Healthy Buildings must be warm, well ventilated and dry

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Most people spend 80 – 90% of their time indoors, which means the indoor environment is where people meet many of the influences that affect their health and wellbeing, for good or ill. The impact is serious: just one condition affected by the indoor environment, asthma, kills three people a day and costs the country millions of pounds annually. [1]

We all want the buildings we create and occupy to be healthy, and the sustainable building world often makes special claims to be creating healthy spaces. But are we directing our attention the right way? Which hazards are most important – and which can we actually do anything about?

Analysis of the severity of health problems caused and the number of people affected, for the Department for Communities and Local Government in 2008, suggested that cold is the single biggest indoor health hazard.[2] However, hopefully occupants of sustainable, low energy buildings are safe from the dangers of cold.

But after that, DCLG listed a range of hazards, many of which were related to indoor pollution.

Particulate pollution

Unfortunately, one of the most serious indoor air quality risks identified by DCLG is one over which building designers and occupants have limited control. Particles - predominantly products of combustion - increase the risk, and the severity, of heart disease and respiratory illnesses, and are blamed for many premature deaths.

The main source of particulate pollution is traffic, especially in UK cities[3] (this leads to ozone pollution as well, see box). Industrial processes and coal and biomass burning also contribute.

Some of these particles can be kept outside if a fully ducted (usually, MVHR) ventilation system is used with extra fine filters fitted . Although no filter can remove all the particles, they collect a proportion, especially of the larger ones,[4] and there are anecdotal reports of householders enjoying better health after filtered ventilation is installed.[5]

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[1] www.asthma.org.uk

[2] Review of Health and Safety Risk Drivers: BD 2518, DCLG. Non- indoor toxin issues included accidents (falls, fire, burns), electrical hazards, overcrowding and insanitary conditions. http://webarchive.nationalarchives.gov.uk/20120919132719/www.communities.gov.uk/publications/planningandbuilding/reviewhealthsafety

[3] http://cleanairinlondon.org

[4] http://www.afprofilters.com/european-filterclassification.html

[5] http://www.energysavingtrust.org.uk, Retrofit-diaries, Hounslow Passivhaus Retrofit

However particulates are also created indoors, for example by frying (or burning) food, by cookers themselves, tobacco smoke , open fires and stoves, and also candles. These sources can lead to indoor concentrations of particles greatly exceeding those outdoors.

Moisture

Of the hazards that arise indoors, excessive moisture is probably the most significant, not least because of the role it plays in encouraging mould and house dust mites. These in turn exacerbate, and may even cause, a range of common and disabling health problems including allergies such as asthma, and other respiratory conditions.

Moisture may also make people more likely to pass on infections to one another. Moisture, and the fungi and pests it encourages, damage a building's structure, decor and furnishings and occupants' clothes and possessions, and lead to misery and demoralisation.

Humid air is not itself uncomfortable (it often approaches 100% outdoors in the UK in winter and we don't suffer) - though high humidity is unpleasant in the heat, as it impedes our natural cooling via sweating.

You can't just keep on lowering humidity though (even were that possible) as very low humidity can be uncomfortable, leading to eye, throat and skin discomfort. Very low humidity also seems to make people more prone to catching colds.

Mould growth takes off when surface moisture activity is high - and is always a risk if there is persistent condensation. The more moisture there is in the air, the higher the risk, hence the importance of source control and ventilation. But basic physics means that surface temperatures are also important. Fabric and ventilation have to work hand-in-hand.

If the air coming into contact with a cool surface (be it a glass of beer or a window reveal) contains more moisture than air can hold as vapour at that temperature, the surplus will condense out onto that surface.

Indoor surface temperatures are in turn set by a combination of indoor air temperature, outdoor temperature, and the conductivity (or lack of it) of the fabric between the two.

Factors that will increase indoor surface temperatures and minimise condensation are therefore good insulation, and an efficient building overall (so occupants can afford to maintain indoor air temperatures). Well-specified fabric is thus about more than saving energy, it's also about health. (see photo).

There is a particular issue with internal wall insulation, which by its nature, will keep the inner face of masonry cold. If warm moist air can get behind the insulation, the results can be dreadful.

While with a modern efficient fabric, condensation and mould may not become a problem unless relative humidity reaches 65% or above, there may be problems at lower humidity levels where fabric is poor. And house dust mites start to multiply when indoor humidity reaches 50%. As house mite expert Dr Marcella Ucci of University College London told a recent event organised by the

Alliance for Sustainable Building Products, it probably isn't possible to completely eliminate dust mites by reducing humidity. Nonetheless, she believes, lower indoor humidity is helpful. Intervention studies where steps have been taken to lower indoor humidity have seen symptoms improve. [6]

Overall, indoor humidities in the range of 40% and 60% are most commonly recommended, for the healthiest and most comfortable conditions. See for example goodhomes.org.uk[7]

Bathing,cooking, washing and ironing – and breathing -- release considerable quantities of water – perhaps 4-5 litres per person per day, but depending very much on individual habits.[8] BS 5250:2002 & PH ref and maybe my other ref too from the US

In naturally ventilated buildings in particular, Part F (Ventilation) of the Building Regulations expects intermittent extract to take a lot of the strain (50% of cooking moisture and a full 100% of that from bathing), despite a recommended run-on time of only 15 minutes.

Realistically, the moisture from a shower, cooking a meal, or the hanging up laundry will be absorbed into the furniture and walls, and left on the surfaces and towels and released back over hours, rather than minutes, which is why the 24-hour background ventilation rate is crucial. It should also be able to accommodate the widely differing possible lifestyles of different occupants.

However, occupants too could do with being a lot more aware of the consequences of their choices, and how to mitigate them, as we'll see below.

Lead, **radon and carbon monoxide**

Moisture and its nasty fellow-travellers are by no means the only indoor health hazards highlighted by DCLG. It's vital to be very careful when there is a possibility of lead in old paintwork, and lead was used in paint up until the 1960s, so it's not just historic buildings that pose a risk.

Radon, thought to be the second biggest cause of lung cancer after smoking, can be tested for, and indoor levels reduced by a combination of exclusion, and good ventilation. Part C of the Building Regulations gives some recommendations, though the Health Protection Agency has suggested these could be strengthened.[9]

The dangers of acute carbon monoxide (CO) poisoning are well-known, but chronic low-level exposure may cause serious health problems – which might never be attributed to the CO that is causing them.

This was highlighted by a study in which people arriving in four hospital casualty departments were given blood tests for exposure to carbon monoxide. Researchers found five times as many patients had probably or definitely been affected by carbon monoxide, than would otherwise have been

[6] IAQ Science, Lawrence Berkely National Laboratory and Louise Woodfine, British Journal of General Practice, Nov 2011

[7] See for example goodhomes.org.uk

[8] BS 5250:2002

[9] UK Indoor Air Quality, Parliamentary Briefing, 2010

suspected. Many elderly patients had exacerbations of chronic obstructive pulmonary (lung) disease; children and healthy adults were also affected with symptoms such as headache, malaise and fatigue, which would otherwise have been put down to viral illness.[10]

Faulty boilers and stoves and cooking on gas, with a pan much larger than the ring (chutney makers beware), may cause CO pollution.[11] This is not a new problem - carbon monoxide levels above recommended limits were found in around one in six kitchens in a study in 2002 – there was a clear link between under-use of ventilation and indoor pollution in this study.[12]

Guidance is available to minimise the risk of CO poisoning from woodburning stoves, and a CO monitor should always be used. There is an obvious danger in combining woodburning stoves (or indeed gas fires) with continuous extract mechanical ventilation, because the low pressure from the extract could draw carbon monoxide into the room. This may be a combination best avoided.

VOCs

The volatile organic compounds (VOCs) that are frequently found indoors have been associated with childhood leukaemia, birth defects, neurological problems, retarded growth, and developmental problems, endocrine disruption and cancer.[13]

"Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors," according to US health and environmental agencies. The evidence about the safety and recommended exposure levels for these chemicals comes mainly from occupational exposure and from animal testing -- much of which makes for uncomfortable reading. As the agencies add, "not much is known about what health effects occur from the levels of organics usually found in homes."

Indoor VOCs generally originate from household products rather than construction materials or furnishings, but as VOC levels tend to be highest in newly built homes, fabric and finishes clearly play a part. [14] Paint, solvents, aerosols, cleaning products; insect repellents, air fresheners, glues, dry-cleaned clothing – and any product with an added perfume -- release VOCs into the air. Even natural products give off VOCs: some softwood materials fail to meet the criteria for certain environmental labels because of this.

The main VOC associated with building materials themselves is formaldehyde, found in urea formaldehyde foam insulation, and in the glue that binds many "pressed wood" products such as chipboard and particleboard.

Formaldehyde is an irritant, and possibly a carcinogen. As formaldehyde was identified as a source of indoor pollution a while ago, more product information is available for formaldehyde emissions than it is for most other VOCs. Part D of the building regulations also makes some recommendations about urea-formaldehyde foam insulation.

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[10] Simon Clarke et al BMJ December 2012, http://bmjopen.bmj.com/content/2/6/e000877.full?rss=1

[11] www.hackneyhomes.org.uk

[12] http://www.umad.de/infos/cleanair13/pdf/full_104.pdf

[13] US Centres for Disease Control & Environmental Protection Agency

[14] http://www.nhbcfoundation.org/Researchpublications/MVHRsystems/tabid/585/language/en-US/Default.aspx

Emission rates of some other VOCs from building materials are given in some environmental labels (see below) – but information about which levels, of which compounds, should be of most concern, is harder to pin down.

Regulation, labelling and standards

As the Greenspec website warns, less scrupulous manufacturers may try to imply that a performance declaration is in fact a performance standard - the Greenspec page on "greenwash" is well worth a look to help sort out what is meaningful from what is spin.

In Eurpope, what manufacturers are required to declare (as opposed to how they are to declare it, which is covered under the CE marking system) is a matter for individual states, and as Dr Derrick Crump of Cranfield University told the ASBP event, the UK is not likely to require any declarations relating to emission levels of, for example, VOCs.

Some countries do require considerably more information. In France, products must all be labelled in one of four indoor emissions classes . In Germany under the DIBt / AgBB scheme, products have to meet specific standards on VOC emissions and carcinogens.

However, here in the UK, there is a tendency towards resisting regulation as a "burden on business" with a presumption in favour of "voluntary" and "industry-led" schemes. (Some of these do exist, for example, the VOC labelling now well-established on paints.)

Calls have been made for mandatory labelling or regulation here too, to make it easier to select healthier products. In 2004 the Sustainable Buildings Task Group was told that labelling would not be possible, because of EU trade rules, but as Lynne Sullivan who sat on the group, points out, the fact that Germany and France now have mandatory labelling schemes suggests this was not true. The call for mandatory guidance was repeated in 2013 by the Zero Carbon Hub[15] but this too has been ignored.

Specifiers wanting help with selecting healthier products can try to find out about products that have been classified under other national systems, and they can also turn to some of the voluntary international labelling schemes, and check if they offer the information required. One of the strictest is NaturePlus – though the list of UK-available products so far is fairly short. [16]

Are we ventilating right?

There is a general assumption that as airtightness increases, good ventilation becomes more difficult. People then sometimes argue this makes it even more important to control the sources of indoor air pollution.

[15] Zero Carbon Hub Ventilation and Indoor Air Quality Task Group report 2013 http://www.zerocarbonhub.org/sites/default/files/resources/reports/Mechanical_Ventilation_with_Heat_Recovery_in_New_Homes_Final%20Report.pdf

[16] http://www.asbp.org.uk

While there is no argument about the importance of minimising indoor air pollution, whatever its source, this has always been important.

However, the uncertainty and lack of information about indoor toxins make it clear that while you can lessen it, no-one can reliably prevent indoor air pollution via source control. And anyway, however carefully the building components and contents are chosen, this will never mean ventilation becomes less important – not least because normal human existence is itself polluting in a confined space!

Is it good enough, then, to accept that there is a trade-off between ventilation and warmth, comfort and efficiency? Surely, no self-respecting designer or builder should be willing to compromise on either? - any more than they would compromise, say, electrical safety in order to make the plumbing work properly.

While there are examples to be found of good practice and good air quality with all sorts of ventilation systems, there is a long and continuing story of badly ventilated homes in the UK.[17]

Derrick Crump has spent more time than most looking at this. When at the BRE, he summarised the findings of four largish studies (of 40 - 800 buildings) from the 1990s, which revealed high formaldehyde and other VOC levels in many homes – with even the average levels exceeding the recommended limits in some samples.[18]

A 2002 study of 37 houses built since 1995, but roughly as "leaky" as the UK average, found two-thirds had ventilation rates below the recommended 0.5 ach, and again, significant instances of poor IAQ.

One recent study of natural ventilation examined what had actually been installed, and discovered that few of the study dwellings met the then Part F recommendations for ventilation capacity.[19] Investigations have also highlighted instances of poor installation of mechanical ventilation, and poor air quality in some cases.[20]

But to make matters worse, a consistent finding right through from the earliest studies has been that occupants do not use their ventilation as intended. They switch off fans because the noise is a nuisance, or because they are worried about running costs, they close vents because of draughts - and some are not aware of the ventilation at all.

The importance of ventilation will never go away. Increasing airtightness is highlighting what was already an ugly state of affairs. No matter how "safe " you make your building, no matter how

[17] Ventilation And Indoor Air Quality In New Homes, Derrick Crump, Sani Dimitroulopoulou et al, BRE; Ventilation and Indoor Air Quality in Part F 2006 Homes DCLG 2010; Stirling Howieson, Department of Architecture, University of Strathclyde

[18] Presentation "Indoor-outdoor; legislation and exposure", BRE (this may no longer be available online)

[19] DCLG 2010, as above

[20] http://www.nhbcfoundation.org/Researchpublications/MVHRsystems/tabid/585/language/en-US/Default.aspx

careful the occupants are, toxins will inevitably get in, tracked in on shoes, brought in as purchases – and arising from day-to-day activity.

While knowledge – and requirements – relating to thermal performance have made progress, it is plain that ventilation has a long way to go – in terms of how it should be designed, how it is installed, and how occupants understand and use it. It's not just technical performance and good installation; with all ventilation systems, if the design and installation is not geared around the occupant experience, it will just get shut off.

In conclusion

Householders concerned about a healthy environment need to be aware of the many ways they can affect the indoor environment – not just ventilation and moisture control, but also how clean they keep their home, which products they use, and the things they burn, deliberately or otherwise.

Designers and builders should do what they can to specify healthy products (not least because of the impacts on the manufacturing workforce and the wider environment), but must always be aware of the inadequacy of the information. Their biggest responsibility is to ensure occupants of their buildings can be warm, comfortable, and able to enjoy adequate ventilation all the time.

But it is equally important that occupants understand their role – it is always a team effort. Designers, installers and occupants – and manufacturers - must all appreciate that they have an active role in keeping dwellings healthy.