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Comparison of Energy Performance Requirement Levels:

Possibilities and Impossibilities

Summary report

Main author:

Marleen Spiekman, TNO

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SUMMARY

The main recommendations, which are described in more detail in part A, can be summarised as follows.

Comparing the energy performance (EP) requirement levels among the countries of Europe constitutes a major challenge. From the comparison of for instance the present Dutch requirement level (EPC) of 0,8 with the present Flemish level of E80, you can easily see that direct comparison is not possible. Within ASIEPI we developed a method for comparing EP requirement levels and while doing so, we learned several lessons which lead to the following conclusions and recommendations:

- Although at first sight it may seem easy to make a comparison of EP requirement levels among countries, in fact it is difficult to propose a fair and robust comparison method. In that respect: be careful when interpreting results of comparison studies, since it is hard to completely understand a comparison study if you don't know all boundary conditions and since conclusions might therefore be misleading.

- Countries take into account a different set of energy uses in the assesment method of the EP requirements. Some only take into account heating and cooling needs, while others also incorporate heating and cooling systems, hot water, various auxiliaries and/or lighting. This is a problem when making a comparison since the methods are overall performance methods not component methods: A moderately insulated house with an efficient hot water boiler can be as good as a house with much insulation and a less efficient hot water boiler. If the water boiler is not taken into account in some countries, by definition this means comparing apples with oranges.

- In addition, there is no harmonised way of assessing building components and systems. Current standards often mix common procedures with national choices, which make comparing assessment results far from evident.

- The previous two issues **make a robust comparison at this stage simply not possible**. The situation might partly change due to the recast of the EPBD which (again, but now explicitly) demands that countries enlarge the scope of their EP assessment to include technical systems and hot water. It is recommend to continue the development of harmonised CEN Standards because these are crucial for proper comparison. Measures which clearly influence the energy efficiency of a building in a country should be a variable part of the national EP methods and also CEN Standards should address all these relevant national measures (even if they are only relevant in only a small part of Europe), so a uniform assessment is possible. For this it is important that all countries support the European methods. Developing European methods should be done by the intensive involvement of the Member States.

- The severity of energy performance requirement levels varies within countries with, for example, building types, shapes, and system choices. Therefore, a simple rank among countries does not exist, which makes comparison prone to unfair comparisons or even manipulation.

- The method developed within ASIEPI is far from perfect, but taking into account the complexity of the task, it is a good start. It is designed to suit expected future developments, e.g. within CEN and ISO, which will make the comparison method more

suitable in the future. The method includes an index to incorporate the severity of the climate.

In general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, would be in place.

- Since the need for European and worldwide comparison of energy use will expand, we recommend to further develop the climate severity index and eventually incorporate it within CEN and ISO.

Part B gives an overview of all project material that is available on this topic.

Part C gives a brief description of the overall project, its partners and sponsors.

TABLE OF CONTENTS

SUMMARY **3**

TABLE OF CONTENTS **5**

Part A: Final recommendations

1. INTRODUCTION **7**

2. LESSONS LEARNED **8**

2.1 Introduction 8

2.2 The EP-regulations are dynamic 8

2.3 National methods contain different energy uses 9

2.4 One requirement level doesn't mean one severity of energy saving measures 10

2.5 Climate severity is a crucial factor in the intercomparison 12

2.6 Context cannot be overlooked 13

2.7 Compliance and control 14

2.8 Conclusions 14

3. COMPARISON METHOD **15**

3.1 Introduction 15

3.2 Step 1: Description of the cases 15

3.3 Step 2: National calculations of average insulation levels 16

3.4 Step 3: Uniform calculated energy use 17

3.5 Step 4: Climate Severity Index 17

3.6 Step 5: Qualitative evaluation 18

3.7 Conclusions 18

4. CONCLUSIONS AND RECOMMENDATIONS **19**

4.1 Conclusions 19

4.2 Recommendations 19

5. REFERENCES **20**

PART B: BIRD'S EYE VIEW OF THE PROJECT RESULTS

6. INTRODUCTION **21**

7. PUBLISHED RESULTS **21**

7.1 Technical reports 21

7.2 Information papers 23

7.3 Web events 24

7.4 Presentations-on-demand 25
7.5 Abstracts and conference papers 26

PART C: GENERAL PROJECT DESCRIPTION AND ACKNOWLEDGEMENTS

8. GENERAL PROJECT DESCRIPTION 27
8.1 Introduction 27
8.2 Project materials 27
8.3 Project partners 28
9. ACKNOWLEDGEMENTS TO CONTRIBUTORS 29
9.1 Project partners 29
9.2 Subcontractors 32
10. ACKNOWLEDGEMENTS TO SPONSORS, OTHER ASSOCIATES AND FUNDING PARTNERS 33
10.1 Overall project sponsors 33
10.2 Partner associations 33
10.3 National cofinancing 33

Part A: Final recommendations

1. INTRODUCTION

EP stands for Energy Performance. This term is abbreviated throughout this rest of this report.

For outsiders, a national EP **requirement level** is quite a black box. It is almost impossible to have an idea of what such a national requirement level means exactly when one is not working with the national calculation method in question regularly. For instance, the EP requirement level for residential buildings in Flanders (Belgium) is presently E80, whereas the Dutch EP requirement level (EPC) is presently 0,8. What do these levels mean? What does it mean that recently in Flanders the EP requirement level has been tightened from E100 to E80? And is this step comparable, bigger or smaller compared to the planned tightening in the Netherlands from EPC 0,8 to 0,6?

The **calculation methods** to assess the EP levels differ from country to country. This is partly due to the fact that the EPBD is a good example of application of the subsidiarity principle: the framework is set in the directive, but the Member States have the control over the details. And even if in the future the EP methods will be fully harmonised by CEN, there are a lot of national differences which influence the energy use, as for instance national health regulations influence the building ventilation rates. Also more obvious differences between countries, like building use, indoor climate conditions, outdoor climate, construction traditions, availability, usability and cost of technologies and labour, to name a few, make a comparison of the requirement levels between the Member States far from evident. This is especially true in a legislative environment.

That energy uses calculated by national methods give incomparable results can be illustrated by a study performed for the Flemish Government (1) where the energy use of a single family house was calculated with the Flemish, Dutch, French and German method. Given that the climate in these neighbouring countries is very nearly the same, the energy uses should be more or less similar, which they were not, see figure 1. Taking into account the fact that in the Netherlands and France energy use for lighting was part of the total energy use, which wasn't the case in the other two countries, the results clearly show that the national methods give incomparable results. A uniform method to assess the energy use in a similar way is necessary (but not enough) for a robust comparison.

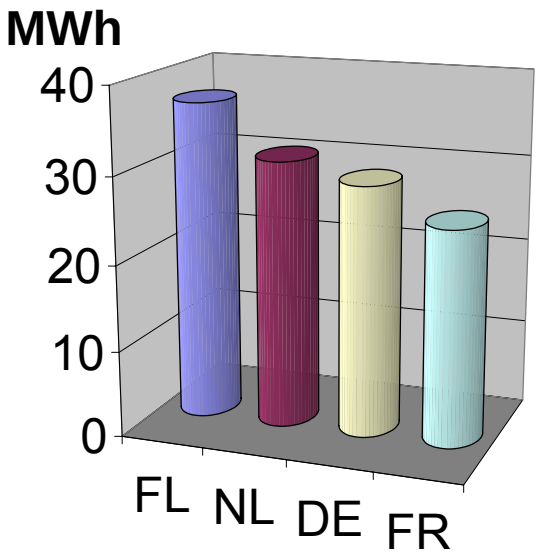


Figure 1: Energy use of the same single family house, calculated with 4 national EP calculation methods

A **method for comparing** EP requirement levels is an important tool for several groups.

- The ambition of the European Commission is for new European buildings to become 'near zero energy buildings' in 2020. Monitoring the progress of the individual countries and comparing the interpretation of this ambition among the countries of Europe is crucial to determine where extra resources are necessary to be able to reach the common goals.
- It would enable Member States to get an impression about where their EP requirement levels stand compared to their neighbours.
- And in the rapidly evolving European playing field of improving EP requirement levels, it is important that industrial companies and branch organisations are informed on the relative tightness among the countries: the EP requirement levels influence the market potential of energy saving products in countries.

Within ASIEPI we developed a method for comparing EP requirement levels and while doing so, we learned several lessons. The method and these lessons learned are summarised in the next paragraphs together with the conclusions and recommendations we drew from our experiences.

2. LESSONS LEARNED

2.1 INTRODUCTION

Developing a method to compare EP requirement levels is a challenging task. One of the most valuable results of this development probably isn't the actual method itself, but the lessons learned during the process. These lessons l provide an important source of information about possible pitfalls related to the comparison of energy uses and EP requirement levels among countries. This knowledge is crucial for a proper comparison, to avoid assessors stepping into various traps, and therefore form a crucial part of the comparison method.

Pilot studies

This chapter will focus on these lessons and will illustrate them with results of the pilot studies which were performed.

2.2 THE EP-REGULATIONS ARE DYNAMIC

It is important to realise that EP policies, methods and procedures are dynamic. During the ASIEPI project several countries tightened their EP requirement levels and changed, or are in the process of changing, the EP calculation method, like Italy, Germany, Denmark, France, Belgium and the Netherlands.

This has several consequences:

- The continuously and rapidly changing methods make a detailed analysis of the formulas used in the EP calculations for comparison reasons unrealistic. The CENSE project (2) has shown that at the moment various formulas incorporated by national standards are comparable globally, but vary in the details. That differences in details can have a significant effect can be seen from a comparison between the Dutch and the Flemish method. These two methods are quite similar, more similar than many of the other national methods in Europe, but of course they vary on details. The impact of these details can be seen in figure 1 in the introduction: The energy use of the house calculated by the Flemish method is higher than the energy use of exactly the same house calculated by the Dutch method. And this difference becomes even bigger if you would exclude the energy use for lighting, which is taken into account in the Dutch, but not in the Flemish calculation (and which doesn't fall in the category 'details'). During the particular comparison study (1) an

effort was made to compare the Dutch and Flemish method in detail to see what exactly produced these differences. Even though the methods were written in the same language and the developers of both methods were involved themselves, a satisfying answer wasn't found. This illustrates that comparing formulas is difficult in the first place, because the differences will mainly be in the details, not only in the general philosophy of the methods. Adding to the fact that methods are changing rapidly, sometimes even continuously, the conclusion is that comparing methods on formula level is unrealistic.

- Another consequence of the rapidly changing national methods has been that the results of the studies done in this project age quickly as well. Some examples:
  - *During the project the EP requirement levels in Germany and Flanders were tightened. Part of the comparison studies done in ASIEPI give a too conservative picture of the German and Flemish requirement level.*
  - *During the project the Polish method became official. The official method differs drastically from the draft-method, which had been used in the first part of this study, while awaiting the formal method.*
  - *In the last phase of the project, the Italian method expanded, among other things, the energy uses which are taken into account.*

The result is that some comparison results within ASIEPI are outdated: The current situation of some countries may have changed to better insulation levels.

In conclusion, the lesson is clear: since national EP calculation methods and EP requirements are changing rapidly, the comparison method should be relatively simple (as opposed to comparing methods on formula level), and in any case the results will have a limited tenability.

2.3 NATIONAL METHODS CONTAIN DIFFERENT ENERGY USES

The first pilot study which was performed by all partners, gave crucial insight. In the first pilot study all partners were asked to perform an EP calculation for a specific single family house. A drawing of this house is given in figure 2.

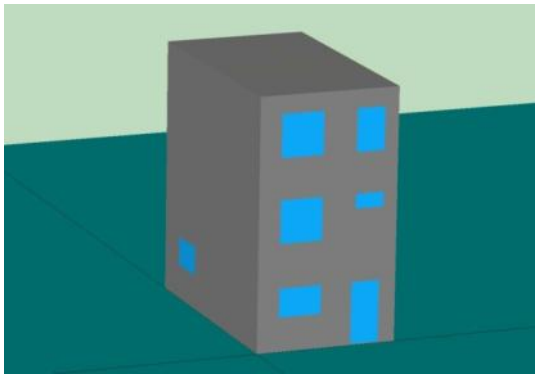


Figure 2: Pilot house

The task was to equip the house with a set of energy saving measures so as to fulfil the EP requirement level in their country. The result was a general list with energy saving measures for every country, like boiler types, insulation values, window types, etc. Two things were clear from these results:

1. Comparing these sets of measures would only be possible with fully harmonised CEN standards and experience from a previous study (1) learned that even than a precision of say more then 20% will probably never be reached.
2. In several countries various sets of energy saving measures needed to fulfil the national EP requirement level didn't contain heating and cooling systems, measures to reduce the energy use for domestic hot water and/or measures to reduce the energy use for lighting. This finding made it clear that a comparison of EP requirement levels in Europe isn't possible at this stage, since the performances which would be compared have completely different definitions.

For instance: In Finland the EP requirement is based on the heating need only, while in the Netherlands the EP requirement is based on the energy use for heating, cooling, domestic hot water and fans, including the energy use of the systems. To reach the EP requirement level in the Netherlands a relative poor efficiency of the domestic hot water boiler can be compensated by better insulation of the building and vice versa, while in Finland the efficiency of the domestic hot water boiler is no issue in the EP requirement level of a building. The insulation levels of the Finnish and Dutch building cannot be compared: a lower insulation level in the Netherlands could mean that the EP requirement is less tight, but it could for instance also mean that the energy requirement is more tight because the domestic hot water boiler has a very good efficiency which more than compensates for the lower insulation level.

This second aspect makes it impossible to compare EP requirement levels at this moment, therefore the results of all the ASIEPI pilot studies cannot be used for comparison. However, they are still useful in the process of developing an assessment method for comparing EP requirement levels in the future, once the issue of different energy uses is solved.

2.4 ONE REQUIREMENT LEVEL DOESN'T MEAN ONE SEVERITY OF ENERGY SAVING MEASURES

By performing several pilot studies in a systematic way important issues were discovered related to the severity of the sets of energy saving measures in the different countries.

An important lesson was that there is not 1 level of energy saving measures for all situations attached to an EP requirement level in a country. It would have been nice if there was only one level of energy saving measures per building function, since ultimately many people like to rank all countries simply on one scale. But in fact some houses need more severe energy saving measures to reach the EP requirement than other houses.

Before further analysing this issue, the pilot studies briefly are explained: Because it wasn't possible to compare the sets of energy saving measures in the first step (see 2.3), the strategy was changed. In a second step, all partners were given a set of cases, including a detached house, a semi-detached house and a row house. All houses are equipped with a specific boiler, a specific ventilation system and a specific hot water system. The question to the partners was: "What is the average insulation level needed in the houses to fulfil the EP requirement in your country?." Each country representative thus needed to make an EP calculation for each of the three cases with his national EP method.
The result for one of the houses (the same house as shown in figure 2) can be seen in table 1.

MS	$U_{average}$ (W/m²K)
BE	0.54
CZ	0.50
DE	0.47
DK	0.36
ES	0.80
FI	0.25
FR	0.56
IT	0.70
NO	0.23

Table 1: Average insulation levels, needed to fulfil the EP requirement level in various countries for a specific semi-detached house (values for 2008).

Note that a low U-value means a high insulation level.

Based on the results in table 1 in a first instance one could think that the EP requirement level is higher in Norway than in Italy because the insulation level is much higher in the former. But due to climate differences it is not as easy as it looks, as is shown later in this chapter.

One out of many aspects that influence the level of energy saving measures is the loss area and the way countries deal with loss area compensation. Table 2 illustrates different country approaches to heat loss area compensation. The table shows the average U-value for floor, roof and facades which is needed to reach the EP requirement in each country for a detached house, semi-detached house and row house of the same size and form.

(Due to the fact that the ratio of window to opaque construction area differs among the three house types and the fact that these different ratios influence the average U-value and with this interfere in the comparison of the insulation levels, table 2 contains values of the average opaque U-level only.)

Detached house | semi-detached house | row-house

MS	U_{opaque}
ES	0,55
DE	0,33
BE	0,30
FR	0,34
FI	0,17
NO	0,11

MS	U_{opaque}
ES	0,52
DE	0.35
BE	0,33
FR	0,32
FI	0,15
NO	0,13

MS	U_{opaque}
ES	0,47
DE	0,38
BE	0,39
FR	0,29
FI	0,13
NO	0,16

Table 2: Average insulation levels of the opaque areas (floor, walls roof), needed to fulfil the EP requirement level for a specific detached, semi-detached and row house (values for 2008/2009, U-values in W/m²K)).

In this example, in Germany, Belgium and Norway a detached house needs more insulation than a row house, which makes sense since the energy losses are higher for a detached house. In Spain, France and Finland it is the other way around in this example: the detached house needs less insulation than the row house, due to other compensation rules. Differences in compensation rules can for instance occur when countries deal differently with the fact that different building shapes often have different window to wall ratios.

Another example of an aspect that influences the level of energy saving measures is the effect of the compensation of certain heating system types. Table 3 shows the average insulation needed to fulfil the EP requirement level for a specific house with a condensing boiler versus an electric resistance heater in Germany, Belgium and France. When calculating the absolute primary energy use of the houses in the three countries the primary energy uses increases strongly in all three countries

when changing from a condensing boiler to an electric heater. But the amount of insulation needed in France doesn't change in this example, because the maximum allowed primary energy use also increases (since the reference house then also assumes electric resistance heating). This contrasts with Germany and Belgium where the amount of extra insulation to compensate for the electric heating is so big, that it is not realistic in practice.

CB = Condensing boiler

MS	$U_{average}$ (W/m²K)
DE	0.42
BE	0,42
FR	0,56

EH = Electric heating

MS	$U_{average}$ (W/m²K)
DE	Impossible*
BE	Impossible*
FR	0,56

*Not possible, even when house is better insulated than the house with the condensing boiler

Table 3: Average insulation levels, needed to fulfil the EP requirement level for a specific house with a condensing boiler versus an electric heater (values for 2009).

In conclusion: although there might be only one EP requirement level for houses in a country, the severity of the sets of energy saving measures will vary from 1 house to another, due to aspects as compensation of the loss area and compensation of certain heating system types.

2.5 CLIMATE SEVERITY IS A CRUCIAL FACTOR IN THE INTERCOMPARISON

It is clear that climate differences among the countries complicate the comparison. This is easily seen when the insulation level needed to reach the EP requirement level is compared between for instance Italy and Finland for a similar house. Table 1 shows that in Finland more insulation is used than in Italy: The U-value for the specific Finnish semi-detached house is 0,25 W/m²K, while the U-value for the specific Italian semi-detached house is 0,70 W/m²K (and all other energy saving measures are more or less comparable). But in figure 3 it can be seen that the energy use of the Finnish house is higher than the energy use of the Italian house, despite the extra insulation.

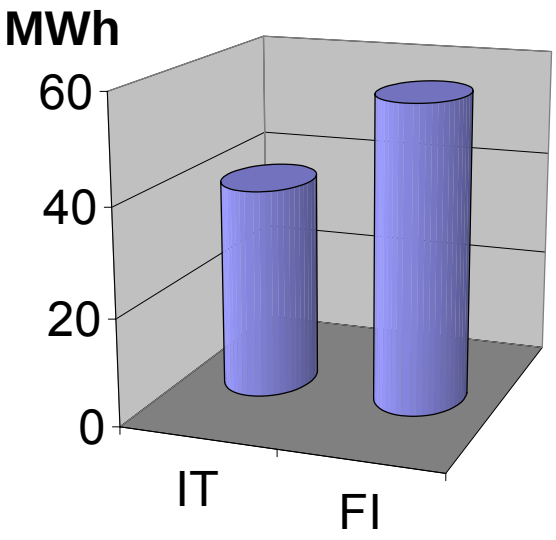


Figure 3: Energy use of a Italian house with an average U-value of 0,70 W/m²K and a Finnish house with an average U-value of 0,25 W/m²K.

So the question remains: in which country is the requirement level the most tight?

To answer this the climate severity index was introduced. This index is based on the method used in Spain where they face very hot climates in the south and rather mild climates in the north-west (8,11).
In short, the severity index is a sophisticated version of the degree days, taking into account the summer as well as the winter severity of a location. The higher the index is, the larger is the severity of the respective climate.

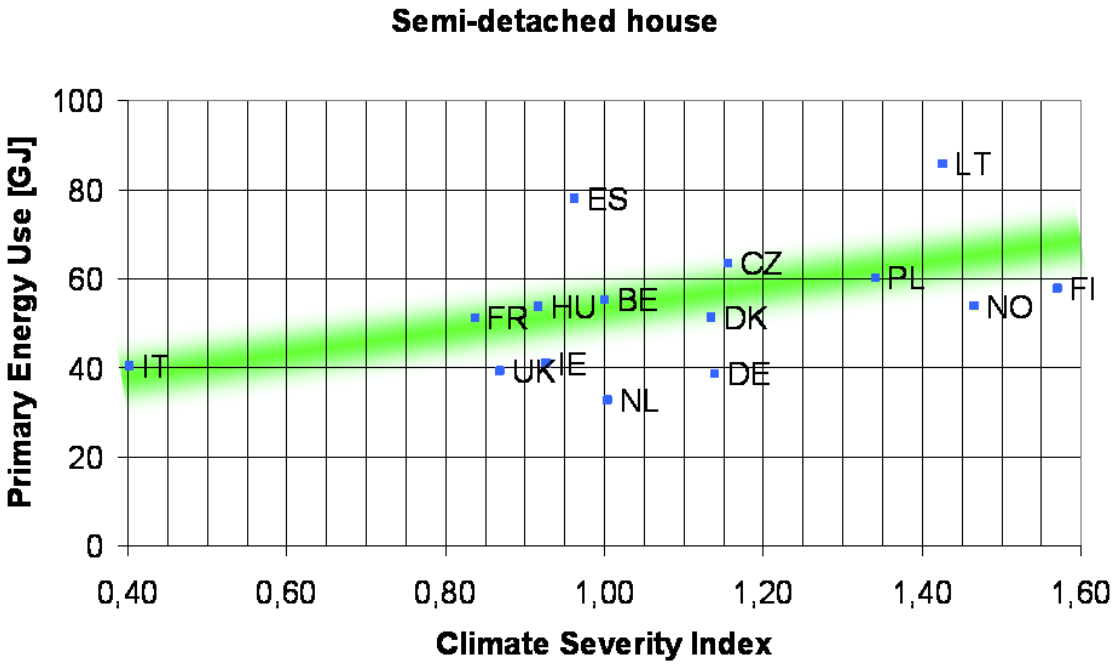


Figure 4: The graph shows the total primary energy use for the semi-detached houses used in the comparison method plotted against the climate severity indexes. Note that the results can only be interpreted in context of all remarks given in this report. Note that the figures in the graph should be handled with extreme care and can otherwise be misleading due to the fact that the energy performance calculations in some countries are based on energy needs and in other countries on total energy uses. Take for instance the case in Spain: in Spain the energy performance requirement is based on energy needs. The consequence is that mandatory measures on system level (like solar collectors) are not compensated within the energy performance requirement if they are left out, as has been done for the sake of the comparison study. In other countries, where solar collectors also are mandatory, but where the energy performance requirements are based on total energy uses, the lack of solar collectors in the comparison study is compensated by other measures. The consequence is that this results in a relatively higher energy use for Spain in the comparison. This example illustrates the fact that at this stage only apples and oranges are compared. The same holds for efficiencies of boilers and COP's of cooling systems.

Figure 4 illustrates how the severity index will work within the comparison method and contains the correlation between the severity index of the locations and the total energy use of a certain house on these locations. Every dot in the graph is a different city in Europe.
Instead of a relative ranking of all the countries in a list, the graph results in only 3 groups: the EP of all countries near the line is more or less equally tight, while the countries in the group above the line are a bit less tight than average and the group below the line are a bit more tight than average.

This '3 group approach' is seen as a big advantage of the method, since there are too many catches in the rest of the method to give a robust ranking of countries anyway.
Note that the method to determine the Climate Severity index is not yet fully developed and needs to be thoroughly evaluated and improved.

2.6 CONTEXT CANNOT BE OVERLOOKED

Another lesson which is discussed is the obvious fact that house typologies and the

effectiveness of energy saving measures can differ largely per country or region. Ideally, the comparison methodology is not based on a set of fixed cases, but on a free choice of house typologies and a free choice of energy saving measures per country or region.

At this moment though, there is no harmonised method available to calculate the total energy use of different houses with different energy saving measures on different locations in a completely uniform way.

For now the comparison method will use the simplified calculation method EPA-NR which has been developed within a European project some years ago (3). Of course EPA-NR is not a completely uniform, harmonised method, but an umbrella based on simplified approaches and estimated performance values for several components. By deliberately using fixed cases with a selected set of energy saving measures we try to minimize the disadvantages of not having a good uniform calculation method.

Once the 2nd generation CEN and ISO standards become available, the fixed choices can be replaced by country and region specific choices. This flexibility will make the comparison method more suitable in the future.

2.7 COMPLIANCE AND CONTROL

Within the ASIEPI project the issue of compliance and control has been addressed [9]. Control is handled differently in the Member States and also related to compliance large differences can be seen. The level of compliance and control is factor which can have an effect on EP requirement levels. Some examples:

- Some countries, for instance Flanders (Belgium) chooses to implement a moderate EP requirement level (compared to a severe level) in combination with a heavy control system in order to achieve a high compliance. Whereas in other countries the EP requirement level can be more severe, while the compliance in practice might be much lower. In such cases, comparing the EP requirement levels might not reflect the energetic quality of the houses build.
- A more concrete example: In the Netherlands air tightness is a variable parameter within the EP requirement of a building. To get a building permit a certain air tightness of the future building is claimed. The value claimed is almost never tested after construction, so there is no proof whether the building complies to the EP level which was promised in the request for the building permit. There is a reasonable chance the promised value will not be reached, and with this the severe EP requirement level will not be reached.

This example illustrates an EP requirement level itself does not say everything about the energetic quality of the houses build in a country.

2.8 CONCLUSIONS

During the development of the comparison method several lessons were learned regarding the development and use of EP calculation methods on national and European scale.
These lessons are worthwhile for developers of calculation methods related to legislation and policy makers, since it is important to know what the possibilities and the impossibilities are regarding the comparison of EP requirement levels. Knowledge of these lessons learned will help to avoid pitfalls in the actual comparison of energy uses and EP requirement levels. But also it will help to avoid pitfalls in developing methods and policies related to comparisons like this.

3. COMPARISON METHOD

3.1 INTRODUCTION

It is clear from the lessons learned that developing a comparison method is not easy. All the different methods, including the one we finally adopted, have their advantages, but also their disadvantages (a short overview of possible alternatives is given in [10]). Within the limits that exist at present, a fair and robust comparison seems impossible. However, to draw the conclusion that no comparison method should be delivered might be counter productive: there is a need for comparison and with or without the ASIEPI method people will compare.
Therefore ASIEPI presents a method which isn't completely fair and robust, but which is transparent about the pitfalls. The charm of the ASIEPI method is that it can be adapted in the future to expected developments, for instance within CEN and ISO. This will make the comparison method more suitable in the future.

The comparison method is divided into 5 steps. The following paragraphs describe each step and discuss various issues.

3.2 STEP 1: DESCRIPTION OF THE CASES

The first step contains several fixed cases: a detached house, a semi detached house and a row house. The houses are all equally large and all have the same shape. Figure 5 shows the floor plans and facades of the semi-detached house and Figure 2 shows a 3-D image of the same house.

The energy saving measures of the three houses are fixed to:

- A condensing boiler with an efficiency corresponding to the minimum imposed by the European Boiler Directive for heating and domestic hot water
- Natural ventilation supply and mechanical ventilation exhaust
- No cooling system, unless this is usual in a comparable house in a country
- No other energy saving measures as solar collectors, photovoltaics, heat pumps, etc

Figure 5: Floor plans and façades of the semi-detached house

At this moment it is necessary to fix the houses as well as the energy saving measures. The form of the houses as well as the energy saving measures have been chosen in such a way to facilitate comparison. The form of the house is simple to minimise measurement errors (complete elimination of these kind of errors appeared to be impossible even with these simple forms, as we found out during the project).
The energy saving measures were also chosen for simplicity and comparability. For instance, the assumption was made that basic condensing boilers would be more or less similar all over Europe. That this assumption could be made, was shown in a study performed within ASIEPI. In this study the efficiency was compared of the basic condensing boilers which were used by the countries in the pilot studies (4). The study showed that the respective efficiencies were close to one another.
To avoid comparison problems due to the

lack of harmonised assessment methods, the amount and complexity of systems and the complexity of the building physics was kept as low and simple as possible: no heat recovery, no additional active or advanced passive heating or cooling systems (besides a basic condensing boiler and, if needed, a mechanical vapour compression cooling machine).

This choice has several disadvantages which are accepted for now, due to lack of proper alternatives:

- House typologies and the effectiveness of energy saving measures can vary largely per country or region. By fixing these choices, the method might not be comparing realistic situations in various countries, which puts into question the results of the comparison.
- Since more advanced or complex energy saving measures are excluded, countries where the EP requirement level is very tight have trouble to participate in the comparison, since more advanced or complex measures simply are needed here to fulfil the EP requirement in these countries. Since the tightening down to EPC 0.8 in 2006, the Netherlands faces these difficulties. And since Germany tightened its EP requirement in the fall of 2009, also for that country the fixed measures start to become a problem. So, in the near future, as the EP requirement level in more countries becomes tighter and tighter, new fixed measures are needed, along with good and harmonised methods to assess the efficiency and effect of these measures.
- Even though the main energy saving measures are fixed in a way to make the national calculations as comparable as possible, many details cannot be excluded or fixed in this way. These aspects will introduce an error in the comparison study. Two of these aspects are for instance the severity of thermal bridges and the level of air tightness. The impact of these aspects can be quite large, therefore a study was performed into how they could be taken into account in the comparison (5, 6). Since the results were inconclusive, these aspects are not taken into account for now. The same goes for many other details, often related to building use.

It is expected that with future developments of harmonised CEN and ISO standards, it will be possible to make a shift from fixed house typologies and fixed energy saving measures to free choices of both for each country or region. This eliminates the first two disadvantages. And with these developments also the third disadvantage would be reduced, because more and more aspects can be properly taken into account. But these developments won't eliminate this problem entirely: In general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, would be in place.

3.3 STEP 2: NATIONAL CALCULATIONS OF AVERAGE INSULATION LEVELS

The second step is that all countries calculate the average insulation level needed to fulfill the EP requirement level in their country. This is calculated for each of the three houses from step 1. For each country the calculations are performed with the respective national EP calculation method. The result is a list of average insulation levels for each house and each country of which examples are given in table 1 and table 2.

This lists of average U-values form a good basis for comparing the EP requirement levels, although of course the issues described in step 1 should always be kept in mind. A direct comparison of the U-values makes no sense for countries with different climates, therefore step 3 is necessary.

3.4 STEP 3: UNIFORM CALCULATED ENERGY USE

To make the results comparable, the total primary energy use of the houses is calculated for each country, taking into account the country's or region's climate and the average U-value needed to fulfil the EP requirement level in each country or region.

Since there is no good and fully harmonised method available to do such calculation, for now EPA-NR is used. EPA-NR (3) was developed within a European project some years ago. It is not a completely uniform, harmonised method, but an umbrella based on simplified approaches and estimated performance values for several components. Although a good and fully harmonised method is preferred, EPA-NR is a reasonable alternative as long as the comparison method uses simple cases only.

3.5 STEP 4: CLIMATE SEVERITY INDEX

But also total energy uses are not comparable directly, as could be seen in paragraph 2.5. Therefore the energy uses are correlated with the climate severity index, as described in the same paragraph, resulting in a graph for each house typology, as illustrated in figure 4. For each house typology it can now be determined if a country or region has an average, a bit worse or a bit better EP requirement level, compared to the other countries.

To show the potential of the Climate Severity Index, within ASIEPI a first attempt has been made to determine the Climate Severity Index for the countries involved in ASIEPI, which resulted in the indices given in table 4. The methodology used to determine these figures is described in (7) and (8).

Country	City	CSI_H	CSI_C	CSI_T
BE	Brussels	1.00	0.00	1.00
CZ	Prague	1.16	0.01	1.17
DE	Berlin	1.14	0.02	1.16
DK	Copenhagen	1.13	0.00	1.13
ES	Madrid	0.52	0.44	0.96
FI	Helsinki	1.57	0.00	1.57
FR	Paris	0.84	0.05	0.89
HU	Budapest	0.92	0.23	1.15
IE	Dublin	0.93	0.00	0.93
IT	Rome	0.40	0.45	0.85
LT	Vilnius	1.43	0.01	1.43
NL	De Bilt	1.00	0.00	1.00
NO	Oslo	1.47	0.00	1.47
PL	Warsaw	1.34	0.00	1.34
UK	London	0.87	0.01	0.88

Table 4: Climate Severity Index for heating (CSI_H), cooling (CSI_C) and both (CSI_T), as determined with the provisional method (not generally usable for instance for non-residential buildings)

It should be noted that the climate severity index derived for this purpose has not yet been thoroughly evaluated, so the use of these values should be handled with extreme care. Looking at the potential strengths of the climate severity index, and the expectation that the need for European and worldwide comparison of energy use will expand, it is highly recommended to further develop the climate severity index

and eventually incorporate it within CEN and ISO.: With a thorough foundation, a proper evaluation and wide international support, the climate severity index can become a powerful tool in the comparison of energy uses among different climates.

3.6 STEP 5: QUALITATIVE EVALUATION

As discussed before, making a fair and robust comparison method seems impossible at this moment (see 3.1) and it should be clear that the proposed method of ASIEPI is a pragmatic method. Although designed with care to reduce the error resulting from these pragmatic choices, unwanted differences between countries cannot be avoided. With this a certain amount of "comparing apples with oranges" will take place.
Therefore the final step in the comparison method is a qualitative assessment: all countries are able to review the results of step 1 to 4 for all countries and comment on the findings. This qualitative evaluation will not be able to change the quantitative results, but they can put them in perspective. It is stressed that quantitative results of the ASIEPI comparison method can never be judged without the qualitative feedback of the countries and the results should always be nuanced with this.

3.7 CONCLUSIONS

The proposed comparison method developed by ASIEPI clearly is a pragmatic method. The fact is that at this moment there are no good and harmonised measurement and calculation methods available to assess the energy use of buildings in a comparable way despite contextual differences. This lacuna makes a fair and robust comparison impossible. By being transparent about the issues related to the comparison method, by focusing on lessons learned and by giving room to a qualitative evaluation of possible differences, the ASIEPI method tries to deal with this lack in the best possible way.
The ASIEPI method is designed in a way that future developments within for instance CEN and ISO can be incorporated. These future adoptions will make the method more fair and robust, gradually shifting towards the original goal. Although it needs to be emphasised again that a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, were be in place.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

From the previous chapters the following can be concluded:

It is clear that making a comparison of EP requirement levels among countries is easy, but making a fair and robust comparison is not. **At this stage a robust comparison is not possible** due to the variety in the types of energy uses which is taken into account in the various national methods and due to a lack of a harmonised way of assessing building components and systems.

There is not one level of energy saving measures for all situations attached to an EP requirement level in a country. A simple order among countries does not exist, which makes comparison prone to unfair comparisons or even manipulation.

And the final conclusion is that although the developed comparison method is far from perfect, it is designed to suit expected future developments, for instance within CEN and ISO, which will make the comparison method more suitable in the future. Although one should realize that in general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, were in place.

4.2 RECOMMENDATIONS

This leads to the following recommendations:

Be careful when interpreting comparison studies: it is hard to completely understand an intercomparison study if you don't know all boundary conditions and conclusions might therefore be misleading.

It is recommended to continue the development of high quality and harmonised CEN Standards because these are crucial for proper comparison. And to expand the comparison method developed within ASIEPI with these harmonised methods.

All energy saving techniques that are relevant in a given country should be included in the national EP-methods. And CEN Standards should incorporate all these relevant national techniques, so a uniform assessment is possible.
For this it is important that all countries support the European methods. Developing European methods should be done by the intensive involvement of Member States and can never be a one man job.

And finally, since the need for European and worldwide comparison of energy use will expand, it is recommended to further develop the climate severity index and eventually incorporate it within CEN and ISO.

5. REFERENCES

(1) Flemish study: small scale comparison of the EP-requirements between Flanders, the Netherlands, Germany and France. Links to several reports related to this study can be found on: *http://www.asiepi.eu/wp2-benchmarking/related-information.html*

(2) "Why we need a 2nd generation of CEN standards on energy performance of buildings", Presentation of Dick van Dijk (TNO) on ASIEPI web event "Comparing Energy Requirements Across Europe", February 24, 2010.

(3) Website of EPA-NR

(4) Pilot study EP comparison. Step 4: Comparison of components by experts. (Space heating and domestic hot water systems, fans). Heike Erhorn-Kluttig, Hicham Lahmidi

(5) Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of air tightness. Antoine Tilmans, Dirk Van Orshoven

(6) Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of thermal bridges. Antoine Tilmans, Dirk Van Orshoven

(7) "Climate influence on Energy Performance levels - Towards a new (simplified robust and transparent) version of the Climate Severity Index approach", Dick van Dijk, Marleen Spiekman (TNO) and Servando Alvarez and Jose Luis Molina (AICIA), PowerPoint presentation, March 31, 2010

(8) "Comparison between minimum requirements for different climates", Servando Alvarez and Jose Luis Molina, AICIA- University of Seville, December 2009

(9) Website ASIEPI on Compliance and Control: *http://www.asiepi.eu/wp-3-compliance-and-control.html*

(10) '"Comparing Energy Performance Requirements over Europe: Tool and Method (ASIEPI deliverable D2.1c)", Marleen Spiekman (TNO), 31 March, 2010

(11) "How can we deal with climate differences? Experiences from Spain and adaptation to Europe", Presentation of Servando Alvarez (AICIA) on ASIEPI web event "Comparing Energy Requirements Across Europe", February 24, 2010 *http://www.asiepi.eu/fileadmin/files/WebEvents/WebEvent_2.2/ASIEPI_WP2_WebEvent2_04_ClimateDifferences.pdf*

Part B: Bird's eye view of the project results

6. INTRODUCTION

To develop a method for comparing EP requirement levels, various steps have been taken, like the development of a set of reference buildings and the development of several pilot studies, resulting in lessons learned about possibilities and impossibilities of the comparison and resulting in a first impression of a cross section overview of EP requirement levels in Europe. All these steps resulted in 3 main topics :

1. The comparison method itself, with background information on main aspects of the method, like the climate severity index used within the method;

2. The cross section overview of EP requirement levels in Europe, although it should be noted that from the lessons learned mentioned before it is clear that at this stage a robust cross section overview of EP requirement levels is not possible;

3. The description of the set of European reference building, which initially was developed to be used in the comparison method, but is useful in European wide energy calculation and comparison studies in general.

This information was made available in the following publications.

7. PUBLISHED RESULTS

7.1 TECHNICAL REPORTS

A summary on the main results related to the development of for comparing EP requirement levels are described in the final report: Comparison of Energy Performance Requirement Levels: Possibilities and Impossibilities - Part A: Final recommendations, published 31 March 2010 (see part A of this document). This final report contains a global description of the comparison method developed within ASIEPI and the lessons learned during the development process.

In addition to the final report three working reports and an Excel Tool have been published (*>link)*:

- *"Reference buildings for EP calculation studies"*, published in November 2009.

The choice of the building geometry is often one of the first determinations during comparison studies of energy performance levels over Europe, but also during other European calculation studies. With this in mind, one of the subtasks of ASIEPI has been to gather a set of reference buildings. The aim of the set of reference buildings is to give an idea of typical houses build in Europe. When we make calculations on the European level, we often extrapolate the results of one house, without the results that houses in Finland might look totally different from houses in Spain. Of course it is not possible to determine a typical house for a whole country. With this report a handle is given for information on the variety of typical houses in Europe.

- "*Comparing Energy Performance Requirements over Europe: Tool and Method",* was published in March 2010. One of the challenging tasks of the ASIEPI project was to develop a method to compare the energy performance requirement levels of the countries of Europe. We found that all alternatives we considered have their advantages and disadvantages. And although the method we finally developed is far from perfect, it is designed to suite expected future developments, for instance within CEN and ISO, which will make the comparison method more suitable in the future. This report describes the ASIEPI comparison method and accompanying tool.

- "*ASIEPI Excel Tool*", was published in March 2010. The comparison method is accompanied by the ASIEPI Excel Tool. The tool is based on EPA-NR and is a first step in harmonising the total primary energy calculations of the houses used in the comparison approach.

- "*Comparing Energy Performance Requirements over Europe: Cross section overview*", was published in March 2010. During this development of the comparison method several pilot studies were performed. These give a global impression of the severity of the energy performance requirement levels for dwellings of the participating countries. Although one of the main conclusions of the development of the comparison method was that a robust comparison of energy performance requirement levels at this moment is not possible, this report shows a first impression of a cross section overview of EP requirement levels in Europe.

In addition to the working reports some expert material has been produced:

- As part of the pilot studies performed for the development of the comparison method three reports have been produced on detailed comparison of components:

  - *"Pilot study EP comparison. Step 4: Comparison of components by experts. (Space heating and domestic hot water systems, fans)"*, published March 2010.

  - *"Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of air tightness",* published March 2010.

  - "Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of thermal bridges.", published March 2010.

- Also as part of the development of the comparison method first development steps have been taken to incorporate a climate severity index in the method. Information on the role of the climate severity index in the comparison method can be found in the final report *"Comparison of Energy Performance Requirement Levels: Possibilities and Impossibilities - Part A: Final recommendations"* (as described above, see part A of this document) and the working report "*Comparing Energy Performance Requirements over Europe: Tool and Method*" (as described above). More information about the climate severity index can be found in the following material:

  - *"Climate influence on Energy Performance levels - Towards a new (simplified robust and transparent) version of the Climate Severity Index approach"*, PowerPoint presentation, March 31, 2010.

  - *"Comparison between minimum requirements for different climates",* December 2009.

  - *"How can we deal with climate differences? Experiences from Spain and adaptation to Europe"*,

Presentation on ASIEPI web event "Comparing Energy Requirements Across Europe", February 24, 2010

Finally, also a brainstorming document has been drawn up that deals with the tightening of the EP requirement levels in relation to economic aspects:

- *"Tightening the EPB-requirements: turning the potential into reality"*, published in March 2010. The work programme of ASIEPI, as established in 2006, set as objective to investigate possible methods to compare the energy performance requirements among different countries. In the mean time, the recast of the EPBD has been developed. Observing that comparing the requirements between countries is not only extremely difficult at the present time, but also not the most relevant approach (given the different boundary conditions in different countries, e.g. for costs of labour and materials), the recast now calls for an internal economic analysis within each country in order to establish requirements that are cost-optimum or better. This new approach was outside the contractual scope of the ASIEPI project, and not many resources could be allocated to study the issues related to this different way of doing. Still, based on the general familiarity of the project partners with EPB-regulations, some elementary considerations on this complementary topic have been put onto paper in the framework of the project. This brainstorming paper may serve as an inventory of some of the many challenges in order to achieve a sustained reduction of the energy consumption in reality.

7.2 INFORMATION PAPERS

Four Information Papers have been published (*> link*):

- **P065** *"Comparing Energy Performance Requirements over Europe"*, published in March 2008. This information paper summarises the aims of the study on comparing the energy performance requirement levels between the EU Member States, which is one of the tasks in the ASIEPI project. For everyone involved in the discussion on the comparison of energy performance requirement levels in Europe, it is crucial to understand the challenges involved in this task. Therefore this paper gives an overview of the most important lessons learned from a preliminary comparison study of the EP requirement levels in four Member States.

- **P158** *"A set of reference buildings for energy performance calculation studies"*, published in March 2009. The choice of the building geometry is often one of the first determinations during comparison studies of national energy performance requirements. Experiences with intercomparisons carried out show that the results are influenced already by this choice as they can depend on the type of the building and because of different calculations methods for floor and envelope areas also on the building geometry. ASIEPI has collected possible reference buildings from various EU Member States which are presented in this paper. Earlier intercomparison studies have shown that already the calculation of floor areas, envelope areas etc. lead to different results when national calculation standards of several European Member States have to be followed. In most cases one or several representative buildings for the country that launched the study have been used for the comparison. As many influence factors are related to the floor area, other areas or volumes (e.g. default values for internal gains or the

ventilation losses), this can produce the first differences regarding the energy performance results. Also the results of the comparison can be quite dependent on the type of building that has been chosen as reference building. This is valid for different types of dwellings (single-family house vs. multi-family house) as well as for residential vs. non-residential buildings.

- **P164** *"Developing a Method for Comparing Energy Performance Requirement Levels among Europe"*, published in December 2009. Within ASIEPI a methodology was developed to make possible a comparison of energy performance requirement levels among Member States of the EU. An unexpected finding has been that far from all the EU countries consider all energy uses in their energy performance calculation method required by the EPBD (Energy Performance of Buildings Directive). The energy use for fans, domestic hot water and cooling are among the energy uses which are not taken into account by various countries. This largely complicates the comparison over Europe. What also complicates the comparison is that sets of energy saving measures are not equally relevant in all climates in Europe. The paper summarises the difficulties in comparing the national regulations and presents options for the comparison.

- **P192** *"Comparing Energy Performance Requirement Levels: Method and Cross Section Overview"*, published in March 2010. One of the challenging tasks of the ASIEPI project was to develop a method to compare energy performance requirement levels. During this development pilot studies were performed. These give a global impression of the severity of the energy performance requirement levels for dwellings of the participating countries. This information paper describes the comparison method which has been developed during the project and shows the results of the cross section overview.

7.3 WEB EVENTS

In a series of 10 web event organised by ASIEPI, two web events were held on the topic of comparison of EP requirement levels, being web event no. 2 and web event no.10 (*> link*):

- **ASIEPI web event 2** on *"Comparing Energy Performance Requirements Across Europe"*, was held in January 2009. This web event on January 27 has given a glance of some pilot study results of the comparison of requirements and share with you why comparing the requirements among the countries in Europe isn't evident. For everyone involved in the discussion on the comparison of energy performance requirement levels in Europe, it is crucial to understand the challenges involved in this task.

  The strictness of the requirement levels is set on national level- Already the Member States are obliged by the EPBD to tighten the energy performance requirement levels every few years on national level. This development of the EP requirement levels in the Member States will be monitored. The results of the ASIEPI project will contribute to this monitoring.

  To increase the impact of the Energy Performance of Buildings Directive (EPBD) the EPBD is being recast. A proposal of the recast was published two months ago. The key issues of the recast has been discussed during this web event.

Introduction
Welcome and Introduction, *by Peter Wouters, BBRI,*

coordinator of the ASIEPI project
Presentations
EU Energy Policy for Buildings - Recast Directive proposed *by Gergana Miladinova, DG TREN*
Introductionr to the comparison study *by Marleen Spiekman, TNO, WP5 leader*
Lessons learned from comparing Germany, France, Netherlands and Flanders *by Peter D'Herdt, BBRI*
Comparing EP requirements over Europe. First results of ASIEPI project *by Marleen Spiekman, TNO*
Discussions
Questions
Conclusion and closure *by Peter Wouters, BBRI*

Program of ASIEPI web event n°2

- **ASIEPI web event 10** on "*Comparing Energy Performance Requirements across Europe: possibilities and impossibilities*", was held on February 2010. The tightness of the energy performance (EP) requirement levels is a hot topic in a lot of European countries. For instance Germany just tightened its EP requirements with 30% per October 1 and various other countries, like the Netherlands and Denmark have a long term planning for tightening their EP requirements in several steps. But how can we compare these EP requirements among the countries of Europe? Within the EU project ASIEPI we have developed a method for comparison. This second webevent on this topic gives an update on the results of the development of the method, addressing several issues like: how can we deal with climate differences and what is happening with the European Standards, how will the recasted EPBD change and what are challenges ahead. It also gives a glimpse of what is happening in the U.S. in the field of Energy Performance of Buildings.

Introduction
Welcome and introduction to ASIEPI *by Marleen Spiekman, TNO*
Presentations
Recast of the EPBD: How will the EPBD change and what are challenges ahead? *by Eduardo Maldonado, CA-EPBD coordinator, with an intervention of Martin Elsberger, DG TREN*
Developing a method for intercomparison of EP-requirement levels: Did we succeed? *by Marleen Spiekman, TNO*
How can we deal with climate differences? Experiences from Spain and adaption to Europe *by Servande Alvarez, AICIA*
Intercomparison of EP requirements without harmonized Standards? Why we need a 2nd generation CEN standards *by Dick van Dijk, TNO & Coordinator CENSE project*
How does Europe deal with Energy performance requirements for renovation and public buildings? Results from an European enquiry *by Anna Wiszniewska, NAPE*
Energy performance in the U.S. developments at ASHRAE *by Jaap Hogeling, CEN*
Discussions
Questions
Conclusion and closure *by Marleen Spiekman, TNO*

Program of ASIEPI web event n°10

7.4 PRESENTATIONS-ON-DEMAND

The following presentation-on-demand are available:

- **ASIEPI presentation-on-demand 1** "*Inter-comparison of requirement levels in Member States*", published in January 2009, gives an overview of the development of the comparison method at the time the presentation was published. Although the presentation dates from the middle of the project, it gives an explanation of the two first pilot studies conducted in

the development of the method. Many interesting lessons can be learnt from these pilot studies and this information stays current. (*> link*).

- **ASIEPI presentation-on-demand 6** "*Main lessons learned and recommendations from the IEE SAVE ASIEPI project*", published in March 2010 in several different languages, focuses on guidelines for Member States on all the topics ASIEPI has focussed on. (*> link*).

7.5 ABSTRACTS AND CONFERENCE PAPERS

Two conference abstracts were accepted for the AIVC conference 2009:

- *"Comparing Energy Performance requirement levels among Member States of Europe (EU ASIEPI project)"*, was presented at 30th AIVC Conference "Trends in High Performance Buildings and the role of Ventilation". Held in Berlin, Germany, in October 2009. Abstract:: For outsiders, a national energy performance (EP) requirement level is quite a black box. Within the EU ASIEPI project (www.asiepi.eu) we are developing a methodology to make a comparison of EP requirement levels possible among member states of the EU. An unexpected finding was that far from all EU countries consider all energy uses in their EP method required by the EPBD (Energy Performance of Buildings Directive). The energy use for fans, domestic hot water and cooling are among the energy uses which are not taken into account by various countries. This largely complicates the comparison over Europe. What also complicates the comparison is that sets of energy measures are not equally relevant in all climates in Europe. The recast of the EPBD proposes to take into account a cost optimal level. This might be a way of properly reflecting local issues, although developing such a method on European level is a big challenge.

- *"Treatment of envelope airtightness in the EPB-regulations: some results of a survey in the IEE-ASIEPI project."*, was presented at 30th AIVC Conference "Trends in High Performance Buildings and the role of Ventilation". Held in Berlin, Germany, in October 2009. 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 was made among the participating countries. Also a quantitative comparison on a sample building was 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.

Part C: General project description and acknowledgements

8. GENERAL PROJECT DESCRIPTION

8.1 INTRODUCTION

ASIEPI is the acronym of the full project name:

ASsessment and **I**mprovement
of the **EP**BD **I**mpact
(for new buildings and building renovation)

The project took two and a half years and was completed in March 2010.

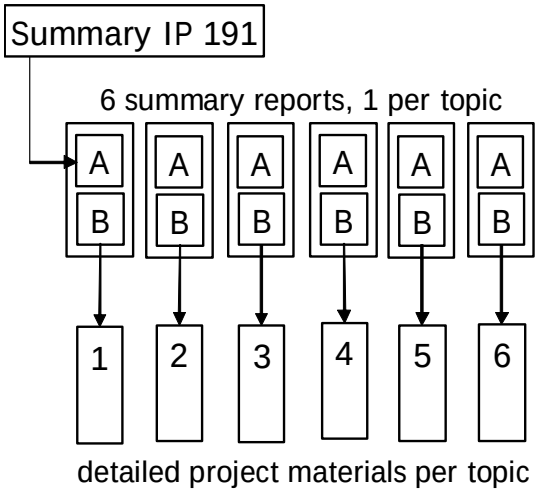
The main objective of the ASIEPI project has been to formulate suggestions to policy makers on how to improve the quality and the impact of the regulations on the energy performance of buildings with respect to 6 specific issues:

- intercomparison of the levels of the EP-requirements
- impact, compliance and control of legislation
- effective handling of thermal bridges
- stimulation of good building and ductwork airtightness
- support for the market uptake for innovative systems
- stimulation of better summer comfort and efficient cooling

Several major aspects of each of the topics have been analysed. The results are documented in a full suite of project data. Among others, these data provide insight in the potential problems and give guidance with respect to possible solutions. However, as the project had to conform to the objectives of the IEE-SAVE programme, no new, ready-to-use methods were developed, but instead awareness of the challenges was raised and existing best practice to achieve more effective EPB-regulations were highlighted.

8.2 PROJECT MATERIALS

The ASIEPI project has produced a broad set of dissemination materials.



As illustrated in the figure, the project results are structured as follows:

- An information paper (IP191) briefly summarises the main conclusions and constitutes the gateway to the project.
- The present document is 1 out of the 6 summary reports, each dealing with 1 of the topics listed above. Parts A of these final reports describe the major findings and the final recommendations. Parts B give a synthetic overview of all the other information that the project has made available on that topic.

- Finally, a wide range of information materials provide a more comprehensive, in-depth coverage of many different aspects of each of the topics.

The different project outcomes come in a variety of electronic formats:

- summary reports
- detailed technical reports
- information papers
- recordings of internet information seminars
- presentations-on-demand
- conference abstracts and papers
- other related material, such as documents supplied by third parties

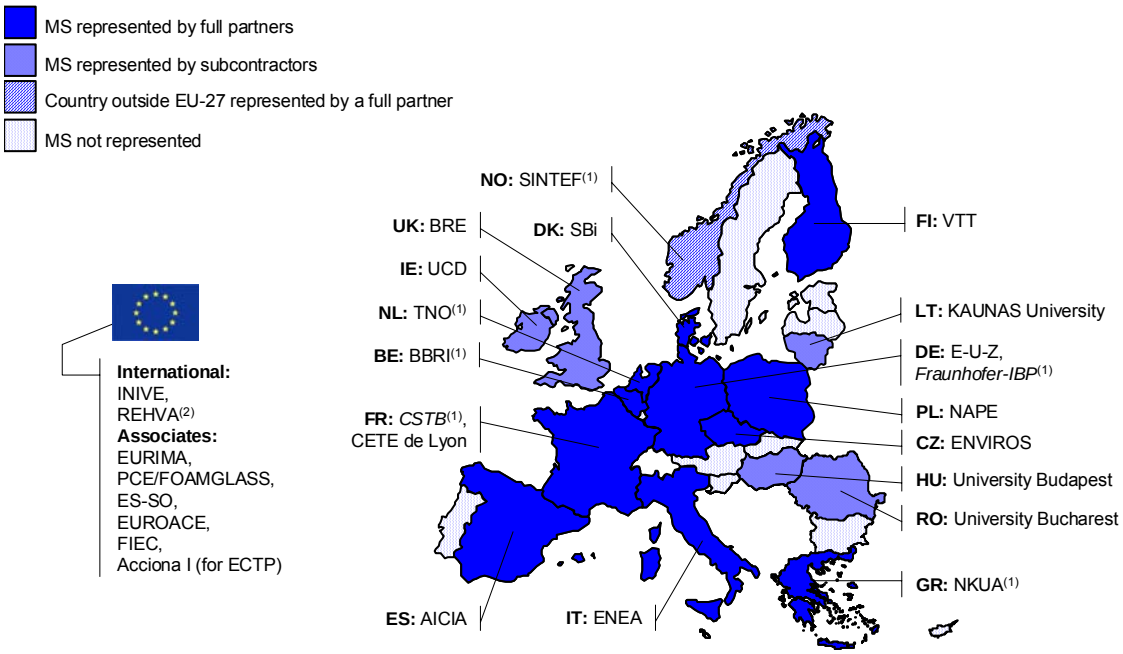
All materials are available on the project website www.asiepi.eu.

8.3 PROJECT PARTNERS

As shown in the figure, the project had full partners in 12 countries and subcontractors in 5 more countries. The chapter "Acknowledgements to contributors" lists all the organisations, together with their contributing collaborators.

Furthermore, there were 6 Europe-wide associations acting as associated partners. These are listed in the chapter "Acknowledgements to sponsors, other associates and funding partners", which also lists the national cofunding agencies.

Through this large number of countries involved, a good reflection was obtained of the EPB-practices across all of Europe at the time of the project. For most topics, surveys have been made in these countries in order to see how the EPB-regulations deal with each of the issues.



(1) INIVE member
In the MS where there are two participants, the national contact point is in *italic*.

9. ACKNOWLEDGEMENTS TO CONTRIBUTORS

This report was produced as part of the ASIEPI project, which was coordinated by INIVE.

National contributions to the project were made by the following partners and subcontractors.

9.1 PROJECT PARTNERS

EUROPE

International Network for Information on Ventilation (INIVE)

www.inive.org

EUROPE

Federation of European Heating, Ventilation and Air-conditioning Associations (REHVA)

www.rehva.eu

Olli Seppänen

Thierry van Steenberghe

BELGIUM

Belgian Building Research Institute (BBRI)

www.bbri.be

Antoine Tilmans

Clarisse Mees

Dirk Van Orshoven

Nicolas Heijmans

Peter D'Herdt

Peter Wouters

Samuel Caillou

Administrative support:

Erika Malu

Stéphane Degauquier

CZECH REPUBLIC

ENVIROS, s.r.o. (ENVIROS)

www.enviros.cz

Jan Pejter

DENMARK

Danish Building Research Institute (SBi)

www.SBi.dk

Kirsten Engelund Thomsen

Jørgen Rose

Søren Aggerholm

FINLAND

VTT Technical Research Centre of Finland (VTT)

http://www.vtt.fi/

Jari Shemeikka

Jyri Nieminen

Mikko Nyman

FRANCE

Technical Studies Centre of the Ministry of Equipement of Lyon (CETE de Lyon)

www.cete-lyon.developpement-durable.gouv.fr

Rémi Carrié

Gaëlle Guyot

Whilémine Lecointre

FRANCE

Scientific and Technical Center for Building (CSTB)

www.cstb.fr

Hicham Lahmidi

Jean-Robert Millet

Benoit Vinot

Franck Leguillon

GERMANY

Energy and Environmental Center Deister (EUZ)

www.e-u-z.de

Bernd Rosenthal

Wilfried Walther

GERMANY

Fraunhofer Institute for Building Physics (Fraunhofer-IBP)

www.ibp.fraunhofer.de

Hans Erhorn

Heike Erhorn-Kluttig

GREECE

National & Kapodistrian University of Athens (NKUA) – Group of Building Environmental Studies (grbes)

http://grbes.phys.uoa.gr/

Kyriaki Papadopoulou

Marianna Papaglastra

Marina Laskari

Mattheos Santamouris

ITALY

Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)

www.enea.it

Marco Citterio

Michele Zinzi

THE NETHERLANDS

Netherlands Organization for Applied Scientific Research (TNO)

www.tno.nl

Marleen Spiekman

Dick van Dijk

NORWAY

SINTEF Building & Infrastructure

www.sintef.no

Arild Gustavsen

Peter Blom

Peter G. Schild

Tormod Aurlien

POLAND

National Energy Conservation Agency (NAPE)

www.nape.pl

Aleksander Panek

Andrzej Wiszniewski

Andrzej Rajkiewicz

Joanna Rucinska

Malgorzata Popiolek

Szymon Firląg

SPAIN

Asociación de Investigación y Cooperación Industrial de Andalucía (AICIA)

www.aicia.es

Servando Álvarez

José L. Molina

9.2 SUBCONTRACTORS

HUNGARY

Budapest University of Technology and Economics (BME)

www.egt.bme.hu

Andras Zold

IRELAND

University College Dublin Energy Research Group

(UCD ERG)

www.erg.ucd.ie

Patxi Hernandez

Vivienne Brophy

LITHUANIA

Institute of Architecture and Construction of Kaunas University of Technology

(KTU ASI)

www.asi.lt, www.ktu.lt

Raimondas Bliudzius

ROMANIA

Technical University of Civil Engineering of Bucharest (UTCB)

www.utcb.ro

Octavia Cocora

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Building Research Establishment Limited (BRE)

www.bre.co.uk

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10.1 OVERALL PROJECT SPONSORS

EuroACE
The European Alliance of Companies for Energy Efficiency in Buildings

www.euroace.org

eurima
European Insulation Manufacturers Association

www.eurima.org

EUROPEAN SOLAR SHADING ORGANIZATION
Energy Savings & Comfort

www.es-so.com

FOAMGLAS
Building

www.foamglas.com

10.2 PARTNER ASSOCIATIONS

FIEC European Construction Industry Federation

www.fiec.eu

acciona

www.acciona.com for ECTP

10.3 NATIONAL COFINANCING

BELGIUM

BBRI's contribution was cofunded by:

The Federal Public Service Economy, SME's, independent Professions and Energy

The Flemish Region

The Walloon Region

The Brussels-Capital Region

FINLAND

VTT's contribution was cofunded by:

Paroc Oy Ab

Saint-Gobain Rakennustuotteet Oy

Rakennustuoteteollisuus RTT ry

FRANCE

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The French Minister of Ecology, Energy, Sustainable Development and Sea

GERMANY

Fraunhofer-IBP's contribution was cofunded by:

Fraunhofer Institute for Building Physics

LITHUANIA

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Certification Centre of Building Products

THE NETHERLANDS

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enova

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National Energy Conservation Agency (NAPE)

www.nape.pl

Association of Energy Auditors

www.zae.org.pl

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www. energiaibudynek.pl