A new low-energy house in Derbyshire

The brief

The requirement was for a light, comfortable and spacious house for a reasonable price, using mainly reusable materials and enabling super-low utilities bills.

The challenges

Conventional British houses tend to generate high utility bills because heat escapes through walls, floors, roofs and windows. If windows are opened for airing purposes, even more heat is lost. Heating is usually done using gas or electricity, both of which have been subject to large price rises. By ignoring the path of the sun in orienting houses, a great source of free heat is left untapped.

The recommendations

Orientation

To take full advantage of the sun's warmth and light, the house was oriented due south.

A full-width conservatory on the south side would provide free heating of the living room on sunny days in the cold season, whilst staying closed on sunny days in the warm season to stop overheating of the living room. Partial shading would prohibit the sun entering the living space in the height of summer.

Many east and west facing windows would enable optimal use of natural light. Minimal north-facing and no south-facing windows would prevent excessive heat loss or gain, respectively.

Two storage rooms on the north side would function as "extra insulation". Since the freezer would be located in one of these stores, the energy consumption of the freezer would be minimised, whilst the heat generated from the freezer would prevent temperatures to go too low in the store.

Super-insulation

To stop heat escaping, the following super-insulation measures were recommended:

The walls and roof would be insulated to a thickness of 25cm. To enable these kinds of sizes, a timber frame was recommended using Masonite. These are H-shaped spruce beams made in Sweden and using some recycled wood in its production. Fillcrete's insulation material (made of recycled newspaper and not containing any harmful substances) would provide the necessary high u-value.

To insulate the floor, a 20cm layer of Styrofoam insulation material was laid underneath the 10cm concrete slab.

Windows would be double low-E glazed.

Heating

Due to the exceptional standards of insulation, no central heating would be needed. A ventilation with heat recovery unit would provide high air quality, low moisture and low heat loss.

A heat recovery system extracts air from the kitchen, bathrooms and utility room through a heat exchanger. The system then supplies fresh air to the bedrooms and living rooms through the same heat exchanger with 90% of the heat being transferred. This would mean that the property would benefit from a constant supply of pre-heated fresh air without the need to open windows.

A high efficiency wood stove in the living room would supply heat during the coldest four months of the year. The living room air that was warmed by the sun or the wood stove would be circulated around the house by the heat recovery unit.

Surplus heat would be used by a heat pump situated in the utility to heat the domestic hot water. A heat pump transfers energy in the form of heat from a cooler location to a warmer location. It uses the refrigeration process and transfers low temperature energy to a refrigeration loop, compresses the refrigerant to a high temperature, and transfers this heat to the hot water and heating distribution system.

There are several different kinds of heat pumps available, depending on where the energy is sourced. For this project an air to water heat pump would be most cost-effective.

Further measures

No gas connection would be needed to the house. Although cooking with gas is preferred by most people, induction cooking performs at least as well, with the benefit of avoiding water vapour generated by gas flames.

10 m2 of photovoltaic cells (Sunslates) on the roof would provide approximately 1000 kWh of electricity per year from daylight, which would cut down electricity bills. To provide the highest yield, the roof was pitched at the optimal angle of 40°.

A utility provider was recommended who offered the possibility to buy green electricity and sell surplus electricity.

A 5000 litre rainwater tank would supply water to toilets, washing machine and the outdoor tap. Low flush toilets and thermostatic taps would further help cut down on water bills.

The reality

Seven years after completion the house has proven to function even better than expected.

Electricity bills have been as low as £250 per year.

The house has stayed relatively cool in summer and has been warmed up beautifully in winter through solar gain and the wood stove. Some years the cold season was a bit longer than 4 months, and other years a bit shorter; depending on cloud cover. The bedrooms had an amazingly constant temperature, even though they were not directly heated.

Air quality has been exceptionally good; always fresh and dry. The heat recovery unit always supplied enough fresh air, even when the wood stove was burning. No windows had to be opened.

The rainwater tank has not been empty, apart from one summer when a new pond was filled up from it.