Last month we looked at the origins of the Passive House movement. The first Passive Houses were completed in 1991 in Darmstadt, Germany, and in 1996 the Passivhaus Institut was founded there to investigate and promote Passive Houses. All climates are catered for in the standard, and the Passive House methodology has been spreading around the world. In the UK, the largest development of Passive Houses is the social housing at Saffron Lane, Leicester with 68 homes. (Social housing and selfbuild lead the way, not speculative house building.)

In practical terms, a Passive House requires:

- Ultra insulation.
- Negligible thermal bridging.
- Very energy efficient windows.
- An airtight envelope.
- A ventilation system with efficient heat recovery.

Any heating that is required in a Passive House is minimal, and can, if so desired, be achieved by heating the supply air of the ventilation system. (Though in common practice, small heat sources such as heated bathroom rails are often provided to aid the perception of warmth.)

No central heating system is required. Comfort is high. The air is clean. Running costs are low.

The Passive House Planning Package

For calculating the figures required to make a Passive House assessment, the Passive House Institute publish the 'Passive House Planning Package' – PHPP. This is an Excel workbook with more than 30 spreadsheets (or 'worksheets'). The first version appeared in 1998, and the current version is PHPP9, released in 2015. (Price €190.)

The Passive House Standard

To meet the standard, a house (or indeed any building) must satisfy the following four criteria:

1 Space Heating

Per square metre of usable floor area, at least one of the following two requirements must be met:

- The power required for heating in very cold weather is no greater than 10 watts.
  – In Passive House parlance, 10 watts is is the maximum 'Heating Load'.
  (The weather parameters for what I have called very cold weather are supplied with the local climate data for PHPP. See the Footnote, 'Correction'.)

  And/or:

- The annual amount of energy required for heating is no greater than 15 kWh.
So little heating energy is required in a Passive House that 'free' heat accounts for most of it:

- **Solar gains**
  The solar gains through windows are a major factor, both in winter (desirable) and in summer (undesirable). South facing glazing is the most useful, overall.

- **Internal Heat Gains**
  Body heat is given off by the occupants of the house. PHPP makes some rather arbitrary assumptions to guesstimate the amount. Also the methodology makes a guesstimate for the heat given off by the use of electrical appliances: lights, washing machine, TV, computer, etc.

2 **Primary Energy**

Per square metre of usable floor area:

- **The annual amount of primary energy required must be no greater than 120 kWh.**
  - The 'primary energy requirement' is for space heating, hot water, and domestic electricity (including appliances and lighting).

What is 'primary' energy? It is energy at its natural source. Consider for example electricity being produced by a gas-fired power station. The generation process is about 40% efficient – most of the energy of the gas is lost as heat. (In the UK, the heat is generally wasted, though in nortic countries it is often piped along under the streets to warm the buildings.) So for 1kWh of electricity, 2.5 kWh of gas energy is required (2.5 = 1/0.4). But before that, some energy has to be used to get the gas out of the ground and transported to the power station. And later, some energy is lost in the transmission of the electricity via the grid to the home. (For wind and solar electricity, there is no energy cost upstream of the turbine or PV panel.)

So how much primary energy is required to supply a home with 1 kWh of electricity? Some people who are adroit with figures work out the proportions of domestic electricity that come from gas, coal, nuclear, and biomass power stations, and from renewables, they add in grid losses and the energy required upstream of the power station, and so they come up with a figure for the primary energy for 1 kWh of domestic electricity. I trust that by now the reader is somewhat sceptical about the exact figure, but on the other hand, some figure is probably better than no figure.

The conversion figure in PHPP is 2.6, ie, 1 kWh at the domestic electricity meter requires 2.6 kWh of primary energy. In reality, of course, the figure varies from country to country.

For comparison, the SAP2012 conversion figure is 3.07. It is being proposed for SAP2016, that this Primary Energy Factor should be reduced to 2.36. This reflects the move away from inefficient coal fired power stations towards more efficient, gas fired stations and to wind and solar electricity. Using electricity to heat a home is becoming somewhat more acceptable, emissions-wise. (For SAP2016, the proposed figure for the Primary Energy Factor for mains gas is 1.13.)
How much domestic electricity is used in a house? The answer obviously depends on the occupants, which is why SAP excludes this factor from its calculation (except for lighting). PHPP, on the other hand, does include an allowance for the use of electrical appliances. This varies with the number of occupants, and that varies with the usable floor area – one person per 35 square metre of usable floor area is the default figure.

3 Airtightness

A Passive House must be tested for airtightness, using a 'blower door' test.

- The maximum air leakage allowed in the test is 0.6 air changes per hour
  – averaged over test pressures of plus 50 Pascal and minus 50 Pascal.

(I'll be looking at Airtightness in more detail in a later article.)

4 Thermal comfort

In wintertime, if the criteria above are satisfied, a temperature of 20°C can be maintained indoors. Moreover, the temperatures of all internal surfaces – in particular the window surfaces – will be at least 16.5°C, giving a feeling of comfort.

In summertime, the intent is to keep the indoor temperature below 25°C most of the time. So:

- The indoor temperature must not be over 25°C for more than 10% of the hours in a year.

The figure of 10% sounds reasonable, but since overheating is only likely during the three months of summer (June, July and August), temperatures over 25°C are not allowed for more than 40% of the time during the summer. That figure, 40%, seems an excessive allowance. (The Passivhaus Trust and the UK Passive House certifiers think that the annual limit should be 5%.)

In practice, I don't expect there will be very many hours of overheating for Passive Houses in the temperate climate of the UK (except possibly for houses which have exceptionally large areas of glazing).

Cooling

In this article there are many references to the energy required for heating a Passive House. The complete Passive House standards make parallel references to the energy required for cooling. I omit these as, in my view, the installation of air conditioning in a house in the UK is both unnecessary and undesirable.

Climate

The PHPP methodology is applicable for any climate. It comes with a default German data set, but PHPP sold in the UK should come with 22 UK data sets installed, ranging from South West England to the Shetland Isles.

'Much experience on how to build Passive Houses has been gained in Central Europe, the birthplace of the Passive House Standard. It would be unwise, however, to blindly apply successful Central European Passive House design to other regions and climates. Both the advantage
and the challenge of the Passive House Standard is that it can and should be applied to regional building traditions and climatic conditions.¹


Cost analysis

Compared to a conventional new house, a Passive House has ultra insulation, top quality windows, and a HRV system. (HRV: Heat Recovery Ventilation, otherwise known as Mechanical Ventilation with Heat Recovery, MVHR.) These appreciably add to the cost of building a Passive House. Achieving airtightness, too has a cost, though it is mainly a case of workers taking care on site. On the other hand, there is the appreciable saving that results from not installing a conventional central heating system. Overall, the build cost may be greater by, say, 4%.

Set against this are the future cost savings arising from the greatly reduced heating bills. Within a decade or two, the extra capital cost is likely to be recouped. Building to Passive House Standard makes economic sense. The fact that only a tiny fraction of new build in the UK is built to the Passive House Standard is an indication of a dysfunctional housing market, not an uneconomic standard.

Of course, the economic benefit of building to the Passive House standard is not the only one. A more important benefit is the well being that comes from living in a comfortably warm space filled with fresh, clean air.

Passive House Certification

Only a minority of Passive Houses are certified, but the proportion is likely to rise in the future as building to the Passive House Standard becomes compulsory in some localities – though not yet in the UK.

For the selfbuilder who wants to build to the Passive House Standard, the greatest benefit comes from living in a house that has been designed and built to the highest energy standard. But the certificate itself would be useful if the selfbuilder should want to sell the house in years to come. Currently in the UK there are four companies who are accredited Passive House Certifiers. (See Further Info.)

Plaques are available for fixing to certified houses!

FOOTNOTE: Correction

Last month I wrote that with a temperature outside of –10°C, the Heating Load must be no greater than 10 watts per square metre of the usable floor area. Even as I wrote it, I thought that a temperature of – 10°C was rather severe for the UK, but that is the temperature quoted in the useful Passivhaus Handbook by Cotterell and Dadeby (on Page 18).

In fact, the temperature of –10°C, applies to a house in the German standard climate. As we will see next week, in the more temperate climate of the UK, a more benign figure applies (eg, for a house in the Midlands, – 1.6°C).
FURTHER INFO

The Passivhaus Handbook
– A practical guide to constructing and retrofitting buildings for ultra-low energy performance.
By Cotterell and Dadeby.
Published by Green Books, 2012. 256 pages, £35.

The Passivhaus Designer's Manual
– A technical guide to low and zero energy buildings
Edited by Hoppe and McLeod.
Published by Routledge, 2015. 326 pages. £35.

Active for more comfort: Passive House
– Information for property developers, contractors and clients
Free pdf, published by iPHA. 76 pages.
www.passivehouse-international.org.

Passive House Institute
Their extensive website can be viewed in German or English. (The Deutsch/English button is at the top right of the webpage.)
A few pages are currently available only in German. A simple way to get a translation is to use the Google Chrome browser which automatically gives a popup asking if you want the page translated.

Passipedia
The Passive House web resource.
www.passipedia.org.

BRE Passivhaus
www.passivhaus.org.uk.

Passive House Trust
The UK Passive House Organisation.
For a simple introduction to the Passive House approach, download their pdf: Passivhaus Goes Personal.
www.passivhaustrust.org.uk.

How to build a Passivhaus – the UK Passivhaus knowledge base
A website published by the Passivhaus Trust, above.
www.howtopassivhaus.org.uk.

Passive House Database
Details for Passive Houses worldwide, with more than 50 individual homes listed for the UK (with usable floor areas from 69m² to 420 m²).
www.passivhausprojekte.de.

PHI accredited building certifiers (for the UK):