Impact of low energy buildings on indoor air quality (IAQ)

Introduction

The building codes implemented during the last thirty years have led to a better insulation and air tightness of constructions in order to limit heat losses and save energy. In parallel, the available living space has been reduced to suit present day needs and to adapt itself to the increased costs of the real estate markets, leading in some cases to over occupancy of accommodations.

These factors have contributed to a deterioration of the indoor air quality (see report of OQAI "Observatoire de la Qualité d'Air Intérieur" (3) on IAQ in French accommodations). The current reinforcement of building codes following European directive, will make this situation even worse if they are not completed by further changes in how we ventilate these areas.

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Presence of moisture in housing

In France, forty percent of existing dwellings have fungus problem and more than twenty three percent have moisture problems. The main causes are a defect or an absence of the ventilation system and unfavourable climatic conditions (according to an ESMHA study (1), the age of building is not a relevant cause). In parallel, over occupancy is further increasing the risk of moisture problems in dwellings. Over occupancy rates are noticeable in cities with a combination of high real estate prices and low purchasing power, leading to difficulties in obtaining an appropriate accommodation (i.e. size of dwelling compared to family size) (5).

Effect of moisture on health conditions

Moisture problems in dwellings exist with 75% of the patients that have respiratory problems; they develop a further risk of allergy due to dust mites. A humid accommodation increases the frequency of respiratory problems from 30% to 50%, especially asthma (Professor D. Charpin (2)). Moisture increases allergies (already 30% of population is allergic), asthma, respiratory problems and microbic VOC (Professor De Blay (2))

Ventilation system in existing buildings

In recent French dwellings (built after 1982 or renovated with mechanical ventilation systems) the OQAI study (6) revealed a better indoor air quality thanks to mechanical ventilation systems. Nevertheless, approximately 50% of the measured air flows are below the rates of official French rules. It is mainly due to defective installations or the lack of maintenance. This point has to be improved by incentives or rules that allow for certifying contractors to install ventilation systems and perform the appropriate maintenance.

This point is particularly relevant in schools where there is a proven, direct link between air pollution and ventilation systems (7). The relation between the presence of ventilation systems and a healthy environment is frequently pointed out as positive.

Relation between building air tightness and Indoor Air Quality (IAQ)

The air flow entering through the infiltrations of the building (defects of construction and lack of insulation) are important and have to be taken into account to appreciate the IAQ. They are part of the renewed air and the French OQAI study (6)

has highlighted the predominant part of air infiltrations in the total air renewal of dwellings.

In order to better understand how infiltrations are influencing IAQ, we have made simulations using SIREN software from French CSTB official body ("Centre Scientifique et Technique du Batiment").

The more the building is permeable and under negative pressure, the more the impact of infiltrations is high. The level of infiltrations will then depend on the type of ventilation system and level of air tightness of the building. In order to evaluate the IAQ in a simple manner we have used the classification of EN 13779 standard based on incoming fresh air flow per person.

In **Figure 3** and **Figure 4** one can see the origin of incoming fresh air in a detached house of 84 sq meter occupied by 4 persons depending on air tightness and ventilation system.

Figure 3 shows that in the case of a single way ventilation system (humidity controlled exhausted air) **more than 70% of the fresh incoming air is entering through building infiltrations.** So, if air tightness is improved, i.e. from 1.3 to 0.6 as required by French RT 2012 building code, it will lead to a reduction of fresh incoming air of 33% and change the IAQ from average to moderate level (EN 13779).

In the case of a cross ventilation system (**Figure 4**), fresh incoming air by the ventilation system is not influenced by air tightness as air is mechanically driven in the building. The increased air tightness of the house is still leading to a reduction of incoming fresh air but to a lower extent (minus 24%) due to the mechanical control of incoming air from the ventilation system and balanced air pressure in the house. Air tightness has a big influence on IAQ and needs to be taken into account to determine the air flow rates of the ventilation system; they should not be considered independently.

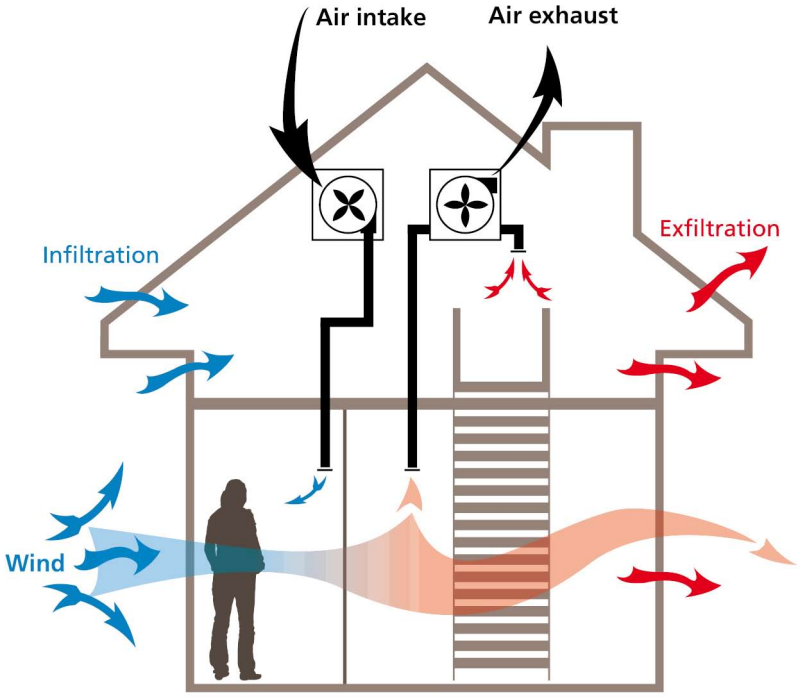

Figure 1. Building air flow.

Air quality category	CO2 concentration (ppm) above outdoor level	Fresh air flow
Excellent Air quality	< 400	> 54 m3/h/pers
Average Air quality	from 400 to 600	from 36 to 54 m3/h/pers
Moderate Air quality	from 600 to 1000	from 22 to 36 m3/h/pers
Poor Air quality	> 1000	< 22 m3/h/pers

Fresh air flow to respect in relation with Indoor Air Quality wished (EN 13779)

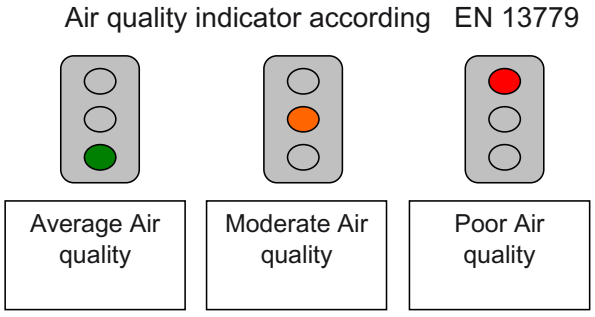

Figure 2. Air quality indicator.

International overview of specified air flow rates compared to IAQ standards

Each European country has its own recommendations or official rules regarding ventilation of buildings and minimum air flow rates re-

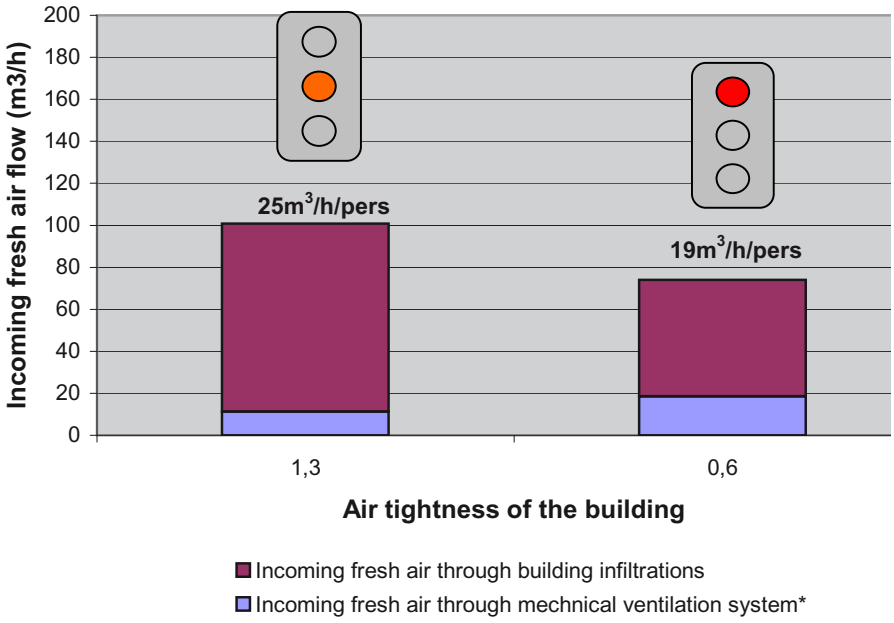

Figure 3. Incoming fresh air repartition with humidity controlled ventilation system.

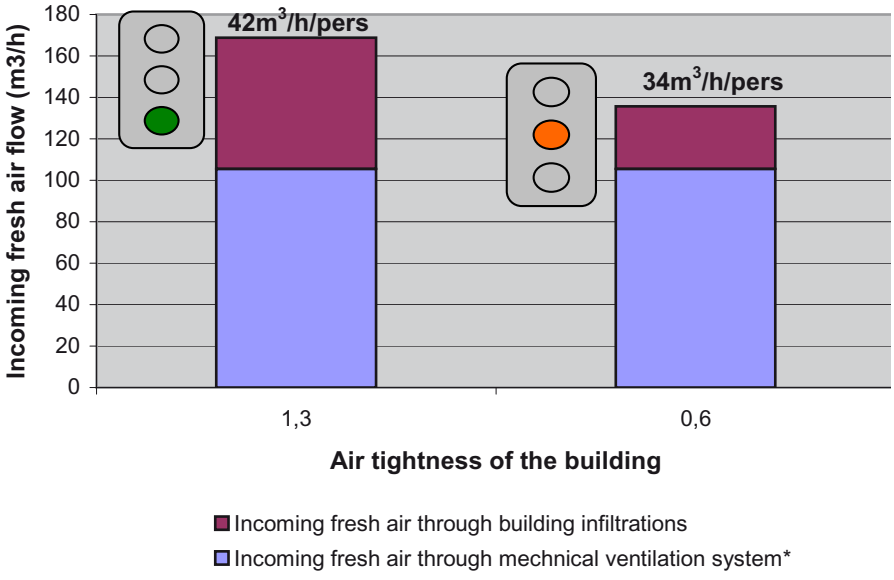

Figure 4. Incoming fresh air repartition with cross ventilation system.

quired. **Figure 5** shows the recommended ventilation rates (including building infiltrations) of the different European countries for a 110 sq meters detached house occupied by 4 persons. A focus has been made for France to compare the situation between current building code (RT 2005) and the upcoming one (RT2012) in order to measure the impact of the reduction of building infiltrations.

None of the airflow rates used in different European countries reaches the "normal" level of IAQ as defined in EN 15251 for newly built or renovated dwellings. Only the Netherlands reaches the "moderate" level.

In France the air flow rates of standard single way exhausted air ventilation systems are very close to the European "moderate level" but most of the systems already used in new French buildings are using humidity controlled ventilation systems with an average air flow rate inferior to the European standards. When taking into account reinforcement of building air tightness, required by the upcoming RT 2012, the airflow rates will be further reduced ensuring worse results than those of all other European countries and not compatible with the European standard. One can realistically predict very poor IAQ in new French dwellings, unless people go back to opening windows, which in turn would be in direct opposition of the RT 2012 goal of saving heating energy.

Relation between IAQ and window opening

The duration of window opening varies from 30 minutes to 1 hour per day depending on family size and types of rooms. It has been proven that window opening is not linked to the type of ventilation but is very specific to each person. Usually, people open the windows less during the heating season. Even during the peak of indoor air pollution some don't feel the need to open windows. Window opening cannot also be considered a solution for exhaust pollution originating from furniture and other products used for construction or decoration. In France, one third of dwellings have no windows in the bathroom where humidity levels are highest (4, 6 and 8). Window opening is a cultural behaviour and cannot be substituted to ventilation systems.

Conclusion

The coming new building codes designed for saving energy in new buildings is a clear threat to the IAQ if they are not completed by a

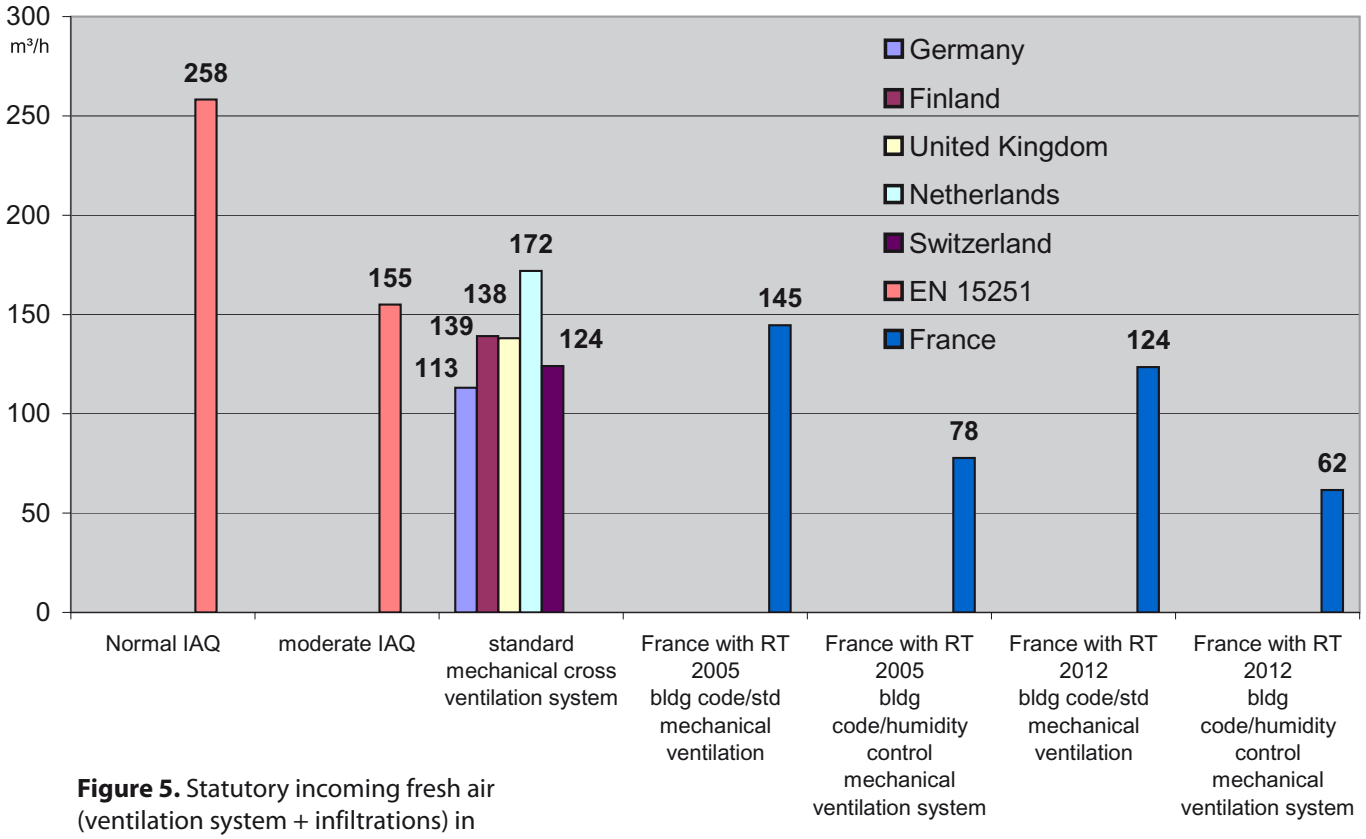

Figure 5. Statutory incoming fresh air (ventilation system + infiltrations) in different European countries compared to EN standard.

revision of the rules regarding ventilation. These new rules will have to take into account air infiltrations of the building which are today ignored, though they represent the majority of fresh, incoming air and will be largely decreased in low energy buildings. Ventilation systems will then become predominant as well as the quality of their installation and maintenance which is today largely disregarded in most European countries. Ventilation systems in accommodations are too often chosen only for price considerations while they are going to be one of the main HVAC product solutions for maintaining good IAQ and low energy consumption. Increasing total airflow rate is possible without creating additional heat losses and creating noise problems. Solutions already exist but are insufficiently used due to lack of concern and information.

Solutions for optimizing IAQ and energy consumption

- Heat recovery ventilation systems (static or using heat pumps). Heat recovered can be used in different ways (heating fresh incoming air, domestic sanitary hot water, water for central heating)
- Modulated ventilation on large air flow scales, based on real indoor pollution and taking into account real occupation
- Combination of both systems

Sources

[1] Effets Sanitaires des Moisissures dans l'Habitat : Enquête ESMHA, pilote d'une étude épidémiologique (November 2010) – Observatoire régional de santé d'Ile-de-France.

[2] Livre blanc sur la qualité de l'air intérieur (February 2011) – FFT (Fédération Française des Tuiles et Briques).

[3] Campagne nationale logement : Etat de la qualité de l'air dans les logements français (November 2006) – OQAI (Observatoire de la Qualité de l'Air Intérieur).

[4] Campagne pilote : Etude 90 logements et 9 écoles (July 2004) – OQAI (Observatoire de la Qualité de l'Air Intérieur).

[5] Santé.gouv.fr en basse Normandie – Précarité face au logement : inconfort et suroccupation.

[6] Etat de la ventilation dans le parc de logements français (June 2009) – OQAI (Observatoire de la Qualité de l'Air Intérieur).

[7] Impact énergétique et sanitaire du renouvellement d'air dans deux écoles primaires (November 2004) – OQAI (Observatoire de la Qualité de l'Air Intérieur).

[8] Comportement des occupants vis-à-vis de l'ouverture des fenêtres (November 1990) – EDF (Electricité de France).

[9] Impact de la perméabilité sur la qualité d'air intérieur.

[10] Comparaison européenne des réglementations existantes sur la ventilation.