LOW AND ZERO CARBON HOMES: INTERNATIONAL PERSPECTIVES ON THE PERFORMANCE CHALLENGE

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FOREWORD

ABOUT NHBCF

NOTE

The method of researching this work was to identify knowledgeable individuals in three mainland European countries, and to visit them in order to obtain their perspectives on the gap between the designed and as-built performance of homes in their respective countries. This report is based on the individuals' specific experiences and insights; it is inevitable that others will have different perspectives on the issues explored.

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EXECUTIVE SUMMARY

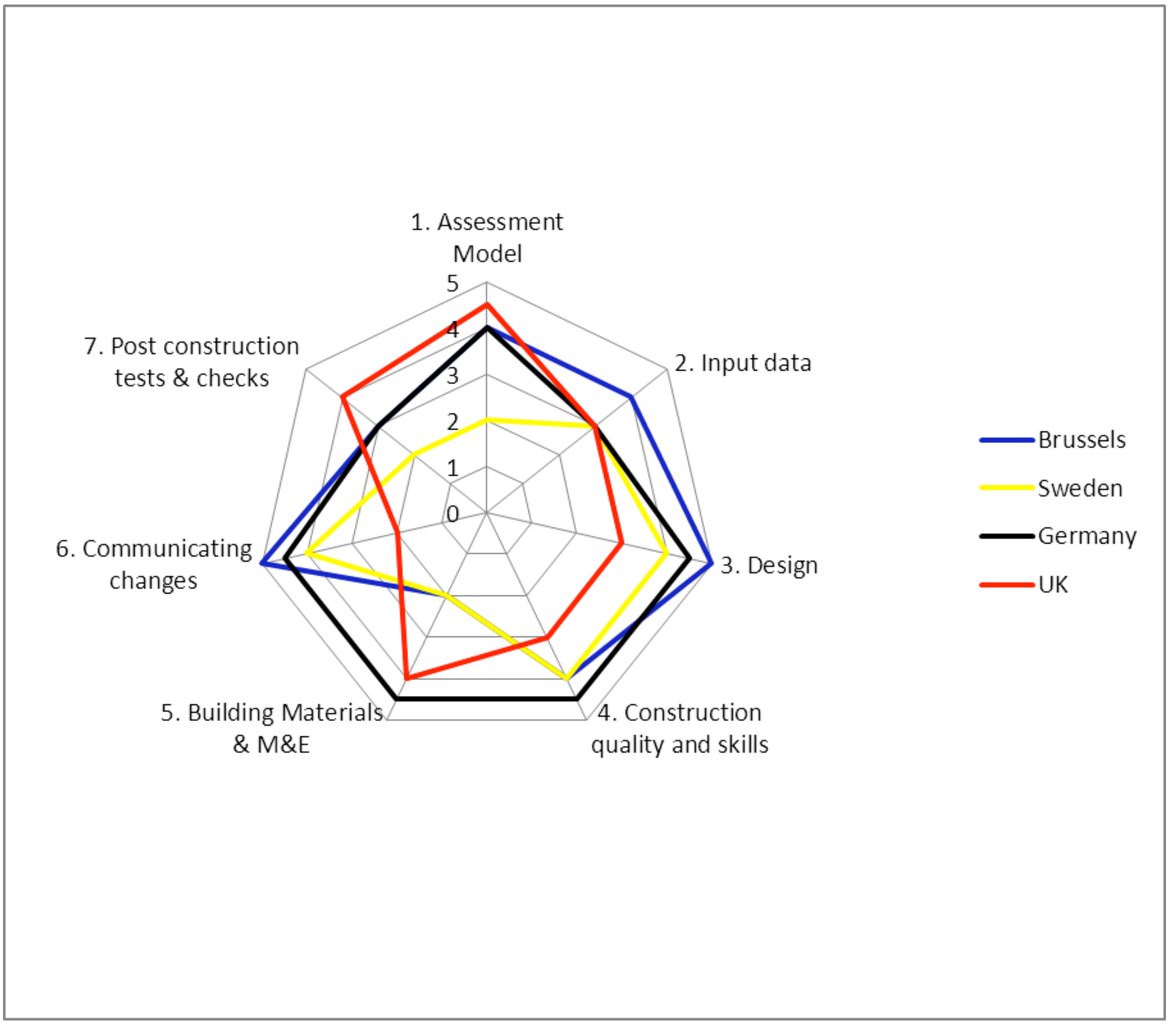


Fig 1: Comparing progress in addressing the performance gap

This study compares how three mainland European jurisdictions - the Brussels Capital Region, Sweden and Germany - are addressing the gap between designed and as-built performance in new build homes compared to the UK. Whilst acknowledging its importance, Sweden and Brussels are less concerned than Germany and the UK about this issue. This in part is due to a high level of confidence in the current situation in Sweden and Brussels. Having noted this there is still much that is worthy of UK consideration.

Box out: The relative performance of Brussels, Sweden, Germany and the UK is illustrated in the spider diagram in figure 1, where the performance of each has been given an indicative score by the authors according to the results of the research. In this figure, each jurisdiction's performance is represented by a coloured shape. Each shape extends along the 'spokes' of the diagram in a way which represents that jurisdiction's 'score' (where 1=poor and 5=very good) against each of the seven themes developed in the NHBC Foundation report NF41, "Low and zero carbon homes: understanding the performance challenge"[i]. The seven themes are summarised below.

1. THE ASSESSMENT MODELS

*"Is the **assessment model** that was used to make the prediction accurate and has it been correctly implemented in the software by the designer?"*

Brussels and Germany have similar energy assessment methodologies to the UK in that they have government-recognised modelling tools and use energy assessors to operate them. Germany currently has two methodologies, but it is expected that one of them will be phased out.

In Sweden there are no government-recognised tools. Different software packages can be used as long as they operate in a manner consistent with Swedish building regulations.

There are procedures for introducing new energy saving technologies, but they have to wait for a new version of the energy assessment model to be produced, unlike in the UK where additions can be made between revisions of the model using SAP Appendix Q.

2. CONTROLLING THE ACCURACY OF DATA IN THE MODEL

*"Is the models' **input data** correct (and if not, is that due to the conventions or the user)?"*

In Brussels and Germany the equivalent to the UK's SAP Assessor inputs data in a similar manner to their UK counterparts, and their work is similarly sampled for quality control purposes.

However, energy assessors in Brussels and Germany are also energy consultants who have a site inspection role. It is therefore possible that through this greater involvement their work will be more accurate, since the loop is closed between the original data entry and the actual construction.

Having multiple models (two in the case of Germany and many more in the case of Sweden) increases the likelihood of different calculated design outcomes for the same building.

3. CONTROLLING DESIGN COMPLEXITY

*"Is the home's **design** overly complex, presenting unreasonable challenges to the construction team?"*

In Brussels much consideration has been given to making overall designs simpler to build. It is an architecture-based approach which in a UK context may be aesthetically unacceptable.

In Sweden and Germany the effort has been put into developing new design details to cope with traditional features such as dormer windows. In Germany these take the form of accredited details, a model that could be more fully considered in the UK.

4. CONSTRUCTION QUALITY AND SKILLS

*"Are there fundamental **construction quality and skills** issues?"*

The site trades in Brussels, Sweden and Germany are considered to be highly skilled overall, although education is still thought to be necessary to understand issues around airtightness barriers. The trades are viewed as highly competent in all other areas of energy efficiency such as fitting insulation, the avoidance of thermal bridging and the installation of ventilation systems. The apprenticeship training in Germany appears to be particularly thorough.

The assessors and architects in Brussels and Germany also provide a site quality control function as they inspect the site during the construction process to check that it conforms to the original design.

5. PERFORMANCE OF MATERIALS AND M&E IN PRACTICE

*"Do **building materials and mechanical and electrical (M&E) systems** perform as well in practice as laboratory tests predict?"*

Brussels does not appear to use 'in-use factors' which take into account the actual (as opposed to predicted) performance of products and materials.

Swedish insulation manufacturers supply "practical" as well as laboratory insulation values with their products for use in calculations. For ventilation systems it is possible for energy assessors to incorporate efficiency loses from the duct work into their calculations, but not all will do this.

Germany has introduced in-use factors for insulation, and items such as mechanical ventilation systems have to obtain an independent "Mark of Conformity". The "Mark of Conformity" is similar to SAP Appendix Q system in that it incorporates in-use factors, but it does so for a wider group of products.

The situation in Sweden is more complex. With a variety of different software tools it is possible that some do incorporate in-use factors, at least for insulation products.

6. CONTROLLING AND COMMUNICATING CHANGES IN SPECIFICATION

*"Do changes in specifications get properly **communicated**?"*

The opinion of those interviewed in all of the countries was that changes in specifications are rare, and that when they do occur they are communicated diligently. The role of the energy assessor as a site inspector in Brussels (supported by the architect's inspections) and in Germany clearly helps to maintain control.

In Sweden overt control appears to be less marked, but the awareness at site level of performance issues is very high.

7. POST CONSTRUCTION TESTS AND CHECKS

"Are the **post construction tests and checks** appropriate and adequate?"

None of the countries studied has a testing regime as rigorous as the UK's current airtightness testing. Various suites of specialist tests are used, but usually only for ad-hoc research or when a problem has already been identified.

More rigorous tests are carried out where the Passivhaus standard has been adopted.

FURTHER RESEARCH

Four particular areas arise from this study, which are worthy of further research for the UK context:

a. UK SAP assessors have no site inspection role. The inspection role of the energy assessor in Brussels and Germany, however, appears to have an important function in controlling site practice and product substitution. Unsurprisingly this enhanced role has a cost implication.

b. The UK applies in-use factors to novel 'technical' products through SAP Appendix Q, but in Germany in-use factors are applied more widely to 'basic' construction elements such as insulation.

c. The energy penalty that can arise from architectural features such as steps, staggers and dormer windows is mitigated in Germany by the use of accredited thermal design details.

d. There is a general trust in the quality of trade skills, and a continued upgrading of site skills and knowledge in the area of energy efficiency.

INTRODUCTION

This report reviews the approach of three international building regulation authorities to the issues identified in the NHBC Foundation report "Low and zero carbon homes: understanding the performance challenge"[ii], in relation to the UK's approach. That report identified seven key questions that need to be considered in order to understand how a performance gap can arise, and the same seven headings have been used throughout this work in order to provide a clear and consistent basis for comparison:

1. Is the **assessment model** that was used to make the prediction accurate and has it been correctly implemented in the software by the designer?
2. Is the models' **input data** correct (and if not, is that due to the conventions or the user)?
3. Is the home's **design** overly complex, presenting unreasonable challenges to the construction team?
4. Are there fundamental **construction quality and skills** issues?
5. Do **building materials and mechanical and electrical (M&E) systems** perform as well in practice as laboratory tests predict?
6. Do changes in specifications get properly **communicated**?
7. Are the **post construction tests and checks** appropriate and adequate?

In this study the three jurisdictions visited were the Brussels Capital Region, Sweden and Germany. Through face-to-face meetings, the authors explored common practice from the perspectives of the people who we met, where the practice affects the potential gap between designed and as-built performance.

BRUSSELS CAPITAL REGION - CONTEXT

Brussels Capital Region is one of the three regions of the federal state of Belgium (the other two being Walloon and Flanders). Separate building regulations apply in each of the jurisdictions. The Brussels Capital Region has a population of 1.1 million, which is expected to rise to around 1.3 million in the near future. Despite this rate of growth, house prices are relatively low in comparison to the UK. Energy efficiency regulations were modest until only a few years ago, but have become much more demanding recently.

All social housing and public (council) housing must be fully Passivhaus certified. All private housing will be Passivhaus equivalent, if not fully certified, by 2015.

Energy assessors are known as 'PEB Advisors' (PEB being the name of the software tool used). The PEB Advisor is employed by the client, not the contractor as would be the case in the UK. As well as modelling, they advise the client and construction team, inspect the work on site and produce a full report. The PEB Advisor typically charges up to €3,000 for a medium sized family home.

Architects are also employed by the client to represent their interests. The architect's normal role in energy efficiency is to develop the materials and M&E specifications on the advice of the PEB Advisor, and to monitor the construction work on site.

Masonry construction is traditional in Belgium, although in Brussels many apartments of concrete construction are being built (see figure 2).

Figure 2: An opening in a Brussels apartment block showing the concrete inner leaf with masonry outer leaf

SWEDEN - CONTEXT

Sweden has a population of 9 million, and has a long history of building energy efficient homes. Double glazing and insulation were first stipulated in the 1930s. Mechanical ventilation with heat recovery (MVHR) was first required in the 1960s – although mainly for comfort rather than energy efficiency.

District heating is usually used in apartment buildings where it is still common practice for occupants not to be charged for their heating. Private homes usually use electricity or biofuel for heating. There is very little gas or oil heating for private dwellings.

Swedish regulations are currently known as the 'BBR'[iii]. For most buildings the BBR sets out the maximum specific energy and thermal transmittance values, but it also gives an option for the smaller individual houses to comply with regulations using an elemental approach, in which a U-value must be achieved for each part of the building fabric.

Unlike in the UK, there is no prescribed software tool to calculate these values. However, the BBR states that, "*When calculating the building's predicted specific energy use, appropriate safety margins should be applied to ensure the requirement for the building's specific energy use is met when the building is put in use."*

Around 8% of all new buildings are certified to the Swedish Passivhaus standard. This is similar to the international Passivhaus standard, but requires less information. A verified Passivhaus needs to provide information on the calculations, airtightness, moisture content of the materials and the energy used in operation.

Consultants are appointed to projects through two main mechanisms: the "General Enterprise" in which the client hires everyone directly, and the "Total Enterprise" in which the consultants are hired by the main contractor.

Homes in Sweden since the 1960s/70s have tended to be either apartments built in concrete with district heating, or individual dwellings built in closed-panel timber frame construction (see figure 3),with mostly electric heating (often in the form of heat pumps).

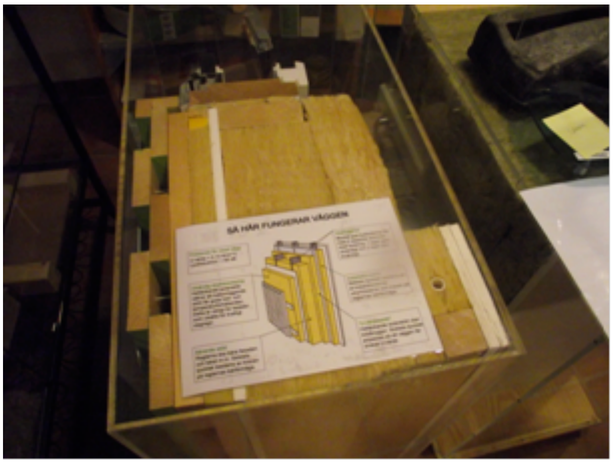


Figure 3: Cross-section of a typical Swedish dwelling timber frame wall

GERMANY - CONTEXT

Germany is a federal state split into 16 regions, and has a population of 82 million (although this is dropping). Building regulations are nearly identical throughout the regions, with only minor differences. House prices vary across the country, Bavaria being the most expensive. A typical 3 bedroom property costs in the region of €200,000 to €300,000.

There is much encouragement for energy efficiency, with German building regulations changing regularly to set a benchmark for the construction industry. The German regulation 'ENEV' stipulates minimum energy requirements for new build houses in a similar way to the English and Welsh Approved Document L1A.

There are currently two energy assessment methods in Germany, known as 'DIN V 4108-6' and 'DIN V 18599'. DIN V 18599 is a newer standard used for domestic and non-domestic buildings, and is expected to replace DIN V 4108-6 in the near future.

An energy assessor is used similarly to the UK, either directly employed by the housing developer or contracted. The energy assessor provides advice to the construction team as well as carrying out the energy assessments. For these services, an energy assessor is paid €1,000 - €1,500 for a medium sized family home.

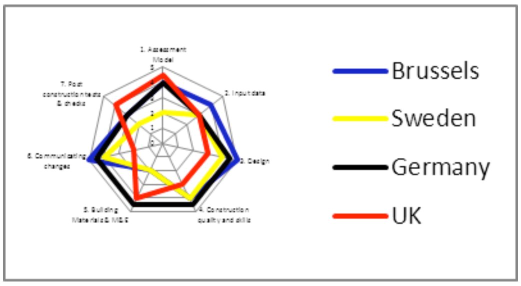
Construction methods vary between regions. Cavity walls, timber frames and solid walls with external insulation are all common.

Fig 4: German clay honeycomb block (solid wall) masonry construction (rendered on the left and prior to render on the right)

The remaining sections of this report discuss the seven themes affecting the gap between designed and as-built performance, with the common practices of each country discussed under the heading of each theme.

1. THE ASSESSMENT MODELS

*"Is the **assessment model** that was used to make the prediction accurate and has it been correctly implemented in the software by the designer?"*



A Note on SAP

SAP is the Government's Standard Assessment Procedure for assessing the energy performance of dwellings. It is a static model that calculates the space and water heating requirements for each month of the year. The calculations are independent of factors that relate to individual characteristic of the household occupying the dwelling[iv].

BRUSSELS CAPITAL REGION

The ISO13790-compliant software that is used in Brussels and Walloon is known as 'PEB', although different target levels are required in the two regions. Like SAP, PEB is a static model that covers space heating and hot water and calculates on a monthly basis. Thermal bridges are modelled, and airtightness values can be specified. If no values are specified, default values are used.

If new technologies are being developed, an official request can be made to the regional government to incorporate the performance of the technology into the model. There is no equivalent to the UK's SAP Appendix Q methodology, where new products can be independently tested for inclusion in the model.

The software is internet-based and is regularly updated and refined. It is viewed as a popular tool that is being continually improved.

Passivhaus certified buildings require the use of the international 'Passivhaus Planning Package' (PHPP) software, but the belief in Brussels is that PHPP does not comply with ISO13790 and so PEB software has to be used for building regulations compliance (and a Passivhaus compliant update of the PEB software will continue to be used when the Passivhaus standard becomes mandatory in the region in 2015).

SWEDEN

A variety of methods for calculating the energy efficiency of a property can be used. This ranges from dynamic modelling for flats and apartments and portfolio houses from manufacturers, through to static modelling such as PHPP or simpler models for small developments. It is even possible in the case of one-off houses to use hand calculations, particularly where the elemental approach has been adopted where it is only necessary to show that certain U-values have been achieved for wall, roof, foundations, fenestration etc.. There does not appear to be any desire to harmonise these approaches. A long tradition of building energy efficient homes has created a culture of confidence in the ability of professionals to accurately calculate energy use.

Even the most basic computer based models available from the web[v] take into account U values, thermal bridging of key elements, ventilation and airtightness.

None of the methods calculate carbon dioxide emissions, nor do they produce EPCs.

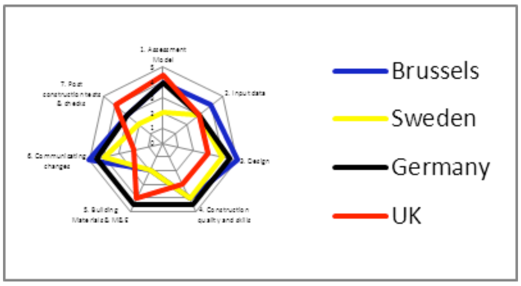
GERMANY

Both the DIN V 18599 and DIN V 4108-6 software packages are ISO13790-compliant. Like the UK's SAP, they are static models that cover space heating and hot water on a monthly basis. Unlike SAP, however, they only use one zone per dwelling. The calculation methods behind the two DIN standards are different, and therefore the results differ. DIN V 4108 is still the most commonly used standard, but there is a move towards just using DIN V 18599 which can cover non-domestic buildings as well. DIN V 18599 is updated regularly and can be purchased from various software developers for €400 - €1500.

There is no procedure for new technologies to be incorporated into energy assessment software between major revisions (as per the UK's SAP Appendix Q). The technology would have to be tested and then incorporated in the next version of the software.

2. CONTROLLING THE ACCURACY OF DATA IN THE MODEL

*"Is the models' **input data** correct (and if not, is that due to the conventions or the user)?"*



BRUSSELS CAPITAL REGION

All data for PEB is entered manually into the model by a PEB Advisor. Like the UK's SAP model, the results of airtightness tests can be entered to produce an as-built result. A PEB advisor has to be qualified as an architect, engineer or equivalent and receives additional training for the role. Training takes ten days and culminates with a formal examination.

PEB reports are sampled and reviewed by the regional government under a similar method to that used for checking SAP reports in the UK.

SWEDEN

Modelling is carried out by the M&E engineer where this is included as part of specifying the heating system. The BBR requirements are considered to be well within the capability of the normal Swedish building practitioners.

The dynamic models can in some cases take dimensions directly from CAD drawings, reducing the risk of inaccuracies occurring. However the multitude of different calculation methods does mean that different results can be obtained for the same building.

Software models are only used at the design stage. Unlike the UK, results from on-site testing are not fed back into the model.

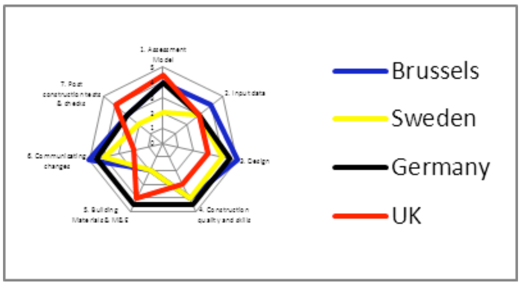
GERMANY

All data for DIN V 18599 and DIN V 4108-6 is entered manually into the software model by the energy assessor. Like the UK's SAP, the results of airtightness tests can be entered to produce an as-built result. A large amount of data has to be entered and, as is the case in the UK, this provides opportunity for error, something which is a cause of concern in Germany.

Energy assessors are construction professionals such as architects or engineers. One route to registration is by formal course and exam has to be sat before an individual can become a registered assessor. The assessor must have at least 3 years' professional experience in the construction industry and has to have created a portfolio for evaluation before they are added to the register. This rule is common throughout Germany but the process may vary slightly from state to state. Assessors pay an annual subscription to be on the register.

3. CONTROLLING DESIGN COMPLEXITY

*"Is the home's **design** overly complex, presenting unreasonable challenges to the construction team?"*



BRUSSELS CAPITAL REGION

There is a wide awareness amongst the general population in Belgium of issues surrounding energy efficiency in housing, with over 300,000 attending Belgium's major sustainable housing show. This knowledge is reflected in a growing understanding of the implication for house design. With the push towards the Passivhaus standard there is an expectation that most new homes (whether they are Passivhaus or not) will not take traditional forms. Architects and clients expect to create designs in which the detailing provides cost effective means of achieving energy efficiency. There is therefore a move away from features such as dormer windows and very large areas of glazing.

Fig 5: Typical Brussels new build - in this case a Passivhaus apartment block with a very simple structural form and solar shading

SWEDEN

There is little evidence of complexity being designed out of houses in Sweden. Swedish houses still bear many of the challenging features that you might see in UK houses, including steps, staggers, dormer windows and integral garages. However bay windows, sliding sash windows and large expanses of glass do not generally feature in Swedish designs.

What does appear to be happening is increased experience in designing thermal details for challenging features. A good example of this is the Passivhaus family home in Alingsås shown in figs 6 and 7, which includes steps, staggers, an integral garage, a balcony and, to the rear elevation, reasonably large windows.

Fig 6: Family home in Alingsås (view from street) showing steps, staggers and integral garage

Fig 7: Rear view showing steps, staggers, glazed areas, integral garage (which is multi-storey) and balconies

GERMANY

Except in Passivhaus developments, it is common in Germany to design and build challenging architectural features (see, for example, fig 8). However there is a catalogue of accredited details for such designs that show how thermal bridging can be minimised. Accredited details have pre-calculated thermal bridging values that can be entered into the energy assessment software. As an alternative to calculating thermal bridge values, relatively punitive default values can be used. This approach appears to be working well.

Fig 8: A new house in Bavaria constructed of clay honeycomb blocks showing challenging design features such as a balcony, dormer window and a chimney.

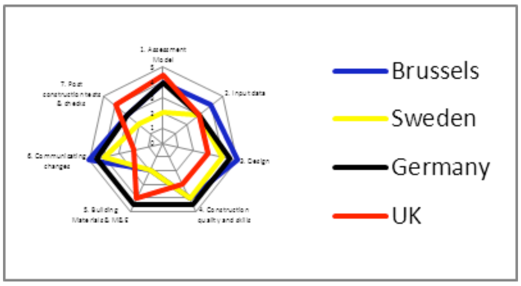
It is the responsibility of the architect along with specialist consultants to ensure that the design details comply with the German Building Regulations.

A fabric-first approach is being promoted by the German government and there is a growing awareness of the implications for this across Germany. Care in detailing can often be seen, for example in the use of perimeter insulation around foundations (see fig 9).

Fig 9: Perimeter insulation installed to the foundation of a new build property.

4. CONSTRUCTION QUALITY AND SKILLS

"Are there fundamental ***construction quality and skills*** *issues?"*



BRUSSELS CAPITAL REGION

There is no government-based building control function in Brussels. Instead inspections are carried out by the architect and the PEB Advisor. Typically the PEB advisor visits a dwelling two or three times during its construction, and the architect visits at least weekly. The individuals who were interviewed for this report expressed great confidence in this system.

With the exception of Passivhaus projects where airtightness is checked during the construction process, no tests are conducted on Brussels houses during construction.

As in the UK, most trades are sub-contractors. There is a consensus that although their work is generally of a high standard there is still a need for more training for all trades in the area of energy performance. Construction schools are therefore starting to train trades about energy efficiency and how their actions can impact building performance.

On medium to large projects such as apartment blocks and commercial buildings sub-contractors are expected to produce drawing details if they intend to penetrate the airtightness barrier. These drawings are reviewed by the architect who must approve them before the work is carried out. Best practice guides do exist for these details, but nothing that could be called a standard or accredited detail. It is anticipated that such details will become more prevalent on small projects, even for individual homes, between now and 2018 (when the Passivhaus standard becomes mandatory in the region).

SWEDEN

The local authority architect's office is the closest equivalent to the UK's building control bodies, but they do not visit site.

The level and nature of site inspection is at the discretion of the client. For example the client might appoint a clerk of works, but this is unusual. An airtightness test could be asked for, but this would probably only occur if the Passivhaus standard had been specified.

The primary means of ensuring quality on site is through the skills of the trades (see fig 10). As in the UK the trades tend to be sub-contractors, but they have been accustomed to installing high levels of insulation and mechanical ventilation systems for many years. They are therefore viewed as being capable of avoiding critical problems that can occur. Maintenance of an airtightness layer in very high performance buildings is still considered to be an area of weakness - although the typical Swedish construction methods (concrete or closed panel timber frame) are inherently airtight by UK standards.

Fig 10: A well-implemented Swedish airtightness detail

GERMANY

Building control is carried out by a range of construction professionals and not by the local authority.

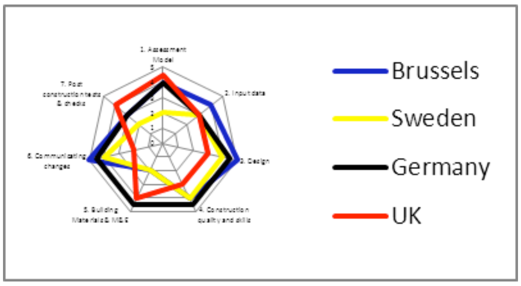
It is understood that a typical builder will attach great importance to supervising the construction activities. In addition when work has been carried out, the sub-contractor has to write to the architect / specialist consultant to state that they have completed it and it is to the appropriate standard.

The architect, energy assessor and construction supervisor are employed by the builder / client to carry out quality inspections and material checks. With the exception of special projects where airtightness and thermography are used, it is unusual for tests to be conducted while the building is being constructed.

As in the UK, most trades are sub-contractors. Trades are well aware of the high standard needed in the energy performance of homes and are trained accordingly. The typical trade undertakes three years' learning and several years practice as an apprentice before taking a final exam to become a competent member of their trade. This apprenticeship approach is strongly supported.

5. PERFORMANCE OF MATERIALS AND M&E IN PRACTICE

*"Do **building materials and mechanical and electrical (M&E) systems** perform as well in practice as laboratory tests predict?"*



BRUSSELS CAPITAL REGION

Although it is recognised in practice that components and materials do not always perform as laboratory tests predict, no remedial measures such as the application of in-use factors are used within the modelling software. However architects might over specify in some circumstance to guarantee performance.

SWEDEN

Insulation manufacturers supply to energy assessor practical insulation values as well as laboratory ones. Additionally for things such as ventilation systems some energy assessors will model efficiency losses from the duct work, although others will just use manufacturers' data.

However it should be noted that there does not appear to be much commercial pressure to design buildings to the absolute minimum specification and that as a result this issue is less critical.

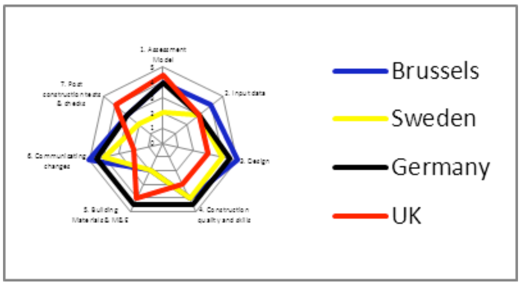
GERMANY

It is recognised that components and materials do not always perform as EN tests predict. Additional tests have to be carried out on materials and components in order for them to be used in the energy assessment software. This is a similar process to the UK's SAP Appendix Q approach, but it covers a wider range of products.

The German building regulations include a rule whereby the thermal conductivity of insulation has to be set 5–10% higher (ie. worse) than the value obtained from laboratory testing.

Services such as mechanical ventilation systems can only be specified in the energy assessment tool if they have achieved an independent “Mark of Conformity” which verifies their performance.Controlling and communicating changes in specification

*“Do changes in specifications get properly **communicated**?”*



BRUSSELS CAPITAL REGION

During the design phase it is standard practice for the PEB Advisor to inform the architect on the required performance of the components and materials in the building. The architect specifies all components and materials and supplies this information to the contractor. The contractor then provides technical data sheets for all the ordered products to the architect and the PEB Advisor, and the architect has to approve these. If the contractor cannot obtain the specified materials, they have to refer this to the architect who will verify (and if necessary change) the specification accordingly. Finally the architect visits the site to check use of the appropriate components and materials.

Those interviewed expressed a great confidence in this system, which appears to offer considerably more rigorous control than is normal UK practice.

SWEDEN

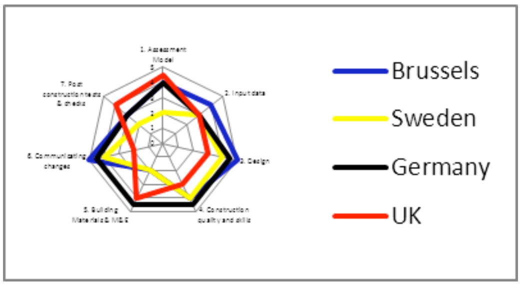
Changes to specification in buildings are unusual. Opinion is that where it does occur, for example because a cheaper alternative is available, the contractor will always check with the client or developer before any such change is made. However as there is no formal inspection regime, unless a clerk of work has been appointed this is difficult to verify.

GERMANY

The architect together with the specialist consultants detail the materials/products to be used on the development in a 'tender and performance' specification. The contractor installs the material in accordance with the specification, under a strict inspection system operated by the construction teams themselves. As a result, those interviewed did not see changes in materials as a problem in Germany.

7. POST CONSTRUCTION TESTS AND CHECKS

*"Are the **post construction tests and checks** appropriate and adequate?"*



BRUSSELS CAPITAL REGION

The only verification that occurs for normal projects is a post-occupancy survey to check whether internal temperatures are maintained within reasonable bands in both the summer and winter months.

Unlike in the UK, where there is increasingly widespread airtightness testing, airtightness tests only occur if an air permeability value was specified at the design stage. This practice is, however, becoming increasingly common, since the default value to be used in the absence of a test is punitive.

Currently around 1 project in 20 can apply for 'exemplary status'. These buildings are monitored for their energy consumption to obtain information that can be applied to future projects. These projects are subsidised by €100/m^2

Thermography is sometimes used, but usually only when a problem has been identified.

SWEDEN

Up until 1996 the local authority architect's office checked the airtightness of a sample of dwellings. Since then it has been at the discretion of the client, and a final check test is unusual unless a Passivhaus has been specified.

The Swedish Passivhaus standard calls for moisture content testing of materials in order to avoid mould growth and difficulties in achieving demand temperatures as well as evidence of the energy used in operation. Heat flux tests, monitoring of the internal environment and thermographic imaging are also sometimes used, but only as research tools.

The BBR requires that it should be possible for the client to measure the performance of the building in-use by measuring and summing up the various energy inputs over a continuous period of 12 months and to be able to compare this with the usage predicted by calculation. For most communally heated apartment buildings, it is likely that performance monitoring will continue beyond the 12 month initial period required by the BBR. If the building fails to conform to the design calculations then the municipality can enforce change, but the Swedish interviewee was unaware of the regulation ever having been enforced as in practice it is accepted that buildings performance will vary depending on the patterns of occupation.

This is likely to be reflection that historically within Sweden the emphasis has been more on comfort in-use than on energy efficiency for its own sake.

GERMANY

The only post-construction test that is mandatory in Germany is an air permeability test and this is only the case when mechanical ventilation with heat recovery (MVHR) has been installed (see fig 11). In this instance every house has to be tested. Where MVHR is not installed, a conservative default value is then set in the modelling software and an air permeability test is not required. This approach differs to that in the UK where in effect all houses are tested.

Fig 11: An airtightness blower door test in progress. In this case in the UK

Other tests such as thermographic imaging and heat flux tests are sometimes carried out, specifically when an occupant raises an issue with thermal comfort or high energy bills. These tests can also be carried out on a project of special importance, such as a research project.

CONCLUSIONS

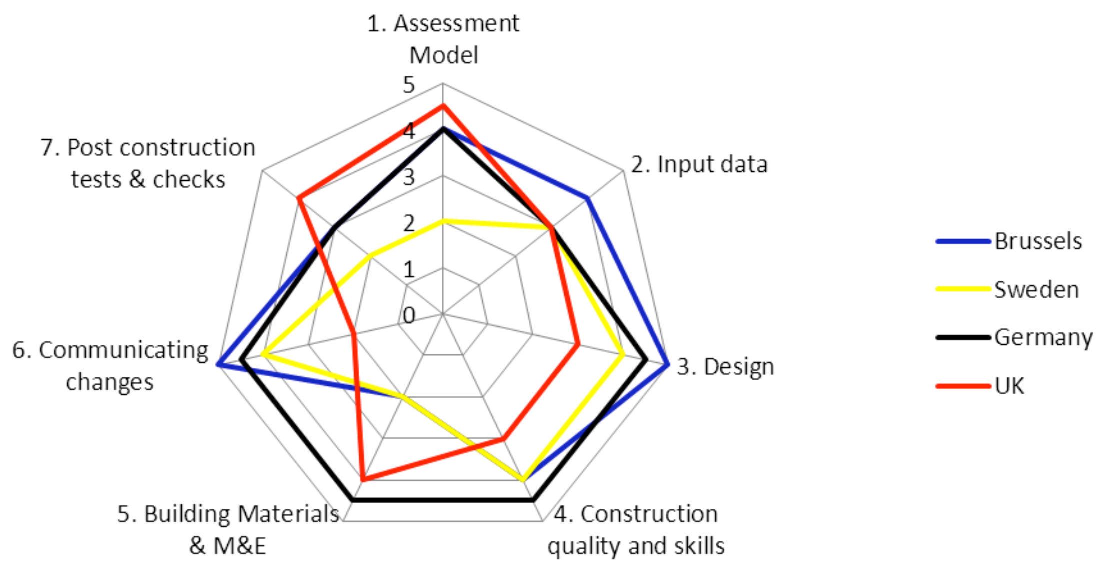


Figure 12: Comparing progress in addressing the performance gap

There is a great deal of consideration being given to the performance of new homes in the UK. This study has shown that in some areas the UK is at the forefront of best practice compared to Brussels, Sweden and Germany, but in other areas there is clearly scope for learning.

A detailed study of the different software models to compare their absolute accuracy was outside of the scope of this work, but the SAP assessment model appears to be very similar to its Brussels and German equivalents (insofar as it is a static model, its calculations are monthly and it complies with ISO 13790). SAP Appendix Q, which allows for the introduction of innovative technologies at any time during the software lifecycle is, in this respect, unique to the UK.

Where countries have more than one permitted model (notably Germany and Sweden), consistency of results is a cause of concern. In some cases there is a large amount of data to be entered, and a great deal of knowledge is required by the software users.

Brussels appears to be taking a lead in removing complexity from designs, but it is a route that may be aesthetically unappealing in the UK context. The different approaches in Germany and Sweden of developing new ways of detailing challenging design features, and in the case of Germany granting 'accredited' status to such details, is worthy of further research in the UK.

Those interviewed expressed similar views on site skills and the quality of construction work. In general there was a very high level of faith in the skills of the site trades, although some concerns remain about whether trades people fully appreciate the importance of maintaining the airtightness barrier.

The site inspection regime is particularly interesting in Brussels, where the architect and PEB Advisor visit the site regularly to check materials and construction practice. German practice is also strong in this area. This additional role comes with a cost of €1,000 - €3,000 per individual family home. Even so, the UK may wish to consider whether extending the role of the SAP Assessor to include site inspection might help to control product substitution and to develop construction practice in general.

The UK, Sweden and Germany appear to have given more consideration to the performance in practice of materials and services than Brussels has. Sweden's insulation manufacturers supply in-use insulation values and Germany has introduced in-use factors for insulation. Germany and the UK both have systems to apply site-appropriate data for new energy saving technologies (SAP Appendix Q in the UK and the "Mark of Conformity" in Germany).

Finally, the UK's current airtightness testing regime appears to put it at the forefront of post-construction testing among the countries surveyed, although this from of testing will become more common in other places, particularly Brussels, with the greater adoption of Passivhaus and similar performance standards.

FURTHER RESEARCH

Four particular areas arise from this study, which are worthy of further research for the UK context:

a. UK SAP assessors have no site inspection role. The inspection role of the energy assessor in Brussels and Germany, however, appears to have an important function in controlling site practice and product substitution. Unsurprisingly this enhanced role has a cost implication.

b. The UK applies in-use factors to novel 'technical' products through SAP Appendix Q, but in Germany in-use factors are applied more widely to 'basic' construction elements such as insulation.

c. The energy penalty that can arise from architectural features such as steps, staggers and dormer windows is mitigated in Germany by the use of accredited thermal design details.

d. There is a general trust in the quality of trade skills, and a continued upgrading of site skills and knowledge in the area of energy efficiency.

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Hans Eek, Architect, Pasivhuscentrum (shown here with a happy client)

Germany

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REFERENCES

[i] Low and zero carbon homes: understanding the performance challenge, NHBC Foundation report NF41 , February 2012

[ii] Low and zero carbon homes: understanding the performance challenge, NHBC Foundation report NF41, February 2012

[iii] The BBR in English can be found at: http://www.boverket.se/Om-Boverket/Webbokhandel/Publikationer/2008/Building-Regulations-BBR/

[iv] The Government's Standard Assessment Procedure for energy Rating of Dwellings, 2009 Edition, Published on behalf of DECC by BRE, Rev. October 2009

[v] http://energihuskalkyl.se/menus/index/23