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GET READY

ENERGY CONSUMPTION AND PASSIVE HOUSES

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ENERGY CONSUMPTION IN HOUSES

In most households, fuel bills already represent a significant proportion of monthly expenditure, and the share is likely to increase with the steadily rising prices of gas and oil. Annual heat consumption depends on a number of factors, including the type and age of your home, how well your building is insulated, and your energy consumption habits. As appropriate heating and ventilation can lead to both energy and financial savings, this brochure is designed to help you look more closely at the general principles of heating your home.

Fig. 1. Passive house in Darmstadt, Germany. | Image: © J. Gerstenberg | PIXELIO

Domestic energy consumption can be expressed in various ways. Annual heating demand indicates how much energy is needed to keep your home warm (generally at least 19 °C), and is the most commonly quoted figure. It is measured in kWh/m²a (kilowatt hours per square metre per year). The value has a relatively wide range: the most efficient so-called passive houses need only 10 to 15 kWh/m²a; while old buildings without insulation may need 400 kWh/m²a or even more. To help you visualise these figures, you should bear in mind that 10 kWh/m²a means that you need 1 litre of fuel oil to heat a square metre of your home. If your home is 100 m² you will therefore need 100 litres of fuel oil to keep your house warm, provided you have an efficient passive house. If you have an old, badly insulated home with an annual heating demand of 300 kWh/m²a, you will need around 3,000 litres of fuel oil. If we assume that the price of fuel oil is EUR 70 per 100 litres, this means a substantial difference of around EUR 2,000 per year between a passive house and an old building.

Fig. 2. Energy passport after an energy audit was carried out: clearly, it's time to act for the owner of this house! | Image: © ehuth | PIXELIO

Building energy consumption can also be expressed in terms of primary energy demand, calculated in kWh/m²a. This includes heat energy, ventilation, hot water and auxiliary energy. It also takes into account the source of energy and the energy needed for conversion and transportation, that is renewable sources (solar, wind, biomass) or non-renewable sources (coal, uranium, biomass transportation).

Buildings can be evaluated according to their heat energy demand on a scale from A to G (or in some countries, from green to red). An energy passport or certificate is issued after an energy audit has been carried out in the building. When you purchase a house or rent a flat, the seller or landlord must make this energy passport available according to European legislation.

PASSIVE HOUSES

Passive houses are the most efficient buildings available on the market. Several thousand passive houses have been built in Europe and many more will follow in the coming years. The idea behind the passive house is to ensure an airtight, well-insulated building envelope that prevents unwanted heat loss through the walls and roof. The figure often quoted in relation to passive houses is annual heating demand, which may not exceed 15 kWh/m²a (or 1.5 litres of fuel oil per square metre). This figure was originally calculated for climate conditions in Germany.

The definition of a passive house is however independent from climate conditions: "A passive house is a building in which thermal comfort is solely guaranteed by re-heating (or re-cooling) the volume of fresh air that is required for satisfactory air quality without using circulating air" Due to its well-insulated walls and roof, a passive house requires no conventional heating system. Heat generated by the sun, the building inhabitants and electric devices already provides a big proportion of the energy needed to heat the interior. On cold days, small wood-burning stoves or pellet heating system can provide additional warmth. The air inside a passive house is exchanged through a ventilation system with a combined heat exchanger. In this way, the interior of the building is constantly supplied with fresh air from outside, which is heated through the heat exchanger by the outgoing air.

However, the low energy demand of passive houses is ensured not only by modern technical solutions. The buildings themselves should be compact and simple, without too many surfaces, since the ratio of external surface to heated volume is an important factor in preventing energy loss. The more compact the structure, the less energy is lost. The orientation of the building is equally important. The largest area of window should be directed towards the south, while the north-facing façade should have smaller windows. The living rooms should be on the south side in order to take maximum advantage of the solar gains. Kitchens and bathrooms should be located on the north side. In colder climates, the south-facing façade should be free of the shade of trees. In summer, overheating can be prevented by an overhanging roof that casts a shadow when the sun is high. In warmer climates, however, deciduous trees can provide a good source of additional shade on hot summer days.

The layout of the building is just as important as the orientation. An architect or engineer should check the construction thoroughly for possible air leaks and thermal bridges. These are weak points in the construction where two structural surfaces meet or where materials that are poor insulators come into contact, allowing increased heat flow.

Windows:

In an average house, the windows account for 10 to 20 percent of heat loss. In passive houses, such losses are minimised by installing triple-glazed windows. The heat transmission of building components is expressed by their so-called U value, measured in watts per square metre at a temperature difference of one degree (K). The higher the U value, the lower its thermal resistance, therefore the more heat/ energy passes through the building component. An average two-pane window has a U value of 2.9 W/m²K. With three panes and an additional heat protection glazing, the U value can be as low as 0.7 W/ m²K. Apart from the glazing, also the frame should be designed to prevent thermal losses.

Fig. 3. 30 cm of insulation being installed at a pssive house. | Image: C. von Knorre

Insulation

The insulation in passive houses is much thicker than average. As for windows, heat transmission through walls can also be expressed as a U value. The U value depends on the property of the material used, but in general a 10-cm layer of insulation will have a U value of around 0.4 W/m^2K. Increasing the thickness of the insulation to 40 cm will reduce the U value to 0.1 W/m^2K, that is, a reduction of 75 percent.

Airtightness and blower-door test:

As passive houses must be absolutely airtight, the construction workers have to detect the smallest air leaks and ensure that they are sealed. The points at which cables and pipes penetrate the building's outside walls need to be thoroughly sealed. When the building work is complete, its airtightness is tested using the so-called blower-door test. During this procedure, a fan is used to draw air out from the inside of the house, creating a small pressure difference between the inside and outside. This pressure difference forces air through the holes and penetrations in the building envelope, making it possible to measure the building's airtightness. In a passive house, air exchange during the blower-door test may not exceed a certain level.

Fig. 4. Equipment to perform a blower-door test | Image: W. Walter

Costs and benefits

Low-energy houses – that is, houses that have an annual heating demand of between 50 and 70 kWh/m^2a – are becoming the norm in

new constructions. In many countries, components for passive houses are available off the shelf.
There is still some debate about the additional costs incurred when building a passive house. In general, it can be assumed that passive houses are around 10 percent more expensive to build than an "average" house. Most of the extra costs arise from construction elements, such as the thicker insulation, better windows and a ventilation system that will occasionally require new filters. However, if you want your building to be officially certified as a passive house there will be some additional expenses to take into account. On the other hand, your annual heating bill will be drastically reduced and you will not need to install a conventional heating system. Given that passive house standards will be required for all new houses in the future, and bearing in mind that energy prices are set to increase even further, it makes sense to choose passive-house solutions as early as possible.

ZERO-ENERGY HOUSES AND BEYOND

In the next few years there is likely to be a further tightening of building standards, ensuring that all new constructions will have a very low annual heating demand. But this will not mark an end to innovations and new technologies in the building sector. A zero-energy house, for example, harvests energy via small wind turbines and solar panels on the roof, using biomass for additional space heating. At the same time, the building envelope and the heating and ventilation systems are extremely efficient and optimised for solar gains. A zero-energy house therefore consumes no fossil fuels and is carbon neutral. Some of the most efficient buildings even produce more energy than they consume, making them plus-energy houses.

FIND OUT MORE...

There are many books available on energy-efficient technology, solar-optimised planning and passive houses, most of which are written in German or English. It is worth checking your local library and browsing on the Internet. The following English-language websites are a good starting point:

http://passipedia.passiv.de/passipedia_en/start (Wiki on passive houses)
http://www.passivhausprojekte.de/projekte.php?lang=en (database of certified passive house projects)