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BRIEFING

Energy efficiency in old buildings

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Buildings account for 44% of the UK's total carbon emissions and single glazing in buildings is a major source of heat loss. The need to tackle this on both environmental and economic grounds is assuming much greater importance.

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Selectaglaze's units are purpose made with a wide choice of styles and finishes. They are fully factory assembled allowing rapid installation with minimal disruption. They do not alter the appearance of a building so therefore offer an ideal solution for Listed buildings or those within conservation areas.

Besides the improvement in thermal insulation secondary glazing will offer significant noise insulation, in the order of 45dB, an important factor for inner city areas, and can also enhance security to Secured by Design standards.

Refurbishment or upgrade projects are often "fast track", requiring close co-operation between client, contractor, specialists and the professional team. Established in 1966 and a Royal Warrant Holder since 2004, Selectaglaze has a wealth of experience working on this basis in buildings up to Grade 1 listed. The company also offers a technical and specification advisory service to ensure the correct interface with other trades. Programmes are particularly important and proactive site surveys, linked to a modern production facility working on "Lean principles", ensures projects are delivered on schedule.

Selectaglaze founded in 1966 and a Royal Warrant holder since 2004, works with a very wide range of clients and has developed particular expertise in the treatment of period buildings. The company provides an extensive range of literature and guidance notes covering acoustics, thermal performance and security and also offers a technical advisory service and a RIBA approved CPD Seminar.

For further information, please contact the Marketing Department
Tel 01727 837271
Email enquiries@selectaglaze.co.uk
or visit the company's comprehensive website at:
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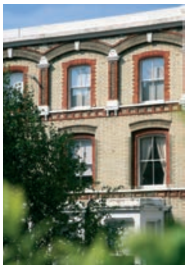

Cover: A Victorian terrace in London typical of the many solid-walled buildings that may benefit from sensitive, well-informed energy efficiency measures. Image: Roger Hunt

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Introduction

Douglas Kent, Technical and Research Director, Society for the Protection of Ancient Buildings.

Old buildings are sustainable, their very existence demonstrates this, but they can still frequently benefit from sensitive, well-informed energy efficiency measures. Early on, the SPAB recognised that such upgrading is important if our precious national asset of older buildings is not to be perceived as a liability or unaffordable luxury. Accurate information is a pre-requisite for good building conservation work so we had to ensure our advice to others on energy efficiency improvements came from a sound understanding of how old buildings perform in practice, not just theory.

In 2007, with this in mind, we started at our own headquarters in Spital Square by commissioning an energy assessment of the building, which began life as a silk merchant's house around 1740. That was only the beginning. As the heritage sector began to explore how old, solid-walled buildings could be made energy efficient, without destroying what makes them special, we invited Dr Paul Baker of Glasgow Caledonian University to undertake a study throughout 2009. This measured the heat loss through the rear brick wall of our building via its in situ 'U-value'.

The results were groundbreaking. Whilst the theoretical U-value for our 1740s property was 1.23 W/m^2K, the in situ measurements gave a significantly better actual figure of 0.6 W/m^2K. Ours was the first example to use calculated and in situ data to prove that old walls can perform better than previously believed. Our subsequent monitoring of numerous other buildings shows 77 per cent of walls performing significantly better than predicted. This is important because not only do older, solid-walled houses represent 20% of all dwellings but U-value calculations underpin energy reduction standards and the associated legislation.

In addition to this work, the SPAB has embarked on further research into the performance and energy profiles of old buildings, as we explain on the following pages. Old solid-walled houses – most of those pre-dating about 1919 – usually need to 'breathe' unlike their modern counterparts. Consequently, different approaches are required when working with traditional and modern buildings to reflect their contrasting nature. The research underway is essential to inform best practice.

Our concern has been that a laudable drive to upgrade the thermal efficiency of the country's older building stock could do more harm than good. In particular, the use of standard non-breathable materials and excessive sealing-up risks damaging both old buildings and their occupants' health while saving little, if any, energy. This is why the SPAB, along with other bodies and individuals knowledgeable about old buildings, wrote to The Times in August 2011 expressing our concerns about the implementation of the Government's 'Green Deal' initiative for funding energy efficiency upgrades.

Thankfully, our concerns were recognised and the SPAB now supports the Green Deal and is working, along with others, to guide its ongoing implementation. The Green Deal has been hugely successful in highlighting the issues of energy efficiency in old buildings and, more importantly, will aid appropriate upgrading. Accordingly, this SPAB Briefing aims, through the words of some of the leading practitioners in the field, to bring clarity to the methods, materials and debate that will help ensure our historic buildings continue to be sustainable into the future.

IMAGE: DOUGLAS KENT/DAVID GIBSONE

Dr Paul Baker of Glasgow Caledonian University prepares to monitor a timber-framed house.

IMAGE: JONATHAN GARLICK

Understanding old buildings

The SPAB is at the forefront of research into the energy efficiency of old buildings. Jonathan Garlick, SPAB Technical Officer, explains the Society's achievements and concerns.

For all their apparent simplicity, old buildings are surprisingly complex and diverse. This is why the SPAB advocates that the need to understand a building comes before anything else. It holds true when we think about introducing energy efficiency measures. The problem here has been that, until recently, we have lacked the data to base our decisions on hard facts. Without that data we could, unintentionally, be doing untold, invasive damage. This is why the Society is undertaking research projects.

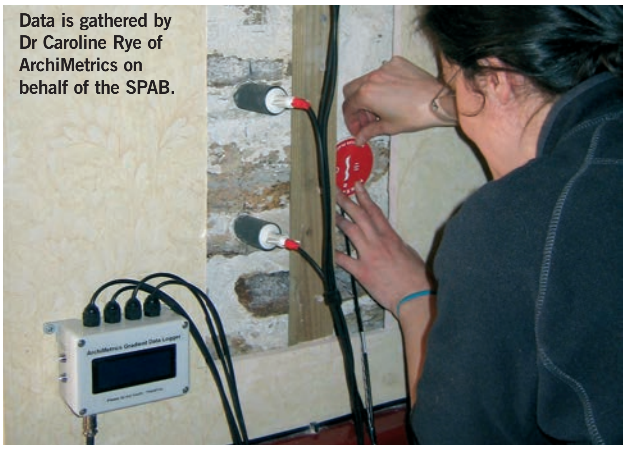
Results from the first stage of the SPAB's research on the energy efficiency performance of old buildings suggest that standard U-value calculations, used across the construction industry to measure the rate of heat loss through materials, underestimate the thermal performance of traditional walls. In some instances, it now appears that actual heat loss through vernacular materials such as wattle and daub, cob, limestone, slate and granite can be up to three times less than previously calculated. These findings - and those from Historic Scotland and English Heritage which have looked at sandstone and brick constriction - are significant.

They tell us that we need to think very carefully before rushing in because they suggest that conventional industry practices are struggling to accurately represent the thermal performance of traditionally built walls. Ultimately, this could have negative consequences for historic buildings as calculated theoretical U-values, suggesting a poorer performance, may lead owners and professionals to adopt disproportionate energy saving interventions that may not only be unnecessary, but also invasive and potentially harmful to the fabric of a building and its occupants.

U-values are not the complete story. Energy efficiency is also about our behaviour in a building, moisture content in the structure, humidity, temperature, air-tightness, the quality of the air we breathe. Since our U-value report was first published in 2010, the SPAB has undertaken two further significant research projects.

Firstly, the Building Performance Survey measured the internal environment and fabric of traditional buildings before and after retrofitting. It looked at issues including air-tightness, air quality and the way people's behaviour inside a building can affect its performance. Secondly, as part of this ongoing survey, the SPAB has presented findings from a hygrothermal study. Once again we discovered a significant discrepancy between expectation and reality.

Along with research elsewhere into the thermal performance of windows and other building elements, this SPAB research begins to give us a clearer picture of how buildings can be retrofitted to achieve effective long-term energy efficiency through minimum intervention.



Data is gathered by Dr Caroline Rye of ArchiMetrics on behalf of the SPAB.

IMAGE: JONATHAN GARLICK

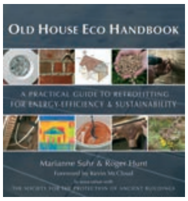
The Green Deal

Our research has been particularly important in showing that some 'improvement' measures originally promoted by the Government's Green Deal could have had potentially harmful implications for older buildings. The Green Deal is a scheme that can help make energy-saving improvements to homes and businesses without all the costs having to be paid in advance. Although it is a loan, not a grant, the savings made on energy bills after the improvements have been undertaken should cover the repayment of the loan. The process involves a Green Deal assessment of the property to see what improvements can be made and how much could be saved on energy bills. A certified Green Deal installer then undertakes the work.

The Green Deal gave impetus to those representing the building conservation world. We came together and focused our energy and knowledge under the collective banner of the Sustainable Traditional Buildings Alliance (STBA). As a group we put the problems to government and were able to apply pressure on them to recognise the importance of understanding the way traditionally constructed buildings perform. We successfully demonstrated that there is no 'one size fits all' solution for buildings in terms of energy efficiency performance or interventions and have been instrumental in shaping and influencing aspects of policy.

Among the ongoing achievements of the STBA is a gap analysis which has identified where knowledge is lacking; a 'knowledge hub'; and a 'guidance wheel'. The Green Deal itself has been good in that it has provoked a discussion about energy efficiency in older building that might otherwise not have been had. What we must ensure is that assessments are linked to contractors who understand old buildings.

Spreading the word



Research and knowledge is of little use unless it is disseminated. *Old House Eco Handbook, A Practical Guide To Retrofitting For Energy-Efficiency & Sustainability* by Marianne Suhr and Roger Hunt, with a foreword by Kevin McCloud, is published by Frances Lincoln in association with the SPAB.

The book is a companion to the highly successful *Old House Handbook* and is based on both the SPAB's own research and the latest thinking in the field of sustainability and traditional buildings. By examining the potential impact of eco improvements, ranging from increased airtightness to the installation of solar panels, it aims to provide feasible solutions.

Alongside the book, the SPAB offers courses for homeowners and professionals on improving the energy efficiency of old houses. These offer practical advice on how to make buildings energy efficient and low carbon without devaluing their future sustainability or character.

The way ahead

The way we approach energy efficiency is still evolving and our projects, like any good research, have thrown up many new questions. A growing number of individuals and other organisations are now looking to understand the data and are undertaking research. Meanwhile we are continuing our own projects. We do know that natural insulation and other traditional materials are performing best in old buildings. We also know that we have to consider the risks every step of the way. What we have sought to provide through our reports and guidance are practical starting points that attempts to tread the delicate path between the needs of our heritage and the needs of tomorrow.

Maintenance is crucial to a building's sustainability.

IMAGE: RALPH HODGSON

Join the SPAB

The Society for the Protection of Ancient Buildings was founded by William Morris in 1877 to counteract the highly destructive 'restoration' of medieval buildings practised by many Victorian architects. Today it is the largest, oldest and most technically expert group fighting to save old buildings from decay, demolition and damage. A firm set of principles, backed by practical knowledge accumulated over many decades, is at the heart of the Society's philosophy.

The SPAB is a charity representing the practical and positive side of conservation, not only campaigning but training, educating and offering advice through an expert telephone helpline and publications, including the Society's acclaimed quarterly Magazine.

The SPAB runs specialist courses for building professionals, homeowners and those who care for churches and other public buildings. Members include many leading conservation practitioners as well as homeowners, living in houses spanning all historical periods, and those who simply care deeply about old buildings.

Thousands of structures survive which would have been lost, damaged or badly repaired without the SPAB's intervention. Indeed, many of the most famous buildings in Britain are cared for by some of the several thousand people who have received the Society's training.

By becoming a member of the SPAB you are adding your voice and giving weight to the Society's work and influence.

To find out more visit www.spab.org.uk or e-mail info@spab.org.uk to request a complimentary copy of the Magazine.

Adding sheep's wool insulation prior to re-thatching.

The intelligent way

The building conservation world must devise a new green approach that can steer a sustainable course for the future says Geoff Rich, a partner at Feilden Clegg Bradley Studios.

Our generation faces the most important environmental challenge we have ever seen. For the historic environment to have a sustainable future, our world – the world of structures, materials and places – must embrace these challenges. Those who care about historic buildings must appreciate both the issues and the consequences of our actions. Our instinct to conserve, repair and re-use gives us a sound grounding. That wish to protect and manage a scarce resource has to be embedded in every architect's vision, every site manager's head and every crafts person's hands – preferably in every client's commission too.

Many larger contractors are extremely well-versed in issues of sustainability. Their corporate commitment to environmental conservation may be entirely genuine, but sometimes there's a disconnect between the company's idea and those that use the tools. Often, because they're subcontracted, or detached by one, two or perhaps even three levels from those who have agreed a sustainability policy, the commitment at a practical level is much reduced.

In today's building industry, where environmental improvements are too often measured by ridiculously simplistic 'tick-box' assessments, undertakings made at design stage often bear little relationship to actual outcomes. The problem is that once the boxes have been ticked there's no commitment within the industry to post-occupancy evaluation or monitoring of the user patterns. One way to encourage more 'ownership' of sustainability and to tighten performance is for contractors to commit themselves to an understanding of real performance where this has failed to follow the intended environmental model.

The conservation sector has the skills and the intelligence to play a leading role in shaping the way forward. I believe we need to be positive about the challenges. We must seek ways to work individually and together to tackle the problems. Through this we can also help prevent old buildings being perceived as an environmental liability with limited use. You don't have to look far to find important and inspirational work being undertaken by communities who are working to better understand their historic buildings and apply environmental solutions for the longer term. Among the leaders in the field here are those church congregations that have already embraced the Church of England's 'Shrinking the Footprint' campaign.

It falls to us in the building conservation community to embrace the challenge of taking a knowledgeable and environmentally-sound approach to construction to its next level. I'm sure William Morris and John Ruskin would have been at the forefront of such an approach in their day. But it's now for us to find a new way forward that can steer an intelligent and sustainable course for our generation and for those of the future.

www.fcbstudios.com

The Victorian house with lightweight insulating render applied to the flank wall.

Terraced house retrofit

A chilly Victorian home prompted James Ayres, a director at Lime Green Products, to take on the challenge of cutting heat loss.

When I moved into Abbey Foregate, in Shrewsbury, Shropshire, I had little idea that the 1820s brick facade hid the remnants of a much older oak frame core; nor that, despite having a modern central heating system, the end of terrace house would be bitterly cold in wintery weather. So the timing was fortuitous when the SPAB started to look for homes to study both before and after insulation upgrades, just as I started considering how to improve my own house. A few weeks later, monitors were installed to measure the U-values of the wall, humidity at different depths, air quality inside the room and temperatures throughout the wall and outside.

There were a number of reasons for the cold. The 'front' door leads to an open corridor through to the backyard, essentially leaving the small sitting room with three solid brick external walls that were uninsulated. Secondary glazing had been fitted to the leaky old sash windows, but not very well and draughts howled through the gaps in bad weather. Finally, some of the walls were much thinner than expected: the gable was formerly a party wall to a now demolished house and, as a result, is just 115mm (4.5 inches) thick.

Breathable walls

Most of the work has been to the walls. Varying between 115mm (4.5 inches) and 340mm (13.5 inches) thick, these are of solid brick and still coated with the original lime plaster, although it was in very poor condition. Internal wood fibre insulation seemed to offer many benefits – breathability, high thermal mass, eco-friendliness and hygroscopicity. After some patching to the plaster, 40mm of wood fibre insulation board was fixed mechanically directly over it, without any studwork or vapour barriers.

Wood fibre presents a challenge when it comes to plastering: it's smooth and contains a few percent paraffin wax, which means that achieving a good bond with the plaster is difficult; but I wanted to maintain a very traditional lime plaster look. I'm in the lucky position of working at Lime Green where we have a well-equipped lab. So, after plenty of bench trials and destructive testing, we formulated a lime mix I was convinced met both my aesthetic requirements and the technical demands of application directly on to wood fibre.

Testing at Sheffield University has confirmed that the breathability of the plaster is the same as found with lime putty. This was an important concern for me, as the wall is more vulnerable to dampness than might be at first apparent. There are large oak beams from a previous dwelling running parallel to the facade and the window lintels are timber, built to be boxed in behind lath and plaster. After removing plasterboard and a plastic membrane (installed probably during the 1980s or 90s) I found the timber had mould and early stages of rot present. In fact, the metal bead used on the corners had rusted badly enough to crumble as I removed it so the area over the lintel was replaced with lath and lime plaster. I believe this will be much less likely to cause the lintels to deteriorate any further, although it does mean sacrificing some insulation in this area.

Finally the Lime Green plaster was finished with natural casein paint, again to maintain the breathability of the wall. Externally, a lightweight insulating, through-colour render was applied to the flank wall with an average thickness of 20-25mm.

Stove and flue

The very large flue had an open gas fire with a 1980s reproduction inglenook in place. This was replaced with a small woodburning stove and a metal flue lining was installed. The lining is surrounded by vermiculite to provide insulation to the flue and the chimney breast. On a purely subjective basis this has made an enormous difference, perhaps the biggest benefit of all, as heat is no longer sucked up the flue in windy weather.

Windows

The original sash windows were in fair condition but were far from airtight. Rather than attempt to rebuild them, it seemed much simpler to fit secondary glazing behind, with the secondary units being double-glazed. These were made by a local carpenter, with the thinnest appearance possible so as not to detract from the sash. This meant I could achieve a good airtight modern window without changing the external appearance of the house or removing the sash windows. Depending on space available, either a thin layer of wood fibreboard or aerogel insulation was applied on the reveals – critical to prevent thermal bridging (cold spots) or condensation forming. Expanding sealing tape was fitted between the old windows and the frame of the secondary glazing to keep them draughtproof even after movement.

Ceiling insulation and loft hatch

The roof space was already insulated with 100mm of mineral wool, so was topped up to 270mm. Thermal imaging showed plenty of cold air leaking around the loft hatch so I sealed this with silicone – easy to remove with a razor blade if I need access.

Outcomes

Two years on and the monitors are still in place, logging the temperature and dew point every five minutes. The data is being gathered and analysed by Dr Caroline Rye of ArchiMetrics on behalf of the SPAB. The outcomes at Abbey Foregate have been pleasing so far. The air tightness has been measured by Diane Hubbard of Green Footsteps, both before and after upgrades were made, and there has been a reduction in air permeability of around 25 per cent, probably largely down to the secondary glazing. Interestingly, the actual figure after upgrades is 8.5 $m^3h^{-1}m^2$ @ 50pa, which is slightly better than the figure of 10 $m^3h^{-1}m^2$ @ 50pa required for new build dwellings by building regulations.

As might be expected, the heat loss through the walls has shown substantial improvement. The U-value before insulation on the south wall was measured in situ at 1.48 W/m^2K and after insulating at 0.48 W/m^2K, so a reduction of around two-thirds with just 40mm of insulation and 10mm of plaster. The real


Monitoring underway using an external thermocouple.


IMAGES: JONATHAN GARLICK

James Ayres and Diane Hubbard assessing air tightness with a thermal imaging camera.

interest lies in the moisture and condensation risk in the wall. At the time of writing (late November) the insulation and inner half of the brickwork has a relative humidity (RH) of around 70 to 75 per cent, lower than the 80 per cent RH figure widely accepted as being necessary for the growth of mould or rot.

What is really noticeable is that it bears no relation to the prediction given by conventional methods, which are widely used throughout the construction industry and incorporated into building regulations. Using a Glaser diagram would lead one to believe that the critical interface between the wood fibreboard and underlying plaster would reach 100 per cent RH by November in any year. It would then continue accumulating water throughout the winter followed by drying in the summer. In fact, that did not happen last winter, and shows no signs of doing so this winter either.

It may take the wall several years to reach equilibrium after being insulated, so it is perhaps too early to make bold claims. Nevertheless, the moisture has been managed in a very satisfactory manner so far and very differently to the manner predicted by conventional methods of moisture risk analysis.

www.lime-green.co.uk

IMAGE: PARITY PROJECTS

Assessing the building and understanding the occupant's lifestyle is the first step towards achieving a sensitive energy efficiency strategy.

The need for assessment

With every building different, Russell Smith, Managing Director of Parity Projects, believes individual retrofit 'masterplans' are vital.

Unfortunately, 'retrofitting' buildings to make them more energy efficient is often a complex business – particularly when applied to older homes – so it can be hard to work out where to start. Most of the information out there is either supplied by manufacturers with a vested interested in making their products sound like a must-have, or is given in the form of generic advice that applies to the mythical 'typical' house or the 'average' family.

But if, for example, you live in a 16th century farm cottage, Georgian townhouse or a Victorian terrace, packed with character and historic detail, you probably don't feel that recommendations for a 'typical' house really apply to you. And I'd be inclined to agree. I believe that every house, not to mention every household, is different. Even houses that were built at the same time and appear similar from the outside are likely to have been modified in different ways over time, and will be occupied by people with different habits, needs and budgets.

Appreciating these differences is vital. For example, the energy efficiency measures that are right for a single professional tend to be very different to those needed by a retired couple. Similarly, you'd likely recommend very different things for an off-grid house in Cumbria compared to a townhouse in Bath. If measures are applied in a generic way, there's every chance that you might end up spending money on work or systems that don't achieve the desired results, or spending more money than you need to. You may also cause problems for the future. For instance, inappropriate insulation can result in dampness and decay.

To avoid these mistakes, the best way forward is to undertake an assessment that is specific to your home. It's an approach now enshrined in UK retrofit policy, with the government incorporating assessments as a key stage in the Green Deal.

Green Deal assessments are designed to be mass-market, quick and cheap, enabling broad estimates of costs and benefits to be made as a gateway to Green Deal finance. This level of assessment is all well and good but I believe that it's important to have a much more individual 'masterplan'. The idea behind creating a masterplan is that it goes into much more detail to allow the identification and comparison of a greater range of solutions. Importantly, taking this approach also allows us to be much more considerate of the complexities of older buildings. For example, focussing on measures that don't interfere with period features, or assessing the relative benefits of breathable insulation materials that pose a lower risk to vulnerable walls.

Alongside the specifics of your home, a thorough assessment should also be capable of accounting for your wider plans. If you're thinking about re-decorating, installing a new kitchen or building an extension, for example, you should consider what energy efficiency measures you can install at the same time. When undertaken alongside other home improvements, the additional cost of a retrofit can be much, much lower than if it's undertaken as a stand-alone project.

If that sounds complicated, don't worry. In recent years the sector has grown significantly and there are now an ever-increasing number of companies out there that can help with expert advice and support – from up-front planning and analysis to project management. With a little bit of careful planning, there's no reason why even the most traditional of properties can't be an 'eco' house. And, in most cases, it should be achievable at a very reasonable cost.

www.parityprojects.com

Points of view

Glazing in traditional and historic buildings has always been a sensitive area for homeowners, building professionals and conservation bodies. The use of double- and triple-glazing to improve energy efficiency has only heightened the debate. Here the options are considered.

First, Chris Wood, head of English Heritage's building conservation and research team, sets out the case for traditional glazing.

Windows have a profound effect on the appearance of historic buildings and give obvious clues about their history and development. They can also help visually link groups of buildings, particularly terraces. In addition, windows can be important artifacts in their own right, made with as much skill and ingenuity as a piece of antique furniture. Old windows are surprisingly resilient and reflect the age, weathering and movement of a building over the centuries. Although when built they would have been neat and square, over the years many have been adapted to accommodate building settlement or deflections. And so much the better they look. Many coats of paint will have enhanced this somewhat organic appearance. All of this is lost when a window is either replaced or adapted to accommodate double-glazing.

Virtually all historic or traditional windows were single-glazed. To a large extent the design of traditional windows reflects developments in glass production and availability, cost, fashion, and the influence of taxes. Whatever the design, all the component parts had purpose. For example glazing bars, although becoming increasingly slender through the 18th and early 19th centuries, were there to support the individual panes of glass and strengthen the sash, as well as enhancing the proportions of the individual house or terrace.

Historic handmade window glasses are much thinner and lighter than modern glass. Therefore, it is usually impossible to install double-glazed units - even the 'slim-profile' type – in existing windows without enlarging the glazing rebates. This nearly always involves not only the loss and replacement of the historic plain glazing but the glazing bars, if not the entire sash. Also, because double-glazed units can be four times the weight of the old glass, there is much more wear and tear on moving parts.

It is not uncommon in multi-pane windows for large, individual double-glazed units to be used with glazing bars that are simply stuck on the outside and inside, serving no function. These look most incongruous when viewed close-to, as does the double reflection in the two panes. Handmade glass is a rarity and, where it survives, should always be retained. Crown glass, so redolent of the Georgian era, is especially precious; not just because of its far more interesting lustre and sparkle, but because comparable glass is no longer made today. Is it likely that replacement double-glazed units will perform satisfactorily for 200 years?

Traditional timber windows have proved to have great longevity. Much of this is due to the quality and durability of the timber used;

IMAGES: ROGER HUNT

**Old glass provides interest and depth to windows.
Right: High quality plastic secondary glazing is held in place with magnetic strips.**

even the humble terraced house had windows made from slow-grown Scots pine imported from the Baltic region. This was of a quality virtually unobtainable today. Even though many buildings were not regularly maintained, most of these windows survived, only to be replaced with double-glazing made from plastic, or much inferior timber which is heavily impregnated with preservatives.

Single-glazed windows can be repaired and improved to reduce draughts and retain heat within the room. In the 18th and 19th centuries great use was made of blinds, awnings, shutters and curtains to do this. Recent tests have shown that these same measures can match the thermal performance of double-glazing. Secondary glazing performs even better still. Some of these systems are lightweight and can be removed in the warmer months when two panes of glass are not needed.

Installing double-glazed windows has resulted in the loss of millions of historic windows and their replacement by ill-matching caricatures which can never replicate the originals. Even where traditional windows are retained, their appearance, historic values and functionality are diminished when their glass is replaced with double-glazed units. A high price for an alteration that is unlikely to pay for itself within its service life.
www.english-heritage.org.uk

Secondary glazing

A number of companies now specialise in secondary glazing for old buildings so various options are available. All comprise an extra layer of glass or high quality plastic that fits to the inside of the existing window and, if well designed, this is unobtrusive with modern systems more discreet than those of the past. Units may be made with slim-profile aluminium frames, powder-coated to match internal paint schemes.

Where windows need to be opened, sliding secondary glazing is the answer. For windows that are never opened, or are permanently closed during the winter months, a single secondary glazing panel held in place by magnetic strips is a good option. These systems are easy to install with the magnetic strips fitted around the edge of the glazing while a second magnetic or metal strip is stuck to the window frame so the panel simply drops into place. The strips fixed to the window frame may be painted the same colour as the woodwork so they are inconspicuous when the panel is not in place.

For thermal insulation, the optimum air gap between panes is 20mm. A little ventilation should be maintained through the outer window to prevent condensation on the inner face.

Panels that are removed during the summer are best wrapped and stored under a bed. Even if the panels are not removed for storage, magnetic systems allow the secondary glazing to be easily lifted out for cleaning. Remember that the bigger the window, the heavier and more unwieldy it becomes, making lifting out more difficult; this is where plastic glazing has a definite advantage.

If you measure the window and assemble the panel yourself, this type of glazing is also much cheaper than glass. When ordering secondary glazing bear in mind that careful measurements or a template are essential as old windows are often out of square.


IMAGE: MALCOLM FRASER ARCHITECTS

Double glazed panes fitted into an existing window in Edinburgh.

Calum Duncan, Senior Architect at Malcolm Fraser Architects in Edinburgh, examines the case for double-glazing.

In considering the place of double-glazing in refurbishment, we should acknowledge that the glazed elements are part of a wider structure, where improvements are also possible, and that there are many ways of improving thermal performance before double-glazing is necessary. In addition, we must give consideration to what remains; retention of original material being the accepted starting point. However, what is extant may vary in quality, authenticity and condition. In the case of catastrophic damage, such as after a fire, nothing remains at all. The detailed nature of a repair or replacement would be considered by our practice in relation to the significance of the historic material and the technical and aesthetic impact of any intervention.

From our experience in Scotland, there appears to be a reasonable view in the approach taken by conservation authorities. There has developed a hierarchy of interventions that allows retention of important elements where they survive, yet deliver the thermal improvement that owners are expecting and sometimes legislation is demanding.

Advances in glazing technology allow many more options in the housing and mounting of glass, especially in their use in multi-pane sash and case windows. This has also allowed the retrofitting of new glass into existing, and sometime historic sashes. In Scotland, where slim-profile double glazed units were first developed, the debate has mainly pondered on the durability of this new type of unit. While durability of the slim-profile double glazed unit has been cited as a reason not to use them, this is a problem of manufacturing and quality control, not one of principle. It is for the industry to resolve these issues and manufacture products that suit the job and the needs of designers.

It should be emphasised that in cases where original glass survives which has a clear historical value, removal would not be appropriate and less invasive measures may be available. However, across the UK the amount of historic glass in situ is minimal. The replacement of a modern float glass with a newer version of the same technology can hardly be a detriment, if it gives the existing timber of the window an on-going alternative future to removal and replacement.

Where a replacement window is required, it is a straightforward matter to manufacture a new timber sash and case window. It is technically possible to construct this, with current slim-profile double glazed units, to even the thinnest of astragals and traditional patterns and proportions. There might also be a small irony in that, while the sector seeks to preserve examples of innovation in construction techniques of the past, it sometimes inadvertently prevents that story from continuing in the appropriate idiom of timber windows.

Where modern double-glazed timber windows do look wrong, it is generally the fault of the design, not the principle of how such units can be used. In seeking the manufacture of new windows, ironically, it is the smaller joinery workshop that is often more flexible and adept at respecting traditional profiles and proportions than larger scale manufacturers. Larger manufacturers of timber windows seem reluctant to move from oversized styles and heavy margins, possibly for concerns over the perceived movement or distortion of thinner timber sections.

There are also considerable benefits in seeking to ensure that the manufacture of timber windows is a volume activity – this will help keep prices within reach of homeowners and maintain bench and site joinery skills. If this is not done, we risk commoditising the supply chain and making the proper custody of a traditional building feasible for only the well-off or those who can access grants.

www.malcolmfraser.co.uk

IMAGE: ROGER HUNT

Ventilation and health

Neil May, Managing Director of Natural Building Technologies, explains why achieving good ventilation is a crucial consideration in any building.

The renovation of older buildings is usually considered to mean the renovation of their fabric. Ventilation is often taken for granted because, in many older buildings, it is an accidental process occurring through gaps in the fabric, frequently around and through windows, under floors, up chimneys and through roofs. Where deliberate ventilation measures are devised for the renovation of older buildings, they are typically limited to extractor fans in bathrooms and kitchens.

However, it cannot be emphasised enough that when an older building is renovated, particularly where modern standards of living and low energy use are part of the renovation plan and a ventilation strategy is not stipulated, there may be considerable risks to the health of occupants and to the health of the fabric.

The risks to fabric are almost entirely due to moisture, while the risks to human health are partly due to moisture and partly to do with toxins and particulates. This article only covers the issues of moisture as these are the most common and, if they are addressed correctly through ventilation, nearly all of the issues associated with toxins will also be resolved.

Modern standards of living and low energy use are highly desirable for older buildings. Without them, older buildings will become uninhabitable or uncared for. This is not to say that all such buildings must be renovated to new build standards of energy use. Indeed, the existing building fabric and the planned future use must be the main determinants of how a building is modernised. Even so, some buildings are far easier to renovate to modern standards than others, so there cannot be one rule or approach for all buildings.

High moisture levels in buildings lead to increases in moulds, bacteria, and insect and dust mite activity, which affect fabric health and human health

Moisture

Modern standards of living introduce vast quantities of moisture into older buildings through bathing, cooking and high occupancy levels. At the same time, to make an older building both comfortable and energy-efficient, draughts must be reduced. It is this combination of high moisture production and airtightness which can create major problems.

High moisture levels in buildings lead to increases in moulds, bacteria, and insect and dust mite activity, which affect fabric health and human health equally. In fabric terms the result will be condensation, damage to finishes, structural damage, insect infestation such as woodworm, and even freeze-thaw damage to masonry. In human terms diseases such as asthma, bronchitis, pneumonia, and more serious auto-immune problems have been shown to result from mouldy housing and dust mite infestations.

Increases in the incidence of these microbiological pollutants are directly related to the relative humidity in a building. The growth of these pathogens is also linked to temperature: different kinds thrive at different temperatures. But, in general, warm and moist buildings are excellent breeding grounds for many types of pathogens and insects. However, buildings without heating are likely to have much more condensation overall, as heating enables the air to carry more water, and this presents its own problems.

There is a key relationship between insulation, airtightness, heating and moisture when it comes to the risks moisture poses to fabric and human health. If we accept that older buildings have

IMAGE: DOUGLAS KENT

Previous page: The presence of moisture quickly leads to decay and mould growth. Left: Condensation is particularly noticeable on cold surfaces in rooms where the relative humidity is high and ventilation is poor.

to be warm, more airtight, and able to cope with modern bathing, cooking and living conditions, then the two key ways to prevent moisture related problems are the insulation of the building and the ventilation strategy.

As regards insulation in old buildings, the main factors are that it is installed at even levels wherever possible so as to minimise the chance of condensation-inducing cold spots, and that it should be 'breathable' or moisture-open, so that moisture is not trapped in the fabric.

Breathable insulation materials are able to absorb and desorb moisture rapidly as relative humidity increases and decreases. However, they are not a substitute for a good ventilation system and, without such a system, the challenges of making insulation work effectively increase considerably.

Achieving a coherent insulation strategy that actively deals with moisture is relatively difficult in many older buildings, particularly around openings and junctions and in complex structures. If it is too difficult to achieve, it is sometimes better (as far as moisture risks are concerned) to have no insulation and just ensure that the heating and ventilation systems are good.

Ventilation

Installing a ventilation system is not without its challenges but, if we want to live to modern standards while preserving traditional buildings, we have to come to grips with it.

There have in fact been several reports over the past few years showing how poorly ventilation systems have performed in new buildings. In the work for Part F of the Building Regulations in 2010, the brief survey of both natural and mechanical ventilation systems found that over seventy per cent of all system types fail to achieve the required air changes in practice. Other recent research into mechanical ventilation with heat recovery (MVHR) systems has found an even worse failure rate. In most analyses there is not one single cause of failure, but rather a combination of poor design, procurement, installation and use.

In the renovation of older buildings there is a further difficulty in that the existing building structure and layout cannot be changed and there is unlikely to be a mechanical and electrical consultant or expert there to advise. Too often the problems start with an inadequate (or non-existent) assessment, which needs to take into account not only the fabric risks and complications but also the practicality of installation and the planned use of the existing building.

Designing without understanding the practicalities will lead to failures. It is far better to specify a system that works to seventy per cent of the theoretical requirement, than to specify a high performance system which cannot be installed correctly or is difficult to operate.

Ventilation systems should all be whole-house systems. Unfortunately many are not. Particularly in the retrofit of older buildings, it is common to install 100mm (4 inch) fans in bathrooms and not much else. The options for ventilation in older properties are: mechanical, with or without heat recovery; passive stack; natural (i.e. trickle vents in windows) with fans.

In addition, the first two options – mechanical and passive stack – can also be demand-controlled. This demand control means that the ventilation systems respond to moisture or some other trigger – such as volatile organic compounds (VOCs) or movement – to operate when needed, rather than being in operation continuously. This can save energy and unnecessary draughts.

Furthermore, all of these systems apart from the third option require ductwork to ensure effective whole-house ventilation. Ductwork requires good design and application, and can be intrusive. Here, as elsewhere, good assessment and design will enable an effective and compatible solution. We must not compromise on this.

Each system has its value although, in older buildings, unless a very high standard of airtightness can be achieved, the MVHR option is probably unwise, as it will be expensive and inefficient. The decision about which other option to use will depend on the existing building structure and condition, its context and the planned use.

What is most important is that any specification must be deliverable in reality and that a joined up process of design, installation, commissioning and use must be put into place.
www.natural-building.co.uk

Insulation issues

Solid wall insulation is one of the most challenging aspects of retrofitting old buildings. Paul Mallion, a chartered building surveyor, certified Passivhaus designer and a director of Conker Conservation, examines the concerns and the options.

Insulating and draughtproofing buildings can reduce energy demand and increase comfort, but these measures need to be undertaken as part of a considered holistic approach. Consideration should be given to user behaviour and expectations, ventilation and heating strategies. In addition, care needs to be taken not to compromise the building's aesthetics or special interest; loss of historic fabric and the accelerated deterioration of components must also be guarded against.

The walls of old buildings are one of the most widely variable elements of construction. Generally they rely on the breathability of the materials to prevent problems with moisture, consequently they are challenging to upgrade. Common forms of traditional construction are solid brick; solid stone; stone with rubble infill; earth; and timber frame with tile hanging, weatherboard or plaster. In some old buildings various types of cavity wall exist.

The first step when assessing if a solid wall can be upgraded is to fully understand and evaluate the building in its current condition and use. This involves assessing the method of construction and the structural and physical condition internally and externally. Any special features or details that contribute to the special character of the building must be noted and retained, such as external brick or render details, internal cornices or plaster details.

A condensation assessment should always be carried out when introducing thermal insulation to an historic building. These assessments are often provided by insulation manufacturers free of charge but, in my experience, they can be over optimistic in order to show products in the best possible light. It is best to ask an independent consultant to carry out the assessment. This should model a range of materials and installation options, such

Internal insulation has many risks, therefore needs the greatest care and attention to detail

IMAGE: ROGER HUNT

as different occupancy patterns, different weather conditions, different vapour control layers. This will highlight the variables that could give rise to condensation, allowing the designer to create a robust solution.

Internal solid wall insulation

Internal insulation has many risks, therefore needs the greatest care and attention to detail. This is due to the fact that less heat escapes through the walls, therefore the walls will be cooler. If any moist air passes through the fabric it will cool down and may condense into a liquid within the wall (interstitial condensation).

Studwork lining

A timber studwork frame can be constructed against the external walls, with the gaps between the studs filled with insulation. It is advisable to leave a ventilation gap between the back of the studs and the wall, as condensation can occur on the internal face of the wall. A breather membrane should be used at the back of the studwork to hold the insulation in place, therefore thought needs to be given as to how to locate it, either prefabricating the stud panels or pinning the membrane between head and sole plates.

I always recommend a flexible insulation that can be squeezed into the studwork without any gaps. Sheep's wool, hemp batts, and wood fibre bats are very effective. Higher performance rigid boards can be used, but these tend to be difficult to install with a tight fit and any gaps result in a dramatic drop in performance.

Some plasterboard manufacturers use light-guage metal framework fixed to the wall in lieu of timber. Mild steel is an excellent

Making an assessment

There are a number of key points that should always be considered:

Does the wall need to 'breathe'?
In masonry external walls there is an equilibrium between moisture ingress and evaporation. When in good condition with suitable finishes, plasters and pointing, the wall will dry out quickly after rainfall, or absorb then safely re-release moisture during periods of high humidity. Adding impervious layers to the wall – such as non-breathable insulation materials – will alter its equilibrium and risk exacerbating or creating a damp problem.
Most of the high-performance insulation materials available today are non-breathable, made from petrochemicals or metal foils. They can be highly effective when used correctly in the right situation. Breathable materials may have slightly lower thermal performance but have less chance of upsetting the moisture balance in an old wall.

Is the wall subject to wind driven rain?
Driving rain can cause problems when walls are internally insulated, especially systems incorporating a vapour control layer as moisture may become trapped.

Are there existing damp problems?
Before insulation is added any moisture-related problems within the wall must be rectified at source. If not they will be exacerbated by the installation of insulation of any type.

Is the building listed, does is have an article 4 designation or is it within a conservation area?
If yes, there are likely to be restrictions on any alteration to the external appearance or the internal fabric affecting the character or special interest of the building. Advice should always be sought from the local planning department/local conservation officer.

Is the building part of a terrace that needs to be considered as a whole?
Altering the appearance of one property may ruin the overall appearance of the terrace.

What is the proportion of wall in the property relative to the whole building?
Some properties have large roofs with low eaves, leaving a relatively small wall area, in which case more attention should be paid to roof insulation. Mid-terrace houses have a relatively small external wall area in proportion to the total heat loss surface.

What is the size of windows relative to the walls?
A wall with large windows, such as the front elevation of a Georgian house, has a small amount of wall surface. The windows can account for up to five times more heat loss than the walls (typical solid wall U-value being in the region of 1.5W/m²K, single-glazed windows being 5.6 W/m²K)

How much floor space will be lost if internal insulation is used?
If a back addition with three external walls is to be insulated, the effect on floor area could be considerable. Internal insulation may also impact on stairs, landings and door openings, be aware of minimum widths for access and safety.

How will window and door openings be detailed?
Careful detailing is paramount whether internal or external insulation is used – this must not be left to the installer to work out. Air tightness, weather protection, condensation, minimising thermal bridges, minimising impact on daylight and aesthetic implications all need consideration.

Will gutters and eaves need to be adjusted?
With the installation of external insulation it is likely that eaves will need to be extended and gutters, downpipes and drains may need repositioning.

Damp-proof course
Any existing damp-proof layers need to be protected and not bridged. If a DPC does not exist, use insulation materials that are not hygroscopic close to ground level.

Can continuity be assured?
Insulation must be continuous, and not truncated at floors or roof. Creating continuous details needs careful assessment, and even more careful execution on site.

Previous page: timber-framed house insulated internally.
This page: Wood fibre (left) and sheep's wool insulation are natural and breathable.

IMAGES: LEFT AND CENTRE, MARIANNE SUHR; TOP, ROGER HUNT; BOTTOM RIGHT, PAUL MALLION

thermal conductor, therefore not a logical choice in my opinion.

Thermal plasterboard

A wide range of plasterboard laminates are available with mineral wool, polystyrene, PU, and phenolic foam insulation bonded, usually with a vapour barrier of aluminium foil or polyethylene. Although not regarded as good practice in old buildings, manufacturers claim that these can be applied direct to a solid wall or fixed over timber battens. Careful condensation assessment is important, as the built-in vapour barrier is interrupted at each board joint and every fixing. Ideally the wall's surface should be flat and smooth; do not apply to bare masonry.

Wood fibre and lime plaster

Wood fibre comes in different grades and densities, for different uses. Certain grades can be fixed direct to internal walls and plastered with lime. As above, they should be applied to smooth surfaces or a parge coat of plaster should be applied to smooth out rough masonry. As these materials are very breathable, a vapour control layer is not usually required unless a non-breathable coating has been applied to the exterior.

Other solutions include insulating plasters made from lime and hemp, or lime and granulated cork, and calcium silicate boards. These have modest insulating properties, but are very breathable and have humidity-regulating properties which can benefit old buildings.

External solid wall insulation

Insulation and render

Insulation boards can be applied direct to the building face if flat, smooth and in good condition. A rough surface may need to be smoothed out with a parge coat of lime render. Cork or wood fibre are ideal for this purpose, both can be used with modified lime render.

Foamed plastic insulations are also available. These perform well and are affordable but are not breathable and result in landfill waste which will not biodegrade. However, they can be useful if the wall in question is not breathable due to existing surface coatings or is below damp-proof course level.

Lime hemp render and lime renders with granulated cork can be used, finished with lime plaster, though the insulating properties are only modest, they suit certain situations.

Timber stud frames

Just as for internal insulation, a timber framework can be constructed to support insulation externally and filled with a flexible insulation batt. The external finish may be timber boarding, tile-hanging, or a layer of wood fibre which can be directly rendered.

Timber-frame buildings

There are particular risks when insulating timber frames, as interstitial condensation can be devastating over a long period of time. Condensation analysis is essential but, if done correctly, the thermal properties can be greatly improved with little visual intrusion.

Insulation can be installed in the voids between studs, but only if there is sufficient depth and if the external finish is breathable or has a ventilated layer. When weatherboarding or tile hanging needs to be replaced, this is an ideal opportunity to add a counter batten and breather membrane, allowing the full depth of the timber frame to be insulated behind.

Where original medieval wattle and daub infill panels to timber-framed buildings have already been lost, they can be replaced with a hemp lime mix or wood fibre insulation boards finished with lime plaster. Original wattle and daub has been shown to be a surprisingly good insulator.

Conclusion

Insulated walls allow greater comfort for the occupants in both summer and winter and reduce energy consumption, but there are many risks to consider before altering an old building. The ongoing research by the SPAB and its partners is improving our understanding of these risks and providing proven solutions. Every building is different and needs to be carefully assessed to ensure its longevity.

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Wood burning stoves can be a good heating solution.

Holistic heating

Steven Coulsting, a consultant at Encraft, considers the options for heating old buildings.

A heating solution for an old building should be holistic. The strategy must encompass fabric energy efficiency, various available heating options, renewable energy and the way we use the building. The importance of enhancing the efficiency of the fabric should not be overlooked or regarded as an afterthought. Improvements, that include minimising fabric heat losses and increasing air tightness, lead to a reduction in heating system size, radiator sizes, heating costs and carbon emissions. Underfloor heating systems may also become viable.

The most traditional form of heating is the open fire burning either wood or coal. An open fire will typically be 15 per cent efficient with the remainder going up the chimney. A chimney draws air from the room, especially when the fire is lit, which is replaced by cold air being drawn into the building from outside. However healthy this may be, as a source of heat it is the least efficient or sustainable; and, in the case of coal, the highest in carbon emissions.

A high-efficiency wood burner might, where appropriate, be installed in a traditional fireplace. Where this can be achieved without harm to historic fabric 80 per cent efficiency is possible. The chimney flue should be effectively sealed by a register plate through which the burner flue pipe passes. Combustion air should be supplied by a dedicated pipe from outside to avoid cold draughts. Such stoves may heat a single room; others, with a back boiler, may supply hot water and/or a central heating system. Chimney lining is a vital consideration due to the risk of fire.

The importance of installing and using heating controls is often overlooked

Heating fuels may be classified in different ways: solid, liquid and gaseous; fossil fuels and renewables; and low and high carbon. For those properties on the gas grid with an old gas boiler, the simplest option is replacement with a new, efficient condensing boiler. Recent advances in technology have resulted in boilers that are much more efficient, typically 90 per cent. Replacing an old G rated boiler (efficiency 70 per cent or less) will reduce annual fuel bills by £300 and CO_2 emissions by 1,200kg for a typical house. A 'combi' boiler will save space through the elimination of a hot water cylinder and will be more efficient for houses with normal to low hot water demand. A hot water cylinder is normally required where demand is high or where there are solar thermal panels.

Alternatives to gas for those properties off the grid include oil, LPG, coal and biomass. The efficiency of a modern condensing oil or LPG boiler is typically around 90 per cent, whereas the efficiency of a coal boiler will be in the range 50 to 75 per cent. This combined with the fact that coal has the highest carbon emissions, second only to electricity, makes coal an undesirable option.

Biomass covers a range of fuels: logs, wood chips and pellets being the most popular. The efficiency of biomass boilers is from 65 per cent for logs through to 90 per cent for a pellet boiler. Logs can be the cheapest form of biomass fuel. However, they take the greatest storage space, produce the most ash and are the most labour intensive. Pellets, on the other hand, are the cleanest and most easy to handle with the least maintenance. Wood chips lie between logs and pellets in terms of cost and ease of handling. Wood chip boilers have automated feed mechanisms, although

Solar panels do not need to be on buildings.
Below: Wood pellets are a popular form of biomass.

these are somewhat more prone to mechanical problems than the pellet versions.

For historic buildings located in the countryside, such as mansions and farms with outbuildings, biomass is often an attractive solution, especially where wood is available on the estate or locally. The Renewable Heat Incentive (RHI) for biomass is currently available for commercial properties and will become available for domestic properties in the first half of 2014.

When comparing gas, LPG, oil, biomass, electricity and coal, the cheapest to run are generally gas and biomass (with RHI). Also they are the lowest carbon emitters. In fact, biomass is classed as almost zero carbon. However, the assessment of carbon emissions from biomass is rather a complex matter with a lot depending upon its source and its proximity. The fuels that generally come out worst are electricity and coal; the most expensive being electricity and LPG. Oil is somewhere in the middle but somewhat worse than gas in terms of price and carbon emissions.

Some old buildings are fitted with a range; either an original cast iron fitting or a modern version running on coal, oil, gas or electricity. Typically these appliances are left on for a large part of the day, have a high thermal mass and are not very well controlled as a source of heat, particularly those burning solid fuel. Although they provide an enjoyable source of radiant heat and may be used for cooking, they tend to be a poor choice in terms of energy efficient heating.

The importance of installing and using heating controls is often overlooked and can make a very significant difference to annual energy consumption. From several house of similar form and occupancy that I have recently surveyed, the annual energy consumption per unit area of the highest was five times that of the lowest. This was due to personal comfort preference and the fact that the former exercised minimal control over heating. In a domestic situation, the use of a simple programmer with thermostatic valves to the radiators will make all the difference.

Heat pumps, including ground and air source types, are popularly hailed as an ecological form of heating. The reality is not that simple; where gas is available heat pumps generally offer little advantage in terms of price and carbon savings. Heat pumps do use electricity, even if more efficiently than regular electrical heaters. They compare better against oil and LPG in off gas-grid locations and, with the advent of domestic RHI in 2014, they are due to become more popular. Heat pumps work well with underfloor heating systems due to their low output temperatures. However, the installation of underfloor heating may be too disruptive for many old buildings and the output may not be adequate to heat buildings with high fabric heat loss. The alternative of using radiators results in very large radiator sizes which may be unacceptable.

Solar thermal panels should not be forgotten. Although generally lacking the ability to supply space heating, they complement other forms of hot water heating well. Their aesthetic suitability for installation on an old building may pose problems but, in some cases, it is possible to install the panels on outbuildings or as ground arrays.

Whatever your heating preference, it is important to consider each situation and the merits of each technology in context rather than applying a one size fits all solution. With improvements in efficiency, the development of new technologies and the availability of RHI, there are opportunities today that did not exist just a few years ago. Properly considered choices can make a big difference to your comfort, your building, the economic sustainability of the chosen solution and the building's carbon footprint.

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Foster's Mill at Swaffham Prior, Cambridgeshire.

IMAGE: JONATHAN COOK

Mill power

Traditional milling and millwrighting specialist Martin Watts looks at the relationship between buildings and natural energy.

The generation of renewable energy from water and wind is not a new phenomenon. The power of water was harnessed through the use of waterwheels over two millennia ago and wind-powered machines are recorded in central Asia by the 10th century AD.

England probably had some 10,000 mills by 1300 and, although estimates vary, there were perhaps 60,000 windmills and water-powered sites in Britain in the early 19th century. While the main use of both water and wind was to drive millstones for grinding corn, water power - being more adaptable than that of wind - was harnessed to serve a range of industries, in particular textile production and metalworking.

Only a tiny proportion of the wind and watermills that were at work in the early 19th century survive today. Most are now protected as historic buildings and many of those that retain machinery have been repaired and returned to working order. A number of watermill sites have also been adapted to generate electricity, so the potential for mill power remains.

The judicious and honest repair of historic buildings such as mills, which in many places are on sites that date back to the Middle Ages, is certainly one of the best ways to ensure their survival. To carry this essential process forward in economically stringent times, it is now necessary to deliver some sort of return. While mills are still being adapted and converted to domestic use, and in many cases being lost as working, productive machines, the potential of others is being realised.

Mills of all types have long formed one of the focal points of a community and they can still provide an important centre for local interest. A small number of both wind and water mills remain in use, producing wholemeal flour and other products on a small-scale commercial level. Some are run as businesses, others by trusts and groups of volunteers who are responsible both for the preservation of the building and its historic machinery, and for demonstrating its capabilities.

The small-scale production levels associated with historic mills and the craft traditions in which both the buildings and their products are rooted, make the output potential of traditional mills most suited to specialised production, such as organic flour.

Some mills supply artisan bakers, with bakeries located either on site or close by, as at Redbournbury Mill, just north of St Albans, Hertfordshire, or the Town Mill in Lyme Regis, Dorset. Foster's Mill at Swaffham Prior, Cambridgeshire, grinds wheat sourced from local farms wherever possible, offers products ranging from organic wholemeal flour to muesli and has an online shop. It also supports local bakers, promotes tasty, top quality bread and champions the Real Bread Campaign.

While the rivers feeding watermill sites potentially offer the opportunity for electricity generation, this must always be balanced with the need to conserve the integrity of the mill's structure, any historic machinery and the surrounding environment.

In North Yorkshire, the Renewable Heritage Trust was formed to rescue Howsham Mill near Malton, from ruin. The building had suffered neglect and vandalism resulting in the loss of most of the milling machinery and much of the waterwheel itself after it fell out of use in the 1940s. Now the mid 18th century water-powered corn mill has been given a new lease of life as an environmental education centre, generating hydro-electricity. Its waterwheel has been renovated and an Archimedean screw turbine has been installed alongside, together generating electricity with a maximum output of about 30 kW. Revenue from selling surplus electricity to the grid will fund future renovation work and the costs of running the project.