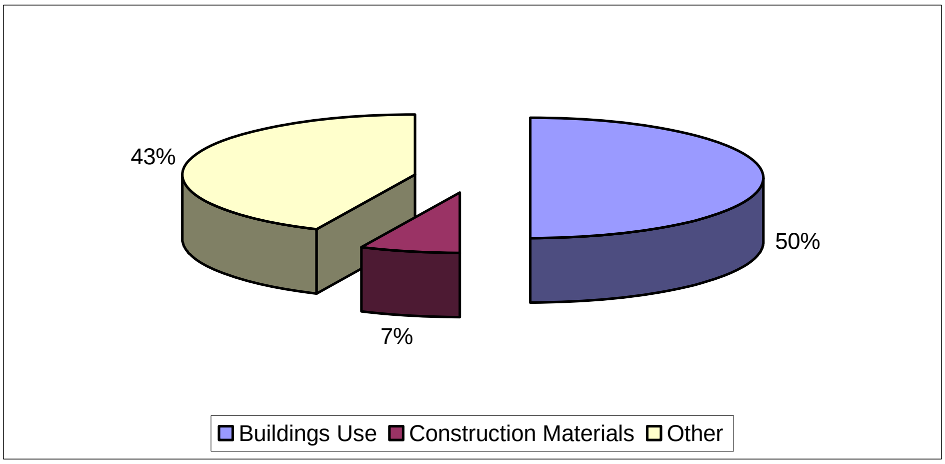
Traditional Materials and Energy Efficiency By Neil May

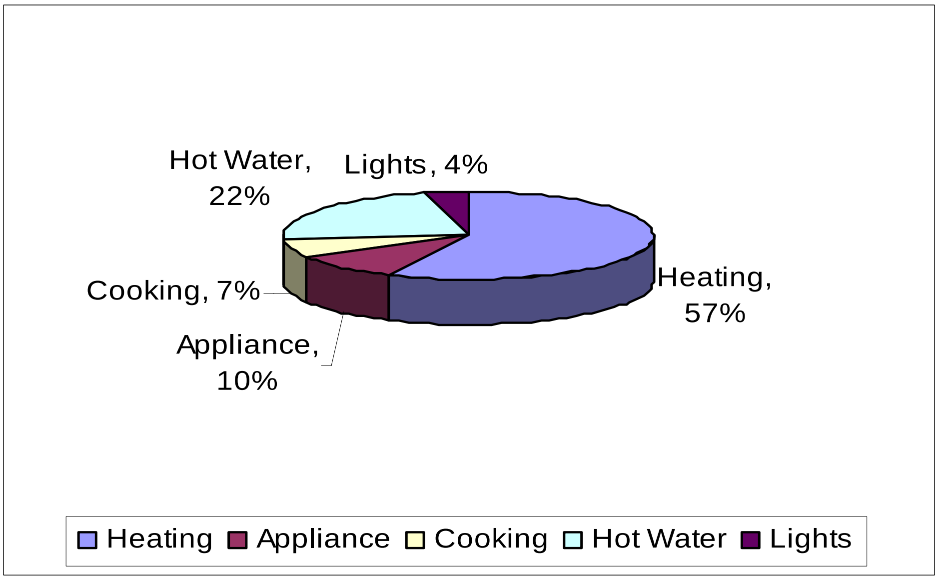
Over the past six months there has been a sea change in attitudes to environmental issues and particularly to the serious and imminent threat of Climate Change. These concerns are now so heightened that finally Governments and individuals seem prepared to take concerted action to address the problem. On the whole this is a good thing, because to continue as things are is simply not an option, but it also brings with it the risk of taking actions which are either not thought through correctly in their own regard and so have a negative rather than a positive effect as regards Climate Change, or which ignore other issues also of great value, which also have an important role in the survival of the human race.

Buildings, Energy and CO2

The chart below shows the proportion of CO2 emissions in the UK from buildings in use, the construction process (mainly due to the CO2 from the manufacture of building materials) and from all other sectors including industry, transport, agriculture etc. Buildings in use contribute about half of our CO2 emissions (and consume about half of our energy use).



The next chart shows where these emissions come from. Over half of our energy use and CO2 emissions from building use come from heating our buildings.



In historic buildings it may be that the proportion of energy used in heating is even greater than this.

We cannot ignore this situation. While the use of renewable energy, or the use of woollen underwear are good solutions for individual buildings there is not enough renewable energy and not enough people prepared to live like their medieval forebears to make this a realistic solution. It is imperative therefore that we make our historic buildings more energy efficient. This is mainly done through

- Insulation of the building shell
- Reducing air leakage from the building shell

However there are great risks with this. The three main risks are

- Damage to building fabric
- Damage to human health
- Failure to improve the building performance.

This last point has been well investigated by Richard Oxley and Peter Warm in their CIBSE "Guide to building services for historic buildings", where the amount of air leakage in some of the buildings investigated was so high that insulation was almost pointless. However if good airtightness can be achieved on old buildings, and insulation installed there are great risks to building fabric and human health because of cold bridging and trapped moisture.

The burning question is therefore: Is there a way to renovate old buildings, improve their energy performance and not put fabric and human health at risk? It is my conviction that only natural materials which are fully breathable (that is vapour permemable, hygroscopic and with some capillary qualities) are compatible with historic building fabric. Indeed these materials are often adaptations of materials which have been used for centuries in old buildings and which have evolved for modern needs. I am talking mainly about wood, natural fibres and unfired clay. Furthermore these materials are not second best to their synthetic equivalents. They are on the whole far better materials in terms of performance, and in addition are renewable and sustainable materials which meet all other key sustainability criteria. For me this is the exciting thing about traditional technology. It is not the past but the future of buildings, if we can adapt it to present and future needs.

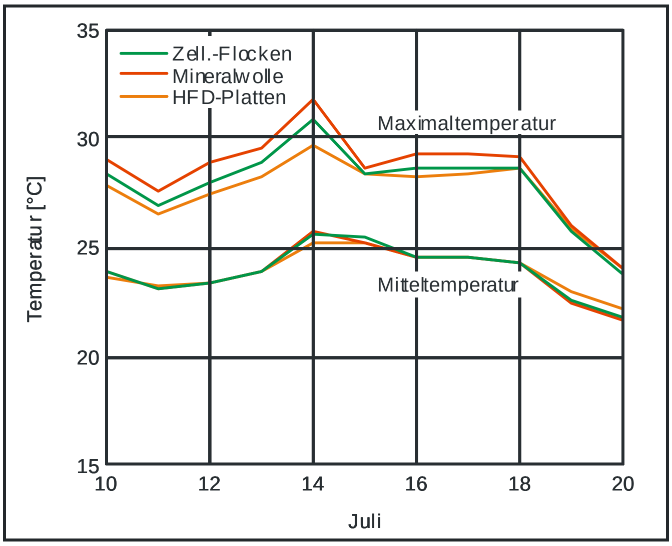
<u>How natural materials can actually improve energy efficiency of buildings</u>

Natural materials tend to be much more complex than highly processed materials, and have different qualities. If used correctly they can considerably enhance building performance. For example in comparing natural fibre insulation with synthetic and mineral/ glass based insulations the following can be asserted:

Durability: natural fibres are on the whole much stronger than glass and rock fibres. Much conventional fibre insulation collapses and degrades over a few years (note that loft insulation which is now a damp squib). If buildings are to last over 100 years then we need insulation to last at least as long, particularly in areas where it is difficult to replace or renew. Natural fibres are known to last this long in the correct environments. As regards gas blown insulations, there remains a significant question as to whether these gases will remain for the life of the building. In many peoples opinion only air based insulation is guaranteed. And as regards multi-foil insulation, there are major concerns about the claims made by the manufacturers.[1]

Thermal performance with moisture: natural fibres absorb and desorb moisture hygroscopically, unlike synthetic fibres. Far from reducing their overall thermal resistance this has been shown to improve performance in comparison with conventional materials[2]. In one study comparing flax insulation with mineral wool insulation with a similar ***designed*** thermal performance over a bathroom, the thermal resistance of the flax insulation fluctuated more than the mineral wool, but overall had about 10% better resistance.

Specific heat capacity: most natural fibres have a specific heat capacity of about 2000J/kgK, compared with 800J/kgK for mineral wool, and 1400J/kgK for plastic insulations. When combined with the higher density of most natural insulations this means that the ***thermal mass*** of natural insulations is considerably higher than conventional insulations for the same thermal resistance. This means that they give far better thermal storage and overheating protection both of which are increasingly important in energy efficiency strategies, particularly in light weight structures.



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Picture 4 Calculated medium and maximum room temperatures on two selected hot summer days in an attic conversion with rafter insulation of mineral wool, cellulose and wood fibre (HFD-Platten) boards. While the mean value of the temperatures hardly varies, the maximum value of the woodfibre board insulation remains ca. 2 degree lower, due to its high thermal capacity.

The multi-functionality of bonafide natural insulation products extends also to their acoustic performance, which again is far superior to synthetic fibres and plastic insulants, thus making them highly cost effective in designs where thermal resistance, overheating control and acoustic insulation are all required. Add in their breathable qualities and the products become cheap.

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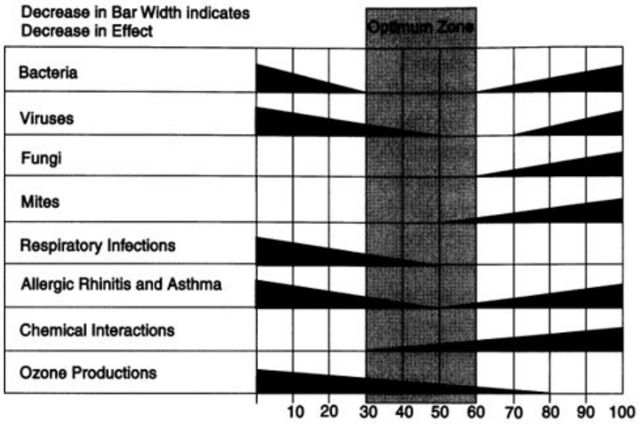
[1] See the report commissioned by Celotex at www.**celotex**.co.uk/pdf/Multi-**foil**_Bulletin.pdf and also the recent ruling by Trading Standards brought against Tri Iso Actis by John Willoughby

[2] Ie *Hygrothermal Properties of Ecological Insulation Materials – a closer look by Dr M Krus and Prof K Sedblauer of the Fraunhofer Institute for Building Physics pages publ 2002. Also work done by Cardiff University on flax insulation still to be published*

The importance of breathability

It is when we address the issue of breathability in buildings that the critical importance of natural materials becomes most self evident, both as regards energy efficient designs and also generally. Breathability is not about air but water, which is the cause of most building decay and most sick building problems. Breathability is not only about vapour resistance, but the hygroscopic and capillary qualities[3] of materials, which all have a critical role in building performance. It has been long understood by building conservationists how important it is to have breathable materials in historic structures in order to preserve the historic fabric. This is all to do with controlling relative humidity in buildings, not only through vapour permeability, but also through hygroscopic buffering[4]. It has also been long understood that relative humidity control is also vital in the control of moulds, dust mites, bacteria and even of VOC reactions which affect human health.

Figure 18-1: The Sterling bar graph



The conditions which encourage the growth of bacteria, moulds etc which affect both human and building fabric health are the same. If RH is kept at between 40 and 60% then none of these viruses, moulds, fungi, bacteria etc can survive. (30- 40% is actually too low for human health due to the effects of static)

This building conservation argument can and must be extended to virtually all building renovation, particularly as we attempt to introduce the high levels of airtightness necessary for effective thermal performance. This brings with it huge perils to both human and fabric health if we get it wrong. While ventilation remains the main and most important means of moisture control it is neither possible nor desirable in my opinion to rely on ventilation as the ***only*** solution to moisture control. The building shell must be mainly ***self sufficient*** in itself with regard to both thermal and moisture performance if it is to be robust, hackable and healthy for the life of the building in the uncertain times to come.

Furthermore in the crucial search for renovation solutions to thermally upgrade our existing building stock, ***only*** fully breathable materials can deal with the complications of design, access and workmanship to deliver solutions which work and

[3] please see my extensive essay on "Breathability: the Key to Building Performance" on www.natural-building.co.uk
[4] For example Minke shows how unfired clay buildings passively control moisture in buildings over many years by hygroscopic buffering (Earth Construction by G Minke publ WIT Press 2000). Hygroscopic buffering is also used in museums and archives and has been shown to be more effective than air conditioning in keeping relative humidity constant.

which do not rot the structures or increase the levels of asthma and ill health which already result from our poor building designs and methods.

It is predominantly natural materials, such as natural fibres and unfired clay, which have the qualities required for this task. [5]

Conclusion and caveat

While natural insulation materials, based on traditional materials and technologies, can provide excellent solutions for improving the energy efficiency of old buildings, this does not mean that any kind of natural material is ok in any situation. There are considerable risks for example to the internal insulation of old buildings, which need careful design and application.

On the whole however traditional natural materials in modern forms such as insulation do provide a way forward for improving the energy efficiency of historic buildings, provided that this is done with proper understanding of the building physics and biology of the individual buildings and with proper care in application. We are only at the start of this learning process and we need to tread carefully. However the exciting thing for me is that this learning is not only relevant to the renovation of all solid wall and historic buildings, but may yet be shown to be the way forward for new and modern buildings as well.

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[5] Again see my article on Breathability, or works by Tim Padfield on www.natmus.dk/cons/tp/tp.htm