State of the Art of Non-Residential Buildings Air-tightness and Impact on the Energy Consumption

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ABSTRACT

Starting January 1st, 2013 the French thermal regulation will impose a minimum requirement for residential buildings air-tightness. However, nothing is planed for non-residential building, for two reasons:

- There is no clear view on the level to be imposed on non-residential building air-tightness
- Air-tightness impact on energetic consumption is different in non -residential and in residential buildings.

Through the measurer's authorization process, it is possible to collect any measure done in France by certified measurer [1]. This paper first presents the analyse of those data and the non-residential buildings air tightness level according to their volume, kind of construction and use. It also compares these results with the level of residential buildings

Then the paper presents an estimation of the impact of air-tightness on energy consumption, according to various parameters (climatic zone, kind of ventilation, kind of building...). Calculations were realized with thermodynamic calculation tool included in the French national thermal regulation.

KEYWORDS

Air-tightness, Thermal regulation, energy performance, non-residential buildings

INTRODUCTION

Building airtight is a compulsory condition for low energy buildings. For residential building a minimum air-tightness is required for most low-energy labels such as BBC-Effinergie, Passiv'Haus, Minergie and shortly in the 2012 French thermal regulation (RT2012). Requirements are less easy to set for non-residential buildings.

Indeed, non-residential building air-tightness measurement may require very specific equipments. Moreover as there are much less measurements in non residential buildings, the state of the current building stock is little known. Finally, as there are various kinds of non-residential buildings, it is important to know the impact of air-tightness on energy consumption, according to the use and the location of the building before setting a requirement.

This article first presents the state of the art on non-residential buildings air-tightness from a trusted database. It will include the distribution by kind of building, year of construction, and kind of construction.

Secondly, this paper discusses the impact of air-tightness on non-residential buildings energy consumption according to their use, their localisation, the kind of heating and of ventilation. All calculations are done with the new EP-calculation tool included in the 2012 French thermal regulation.

The objective of this study is to estimate the feasibility and the opportunity to add a requirement on air-tightness for low-and very low-energy non-residential buildings.

STATE OF ART OF AIR-TIGHTNESS IN NON-RESIDENTIAL BUILDINGS

The analysed data

The 188 measurements analysed in this paper are extracted from the measurement databases of "licensed technicians" authorized to perform pressurization tests in low-energy (BBC-Effinergie certified) buildings. In fact, the authorization process described by Carrié et al (2010) [1] requires for each authorized technician to produce an annual report that includes results of all of his air leakage measurements. Therefore, the sample is heavily biased towards low-energy buildings: 29% of the tested non-residential buildings were involved in a BBC-Effinergie certification process, whereas the market share for this certification is only 3% of all new constructions. As a result, even if there is no air-tightness requirement for non-residential buildings, the distribution is certainly quite optimistic as BBC builder are mostly aware of air-tightness impact.

The 188 measurements include offices, schools, restaurant, etc. and present various constructive techniques, the repartition is given in Figure 1.

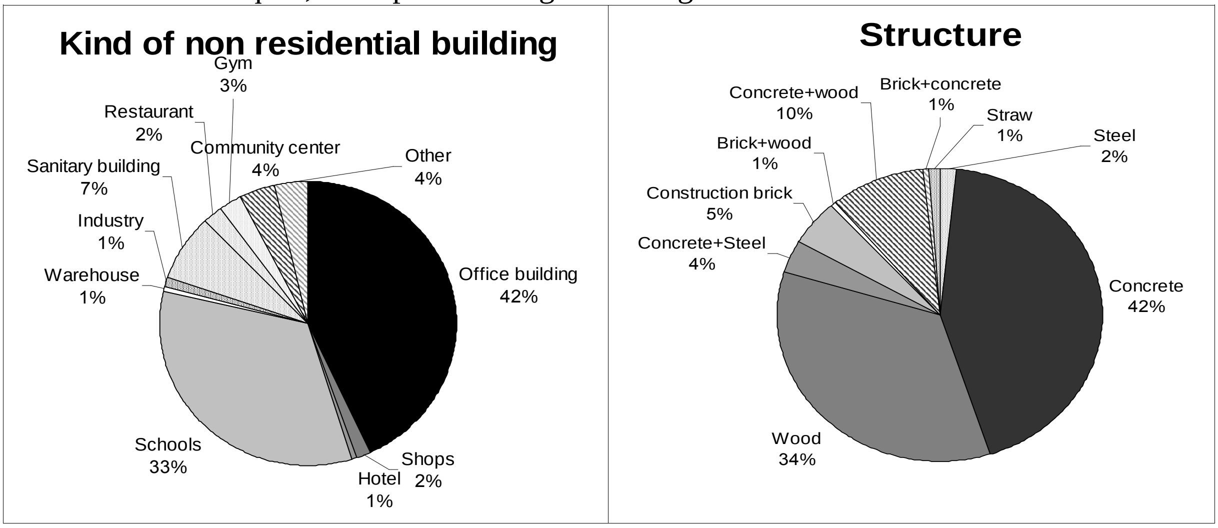

Figure 1: distribution of measured buildings

Most of the measured buildings are small and newly built, Figure 2 shows that more than 80% were built in the last ten years and 90% are less than 5000m^3.

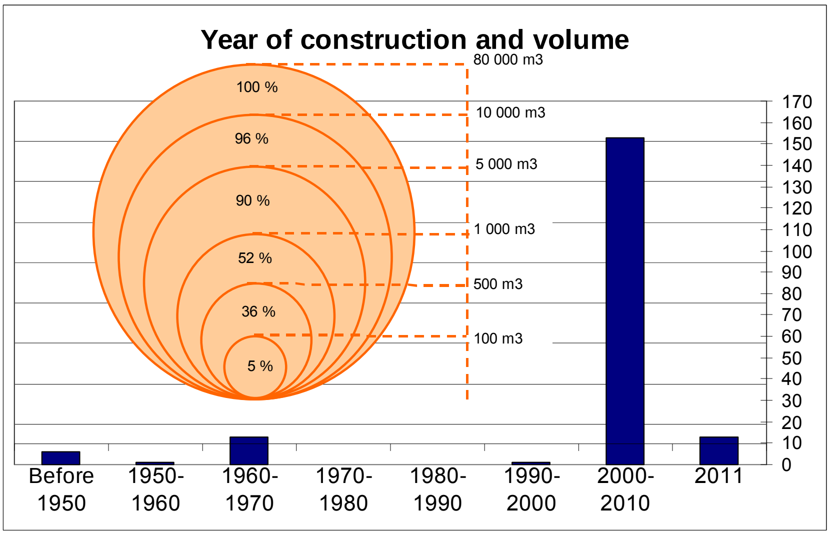

Figure 2: Volume and construction year of measured buildings

Those buildings are located all over France, their thermal insulation is either interior (43%), or exterior (20%) or else distributed (37%). They are equipped with various kind of ventilation system: ventilation with recovery system (67%), extraction only (28%) and natural ventilation (5%). Thus this sample is quite representative of every kind of construction in France.

Building air-tightness results

The average air-tightness in the 188 studied non-residential buildings is $Q_{4Pasurf}$= 2.28m^3/h.m², the median is $Q_{4Pasurf}$=1.28 m^3/h.m² and the standard deviation is 2.57m^3/h.m². Figure 3 and Figure 4 represent the distribution of measured air-tightness for each kind of building and for each constructive technology.

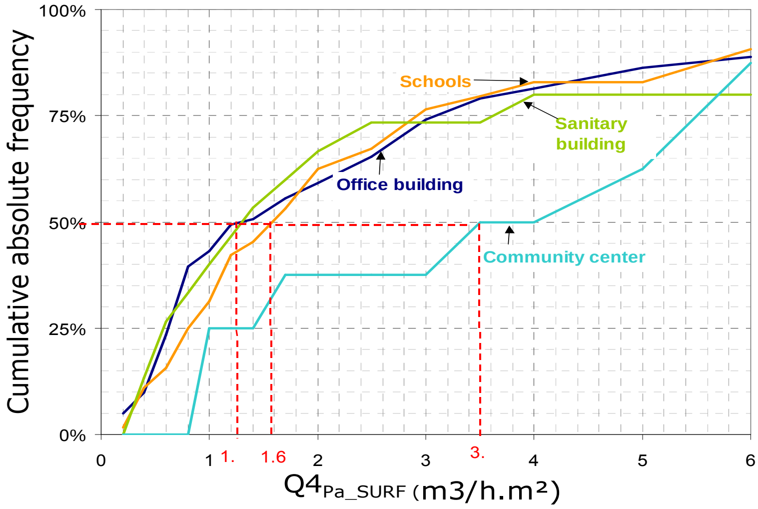

Figure 3: Distribution of measured air-tightness for each kind of building

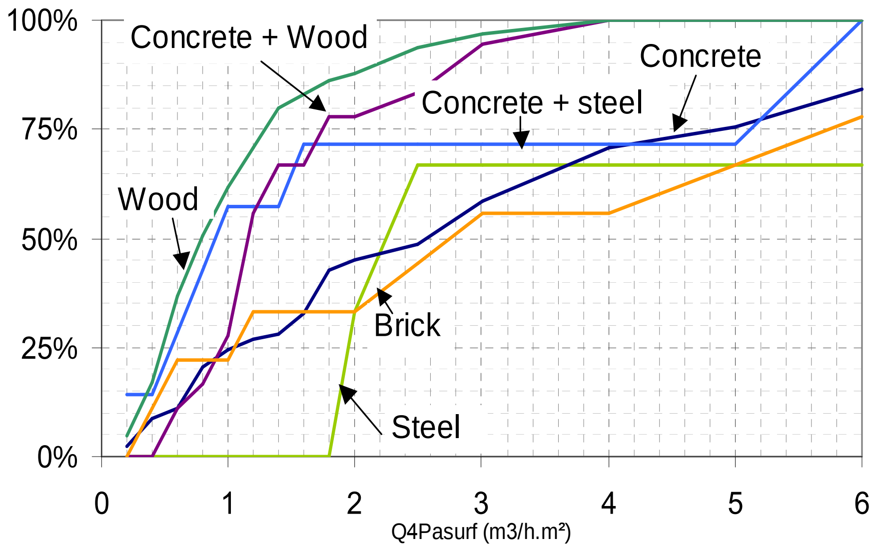

Figure 4: Distribution of measured air-tightness for each construction kind

Figure 3 shows that there is no real differences between each kind of buildings, excluding community center but we only have a small sample for this kind. However Figure 4 strongly highlights differences between each construction kind : wood and concrete + wood structure get much better results than others. Indeed the air-tightness average for wood structure is 1,00 m^3/h.m² whereas the average for all other structure is 3 m3/h.m². Nevertheless this difference is not irrecoverable as among the 188 measures the minimum value is obtain for a concrete structure and is 0.07 $m^3/h.m^2$.

Table 1 compare the previous values with those obtained in apartment buildings for which we have more than 400 measurements.

	Non residential building	Apartment building
Average	2.28 $m^3/h.m^2$	0.86 $m^3/h.m^2$
Standard deviation	2.57 $m^3/h.m^2$	0.80 $m^3/h.m^2$
Median	1.28 $m^3/h.m^2$	0.65 $m^3/h.m^2$

Table 1: Comparison between residential and non-residential building

Table 1 shows that apartment buildings get much better results than non-residential buildings, whereas both volume and construction kind are not much different. So it seems obvious that if an air-tightness level was compulsory in non-residential buildings (as in apartments building), results would easily be improved.

IMPACT OF AIR-TIGHNESS IN NON-RESIDENTIAL BUILDING

Procedures

The EP-calculation tool for the new French regulation, RT2012, is ready to make sensitive analysis So we developed an interface with an Excel spreadsheet to make automatic sensitive analysis for the following parameters:

- Building air-tightness
- Geographic localisation
- Duct air-tightness
- Ratio of duct outside the heating volume
- Recovery coefficient of the ventilation system.

To make the sensitive analysis tested buildings for the validation of the EP-calculation tool are used. For each building, we have at our disposal an xml file readable by the EP-calculation tool. The Excel tool automatically modify the xml file and launches the executable (dll) of the EP-calculation.

The sensitive analysis has been done on two non-residential buildings: a 1331 m² wood-heated primary school and a 613 m² gas-heated office building.

Parametric Values :

- two ventilations systems (extraction only and recovery system) and the three climatic zones (Oceanic (Nantes), Mediterranean (Marseille), Continental (Paris)) were tested.

- $Q_{4Pasurf}$=1,2 $m^3/h.m^2$ and 3 $m^3/h.m^2$. These 2 values represent the median of data and the largest default value for non-residential building in the French thermal regulation.

Consumption is evaluated in primary energy which mean that electric consumptions are multiplied by 2,58.

Results

Figure 5 shows that, depending of the ventilation system, improving air-tightness from $Q_{4Pasurf}$= 3 $m^3/h.m^2$ to 1,2 $m^3/h.m^2$ leads to a 13 to 37% decrease of energy consumption for those two low-energy buildings. It represents from 6 to 17 kWh/m².year.

If the sole heating consumption is estimated, air-tightness can be responsible for an over-consumption of almost 200% (Figure 5 - see Marseille, ventilation with recovery system). In fact, in this climatic zone, low-energy building offices have very low heating needs, as climate is mild and building get high internal and solar gains.

For both school and office building, air-tightness impact is strongest in oceanic climate, because it's the windiest French climate and it is less mild than Mediterranean's. Nevertheless, no cooling system has been modelled yet and this could change the impact.

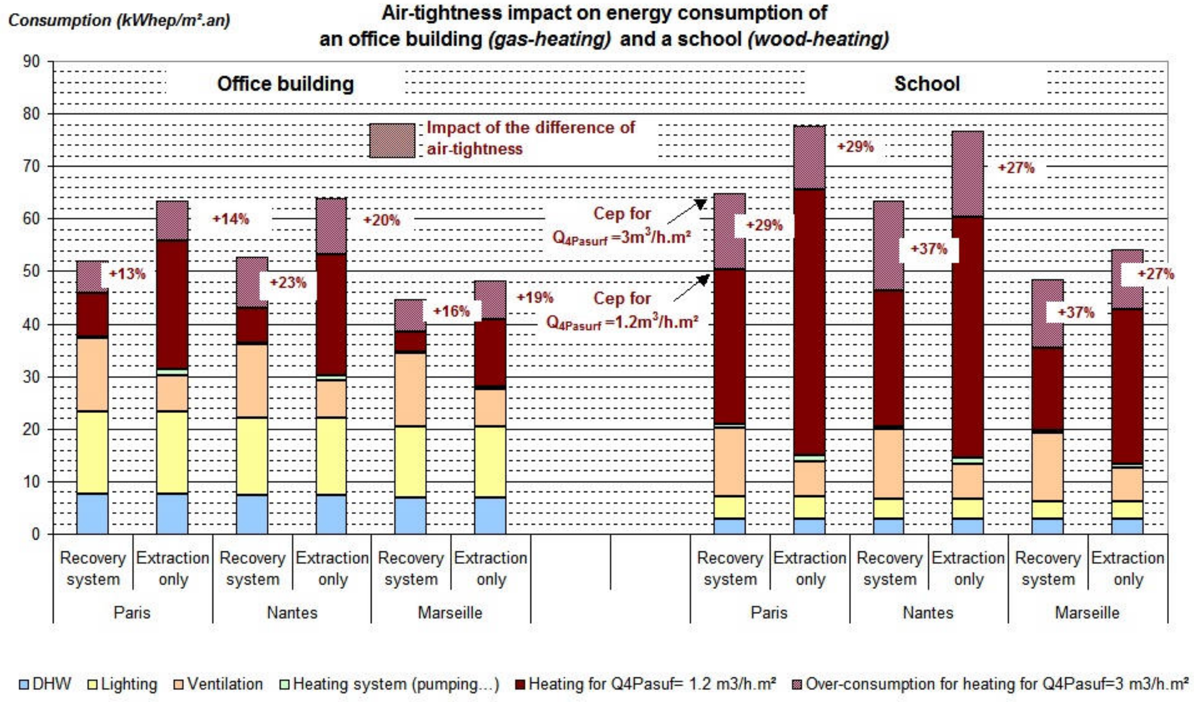

Figure 5: Air-tightness impact on energy consumption for two non-residential buildings

As expected, if heating consumption only is taken into account, the impact of air-tightness is much more important in buildings equipped with recovery systems ventilation than with extraction systems ventilation.

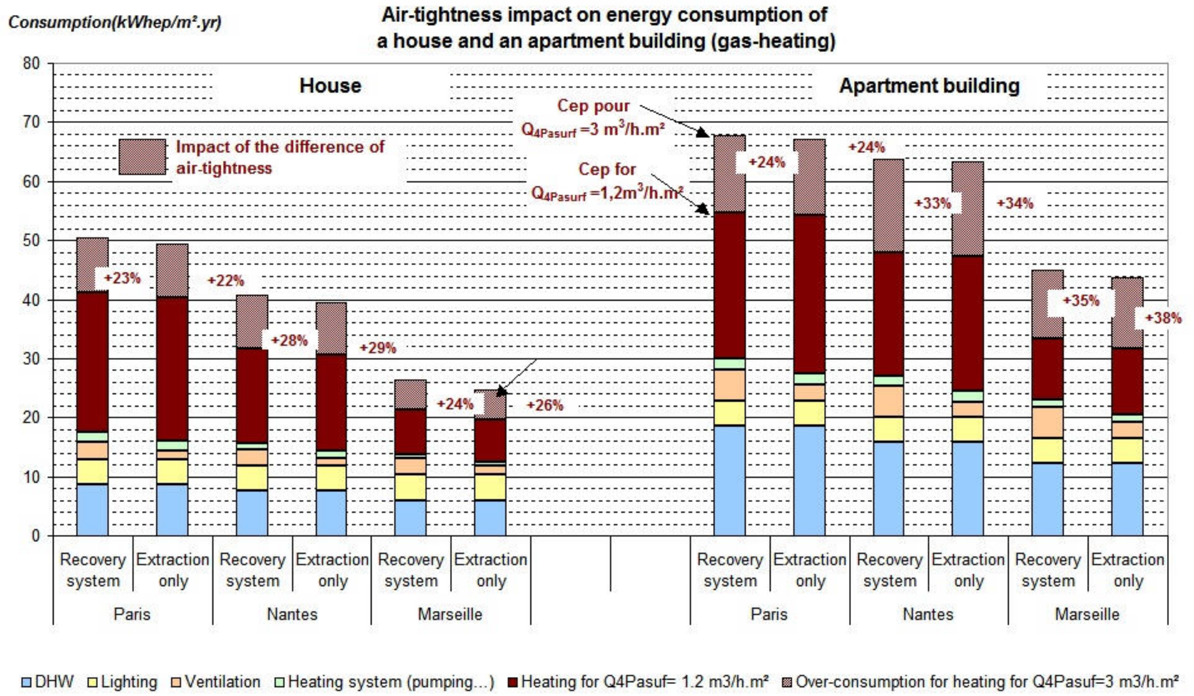

Figure 6: Air-tightness impact on energy consumption for two residential buildings

As far as the objective of this study is to estimate the opportunity of adding an air-tightness requirement in non-residential low energy buildings, its impact should be compared with residential buildings where this requirement does exist.
Figure 6 shows the same evaluation for an apartment and a house. It shows that the impact is almost the same in the apartment and in the school. The impact in the office building is smaller but as it can reach 23 % it still seems opportune to control the air-tightness.

CONCLUSION

The objective of this study was to estimate feasibility and opportunity to require air-tightness level for low- and very low-energy non-residential buildings.
On measurement feasibility, 95% of measures, performed on non-residential building, were made on less-than-6000m3 volume. Technically, this volume requires 3 classical blower-doors for an air-tightness of Q4Passurf=1,2m^3/h.m² when reaching 50Pa is required. Three blower-doors are easy to gather as measurers are an organised network, but more than three seems more difficult to gather, as there are only few measurement over 6000m3. Anyway, in such case, measure adjustments could be allowed (dividing the building, reaching only 25 Pa, etc.).
The second point was the level of requirement ; technically $Q_{4Pasurf}$= 1,2 m^3/h.m² seems a reasonable value for schools, office buildings, hotels, sanitary buildings, community centers and restaurants. Their building techniques are more or less equivalent to residential buildings and this value is close from the measures median we have. Nevertheless it's important to keep in mind that, according to our data, this value may be easier to reach with wooden-structure for example, than with steel-structure for example.
The third point was the requirement request opportunity : the sensitive analysis showed that such a requirement was as interesting for non-residential as for residential building, with a potential global consumption gain of more than 30% for some kind of buildings. Thanks to our automatic tool, this study will be easily extended to others kind of buildings, when their xml files (readable by the EP-calculation tool) will be available, including buildings with air-conditioning system.

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