Air quality in Passive Houses

Building performance evaluation is demonstrating the success of the Passive House approach. But better building regs would help the wider industry

Words: Justin Bere Image: Tim Crocker

Recent research from the UK Technology Strategy Board's (TSB) Building Performance Evaluation programme shows that UK Passive House buildings can provide valuable lessons in how to build homes that reliably deliver exceptionally high air quality. Yet while certified Passive House buildings that have been the subject of analysis appear to be performing excellently in terms of air quality, reports (including in PIP, Feb/March 2013) suggest that some low energy buildings are failing to perform as designed, with blame falling on the underperformance of heat recovery ventilation units.

Quality records

One of the earliest and most striking results to come from Building Performance Evaluation studies of Passive House-inspired Retrofit for the Future projects and certified UK Passive House buildings was their optimal indoor relative humidity (RH) levels. Whether summer or winter conditions, retrofit or new build, research has found optimal conditions of 30%-60% RH have been consistently achieved, one of the most important factors in maintaining very high air quality for comfort and health.

Following reports in the press about damp air associated with clothes-drying in some non-Passive House but still relatively draught-free buildings, bere:architects carried out research to see whether the same problems would occur in a certified Passive House. The investigations took place at two Passive House-certified social housing pilot research houses for BRE, the Larch and Lime houses at Ebbw Vale in Wales. Both houses air dry clothes indoors several times a week. Clothes drying and showers were distinguished by checking water use (see graph, page 39). Showers were found to have more of an effect on humidity than clothes drying, although in neither case did RH exceed the optimal range and RH spikes from both sources cleared within three hours.

Further evidence of air quality came from Dr Ian Ridley (UCL and RMIT) who reported in January 2013 that 'the living room RH in Lime House lies in the recommended range of between 30%-70%, for 71% of the time. The living room RH in Larch House lies in the recommended range of between 30%-70%, for 75% of the time', concluding... 'the ventilation systems are performing well in removing moisture.'

Likewise, CO_2 levels have been found to consistently remain at optimal levels in both buildings. For example, CO_2 levels at the Larch House in Ebbw Vale in Wales – a three bedroom house of just under 100m², housing two adults and two children – were never found to reach 1400ppm (optimal levels are ≤1500ppm), and generally CO_2 levels were consistently well below 1000ppm – a result that is unlikely to be matched except in the most draughty 'naturally ventilated' houses.

Further, air quality tests carried out by Derrick Crump of Cranfield University for bere:architects, and funded by the TSB, may provide some early indications that a combination of air-tight window seals and heat recovery ventilation systems may significantly reduce levels of harmful particulates. It is quite difficult to make comparisons because the study was small and there are of course a lot of influences, but comparing the Passive House at 4 Ranulf Road in north London with a conventional house in the same street, harmful PM2.5 particulate levels inside the Passive House are approximately half those of the conventional house.

VOC levels were also found to be low in all three certified Passive Houses tested, an important factor in air quality.

Flawed regulations

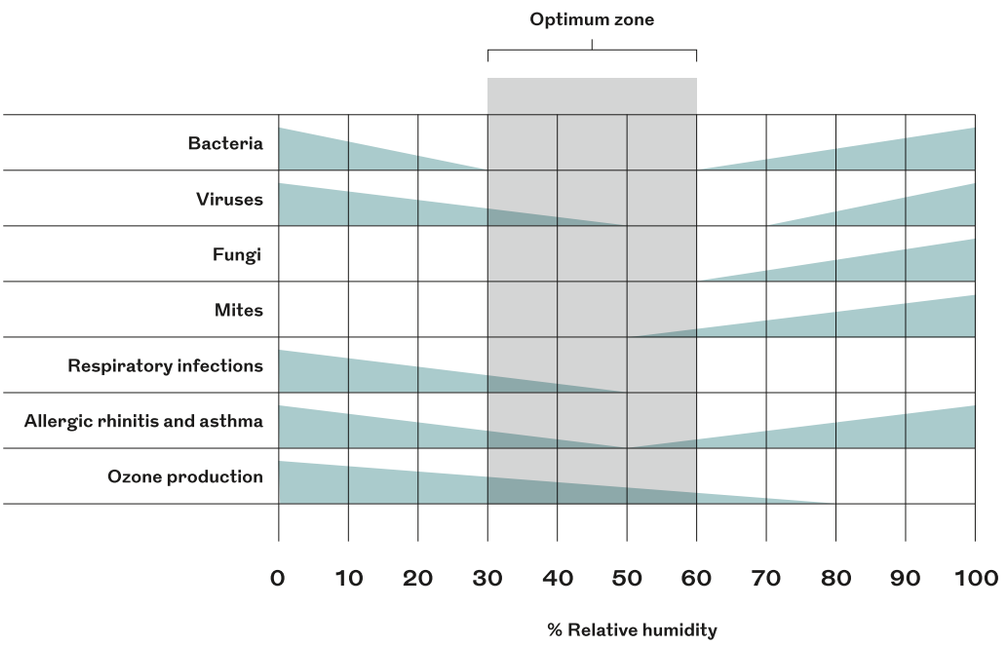
Andrew Farr of the Green Building Store is one of the UK's most respected experts in the correct design and commissioning of ventilation systems. He says crucial faults in the Building Regulations encourage bad practice among inexperienced designers and house builders.

Farr points out that current guidance makes no requirement to design for pressure loss inside the ducting. Ducting with high resistance will cause increased energy consumption and potentially inadequate air supply in some rooms while over-ventilating others. And poorly designed systems with high duct resistance create unnecessary noise pollution, which may lead users to turn off systems.

Farr adds that by measuring the intake air pressure and comparing it with the room supply terminal measurements, it is possible to detect defects due to poor workmanship in the supply ductwork. Similarly, by measuring exhaust air pressure and comparing it to room

Below: The Larch House at Ebbw Vale was found to maintain excellent air quality in clothes drying tests.

Optimum relative humidity for air quality



Right: Peaks in water consumption help to distinguish where relative humidity spikes are caused by water use (eg showers or baths).
Eco shower 10litres/min
Standard shower 15litres/min
Washing machine 12litres/min
Bath 35litres/min

extract air terminal measurements, it is possible to detect workmanship defects in the extract ductwork. Making such methods standard practice would help contractors check for ductwork defects, a common cause of problems.

Crump, who works with the Zero Carbon Hub group on MVHR and indoor air quality, has said the group's latest report (to be published soon) 'highlights many problems observed on a number of developments aiming to deliver energy efficient homes in the UK, and although examples of bad practice are documented there is evidence that certified Passive House homes may perform OK', adding that 'the essential message of the MVHR/IAQ group is the need to change our ways rapidly'. He concluded that the ZCH report evinced a 'need for more performance evaluation data and that IAQ (as well as energy performance) should be a key aspect of that.' He highlighted the importance of good design and quality control throughout construction, commissioning and lifetime maintenance.

Maintenance

Maintenance is crucial for all aspects of building performance and filters must be changed in heat recovery ventilation systems. Peter Dyment of filter manufacturer Carnfil Farr, discussing intake filters, pointed out that visual analysis alone can be misleading. The large particles that quickly become visible in the filters are not necessarily what stop the flow of air; it's the slower build-up of fine particulates trapped in a fine grade pollen filter that is the main factor affecting maintenance intervals. Research on filter change intervals should focus on pressure loss across the filters as the key determinant of expiry.

In the meantime bere:architects is concentrating on facilitating filter changing on our own projects. A solution, developed for the as-yet unbuilt Chestnut House at the BRE in Watford, has been manufactured and installed as a prototype for testing in a Passive House building. It is designed to allow filter changing intervals to be extended to up to two years and for the operation to be carried out without entering the building. Making maintenance cheap and easy to achieve, potentially under an annual maintenance contract, is an important step in scaling up applications.

I hope that the conclusions some readers may previously have arrived at might now be modified in the light of the new evidence of exceptionally high air quality being consistently achieved in well designed, commissioned and maintained certified Passive House buildings. This is in stark contrast to the poor air quality and cold, damp conditions that are found in many ordinary houses in the UK, both existing and new build.

We would argue, therefore, that the reported failures in the ordinary UK housing stock could and should be addressed by improvements to the UK Building Regulations as outlined above. The opportunity for improvement is well documented in some of the Technology Strategy Board's Building Performance Evaluation case studies, and there is an urgent need to improve the regulatory standards surrounding the ventilation of buildings. The only other option would be to abandon people to cold, draughty and energy profligate homes that are unaffordable to keep warm, dry and healthy in the cold winter months. Such a scenario would also mean abandoning all hope of reducing our CO_2 emissions; and that is surely an unacceptable prospect.

Larch house – interior relative humidity (%) over one month period in winter