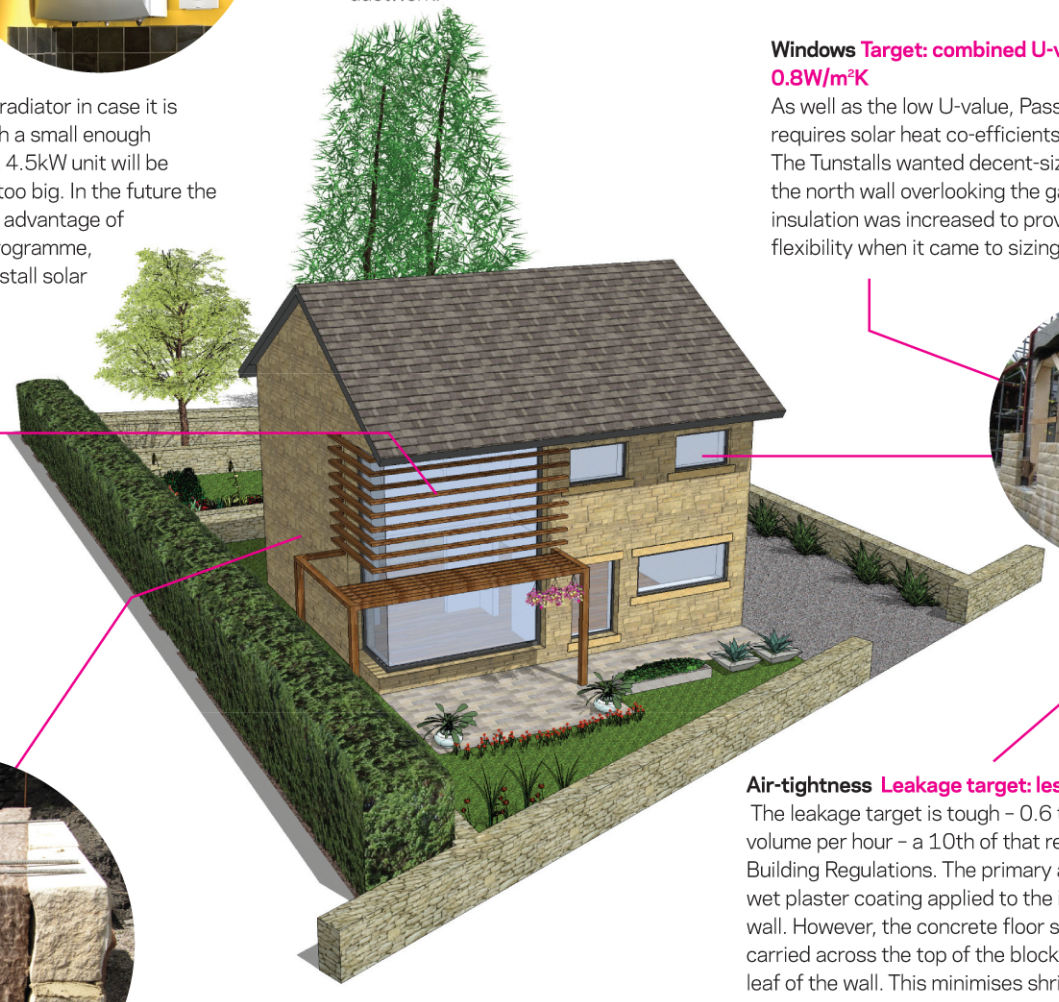
Heating Target: 3kW heating load
A conventional gas boiler will provide hot water and feed towel rails in each of the two bathrooms. This should be all the heating that is required, but piping will be installed for a radiator in case it is needed. Finding a boiler with a small enough capacity was a challenge. A 4.5kW unit will be used, but this is still a third too big. In the future the Tunstalls are hoping to take advantage of Kirklees council's Restart programme, which will offer a grant to install solar thermal panels.

Mechanical ventilation Target: 99% heat recovery
This is an essential part of Passivhaus building design. A unit from Paul Comfort Ventilation Systems in Germany will be used. In winter it transfers up to 99% of the heat from the outgoing air to the incoming air. One of the reasons for using timber I joists was to accommodate the system's ductwork.



Windows Target: combined U-value of 0.8W/m²K
As well as the low U-value, Passivhaus also requires solar heat co-efficients of about 50%. The Tunstalls wanted decent-sized windows in the north wall overlooking the garden, so the wall insulation was increased to provide greater flexibility when it came to sizing these.

Thermal bridging This is inevitable in any building but needs particular attention with Passivhaus design. See overleaf on how they are tackling it.

Super-insulation Target: U-value of less than 0.15W/m²K for external envelope
To achieve this, 100mm fibreglass batts will be used three deep in the wall cavities, a 500mm fibreglass quilt is specified for the roof void and 225mm of polyfoam insulation is used beneath the concrete floor slab.

Thermal bypass This is not to be confused with air-tightness and refers to the air movement that can occur through or around the insulation in the cavity wall, which dramatically reduces its effectiveness. This might occur if wind can penetrate the outer leaf or if the insulation is badly fitted with gaps that allow air to circulate. At Denby Dale the idea is to use soft fibreglass insulation that can be fitted into the cavity to avoid any gaps and careful construction of the outer stone wall to act as a wind barrier.

Air-tightness Leakage target: less than 1m³/h/m²
The leakage target is tough – 0.6 times the house volume per hour – a 10th of that required by Building Regulations. The primary air barrier is the wet plaster coating applied to the inner leaf of the wall. However, the concrete floor slab is also carried across the top of the blockwork of the inner leaf of the wall. This minimises shrinkage cracking between the wall and floor, which can be a big problem. In addition, the wall plates supporting the first floor are fixed to the wall early in the build programme and this necessitated plastering this section of wall early to ensure the continuity of the air-tightness barrier.

For the window openings, a plywood box is set into the wall. This gives a good basis for air-tightness with an adhesive backed tape attached to the plywood with a fleece wrapped into the wet plaster, making the junction between the plywood and plaster air-tight even after the inevitable shrinkage cracking. Another tape is used to seal the gap between the window and the plywood box.