Stimulating better envelope and ductwork airtightness with the Energy Performance of Buildings Directive

F.R. Carrié, M. Fleury, G. Voisin
Centre d'Etudes Techniques de l'Equipement de Lyon
46 rue Saint Théobald
F – 38081 L'Isle d'Abeau Cedex, France

T. Aurlien
SINTEF Byggforsk
PoBox 124 Blindern NO-0314 Oslo, Norway

ABSTRACT

The Energy Performance of Buildings Directive mentions that each member states' energy performance (EP) calculation methodology may include envelope airtightness. In fact, many member states have included envelope airtightness in their EP calculation method. Many countries have also specific requirements for ductwork airtightness. However, they seem to be unequally successful in achieving a market transformation. This paper describes the mechanisms that have been used in some countries, with a special focus on success stories which could inspire other member states. The measures include actions directly related to the EP regulation as well as accompanying private or public initiatives (e.g., pilot projects, training). The paper is based on the analysis of a questionnaire submitted to experts in 13 countries as well as interviews and a literature review. It appears that adequate tuning of the EP regulation and ambitious low-energy buildings initiatives are excellent drivers to change the envelope airtightness market; however, in general, there remains a lack of practical tools for designers and craftsmen to build airtight envelopes although appropriate industrial products are available. As for ductwork, careful design coupled with widespread use of pre-fitted seals appear to be the dominant common element of success stories. This work has been performed in the framework of workpackage 5 of the ASIEPI project funded under the Intelligent Energy Europe programme.

KEYWORDS

air infiltration, envelope, ductwork, leakage, airtightness, energy consumption, market

1. INTRODUCTION

One objective of the EU SAVE funded project ASIEPI (Assessment and Improvement of the EPBD Impact, October 2008 until March 2010) is to study the issue of building and ductwork airtightness. The specific work package entitled 'Stimulation of good building and ductwork airtightness through EPBD', aims to give a clear picture to policy makers regarding the way better envelope and ductwork airtightness is stimulated in the member states, including indications on the impact of the measures taken to transform the market.

The reason behind this concern lies in the potentially large energy and ventilation impacts of envelope and ductwork leakage. To give and idea, in Belgium and in Germany, it is estimated that envelope airtightness accounts for about 10% of the energy performance level. In these countries, the potential benefit of better envelope airtightness is similar to the installation of solar collectors.

We have submitted a questionnaire to 13 experts in the 13 countries (BE, CZ, DE, DK, ES, FI, FR, GR, IT, NL, NO, PL, PT) represented within the ASIEPI consortium in November 2007. The survey included 22 questions dealing with the way envelope and

ductwork airtightness is taken into account in the regulation; the market uptake of better envelope and ductwork airtightness and reasons behind; and the major barriers towards better airtightness.

This paper summarises the results of the questionnaire and gives ways to explore to achieve better ductwork and envelope airtightness based on the success stories and trends observed.

2. OVERVIEW OF AIRTIGHTNESS IN NATIONAL REGULATIONS

Most (10/13) (BE, CZ, DE, DK, ES, FI, FR, NL, NO, PL) countries investigated take into account envelope airtightness in their energy performance calculation procedures (Figure 1). At least 7 out of these 10 countries give the possibility to reward good envelope airtightness as it results in a lower "regulatory" energy consumption. Six countries also have minimum requirements on envelope airtightness (CZ, DE, DK, ES, NL, NO); in Spain specific requirements apply only to windows. In general, there is no requirement for existing buildings except in case of major renovation (CZ, DE).

Six countries (CZ, DE, GR, IT, NL, NO) do not have specific regulations dealing with ductwork airtightness, seven (BE, DK, ES, FI, FR, PL, PT) do (Figure 2). Five countries (DK, ES, FI, PL, PT) have a minimum requirement, three of which (ES, FI, PT) have compulsory testing at commissioning. Two (BE, FR) take into account ductwork leakage in their calculation procedure, although it is limited to some building types in Belgium (Flemish region). Ductwork leakage has been identified as a major source of energy wastage in Nordic countries (DK, NO, FI) for several decades. It is has been resolved with the widespread use of duct components with pre-fitted joints and therefore, does not seem to be a critical issue in these countries. No country surveyed has requirements for existing buildings.

The compliance schemes to the regulation obviously depends on the nature of the requirements. Most of the time, a pressurisation test has to be performed to be able to claim for a reward for good envelope or ductwork airtightness. In theory, the compliance to a minimum requirement should be systematically tested. However, to our knowledge, this is done only in the UK, where envelope pressurisation tests are compulsory since 2006 in all new buildings. This requirement extends the previous one in force since 2002 for large buildings (over 1000 m^2). Note that although compulsory testing does not apply in Denmark and Germany, these countries test respectively 5% and 15-20% of their new buildings. Also, ductwork testing is very widespread in Denmark.

There exists alternative routes to pressurisation tests. Quality management approaches are rewarded in Finland and in France. In other words, if a builder proves that he has implemented a quality management approach to obtain good envelope airtightness, he can use a value different from the default value in his energy performance calculation. In Finland, this route is targeted primarily at pre-fabricated houses. In France, the alternative route is applicable by all builders of individual houses. The approach has to be approved by the ministry based on a dossier filled by the builder that includes airtightness measurements on a sample of buildings. A few dossiers are being processed in 2008.

An alternative route had been explored in the UK as well some years ago, based on the adoption by builders of "robust" construction details for residences, defined in a reference document. However, we heard that the evaluation of the scheme, based on leakage measurements of buildings that went through this process, did not give satisfactory results: apparently, about half of the buildings tested failed.

The UK experience calls into question the relevance of the more recent French and Finnish approaches, although it is clear that the success of such schemes depends heavily of fine tuning. In fact, these approaches appear similar in principle, but they include important differences in their implementations. Therefore, especially if found successful, these approaches should be carefully evaluated, in particular to identify the

keys to success and barriers, so that other countries could benefit from their experience.

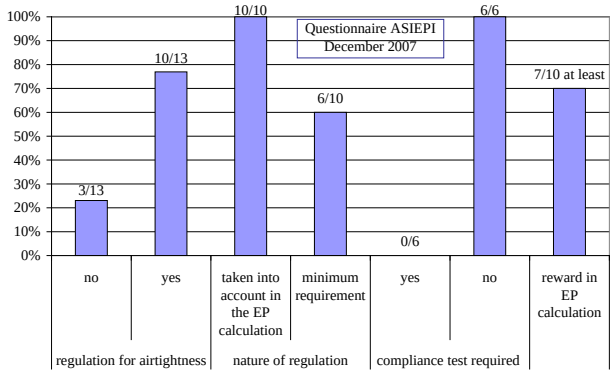

Figure 1. Overview of envelope airtightness in national regulations.

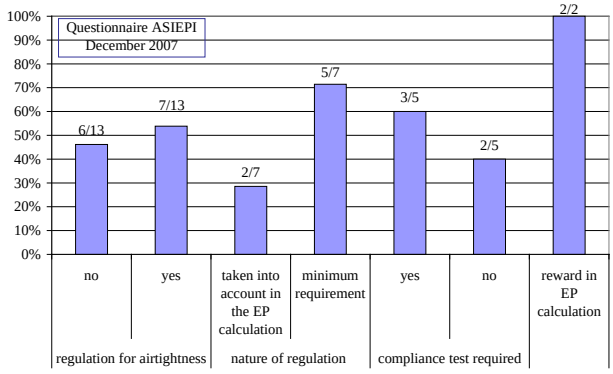

Figure 2. Overview of ductwork airtightness in national regulations.

3. MARKET STATUS, TRENDS AND BARRIERS

Most countries (11/13) underline a change in practice as regards envelope leakage (Figure 3); this is not felt only in Finland and in Spain. The experts questioned explain this change with the regulatory measures as well as with the positive influence of a few pilot projects. Nine experts have mentioned the pilot projects in their questionnaire, among which: the many German projects certified by the PassivHaus Institute; the AISE project in Finland; some projects financed under the PREBAT programme in France; and the Wroclaw passive houses in Poland.

On the other hand, there does not seem to be a trend towards better ductwork airtightness. Only four countries (DE, FI, NL, NO) consider that there is a growing interest for this subject, although duct leakage is probably already better addressed in these countries than in the rest of Europe, especially in Finland and Norway where pre-fitted seals are widely used already (Figure 4).

Regarding the barriers, the experts were asked to answer the following questions :

- are there tools to help owners, designers, builders, craftsmen build tighter envelopes/ductworks ?
- are there companies offering pressurisation tests in your country ?
- how often are buildings or ductwork pressure-tested ?
- are there pressurisation tests for multi-family or large buildings ?

Figure 3 and Figure 4 summarise the quantitative answers provided. Globally, it appears that there is lack of practical tools to raise awareness among owners and provide guidance to designers, builders, and craftsmen. Nine (9/13) countries do not have documentation for practitioners. Among the four remaining, technical guides are explicitly mentioned in Germany, the Netherlands, and Norway. The Czech Republic mentions seminars and working groups on this issue. Specific projects giving technical details and methods to achieve better envelope and ductwork airtightness are underway in France.

Note that the experts feel that envelope airtightness is rarely (4/13) (DE, DK, NL, NO) or very rarely (9/13) tested in all countries investigated; these tests are frequent in none of the 13 countries (Figure 3). The experts feel that few or very few companies can perform pressurisation tests except in Germany, Denmark and the Netherlands. Interestingly, the number of companies offering this service has increased significantly in France within the last year due to the increasing demand induced by the significant reward for better airtightness in the EP calculation.

Technical difficulties associated with the measurement of large or multi-family buildings are also underlined in the questionnaire answers. These are extremely rarely tested; besides, the tests are performed on a building zone (e.g., an apartment) rather than on the whole building

envelope as required by EN 13829. In the Netherlands, Norway, and Poland, the test is always performed on a sample of apartments or on a building zone (for NL and PL).

Finland mentions the description of quality control procedures for ductwork as tools to achieve better airtightness. On the other hand, Norway says that the single most important measure is that almost all new duct systems are round steel with self-sealing rubber joints, which have airtightness class D. This comment is consistent with the conclusions of the SAVE-DUCT project where Belgium, France, and Sweden were represented. However, there may remain design issues not properly addressed in some countries that prevent the widespread use of these products: the use of duct components with pre-fitted seals is clearly a relevant answer to the problem, but it requires a more careful design as these components cannot be used with as much flexibility as raw components. For example, the benefit of a pre-fitted tee-junction vanishes if the component has to be customized on site because a water pipe is in the way.

Ductwork pressurisation tests are very rarely performed, except in Denmark (frequently) and the Netherlands (rarely), and probably in Finland (Figure 4). In Denmark, ductwork pressurisation tests are commonly performed by the installer at commissioning. Many companies offer this service in Finland; in other countries, these tests are performed mostly by research laboratories (FR, PL) and manufacturers for quality control (DK, FL, NO). No significant trend has been identified.

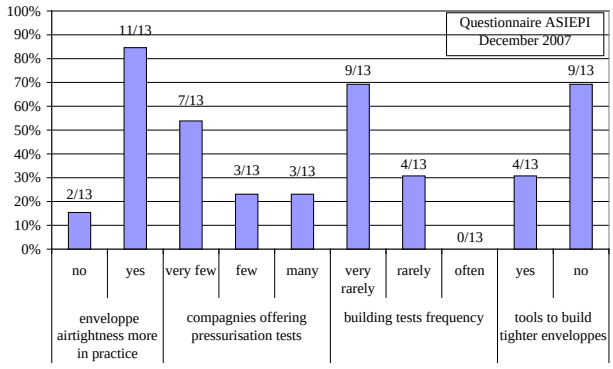

Figure 3. Market status, trends and barriers on envelope airtightness.

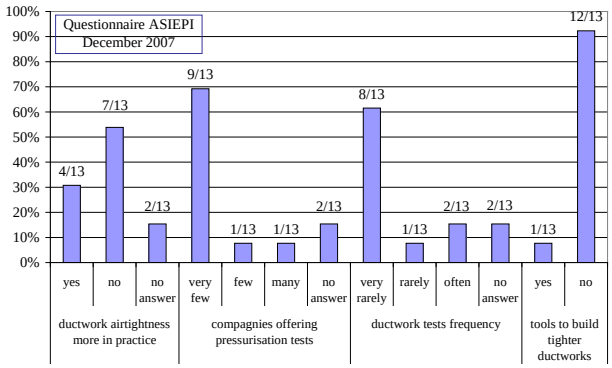

Figure 4. Market status, trends and barriers on ductwork airtightness.

4. SUCCESS STORIES TO LEARN FROM

Many years ago, in the 1970s, envelope airtightness had already been identified as a major problem to efficiently ventilate buildings. In the Air Infiltration Review (AIR) of August 1980, an article entitled ‘Build tight – ventilate right’ already very well described the challenges. However, since then and until 3-5 years ago, little had been done in most countries. One noteworthy exception is Germany where the pioneering work on very low energy buildings by the PassivHaus Institute has provided excellent roots for disseminating the concept and realisation airtight buildings.

This growing concern for very low energy buildings that generates pilot and research projects in the member states is probably one key explanation of the positive signs of a market transformation felt in many countries (11/13).

Another key reason certainly lies in the energy performance regulation requirements. Most (10/13) countries investigated take into account envelope airtightness in their EP calculation procedure as suggested by the EPBD. If well-adjusted, the reward given for better airtightness can be a major driver for change as it can be a very cost-effective measure to reduce energy use (as mentioned previously, the potential benefit of an airtight envelope is in some countries similar to the installation of solar collectors).

The last key reason we identified is the dissemination strategy. In fact, the communication around pilot projects and the EP regulations has intensified in the last few years. In France, in 15 months, over 700 persons have participated to 5 events that specifically addressed airtightness in various regions. 5000 persons have attended to the 66 national campaign events on the new energy performance regulation (RT 2005). This is good of course but probably insufficient if practical local tools to build airtight are not available. All experts mentioned a lack of such tools, except for Germany where an association for airtightness has published practical recommendations (FliB, 2001). Recommendations should be available in France before the end of 2008.

Regarding ductwork leakage, the major reason behind the success stories observed in Denmark, Finland, and Norway lies in the widespread use of ducts with pre-fitted seals. Maybe this reason hides another one, which is the careful design of ventilation systems and ductwork in these countries compared to most other countries investigated. In fact, it is proven that pre-fitted components are very efficient solutions; however, this is not the case when they need to be customized on site, for instance, because unexpectedly a water pipe is in the way. Therefore, the challenge is precisely to avoid customisation on site, which means that extra care should be given at design stage. In sum, careful design coupled with widespread use of pre-fitted seals is certainly one way to explore to drive the market towards tighter duct systems.

5. CONCLUSIONS

Based on the analyses of the questionnaires filled in by the experts, we have identified that the market is changing towards better envelope airtightness in many countries. This is due to a combination of measures that push the market, in particular, the EP regulation, which in some cases, significantly rewards good airtightness, as well as pilot and research projects; and measures that pull the market, for instance, awareness raising seminars and campaigns, etc. Note however that the lack of practical tools (e.g., catalogues of construction details) to build airtight envelopes is probably a significant barrier to a faster transformation. The situation is quite different for ductwork airtightness which may be explained in many countries by a combination of a lack of attention paid to the design and commissioning of ductwork and the limited use of pre-fitted seals although they have proven to be very effective. In sum, while most key elements for a market transformation on envelope airtightness appear to be present, many seem to be missing for the duct market starting with the care given to ventilation systems design and commissioning. Awareness raising among prescribers, designers, and craftsmen, as well as the availability of adequate tools to help ductwork designers seem essential to widen the use of pre-fitted seals which is obviously one very effective response to this problem.

6. DISCLAIMER

ASIEPI has received funding from the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278. The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Communities. Neither the European Commission nor the authors are responsible for any use that may be made of the information contained therein.

REFERENCES

EN 13829 (2000). *Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method* (ISO 9972:1996, modified).

EN 13465 (2004). *Ventilation for buildings – Calculation methods for the determination of air flow rates in dwellings.*

FliB (2001). *Luftdichtheit von Gebäuden, Anforderungen, Planungsund. Ausführungsempfehlungen sowie* - beispiele. Technische Empfehlungen und Ergänzungen des FLiB e.V. zur DIN 4108-7, Ausgabe August 2001.

Table 1. Synthesis of ASIEPI WP 5 questionnaire.
December 2007.

	BE	CZ	DE	DK	ES	FI	FR	GR	IT	NL	NO	PL	PT
Overview of airtightness in national regulations													
Envelope airtightness													
Envelope airtightness in EP regulation	X	X	X	X	X	X	X			X	X	X	
Minimum requirement for envelope airtightness		X	X	X	X					X	X		
Compulsory testing at commissioning													
Envelope airtightness in EP calculation	X	X	X	X	X	X	X			X	X	X	
Reward in EP calculation for envelope airtightness	X	?	X	X	?	X	X			X	X	?	
Alternative for reward pressurization test						X	X						
Requirement for existing buildings (if major renovation)		X	X										
Ductwork airtightness													
Ductwork airtightness in EP regulation	X			X	X	X	X					X	X
Minimum requirement for ductwork airtightness				X	X	X						X	X
Compulsory testing at commissioning					X	X							X
Ductwork airtightness in EP calculation	X						X						
Reward in EP calculation for ductwork airtightness	X						X						
Requirement for existing buildings													
Market status, trends and barriers													
Envelope airtightness													
Change in practice as regards envelope airtightness	X	X	X	X			X	X	X	X	X	X	X
Documentation for practitioners about envelope		X	X							X	X		
Frequent pressurization tests on envelope													
Many companies performing envelope pressurization tests			X	X						X			
Ductwork airtightness													
Change in practice as regards ductwork airtightness			X			X				X	X		
Documentation for practitioners about ductwork						X							
Frequent pressurization tests on ductwork				X	X	X							
Many companies performing ductwork pressurization tests						X							