Evolution of Energy Performance of Houses and the Interaction with Energy Performance Regulation: an Analysis of the Flemish EPBD-Database

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Abstract

Energy performance regulations for buildings are continuously updated. Projections within the future are being made, fixing now what will be the standards for new buildings for the following decades. The construction sector itself is also evolving, trying not only to follow those new rules, but often trying to look ahead, developing, testing and launching today the prototypes of tomorrow's buildings and components. To optimise public and private decision making, one has to analyse both the current status as well as the ongoing evolutions and the interactions between the market and the regulatory framework. Within this scope, analyses are conducted in Flanders on the EPBD-database, which contains detailed data on all new residential buildings since 2006. The analysis presented in this paper shows the impact and importance of specific regulations and incentives. In spite of the tightening regulations, huge discrepancies remain visible between a small yet increasing group of low energy, and passive house 'pioneers' and premium hunters, as opposed to a trailing group, flirting with the legally imposed limits. The analysis of the data therefore proves the role of as well as some challenges for future decision making, while quantifying the real status and evolutions of the building sector.

Keywords – energy performance; EPBD-database; decision making

1. Introduction

Since January 2006 every newly built dwelling or major renovation has to meet the legislation on energy performance and indoor air quality. The demands depend on the nature of the work and the function of the building. For this purpose the E-level and K-level were introduced. The E-level marks the overall energy performance of a building, the K-level qualifies the degree of insulation. The lower the level, the better. The Flemish Energy Agency collects the information of every dwelling in the energy performance database [1].

This paper discusses the most important results of a MSc dissertation that used the information from that database for the development of a set of reference dwellings, that ought to be representative for newly built Flemish dwellings. The first part of the dissertation consists of a broad literature review that examines projects from different countries where reference or typical dwellings are used; Senvivv [2], Sufiquad [3], El^2EP [4], TABULA [5], Deutsche Gebäudetypologie [6] and Voorbeeldwoningen Bestaande Bouw [7]. The second part focuses on the distribution and evolution of the parameters and the correlations between them. This paper only reports on the results of the part concerning the database.

2. Sample and Method

The energy performance database contains the characteristics of 43.336 dwellings, from the period between 2006 and 2010. Apartments, which are considered as individual flats in the Flemish EPBD-legislation, represent 45% of the dwellings, detached houses 26%, semi-detached 20% and terraced houses 8%. The parameters contained in the database vary from geometric and building envelope parameters to insulation values and theoretical energy demand. For the most parameters only the values between the 1st and 99th percentile were taken into account, to exclude possible incorrect values.

3. Results

The distribution of the gross floor area outlines a right skewness for every housing type, except for apartments. The semi-detached and terraced houses have a similar spread. (Medians: apartment: 94 m^2, detached: 250 m^2, semi-detached: 185 m^2, terraced: 170 m^2).

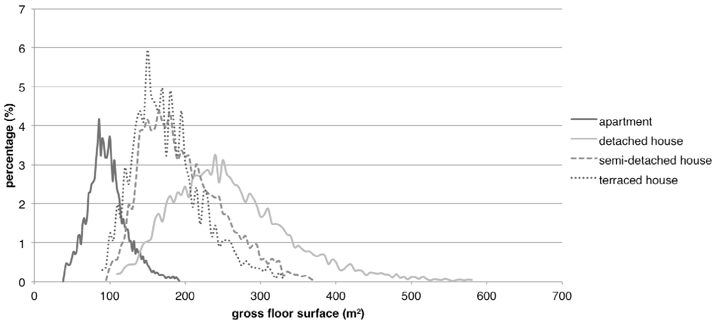

Fig. 1 Distribution of the gross floor area for all housing types

Figure 2 shows the distribution of the normalized heat loss surface. The chart displays a relative normal spread for single-family dwellings, with a gradual difference between each. The apartments are clearly divided into two groups, this is caused by the different types of apartments that exist in a single building. Apartments who are enclosed by others have a smaller heat loss surface than those on the corner, top or floor of a building.

The analysis of the evolution between 2006 and 2010 revealed a notable rise of the heat loss surface per m^2 gross floor area for apartments. This could indicate that big apartment buildings are built less. The smaller the building, the smaller the share of enclosed apartments in that building.

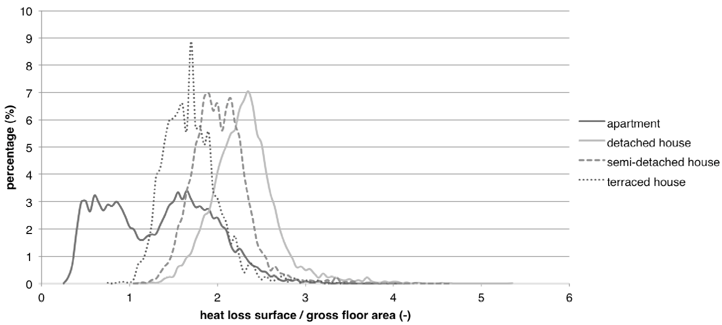

Fig. 2 Distribution of the heat loss surface per m^2 gross floor area for all housing types

The same trends are shown in the distribution of the compactness (the ratio of the heated volume and the heat loss surface): a small gradual difference between the single-family houses and the different types of apartments. Two groups can be distinguished, a group with a low compactness (from 1 to 2,5m), and a group with a high compactness (from 2,5 to 8m). Both groups contain approximately the same number of dwellings.

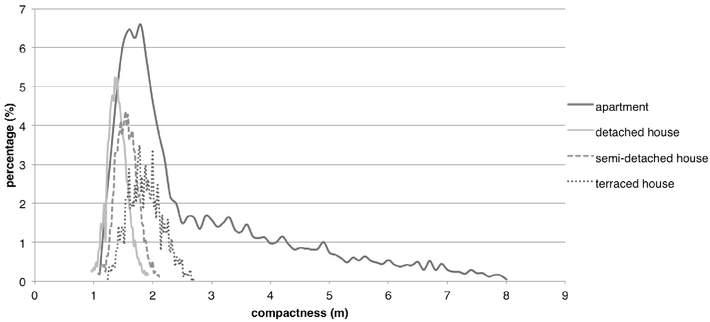

Fig. 3 Distribution of the compactness for all housing types

Figure 4 and 5 show both the distribution of the window surface (glass + frame). One is normalized by the gross floor area, the other by the heat loss surface. The first chart displays a strong resemblance between the housing types, especially between apartments and detached houses, and between semi-detached and terraced houses.

When the window surface is divided by the heat loss surface, you would expect a more considerable difference between a terraced, semi-detached and detached house, because of the variation in heat loss surface. However, as figure 5 proves, this seems not to be the case. The resemblance between those housing types is even stronger than in figure 5. Furthermore, the high values in the distribution of the apartments are rather distinct.

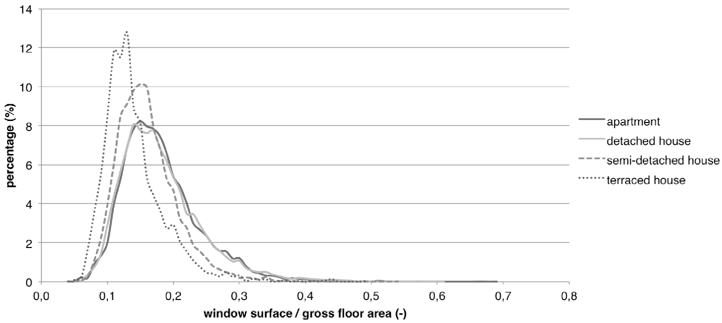

Fig. 4 Distribution of the window surface per m^2 gross floor area for all housing types

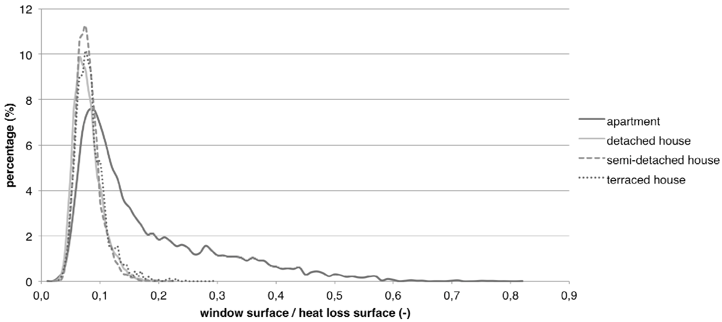

Fig. 5 Distribution of the window surface per m^2 heat loss surface for all housing types

The average U-value in figure 6 is the mean of the U-values of every construction component in the building envelope weighted by their surface area. There are maximum allowed U-values for every kind of construction part: 0,3 W/m^2K for roofs, 0,4 W/m^2K for outside walls and 2,5 W/m^2K for windows.

The chart demonstrates a similar distribution for the single-family houses. The detached house displays the best score, followed by the semi-detached and terraced house. Around the U-value of 0,18 W/m^2K, there seems to be a small group of dwellings with a remarkable good level of insulation. For the apartments, this group of pioneers is missing. This housing type has instead a group of laggards, with an U-value of 0,80 W/m^2K. In some apartments the urge to insulate very well may be not that big, because the high compactness automatically leads to a rather low K-level (see (1)).

Furthermore, the analysis of the evolution of the average U-value between 2006 and 2010 demonstrated a notable decrease of circa 20% for all housing types.

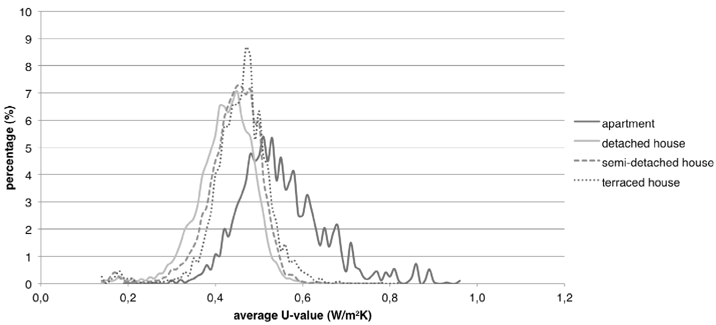

Fig. 6 Distribution of the average U-value for all housing types

The K-level is, as you can see in equation 1, determined by the compactness, the ratio of the Volume V and the heat loss surface A, and by the average U-value U_m. For apartments, this calculation is based on the entire building. The graph displays a peak before K45, this level was the legal demand before 2010, the requirement today is a maximum of K40.

The same pattern as in the previous chart is demonstrated here, there is again a small gradual difference between the single-family houses. Furthermore, the group of pioneers, with a K-level around 14, doesn't count any apartment building. Instead, there is a high percentage of apartments with a K-level slightly lower than K45, the legal demand. An explanation for this could be the fact that real estate agencies, which built a great share of the apartments, aim merely at achieving the legal demands. Since they are not affected by the energy bill, low consumption does not directly incentivize them to aim for a lower K-level.

$$\begin{cases} V/A \leq 1 & \Rightarrow \quad K = 100 \cdot U_m \\ 1 < V/A < 4 & \Rightarrow \quad K = \dfrac{300 \cdot U_m}{\left(\frac{V}{A} + 2\right)} \\ 4 \leq V/A & \Rightarrow \quad K = 50 \cdot U_m \end{cases} \tag{1}$$

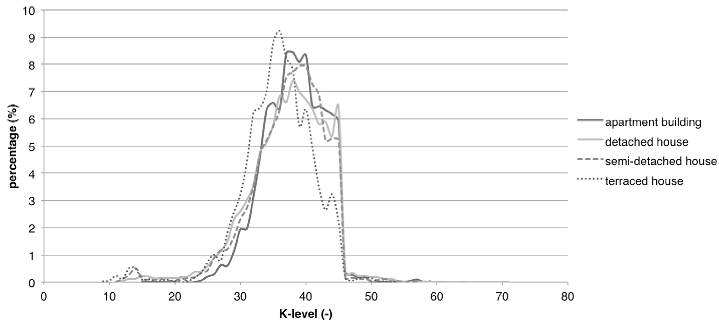

Fig. 7 Distribution of the K-level for all housing types

Figure 8 gives the cumulative distribution of the living room area. It is not possible to calculate all the exact areas, the database contains only the areas between 20,8 en 41,6 m^2. There is a clear difference between the housing types, the biggest area belongs to the detached houses, the smallest to the apartments.

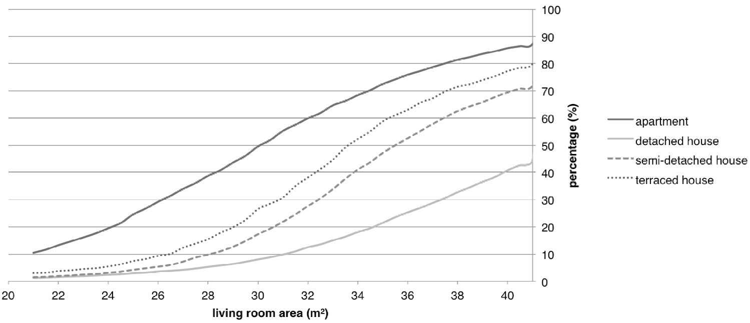

Fig. 8 Cumulative distribution of the living room area for all housing types

The same pattern is shown in the cumulative distribution of the bedroom area: the detached houses have the largest bedrooms, apartments the smallest. The database contains only the areas between 6,9 m^2 and 20,0 m^2.

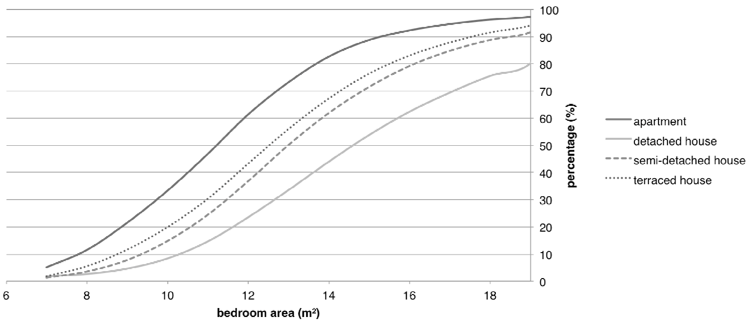

Fig. 9 Cumulative distribution of the bedroom area for all housing types

The dwellings with three bedrooms form the largest category for every housing type, except for apartments, where two bedrooms is the biggest group. Moreover, this latter type is the only one where the dwellings with only one bedroom are well represented.

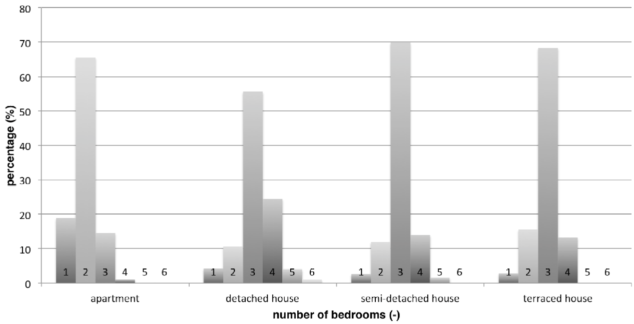

Fig. 10 Distribution of the number of bedrooms for all housing types

Figure 11 and 12 show the correlation between the normalized heat loss surface and the net energy demand for heating for both detached houses and apartments. The linear regression line, its equation and the square of the correlation coefficient are displayed on each chart. Logically, the energy demand is slightly higher for the detached houses, since they have higher values for the normalized heat loss surface. While the second graph shows a very strong correlation (r^2=0,671), the first graph only gives a moderate correlation (r^2=0,218). This indicates that the heat loss surface per m^2 gross floor area is far more determining for the heating demand for apartments than for detached houses.

In order to compare the performances of both housing types, two extra lines are plotted. This method is similar to the one used in the Concerto program [8]. The first line distinguishes the pioneers, the group that performs twice as good as the regression line. In the same way, the second line is used to separate the laggards from the rest. The group of pioneers is clearly bigger for the detached house (4,38 % against 2,62 %). Moreover, the share of dwellings above the regression line is smaller too for the detached houses (52,78 % against 57,34 %).

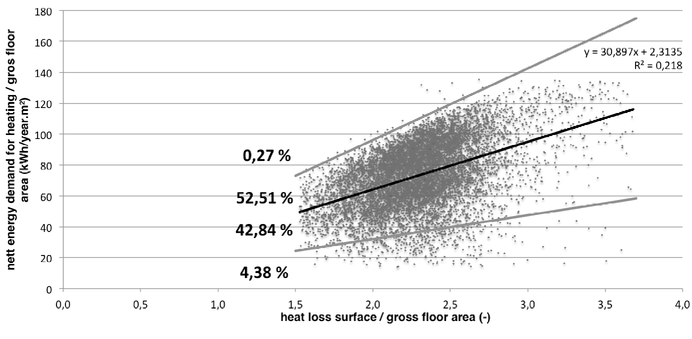

Fig. 11 Correlation of the normalized heat loss surface and the net energy demand for heating per m^2 gross floor area for detached houses

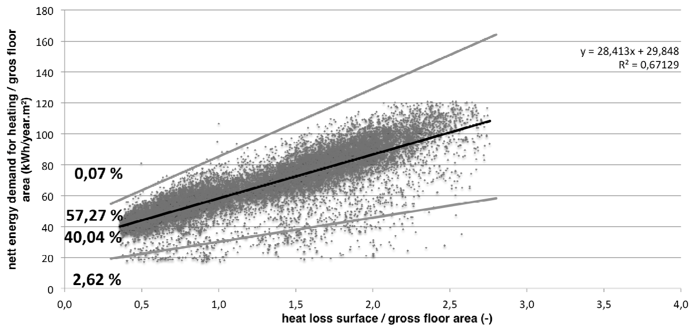

Fig. 12 Correlation of the normalized heat loss surface and the net energy demand for heating per m^2 gross floor area for apartments

4. Discussion

Out of the charts for the average U-value, K-level and the correlation of the normalized heat loss surface and the net energy demand for heating came that the single-family houses all share a group of pioneers, with a high score on energy performance. This group doesn't exist for the apartments. Moreover, the correlation charts prove that the apartment performs in general less good than the other housing types. As stated before, this is probably caused by the fact that the energy bill mostly isn't the real estate agencies' main concern. They only try to achieve the legal demands. More severe requirements may be the only way to encourage this group to aim for a better energy performance.

Another factor is of importance for the average U-value. The distribution of the apartment displays a group of laggards, with rather high U-values. Although they have a high average U-value some apartments may have a proper K-level, because they are very compact. This is the reason why the urge to have a decent insulation in these apartments isn't so high. Again, the only way to push these apartments to a better energy performance may be more severe legal demands.

5. Conclusion

In this paper certain information out of the Flemish EPBD-database is investigated. The distributions of the normalized heat loss surface and compactness show the different types of apartments, caused by the place of the apartment in the building.

The distribution of the window surface normalized by the gross floor area show a strong resemblance between the detached house and the apartment, and between the semi-detached and terraced house. Somewhat surprisingly, the likeness was even more distinct for the window surface normalized by the heat loss surface.

The average U-value and the K-level have comparable distributions. The single-family houses share a group of pioneers, with remarkable good performances. However, there is still a small gradual difference between each. The apartments lack the group of pioneers, instead, the distribution of the average U-value revealed a group of laggards. This housing type generally performs less good than the others.

For the living room and bedroom area, the highest values are noted for the detached house, the apartment has the smallest values. Furthermore, this latter group is the only housing type where the number of two bedrooms is the most common. For the other types this number is three.

Finally a comparison is made between the normalized heat loss surface and the normalised net energy demand for heating for detached houses and apartments. This proves that the heat loss surface is a far more determining factor for the apartments. In general, the detached house performs better, with a bigger group of pioneers, and a lower percentage of houses above the regression line.

Acknowledgment

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