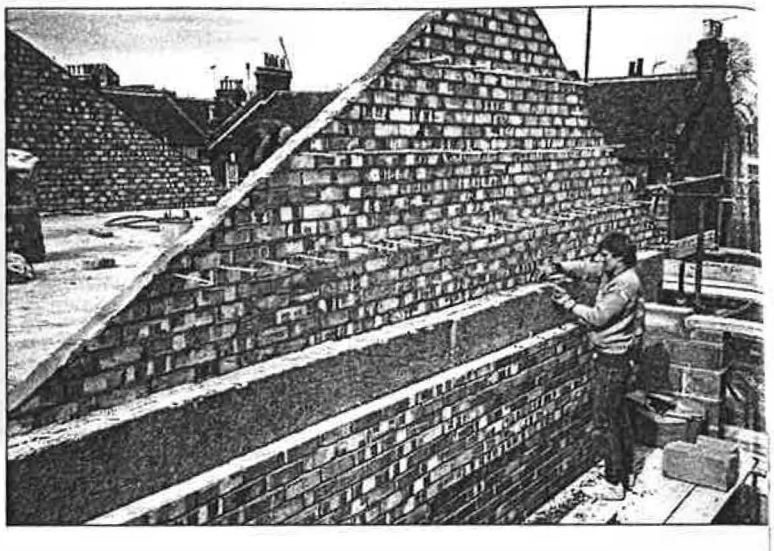
How low can U go?

Awareness of the need for energy efficient houses has never been so high, but are low energy dwellings delivering the performance they promised, or are comfort levels rising?

BY DAVID OLIVIER



Comfort in UK housing is still a compromise between cost and comfort. If comfort becomes cheaper to achieve, people want more of it. This is one reason why the real figures from so-called low-energy dwellings aren't always quite as low as one might expect. Other major reasons are the continuing leakiness of UK buildings and sometimes poor choice of heating systems and controls.

These were the conclusions from a 1996 BRECSU report[1], but is it still the case? Do the energy consumption figures from recent low energy dwellings show a narrowing gap between the UK and other countries, or is the UK still failing in its energy objectives?

The energy consumption data from three notable low energy houses serves to illustrate why low energy objectives are not always achieved in practice. The three dwellings are Reyburn House[2] in London, Lower Watts House[3] in Oxfordshire, and Embleton House, built in 1995 in Twyford, Berkshire.

All the dwellings have U-values of roughly 0·2 W/m²K in ground floors, external walls of 0·2-0·25 W/m²K, windows of 1·3-1·4 W/m²K, roofs of 0·15-0·2 W/m²K and external doors of 0·7-1 W/m²K. They have condensing gas-fired boilers, with radiators or underfloor heating, and mechanical ventilation and heat recovery (mvhr). The chimneys at Reyburn and Embleton are currently sealed-off.

Reyburn House was designed in 1984, based on prevailing Danish low-energy housing practice. Both Reyburn and Lower Watts House have conventional cavity walled construction, while Embleton has used the BECO system (German ISO-RAST). Here, concrete is poured into the gap between two layers of expanded polystyrene permanent shuttering. After the concrete cures, the foam remains to provide thermal insulation. Note that Embleton House was built to a high standard by a local agricultural contractor after local builders had declined to get involved with novel systems.

As a result, Embleton House has one of the best air leakage results on the UK mainland – a little over one air change per hour (ac/h) at 50 Pa. By contrast, Lower Watts House has about 2·5 ac/h at 50 Pa, itself five times tighter than contemporary norms[4]. Reyburn has not been pressure tested.

Measured comfort

In all cases, the reduced consumption of fuel provides a superior standard of comfort to normal, largely because of warm surfaces and absence of draughts. The houses do not have full central heating, and typically the heat emitters are confined to lounges and bathrooms.

'Boiler controls ... are far too complex

Occupants comment that the mvhr systems provide a good internal environment, fully eradicating condensation. The temperatures in Embleton and Reyburn are particularly uniform and amply justify the decision to simplify the heating system.

In Lower Watts House calculations had shown that two peripheral study-bedrooms above the garage could be adequately heated by passive heat transfer, however the conditions were unsatisfactory in severe weather so two small heat emitters were retrofitted.

In winter, the owners of Lower Watts House maintain a whole-house air temperature of around 18°C. This is similar to other figures reported in modern UK housing. However, the occupants of Reyburn and Embleton maintain a mean temperature of above 20°C.

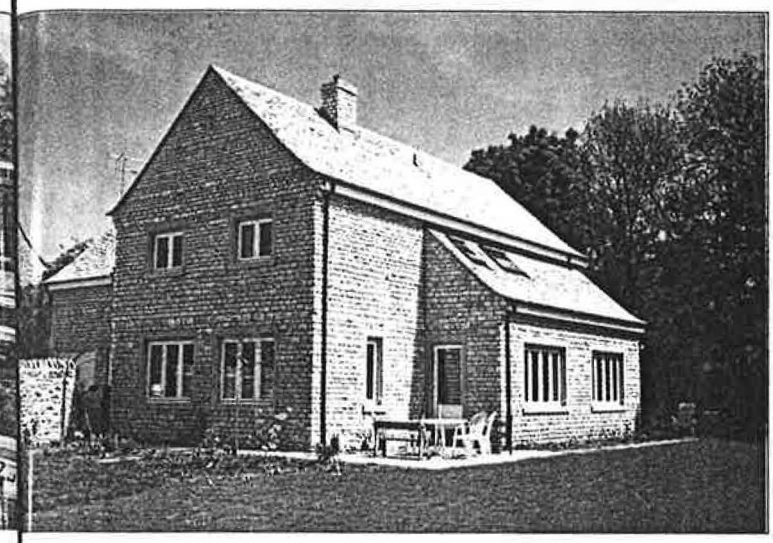
Figure 1 shows the measured energy use of all three dwellings. Gas and electricity consumption are not sub-metered (after all, these are private houses, not research projects), and a like-for-like comparison with normal dwellings is not easy, because they are larger than average. On the face of it, their performance looks respectable when compared to typical low-energy detached houses in mainland Europe and North America, but it is salutary to realise that Canada's R-2000 Program produced 6000 such houses between 1983 and 1998.

Over five years, the electricity consumption of Lower Watts House was reduced slightly by replacing old appliances with more electricity-efficient ones, as they wore out. Otherwise, as has been heard *ad nauseam*, there is some way to go and the issue of more efficient electricity use must be comprehensively addressed. Much of the energy-efficient equipment which is sold abroad is not yet on the UK market.

The radiator system in Lower Watts gives precise control. Gas use fell as the boiler controls were adjusted. Far from being self-learning these systems were far too complex for well-insulated high-mass dwellings, where they can waste more fuel than they save.

Some minor control imperfections remain with the underfloor heating at Reyburn and Embleton, but they are modest failings compared to what was seen elsewhere in the 1995 survey. Many space heating systems totally lacked the control needed. A timber-framed house was found to have a poorly-controlled solid fuel-fired system with a total wood and electricity use of 200 kWh/m²/y. According to the owners, on cold nights the system fires steadily to meet the peak demand. Then, as it warms up outside, it overshoots. Windows are opened for long periods. So what do these energy consumption figures mean?

As economic theory predicts, if the marginal cost of comfort is reduced, then people want more of it. Higher temperatures in turn mean that more insulation would have been economic. This means that comfort is even cheaper, and so on. Research on thermal



FAR LEFT: Reyburn House under construction ten years ago. A good balance was achieved between the high levels of fabric insulation and the simple heating system.

LEFT: Lower Watts House, first featured in the July 1994 issue of *Building Services Journal*, has gradually reduced its energy consumption in accordance with predictions, although largely by replacing old heating appliances with more energy efficient units.

comfort suggests that this feedback process eventually stabilises with operative temperatures in the range 20-24°C. Such temperatures are already used in dwellings in Sweden and Finland. The process now seems to be underway in the UK.

for well-insulated, high-mass dwellings'

The houses at Reyburn and Embleton seem to have reached the right balance in simplifying heating systems so that they are neither over nor under-specified for the reduced heat loss. The experience of Lower Watts House sounds a note of caution – do not go too far until the thermal envelope is better.

This of course, includes reducing air leakage substantially. In Sweden, after 20 years of intensive effort, the industry was able to build tight. Without incentives, it may take the UK even longer. This is because the air leakage of new dwellings is higher than Sweden *circa* 1980. Indeed, it is more on a par with cold-climate dwellings built before the Second World War (figure 2).

Germany and Sweden use whole-house exhaust-only ventilation in fairly tight houses, those with leakage rates of 2-5 ac/h at 50 Pa. Until dwellings have air leakage of less than 1 ac/h at 50 Pa those countries do not recommend using mvhr. From where things stand now, exhaust-only is a more logical step forward in mass housing, yet today all the focus is on mvhr.

A not unreasonable target is to work towards this standard in the 2010 update of the *Building Regulations*. However, unless programs are set up to get to the root of the problems identified in the BRECSU report, the result of applying such technology across the whole UK may not be ultra-low-energy.

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References

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[2]Olivier D, 'Beyond the Building Regs', *Building Services Journal*, 5/89.
[3]Olivier D, 'A low Watts house', *Building Services Journal*, 7/94.
[4]Stephen R K, 'Airtightness in UK Dwellings', BRE 1998.

Further information

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Reyburn House
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Lower Watts House
Liz Reason and Stephen Andrews, ILEX Associates, King Charles House, Park End Street, Oxford OX1 1JD. Tel: 01865 722660.

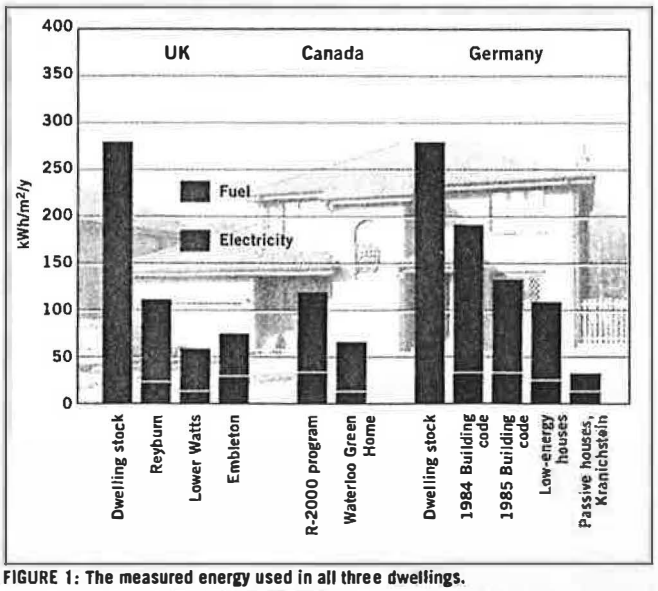

FIGURE 1: The measured energy used in all three dwellings.

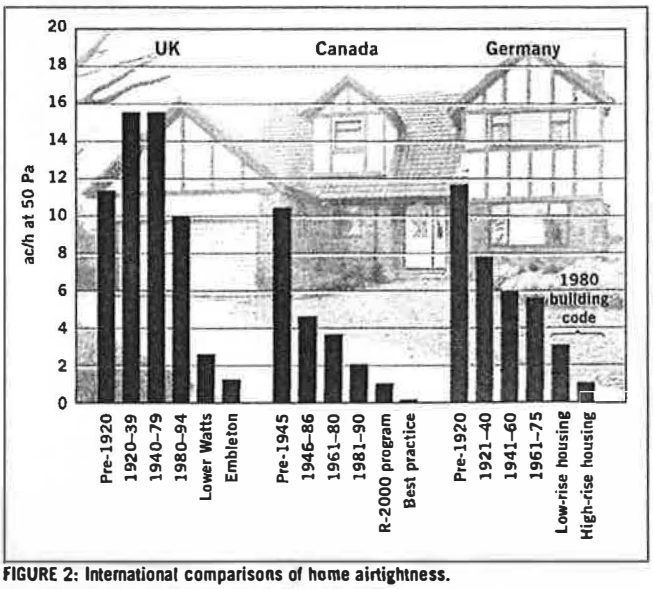

FIGURE 2: International comparisons of home airtightness.