Ventilation tool for improving the usability of ventilation levels related to Spanish regulations

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ABSTRACT

Choosing the right baseline level of ventilation has a big impact in the calculated energy needs of buildings. As designers do usually face usability problems when evaluating this level, they tend to overestimate it, making it needlessly harder to comply with energy efficiency regulations.

In order to help designers to better assess ventilation levels in accordance with the Spanish Technical Building Code (TBC) (CTE) we have developed a tool that can also show the impact on ventilation levels due to usability considerations.

This paper presents this tool as well as some study cases, from which the impact of more flexible ventilation regulations –performance-based- can be appreciated.

The tool is based on existing and in development IAQ regulations.

KEYWORDS

Energy, Building Regulations, Ventilation, Tools

1 INTRODUCTION

With the increase of the energy performance of buildings, both due to energy regulations and general awareness, ventilation (along with infiltration) is becoming a key factor in the building energy needs.

We have observed that designers commonly face usability problems when dealing with ventilation related calculations due to the mismatch between health oriented and energy oriented procedures. This results in an overestimation of the ventilation levels for the evaluation of the energy performance of buildings and to the implementation of ineffective energy saving measures.

This paper shows the two most common failures when evaluating this ventilation levels in the case of residential buildings, their energy impact in two study cases (a single family house and a multifamily block) using the current *Hygiene, health and the environment* Basic Document (DB-HS) of the Spanish building Code (CTE) [CTE06], and what would be the impact of loosing the required ventilation levels according to a draft update of the DB-HS section (DB-HS2015 draft).

The paper shows a tool developed to avoid this kind of sources of error and help designers in the correct assessment of ventilation levels for energy use while staying in conformance to the health requirements in the Spanish Building Code (CTE) [CTE06].

2 CALCULATING VENTILATION LEVELS FOR HEALTH OR ENERGY NEEDS

The *Hygiene, health and the environment* Basic Document (DB-HS) of the Spanish Building Code (CTE) [CTE06] sets minimum ventilation requirements for residential buildings in order to ensure air quality. The ventilation level is calculated from the occupation, space use and area of the several building spaces, but taking in isolation each residential unit of the building and other subsidiary building spaces (like storage rooms, corridors, etc), and considering their supplied and exhausted air needs.

In the case of energy evaluation, the building is instead considered as a whole and the control volume is not coincident with that of the health requirement. More specifically, only the volume inside the thermal envelope is of interest, from which are excluded most spaces out of the residential units. Also, the usual indicator is the net amount of external air which is supplied to the control volume.

These two ventilation levels must be consistent and the health requirements need to be met when evaluating the building energy needs but, due to the mismatches in the two calculation models the common practice incurs in two errors with a significant impact in the energy evaluation of the building, with the effect of overestimating the total air flow:

1. an inconsistent consideration of the building spaces, so the needs of "non inhabited" spaces out of the residential units (such as storage/box rooms) are accounted for in the whole building balance, even when they are not included in the energy model (error 1);
2. a failure to understand the air flows, so the supply and exhaustion air flows are added up instead of balanced (error 2).

3 WEB TOOL

To avoid the aforementioned sources of error, and to assist designers to correctly assess the ventilation needs for energy use, we have developed the web based tool, shown in Figure 1. The user just needs to describe relevant characteristics of the residential unit types and their amount, and the tool displays the ventilation rates for energy modelling, both for the current DB-HS prescriptions and the DB-HS2015 draft.

RESULTADOS	DB-HS 2009				DB-HS 2015 (propuesta)			
Ventilación del edificio para cálculos energéticos (DB-HE)	382	l/s	0.64	ren/h	245	l/s	0.41	ren/h

Tipo	Cantidad	Superficie	Altura	Z. comunes	Dormitorios	S. estar	Loc. húmedos	Aseos/baños	Cocinas
A1	4	55 m²	2.7 m	5 m²	1	1	2	1	6 m²
A2	1	75 m²	2.7 m	0 m²	2	1	2	1	6 m²
A3	1	75 m²	2.7 m	0 m²	2	1	3	2	6 m²
B1	1	100 m²	2.7 m	0 m²	3	1	3	2	6 m²
B2	1	100 m²	2.7 m	0 m²	4	1	3	2	6 m²
B3	1	100 m²	2.7 m	0 m²	5	1	4	3	6 m²
C	1	100 m²	2.7 m	0 m²	5	1	4	3	6 m²
TOTALES	**10**	**770 m²**	**2.7 m**	**20 m²**	**25**	**10**	**27**	**17**	**60 m²**

Figure 1: Web tool user interface

4 STUDY CASES AND SCENARIOS

The building types we have considered are the single family house (Type A) and the multifamily block (Type B) in Figure 2. These buildings are located in Madrid (climate zone D3) and have construction solutions close to the recommendations in Annex E of the *Energy economy and heat retention* Basic Document (DB-HE) of the Spanish Building Code (CTE): energy transmission coefficient $U = 0.25 W/m^2K$ for walls, $U = 0.26 W/m^2K$ for roofs, $U = 0.44 W/m^2K$ for ground-floor and $U = 1.6 W/m^2K$ for windows.

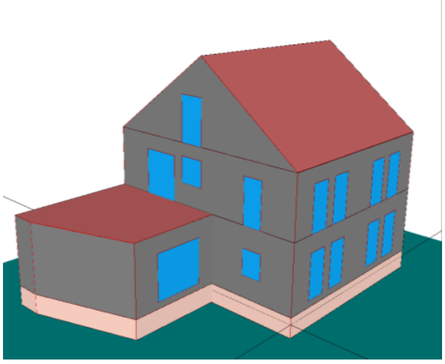 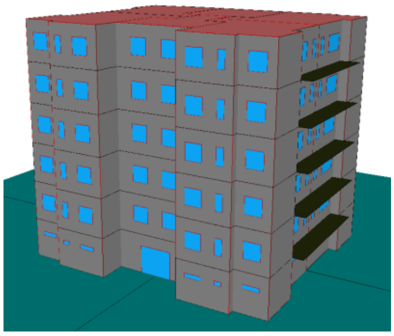

Figure 2: Study cases: building types A and B

We have studied four scenarios for each type, using the current DB-HS evaluation as baseline:

- *scenario 1*, use ventilation levels from DB-HS, but wrongly adding supply and exhaustion flows, and incorrectly considering the ventilation needs of non inhabited spaces;
- *scenario 2*, use ventilation levels from DB-HS, and incorrectly considering the ventilation needs of non inhabited spaces;
- *scenario 3*, use ventilation levels from DB-HS (*baseline*);
- *scenario 4*, use ventilation levels from the DB-HS2015 draft.

Table 1 shows the resulting ventilation levels for the selected scenarios, keeping a reference to the baseline ventilation value.

Table 1: Ventilation levels

Scenario	**Single family house (A)**			**Multifamily block (B)**		
	l/s	ren/h	%	l/s	ren/h	%
1. DB2009 + error 1 + error 2	252	1,00	221	1446	1,32	173
2. DB2009 + error 1	208	0,83	182	1021	0,93	122
3. DB-HS2009	114	0,67	100	835	0,76	100
4. DB-HS2015 (draft)	58	0,34	51	614	0,56	73

We have used the web tool to calculate the ventilation rates for building types A and B in scenarios 3 and 4, as can be seen in Figure 2 and 3.

Figure 3: Ventilation levels for type A, in with the web tool user interface

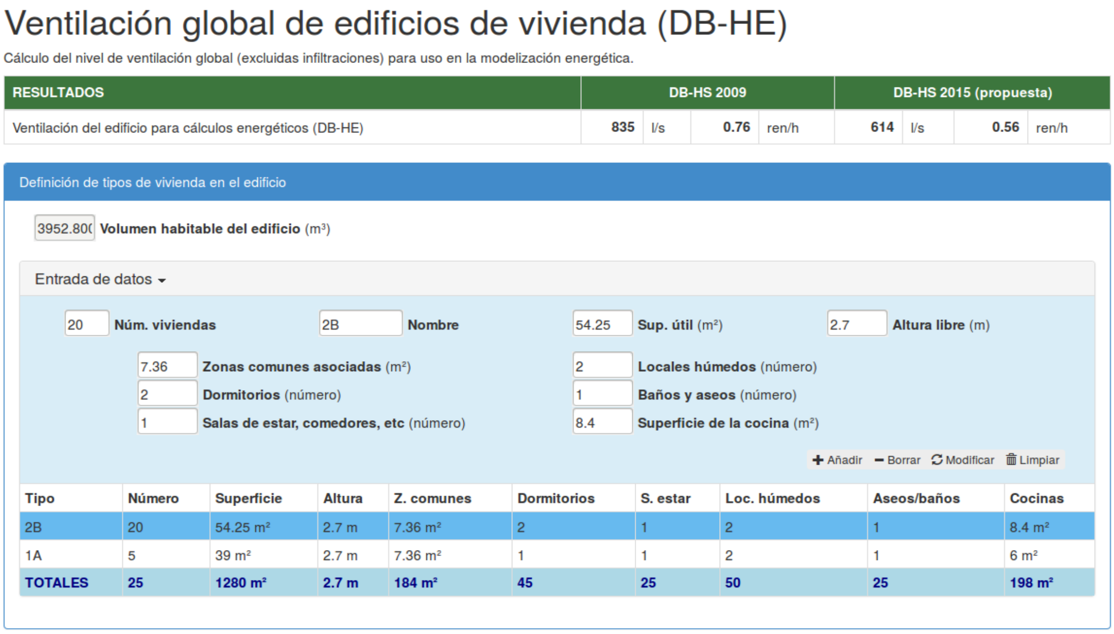

Figure 4: Ventilation levels for type B, in the web tool user interface

5 RESULTS

Table 2 shows the resulting heating and cooling energy needs for the selected scenarios, keeping a reference to the baseline. These energy needs were calculated using the Building Code Energy Use tool *Herramienta Unificada LIDER-CALENER [HULC14]* and their values analysed using the *Visol* tool [VILLAR14].

Table 2: Heating and cooling energy needs

Scenario	Single family house (A)		Multifamily block (B)	
	Heating needs [kWh/m²·y]	Cooling needs [kWh/m²·y]	Heating needs [kWh/m²·y]	Cooling needs [kWh/m²·y]

1. DB-HS + error 1 + error 2	85,50 (198%)	15,60 (112%)	52,05 (197%)	15,04 (106%)
2. DB-HS + error 1	71,40 (165%)	15,01 (108%)	33,96 (129%)	14,39 (101%)
3. DB-HS	43,21 (100%)	13,88 (100%)	26,42 (100%)	14,18 (100%)
4. DB-HS2015 (draft)	30,83 (71%)	13,40 (97%)	18,68 (71%)	14,00 (99%)

Table 3 shows the energy needs due to ventilation for the previous scenarios, in absolute terms and relative to the total net energy needs for each scenario.

Table 3: Ventilation weight for heating and cooling energy needs

Scenario	**Single family house (A)**		**Multifamily block (B)**	
	Ventilation in heating needs [kWh/m²·y]	Ventilation in cooling needs [kWh/m²·y]	Ventilation in heating needs [kWh/m²·y]	Ventilation in cooling needs [kWh/m²·y]
1. DB-HS + error 1 + error 2	90,60 (106%)	-12,90 (-83%)	75,30 (145%)	-14,80 (-98%)
2. DB-HS + error 1	75,60 (106%)	-13,40 (-89%)	56,00 (165%)	-15,50 (-108%)
3. DB-HS	45,60 (106%)	-14,50 (-104%)	47,60 (180%)	-15,80 (-111%)
4. DB-HS2015 (draft)	31,20 (101%)	-14,90 (-111%)	36,20 (194%)	-16,20 (-116%)

Figure 5 depicts the results from tables 2 and 3.

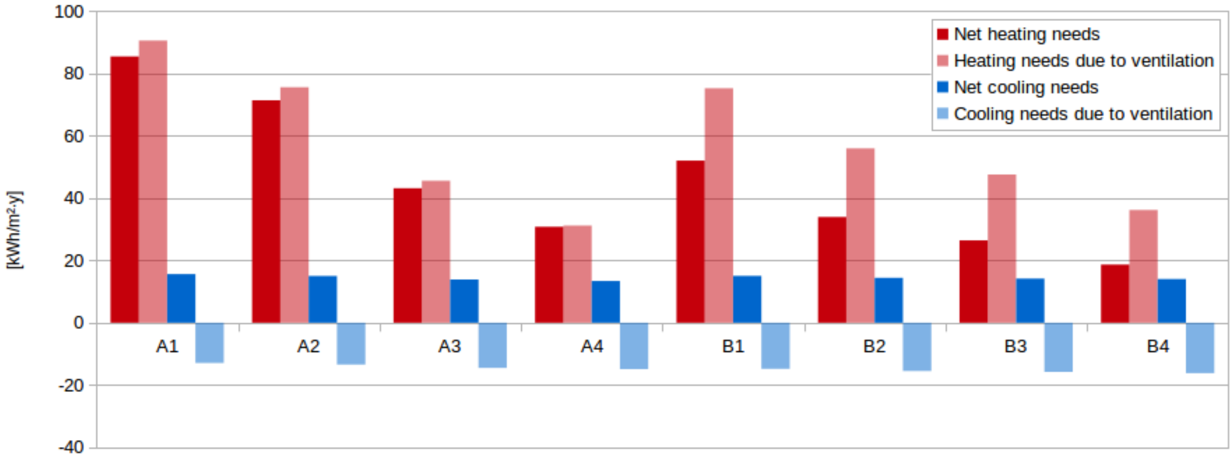

Figure 5: Net energy needs for heating and cooling and energy needs for heating and cooling due to ventilation

6 CONCLUSIONS

For the selected scenarios, building types and the climate zone we have studied, we can see the great impact of the two most commonly detected sources of error when evaluating the ventilation levels for energy use. These errors can almost double the estimated energy needs in some cases, with more impact in the heating needs and less impact in the cooling needs. Also, ventilation and infiltration represent a great share of the energy needs, ranging from roughly the net energy needs for cooling to twice the net energy needs for heating.

It is interesting to note that ventilation tends to have an increasing weight in the net energy needs, as ventilation levels go down, even when, overall, the use of stricter ventilation levels (still complying with air quality requirements) can lead to significant reductions in the building energy needs.

These results show the importance of a correct estimation of the ventilation levels for use in energy modelling, and how calculation errors or regulation requirements have a significant impact in the energy budget and profile of the building, leading to different cost effective energy saving measures. Also, it proves the usefulness of a tool to help users to avoid the most common mistakes.

7 REFERENCES

[CTE06] Real Decreto 314/2006 de 17 de marzo (BOE 28 de marzo de 2006). "Código Técnico de la Edificación". Ministerio de Vivienda, Madrid, 2006.

[HULC14] Herramienta Unificada LIDER-CALENER. Herramienta informática de verificación de la exigencia de Limitación de demanda energética del CTE. Ministerio de Fomento, Ministerio de Industria, Energía y Turismo, IDAE. Madrid, 2014. http://www.codigotecnico.org

[VILLAR14] Villar Burke, R.; Jiménez González, D.; *Visol: Visor de archivos de resultados de LIDER*, Madrid, 2014. http://www.rvburke.com/visorlider.html