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Newly-built passive houses in Lockerbie, Scotland

Passive House
Low-energy buildings

Key words
energy consumption
heating
insulation
buildings

Heating accounts for over half of the energy used in homes in the UK. In this article, we look at buildings designed to cut heating demand almost to zero.

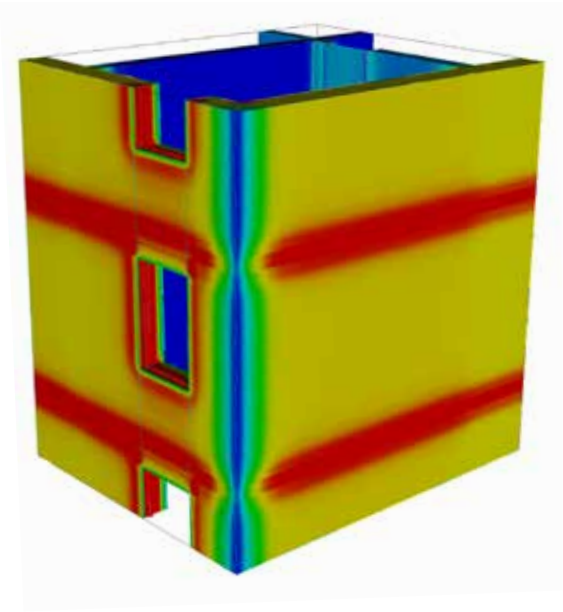
There are over 70 000 **passive houses** in Europe – just a few of them in the UK. To be described as 'passive', a house must meet strict criteria for energy use. In particular, its demand for heating must be less than 15 kWh/m^2 per year. Let's look at what this means.

1 kWh is 1 kilowatt-hour, a unit of energy. These are the units clocked up by an electricity meter. Big houses need more heating, so the floor area must be taken into account. A passive house with a floor area of 100 m^2 would need 100 ´ 15 = 1500 kWh of heating in one year. Compare this with the average energy consumption of 18 000 kWh and you will see what a demanding target this is.

Insulation

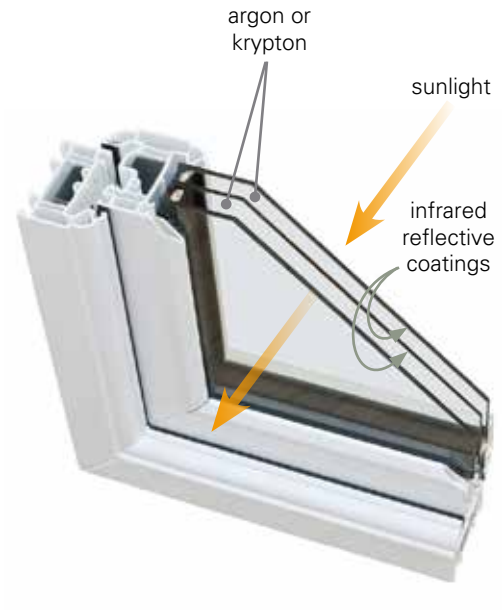
Of course, good insulation is essential in a passive house. However, there is more to this than thick walls and triple glazing. Passive house designers look for thermal bridges – any points where heat can conduct out of the building. These include window and door frames which must be insulated over, and points where walls meet floors and ceilings.

A typical newly-built house in the UK has a heating demand of 120 kWh/m^2, 8 times that of a passive house.



This computer model shows thermal bridges – points where a house will lose energy most quickly.

Triple glazed windows are made of three sheets of glass. The spaces between are filled with argon or krypton, noble gases which are poor conductors of heat. The glass lets in light from outside and this contributes to the energy supply of the house. The inner surfaces of the glass are coated with a layer that reflects infra-red radiation back into the house.



The uPVC frame of a triple-glazed window is designed to minimise heat loss.

Ventilation

Most people enjoy a sense of fresh air in their homes. But when warm air leaves a building, it takes energy with it. There are two ways this can be reduced in passive house design.

Firstly, draughts and leaks must be minimised. With windows and doors closed, the building is pressurised to 50 Pa above the outside air pressure and the rate of air flow outwards is measured. For a passive house, less than 0.6 times the air volume of the house must escape each hour.

Secondly, a mechanical ventilation heat recovery (MVHR) system must be used. Outside air is gently blown into bedrooms and living rooms. Air is drawn out of bathrooms, toilets and kitchens (where it is more likely to be damp and smelly).

To avoid heat loss, the MVHR system includes a heat exchanger. Warm air leaving the house passes through tubes; its energy conducts through the walls of the tubes to warm the cooler incoming air. In this way 75% of the energy in the warm air can be recovered.

What the residents say

A passive house costs 5-10% more than a conventional low-energy house but the savings in fuel bills and the protection from future price rises makes the expense worthwhile in the long run.

Some people fear that the ventilation system will give a claustrophobic feel or produce a constant draught, but this is not so. And you can always open the windows.

Each person in a house contributes about 100 W to the heating, so invite your friends round and save on your fuel bills!

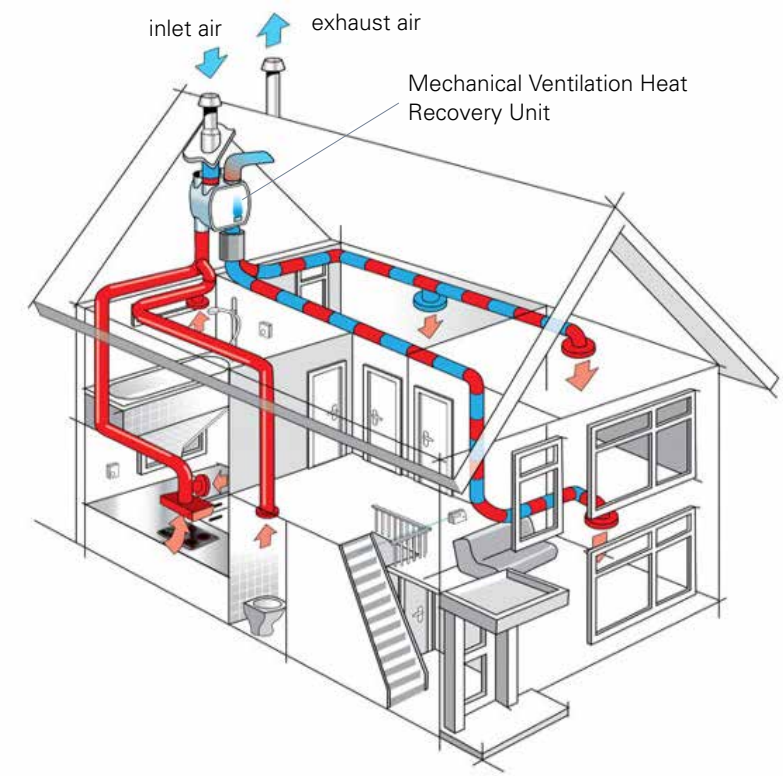
David Sang is Physics editor of Catalyst.

Units of energy and power

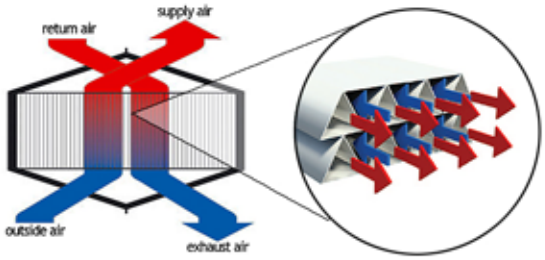
The watt (W) is the unit of power, the rate at which energy is being supplied. One watt is one joule per second.

The kilowatt-hour is a convenient unit of energy. A 1 kW appliance running for 1 hour uses 1 kWh of energy. (1 kWh = 3.6 million joules)

Building materials (including windows and doors) are rated according to their U-value. The walls, roof and floor of a passive house would have a U-value of less than 0.15 W/m^2 °C (watts per square metre per degree C). This means that, for a temperature difference of 1°C between inside and outside, energy will flow out at the rate of 0.15 W through each square metre.



Living spaces have fresh air pumped in (red/blue), while warmer, damper air is pumped out (red).



In the heat exchanger, energy from the warmer exhaust air is transferred to the incoming supply air.

Look here!

The Scottish Passive House Centre: www.sphc.co.uk

The Channel4 TV series Grand Designs has shown several low-energy and passive house projects. Check their archive.

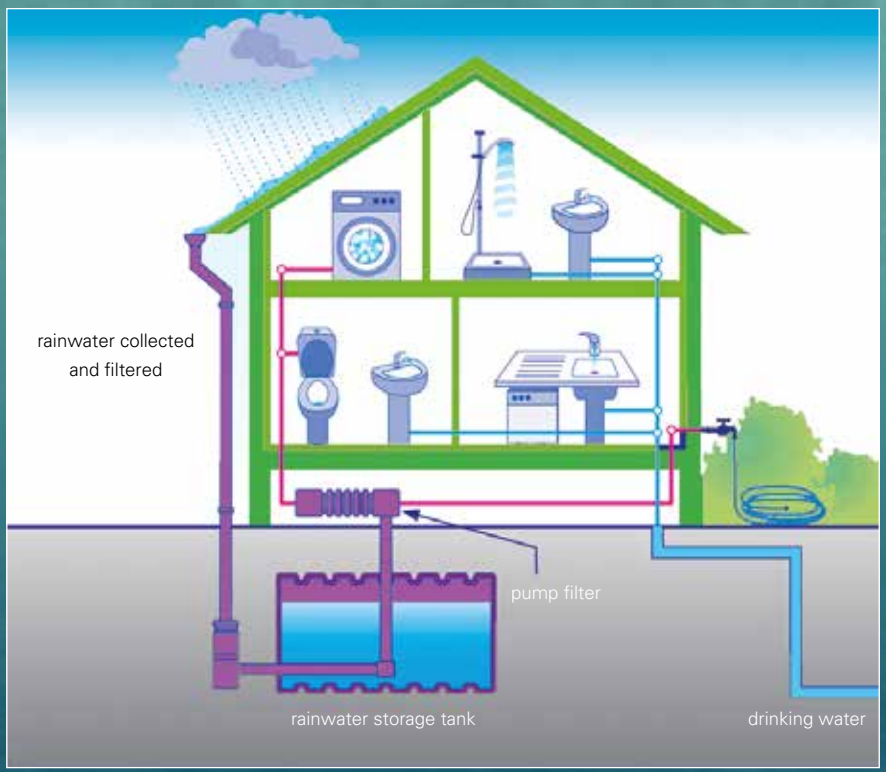
The back page of this issue of Catalyst shows a passive housing scheme in southern Germany.

PASSIVHAUS

In the German city of Freiburg, a series of apartment blocks has been built to meet passive house standards. Cars are excluded, making it possible for children to play safely outdoors. Some of the other environmentally friendly features are shown below.

The south-facing side of the blocks has big windows to allow sunshine to enter. The north side has smaller windows.

The energy of sunlight is used to heat water and to generate electricity.



Why use drinking water to flush your toilet and wash your clothes? It takes energy to purify water to a drinkable state, so rainwater is a better choice. Sewage is sent to a biogas generator.

Each block has a co-generator which burns fuel to produce electricity; waste heat is used to heat water, stored in the red tank.