Passive House or *Passivhaus*?

Passive House is a generic term which has, in the last ten years, at least in parts of Europe, become associated with a "standard" for a specific way to build a house. To many architects in central Europe, particularly Germany, the term Passive House will these days probably provide an image of quite a particular type of house. However to professionals in other areas of Europe, the same term will conjure up a host of general ideas on how to reduce the energy consumption of buildings. Passive House means many things to many people and so it's worth spending two words on the issue.

A Passive System provides an indoor environments with heat, cold, ventilation or light by using and controlling the natural energy flows which surround a building, such as solar radiation and wind. There exists an extended range of passive systems and measures; for example painting external walls white helps cool a building in summer, windows will provide daylight and stacks can drive ventilation. Even the most basic human construction employs some form of Passive System: the thick walls of the mud hut on the Savannah insulate the occupants against the heat of the day and the cold of the night. However in a modern context, interest in employing and improving Passive Systems grew following the oil crisis of the 1970's. Architects began to experiment with Solar Houses which attempted to significantly lower the needs for winter heating fuels. Often these employed large areas of glazing on the south facade of buildings, sometime in the form of greenhouses, to capture and utilise the radiation of the winter sun.

More recently the term Passive Design has come to indicate buildings which integrate low energy active components such as pumps and fans with or along side Passive Systems. The quantity of energy consumed by the active component remains significantly lower than the energy content of the natural energy flow which the component controls. Thus the heat recovered in an heat exchanger will often be at least ten times greater than the electrical energy used by the heat exchanger fan. In many cases the energy demand of the active system is so low that it can be met economically and feasibly by a renewable energy source such as a PV panel.

To many professionals in many countries, and to some laymen, the term Passive House thus indicates a house in which any of the many Passive Systems and measures available are used as the main means to provide light, heat, cold, and ventilation. Though Passive Systems represent the predominant means to providing building services, architects in Spain, Portugal or Italy will not generally link this need to particular requirements in relation to the use of fossil fuels of the type of Passive System to be applied.

In 1991 Wolfgang Feist and Bo Adamson applied Passive Design to a house in Darmstadt, with the objective of providing a show case low energy home at reasonable cost for the German climate. The design proved successful both in terms of energy consumption and comfort such that the same passive systems were applied again in a second construction in 1995 in Groß-Umstadt. By 1995, based on the experience from the first developments, Feist had codified the Passive Design of the Darmstadt and Groß-Umstadt homes, into the *Passivhaus standard*. The standard fundamentally consists of three elements:

i) an energy limit

ii) a quality requirement

iii) a defined set of preferred Passive Systems which allow the energy limit and quality requirement to be met cost effectively

It total more than 6.000 houses have now been built in Germany and elsewhere in central Europe (for example Austria, Belgium, Switzerland, Sweden) which conform to the *Passivhaus* standard. To most professionals in Germany and to many in the general public a Passive House now equates firmly with the *Passivhaus* standard.

Defining a standard for low energy homes offers a number of advantages. Indeed it is likely a major reason for the explosion of the construction of low energy homes in Germany (discussed more fully in the following sections). However though in central Europe, Passive House is increasingly associated with the *Passivhaus* standard this is not necessarily the case in southern Europe (for example Spain, Italy, Portugal and Greece). Here to most architects Passive House generally means any a house constructed in line with any generic Passive Design.

Furthermore not all professionals, some of them involved in Passive Design for many years, particularly like the idea that the generic word Passive is now associated with a specific construction standard. They want the freedom to apply the term Passive Home to any Passive Design, irrespective of whether this home meets the requirements set out in the *Passivhaus* standard.
Associating the term Passive House with a commonly accepted standard in central Europe and with free design in southern Europe is also leading in some parts to an hybrid definition of the term Passive House, which takes into account the limits for heat demand (15 kwh/m²/year) of the Passivhaus standard but not the specific envelope quality or primary energy requirements. This discussion might all seem a little abstract. However as the low energy homes become more common, and incentive programmes and obligations becomes a possibility, then what we mean by Passive House and what we aim to promote and disseminate needs to be clear.

To avoid confusion, this text uses the term Passivhaus in relation to those homes which meet the Passivhaus standard and the term Passive House to refer to homes which integrate some general form of Passive Design (and which may or may not conform to the standard).

The Passivhaus phenomena

The first house conforming to what was to become the Passivhaus standard was built in 1991 in Darmstadt-Kranichstein, Germany. After a slight lull (the second development occurred in 1995, and a third development of 22 terraced homes in 1997), the development of homes which meet the Passivhaus has grown vertiginously. As of 2005, more than 6,000 homes conforming to the Passivhaus standard have been built in Europe, 4,000 of which in Germany. An important boost to Passivhaus development was provided by the EU Thermie funded CEPHEUS project (1998-2001) which oversaw the development of 221 homes in four countries (Germany, Austria, Sweden and Switzerland). Currently the development of Passivhauses in Germany runs at several hundred units a year with a prediction of 20% of the market share by 2010.

Compared to the total annual development of news homes in Member States, which in many cases run into several hundred thousand a year, these figures may seem insignificant. However compared to other attempts at developing and promoting low energy homes over the last thirty years in Europe, the results are quite exceptional.

Though there are no precise numbers, it is likely that the total number of Passive Solar Homes in any one member state fail to add to more than several hundred units. What makes the Passivhaus concept so successful is possibly that the standard codifies precisely energy and quality requirements for new homes and then provides a relatively standard set of solutions by which these requirements can be met. In consequence a Passivhaus is a well defined product, understood by the developer, architect and owner; everyone involved in the process knows what they are getting.

In contrast though the general concept of Passive Design might be understood, the exact outcome of the design process will depend on the skill of the architect. Though there are undoubtedly a large number of well designed Passive Homes there are also a number with problems; in particular the use of large amounts of glazing on the south facade typical of many solar homes, though reducing winter energy demand, leads to overheating in summer.

Though standardising outcomes (energy and comfort) and means (passive systems) might be the main reason for success there are others:

➢ The solutions can be integrated into homes which can have the same aesthetics as current standard developments; for example there is no particular need to have large amounts of glazing on the south facade.

➢ The solutions are relatively cheap; a house built to the Passivhaus standard at most costs 10% more than a standard house though they can be built for the same price. However experience shows that on average a Passivhaus costs just 4-6% more to build than the standard alternative.

A Mediterranean Passivhaus?

The Passivhaus standard was born to respond to the requirements of relatively cold central Europe. Though homes in southern Europe need to be warm in winter this is accompanied by a need to ensure comfort in summer, which at times can be the predominant issue. Traditional
vernacular architecture in southern parts of Spain and Italy reflects this need and modern Passive Design revisits many of these traditional solutions.

Figure 3. White washed houses and narrow streets in the Santa Cruz district of Seville, Spain. Just two of the many different strategies employed by traditional architecture to keep houses cool in summer.

Given the success of Passivhaus in central Europe the Passive-On project has looked to see what elements of the standard could be useful in promoting the diffusion of low energy house design in southern Europe.

On the one hand the analysis has shown that, in certain regions the solutions utilised in the standard Passivhaus, can also provide an effective basis for providing cool homes in summer (though some modifications need to be made to reduce the impact of solar radiation).

However on the other hand, research shows that some of the implicit and explicit requirements of the Passivhaus standard can represent over engineering in southern Europe. For example the Passivhaus standard makes an explicit requirement to limit the permeability of the building envelope \( n_{50} \leq 0.6 \ \text{h}^{-1} \) which makes an implicit need for an active air ventilation system. However experience, for example from Spain and Portugal, shows that effective low energy homes can be built without the need for active ventilation systems and with less stringent building shell criteria.

Passive-On therefore proposes a number of changes to the current Passivhaus standard. The aim is to allow designers in the Mediterranean to adopt those Passive Design appropriate to warm climates whilst ensuring that these provide guaranteed results in terms of energy and indoor quality. As already noted, what makes the Passivhaus concept so successful is that the Passivhaus is a well defined product, understood by the developer, architect and future owner. The new definition makes the same successful concept applicable to warmer climates.

The full proposed revised definition of the Passivhaus standard can be viewed on the Passive-On web site. However the principle changes aimed to make the Passivhaus standard relevant to the Mediterranean are:

- the introduction of an explicit limit for energy demand for summer cooling (15 kWh/m² year)
- minimum requirements for summer comfort; indoor summer temperatures are not to exceed the Adaptive Comfort temperature as defined in the PrEN 15251 proposed standard. Using the Adaptive Comfort model ensures comfortable temperatures compatible with Passive Design.
- relaxing the limit on the air tightness of the building envelope to \( n_{50} \leq 1 \ \text{h}^{-1} \) (and in certain circumstances less) will allow a Passive House to built to the Passivhaus standard without the need for an active ventilation system.

Also in line with the Passivhaus concept the Passive-On project has identified for each country, partner to the project, a Passive Design which allows the requirements of the modified Passivhaus standard to be met cost effectively and practically. These are not intended as exclusive solution sets; designers are free to choose alternative Passive Designs. However any alternative design would need to guarantee the energy and comfort requirements as set out in the standard. (The Mediterranean Passivhauses are detailed in the Design Guidelines developed within the context of the Passive-On project).

Hopefully the development of a modified Passivhaus standard will allow Passive House development to lift off in south as it has in central Europe.

The Passive way to saving !

Experience from Germany where over 4,000 homes conforming to the Passivhaus standard have been built, indicates that the extra cost of construction is really quite limited; on average a Passivhaus costs just 4-6% more to build than the standard alternative.

It could be argued that the marginal cost is low because
standard construction costs in Germany (on average around 1.400 Euro/m²) are high compared to southern Europe. However if standard construction costs are lower in Spain, France or Portugal then so too are the costs of passive solutions. Analysis conducted in the Passive-On project indicates that construction costs of Passive Homes in the five partner countries partner to the project, will be in the region of 3 to 10% higher than construction costs of standard alternatives (see Table 1).

Table 1. Typical construction costs for standard and projected extra costs of Passivhauses as determined in Passive-on.

<table>
<thead>
<tr>
<th>Specific Construction Costs</th>
<th>Standard House</th>
<th>Passive House</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Euro/m²]</td>
<td>[Euro/m²]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>1,400</td>
<td>1,494</td>
<td>6.71%</td>
</tr>
<tr>
<td>Italy (Milan)</td>
<td>1,200</td>
<td>1,284</td>
<td>7.00%</td>
</tr>
<tr>
<td>France</td>
<td>940</td>
<td>1,034</td>
<td>10%</td>
</tr>
<tr>
<td>Spain (Seville)</td>
<td>720</td>
<td>740</td>
<td>2.85%</td>
</tr>
<tr>
<td>Portugal</td>
<td>800</td>
<td>858</td>
<td>7.15%</td>
</tr>
<tr>
<td>UK</td>
<td>881</td>
<td>930</td>
<td>5.54%</td>
</tr>
</tbody>
</table>

However it must be remembered that the final costs of a new home includes the cost of land and the profit margins of the developer and /or real estate intermediaries and can be several times higher than construction costs. For example the average price¹ of new apartments in Milan varies between roughly 4.000 (outskirts) and 7.000 Euro/m² (city centre) . Thus supposing that the marginal increase in construction costs of building a low energy home was passed directly to the home owner without any further mark-up, Passive Homes could potentially sell for only 1-2% more than the standard alternative.

Nevertheless the problem of financing a new home should not be underestimated. Though 10.000 Euro might only represent 7% of building costs, it can still represent a considerable sum for many families. Financing tools as proposed in the Financing Action Sheet of the Passive-On project can thus prove helpful in overcoming barriers posed by financing.

Though a Passivhaus might cost slightly more to build they offer considerable savings in energy bills over their lifetime compared to standard new constructions. A typical Passivhaus requires only 15-25% of the energy required to heat a standard new construction, (Table 2).

Table 2. Heating and cooling energy demand for new homes constructed to minimum current standards in force in member states and the Passivhaus standard.

<table>
<thead>
<tr>
<th></th>
<th>Heating demand</th>
<th>Cooling Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Passivhaus</td>
</tr>
<tr>
<td></td>
<td>[kWh/m² yr]</td>
<td>[kWh/m² yr]</td>
</tr>
<tr>
<td>Germany</td>
<td>90</td>
<td>15</td>
</tr>
<tr>
<td>Italy</td>
<td>111</td>
<td>10.5</td>
</tr>
<tr>
<td>France</td>
<td>69.6</td>
<td>17.4</td>
</tr>
<tr>
<td>Spain</td>
<td>59</td>
<td>8.7</td>
</tr>
<tr>
<td>Portugal</td>
<td>73.5</td>
<td>5.8</td>
</tr>
<tr>
<td>UK</td>
<td>59</td>
<td>15</td>
</tr>
</tbody>
</table>

Considering typical energy prices in place in the different Member States the reduction in gas and electricity bills repays the extra cost of building a Passivhaus in less than 20 years. However in particularly favourable situations pay-back can be as little as 4 years.

20 years might seem a long time but represents only a fraction of the lifetime of a house or an apartment. Houses might be designed to last 50-100 years but often function as homes for much longer. For example in Italy at current demolition rates, which have varied between only 0.1 and 0.5% of total stock since the late 1960’s, current homes will last between 200 and a 1,000 years!

Considering savings in fuel bills over 25 years, the initial investment typically provides returns of between 2 and 10%. At the upper end these returns compare favourable with the alternative investments open to the common investor (stocks and bonds), though at the lower they may be considered undesirably low.

However it is probably rather reductive to consider the extra cost of a Passivhaus solely in the context of a financial investment. Houses built to the Passivhaus standard provide occupants with increased comfort; the air tight envelope removes cold winter drafts, the thick wall insulation increases their temperature in winter and reduces them in summer, and the active ventilation system (in the case of the central European Passivhaus) guarantees a continuous supply of fresh air. Occupant surveys conducted in existing Passivhauses consistently report user satisfaction².

If families begin to consider the extra cost of developing a Passivhaus in terms of the acquisition of improved living conditions, then the issue of pay-back times and Rate of Returns becomes less important if not irrelevant. After all no family ever pretends that a high end fitted kitchen

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¹ Source: Osservatorio sul mercato immobiliare, September 2005.

which costs 5,000 to 15,000 Euro more than a good quality cheaper alternative somehow pays itself back!

**The potential and limits of the Passivhaus**

As of 2005, more than 6,000 homes conforming to the Passivhaus standard have been built in Europe. In Germany a Passivhaus consumes 80% less for heating than a new standard alternative. The 4,000 German Passivhauses translate into annual avoided emissions of CO₂ of 9,600 tonnes/year.

The development of 6,000 Passivhauses in just 15 years is a laudable result, and a similar success is in other countries would certainly be welcome. However though arriving at the development of several hundred Passivhauses a year might be seen as a realistic, if ambitious medium term target in southern European countries, meeting Kyoto targets requires that far more ambitious targets be set and achieved.

Passive-On has developed a “stock model” to determine the potential impact of developing Passivhauses on CO₂ emissions from the national housing stock in four partner countries; Italy, Germany, France and the UK. The stock model considers a number of scenarios, including looking at how to return CO₂ emissions from the residential sector to 2005 levels by 2020. This could be seen as a possible first step in returning emissions to 1990 levels and below as required by the Kyoto protocol.

The situation does vary from country to country. However in all four countries examined flattening off CO₂ emissions at 2006 levels by 2020, would require massive expansion of the development of Passivhauses. In the case of Italy, France and the UK this would require that by 2020:

- All new development reach Passivhaus standard. This would mean the construction of two hundred to three hundred thousand Passivhauses a year in each of the three countries.

- The annual refurbishment to Passivhaus standard of 2% (Italy) to 5% (UK) of existing stock. This would mean the refurbishment of respectively four hundred thousand and one million four hundred thousand in homes the two countries.

In reference to the last point the stock model highlights the importance of addressing existing stock as the only real means of reducing CO₂ emissions from the residential sector. The problem is that the UK, Italy and France each build two hundred to three hundred thousand new homes a year. Though homes meeting the Passivhaus standard might consume 80% less for heating and cooling than do standard homes; the fact is they still consume energy. Thus even assuming that all new homes from 2020 were to reach the Passivhaus standard global emissions will still continue to increase. The only way to stop the growth of CO₂ emissions (and eventually to obtain reductions) in the residential sector is to start refurbishing existing stock.

In this sense Germany is in a slightly more favourable position in that refurbishment rates of existing stock (350,000 homes/year) are currently higher than construction rates of new homes (190,00 new homes/year) and thus the potential already exists to offset demand from new houses by reducing demand from existing stock. In Germany CO₂ emissions could be flattened in 2020 by ensuring that 50% of programmed refurbishments and 70% of new housing achieve Passivhaus standard.

It is true that the Kyoto agreement does not require that the national reductions targets be reflected in each single area of the economy; the National Implementation Plans generally assign different savings targets to different sectors. However given that only seven European countries are currently projected to meet their assigned targets and some are expected to overshoot considerably⁢ (eg. Austria, Spain), it seems clear that many of the

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⁢EU Press Release of 2710-2006. Projected and in brackets target emission of the eight failing countries: Austria +14.8% (-13%), Belgium +1.2% (-7.5%), Denmark +4.2% (-21%), Ireland +13 (+29.6%), Italy +13.9 (-6.5%), Portugal +46.7 (+27), Spain +51.3% (+15%)
current National Implementation Plans will need to be revised. The problem is that no sector in the economy wants targets and works to pass the buck to other areas. Thus a plan which attempted to at least flatten emissions in all sectors, whilst assigning more politically contentious reductions to a limited few might prove a way forward.

As well as the Zero CO₂ Growth scenario Passive-On as also developed a number of other scenarios. Though the details of each scenario differ the important conclusion which emerges from the analysis is that just slowing the growth of residential CO₂ emissions requires the annual development of tens of thousands of new and refurbished Passivhauses. The development of 6,000 Passivhauses in central Europe provides a beacon for the way forward, but the situation now demands that the Passivhaus no longer be seen as the Formula 1 of the housing market available only to the chosen few, but needs to move to become a mass market commodity available to the majority.

Certainly ensuring that all new homes meet the Passivhaus standard requires considerable political commitment, which to some may appear too optimistic. However there are signs that in certain quarters the situation is maturing quite rapidly in this sense. The EU “Action Plan per l’Efficienza Energetica dell’Unione Europea: Realizzazione del Potenziale” approved by the Commission in October 2006, outlines the Commission’s plans for updating the Buildings Directive by 2009, and includes a target for all buildings to approach Passive House levels by 2015. In the UK regulation approved in December 2006 sets targets for energy performance of new homes in the period 2008 to 2016 including a binding requirement that all new homes be zero emission for heating and cooling by 2016.

The way forward

Passivhaus maybe feasible, comfortable and economic but a number of barriers nevertheless hinder their wider development.

Like all new products on the market there is an issue of raising customer awareness. However a house differs from a other goods in that it represents a notable investment for most families and though information campaigns might be useful, it is likely that mainly direct contact (through family and friends) with the “real thing” will generate sufficient interest and understanding to invest in a Passivhaus. Especially since amongst the general public the Passivhaus concept can raise a degree of scepticism in the view of the fact that the homes have no central heating in the traditional sense (how can they ever keep warm?).

At the moment a chicken and the egg syndrome prevails; without the possibility to “experience” a Passivhaus the general public is unwilling to invest in the new “untested” product. To create a self- sustaining virtuous cycle requires a kick start. In Germany this was provided by public sector; both the first Passivhaus apartment block in Darmstadt and the Cepheus project received conspicuous help from the public sector. The development of Passivhauses in Mediterranean countries would likewise benefit enormously from demonstration projects supported by direct financial assistance from local or national government in the early stages of market development.

Public financial support will facilitate earlier development, but much wider actions are required to bring Passivhauses into the mainstream and to do so in a reasonable time. It must be remembered that even with earlier public support it took 15 years in Germany before construction rates arrived at several hundred units a year. As recalled above, contrasting the growth in CO₂ emissions from the domestic sector requires the annual development of not hundreds but thousands of Passivhauses. To achieve the required level of development to avoid long lead in times, requires working on a number of fronts.

The Passive-On project has interviewed over 60 professionals from the private and public sectors in the five partner countries active in developing low energy housing. Based on their considerations and from best practice across Europe, the project has collected a number of proposals to assist the development of Passivhauses. For example:

Training and Development: Training and instruction needs to be improved from the architect to the builder:

Architects need to improve their understanding of building physics such that low energy and passive design becomes integral to all architectural training and not left as an optional subject for the select few.

Builders need to improve their understanding and attention to detail to ensure low design solutions are correctly implemented on-site.

Regulation: Building codes need to be addressed to remove some of the implicit barriers to low energy housing:

High insulation levels means that for the same land footprint as a standard house a Passivhaus will have less useful surface area; council fees and rates should be based on net not gross house volume.

National norms for summer indoor comfort levels should not be so restrictive as to require active air conditioning.

Financing: The public sector can work with private institutions to develop mechanisms to finance the extra cost of purchasing Passivhauses;

Mortgage schemes can be made to reflect the increases household liquidity of Passivhaus home-owners.

Articulating architect and design fees to the measured household energy performance can ensure actual performance matches planned.
Accreditation: Providing independent certification for Passivhauses provides the foundations for most other incentive mechanisms. Accreditation schemes can be extended to cover products and or actual builders and in doing so provides an immature market and “untried” product with a quality control and a guarantee.

These and the other proposals as detailed in the set of six Policy Actions Sheets prepared by the Passive-On project require time to implement but experience from around Europe shows that they are feasible when there is the political will to lead.

Proposals improving the skills of professionals, both designers and builders, will require particular effort, if for no other reason than because of the large number of people involved. However work to improve professional skill requires particular attention if the hoped for increase in demand for Passivhauses is met by a quality offer: providing low quality Passivhaus could damage the market both in the near and long terms.

For more information

More information on the Passive-On project can be found at the Passive-On web site at www.passive-on.org or by contacting the national contact point for Italy at info@passive-on.

Partners

The Passive-On project Consortium includes private and public research institutes with proven experience in the themes of Passive Houses, Passive Cooling and the field of Policy Analysis. Passive-On is co-ordinated by the end-use Efficiency Research Group (eERG) at the Politecnico di Milano University.

Italy: eERG Politecnico di Milano, Provincia di Venezia, Rockwool Italia
France: International Conseil Énergie (ICE)
Germany: Passivhaus Institut
Portugal: Natural Works e Instituto Nacional de Engenharia, Tecnologia e Inovação (INETI)
Spain: Asociación de Investigación y Cooperación Industrial de Andalucía (AICIA)
United Kingdom: School of the Built Environment, Nottingham University
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