Youlditch Studio: Energy Efficiency Measures

Introduction

When we bought Youlditch in October 2003 one of the attractions was the ability to develop a studio for my artist wife. Youlditch is 1,000ft up the west escarpment of Dartmoor with magnificent views across the Tamar valley to Bodmin Moor, south to the coast, and a huge ever changing sky with weather rolling in from the Atlantic.

Youlditch Farm House has one acre of land including old outbuildings, one of which was a 1980s built timber workshop with an asbestos cement roof. This building had fallen into disrepair with extensive wet rot. However, the existence of the workshop would make planning permission more likely for a new building of comparable size on the same site.

Youlditch is a listed building within the Dartmoor National Park. The new studio, being within the curtilage of a listed building, also required listed building consent. The first scheme was turned down and the eventual scheme envelope and architectural style was 'negotiated' with the Authority officers.

The studio was built in the winter of 2008 and spring of 2009. It is a single story structure enclosing 84m^2 of usable space. The existing concrete slab of the old workshop was incorporated within the new ground slab. The east side required a 1.5m high retaining wall below the side of the adjacent Pole Barn. The structure is steel framed and Cedar clad. The roof is steel sheeted (in the style of lead roofing). The glazing provides north light for painting and wide sliding door panels to capture the westerly views and solar gains.

The building was conceived, designed and supervised by Tavistock architect Sue Spackman.

The building works were packaged into: 1) ground works (foundations, slab and retaining wall); 2) steel frame; 3) timber and glazing envelope; 4) roof cladding; and 5) internal finishes and building systems. 1) and 5) were by Tavistock builder Steve Cox and his local sub-contractors. 3) was by timber buildings specialist 'Soutra' from Broadhembury near Honiton.

The following sections only cover the works relating to energy efficiency:

- thermal design
- insulation
- efficient heating and hot water

Thermal design

The design intent was to meet or exceed the then current (2007) Building Code requirements. We recognised that the code requirements for insulation values were likely to be raised in the next revision (2010). As energy costs rise (in real terms) the cost of higher insulation standards become cost effective (save money). The environmental reason for energy conservation is to reduce the carbon footprint resulting from burning fossil fuels.

The code specifies maximum U Value in W/m^{2}k (Watts per square meter per degree centigrade) which determines the rate of heat loss through the composite fabric layers of each structural element (eg roof, wall, window or floor). For sizing the heating source (boiler) the design estimates the maximum required heat load to maintain an indoor temperature of 20^{o}C with an outdoor temperature of (in our case exposed at 1,000ft elevation) of -5^{o}C.

The lower the U value the better the resistance to heat loss through the building fabric.

Other significant factors in heating design are ventilation heat losses and solar gains.

The ventilation system is required to maintain adequate air changes (replacing stale air with fresh air) to prevent a build up of carbon dioxide, humidity and odours. The cold fresh air through vents and draughts around windows and doors displaces warm stale air and therefore represents a heat loss (typically 20% of the heat load).

Solar gains are largely received through the glazing elements on the south and west faces of buildings. Sunshine (radiation) warms the internal building fabric and reduces the required heating, indeed may require increased ventilation (ie open window) to maintain a comfortable indoor temperature. Over the year this can be a significant benefit but is not a factor in the maximum heat load that would occur in mid winter nights or cold cloudy days.

Insulation

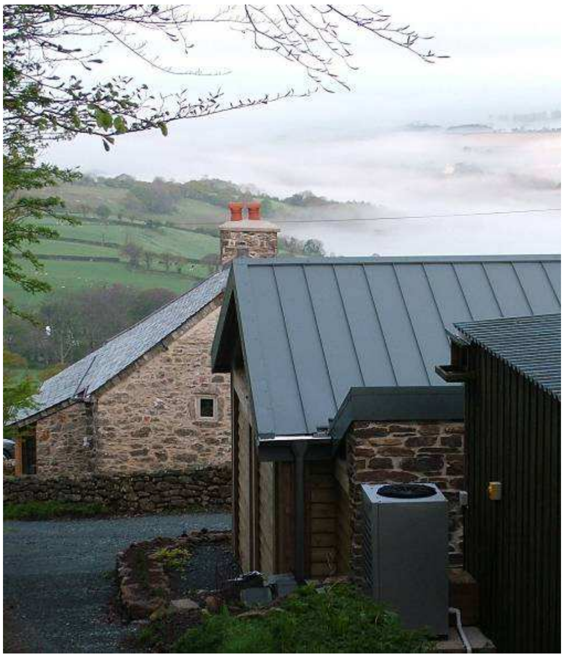
The design for Youlditch Studio incorporated a high standard of insulation into each building element. Rigid thermal insulation board (Kingspan) over the concrete floor slab, fitted within the walls and within the roof. The double glazing of windows and sliding door panels was specified using Pilkington K glass (low emissivity) with a 16 mm gap filled with argon gas.

The following table summarises the insulation:

Element	**2007 Regs U Values**	**Installed thickness mm**	**Achieved U Values***
Roof	0.25	100	0.15 - 0.20
Walls	0.35	100	0.25 - 0.30
Floors	0.25	80	0.20 - 0.25
Windows / doors	2.2	24	1.7

***** the ranges reflect performance uncertainty and variations in how they are fitted

Efficient heating & domestic hot water



Under floor heating was installed in a cement screed over the floor slab insulation. The studio is largely open plan and with a well insulated outer envelope there was no need to control temperature by room. A single thermostat therefore covers the whole building and we generally set the background temperature at about 17°C. With solar gains, the actual temperature tends to rise during the day and fall slowly after dusk.

The heating design indicated a maximum load of about 5kW with 20°C inside and -5°C outside. In more typical winter conditions the model indicates a heat load of 2 to 4kW.

A 'Worcester Bosch Greensource' 6kW air to water heat pump was installed. An air source heat pump is a simple heat exchanger. It works in the same way as a domestic freezer, abstracting heat from within the cold compartment through compression and expansion of a volatile liquid. Even when the outside air temperature is below freezing the air source heat pump abstracts heat efficiently for heating. Air source heat pumps are used extensively in Scandinavia which has subzero temperatures for many months in winter.

The air source heat pump has a coefficient of performance (COP) of about 4. This means that 1kW of electricity required to run the pumps generates about 4kW of heat output. This efficiency makes a heat pump form of electrical heating cost effective (compared to an oil fired system).

Air to water heat pumps are cost effective for under floor heating systems that require hot water at ~ 30°C (rather than ~ 65°C for conventional radiators) in well insulated buildings with a relatively low total heat load. Similarly air to air heat pumps can supply warm air through a whole building ventilation system.

The air source heat pump also provides the (low volume of) domestic hot water required in the studio. It is maintained at ~ 60oC within an inner tank surrounded by the ~ 30oC under floor heating water jacket, which is itself insulated within the unit.

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