Passive Houses Worlswide: International Developments

Henk Kaan, ECN Energy Research Centre of the Netherlands, P.O. Box 1,
1755 ZG Petten, The Netherlands,

Isolda Strom, DHV Building and Industry, P.O. Box 80007,
5600 JZ Eindhoven, The Netherlands

Chiel Boonstra, DHV Building and Industry, P.O. Box 80007,
5600 JZ Eindhoven, The Netherlands

1 Introduction

Before the millennium, the development and building of Passive Houses have mainly been limited to the German speaking countries. However, as the 10th International Passive House Conference proves, more and more interest is raising in other European countries, in the US, in Canada, Korea and other countries. In recent years quite a lot of Passive Houses have been built in amongst others Belgium and Scandinavia. In many other countries the first Passive Houses have been erected and/or are being developed.

Within the IEE (Intelligent Energy for Europe) Programme, the European Commission is supporting the project named Promotion of European Passive Houses (PEP). The goal of this project is to disseminate the positive experience with the Passive House concept that is gained internationally. Participating countries in the project are: Ireland, UK, Norway, Finland, Denmark, the Netherlands, Belgium, Germany and Austria. Furthermore, observers from Poland, France and the Czech Republic are frequently participating in the project meetings and events. The PEP - project is coordinated by ECN (the Netherlands).

In parallel, an EC supported project called Passive-On focuses on passive cooling in Mediterranean climates. This project is coordinated by the Politecnico di Milano.

Although a few Passive Houses have been built outside Europe, Passive Houses are still mainly a European development. Therefore this paper discusses the state of the art in Passive House development in the above-mentioned European countries only. The preliminary results of the PEP project form an important input (soon downloadable from: www.europeanpassivehouses.org) The paper deals with the following questions:

- *What is a Passive House?*

  Following the definition developed by the Passivhaus Institut, a Passive House has a heat demand of 15 kWh/m^2 floor area per year, whilst the total primary energy use in the house is restricted to 120 kWh/m^2 per year. However, this definition was developed taking the German and Austrian climatic conditions as a point of departure. Is this definition achievable for Nordic climates like Scandinavia? Is it too easy to reach for milder climates than Central European?

- *Do Passive Houses make sense?*

  In several European countries the energy performance standards in residential buildings are quite good. Do Passive Houses substantially contribute to energy conservation in the residential building sector? What is their energy saving potential?

- *Can German and Austrian concepts be copied in other countries? Which barriers in realisation of Passive Houses can be identified and how can they be solved?*

  Within the European Union, Germany and Austria are ahead with respect to Passive House building. In these countries thousands of Passive Houses and other passive buildings have been built and more than 50 small and medium sized enterprises developed building products (e.g. insulation, passive solar components, window frames, special glazing, highly efficient heat recovery systems, compact heating units and others) which are suitable to be applied in Passive Houses. The question may rise: why do other countries not follow the German/Austrian concepts, when such convincing examples of very efficient and comfortable houses can be seen in so many places in Germany and Austria? What are the barriers to overcome to adapt these concepts in other countries?

2 What is a Passive House?

The basic idea of a Passive House is to minimise the heat demand for space heating so that the necessary heat can be supplied by additional heat to the ventilation air. Taking into account the outdoor temperature and as a consequence the temperature of the incoming ventilation air, the heat capacity of the air, and the maximum temperature to which the air can be heated to be comfortable, the maximum heat requirement was calculated to 15 kWh/m^2 per year. Experiences in Germany and Austria have convincingly shown that this can be reached in Central European climates. However, in Nordic climates this might be quite difficult, if not impossible. Northern Scandinavia copes with winter temperatures of minus 35 °C and lower. The Finnish and Norwegian partners in the PEP-project have expressed concern that the criterion of 15 kWh/(m²a) is an unrealistic one for their countries. Better components than are currently used in Central Europe would have to be made available. Due to different usage patterns in Northern Scandinavia, a more flexible definition of Passive Houses may also be appropriate. In any case, the result will not be worse than the Passive Houses in more moderate climates: the houses built according to such standard are in accordance with Passive House construction principles and very energy efficient. After long discussions with the project partners, it was decided in the PEP-project to define Passive Houses as follows below, in a popular version (a) and in a more scientific version (b). Furthermore subject to discussion is the question, if only the ventilation air should supply the heat for space heating. The background of this criterion is that by doing so, a separate heating system can be avoided, thus saving costs that can be used for adding insulation, improving air tightness, etc. However, in some countries, for instance in the Netherlands, houses have a (low temperature) water based space heating system which is combined with the domestic hot water supply, and which can be coupled to a solar collector. These systems are relatively cheap and supplying heat through ventilation air only will not have a significant cost reduction effect. The results of the discussion of this item in the PEP-project is also reflected in the definition of Passive Houses:

(a):"The term Passive House refers to a specific building standard for residential buildings with good comfort conditions during winter and summer, without traditional heating systems and without active cooling. Typically this includes very good insulation levels, very good air tightness of the building, whilst a good indoor air quality is guaranteed by a mechanical ventilation system with highly efficient heat recovery".

(b):"The term Passive House refers to a specific building standard for residential buildings with good comfort conditions during winter and summer, without traditional heating systems and without active cooling. Typically this includes very good insulation levels, very good air tightness of the building, whilst a good indoor air quality is guaranteed by a mechanical ventilation system with highly efficient heat recovery. Thereby the design heat load is limited to the load that can be transported by the minimum required ventilation air. However space heating does not have to be carried through the ventilation system. For 40° - 60° Northern latitudes, under conditions specified in the PHPP calculation model:

- the total energy demand for space heating and cooling is limited to 15 kWh per m² treated floor area and year;
- the total primary energy use for all appliances, domestic hot water and space heating and cooling is limited to 120 kWh per m² treated floor area and year.

A Passive House has a high level of insulation with minimal thermal bridges, low infiltration and utilizes passive solar gains and heat recovery to accomplish these characteristics. Consequently renewable energy sources can be used to meet the resulting energy demand.

For 60° and higher latitudes, it is necessary to adjust the figures in order to be able to achieve an ambitious yet realistic solution. This can be done on a national basis. However, the specific heat loss for transmission, infiltration and ventilation (according to EN ISO 13 789) normalized for treated floor area should not exceed 0.5 kWh/(m²a)."

For southern climates, where passive cooling is more dominant, a second addition to the definition should be made. However, in the PEP project this addition has not been discussed yet.

Although it is not impossible to renovate houses according to the above Passive House standard, it might be a difficult task. For the construction of existing buildings or their situation in the urban context do not always offer the required preconditions for a full "Passive House" renovation. However, by taking the Passive House concept as a point of departure, and by using appropriate products and techniques, the result may be close to the Passive House standard. In order to avoid confusions between the "real" Passive House standard and energy efficient renovation using products, techniques and concepts that are appropriate for Passive Houses but do not result into fulfilment of the Passive House criterion of 15 kWh/(m^2a), a new criterion must be defined for existing buildings to label a renovation based on Passive House components, resulting in an energy demand for heating of around 25 kWh/(m^2a).

3 Do Passive Houses make sense?

Compared to the current standard of energy performance in the various European countries, Passive Houses perform quite well. As generally known, national energy policies and EU energy policy is focused on energy conservation in order to reduce CO_2 emissions at least according to the Kyoto targets. Should it make sense, if all the new residential buildings should be built to Passive House standards? This question was discussed in the PEP project. The report can be downloaded from the website. The summarised discussion and the conclusion are given below.

In order to determine the potential CO_2 reduction, the savings on primary energy from fossil fuels must be known. Taking into account the various conversion factors from secondary energy to primary energy, the calculated yearly primary energy uses for a Passive House, in relation to an existing dwelling and a typical new to build dwelling according to building standards are given below for space heating (figure 1) and total household energy (figure 2):

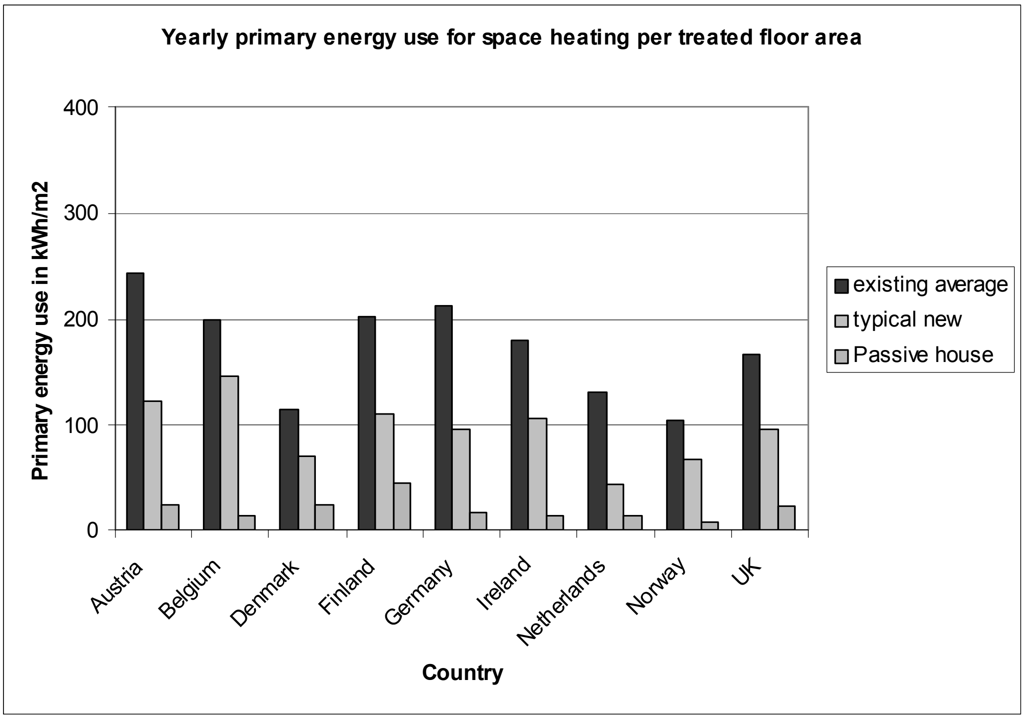

Figure 1: Yearly primary space heating energy use per dwelling, per existing, typical new and Passive House

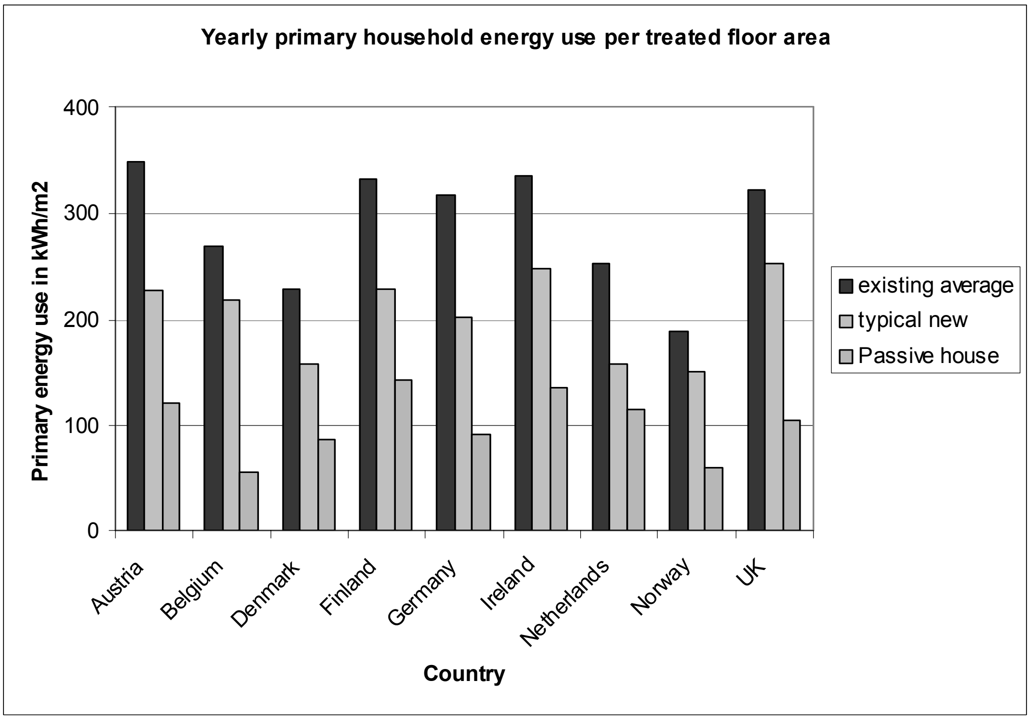

Figure 2: Total yearly household primary energy use per dwelling, per existing, new and Passive House

The energy savings of a Passive House renovation compared to an average existing dwelling, and the energy savings of a Passive House compared to business as usual is given in figure 3.

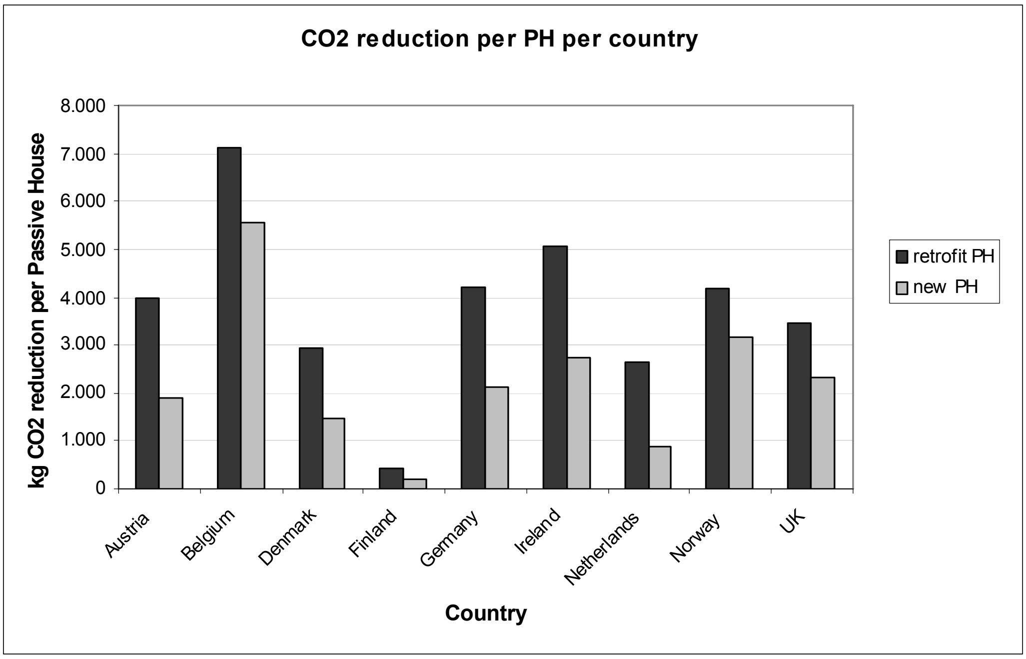

Figure 3: CO_2 reductions per Passive House compared to business as usual (new PH) and to existing dwellings (refurbishment PH)

The graph shows diversity between the participating countries. A part of the differences in CO_2 reduction per Passive House between the countries can be attributed to different levels of energy use, different types of applied energy sources and different conversion factors for each country. Overall, it can be noted that electricity has the highest factor, while district heating and gas, for example, have much lower conversion factors. This means that savings in electricity use will result in much greater avoided emissions than savings in district heating. As this example illustrates, the energy sources used in a Passive House (which differs per country) can have a large impact on the resulting emissions.

The above figure shows for **Austria** a fairly high CO_2 reduction. This is due to the fact that the reference use is fairly high. The current energy use of the typical new dwelling and the average existing household is relatively high in **Belgium**, resulting in a high energy saving potential for the Passive House. **Denmark** shows an average CO_2 reduction per dwelling. Savings are mostly in electricity and district heating use.

The CO_2 reduction for **Finland** is relatively low, due to relatively high energy uses for the Passive House (40 kWh/(m²a), due to climate). Moreover, most reduction is achieved in district heating and electricity, both with relatively low CO_2 emissions in Finland (low CO_2 conversion factor). The CO_2 reduction per dwelling for **German**y is fairly high, for a large part due to electricity savings and reduction in space heating.

The CO_2 reduction per dwelling for **Ireland** is high. Most reduction is due to gas, electricity and heating oil savings. For **the Netherlands** the CO_2 reduction per dwelling is average compared to other countries. Savings are mainly in gas use for space heating. **Norway** has low CO_2 emissions for electricity. Nevertheless, due to high reductions in electric energy use for space heating, the CO_2 reduction is relatively high. The CO_2 reduction per dwelling for the **United Kingdom** is high. Savings are both in electricity and gas use.

To be able to relate the energy saving potential of Passive Houses with the Kyoto targets, it is necessary to bear in mind the Kyoto objective describes a reduction of greenhouse gas emissions by at least 5 % below 1990 levels during the period 2008 to 2012. As Passive Houses are on the brink of large market penetration, the contribution of Passive House to the Kyoto agreement in this period will be small. However, through the Passive House concept a considerable energy saving compared to the business as usual can be obtained. This energy saving potential implies high CO_2 reductions of 50-65 % for each Passive House. Considering the early stage at which Passive House development currently is in most countries, it forms a promising method to contribute to emission reduction in the future, if successfully implemented in national markets. At the time that this paper was written, the energy saving potential calculations which are to be made in the PEP-project have not been finalized yet.

4 Can German and Austrian concepts be copied in other countries? Which barriers in realization of Passive Houses can be identified?

Though the physical principles of Passive Houses are valid in general, the elaboration for the respective countries is quite different. In the first place, the building tradition differs from country to country. In Germany, for instance, outer wall plastering is quite common, whilst in Belgium and in the Netherlands brick cavity walls are mostly applied, and Sweden and Finland have broad experience with wooden buildings. These three various construction methods ask for different constructional solutions. E.g. details of a Passive House will even be different in Belgium compared to the Netherlands since constructors are familiar with local construction materials and detailed solutions. And even when this has technically been solved (which is the case in fact in this example), the solutions found in one country must be adapted to the specific building codes and standards of the other countries. In theory a construction method could be transferred from one country to the other, the practice will show however that this is not that simple. Figure 4 for instance shows the thermal insulation applied in national common practice versus Passive House construction. It is clear, that in most of the countries the building practice must change, if the Passive House standard has to be met.

The brick cavity wall building tradition poses challenges in several countries. To meet these challenges attention must be paid to good detailing, availability of appropriately dimensioned items (such as wall ties), and improvement of site practices will be necessary. If the market conditions allow, alternative wall-types could be developed.

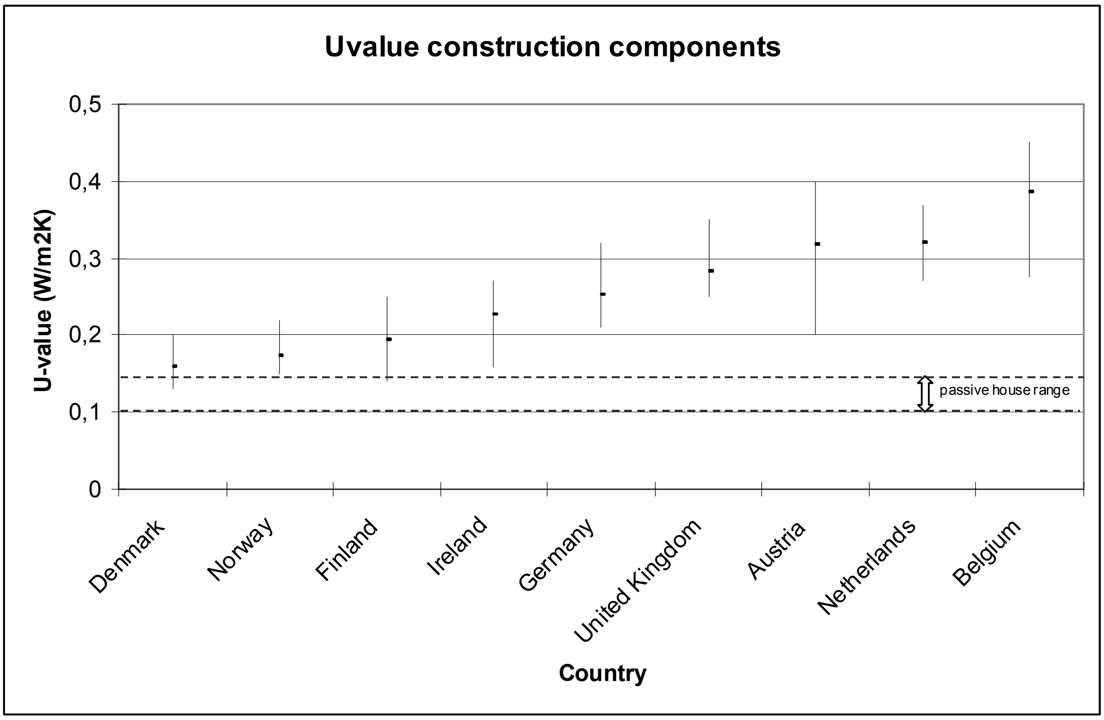

Figure 4: Average U-values of construction components (wall, roof, floor) in European countries

The other barrier that is encountered in several countries is the lack of good window components. However, in other countries (such as Austria) these components are readily available. By temporarily importing these components, this barrier can be overcome. As demand increases it is expected that local availability will improve.

In the PEP project, an inventory was made of barriers and possible solutions.

Most frequently encountered barriers in partner countries are: limited know-how; limited contractor skills; and limited acceptation of Passive Houses in the market. To overcome these barriers, a great deal of attention must be paid to providing practical information and solutions to building professionals, providing practical information and training to installers and contractors and communication about the Passive House concept to the market. The PEP-project is intended to provide this information and knowledge by means of making information packages focused on the specific needs of the country concerned, by means of doing suggestions for certification and accreditation of products, processes and people, and by means of workshops, articles, websites and other forms of targeted dissemination. The Passive House concept has a large potential and stands on the brink of market penetration in many countries. It is a challenge to clear the mentioned barriers internationally in the coming years to reach the status for Passive Houses 'As Business As Usual'.