IN-SITU PERFORMANCES MEASUREMENT OF AN INNOVATIVE HYBRID VENTILATION SYSTEM IN COLLECTIVE SOCIAL HOUSING RETROFITTING

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ABSTRACT

To get closer from comfort and energy levels of new buildings conciliating economical viability for the big retrofitting market : the challenge opens the way to the most innovative ventilation systems. In this context was born a new hybrid ventilation system mixing demand-controlled components and low pressure assistance fan. HR-VENT is an exceptional large-scale monitoring launched in France in the suburb of Paris in order to measure the effectiveness of this new system, as well as to improve the knowledge on the hybrid and standard natural ventilation. This monitoring, lead in collaboration with French corporate partners, will favour the development of new solutions for the ventilation of residential buildings.

KEYWORDS

air, hybrid, ventilation, demand-controlled, passive stack ventilation, fan, low pressure, monitoring, Nangis, HR-VENT, humidity sensitive, gas appliance, energy savings, comfort, retrofitting.

INTRODUCTION

HR-VENT is a project which aims at realising an in-situ validation and actualisation of the knowledge on natural and hybrid ventilation. With more than 700 millions data registered on 55 dwellings during 2 years, this large-scale monitoring will show the effectiveness of the new hybrid ventilation system, a humidity sensitive ventilation assisted by a very low pressure fan. Innovative solution in compliance with the retrofitting expectations of comfort, air quality, energy savings and economical viability, the effectiveness of this complete hybrid system is measured by new specific sensors for pressure, airflow, temperature, humidity rates, which are correlated with outdoor climatic conditions. Co-financed by French ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie), HR-VENT is managed in partnership with French CSTB, Gaz De France, SOCOTEC and Logement Français.

EXPERIMENT IN EXPERIMENTS

AERECO has a long life of monitoring to assess innovative and efficient systems. Improvements in means of measurements as well as in ventilation systems : AERECO manages for years projects to follow the aim to assess innovative and efficient ventilation systems :

- **"Passive humidity controlled ventilation for existing dwellings" - Demonstration project EE/166/87 - December 1993.**

This project, in partnership with several important organisms as French CSTB, Dutch TNO and Belgian BBRI, showed on 3 different sites the **effectiveness of the AERECO humidity sensitive extract grilles in pure passive stack ventilation.**

The dilution of a neutral gas was used to measure the extract airflow (instead of measuring the pressure and the opening section of the grille). Measurements were realised in parallel stacks of dwellings to compare passive extract grilles and humidity sensitive extract grilles.

- **"Very low pressure fan - VBP" - Presentation at 2001 AIVC Conference.**

A series of tests assessed the characteristics of a low pressure assistance fan for passive stack ventilation, prototype of what was going to be the future "VBP" used in NANGIS monitoring. These tests and simulations realised in CERGA laboratory showed the **ability of the fan to increase the airflow levels in PSV with a very low energy consumption.**

- **"Monitoring of two natural exhaust grilles in Hokkaido - Japan" - Presentation at 2002 AIVC / EPIC Conference.**

This monitoring of two humidity sensitive extract grilles in an occupied house in the north of Japan lasting one year showed that **the behaviour of the HS grille "GHN" was conform to the announced performances in term of RH / shutter position. It also confirmed the right choice of the relative humidity range for opening** (RH between 30% and 70%).

- **"Hygrothermal behaviour of a humidity sensitive air inlet" - Presentation at 2003 AIVC Conference.**

A special poster presentation was dedicated to explain the important rule of the humidity sensor's temperature in the humidity sensitive air inlet. It was shown that this technology of air inlet needs a real control of the local thermal exchanges to keep the right RH / opening section characteristics, whatever the outdoor climates.

Today, this monitoring is written to be the logical suite of this long-time monitoring experiment, by improving again the means of measurements (see § " Some innovative and accuracy sensors").

PROJECT DESCRIPTION

Buildings choice

No less than 5 buildings representing 55 dwellings have been chosen among a total of 56 social buildings. The choice of the instrumented buildings have been managed by the need of a large scale, pertinent, representative and various project.

- Different locations and disposition (see figure 1) of buildings to show the influence of the wind effect (speed and direction) on ventilation, that means wind influence on the window (air inlets, windows openings) as well as on the duct "natural" pressure (created at the chimney level).
- Different heights (from 3 to 5 levels) chosen to see the variable effects of stack effect (variable heights of ducts) as well as the influence of different wind directions and speeds on duct pressures (created at the chimney).
- Size of dwellings chosen from 2 to 5 mains rooms to see the influence of both the air volume of the dwelling and the number of air inlets.
- Different configurations inside the dwellings (centred or deported technical rooms, one or two grilles on the same duct, etc…) to analyse these influent factors.

The choice of this site, in social housing, is also representative of what can be built in the new, with its "middle" buildings (8 to 20 dwellings in the same building) with "middle" height.

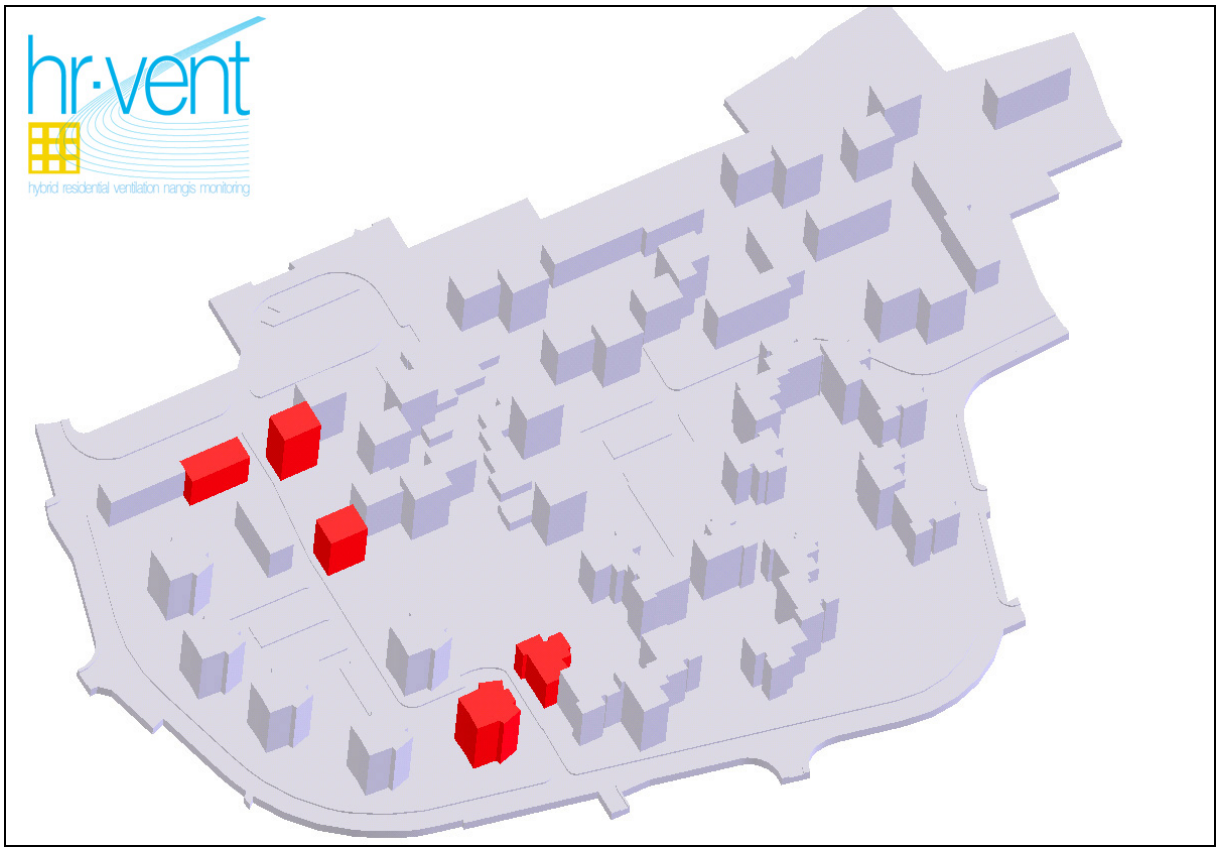


Figure 1 : 3d view of HR-VENT experiment site in " La mare aux Curées", City of Nangis (France). *Note : the experiment buildings are signalised in red.*

Ventilation system

The new ventilation system uses existing natural ventilation ducts. "Classic" humidity sensitive air inlets and extract grilles are installed in the dwelling, while the low pressure fan is installed at the head of the duct. This innovative hybrid ventilation system -the **first one in the world to mix together demand-controlled ventilation with low pressure assistance fan**- is also used in this project to exhaust burnt gas from the gas appliance connected to the ventilation duct in the kitchen. This point reinforces again the interest of this new solution because this co-exhaust (gas and air) is well laid in France (and in some other nations) and needs a real control of the pressure, for obvious reasons of safety.

The new VBP assistance fan (see figure 2) allows to conserve classical PSV ductwork sizing while improving the natural airflow and pressures. Its low electrical consumption and its non-critical breakdown (non significant pressure losses when off) contributes to make it an optimised solution for ventilation, especially in retrofitting when economical aspects are more important.

Inside the dwelling, the humidity sensitive ventilation system, as a "leader" of the demand-controlled systems, contributes to improve the air quality while reducing the heating energy consumption. (see components on figure 3)

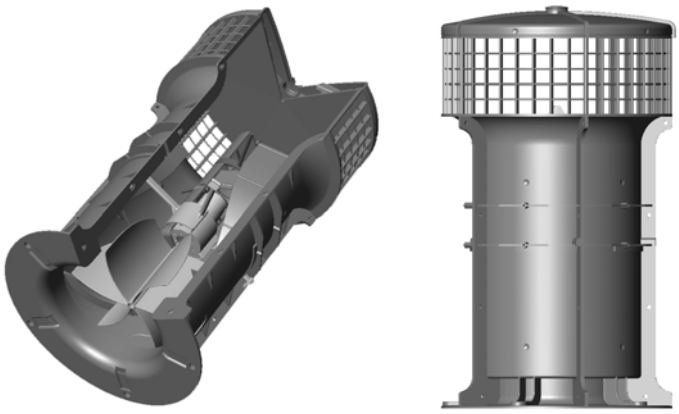


Figure 2 : Very low pressure fan VBP.

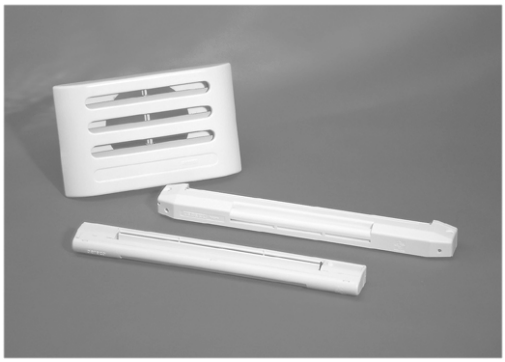


Figure 3 : Humidity sensitive GHN Grille, EHA and EMM air inlets.

Installation

A new monitoring is always a new experiment : a new system to test, with a new method of measurement, on a new architectural environment.

After one year preparation to design the specific low pressure manometer, instrumentation and acquisition system, no less than two months were necessary to install the system on 55 dwellings. The 4 people installation team had to face to the difficult winter meteorological conditions (see figure 6) as well as to structural "surprises" to succeed in installing the whole system.

Figure 4 : Connection to the registering system

Figure 5 : Position of the grille face.

Figure 6 : Setting of the registering system

Equipment

From January 2004 to December 2005, more than 700 million data are going to be registered. The buildings have been equipped by following the scheme presented on figure 7.

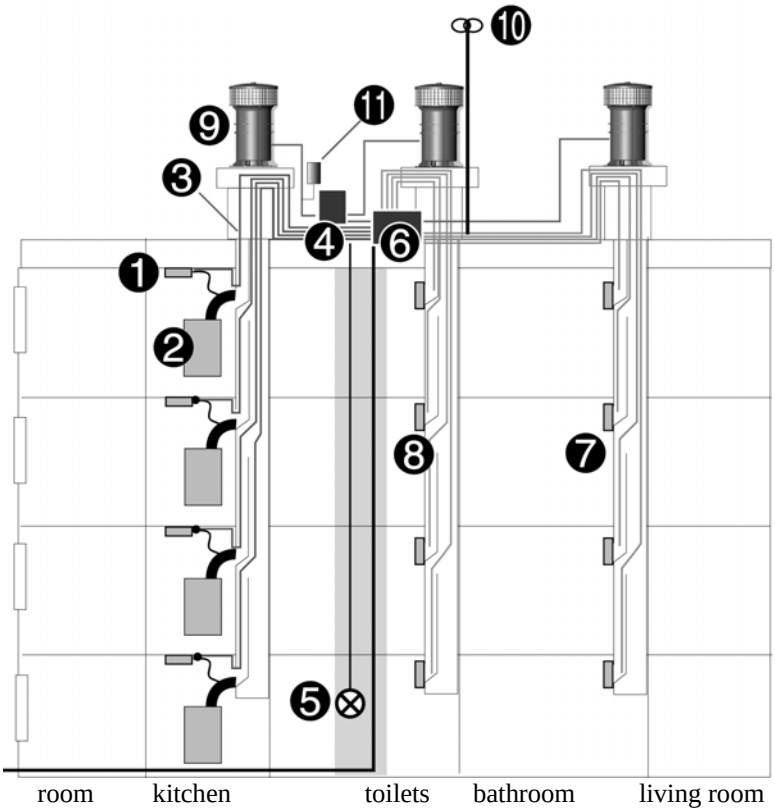
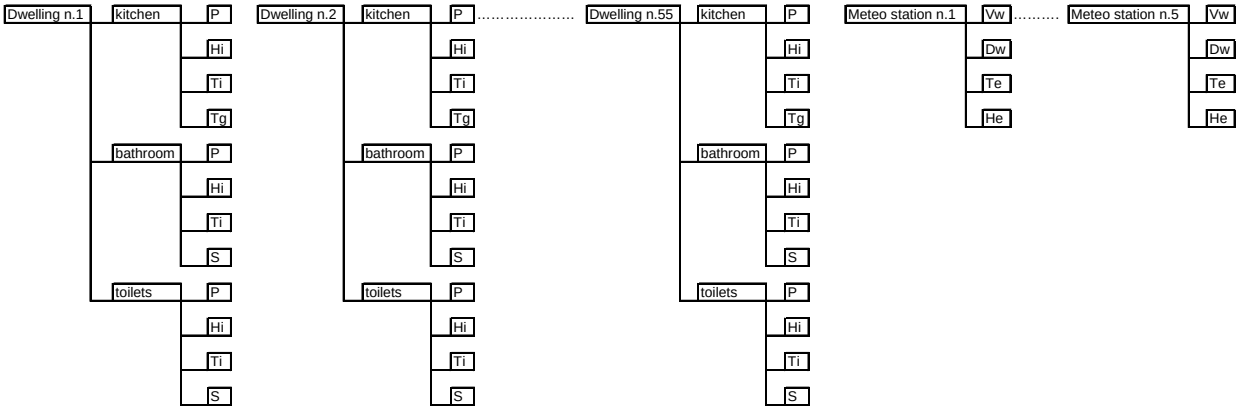


Figure 7 : cut of a schematic view of a building stack (example with 4 levels)

	Component	*Function*
1	**Instrumented grille - Kitchen**	Acquisition of : Pressure / Burnt gas Temperature / Room temperature / Room Relative humidity. Frequency : each minute
2	Connected gas appliance	Hot water production.
3	**Data bus cable**	Carry data acquired by components 1,3 et 8.
4	**Instrumentation box**	Registers data acquired by components 1,3 et 8.
5	Working indicator	Indication of good working of the fans equipping this stack of dwellings.
6	Complete control panel	Transformation of 230 VAC to 15VDC Electrical protection Fan power supply management Simultaneous working of fans management.
7	**Instrumented grille - bathroom**	Acquisition of : Pressure / Grille opening section / Room temperature / Room Relative humidity. Frequency : each minute
8	**Instrumented grille - Toilets**	Acquisition of : Pressure / Grille opening section / Room temperature / Room Relative humidity. Frequency : each minute
9	VBP low pressure fan	Passive stack assistance low pressure fan
10	**Meteorological station**	Acquisition of : Wind speed / Wind direction / External local temperature / External local relative humidity. Frequency : each minute
11	Temperature sensor	Controls the VBP fans speed according to temperature (normal speed / low speed)

Note : Components in charge of registering data are mentioned in bold.

The figures below present the structure of the data registered in the dwellings and in the buildings. The singular quantity of data (more than 700 million) has justified specific means of treatment, with a dedicated server hosting a 20 Gigabytes database. A special tool has been designed to access to statistic results.



Legend :

P : Extract grille pressure (Pa)
S : Extract grille aperture (cm²)
Hi : Relative humidity at the grille (%)
Ti : Temperature at the grille (°C)
Tg : Temperature of gas appliance (°C)
Te : External temperature (°C)
Vw : Wind speed (m / s)
Dw : Wind direction (°)
He : External relative humidity (%)

Some figures :

Buildings	5
Meteorological stations	5
Dwellings	55
Instrumented grilles in dwellings	166
Values per minute per instrument	4
Total values per minute / day / year / 2 years	684 / 984.960 / 359.510.400 / 719.020.800
Database size	20 Gigabytes

Controls

Facing such a huge amount of data requires tools to control validity. From the beginning of the study in January 2004, no less than 1.2 million data were detected to be false due to technical issues : transmission defaults, electronic captors breakdown due to high level humidity, etc… But this amount, when compared to the total amount of data for this period (132 millions), gives a ratio of 0.9% wrong data… **The most important thing is not only to avoid wrong data but to be able to detect them, with the right tools**.

A sharp quality control is also realised by a regular & random take back and test of instrumented grilles in laboratory. Eventual derives of the sensor are rewarded, to increase the reliability of the measurement apparels.

Difficulties

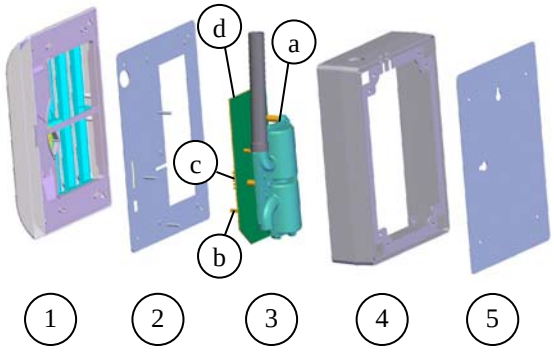
Monitoring, for those who are used to practise this game, is almost always synonymous of difficulties and surprises, moreover when it is realised on a so-large scale. The "short" list below illustrates some of the issues we have had to face to and to solve :

- Data transmission stops
- Bad installation of flexible pressure plug
- Electronic temperature or humidity sensors breakdown (hard climatic conditions with high levels)
- Ducts states and maintenance issues (presence of a bird nest in a duct for more than 7 years !)

Only an appropriate tool (database) and a particular time-spending attention allows to limit the effect of these non-conformities on the data collected. When data continue to be registered, time is counted and the reaction must be the quickest.

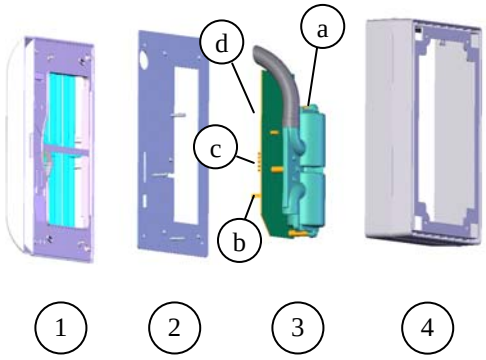
Some innovative and accurate sensors

Not only this project is innovative by the fact that a new hybrid system is installed and measured in a large scale ; HR-VENT has also given the opportunity to design a new type of low pressure manometer : more accurate, adapted to the very low pressure range and economically viable for a large implantation. This sensor uses a patented technology based on hot filaments. It is described on the schemes figure 8 and 9.



1 : fix front cover grille
2 : instrumentation support
3 : instrumentation set
3a : low pressure manometer
3b : thermal sensor
3c : humidity sensor
3d : electronic cardboard
4 : protection box
5 : fixation support

Figure 8: Measurement grille in the Kitchen



1 : humidity sensitive grille + hall effect sensor
2 : instrumentation support
3 : instrumentation set
3a : low pressure manometer
3b : thermal sensor
3c : humidity sensor
3d : electronic cardboard
4 : protection box

Figure 9 : Measurement humidity sensitive grille in the bathroom and toilets

RESULTS AWAITED

Results awaited are several types[1]. They aim to assess, according to meteorological, architectural parameters and to events :

- Effectiveness of humidity sensitive passive stack ventilation
- Effectiveness and improvements brought by hybrid humidity sensitive ventilation
- Working of gas appliances with these systems
- Maintenance and exploitation costs of the new system

Some example of these results :

[1] See abstract : Siret, F., Savin, J.L., Jardinier, M. and Bertin, S. (2004). " Monitoring on hybrid ventilation project - first results." *25th AIVC conference.*

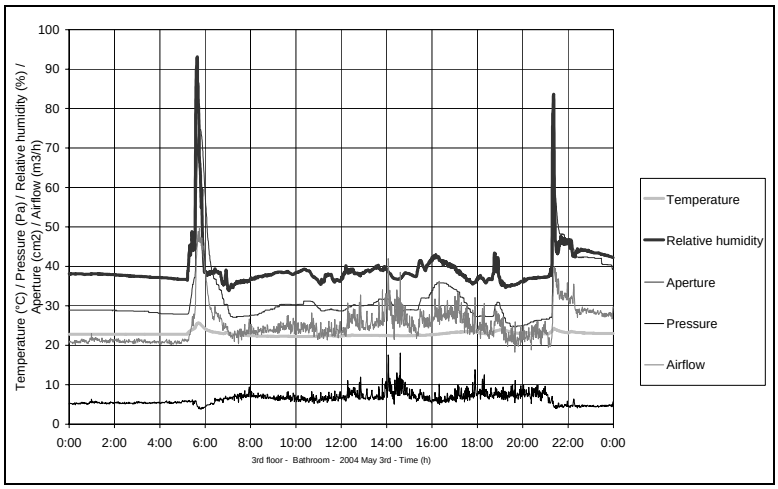


Figure 10 : Variation of parameters registered by a measurement grille during 24 hours.

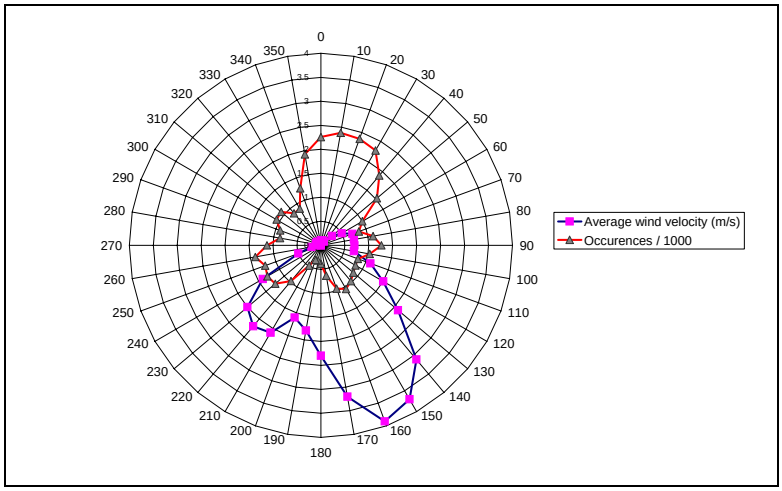


Figure 11 : Repartition of wind speed and direction by frequency on one building terrace, on one month.

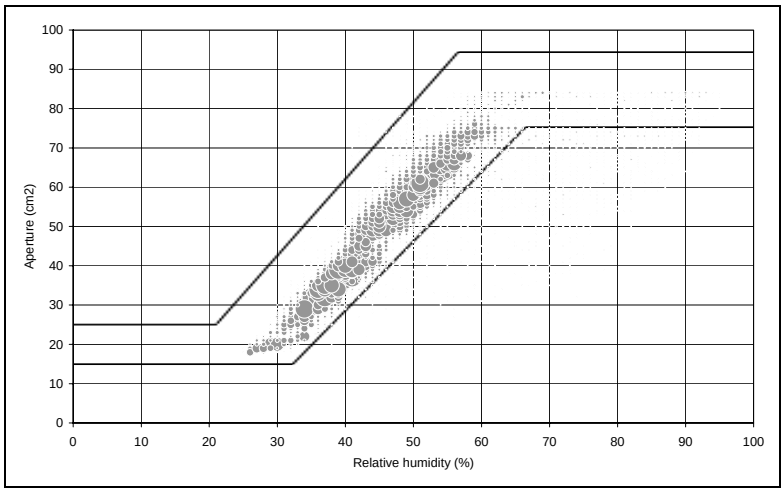


Figure 12 : Repartition of Relative humidity / Aperture couples for one measurement grille, on one month.

CONCLUSION

The first results of HR-VENT project, subject of an other annex article, already show the interest of this monitoring and the richness of the teachings on topics as varied as gas appliance working, wind effect on airflow, etc… The final results publication will bring as many answers to questions often asked on the hybrid ventilation behaviour.

This kind of monitoring must allow to give a place to a new ventilation technology by demonstrating in a scientific and experimental way its performances. Some other monitoring are being studied, like in Malmö (Sweden), to contribute to develop this new technology aimed at answering right to the specific expectations of the residential building retrofitting.

REFERENCES

Siret, F., Savin, J.L., Jardinier, M. and Berthin, S. (2004). " Monitoring on hybrid ventilation project - first results." *25th AIVC conference.*
Siret, F. (2004) and Jardinier, M. (2004). "High accuracy manometer for very low pressure." *25th AIVC conference.*
Wouters, P., Geerinckx, B, L'Heureux, D., Simonnot, J. and Phaff, J. (1993). "Passive humidity controlled ventilation for existing dwellings" - Demonstration project EE/166/87. *December 1993.*