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PassivHaus

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Introduction

The term PassivHaus describes a specific energy performance concept of a building. A PassivHaus is optimised in its thermal performance in such a way that it does not need a conventional heating system. The heating requirement is mainly covered by solar and internal heat gains. Energy losses through ventilation are significantly reduced by the use of a controlled ventilation of the living spaces combined with a high efficient heat recovery system.

Any remaining energy requirement for heating is so little that it can be achieved by coupling a heating coil with the ventilation system to warm the supply air. Alternatively, a simplified version of a traditional heating system can be installed to cover the heating demand in addition to the heat recovery. The result is a comfortable temperature with low energy consumption.

The PassivHaus concept forms a consistent advancement of the low-energy-building through thorough planning, detailing and construction. This concept is not restricted to specific types of buildings. All construction methods (timber, concrete, masonry, steel, etc.) are PassivHaus suitable and can be realised with high efficient, high insulated thermal envelopes. There are various examples of conversions and refurbishment projects where the principles of PassivHaus design have been successfully implemented.

Although construction costs may be increased by the requirement for better thermal insulation and higher quality windows, PassivHaus studies that have been undertaken to date, conclude that the capitalised total costs over 30 years are no higher for a PassivHaus than for that of a conventional new building, as the higher capital costs are compensated by the lower energy costs from the first day.

The PassivHaus concept was developed by Professor Wolfgang Feist and a group of international scientists. Professor Feist founded the PassivHaus Institute in Darmstadt, Germany, which sets the standards for PassivHaus buildings, developed the modelling tool and publishes literature relating to PassivHaus matters.

According to Prof. Feist the definition of a PassivHaus is as follows; "*The heat losses of the building are reduced in a way that almost no heating is necessary anymore. Passive heat sources like the sun, people, internal heat gains from electrical equipment and the heating energy of the exhaust air cover the main part of the heat demand. The remaining heat requirement can easily be provided with the supply air, if the maximum heating load is less than 10 W/m2 treated floor area. If heating the supply air as the only heat source is sufficient, (to heat the building) we call a building a PassivHaus.*"

PassivHaus is not the description of a building type, but a technical standard that is achieved by following a set of design principles.

PassivHaus Requirements
The exact requirements for a PassivHaus are described by the PassivHaus Institute Darmstadt. The principal criteria are: • **Thermal heat requirement** ≤15 kWh/(m²a) • **Heating load** ≤10 W/m² • **Air tightness** n_{50} ≤0,60/h • **Primary energy demand** ≤120 kWh/(m²a) (incl. all electrical consumers)

Efficiency

When compared to conventionally constructed buildings, the most notable difference is the PassivHaus' lower thermal heat requirement with a maximum of 15 kWh/(m²a). This corresponds to approximately 1.5 l fuel oil or 1.5 m3 gas per square metre living space per year.

With a PassivHaus, the heat stays within the building envelope and therefore does not need to be delivered to the building actively. PassivHaus buildings use very little heating energy whilst providing excellent air quality, by design and with low technical effort. Its high energy efficiency lowers CO_2- emissions drastically and as any remaining energy demand for heating can easily be covered by renewable energies, the implementation of the PassivHaus standard not only helps to contribute towards climate protection but at the same time reduces the impact on valuable energy resources.

To date, over 10,000 buildings in Germany have been constructed to PassivHaus standard, amongst those are family homes, apartment blocks, schools, office buildings and multiresidential homes. Scientific measurements and performance assessments have been undertaken in over one hundred of the thousands of PassivHaus constructions already built. Throughout these tests, the positive results achieved present very convincing evidence of the credibility of the PassivHaus concept.

Thermal insulation

The U-value of a construction element represents the heat flow through this element. The lower the U-value is, the better the insulation properties of the element. The maximum U-value for PassivHaus constructions is 0.15 W/(m²K). Using a thermal insulation material with a conventional thermal conductivity of λ = 0.04 W/(mK), this can be achieved with a thickness of d = 25 cm.

The enhanced thermal insulation is not only a good protection against the cold, but also against the unwanted heat transmission in summer time. This assumes that the building's internal heat gains are limited.

A PassivHaus provides stable room climate with evenly warm surfaces throughout, which means draught free, high thermal comfort delivered at low energy demand. Of course a building not only consists of standard construction elements such as walls, roof and floors, but also comprises corners, joints and penetrations. It is in these areas of the building envelope that the heat transfer is usually increased. Avoiding thermal bridges (an area of a building which has a significantly higher heat transfer than the surrounding materials resulting in an overall reduction in thermal insulation of the building) is according to the experiences in PassivHaus construction, one of the most cost efficient saving measures. Therefore for PassivHaus the goal is a thermal bridge free construction.

Airtight building envelope

A frequently asked question is whether a high level of air tightness is really desirable or will it merely keep the building from "breathing". In a building with a high infiltration rate, where air passes through joints from the inside to the outside, water vapour condenses from the humid room air in winter time and can lead to moisture penetration and mildew growth. In addition to unnecessary and uncontrollable heat losses, leakages can also lead to structural damages, unwanted sound transmission and high heat losses. All of these problems can be avoided by building airtight constructions.

The air exchange through gaps and leaks in the conventional building envelope can never be sufficient to keep up hygienic air quality. For that reason additional ventilation is necessary. This is traditionally achieved by opening windows. In a PassivHaus the mechanical ventilation system forms the building's lungs. PassivHaus buildings require an airtight quality of n50 ≤0.60/h. The most effective way of achieving sufficient air tightness is careful planning and construction with a high attention to detail.

In masonry constructions, the airtight layer of the wall construction is formed by the inside render and is therefore easy to achieve. However, there are many examples of airtight solutions for other construction methods that have achieved the highest levels of air tightness.

As every PassivHaus requires a pressure test to fulfil the high quality requirements, any remaining leakages can be tracked down and sealed afterwards. An airtight building offers many advantages; it is draught-free, free from structural damages, energy saving and comfortable.

Windows

Windows form an essential part of a PassivHaus. A U-value for the installed window of equal or less than 0.85 W/(m²K) guarantees low heat losses and high thermal comfort. Even without a radiator in front of the window, the surface temperature on the inside should not be lower than 17°C even on cold winter days.

Big window areas are best built with southern orientation. Rooms with east and west-oriented windows have a higher risk of overheating and therefore require more careful planning. In wintertime, high value windows, when built in south-oriented, collect more solar energy than they lose energy by heat transmission. During summer months the sun is higher, the biggest part of the radiation is reflected from south oriented windows and solar gain is limited.

Of course there are building sites that cannot offer the best possible orientation of the buildings. This does not make the realisation of a building to PassivHaus standards impossible, but implements more challenges for the planner.

PassivHaus suitable windows usually consist of triple glazed panes and insulated frames in order to fulfil the high standards of thermal quality required. Any heat losses at the spacer between the window panes can be reduced by using thermally improved solutions. The location for fitting the window in the wall construction is crucial to avoid thermal bridges at the junction between wall and window construction. When using high quality products, the construction details should be checked to ensure best results possible.

Mechanical ventilation with high efficient heat recovery

With the mechanical ventilation system continually providing hygienic air quality and keeping supply air at a constant and comfortable temperature, manual ventilation is no longer necessary.

Supply air is not polluted by the exhaust air as the system is designed so that the blending of the two never happens. By using a heat recovery unit with a recovery rate of 75 - 90%, comfortable temperature of the supply air can be guaranteed with an energy saving solution. The system is fitted with intake and exhaust silencers and as the continuous air supply can be realised with low air velocity, the air supply is both noise and draught free, thus avoiding any negative impact on comfort. PassivHaus suitable ventilation systems consume much less primary energy than they save in heat losses.

"But can I still open the windows?" - Yes, but you don't have to. Traditional manual ventilation requires the permanent attention and activity of the building users. To remove smell and moisture emissions (from e.g. towels, plants, clothes) windows have to be opened and closed even during hours of absence of the building users or during the night time. In practise most buildings are not ventilated sufficiently. Furthermore the achievement of sufficient natural ventilation in a building constructed to PassivHaus principles results in energy losses that exceed the total heating demand of the building. Therefore the high efficient heat recovery system is mandatory for PassivHaus construction.

Heating

Even a PassivHaus has a heating energy demand to meet. However, this demand is low enough as to enable the ventilation system to distribute the required heating energy. This demand for heating is calculated by the energy losses through transmission and the energy losses through ventilation less the solar gains through windows and less internal heat gains from electrical equipment and building users.

With PassivHaus constructions, savings in heating energy of 90% compared with the average heat demand of existing building stock and of 70%- 80%, compared to buildings according to current building regulations, can be achieved. Any kind of traditional heating system and energy source can be used for heating PassivHaus buildings. However, as the heating demand of a PassivHaus is much lower than those of traditional buildings, traditional heating systems are usually oversized; accordingly adjusted heating systems take advantage of this.

In many cases the energy demand of the heating system is now lower than that of the hot water systems. The room heating can therefore become a by-product of the hot water production.

Costs

Although there are PassivHaus constructions in countries such as Germany and Austria, that have no higher capital costs than buildings according to current building regulations, as a rule of thumb - especially in countries such as the UK where the construction of PassivHaus buildings is still relatively new – it implements a rise of the capital costs of about 5-15%. A large part of these will be compensated by the decreased running energy costs.

Summary

To summarise, the advantage of a PassivHaus construction is an enhanced quality of life due to its high thermal comfort, consistently excellent air quality and financial forward planning over possible future energy price increases.

References and further information

1. http://www.passivhaus.org.uk/
2. http://www.willmottdixon.co.uk/projects/chester-balmore-londons-biggest-residential-passivhaus

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