Treatment of envelope airtightness in the EPB-regulations: some results of a survey in the IEE-ASIEPI project.

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ABSTRACT

One of the topics studied in the European IEE-ASIEPI project (www.asiepi.eu) is the way envelope airtightness is dealt with in the EPB-regulations of the Member States. To this end, a number of surveys have been made among the participating countries. Also a quantitative comparison on a sample building has been performed. The results of this study are used in the development of an instrument to compare the energy performance requirement levels among the Member States. The results illustrate that the different national EPB-calculation methods show different tendencies, revealing sometimes diverging underlying philosophies. Notably the concept and numeric figures of a default value are different, as well as the treatment of very good airtightness: in some methods the stimulus to do better than a certain threshold value becomes very small or is nil. In other countries, the incentive remains proportional all the way to the limit value of perfect air tightness. All these observations are illustrated and explained in the paper.

KEYWORDS

envelope airtightness, ventilation heat transfer coefficient, EPB-regulations, ASIEPI

INTRODUCTION

In the ASIEPI project one objective concerns the development of a methodology to compare the energy performance requirement levels among the Member States. This is being fully explained in project reports, other papers, on-line presentations, recordings of internet information sessions, etc.: see www.asiepi.eu for more information. This wider objective is not discussed in further detail in this paper.

As part of the task to develop a comparison methodology, a sample dwelling was calculated according to the EPB-calculation methods of different countries. In order to gain better insight in the way envelope airtightness is taken into account in the methods, the national calculators were asked to perform an additional calculation, namely to vary their national airtightness input variable and to report the impact on the ventilation heat transfer coefficient (for space heating calculations). They were also asked to make explicit, if possible, the part of the in/exfiltration in the total ventilation heat transfer coefficient. This paper presents and discusses the results of this quantitative exercise, which is only a small fraction of the total work on the comparison of EPB-requirement levels.

In parallel, several countries have translated the chapter on the ventilation heat transfer in their national EPB-calculation methods into English. This compilation gives more analytical insight and is published as a separate project report (1).

The object of the calculations is a semi-detached dwelling with 3 floors, as illustrated in Figure 1. The ventilation system in the building is natural supply and mechanical exhaust.

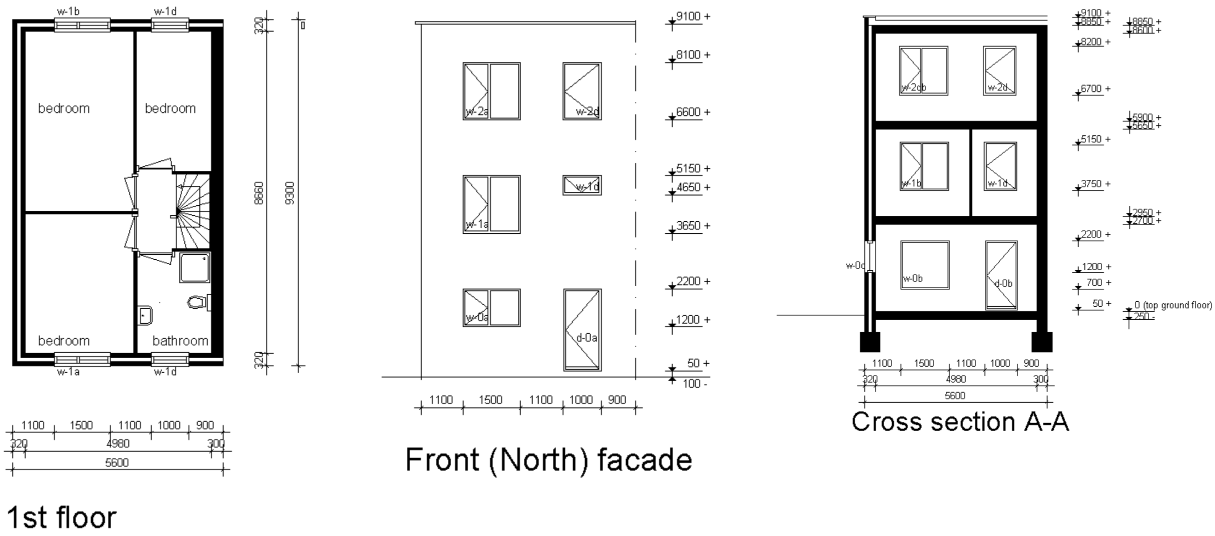

Figure 1: Some views of the test dwelling.

It should be noted that in many countries the EPB-regulations have undergone quick evolutions in recent years. As the work on the comparison method for EPB-requirements was originally initiated early in 2008, the calculations mostly reflect the state of the calculation methodologies at that time. In some countries changes have already intervened in the mean time, or are scheduled to come into effect in the near future. In those countries the results of the present paper might therefore no longer hold true.

RESULTS

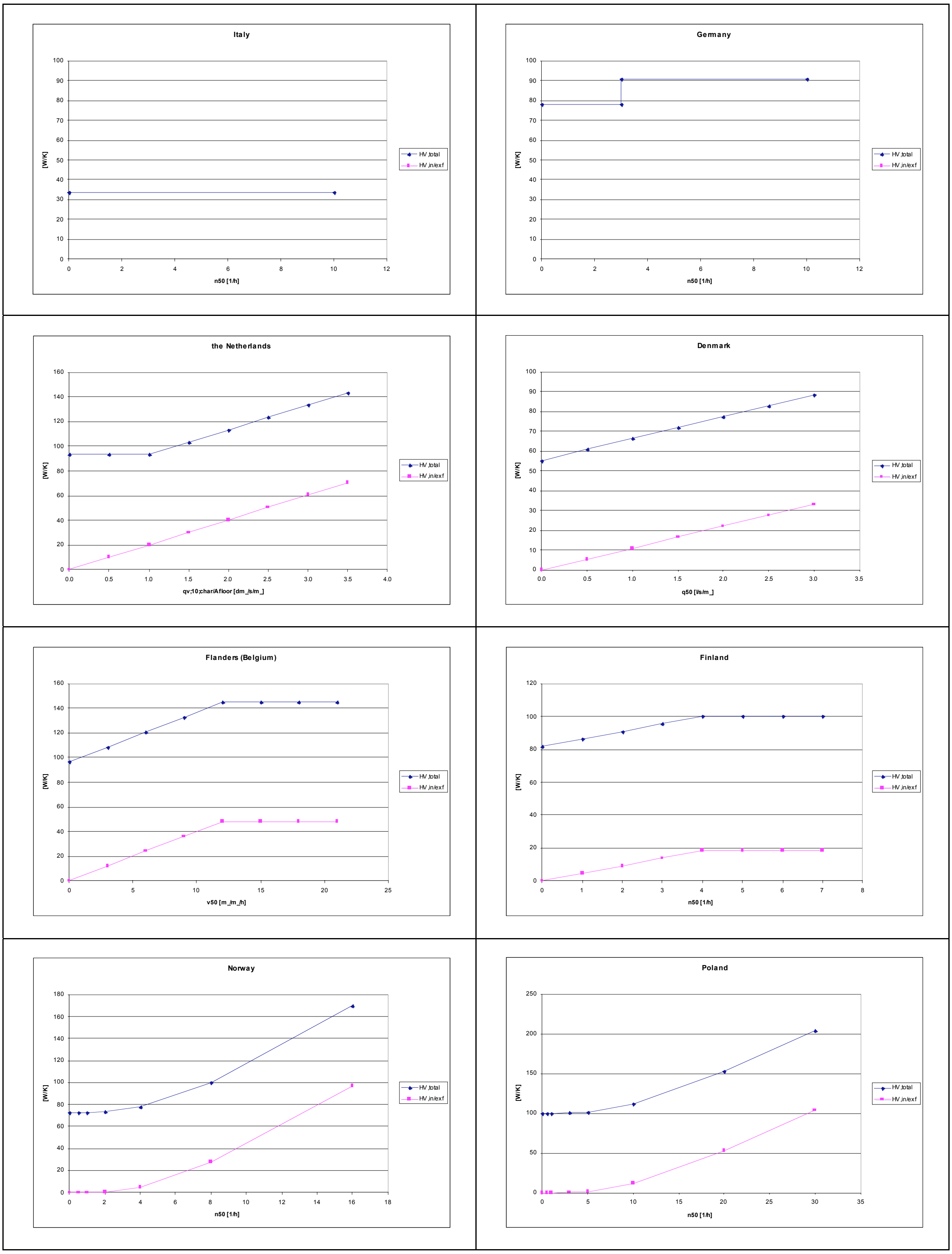

Figure 2: The total ventilation heat transfer coefficient and (if possible) the part of in/exfiltration in it as a function of the national airtightness indicator for 8 countries.

The graphs in Figure 2 illustrate how the ventilation heat transfer coefficient varies in the EPB-calculation methods of several countries as a function of the air tightness. On the x-axis the national input variable for the air tightness is given. Usually 2 curves are shown: one for the total ventilation heat transfer coefficient and, if possible, another one for the part of the in/exfiltration in the total.

Because the outdoor temperatures during the heating season vary strongly across Europe, the ventilation heat transfer coefficient (W/K) was chosen as basis for comparison, rather than the ventilation heat losses (MJ or kWh ...). In this manner the impact of the climate could be strongly reduced and the values could thus be made comparable. Nevertheless, the ventilation heat transfer coefficient by itself may be influenced to a certain extent by the climate too (wind driven air flows and thermal stack effects) but these are considered to be only secondary effects.

For Italy, it concerns a provisional method that was used by the national calculator in the absence of the definitive official EPB-calculation rules and software tools at the time when the initial calculation work started. In this simple model, the ventilation heat transfer coefficient is constant, independent of the airtightness of the envelope.

For Norway, it should be noted that there is a maximum n_{50}-value imposed (2.5/h for the type of dwelling with natural supply and mechanical exhaust which is considered here). Higher values are thus not allowed. However, in order to better illustrate their shape, the curves have been extended in the graph beyond the maximum limit.

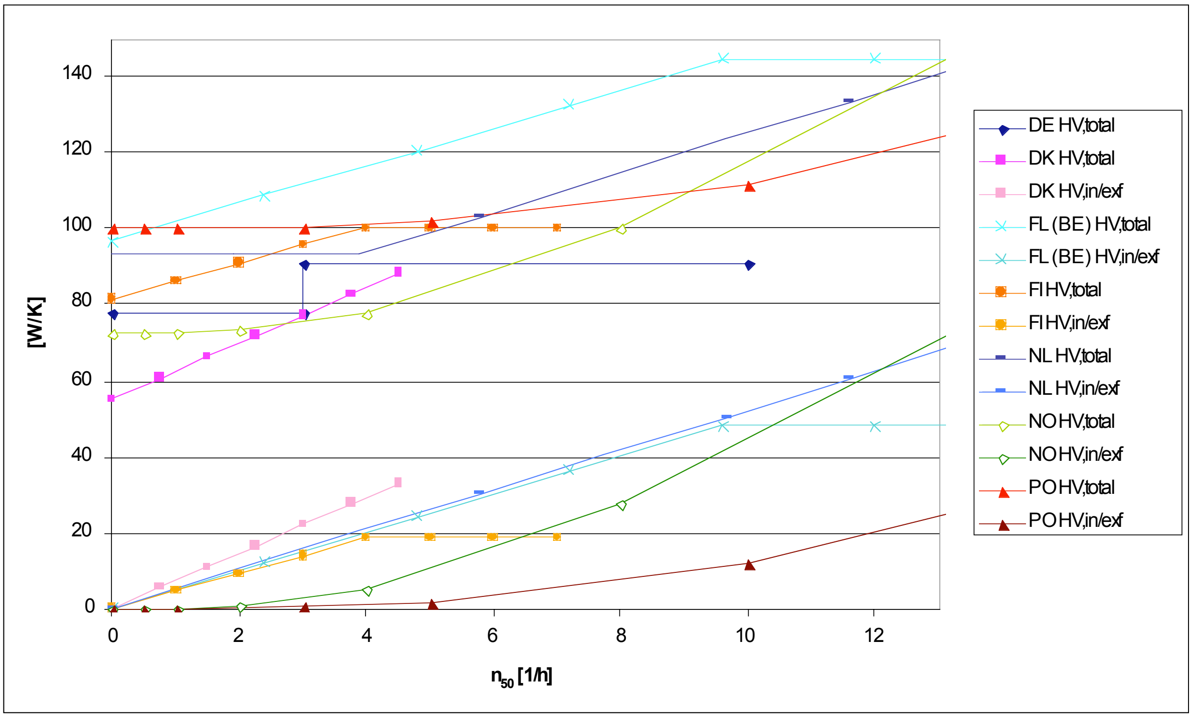

Figure 3: Synthesis graph.

In Figure 3, an attempt is made to represent all countries in a single graph. To this end, some national input figures had to be converted to an equivalent n_{50}-value. This required that some hypotheses be made[1]. Therefore, the curves in the graph should be considered with some caution; the foundation is not sufficiently solid to make an absolute quantitative comparison between the countries (e.g. concerning the slope of the lines).

DISCUSSION

When interpreting the results caution should be exercised. Since it concerns only 1 particular dwelling with its specific features (type of ventilation system, geometry, ratios of areas and volumes, etc.), no general, definitive conclusions can be drawn with respect to the method in a particular country. In several countries, the results would be (strongly) different for another sample building (e.g. another type of building, such as offices; or another ventilation system in a dwelling; or a different dwelling with another shape and size). The purpose here is rather to illustrate some general tendencies and differences of principles.

The bottom family of curves in Figure 3 concerns the part of in/exfiltration in the total ventilation heat transfer coefficient. The following observations can be made:

- In 4 cases (DK, FI, FL-BE and NL), it (mainly) concerns a straight line emanating from the origin. This means that the in/exfiltration losses are considered to increase proportionally with the lack of airtightness.
- In the 2 other instances (NO and PO), the lines are curved, and approach the origin asymptotically to zero. The underlying model is that of EN 832:1998 or EN 13790:2004. (Note that this equation is apparently no longer mentioned in EN ISO 13790:2008). In this calculation model, the form of the curve here is due to the fact that the ventilation system has only mechanical exhaust and no mechanical supply. (Remember, in the sample building the supply was imposed to be natural and the exhaust mechanical.) In the case of a fully mechanical ventilation system with equal supply and exhaust flow rates, the same underlying equation would have lead to a different shape of the curve, namely also a straight line through the origin.
- Only in 2 cases (FI and FL-BE), there is a clear default value: it is always allowed to use this value, even if the real airtightness value (whether measured or not) is larger. Therefore, the curves show a bend: above the default value, the in/exfiltration heat transfer coefficient used in the calculations remains constant. In both countries a measurement of the air tightness is absolutely mandatory if a better than default value is used in the calculations.

[1] When the pressure of the national input variable differed from 50 Pa, i.e. in the Netherlands where 10 Pa is used, it was assumed that a typical value for the exponent (n) in the pressure law, $V_L = C_L\,(\Delta p)^n$, is 0.65. For several countries, also information about areas (floor or heat transfer) or volumes was needed to convert the original airtightness value to an n_{50}-value. This was done with the available data, but may have been the source of some small errors.

The upper family of curves in Figure 3 concerns the total ventilation heat transfer coefficient. The following observations can be made:

- The absolute values vary with more than a factor of 2 (from less than 60 W/K for a well airtight envelope in Denmark, to more than 140 W/K in Flanders if no measurement proves a better performance than the default value). This corresponds, among other factors, to different design practices for ventilation systems in different countries (dimensioning of the equipment) and to different assumptions on its average use.
- It can be seen that, apart from Germany (no separate value for the in/exfiltration) and the Netherlands, both curves of the other countries are always parallel over the entire span. This means that these countries assume that the hygienic ventilation rates, which can be influenced by the operation of the ventilation system, is independent of the airtightness. In other words, it is assumed that the users will not modify their voluntary ventilation behaviour if there are already large uncontrolled in/exfiltration air flow rates present. Or that the ventilation system itself will act differently (e.g. less flow through trickle ventilators) due to a less airtight envelope.
- The German curve shows a peculiar behaviour: it is a step function. If the n_{50}-value is less than 3, a fixed reduction to the total ventilation heat transfer coefficient is applied: the average air flow rate is reduced from 0.7 to 0.6 times the volume.
- In the Netherlands, it can be noted that the total ventilation heat transfer coefficient does not diminish any further if the airtightness drops below a certain threshold value. Apparently, the (implicit) assumption is made that the inhabitants will then increase the voluntary ventilation rate, so that the total air flow remains constant. In the Netherlands, it is also said that such low levels of airtightness cannot be reliably predicted at the time of the building permit, and are therefore not given any bonus anymore in the EPB-calculations. Note that the point below which the total ventilation heat transfer coefficient remains constant, varies depending on the type of ventilation system: for example, it would have been different in case of a fully mechanical ventilation system.

Generally speaking, it can be seen that in many instances the EPB-calculation method gives a bonus all the way to the limit value of perfect airtightness (n_{50}=0). In instances where the total ventilation heat transfer coefficient does not diminish any more below a certain value of the airtightness, i.e. DE and NL for this particular dwelling case, there is no incentive/reward in the EPB-calculation method for further improving the airtightness below this point. Also in instances where it flattens out nearly horizontally (NO and PO for this particular dwelling case), there remains little stimulus in the EPB-calculation method to strive for very good airtightness levels. However, there may be other explicit requirements that impose a certain degree of airtightness (e.g. the maximum n_{50}-value in Norway).

It is not the intention here to discuss which model best represents the real behaviour of the building and its users. The purpose was only to highlight the consequences of some calculation details. When an EPB-calculation methodology is established (whether on international/European level, or on national level), the authors should be aware of such effects, and give careful consideration to it.

FURTHER CONSIDERATIONS

Although the final graphs seem simple and straightforward, several national calculators reported that they found it rather hard to perform the calculations. This is indicative of the fact that the treatment of airtightness is not always very clear in the national calculation methods.

This may in part be due to the fact that until now in many countries the focus of the EPB-regulations has often been primarily on the design process at the time of the demand for a building permit. At that time, the airtightness is unknown, and it is difficult to predict or commit oneself to precise future performances. Even though it is an explicit input variable in the EPB-calculation, many regulations seem therefore to remain vague on the issue of airtightness:

- There are no clear rules how the airtightness should be determined at the time of the demand for building permit.
- There is no unambiguous default value.
- It is unclear if an airtightness test should be performed upon completion, if at the time of the design a better than default value is assumed.
- Etc.

As a result, simple estimation methods (e.g. based on the type of construction, e.g. cavity wall, poured concrete, timber framing, etc.) are sometimes used to establish a value during the design stage. However, no check, by means of an airtightness measurement, is then made upon completion of the building. Consequently, too favourable hypotheses may take hold, with informal default values becoming widely accepted without being contested anymore. The EPB-regulation then doesn't constitute a strong stimulus to pay careful attention to airtightness during design and execution.

Now that, due to the EPBD, certification is being made mandatory for all new buildings upon their completion, this may be an opportunity to create clear rules with respect to the treatment of airtightness in the EPB-regulations. The as-built situation allows for real proof by measurements. It can therefore be advised to regulatory bodies that they only allow better than default airtightness to be used in calculating the certificate if the value is proven by an airtightness test. A further advice is that the default airtightness be unambiguously defined, and that its value be chosen such that there is sufficient incentive to do the effort and expense to perform an airtightness test, i.e. the default value should be sufficiently high. Clear rules should also be spelled out on the consequences when the overall EP-requirement is not fulfilled because the achieved airtightness does not live up to the design hypotheses. Similarly, there should be unambiguous rules about the consequences of not respecting an explicit airtightness requirement (e.g. n_{50} < 3/h).

ACKNOWLEDGEMENTS

Different national contributions were made by many of the project partners. The partners are all listed on www.asiepi.eu.
The ASIEPI project is partly financed through the Intelligent Energy for Europe programme (administered by the EACI). In addition, many project partners obtained co-financing from national instances.

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