Insulation for Sustainability – A Guide

Summary

A study by
XCO2 for **BING**

Global warming is the most immediate threat to global sustainability, driven primarily by **CO_2 emissions**. Achieving optimum **thermal design** of **buildings** can achieve large cuts in CO_2, with numerous other benefits. But at least half of Europe's existing buildings are uninsulated, while current construction standards in most of Europe are also still not high enough.

This guide shows in depth **Why** and **How** we should design well-insulated and energy-efficient buildings, and it discusses the criteria for choosing **Which** insulation material and design of insulating systems. The guide is extensively illustrated with diagrams and illustrative energy modelling.

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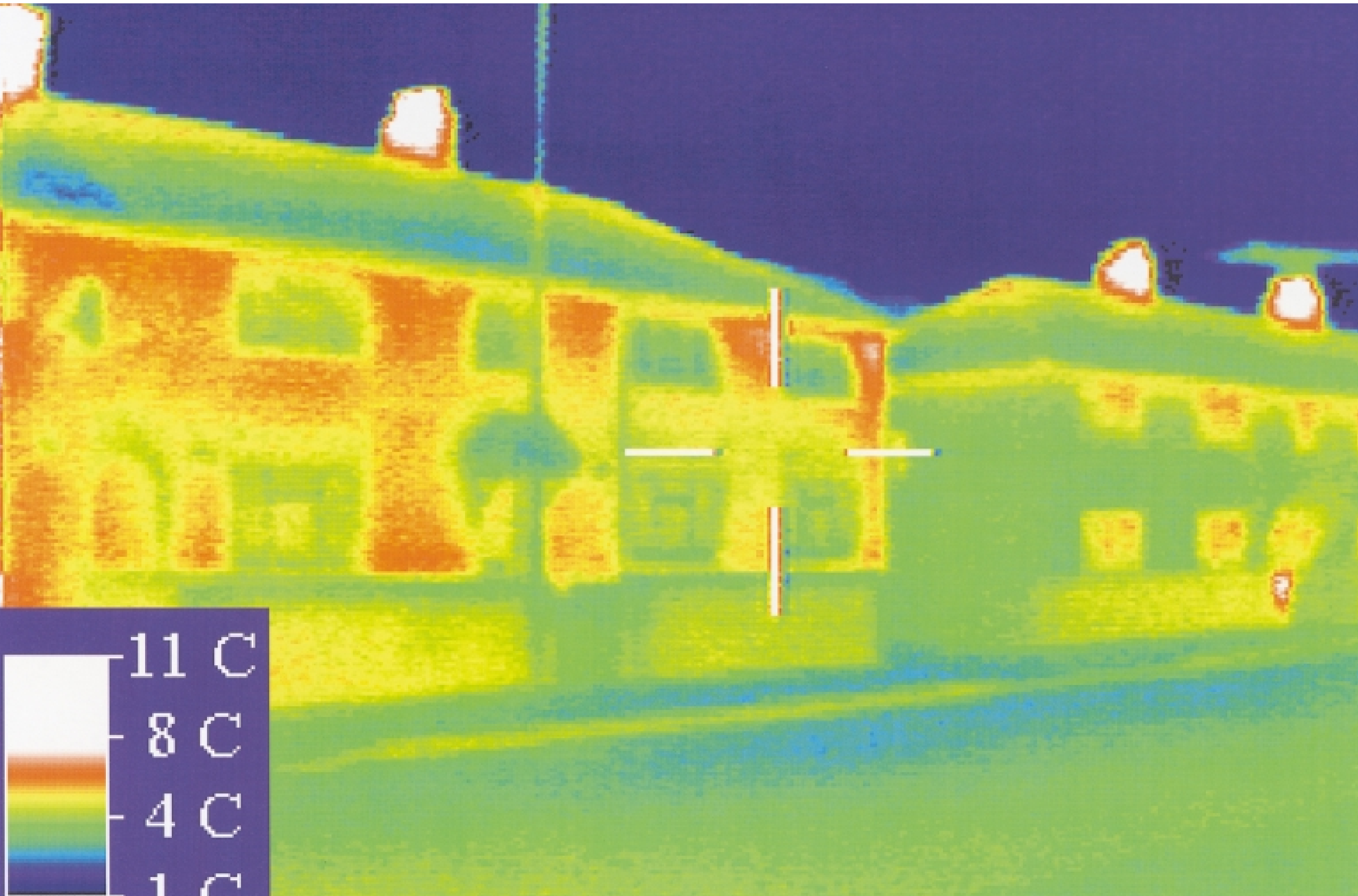

Zero Ozone Depletion Potential (ODP) non-fibrous insulation has emerged from this major study as being amongst the most environmentally sustainable forms of insulation. Such products include rigid urethane insulation. Or at least the zero ODP version.

Summary for Designers

Good thermal design is as essential part of the switch to a low-carbon economy. 40-60% of building energy use is in heating. Aim to achieve excellent U-values (e.g. U= 0.2 W/m^2.K or lower) and choose materials and constructions which will perform for a long time. It is critical to optimise other aspects of the thermal design too: particularly airtightness, glazing area and orientation, and glazing specification. For insulation materials, design and specify for high performance and long life above other factors.

For your free copy of the full version of the groundbreaking “Insulation for Sustainability” report please contact Kingspan Insulation on:

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Executive Summary

Designers need to focus on speeding the transition to a low-carbon economy, which means two things: reducing energy demand, and increasing renewable energy supply. Both elements are essential to achieve the overall carbon dioxide reductions required of 60-90%. That’s why it is critical that we improve the performance of our buildings, and that we develop construction systems and approaches which will achieve excellent thermal performance and which are both affordable and buildable.

It is perfectly possible to design buildings that use very little heating energy, that save money over their lifetime and improve comfort levels. So why don’t more people do it? The fact is that the majority of developers poorly understand the thermal design of buildings, and the overwhelming assumption that ‘low-energy design costs more’ dilutes many a well-intentioned project brief.

‘Insulation for Sustainability’ is an attempt to address this, covering a **Why?**, **How?** and **Which?** of insulation and thermal design for a general construction audience. It looks to establish clear guidelines that cut through the mass of claim and counter-claim on the nature of sustainability and to show how it is possible to make buildings perform better at little extra cost. The answer may seem obvious – ‘use more insulation!’ but building design teams need to know how much, and where, and what?

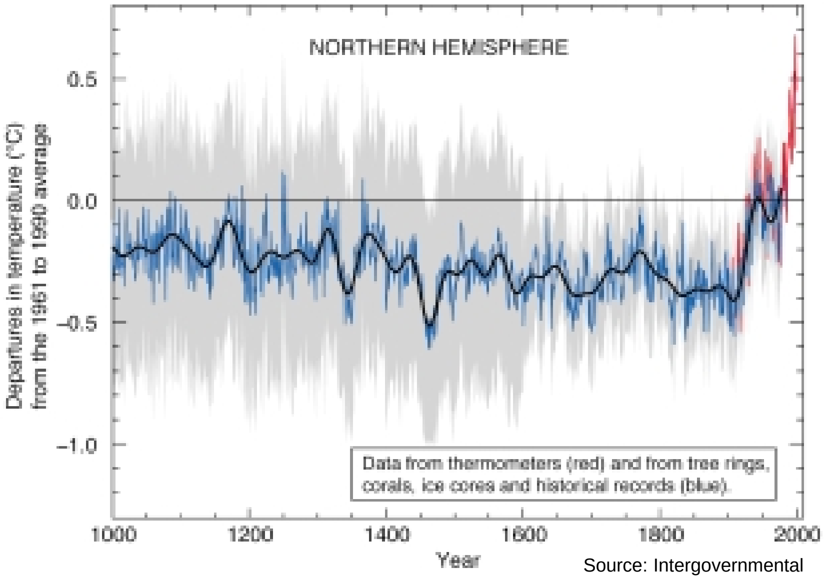
The study focuses on how insulation choices can impact on environmental sustainability. It shows that in buildings, action to reduce fossil fuel energy use (particularly heating energy) is the most important environmental consideration, and shows that the most important criteria for choosing insulation are those of long-term performance and Ozone Depletion Potential.

And of course it’s not insulation on its own, but the whole thermal design strategy, which needs to be considered.

Above all, it’s not rocket science, and it should be mainstream.

'Insulation for Sustainability - A Guide' is the result of a comprehensive research program carried out by widely respected sustainable construction consultants, XC02 conisbee Ltd.

Variation of the Earth's surface temperature over the past 1000 years:

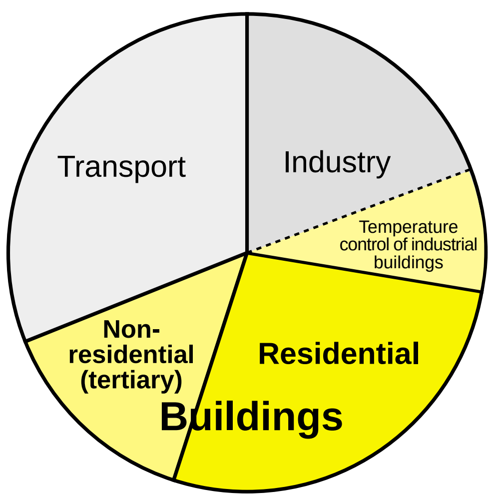


Source: Intergovernmental Panel on Climate Change

Global Warming
The scientists of the IPCC and even the Bush administration now accept that global warming is real, and predominantly man-made. The most important factor in global warming is greenhouse gases, mainly carbon dioxide.

Buildings are responsible for 50% of EU energy use

(including industrial buildings)



Source: DG TREN

Why?

The first question, **Why Insulate?**, may sound obvious.

There are lots of factors in sustainability, and it is important to try to develop a worldview, which balances economic and social issues with the environment. Good insulation design offers many benefits in all fields, although the main focus of 'Insulation for Sustainability' is on environmental sustainability issues, since they have been left out of the equation for too long.

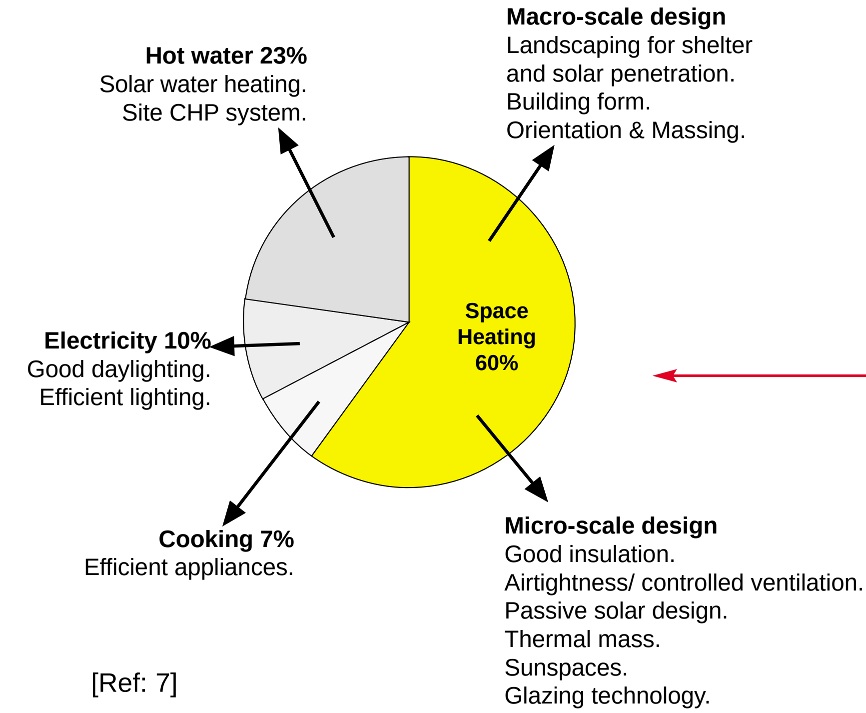
The report argues that there are three main threats to environmental sustainability:
• global warming (climate change driven by man-made emissions of gases);
• resource depletion (including depletion of non-renewable resources); and
• eco-toxic pollution including ozone depletion (damage to renewable resources and ecosystems);

It goes on to argue that the extraction and use of fossil fuels, which is the primary source of man-made carbon dioxide, also causes the majority of non-ozone-depleting, eco-toxic pollution, and is the prime resource depletion issue.

On the subject of prioritising investment in renewable energy, the study comments that energy efficiency measures tend to be cheaper and easier to realise than renewables. Why invest billions in renewables when that investment can be significantly reduced by reducing overall demand? Therefore, action to curb fossil fuel use is the key issue at the heart of environmental sustainability.

By far the majority of delivered energy in Europe is derived from fossil fuels. It is surprising how many people still don't know that buildings are responsible for 40-50% of all delivered energy use in developed countries, and that the majority of *this* is in houses, and the majority of this is in heating energy (60% on average). Reducing the energy used to heat buildings has a major part to play.

Key efficiency design strategies for housing



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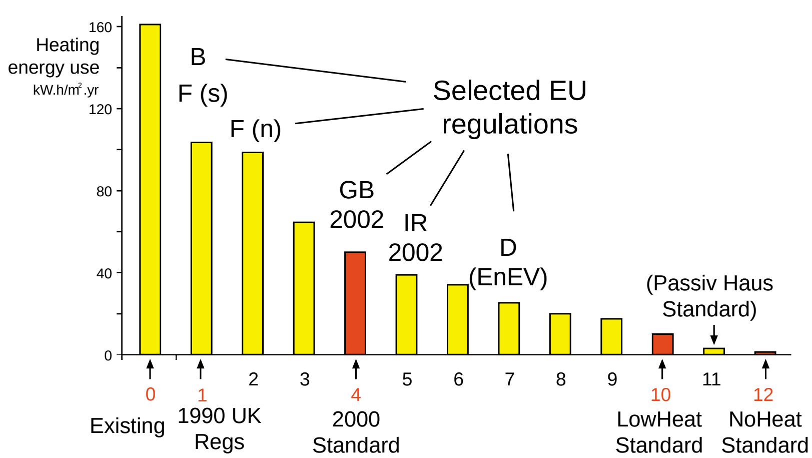
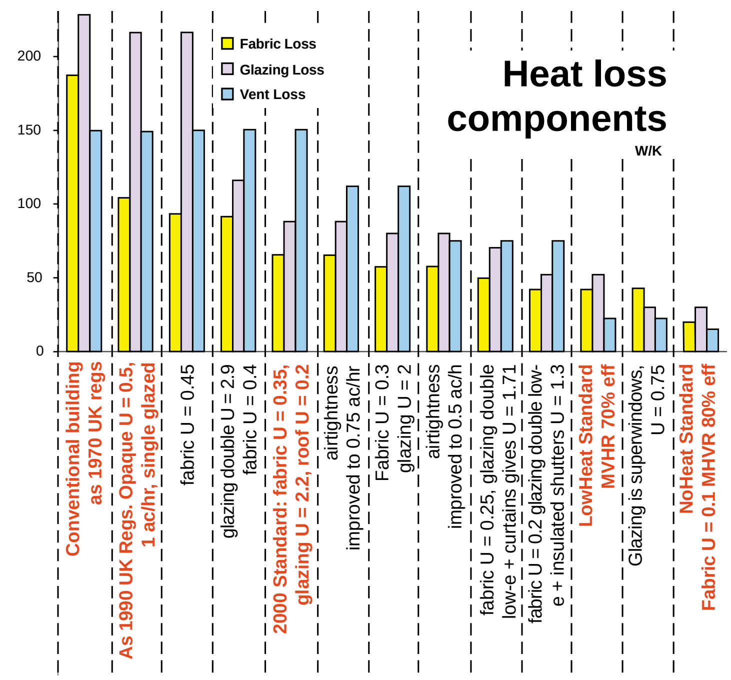
12 steps to a zero-heating house



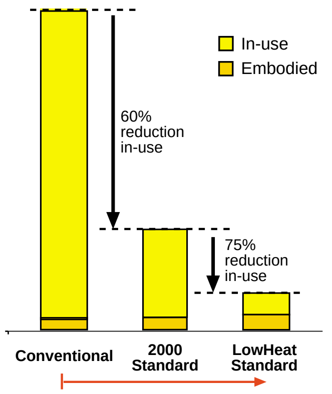


How?

The second question is How to Reduce Energy Use?
The most important part of reducing heating energy use is realising that insulation is only one part of the answer – the full answer is the complex issue that might be described as ‘thermal design’. Thermal design must start with the macro-issues of massing, orientation and shelter before working down to the detailed energy systems – and ‘Insulation for Sustainability’ illustrates these key points, in a diagrammatic thermal design checklist.

The report looks at different design changes on an incremental basis, to see what can be achieved. This approach can be used as part of a financial analysis showing the costs and benefits of each option – a key tool to help convince developers of the benefits of any extra spend on thermal design or insulation. The chart ’12 steps to a zero-heating house’ summarises this approach for a terraced house in London. The lower part of the diagram shows the three components that make up heat loss – and shows that at step 4 - which is 2002 UK Regulations - heat loss through ventilation and air leakage is the most important factor. This means that to improve performance beyond this level, it is very important to increase airtightness as well as insulation levels and it explains why heat recovery ventilation can bring such large savings to heating energy.

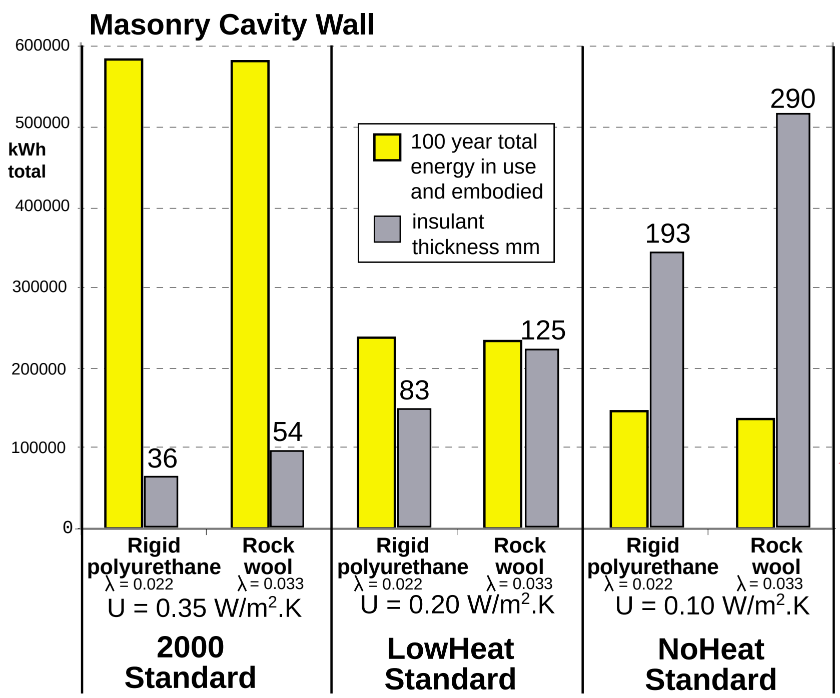
Energy in-use must be optimised first.



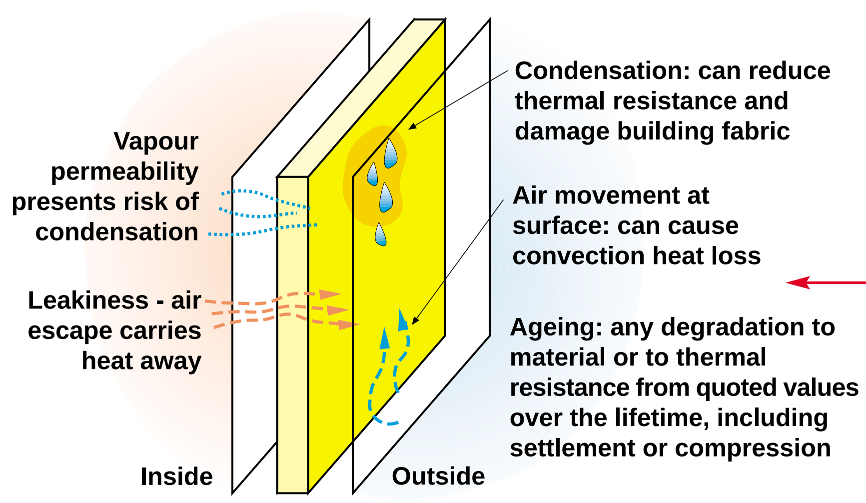
Energy-in-use must be optimised first. Embodied impact can then be reduced if it does not compromise in-use performance

Energy in-use compared to embodied energy in a typical dwelling
Note: 100-year life assumed

For insulation, material type doesn't matter; but performance does:



Challenges to insulation performance



Installation risks: all materials are vulnerable to poor installation leaving gaps or physical deterioration (compression). Good workmanship is essential.

Which?

The last section of the report is based on the question **Which insulation material?**, a subject which does tend to occupy a lot of attention amongst designers. The report shows that it doesn't really matter which insulation you use as long as it is zero ODP – what matters is that you can get high performance, which will be maintained throughout the life of the building. On the decision-making tree for low energy buildings, the question of which insulation material comes way down, falling into detailed design and specification.

The issue that usually receives most attention when choosing materials is embodied energy: but for insulation this is not very significant. For most buildings the majority of the building's energy use over its life will be energy-in-use, i.e. heating, lighting, cooking, etc.. Of course the figures will vary considerably, but on average for a UK 2002 standard house and a 100-year life, the embodied energy for all the materials is about 10% of the total. Designers should only consider the choice of materials once the 90% has nearly disappeared. However, one word of warning is given - don't make a materials switch if it will affect in-use performance!

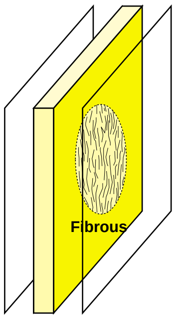
For a very low-energy house, of course the embodied energy is a much higher percentage of the total, and material switches will reduce the overall impact. However, comparing the lifetime energy (in-use plus embodied) for the same construction with different insulation materials, and for different standards (see graph), the report shows that even for low-energy buildings, the total energy is hardly affected by the insulation material choice. Insulation is a low-density material and low mass component of the total.

The total energy use *will* be affected if there is any failure in the insulation to perform, whether through poor installation or lifetime issues. This makes the detailed design critical, and makes it critical to choose the right material.

Guidelines on key issues to achieve longevity in detailing insulation materials: the most significant environmental issue.

Note: as discussed poor workmanship is a common issue to all materials and is not discussed here.

Mineral Fibre



Vapour permeability

Permeable

Moisture / Condensation

Possible in material; water causes large deterioration to thermal performance

Physical degradation

Only likely in cases of catastrophic degradation

Air movement

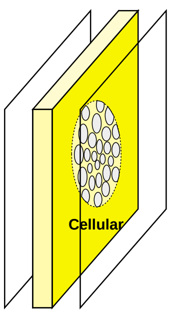
Possible reduction to thermal performance through air movement at surface and throu

Low risk

Design issue

Detailed design issues

Cellular plastic



Vapour permeability

Very low except at butt joints if poorly assembled.

Moisture / Condensation

Possible on surface, only slight effect on thermal performance.

Physical degradation

Only likely in cases of catastrophic degradation.

Air movement

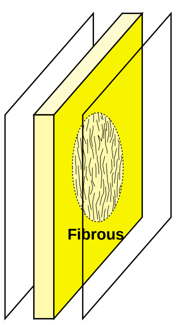
Low permeability especially if joints are taped or interlocking

Low risk

Design issue

Detailed design issues

Plant/animal fibre



Vapour permeability

Permeable, see comment on 'breathing wall'. Not suitable for masonry applications.

Moisture / Condensation

Possible in material; water causes deterioration to thermal performance and fabric.

Physical degradation

Settlement possible; especially if exposed to water or moisture.

Air movement

Low air permeability in some products. If wet-sprayed may help seal gaps.

Low risk

Design issue

Detailed design issues

Performance issues

This means there are really two key issues in choosing insulation materials. The obvious factor is achieving the required thermal performance within the particular construction, but achieving longevity of performance is also essential. A house or other building may last 50-150 years, and the insulation will probably not be upgraded in that time. If the insulation does not perform, then the heat loss will increase, and the house will require more energy, year after year.

The report argues that it may be useful to develop ‘risk factors’ – key detailed design issues and areas of potential failure for each material.

The study compares the performance of mineral fibres (such as rock wool and glass fibre), zero ODP cellular plastics (such as rigid urethane insulation) and plant / animal fibres (such as cellulose and sheep’s wool). On the issue of longevity, it assesses the impact on thermal performance of:

- vapour permeability;
- physical degradation;
- moisture/ condensation; and
- air movement.

The study found that moisture / condensation and air movement were possible design issues in respect of mineral fibre and that vapour permeability, physical degradation and moisture condensation were possible design issues in respect of plant/animal fibre based products. However, cellular plastic was found to be at low risk in all four categories.

For example, the report indicates that condensation or water ingress to mineral fibre can increase the thermal conductivity and heat loss by 100% or more – much more than for cellular plastic materials.

Meanwhile the idea of making insulation from renewable materials seems a winner (for example wool, paper, hemp). But these are protected from pest attack and fire by boron salts, which are water soluble – apparently a weakness if condensation or water ingress does ever occur? (whether through failure of cladding, or plumbing, or something else).

Its clear that the ‘risk factors’ affecting potential failure are something that designers must increasingly consider. The report does not pretend to have the answers to these issues, and there’s clearly a need for the industry to carry out more research on these issues. Detailed design of insulation has never been that well understood, and as thermal performance standards increase, so does the need for knowledge and information.