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Rethinking retrofit

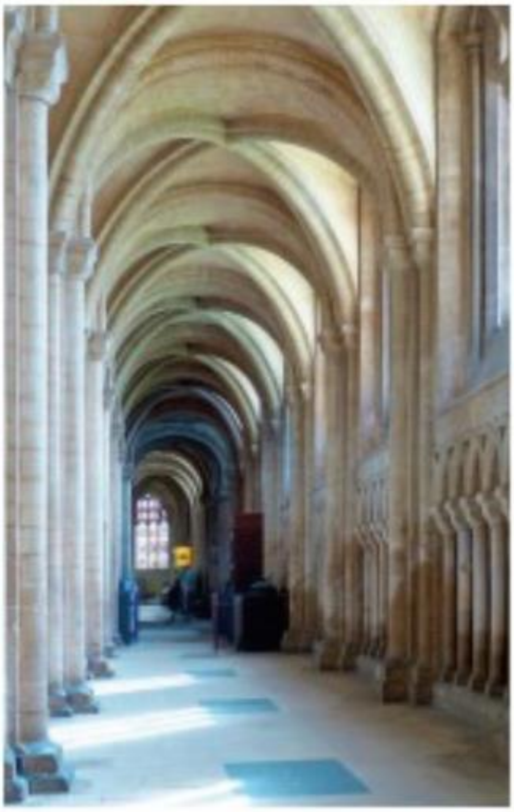
Ill-advised retrofits not only waste carbon, but they can severely damage buildings – through dampness, among much else – that have hitherto worked well for perhaps hundreds of years.

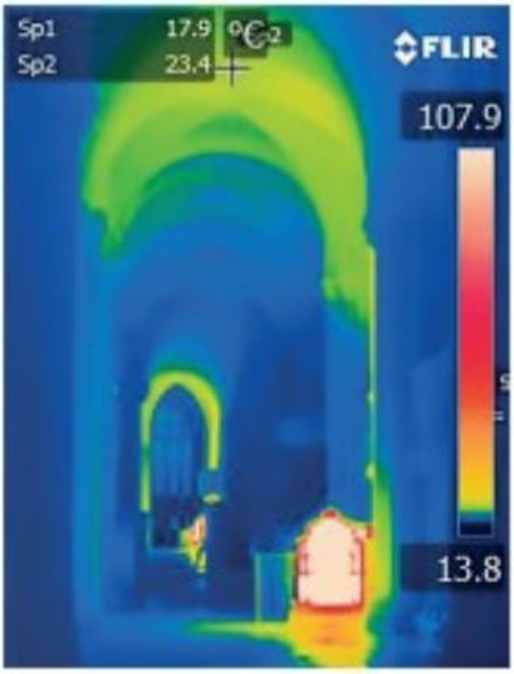
The UK parliament's aspiration that the country be 'net-zero' by 2050 is focusing minds on that substantial portion of carbon attributable to the built environment. While cutting carbon is to be welcomed, there are risks inherent in hasty action, not least maladaptation (where 'improvements' end up costing more carbon than they actually save). Ill-advised retrofits not only waste carbon, but can severely damage buildings that have worked well for perhaps hundreds of years. The potential of 'deep retrofit' to cause damage is well proven, and the energy benefits of adding insulation to many solid walls is much debated. And these are not benign systems that one might add 'just in case'.

Many systems of insulation (together with the vapour barriers crucial to them) lead to damp. Current research appears to indicate that moisture can build up over time due to condensation: and as water builds up in pores and capillaries, it will attract more water. Deep retrofits usually include draught-sealing, limiting the opportunity to decrease indoor humidity. Of even greater concern is systems trapping water from elsewhere, such as gutter and plumbing leaks. External wall insulation often compromises those very elements designed to keep rain from entering the walls, such as eave overhangs, cornices, hood mouldings and sills.

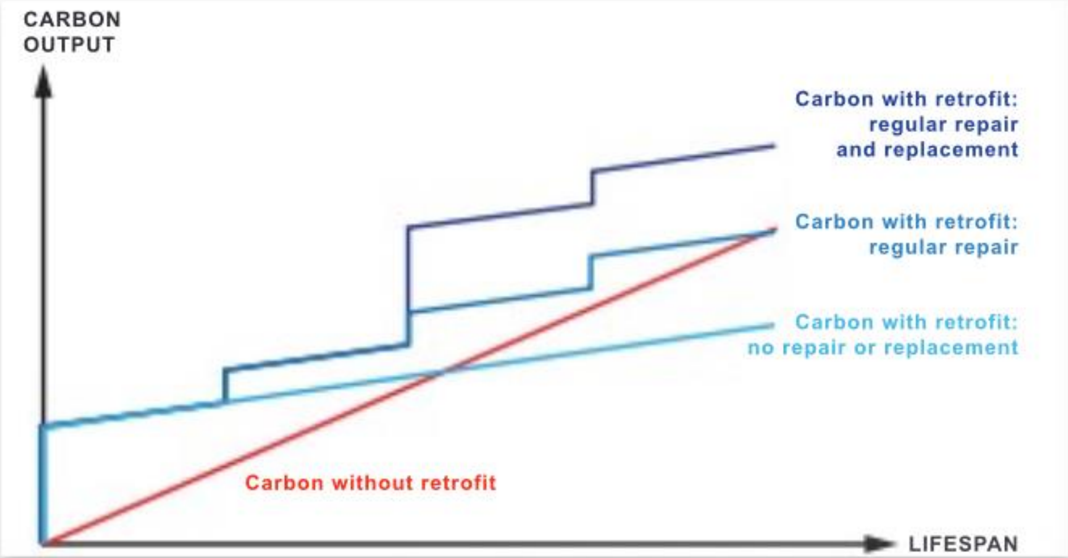
Once a wall becomes wet, it will transfer heat, negating any supposed benefits for carbon and energy. The risk of sealing buildings extends beyond impacts on the fabric: there is a significant reduction in indoor air quality, and not just in older buildings.

Meanwhile, the whole-life carbon costs of retrofit measures are discussed surprisingly little. How much carbon do they cost to make, install and operate? How long will they last? We know triple glazing embodies a great deal of carbon but has such short a life span that that it can not deliver a true carbon benefit; but almost nothing is published about insulation systems. When will replacement be needed, and what would it entail: will it be necessary to strip the roof or walls? We need this information to reduce untimely failure, and to judge whether benefits outweigh risks. Since we are dealing with buildings with extremely long lifespans, carbon costing of retrofit measures must be factored out across many years, and take into account lifespan and replacement. If an intervention





Heating the air, especially periodic heating or heating in spaces with tall ceilings, induces air movement and brings in draughts. Draughts are also an unpleasant side-effect of air conditioning, since to be conditioned the air must be passed through a system of ducts and vented back into the space (Image of Peterborough Cathedral: Tobit Curteis Associates)



Lifespan of retrofit measures

could compromise the building's lifespan, that must also be considered. If the lifespan of a retrofit is short, and the carbon input high, this can easily overwhelm apparent carbon saving over the lifespan of the building.

But in focusing on the mechanics of sealing and insulating buildings, are we missing another still more critical point? These risky and invasive measures are being taken for one principal reason: to prevent the loss of conditioned (heated or cooled) air from the interior. That in turn is because of a paradigm that the comfort of occupants – and therefore a building's use – centres on the interior air temperature. We assume that we can only be comfortable in a very narrow air-temperature range, but this is a paradigm well overdue for questioning.

Looking at history, this emphasis on air temperature is very recent, and arguably a consequence of the burning of fossil fuels. Before the 18th century there were no practical thermometers; and the development of the Rumford grate to burn coal (introduced at the end of the 1700s) was the first attempt in this country to heat the interior air since the Roman hypocausts. This quickly became fashionable, and over the course of the next 200 years, comfort became increasingly based on controlling temperature, and on installing equipment to do that. This proved carbon-hungry from the outset, and it had unintended consequences for comfort, such as greatly increased draughtiness.

As the cost of temperature control rose, buildings began to be sealed to trap the conditioned air. Researchers soon started to point out problems with this: for example, that air temperature is a poor analogy for comfort (which varies from person to person, according to taste and level of activity); and that sealing the building leads to damp and health problems.

What did people do to make their buildings comfortable before the introduction of the space heating? To understand traditional approaches, we need to revisit the underlying causes of thermal discomfort: essentially, an imbalance between a person and their surroundings. The body is an excellent thermal regulator, turning energy from food into heat that circulates through the blood stream. To lose heat, the blood is sent to the skin, so that it can be transferred to the surroundings.

Some two per cent is lost into still air, rising to 22 per cent if the air is moving and the skin is wet. A cold wet day can feel significantly colder than an icy dry day, despite being several degrees warmer, while it is often humidity that makes a hot day uncomfortable: as a marker of discomfort, humidity is extremely important. Some heat is lost by direct contact to surfaces. We know that feet are particularly susceptible: if your feet are cold, you will feel cold. Most heat (60–65%) is lost by radiation into the surrounding surfaces. These processes can be desirable if you are trying to lose heat; when exercising, for example.

All this was well understood in the past by observation. Most actions to combat cold were designed to cut radiant heat loss: floors were covered with mats; cloths were hung on walls, and draped to make canopies that cut heat loss upwards. Contemporary paintings show that drapes occasionally covered entire walls, but more often they were simply hung behind where the person was sitting. In glazed buildings, such as chapels, they were hung across the bottom of the windows to trap the air chilled by the glass as it fell. In summer, when losing heat was desirable, cloths could be taken down: tapestries were packed away over summer. Tapestries are now the best known radiant break, but much more popular in England, were painted cloths, which

A medieval merchant's house in Southampton, from when ideas about space heating were very different (Image: Geni, Wikimedia)

could be found in all types of building, from the smallest London tavern to Hatfield House. In other countries they used leather panels or carpets, and timber panelling was popular everywhere. Radiant breaks were supplemented by well-designed clothing and furniture, coupled with local elements such as hand warmers and hot bricks, or fans in hot weather.

Drapery seems to have begun to be unpopular in the 18th century, perhaps because of the plague – 'hangings' were identified as a possible source of infection – but their absence must have made Georgian buildings very cold, particularly after the introduction of Rumford grates made them very draughty. It is perhaps not surprising that Victorian interiors are famed for drapes and curtains. Their primary purpose forgotten, these once again disappeared with the rise of modernism, and today fashionable interiors are still characterised by large areas of hard surfaces.

If air heating is to deal with this source of discomfort, the air must be kept warm enough for long enough that it can warm the wall surfaces by conduction, until they are as warm as the occupants. It is easy to see why this is so costly. Services engineers often express surprise that underfloor heating is popular for tall spaces with large areas of floor, because it can not raise the air temperature to 'desirable' levels; it works by preventing body heat being lost into the floor. Topping up with perimeter radiators may not be necessary: indeed, if that increases draughtiness, it may be counterproductive.

With this knowledge, we can look with new eyes at the rebound effect. If the occupants believe that the heating or cooling system they have bought will deliver them perfect comfort, but it does not, they will attempt to run it 'harder'. If that makes things more damp or draughty, the result will be a vicious cycle.

Reinstating radiant breaks is clearly desirable, and this need not look old-fashioned: it may be a simple matter of using cloth rather than wallpaper. Today we also have the advantage of a wide range of tools for heating and cooling people that can be run on decarbonised electricity: radiant heaters, heated carpets and electric fans. Moreover, if comfort can be dealt with using little or no space heating or cooling, there is no need for expensive and risky attempts to seal buildings. Reaching for net zero becomes infinitely easier at a stroke.

Many other elements of traditional technology are just as useful as they ever were. To give the obvious example: the vertically sliding sash window has never been bettered as a means of ventilation, with openings at top and bottom for precise control over air exchange. Tools such as these have another advantage: people have been shown to be much more comfortable if they have control over their environment, even if they then choose not to exercise it.

How do we convince regulators, advisors and the general public to question current assumptions around retrofit? We will surely need to find some way of assessing what in the past was 'common sense'. Regulators will wish to quantify change, and air temperature is easy to measure; but comfort has so many nuances that its measurement is very complicated. Methods for robust assessment of benefit is a research vital area, and Historic England has a number of investigations under way. We will be reporting on these as results become available. We will also be interested in your thoughts about how to reach building owners and users.

If you would like to read more about the history of comfort, Historic England has published *Learning from History*, Sarah Khan's exciting report on research for her masters in conservation at the Architecture Association.[1]

[1] Khan, S (2020) *Learning from History: traditional low-energy approaches to comfort*, research report for Historic England (forthcoming)

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