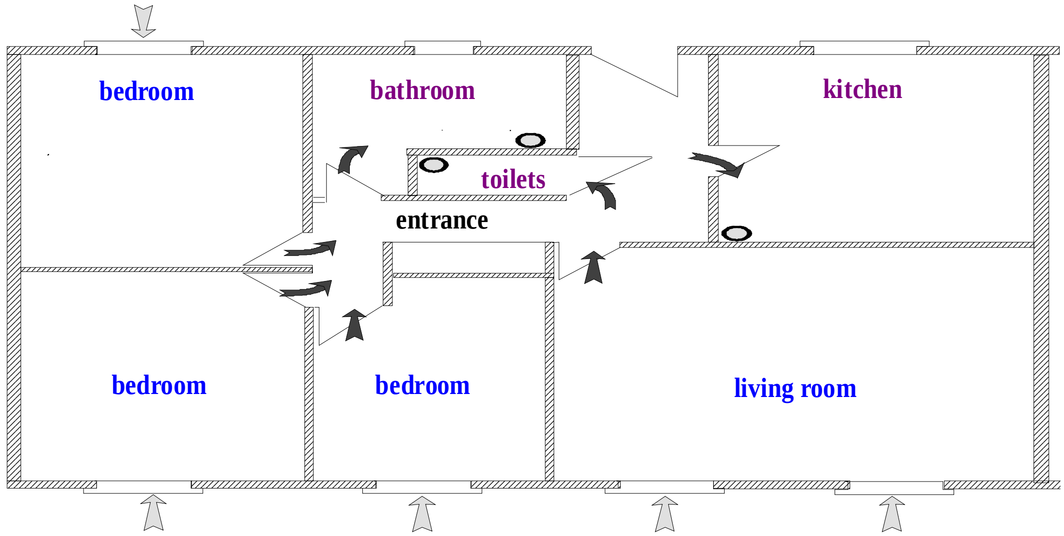


Figure 1 : airflows in a dwelling with mechanical ventilation.

inlets are located in living room and bedrooms,
exhaust vents are located in kitchen, bathroom and toilets.

Occupation and pollutants production.
Figure 2 presents the occupation schedule of the dwelling.

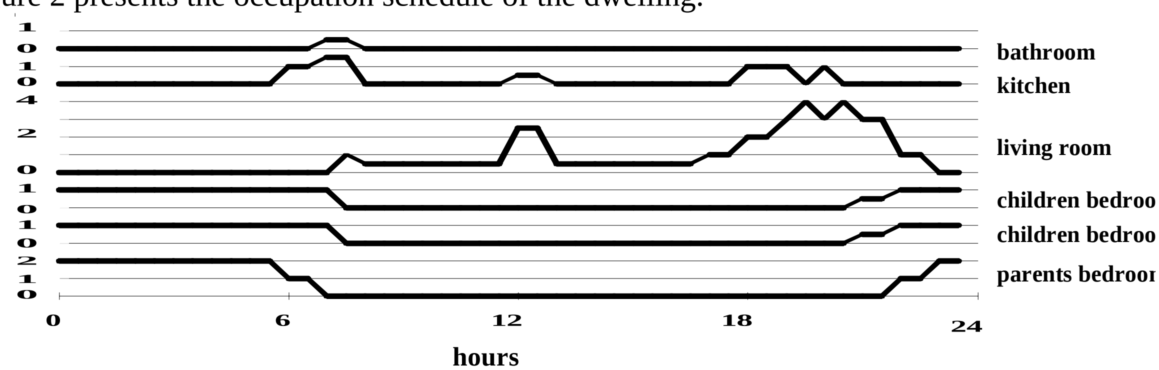


Figure 2 : occupation schedule of the dwelling (number of person)

The CO_2 concentration inside rooms is calculated taking into account pollutants production due to occupation, air renewal due to ventilation system operation and CO_2 outside concentration. The CO_2 outside concentration is assumed as 350 ppm.
The production of pollutants by occupants is
- moisture dissipation 40 g/(h.person)
- CO_2 : waking 16 l/(h.person) , sleeping 10 l/(h.person)

Figure 3 shows the water vapour production in the kitchen and in the bathroom of the dwelling.

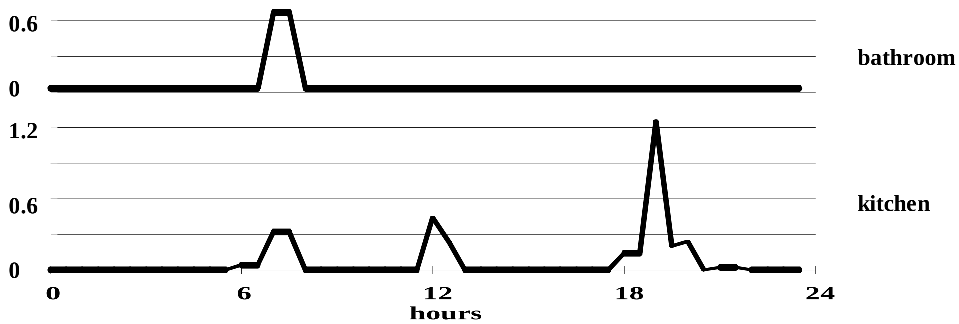


Figure 3 : water vapour (kg) schedule in the dwelling

Humidity calculation

The humidity transfer between the air and the furniture is given by the simplified formula :

$$\frac{dM}{dt} = 0.035 \times S \times RH - 0.018 \times M$$

Eqn 1

where :	t	time (hours)
	M	mass of water in furniture (kg)
	S	equivalent area of the furniture (m2)
	RH	relative humidity in the room

Components description

The curve of the components of the reference mechanical system are shown in Figure 4 :

Figure 4 : simulated curves of components (flow versus pressure)

The curve of the components for a humidity controlled system are given in Figure 5 :

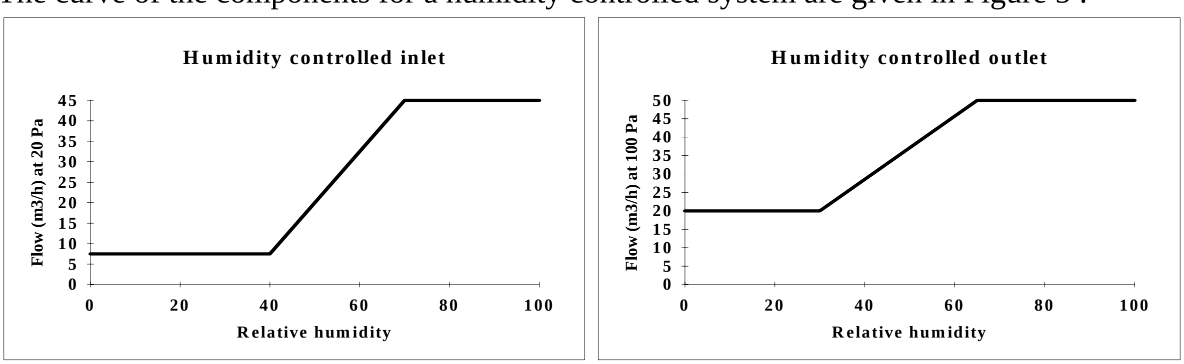
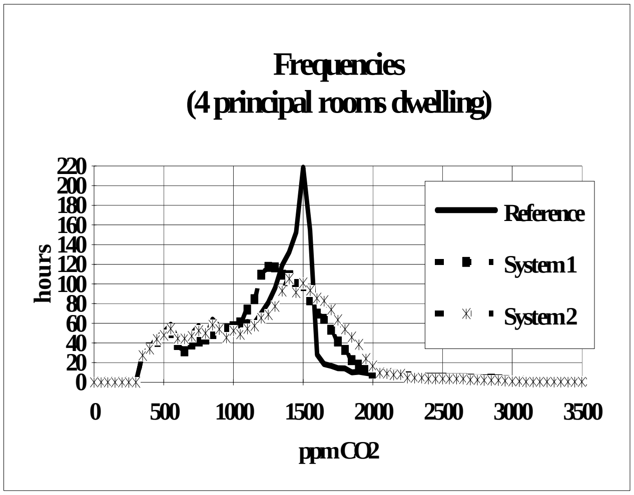


Figure 5 simulated curves of humidity controlled components (flow versus humidity)

Performances assessment

It is necessary to distinguish the pollution due to human activities and the pollution sources due to materials in the building. Even when these second pollution sources are as low as possible, the ventilation system has to exhaust human bioeffluents. CO2 concentration reflects the human bioeffluents concentration.
To compare the systems we calculate the CO2 ppm.hours cumulated basis X in the different habitable rooms which enable a better comparison between the systems than the simple frequencies. To meet the requirement the ppm.hours cumulated basis 2000 have to be lower than 500000.



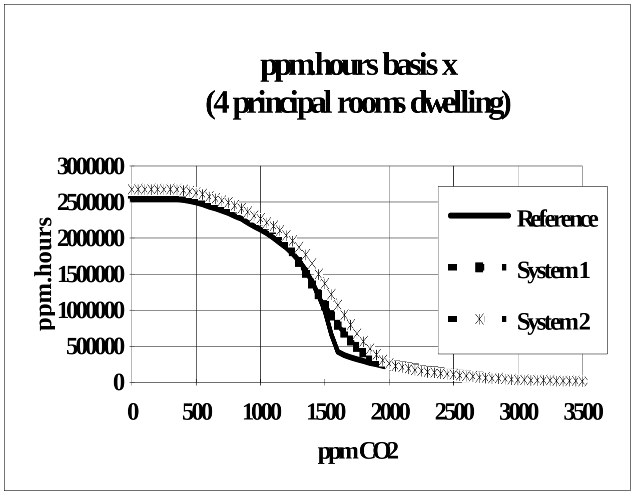


Figure 6 CO2 level in the parents bedroom for two humidity controlled system

In the same way, condensation hazards are assessed by calculation the duration of possible condensation on outer wall in habitable rooms, and inner walls in wet rooms. The results fro humidity controlled system must be at the same level as for a conventional mechanical exhaust ventilation according toTable 1.

Heat losses due to ventilation system.
The DCV and the reference mechanical ventilation systems are compared with an averaged flowrate which give the same heat losses on the heating season (seven month) :

Eqn 2 $$Qave = \frac{\int 0.34 \times Q(t) \times (Ti - Te) \times dt}{\int 0.34 \times (Ti - Te) \times dt}$$

where :	Q(t)	instantaneous ventilation flow rate (m3/h)
	Ti	internal temperature (°C)
	Te	external temperature (°C)
	0.34	specific heat of air (Wh/m3.°C)

In addition, humidity control air inlet areas are assessed through an equivalent area, in order to check their impact on infiltration.

RESULTS

The IAQ and condensation criteria are always met as this point is mandatory.
For energy, in order to simplify the use of the Technical agreement results, a classification was established as presented in Table 2 ,with the following criteria :

1. Air exhaust ratio between the Qave results for the HC system and the reference one,
2. Fan power ; calculated by taking into account the power for base and boost periods,
3. Air inlet ratio between the HC system, and the reference one.

Criteria	**Classes**		
	C	**D**	**E**
Air exhaust ratio	0,65	0,825	0,825
Average fan power (W)	50	50	60
Air inlet ratio	0,60	0,85	0,85
Energy quotation	**4**	**3**	**2**

Table 2 energy classification of humidity controlled systems

A conventional exhaust system is quoted 1 and one point correspond to about 3 % of energy saving. For example a class C system reduce the equivalent energy flow rate of 35 % and reduce the energy needs for the dwelling of about 10 % (which is in line with the fact that ventilation corresponds to about one third of energy needs)

CONCLUSION

In France, DCV ventilation systems are taken into account both in the health and in the energy regulations for dwellings. The assessment method uses annual simulations, on the basis of a comparison with a conventional mechanical system.
This approach is today widely used by French manufacturers for humidity controlled system. and proves that the principle of equivalence can be used in practice for products having strong interactions with the indoor climate.

REFERENCES

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[3]- Ventilation for residential buildings: Arrêté du 24 Mars 1982 (Journal officiel)

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[5]- Technical agreement documents (Avis Technique in French)can be found on the following site : http://www.cstb.fr/frame.asp?URL=/app/atec/atec-cstb/ then click on recherche "simple" and write "ventilation" in the box "produit".