CE138

Energy efficient historic homes – case studies

energy saving trust™

Contents and contacts

Historic homes		3
	Introduction	3
	Listed buildings	3
	Conservation areas	3
	The conservation officer and designers	3
	Existing fabric	3
	Ventilation and draughtproofing	4
	Insulation	4
	Heating and services	4
	Water	5
	Asbestos	5
	Process checklist for work on historic homes	5
Case study 1	Mill Farm, Assington, Suffolk	6
Case study 2	Dolbelydr, Denbigh, North Wales	7
Case study 3	Berg Cottage, Hertfordshire	8
Case study 4	Dymock's Building, Bo'ness, Central Scotland	10
Case study 5	Neely House, Cambridge	12
Case study 6	Wood Farm, Gipping, Suffolk	14

English Heritage – www.english-heritage.org.uk
The Environment Agency – www.environment-agency.gov.uk
The Georgian Group – www.georgiangroup.org.uk
Heath and Safety Executive – www.hse.gov.uk
The Landmark Trust – www.landmarktrust.org.uk
National Trust – www.nationaltrust.org.uk
National Trust for Scotland – www.nts.org.uk
RIBA Register of Architects Accredited in Building Conservation – www.aabc-register.co.uk
Royal Incorporation of Architects in Scotland – www.rias.org.uk
Royal Institute of British Architects – www.riba.org
Royal Institute of Chartered Surveyors – www.rics.org.uk
SAVE Britain's Heritage – www.savebritainsheritage.org
Society for the Protection of Ancient Buildings – www.spab.org.uk
The Twentieth Century Society – www.c20society.org.uk
Victorian Society – www.victorian-society.org.uk

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The National Trust for Scotland

THE NATIONAL TRUST

S·P·A·B

Jonathan Howard and Rory Cullen at The National Trust, Douglas Kent and the technical panel at the Society for the Protection of Ancient Buildings and Emma Adams and Jennie Humphrey, Conservation Officers, Conservation & Design, Planning & Regeneration, Dacorum Borough Council. BRE would also like to thank Sian Loftus at The National Trust for Scotland and Jan Hastie and Katherine Oakes at The Landmark Trust, for helping to find suitable buildings. Thanks to all the owners of the case study buildings for allowing their buildings to be used.

Historic homes

Introduction

Home energy use is responsible for 27 per cent of UK carbon dioxide emissions which contribute to climate change. By following The Energy Saving Trust's best practice standards, new build and refurbished housing will be more energy efficient – reducing these emissions and saving energy, money and the environment.

This guide is primarily aimed at the owners of the hundreds of thousands of historic homes in the UK which are either listed or lie within a conservation area. In England and Wales Part L of the Building Regulations requires that 'sensible and reasonable' energy efficiency measures be incorporated during refurbishment work and it is vital that homeowners understand just what this entails. The case studies in this document describe recent refurbishment projects on a range of historic homes dating from the 16th to the 19th centuries, all of which included energy efficiency improvements. They illustrate just what can be achieved while taking into account a building's historic significance, performance characteristics, design and the materials it is made of (i.e. its 'fabric').

There is generally no reason why historic homes should not be reasonably efficient, comfortable and healthy. Due to their special circumstances they may, however, be treated as special cases in terms of the energy efficiency measures expected by the building control officer. It is important to consider how to reduce carbon dioxide contributions to climate change in any construction work. For a modest investment, energy efficiency features may quickly save money (especially as fuel prices are expected to rise significantly in the future), while in some cases extending the useful life of the building.

With historic properties, the Building Regulations in England and Wales permit the building control officer to adopt a 'reasonable' approach, balancing conservation of fuel and power against the need to conserve the fabric (it is important that any changes avoid condensation problems, though). The final decision will depend on the individual circumstances. It may be regarded as reasonable to upgrade the fabric when undertaking extensive work anyway. On the other hand, upgrading floors and windows, for example, may be judged quite unreasonable if done purely to comply with the letter of the latest regulations, or some other well meaning but ill-considered reason.

Listed buildings

In England and Wales, listed buildings are classified as:

Grade I	–	buildings of exceptional national significance
Grade II*	–	particularly important buildings of more than special significance (* = star rating)
Grade II	–	of special interest, warranting every effort to preserve them.

Scotland and Northern Ireland use similar classifications, labelled A, B and C.

The local planning department (which may have a conservation officer) will determine the specific requirements for any work proposed to historic homes. The type of work requiring Listed Building Consent varies with the building classification.

Conservation areas

Buildings in a conservation area are part of the character and history which is being preserved. As planning controls will apply, seek advice from the local planning authority early in the process.

The conservation officer and designers

Working with the local conservation officer and a specialist design consultant will ensure the correct path of action is followed. The Royal Institute of British Architects (RIBA), the Royal Incorporation of Architects in Scotland (RIAS) and the Royal Institute of Chartered Surveyors (RICS) can advise on specialist building conservation designers in an area.

The Society for the Protection of Ancient Buildings (SPAB) will provide names to the public over its technical advice line, details of which are on their web site (see 'Contacts' on page 2).

Existing fabric

It is vital that the unique characters of historic homes are not put at risk by unsympathetic alterations, unnecessary intervention, or changing environmental conditions: each owner is, after all, only a temporary guardian of this heritage. When considering refurbishment, it is the owner's responsibility to ensure that any work does not cause unlawful or unnecessary damage to the building (fabric and indoor building environment).

Older properties, and especially historic buildings, need to 'breathe' through the entire envelope (i.e. the external walls, floor and roof), allowing moisture to escape and so preventing damp. A thorough understanding of each building's unique environmental characteristics will avoid detrimental effects to the building's breathability caused by misguided material changes.

As a first step, specialist guidance should be sought from the local building conservation officer and, ideally, at least one of the organisations listed on page 2 of this guide. While detailed general rules are not appropriate for individual historic properties, preparation work should include the following:

1. A good understanding of the building's historic significance (refer to the Listed Building Description or Conservation Area Designation if applicable): this will help to create a sympathetic approach to the existing building materials and structure.
2. An assessment of the building's heating and ventilation needs.
3. A presumption of minimal intervention.
4. If possible, any new work should be designed to be reversible by future generations.

Modern homes use physical barriers to stop moisture from penetrating the building envelope, whereas older homes tend to be made of porous materials and are permeable. Be aware that there is an important difference between porosity and permeability:

- Porosity is the ratio of the volume of pore space to the total volume of a solid material. Pores may or may not be interlinked.
- Permeability is the rate at which a liquid or vapour passes through a solid material. Pores must be interlinked.

Modern materials such as concrete or plastic are often inappropriate for use in older homes, harming aesthetics and durability.

Ventilation and draughtproofing

While draughtproofing can be worthwhile in some older dwellings, it can lead to increased moisture levels and cause serious problems with dampness in others. Mould growth and rot damage can occur in a building that has had a stable ventilation rate for hundreds of years. Typically, moisture from the walls and ground floors of an historic building evaporates into the structure itself. In these cases, heating and adequate ventilation allow the moisture to escape: this is how historic homes have survived with dry and healthy rooms.

Some of the case studies included in this guide show different ways of resolving this issue. Specialist advice is available (see also SPAB information sheet No. 4, see page 2 for contact information). An air-pressure test can be used to assess the property's airtightness before and after any changes to draughtproofing, if appropriate.

Insulation

In historic homes it is not usually possible to achieve the ideal of a uniform level of insulation around the building. This means that there are likely to be gaps known as 'thermal bridges'. There are advantages and disadvantages associated with particular insulation materials. Some (and particularly organic insulation materials) allow moisture to escape, but greater thicknesses may be required to achieve the same thermal performance as modern, man made, high performance insulation materials.

The Energy Saving Trust promotes levels well above those of the current building regulations. The target U-values for refurbishment (W/m²K), where appropriate, are:

Roof	0.16
Walls	0.30
Windows	British Fenestration Rating Council (BFRC) rating in band C
Floors	0.20-0.25

U-values are a measure of thermal performance – the lower the better. Although these appear complicated, they are well understood and routinely used by designers. Full details of the Energy Saving Trust refurbishment standards are given in CE83/GPG155 (see back page).

Heating and services

Building services can cause particular problems in historic homes as pipes and wiring are laid into all the main rooms and penetrate the historic fabric. Beware of causing further damage and consider re-using existing services that can be upgraded or repaired. Old services that are no longer required, such as an old light switch or a radiator, can often be retained as a feature and an architectural record. Once gone, these are difficult and expensive to replace.

By law, from 1 April 2005 onwards, most new gas boilers fitted in England and Wales must be high efficiency condensing boilers (with a few exceptions depending on suitability).

The efficiency ratings of new boilers can be checked by visiting www.boilers.org.uk. Additionally, the Energy Saving Trust endorses a range of energy-efficient oil, LPG (Liquid Petroleum Gas) and high-efficiency condensing boilers through the energy saving recommended scheme – visit www.est.org.uk/recommended for more information and access to a full range of endorsed products.

Thermostat controlled heating can prevent wasted energy and ensure that the building maintains a reasonable environment (manually controlled systems can allow internal temperatures to rise quickly and unnecessarily).

Underfloor heating is often best with lime concrete, expanded clay aggregate. It is normally advisable to avoid the use of a damp proof membrane in ground floors, as this will force moisture to the walls, rotting timbers forming the wall frame. The energy used by lighting and household appliances is significant, so energy efficient lighting and energy saving recommended appliances should be used wherever possible.

Water

Minimising consumption and eliminating waste of water resources is an important environmental issue, so water-saving appliances should be selected wherever possible. The Environment Agency has a number of fact sheets on this subject, visit www.environment-agency.gov.uk for more information.

Asbestos

Older homes may contain asbestos in various forms, such as boarding materials, ceiling finishes and pipe insulation. Asbestos was widely used from the 1930s to the mid-1980s. If work disturbs materials containing asbestos, then there is a serious health risk. Surveyors will be able to identify some types of products that contain asbestos, but it is really a task for specialists. If in any doubt, contact the Health and Safety Executive (HSE) and refer to the free asbestos leaflets on the HSE web site. According to the HSE, at least 3,500 people die each year in Great Britain from asbestos-related lung cancer.

Summary

Hopefully, some of the energy saving measures in these case studies will offer guidance for energy efficient options in historic homes. Preparation is the key and will help to avoid problems, as well as saving time and money. It is important to understand the building's performance and qualities and to assess the weaknesses and faults. Think about the use and practicalities of the historic home and how to enjoy living in it.

Process checklist for work on historic homes

1. Before carrying out any work on a building, contact the local authority's conservation and planning departments to see if the property is listed, is subject to an Article 4.2 or 4.1 direction, or is in a conservation area.
2. Check if any of the proposed works require consent – such as listed building consent, planning permission or conservation area consent. Check how building regulations and any other legislation will apply. Ask for realistic estimates of timescales to obtain all the various permissions required, and discuss the likely frequency of work inspection site visits.
3. Any proposed works to listed buildings usually require specialist help and should be carried out by someone with experience and understanding.
4. All listed buildings are listed internally and externally and the listing could also cover other structures within the property boundary.
5. It is sensible to seek advice from the local planning department before making the formal application. Provide photographs of the site, a letter outlining the proposals in a series of bullet points, and sketches with accurate measurements.
6. Repairs to listed buildings must be 'like for like'. The use of traditional and appropriate materials is essential.
7. Alterations to a listed building must be justified and alterations should have the least possible impact on its special historic value.

Bats

If there is any chance of bats using the roofspace, be aware that the Wildlife and Countryside Act 1981 (WCA) protects bats and their roosts in England, Scotland and Wales. As bats generally return to the same roosts every year, the roosts are protected whether bats are present or not. Thus it is illegal to kill, injure or take a wild bat, or intentionally or recklessly damage, destroy or obstruct access to a bat roost. Having bats in the roof does not necessarily mean building work, repairs or timber treatment are prohibited but free advice should be obtained from the local **Statutory Nature Conservation Organisation** before proceeding. The Bat Conservation Trust have plenty of helpful information on their website: **www.bats.org.uk**

Case study 1 Mill Farm, Assington, Suffolk
Grade II listed farmhouse

Front elevation to Mill Farm

Rear elevation before thatching and rendering

The building

The old farmhouse is largely timber frame with a rendered exterior. The remains of a thatched roof had been covered with corrugated iron, and a large, unsightly, flat roof extension stretched across the south west elevation. Inside, the first floor had been partitioned to create a number of small bedrooms, most of which faced north east, with the landing corridor along the south-west side.

Works

The flat-roofed extension was demolished and the first floor layout rearranged to give all the bedrooms a south-west aspect, the corridor being repositioned along the north-eastern side. An extension has been added to each gable end. A conservatory with a glass-roofed veranda runs the length of the south-west elevation to take advantage of solar gain.

Traditional Yorkshire sash windows have been used to match some of the existing joinery. These needed to be single-glazed to avoid fat glazing bars, so timber secondary glazing has been inserted within the window rebates to improve thermal and acoustic insulation.

Materials

Modern construction is designed to keep moisture out completely. Old buildings deal with moisture in a different way: historic construction methods allow a certain amount of moisture in, but the permeability and porosity of the materials (see above) allow moisture to evaporate without damage. As far as possible, breathable materials have been chosen for compatibility with the existing fabric, while at the same time improving thermal performance.

Roof

The thatch is being renewed to a thickness of 450mm, achieving a U-value of around 0.09W/m^{2}K.

Walls

The timber frame walls in both old and new construction now have sheep's wool insulation, achieving a U-value of 0.31W/m^{2}K.

Floor

The damp concrete floor has been removed and replaced with an insulated 'breathable' floor of lime concrete incorporating expanded clay granules. This is laid on a 100mm layer of the same clay granules to provide additional insulation. A damp-proof membrane was not inserted, as this would drive moisture up the brickwork of the chimney stack, which was too massive to successfully damp proof.

Farmyard workshop

The replacement workshop in the farmyard features straw bale construction. A double timber-frame was erected, with straw infill panels (dense bales of barley straw, grown on the farm) on a cavity block plinth with expanded clay granules in the cavity. The straw is rendered with a 4:1 mix of clay (dug from the site) and chalk, the second layer of render being augmented with chopped straw and cow manure. The cracks are then filled with a slurry of clay, and the render limewashed.

A toilet was needed, but the workshop was too low to connect to the existing septic tank, so the owners have installed a composting toilet.

Team details:

Owners: Bob and Anne Cowlin
Builder: John Bradshaw, Assington
Architect: Hilary Brightman, Maldon, Essex

Case study information kindly provided by:
Hilary Brightman, Conservation Architect
Photos courtesy of Hilary Brightman

Case study 2 Dolbelydr, Denbigh, North Wales
16th century gentry house

The building

Dolbelydr is a good example of a high status gentry house and dates from 1579-80. It is important historically as the place where the first Welsh grammar was written and architecturally because it was not extended and so retains most of its original features. The special qualities of this building justified the expense of completely reconstructing the ruinous remains.

The external walls are made of carboniferous limestone rubble set in lime mortar and they average 700mm in thickness. The roof is covered with natural sandstone tiles on a heavy oak structure. Windows are few, small and heavily divided with single-glazed leaded lights. The internal partitions are oak studs filled with lath and daub panels. Upper floor ceilings are lath and plaster under the rafters leaving large open spaces beneath. The original floor was slate flags laid directly upon the earth.

Works

The Landmark Trust carried out the conservation work and the building is now let as holiday accommodation. Priority was given to the correct presentation of the historic fabric as part of a general strategy of returning the house to its original condition. It was considered essential that all the elements should behave in the traditional manner with free movement of ground moisture through the floor and walls. Natural materials were preferred. An oil-fired boiler located in an adjoining outbuilding provides hot water for space heating. The ground floor is heated through underfloor pipes, making use of the thermal capacity of the thick slate floor and eliminating unsightly radiators. The first and attic floors have flat panel radiators. Occupants can turn the heating on or off but the preset thermostatic controls are locked in the boiler house. This is done to prevent overheating of the delicate ancient fabric (the Trust has found that occupants usually turn any available controls to maximum).

Materials

Roof insulation is provided by 50mm of natural sheep's wool; construction constraints prevented any greater thickness. The floor consists of 50mm thick slate slabs on lime mortar (containing the heating pipes) above a 100mm thick lime concrete slab on 150mm of foamed clay pellets laid on bare earth.

Case study information kindly provided by:
Andrew R. Thomas, Architect. Photos courtesy of The Landmark Trust unless stated otherwise

Performance

No comparison has been made between the fuel consumption of this building and that of a similar modern structure. Consumption does not appear excessive in comparison to other Landmark Trust properties, though. The thermal mass of the fabric, the small glazed areas and its radiant heating gives a high degree of comfort, particularly in the cold, damp months. Equally, the high thermal mass and efficient through-ventilation make it very comfortable in hot summer conditions.

Team details

Client: Landmark Trust
Architect: Andrew Thomas

Dolbelydr from the east (top)
The ruined hall looking south before and after refurbishment

Case study 3 Berg Cottage, Hertfordshire
Grade II listed 17th century timber-frame cottage

Front elevation of Berg Cottage – upon completion of the works. With limewashed exterior of oak lath

The building

The cottage was built in 1687, and is currently owned by the National Trust. It had a thatched roof, render on the front walls of the building and weather-boarding at the rear. Works had already taken place to replace ineffective electric panel heaters with an efficient gas condensing boiler and radiator system. However, draughts remained a problem, causing continuing discomfort. Unsuitable impervious cement renders and paints from the early 1930s were having a detrimental effect on the underlying timber frame structure.

Works

An air-pressure test was used to identify where the worst draughts originated, using smoke pencils. It was then possible to alleviate the draught problem without making the building too airtight. The test was carried out in each room – and also in the roof space where monitoring of the existing relative humidity levels and temperature had been carried out over a year. The results indicated that considerable improvements could be achieved with regard to air infiltration through work on the timber framing. However, it was also important not to make the structure too airtight – which would affect the performance and breathability of the fabric.

At Berg Cottage, pressure testing revealed a very draughty 24 air changes per hour. This is much more than necessary to prevent moisture build-up.

The weather-boarding and the tiled roof area directly below the rear dormers were prime sources of air leakage. Gaps around the ceiling hatch were repaired and manually operated extract fans were installed in the kitchen and bathroom. Large air gaps in the structure were filled with lime putty mortars and secondary glazing was added to the leaded light windows. After the airtightness measures had been carried out, a fresh pressure test was carried out to check that sufficient air was still flowing through the cottage.

A room thermostat was added to the heating system; this uses a wireless control technology to avoid cable runs through the building structure.

Materials

Internally, the existing structural timber frame is exposed, with lime plaster on laths – this has been retained. The weather-boarding and render were removed and naturally hydroscopic insulation (sheep's wool) has been added to the voids between the timber framing. To the front, traditional oak laths have been reinstated and a lime and chalk render reapplied.

Beneath the weather boarding at the rear, the structure has been clad with a tongue-and-groove woodfibre board. This has improved insulation and draught-proofing. Interstitial condensation (moisture build-up in the envelope) will not occur as any collected moisture can pass through the structure. The weather boarding has been reinstated.

Team details:

Owner: The National Trust
Building surveyor: Richard Oxley
Energy consultant: Peter Warm

Case study information kindly provided by:
Paul Coleman, Senior Building Surveyor Projects,
The National Trust
Photos courtesy of Oxley Conservation

Berg Cottage achieved the following:

- A sensitive refurbishment based upon a thorough understanding of the building – its cultural value, condition and performance.
- The removal of the causes of damp and decay.
- The use of appropriate traditional materials and methods.
- The introduction of compatible and environmentally friendly modern materials.
- Improvements in airtightness that do not jeopardise the traditional 'breathing' performance of the structure.
- Improvements in comfort levels for the occupants.
- A 50 per cent reduction in fuel consumption and bills .
- A reduction in CO_2 emissions.
- Enhanced condition and serviceability of the building.


Pressure testing: fan equipment in operation at a doorway on the rear elevation


Rear elevation showing works: The woodfibre board can be seen behind the weatherboarding. Junctions are dressed with vapour permeable roofing felt to reduce the risks of draughts

Case study 4 Dymock's Building, Bo'ness, Central Scotland 17th century to 19th century structures, now flats. Category A listing

Dymock's Building before and after refurbishment

The building

Dymock's Building is actually a group of domestic and commercial buildings, dating from the 17th to 19th centuries. The original core was built as a house for a wealthy merchant around 1650; this has an associated commercial yard and store, appropriate for the building's harbour side location. Over the following centuries the property grew and developed. In the early 1700s a major redevelopment took place, bringing the buildings up to date and somewhat raising their status. The prosperity of the town – and the families associated with it – was to change, though; by the 1950s the buildings were no longer in domestic use and instead they were subjected to a series of increasingly destructive commercial uses.

Eventually, the building became vacant and derelict. The opportunity to bring new life to its important historic fabric, and to the town itself, was recognised by the National Trust for Scotland's Little Houses Improvement Scheme. Working with Castle Rock Housing Association, the Trust repaired the building and converted it into flats for rent. The eight flats are all single bedroom and are constructed so as to be suitable for conversion to accommodate individual disabilities if subsequently required.

Works

The challenge was to respect the historic fabric of the building by making as few alterations as possible, while at the same time reinstating its key role in the townscape. A new pattern of internal circulation was required to give access to the new homes: the proposals included a lift rising through all three storeys, level passageways and new openings through the internal walls. All of this had to be achieved while retaining and repairing such historically important and valuable elements as the badly damaged 18th century panelled rooms and the decaying roof structure.

The building has two skins of mass sandstone masonry walls with a rubble core and lime mortar binding. A fine 18th century pine roof structure had survived over part of the building although this, and all of the remaining modern roofs, had been stripped and covered with asbestos cement sheet. Stone crowsteps and chimneys had been taken down, as had an entire gable – although several photographs of the structure were located, showing clearly the roof's earlier form. The timber floors were in a precarious state while the ground floor had been partially excavated and overlaid with an uninsulated concrete slab.

Materials

Ground floor

The existing concrete floor slab was lifted and a new, insulated and damp-proof solid floor has been laid to a new level. This new floor level is almost 600mm beneath today's 'ground level' (the result of 350 years of urban development) so a high performance damp-proof membrane has been carried up the internal face of the external walls to an appropriate level above the external ground surface. The lower level is therefore effectively tanked against the high and extremely variable water table, which necessitates the use of permanent pumps in many other buildings in the town.

External walls

The sandstone and rubble walls were partly covered in modern cement render and partly exposed. The hard modern render and pointing has been carefully removed. A limited amount of rebuilding has been necessary to repair extremely decayed masonry where structural stability was at risk. Hydraulic lime mortar has been built up to fill decayed but otherwise sound masonry. The walls have been repointed using mortar and the whole building harled (rendered) and limewashed.

As the internal structure had largely been removed or was in very poor condition, it was agreed that a new, independently supported structural timber frame should be introduced, supporting the new floors and also allowing the introduction of insulation. A 150mm frame was used and this has been filled with mineral fibre insulation. One result of this unavoidable action has been a drop in the temperature of the masonry fabric with a consequent high risk of condensation forming on the inner face of these walls. A vapour barrier has therefore been fitted to the inner face of the frame, although it is accepted that condensation may still form in extreme conditions. This will be absorbed by the relatively porous walls and, ultimately, lost through evaporation from the vapour permeable outer face.

The first floor panelled rooms were not treated in this way though: they have been reinstated in their original positions without insulation.

Roof

The historic fabric of the roof that remained has been kept in-situ and repaired using sections of new timber, spliced or bolted in place as appropriate. The pitched roofs had all been originally covered using clay pantiles and this has been reinstated on battens, counter battens and sarking. A vapour permeable roof membrane was laid over the sarking and insulation packed between the rafters. A vapour barrier has been fitted on the inner face of the roof structure to reduce the risk of condensation (this removed the need for eaves and ridge vents). Two large areas of lead flat roof are now ventilated on their underside and insulation has been introduced beneath the lower deck.

Windows

Very few historic windows survived, but a fragment of a section from an early 18th century sash and case window was identified. This was copied and new sash and casement windows manufactured. These windows have square section astragals (glazing bars) and have all been produced with single glazing to their original pattern. They have, however, been draught-stripped. The specification required a relaxation of the Building Standards, and was obtained on the basis that the overall thermal performance of the development otherwise complied.

Services

Seven flats and the two common rooms are located within the three storey main building; a further flat is contained within a lean-to courtyard building. Another lean-to section houses a central plant room from which the electrical, heating and water services are distributed. This arrangement has reduced the disruption to the historic fabric and means that a single route is being used for all servicing. Heating is provided by two condensing gas boilers with controls in each flat. This arrangement is efficient and also removes the need to provide (external) gas pipework and individual flues to each flat.

Team details

Client:	The National Trust for Scotland's Little Houses Improvement Scheme
Main contractor:	Hunter and Clark, Glasgow
Architect:	The Pollock Hammond Partnership, Linlithgow
User:	Castle Rock Housing Association

Case study information kindly provided by:
Gareth Jones, Pollock Hammond Partnership, Architects
Photos courtesy of Pollock Hammond Partnership.

Main ground floor courtyard entrance

Case study 5 Neely House, Cambridge
Two Victorian terraced homes

Front elevation after refurbishment

The building

The Neely family enjoy living in their terraced house in Cambridge, but the growth of their family meant they needed somewhere larger to live. When their neighbour's property came up for sale, it provided an ideal opportunity for them to extend their living space without moving away from the area.

The two adjacent Victorian houses were renovated, extended and converted into one large family house. The brief was to provide modern spacious family accommodation using environmental best practice.

Works

The requirement was to provide: a contained entrance hall with lobby and storage; a large lounge; a kitchen; a family eating space/dining room; a children's space/room; a utility room with secondary access; five bedrooms; a bathroom; a second bath/shower-room or en-suite; use of loft space; a wine store; and an external patio area.

This project made use of Design Advice, a free service available from the Carbon Trust. For more information visit www.thecarbontrust.co.uk

Materials

Natural materials with low embodied energy, were selected for use on the project and included natural/organic paints, timber and slate finishes, natural waxes and stains. PVC-U products were avoided by the architects. To improve health standards in the house, non-toxic materials were chosen e.g. ones without formaldehyde. Carpets and other fabrics were avoided in an effort to limit dust mites. Natural daylight and ventilation were also employed.

Insulation

A dry lining system with 100mm of insulation was used to insulate the solid brick internal walls of the original structures. The levels in the existing extension and the new one were increased by 200mm (100mm full-fill cavity wall insulation and 100mm dry lining insulation). Very limited roof space in the attic room – which the new design allocated to workspace, a spare room and an en-suite – meant little headroom, so 200mm of insulation was fitted between the rafters and then battened out for a further 25mm of reflective insulation and plasterboard lining.

On the ground floor, the existing suspended flooring was replaced by a solid floor with underfloor low temperature water heating and 200mm of insulation underneath. Damp penetration was prevented with the use of membrane protection.

Windows and doors

The new windows to the rear and sides of the property are triple glazed, with low-e glass on two of the panes, argon-fill and insulated spacer bars giving a U-value of 1.0W/m^{2}K.

The Victorian sashes at the front of the property have been replaced with double-glazed and draught-stripped timber windows, which match the original style. In the bays, the roofs and side walls were insulated when the windows were replaced. There is even an insulated and airtight cat flap!

Airtightness (original building)

The building achieved 5 air-changes per hour at 50Pa in a fan pressurisation test. As the building fabric did not contain materials that were particularly sensitive, a ventilation system was installed.

Thermal bridging

Thermal bridging was minimised by insulated dry lining, including the window and door reveals. Counter battening was used in the roof and care was taken over insulation edge details at ground floor level.

Daylight design

Daylight was provided to all habitable rooms. Roof lights were added to the courtyard in-fill (the main dining room) – this area had been an external space between the two houses and was filled-in to create a new, light and airy room in the centre of the home. Architecturally, this room was treated differently, an 'external' feel being given to the decoration with earth plaster walls and a slate floor which is linked to but separated from the slate patio area in the garden.

Passive solar

The new dining/family room faces south into the garden and has a glazed façade and rooflights.

Ventilation

Natural passive stack ventilation has been installed with humidity controls.

Heating

A wood burner is located in the centre of building with an external air feed and a shut-off valve. A high efficiency gas condensing boiler supplies an underfloor heating system on the ground floor and radiators upstairs. Room thermostats, radiators with thermostatic radiator valves (TRVs) and weather compensation controls have been included. A solar collector connection is planned for the future.

Appliances

Low energy light fittings are used throughout together with low energy appliances (A-rated white goods).

Team details

Owners: The Neely family
Architects: Gale & Snowden

Case study information kindly provided by:
David Gale, Gale & Snowden, Architects
Photos courtesy of Gale & Snowden

Rear elevation showing daylight provision to courtyard dining area

Case study 6 Wood Farm, Gipping, Suffolk
16th century grade II listed farmhouse

Side elevation of Wood Farm, following refurbishment.

The building

Wood Farm is a mid-16th century Grade II listed farmhouse, once one of the farmhouses on the Tyrell Estate. In common with many such houses, it has been altered unsympathetically over the years and was suffering from advanced rot at the base of the original oak frame.

Works

In addition to the construction of a substantial extension in green oak using medieval jointing techniques, the existing house has been completely refurbished and upgraded. The project was the recipient of two RIBA East Spirit of Ingenuity Awards in 2004.

Materials

The roof consisted of concrete pantiles laid over bituminous felt on battens attached to the medieval rafters. A thin layer of compressed mineral wool was laid over the ceiling joists. This, combined with an ill-fitting ceiling hatch, provided almost no insulation.

The roof coverings were replaced with 300mm of reed thatch laid over a flexible fire barrier. The ceiling was insulated with 200mm of mineral wool insulation. The hatch was draught-sealed, fitted with polyisocyanurate (PIR) insulation and fitted with a second, lower hatch flush with the ceiling.

The walls posed a considerable problem: the original oak studwork was entirely exposed internally and original wattle and daub remained over approximately 50 per cent of the wall area. The wattle and daub has been preserved and stabilised, the remaining infill panels filled with mineral wool insulation and finished with two coats of plaster internally.

The exterior of the frame has been finished in 18mm weather and boil proof (WBP) plywood, a vapour permeable membrane, 50mm x 25mm counter battens, 25mm x 6mm sawn and treated softwood lath, and finally three coats of hair-reinforced lime render. This has given a greatly enhanced U-value, maintained vapour permeability, aided the structural stability of the building without increasing the wall thickness unacceptably – and removed draughts which were an endemic problem.

The floor consisted of bricks laid directly onto the ground or boards laid on joists in direct contact with the ground. In conjunction with the reconstruction of the original brick plinth walls (which were built on the topsoil), the entire floor and wall structure has been rebuilt.

The brick plinth walls were rebuilt using bricks laid in natural hydraulic lime on a firm clay trench floor. The floors were dug out and rebuilt using a total build up of 410mm of hardcore, blinding concrete, damp proof membrane, flooring-grade expanded polystyrene insulation, heated floor screed and a finish of battens and oak boards, floor bricks, tiles or stone.

This specification gave a completely draught-proof floor, highly insulated with an even temperature from the underfloor heating.

The existing glazing consisted of various timber and steel framed windows and some leaded lights pinned directly to the oak frame, all of which were draughty. The new windows are draught-stripped, steel framed, single glazed, traditional leaded lights. These were chosen to be in keeping with the period of the building.

The total glazed area is not large compared with the size of the building and the largest window faces south to maximise solar gain. Heat loss through the windows has not proved a particular problem, largely because the problem of draughts has been addressed.

The front door has been protected by a new, unheated – but insulated and enclosed – porch to reduce heat loss.

The heating system is a fully programmable condensing oil boiler with zone control for different parts of the building. Domestic hot water is provided from the same boiler.

Team details

Owner: Privately owned
Architects: Geary and Black.

Case study information kindly provided by:
Rodney Black, Geary and Black, Architects
Photos courtesy of Geary & Black

Front elevation of the newly insulated timber frame prior to rendering

Further information

The Energy Saving Trust sets energy efficiency standards that go beyond building regulations for use in the design, construction and refurbishment of homes. These standards provide an integrated package of measures covering fabric, ventilation, heating, lighting and hot water systems for all aspects of new build and renovation. Free resources including best practice guides, training seminars, technical advice and online tools, are available to help meet these standards.

The following publications may also be of interest:

Energy efficient refurbishment of existing housing (CE83/GPG155)

Refurbishing dwellings with solid walls – A summary of Best Practice (CE58)

Energy efficiency in New Housing – summary of specifications for England, Wales and Scotland (CE12) (for Northern Ireland CE24)

Central Heating System Specifications (CHeSS) (CE51/GIL59)

Windows for New and Existing Housing – a summary of best practice (CE66)

Low Energy Domestic Lighting – looking good for less (CE81/GPCS441)

Insulation Materials Chart – thermal properties and environmental ratings (CE71)

Advanced Insulation in Housing Refurbishment (CE97)

To obtain these publications or for more information, call 0845 120 7799, email bestpractice@est.org.uk or visit www.est.org.uk/housingbuildings

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