Improving the energy efficiency of a traditional stone house

Edition: 3. 2018

Bob Pringle

This project aimed to: -

- Save money on our energy bills and make the house feel more comfortable
- Avoid the numerous pitfalls that await the inexperienced home improver
- Determine the capital cost of achieving these savings
- Minimise our carbon footprint to protect the planet
- Share our findings with others to aid their home energy refurbishment

About the author

I am a Chartered Agricultural Engineer, who retired from the Scottish Agricultural College in 2004, having worked 35 years advising, teaching and researching on livestock and crop buildings and teaching energy conservation, renewable energy and sustainable farming. A move of home in 2006 provided an opportunity to refurbish our traditional granite stone house and apply knowledge acquired during my working life to improve its energy efficiency and thermal comfort.

Disclaimer

The recommendations made in this document are based on my own considered opinion. I may not have used the best possible or lowest cost materials, but I could not assess every available product. As I have purchased at full price all the materials and equipment myself, I am not linked in any way to a manufacturer or retailer. My logic throughout is based on scientific theory and practical experience gained while refurbishing this house and others before it.

Evaluation of modifications

Some of the modifications made were more extensive and expensive than I would have judged sensible if this were not in part an experimental project, so I have rated the benefit of the modifications to give readers an indication as to their worth.

Feedback for this work in progress

The online forum on the web page allows readers to contribute corrections and improvements to this document. It is a "work in progress", and as such I will endeavor to update it from time to time, this being Edition 3, 2018. If you have expertise in refurbishing other types of houses, I would encourage you to similarly put your experiences on the web.

Referencing

Anybody is welcome to make use of this document in any way they want, in both written and verbal form. However, I would appreciate if you would reference the source as "Pringle, R. T. (2018). Improving the energy efficiency of a traditional stone house, Edition 3. http://www.sustainability-in-practice.org.uk "

Contact details

Bob Pringle,
59 Abergeldie Road
Aberdeen. AB10 6ED.

Email: bobpringle@btinternet.com

Tel: 01224 574493

Acknowledgements

I would like to thank Dr Chris Mullins, the previous owner of this house, for providing me with his records of energy use and savings and for reading and commenting on my initial draft. I would also like to thank my ex-buildings and engineering colleagues at SAC who passed on so much helpful technical information. To Ceri Williams, for his guidance for setting up a web page. To Sue Smith, for her comments on omissions and clarity in the draft. To Prof Branka Dimitrijevic, of CIC Start Online, Glasgow Caledonian University, for supplying the list of references on hard to treat homes. To Malcom Robertson, my previous neighbour, for access to his Home Report. To Grant Tiarney, my new neighbour, for information on his gable clearing. To my wife Ingrid for checking the language and formatting.

Contents

Executive Summary

This publication describes the draught proofing and insulation of an 1890's traditional granite, two story, semi-detached house over a period of eight years to improve its thermal comfort, minimise fuel bills and reduce its annual carbon footprint. These modifications were done while home improvements and room redecoration were being carried out.

The most important aspects to consider in such modifications are described in the following 59 pages, and are summarised as follows: -

- The key measure to improve thermal performance of single skin stone buildings is draught proofing to minimise wind induced ventilation of rooms
- Once buildings are adequately sealed, added insulation will then minimise heat loss from the rooms due to conduction through the walls, ceilings and flooring
- To prevent possible rotting of timber framing between the walls and the lath and plaster (or plasterboard) room linings, these narrow wall cavities must be open to wind induced ventilation. Rooms are therefore sealed but airspaces between the stonework and lath and plaster are kept freely ventilated
- Sealing of the external structure of the house may involve fitting new doors and window frames, or by retro-fitting seals (e.g. the AQ 21 Aquamac seal), which fit into a groove made in the frames using a high-speed router
- Sealing of inside doors can be achieved using the same type of seal. This will prevent draughts into rooms, and prevents rooms yet to be insulated from cooling the remainder of the house
- Points of air leakage can be through doors, window frames, gaps between floorboards, gaps in skirting boards, gaps between floors and skirtings, open fires and chimneys, holes in lath and plaster for cable or pipe access and holes made accidentally during house construction and repairs
- Tradesmen's knowledge and understanding of making buildings thermally efficient varies from non-existent to excellent. Getting tradesmen rather than home owners to do draught proofing or insulation work is therefore no guarantee of quality.
- The movement of vapour in air always moves from a warm space to a cold space, (i.e. usually from inside the house to outside), so the type of insulation used must take account of this if condensation in air cavities between timber frames is to be avoided
- Where vapour movement through walls, ceilings and floors can be largely prevented, using of foil backed plasterboard, any type of insulation material can be used. If the vapour movement cannot be stopped, as with lath and plaster, then porous, mineral wool type insulation materials should be used so that air ventilating through cavities can remove any vapour that does condense
- Insulating room wall linings should be restricted to external, but not dividing, walls

- The very dusty process of replacing lath and plaster with insulation board can be made less dusty by cutting the lath and plaster out in slab sections using a jig saw fitted with a tungsten carbide blade

- Most operations involving lath and plaster and installation of mineral wool type insulation is dusty so good quality half face respirators fitted with replaceable filters should be worn, or even better, fan assisted respirators

- Skirting boards, ceiling friezes, and timber features such as pillars or door frames only allow thin sections of insulation to be used to replace lath and plaster. Options for suitable insulation boards are therefore compared

- Any insulation material should subsequently be lined with plasterboard, or other fire-resistant material, to delay the spread of flames should a fire within the house occur

- The easiest way to insulate the linings of external walls is to fix 50 or 25 mm foil backed insulation board or Styrofoam sheeting between existing studs with tape and then to apply a further thin insulation board over the whole wall followed by plasterboard.

- This second layer of insulation should be 12 mm, so that it can fit behind existing skirting boards and pillars and still leave room for a 12.5 mm plasterboard internal lining. Such thin sheets of insulation material may need to be sourced in bulk from England

- Glass fibre or rockwool in loft spaces tends to reduce in depth over time. In easily accessed places this can easily be topped up. In combs and under floors, where accessibility is difficult, the more expensive, less compressible slabs of mineral fibre should be used

- Thermostatic valves on radiators allows individual rooms to be set at appropriate temperatures, with bedrooms cooler than lounges

- Where open fires and wood or multi-fuel stoves are used, thermostatic valves on radiators will shut down the radiator as heat comes instead from the fire or stove

- While the cost of the insulated stainless-steel flue required by a multi-fuel / wood stove is high for a two-story house, the fuel use is approximately 34 % that of an open fire

- Zone control on radiator circuits allows heating to follow room utilisation, so avoiding unnecessary room heating. Wireless operated valves now available offer an alternative to zoning using motorized valves

- Our three-bedroom two story house cost £350,000 and is now worth £570,000. Over the past six years we have spent £65,962 installing an en-suite, fitting a new kitchen and refurbishing most of the rooms. Of this, £39,496 (60%) was spent on items such as windows, doors, draught proofing and insulation that would hopefully contribute to energy conservation and thermal comfort

- While the author did much of the sealing and insulation work himself, the £39,496 figure was calculated assuming his labour cost was £16.88 per hour

- This expenditure of £39,496 over the eight-year period produced an actual energy cost saving of £1080 at 2015 energy prices. The payback period was therefore well over 60 years at a 7, 5 or 2.5% rate of borrowing. Even if the cost of labour was excluded and the rate of borrowing was only 2.5%, the payback period was still long at 27 years.

- Six benefits result from the above expenditure, 1) the annual cost saving in energy to the owner, 2) the improved thermal comfort of the house, 3) the improvement in the material state of the house, 4) the possible increased value of the house when sold due to its enhanced energy rating 5) the reduced carbon footprint that the government is seeking and 6) the annual 3.38 MWh reduction of electricity generation by utilities that is no longer required

- The reduction in energy bill from £2,074 in 2005 to £ 994 in 2014, (48%), would not meet the “Golden Rule” of the new Green Deal, as the financial savings must equal or exceed the costs. Most, and probably none of this work, would therefore have been eligible for a loan through the deal

- Prior to purchasing the house, the previous owners had achieved a reduction in energy cost from £2,712 to £1988 at 2015 energy prices, a 27 % reduction in energy cost. The combined reduction in energy use by both owners was therefore 67%

- Surveys of houses to assess their thermal efficiency are always going to be dependent on the rigor of building surveyors and the accuracy of their models. A few holes behind fitted kitchens or through doorways could completely alter its performance. The only true check is via gas or electricity meters or oil tank readings

- While there is little conventional financial justification in terms of energy cost savings for carrying out the draught proofing and insulation work, the owners are delighted with the result and do not regret the expenditure

Glossary

Ambient	Outside temperature and humidity
Coombe ceiling	Sloping ceiling due to pitch of roof
Sarking	Timber lining on roof trusses to which slates are attached
U-Value	Conductivity value of insulation, the lower the value, the better the insulation

1. Introduction

Homeowners living in traditional stone houses are often daunted by the complexity of refurbishing their homes to improve their energy efficiency. Where to start? Coombe ceilings and dormers make loft insulation difficult, chimneys for open fires allow heat to escape from radiator heated rooms, and gaps in skirting boards and floor boards allow a multitude of draughts. Tradesmen tell residents that airflow through the house is vital to keep the structural timber dry and happily knock holes in room wall linings and floors to install wiring or pipework, creating further draughts. Some holes, such as that in the lath and plaster behind the electrical consumer unit, are virtually impossible to seal. Grants from energy companies often offer improvements that are impossible to put into practice; they offer loft insulation in houses having inaccessible lofts or suggest foam insulation of wall cavities in housing areas where cavity walls do not exist. If an exasperated homeowner decides to abandon energy conservation measures and instead install renewable energy production, such as photo voltaic panels, he will find that the government's feed-in-tariffs subsidy is only available to households that have been thoroughly insulated first and hold D or better Energy-Performance-Certificate (EPC). He is therefore back to square one.

This publication records my efforts to reduce the energy consumption and improve comfort levels in our semi-detached, two story three-bedroom granite house. All the design work and most of the installation work has been done by me, sometimes on jobs deemed not worthwhile by tradesmen. My aim has been to systematise tasks, to develop a standardised, minimal cost, approach that could be applied to other houses of similar construction. By doing the work myself, I could evaluate the best way to do a job, how to minimise dust production, what special tools were required, what face respirators worked and which tools to use. The work spanned a period of eight years and was scheduled to incorporate energy conservation measures while refurbishing and decorating the house. Gas and electric meter readings have been taken monthly to track the benefits of measures taken.

2. Characteristics of traditional granite stone buildings

a. Structure

Traditional granite stone buildings have external walls between 450 and 600 mm thick. Wooden pegs are driven into the gaps between the blocks, to which vertical timber studs are nailed (Figure 2.1). As the inside of the granite blocks are very rough, the studs must be some distance off the wall, leaving an airspace of up to 75 mm between the stone and studs. The studs are located at about 400 mm centres. Timber laths, 6 x 20-25 mm are nailed horizontally to these studs, with 10 mm gaps between them. Plaster to a depth of 19 mm is then applied to the laths to create a timber and lath composite, 25 mm in thickness. The plaster penetrates the gaps between the laths, which helps to lock the plaster

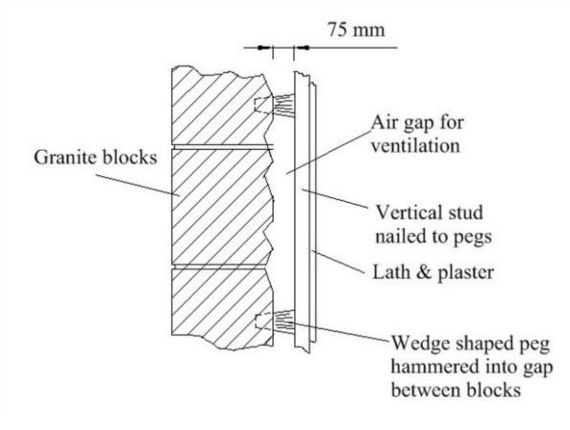

Figure 2.1. Section of granite wall

on to the lath (Figure 2.2). The plaster provides a fire proof lining to which paint or wall paper can be applied. The airspace between the granite and plaster is open at both the top and base of the walls. Air flows through this airspace due to wind pressure and natural convection ventilation and is essential for keeping the timber studs and structural timber dry.

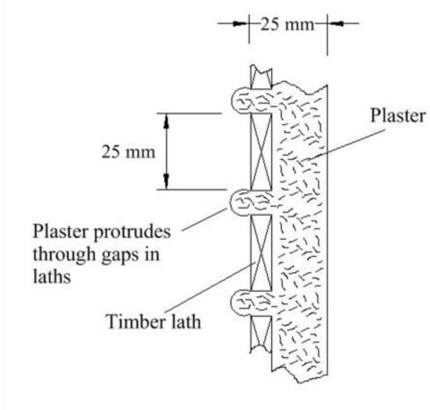

Figure 2.2 Cross section of lath and plaster

Floors consist of tongue and grooved timber boards, often with many gaps between them. These gaps are caused in part by generations of electricians and plumbers removing the tongues to lift boards to install wires or pipe work and partly through boards shrinking due to the warmer room temperatures when central heating is installed. Ceilings are lath and plaster and are applied to the underside of the floor joists. The gap between the ceiling and floor boards is like the gaps between the outer walls and wall lath and plaster, in that it is ventilated by wind and convection (Figure 2.3). In a first floor flat once owned by me, a large square of carpet would hover like a magic carpet in windy weather, due to wind jets entering via gaps in the floor boards.

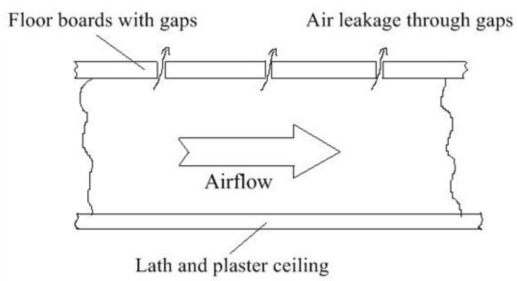

Figure 2.3 Wind induced airflow under floors

Partition walls between rooms, in contrast to the external walls and floors, are closed boxes. These boxes are 120 mm wide, extend the whole height of the house and are lined on both sides by lath and plaster. While the airspace within the partition wall is little influenced by wind pressure, holes in the partition walls for wiring and pipe work do mean that partition walls are not totally closed to ventilation.

b. Heating

The houses, built in the 1890s, were designed to be heated by open fires in grates. Each room had a fireplace with its own chimney. Keeping warm in cold weather was achieved by sitting close to the fire and enjoying the radiant heat emitted. The houses were cold for much of the time, so condensation on cold plastered surfaces, particular on the internal surface of external walls, was an ever-present threat. In a house of this type I visited on the humid Isle of Skye, the owners of the house opened windows and doors at every opportunity, even in damp December days, to allow fresh air into the rooms. Even with such a regime, the wallpaper was slowly peeling from the walls of the front lobby. In my own house in the less humid climate of Aberdeen, 3 mm polystyrene insulation was applied to the lath and plaster of the internal walls in a bedroom prior to applying wallpaper, to avoid condensation on the wallpaper in cold weather. I suspect that this very sensible approach of using ventilation to prevent condensation fostered the philosophy that “these houses needed a good supply of natural ventilation to keep them dry”. Almost every tradesman I meet will quote this adage.

c. Recent central heating modifications

Fitting radiators to such houses not only reduced the relative humidity of the air within the house, making condensation on cold walls less likely, but caused the air within the rooms to become buoyant, so that warm air would escape up the chimney. Most chimneys in bedrooms and some public rooms were therefore closed off, leaving a small ventilator to allow a trickle of ventilation air up the chimney to avoid condensation within the chimney. With the warmer room temperatures, the need for “a good supply of natural ventilation through the rooms” was no longer needed. Instead, the requirement was to seal the rooms as best as possible while ensuring that the spaces between the granite walls and the lath and plaster was kept well ventilated to minimise any risk of condensation and associated wet or dry rot. This is the approach that I have taken in the refurbishments that follow.

3. Wind infiltration and insulation in traditional stone buildings

Almost every advert on home energy efficiency by government or commercial companies talks about insulation, about putting a “woolly hat” on your house to save energy, but rarely mentions the impact of wind and the air leakage it causes. At the extreme, if you left your front and back door open on a cold windy day, even the best insulation would not keep your house much above the ambient temperature. Only by closing the doors and ensuring leaks round windows, doors, skirting boards and cupboards are reasonably well sealed, will room temperatures increase. A temperature difference develops between inside and outside, and this is where the benefit from good insulation is obtained. So, sealing the leaks is the first operation and insulation the second. An indication that leaks are the primary problem is when room temperatures drop rapidly once the radiators go off, or the internal house temperature drops in windy weather.

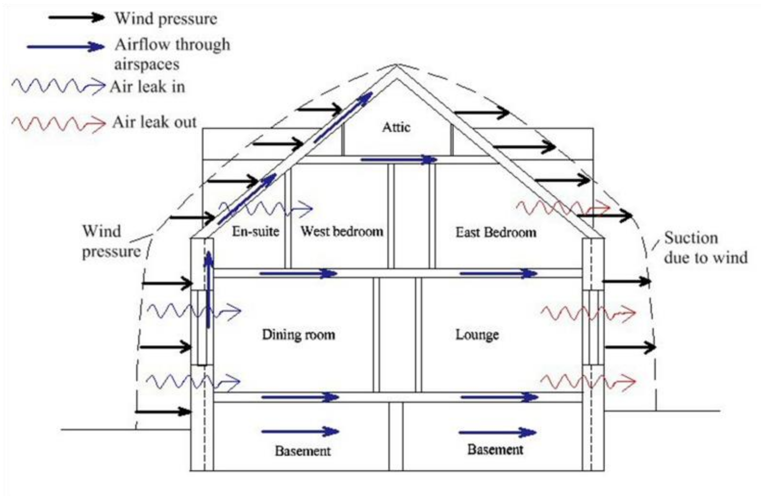

Figure 3.1. Airflows within a granite building due to wind

Wind pressure acts on a house as shown in Figure 3.1. The wall and roof facing the wind will be under pressure while the wall and roof on the other side of the building will be under suction. Anybody who has left both front and back door open at the same time in windy weather will know just how strong a pressure difference this is. The door under suction will slam shut with a bang.

In the roof space, as there are gaps between slates and the timber sarking (boards) below, the wind will flow rapidly across the loft from the windward to leeward side of the roof. Lofts are draughty places. In the living areas below, any leaks in room windows and doors will allow the air to penetrate the rooms and hallways in the windward side of the building and leave via gaps in windows, doors, skirting boards in the leeward side as well as escaping via open chimneys. In the building cellar or foundations, air will be forced into the space below the ground floor and be drawn up between the air spaces between the walls and lath and plaster, to flow out through the roof, which is under suction, or through other gaps in the walls. Floors in the first and second stories will also have a significant air movement through them. While this airflow has the benefit of keeping all the structural timber dry, gaps in floors are points of entry into rooms for draughts.

4. Temperatures within external and internal walls and roof space

Insulation slows the transfer from a warm space to one that is cooler. To assess where the most benefit can be gained from replacing lath and plaster with insulation board, I took several temperature measurements within the cavities of the house. These measurements are shown in Figure 4.1.

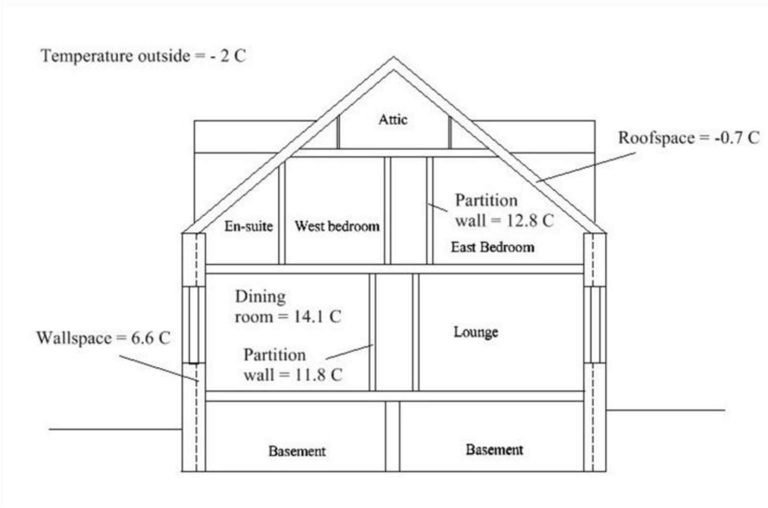

Figure 4.1 Temperatures within wall cavities measured when the outside temperature was - 2°C, on a still night

The greatest temperature differences are between the upstairs rooms and the roof space, including either side of the dormers. The next greatest is between the rooms and the exterior stone walls. There is little advantage in putting insulation between the rooms and the partition walls, as these are at a similar temperature.

5. Strategy for improving energy efficiency of traditional stone buildings

a. Preventing heat loss by minimising air leakage

Heat is lost when colder outside air leaks into the warmer building. While some air leakage occurs by convection, the bulk of leakage is through wind pressure, with one side of the house under pressure and the other under suction. The main movement of leaking air is therefore from one side of the house to the other.

The main points of leakage are doors, windows, fireplaces and holes in lath and plaster; but gaps, as small as 1 mm along skirting boards, can allow significant quantities of air to penetrate. The amount of leakage is dependent on the wind pressure, and the size and number of gaps.

Convection ventilation is usually less of a problem than wind induced ventilation, but is greatest when a fire is lit. This often results in a very significant draught past anyone sitting between the door of the room and the fire. If radiators are fitted into a room with a chimney, warm air being lighter than ambient outside air will cause a flow of warm air to go up the chimney and draw in colder ambient air to replace it. The ambient air can only get in if there are leaks to escape through.

b. Reducing heat loss by conduction through room fabric

Heat always flows across a boundary like a wall from a warm area to a colder area. The rate of heat loss is determined by the resistance to heat transfer of the material lining the room, and the temperature difference between the two sides of the wall. Plasterboard and lath and plaster have a relatively low resistance to heat loss while plastic foams and glass / rock fibres have a high resistance.

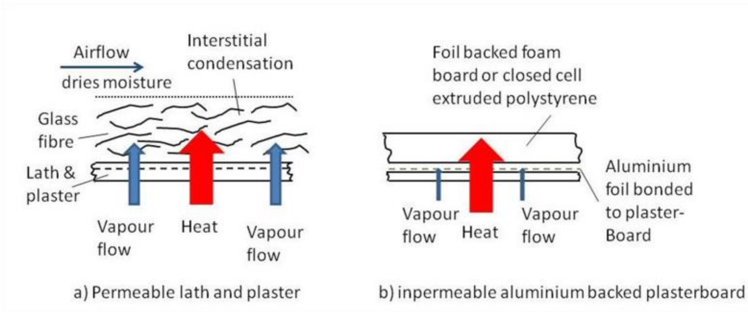

Figure 5.1 Heat and vapour transmission with a) permeable lath and plaster and b) with impermeable aluminium foil backed plasterboard

The effectiveness of insulation materials is usually measured by their thermal conductivity or Lambda (λ) value (W/m ºC)[1] rather than their resistance to heat flow. The lower the conductivity, the better is its resistance. The conductivity of a whole wall is defined by its U-value, which can be calculated from the resistances of the various items that make up a wall or ceiling. A U-value of 0.2 W/m^2 ºC indicates a well-insulated wall while a U-value of a lath and plaster wall, ignoring the stone wall, is about 3.0 W/m^2 ºC, a much higher value, which loses heat faster. The rate of heat loss through a wall or ceiling is proportional to the temperature difference between the inside and outside, so the highest insulation should be installed where temperature differences are greatest. If a wall separates two rooms which are at similar temperatures, there will be little benefit from installing insulation.

c. Dealing with vapour transmission through room fabric

Warm air can hold more moisture in invisible vapour form than cold air. The vapour pressure in a warm room is therefore usually higher than outside. Kitchens and bathrooms create the worst-case scenarios, being both warm as well as having a large amount of vapour produced during cooking or showering. As heat flows from warm to cool, so vapour flows along with it from high humidity to low. This presents the very real danger that, as the heat and vapour flow through the wall or ceiling, the temperature drops in the middle of the wall and the vapour condenses within the wall space. This condensation can soak the insulation, if it is porous and unventilated, reducing its effectiveness and wet the timber in the wall space. The wet timber can subsequently rot.

[1] This unit should be W/m°K, with °K standing for degrees Kelvin, where °K = °C + 273. But as heat transfer is proportional to a temperature difference, the 273 disappears in the subtraction allowing the more common °C unit to be used instead.

Vapour transmission can largely be stopped by aluminium foil, or to a lesser extent by polythene sheeting (Figure 5.1). If new plasterboard is being used to replace existing lath and plaster, then a foil backing can be used to prevent vapour entering any insulation behind the plasterboard. If, however, insulation is being installed at the back of the lath and plaster, as is usual in lofts, then vapour will pass through the lath and plaster into the insulation material. A circulation of air through the insulation is then required to remove this moisture when condensation does occur.

d. Insulation arrangements compared

When replacing lath and plaster with insulation and plasterboard, I have either used insulation boards made of expanded polystyrene (EPS) foam, sandwiched between aluminium film that resist vapour flow or alternatively extruded closed cell foamed polystyrene board (e.g. Styrofoam) which does not need the aluminium vapour barrier. Aluminum backed plasterboard, fixed after installing the insulation, prevents vapour flowing into any airspace.

Where it is not possible to prevent vapour movement, such as when insulation is placed horizontally over lath and plaster ceilings or under leaky, porous, floors, I use rock wool or glass fibre matt. Prior to replacing lath and plaster with insulation board, it is worth considering the options.

In Table 5.1 I have considered a number of alternative wall insulation arrangements and have worked out their respective U-values and cost.

These are shown in diagrammatic form in Figure 5.2, looking vertically downwards from above, with the vertical studs and insulation shown in cross section. As there is usually a considerable air circulation through the airspace between the stone outer walls and the lath and plaster, I have ignored any insulation value due to the stone. The calculated U-values therefore just consider the materials that make up the lining of the rooms.

Table 5.1. Arrangements of sheet insulation, protrusion from stud faces, U-values, and relative costs (Insulation panels are single sheets unless described as being bonded together to form a composite sheet)

Description	**Drawing No**	**Stud size & thickness of insulation**	**Protrusion from face of studs**	**U-Value, insulation**	**Ave U-value including stud**	**Cost exc. VAT and carriage**
		mm	mm	W/m²°C	W/m²°C	£/m²
Lath and plaster	a	50 x 50	25	3.69	-	-
Kingspan EPS sheets	b	50 x 50 50 & 25	37.5	0.27	0.32	12.50
Kingspan EPS sheets	c	50 x 25 25 & 25	37.5	0.4	0.43	10.50
Kingspan & Celotex EPS sheets	d	50 x 25 25 x 20	32.5	0.43	0.43	10.31
Kingspan & Celotex EPS sheets	e	50 x25 25 & 12	24.5	0.52	0.59	9.84
Kingspan & Composite Kingspan K18	f	50 x 50 50 & 25	37.5	0.27	0.36	18.80
Kingspan EPS Sheets, +Space-therm composite	g	50 x 50 50 & 9.5	22	0.32	0.38	86.35

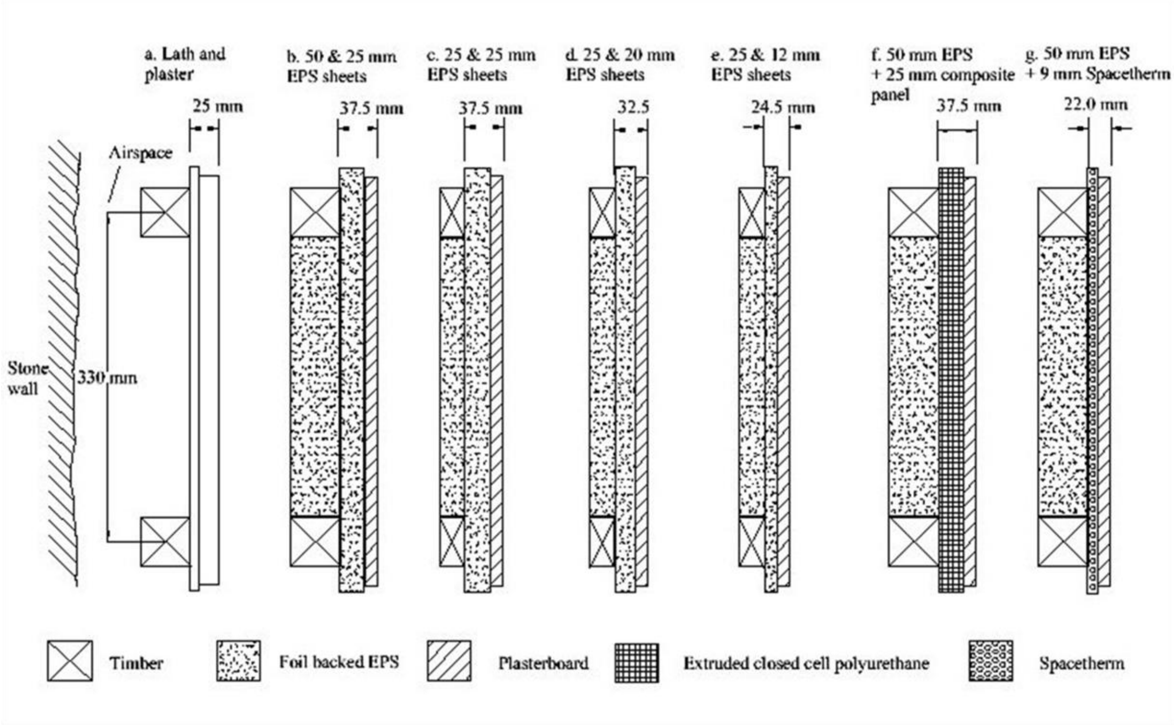

Figure 5.2 Graphical illustration of various arrangements of insulation taken from table 4.1

The aim when replacing lath and plaster with insulation materials is to get the lowest cost, easiest to install material that will give the best insulation within the limits of the allowable protrusion from the face of the studs into the room. Usually the protrusion is limited by the frieze, skirting boards, fireplaces and wooden pillars, which is why table 5.1 includes the protrusion for each insulation arrangement. If the plaster board is going to have a skim of plaster applied, the thickness of the skim, usually 2-3 mm, should be added to the total potential protrusion. If there is no frieze or decorative skirting board or pillars, this protrusion may not be an issue. If the frieze is of a simple profile, and the skirting board is being replaced, it may be better to let the insulation protrude more into the room than the original lath and plaster and renew the frieze.

The U-value of the alternative insulation arrangements has been calculated using standardized values for surface conductance (CIBSE, 2006) and manufacturers figures for the materials' Lambda (λ) values. As insulation material has been put between the existing timber studs, the U-value across a section of insulation will be lower (less conductive) than the U-value across a section of timber stud (Figure 5.2). The average U-value in the table averages the U-value in the proportion of the ratio of width of insulation to width of timber stud.

From table 5.1, lath and plaster has a U-value of 3.69 W/m^2°C, 6.25 times worse than the poorest alternative insulation in the table, so replacing lath and plaster with any sort of insulation will be a considerable benefit to reduce heat energy loss. From a cost point of view, the Spacetherm would only be used in places where there was only room for a total of 22 mm protrusion. The system using a composite Kingspan K18 sheet is a little more expensive than the alternative of using Kingspan or Celotex EPS sheet. The 2.4 x 1.2 m composite panels of Styrofoam and plasterboard are also heavy and too much for a single person to lift. My preferred insulation material is therefore System “e”, Fig 5.2, Kingspan/Celotex (or other manufacturers) EPS/aluminium sandwich, 50 mm where possible, 25 mm where space is limited by granite stones protruding, subsequently faced with 10 mm Kingspan/ Celotex sheet plus followed by aluminium backed plaster board. This fits nicely down behind existing skirting board. The 2-3 mm plaster skim then seals the gap between the top of the skirting and the plastered wall.

e. Summary of strategy

The house owner or energy specialist must decide on a strategy to improve the energy efficiency and thermal comfort of the house. A recommended strategy is listed below: -

- External doors and windows should be sealed or replaced to ensure the building is airtight[2]
- The schedule of refurbishment work should be undertaken in conjunction with the upgrading of kitchens, bathrooms or the redecoration of rooms.
- Changes in plumbing, heating system and electric wiring should be undertaken before doing any insulation work to avoid tradesmen punching holes in newly sealed walls, floors or ceilings. Items to consider are whether to install a solid fuel stove rather than keeping traditional fireplaces, whether to fit heating control valves that allow different zones of the house to be heated at different times, whether showers are to be gas or electric heated, whether solar water heating or a back boiler are to be installed and whether internet connected heating controls are to be fitted.
- If the house is in an area where natural gas is not available, consideration should be given to the fitting of a ground source (or possibly a less efficient air-source) heat pump.
- Seals should be fitted to several internal doors to both stop draughts within rooms and to allow rooms which are yet to be insulated or refurbished to be kept shut, and so allow the upgraded part of the house to be kept warm[2].
- If feasible the lath and plaster adjacent to external walls should be insulated when rooms are being redecorated. This should be considered especially for kitchens, bathrooms, and living rooms, where both room temperature and occupancy is high.
- When rooms are refurbished, doors, skirting boards, windows, floors, cupboards, and fire places should all be sealed. The present vogue of exposing and sanding of leaky timber floors should not be considered unless there is some way of sealing these between the boards.
- Installers of bathrooms, shower rooms, fitted kitchens, etc. should be instructed to seal any[2] holes they make when fitting their equipment.

---

[2] The building must conform to the ventilation requirements requiring sufficient air for human occupancy and to prevent condensation that can occur in very well sealed buildings, but with traditional stone buildings these

- A requirement to pressure test newly refurbished rooms is the only way to ensure tradesmen seal rooms adequately.

6. Guidance for installing insulation

a. Avoidance of condensation in wall cavities

Avoidance of condensation in wall cavities or on the timber structure of a house is paramount. The temporary comfort and cost saving through new insulation will be completely nullified if dry or wet rot develops in structural timber or a building surveyor reports adversely that insulation has been installed in such a way that could result in condensation in wall spaces. To minimise such risk when installing insulation, the following guidelines are suggested: -

- Where no vapour barrier is present, or cannot easily be installed, permeable insulation materials like glass fibre, rock wool, should be used for insulation

- When no vapour barrier is present and permeable insulation is used, there should be enough wind induced air movement in the wall space where the insulation is installed to remove any condensation that does occur in the permeable material

- Since on occasion permeable insulation may become wet for short periods of time, it is safer to use inorganic materials that will not rot or become a home for moths during these periods

Figure 6.1 Insulation materials clockwise from left a) 25 mm Kingspan, b) top Styrofoam/ plasterboard composite , c) right 50 mm Celotex, d) bottom Knauf mineral wool slab

- Where a vapour barrier like aluminium foil is present, sheet insulation boards can be used such as 1) foam sheet, sandwiched between two layers of aluminium foil Figure 6.1) (e.g. Kingspan or Celotex), or 2) a closed cell, extruded foamed polystyrene board (e.g. Styrofoam, Styrodur or Polyfoam) not the expanded, open cell, polystyrene as in coffee cups.

These guiding principles lead on to more practical guidance: -

minimum rates are usually exceeded many times over though leaks in floor boards, skirting boards, window surrounds, etc.

- Lath and plaster ceilings should only be insulated with glass fibre or rock wool laid in the roof space above
- Insulation below tongue and grooved timber floors should be glass fibre or rock wool, unless a vapour barrier like a rubber carpet underlay is always going to be present
- When lath and plaster walls are replaced by insulation and plasterboard, the insulation can either be sheet insulation or mineral fibre. Using plaster board with an aluminium film backing, while not strictly necessary, will give added protection from vapour penetration when using board insulation and should prevent occasional condensation in porous mineral materials. It may also allow the use of organic fibre materials.

Other factors may influence choice of insulation, but these will be dealt with later.

b. Protective clothing and face masks

Carrying out refurbishment in old houses is both dirty and dusty, so getting the right clothing and protective equipment is vital. The following equipment is recommended: -

- Coveralls
- Kevlar gloves (Showa Cut resistant gloves**.** 9/XL 541. Showa Europe, Tour Frankln, La Defense 8 92042, Paris La Defense Cedex- France. www.showa-europe.com)
- Steel toed boots or work shoes
- Bump hat, i.e. a cap with a plastic insert to cushion the head against bumps
- A head torch for working in dark places
- A half face respirator

The bump hat (Figure 6.2) is better than a hard hat for working in lofts, as it is light, grips on the head well and in comparison, with hard hats, projects only slightly above the top of the head. When working in dark spaces, a head torch can be fitted round the cap, to illuminate the working area.

Figure 6.2 Bump hat and twin filter half face respirator

After trying several disposable respirators, I gave up on them all as being only partially effective, and purchased a 3M, respirator, with two replaceable filters (Figure 6.2). This respirator really does keep out the dust. It seals well even when you have a lined face, and the valve lets the exhaust air out in a direction that does not mist up spectacles. Some H&S personnel now stipulate force ventilated respirators, to exclude the possibility of the operator sucking in dust particles when he or she breaths in. This approach is to be recommended.

Figure 6.3 Black and Decker draught detector

c. Specialist tools required

While most tools needed for refurbishment are conventional wood working or stone working tools, some specialist tools are required: -

- Electric jig saw with tungsten carbide blades for cutting lath and plaster
- Detector to locate studs and wire cables behind lath and plaster
- Portable circular saw with depth guide for cutting floorboards without cutting into joists or trailing electric cables
- Portable router for grooving door frames or doors to take seals
- Air leakage detector for checking for leaks round windows, skirting boards and doors (Figure 6.3). Can also use for detecting areas of high heat loss through walls and ceilings due to missing sections of insulation (e.g. poor injection of cavity walls)
- Multi tool for cutting across floor boards, cutting lath and plaster to fit switch boxes and for sanding varnished wood surfaces
- House pressure test rig, which fits within a door frame, to test building for air leaks. This is normally hired with an operator to provide a pressure test report. (See page 46)

7. Sealing the building exterior

The first job is to seal the external doors, windows and fireplaces. This may mean replacing doors and window frames, fitting double glazing and boarding up unused fires, or it may instead mean fitting seals to existing doors and windows. If the house is even minimally exposed to wind, this is the most important task in refurbishing a house.

a. *New doors and windows*

The easiest way to achieve sealed doors and windows is to install new ones. All new building products should have British Board of Agrément (BBA) certificates that specify that the items have been tested for air leakage, insulation value, etc. Three aspects are involved in ensuring the window or door does not leak, the design and quality of the product, defined by its BBA certificate, the seals used and the quality of the installation. Having spent three years getting my new sash and casement uPVC windows to be reasonably draught proof, I would advise any householder to defer the last 20% of the total payment for the windows until after the first gale of wind blows directly on to the side of the house where the windows or doors have been installed. Either by using the back of your hand to sense draughts or by using a thermal imager type draught detector (Figure 6.3), the window can be checked for air tightness. A satisfactory result will trigger the final payment.

Part of the problem, I suspect, is that uPVC, the most common material now used in the UK for windows and doors, bends, so that rubber seals are most compressed near handles, hinges or bolts, and less so as the distance from these increases. The use of multiple handles or bolts (Figure 7.1) minimises this problem but add to cost and change the appearance. Windows using a stiffer structural material like well-seasoned, good quality wood (e.g. Velux, Velfac, NorDan) or uPVC coated aluminium, would appear to suffer less from this problem. Sadly, there is a “race to the bottom” to minimise price, as UK householders tend to buy on price rather than quality. This is what caught me out with our sash and casement windows. Having previously purchased excellent, well-sealed windows from what I believed was a trustworthy source, I did not properly check the BBA of the new windows quoted. These did not have the aluminium core of our previously purchased windows, nor did they have a BBA certificate, despite the supplier suggesting they had. I just thought that if the previous windows were fine the new ones would be good too. A big mistake! At the time of writing the window manufacturer, Veka, do have BBA certification for their pivot windows but not for their sash and casement windows.

Figure 7.1 uPVC door with multiple bolts and latches to counter plastic deforming

With pivot windows, compressible seals are used. So long as the window frame does not bend excessively, and the seals are properly fitted, these give a good seal. With sash and casement windows, with the sash sliding past the casement, a brush seal must be used. Airflow and rain can force their way through the brush, so it is essential that the

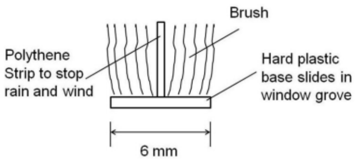

Figure 7.2 Brush seal with a polythene strip insert

brush is fitted with a polythene film insert in the centre of the brush to minimise this potential leakage (Figure 7.2). Not all window installers use this type of seal.

With both pivot and sash and casement windows, the installers must ensure the gaps between the windows and the jambs (fixed frame) or casements are uniform and that the seal matches the gap. Careful final adjustments are needed to ensure this. The recommended final 20% payment encourages tradesmen to take this adjustment seriously.

Green campaigners sometimes have an objection to the use of uPVC as they can produce dioxins when burnt. While this is true, window frames should last 50 + years so it is not like using PVC for packaging, with a life in weeks. In addition, companies like Veka recycle and reprocess this material so that it provides the core of their new windows. This both locks up the uPVC and saves on the energy used to make virgin plastic.

b. Sealing existing windows

Building purists, especially those concerned with preserving traditional building standards, will usually prefer to maintain the original timber windows, and upgrade these rather than replacing them with uPVC. I too was initially persuaded to follow this route. Before doing this several aspects should be considered.

Figure 7.3 One of these three sets of windows is timber. Which one?

- There should be no rot in the jambs or windows, or if there is, it should not be extensive; rotten windows are often not worth repairing. Timber windows require routine painting every few years, while uPVC windows do not

- Next time you walk down a street of traditional stone houses, try to identify which have timber and which have uPVC windows. Figure 7.3 shows two uPVC and one timber window. Which is which and does it stand out?

- Upgrading single glazed sash and casement windows to accept double glazed units increases the depth of the rebate needed to accept the thicker window and may require that the gap between the panes be less

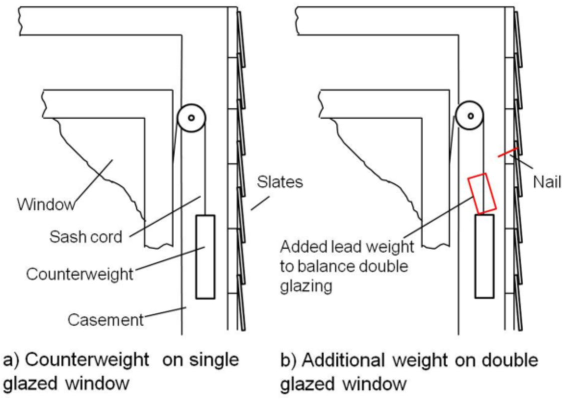

Figure 7.4 Adding weight to counter double glazing can give problems

than the preferred 20 mm, increasing their U-value and heat loss. The windows may not be of enough width to take the wider glazing.

- Upgrading single glazed sash and casement windows to accept double glazing increases the weight of the sash window frame. The existing sash weights therefore no longer counterbalance the frames and their new double-glazed units. Ventrolla, a franchise company which installs a system to upgrade timber windows, solves this problem by supplying a length of lead cylinder, with a hole through its centre, which can be fitted to the top of the sash weights. The sash window with the new double-glazed unit is weighed, and the required length of lead is cut and added to the top of the sash weight. While this should work fine in practice, in my house the lead kinked the sash cord slightly (Figure 7.4), resulting in the sash weight jamming in the casement where the sash weight travels. The window would open nicely three times out of four, but the sash weight would then jam. The odd nail sticking through the vertical sarking when slates were replaced added to the problem. Efforts to secure the lead to the sash weights in other ways failed as the weights are cast iron and difficult to drill. The casement was too narrow to take the width of a sleeve round the sash weight and lead cylinder. Only replacing the sash weights totally with lead, a costly solution, would have solved the problem, but by then I was exasperated and decided to replace the windows with uPVC.

- The casements where the sash weights rise and fall are open to outside. The holes required for the pulley ropes provide a point for air leakage. While the Ventrolla system of seals fitted to the window frames is effective, the quality of the result is totally dependent on the installer doing a good job. Our installer had only one aim, which was to do the job as quickly as possible, so he could get on to another job.

- Improving the sealing and insulation of timber windows using secondary glazing, while effective from a heat conservation point of view, does make opening windows difficult and may result in condensation on the internal surfaces of the glass and the accumulation of dead flies in the airspace between the outer and inner windows. It is useful as a temporary solution, or where single-glazed, coloured glass windows are to be preserved. We have used Glaze and Seal Ltd magnetically secured Poly Carbonate secondary glazing to test their system out.

The decision to keep or replace existing windows is a difficult one. Good money can be spent on upgrading windows which will ultimately be replaced by new. If the windows are in first class condition and the sash weight problem is easily sorted, it may be worth keeping the windows. In all other cases replacement is probably the best approach.

Figure 7.5 Trough and drain hole under front door

c. Sealing existing external doors

While there is often debate about whether to replace windows, in traditional houses the front doors are a real feature and it is a shame to replace them with a modern plastic door, sometimes supplied in imitation grained wood. However, properly sealing a large front door is a major task. The problems are as follows: -

- A trough is often cut in the granite slab under the base of the door to collect rain water, with a drainage hole from the trough through the slab to allow water to drain (Figure 7.5). This is the first point of air leakage.
- The letterbox is usually a slot cut into the door, often fitted with a brush seal, which has little effect in keeping out wind.
- Hinged draught excluders are usually fitted to the base of the front of the door (Figure 7.5) which pivots to seal the base of the door as it closes. As the door step is rough granite, this only seals where it touches, with gaps between.
- Countless generations of cold home owners have applied either 1) plastic or copper sealing strips which seal where they touch, or 2) adhesive foam rubber strip, which is only effective if it compresses when the door closes. However, the foam strip makes the door difficult to lock or unlock. You need to press the door hard against the foam strip to get the mortice lock to slide open or shut. At worst the key breaks due to the force required to turn it.

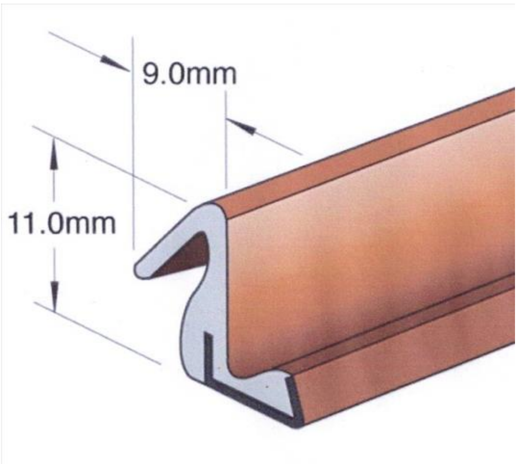

Figure 7.6 Cross section of Aquamac Seal

Having tried several approaches, I have found one to be really effective, the AQ21 Aquamac seal (Figure 7.6). This seal offers little resistance to the door closing, so there is no need to lean on the door to lock it. It can be fitted to either the door or the door frame. It is fitted to three sides of the door, to the top, the opening side and the bottom. Foam strip is used to seal the hinge side of the door, as the hinges prevent a groove being routed. At the hinge side, the pressure required to compress the foam strip has a negligible effect on the door closing.

To fit the seal, a groove must be cut in either the door frame or the door. This requires a high-speed router and a special cutter (Figure 7.7 & 7.8). Routers revolve at 10,000 rpm or more and are somewhat scary to use. For the less confident DIY person, a joiner should be employed to do the routing.

Figure 7.7 High speed router

Figure 7.8 Router cutter

The main decision is whether to cut the groove for the seal in the door or the door frame. To rout a groove in the door, requires the door to be removed from the door frame. With large doors this can be a major undertaking, as the screws in the hinges can be difficult to undo and may get damaged or break in the process. The groove cannot be made where the lock is, so this is a point of air leakage. Once the door is off, the groove can be cut in the door relatively simply.

Figure 7.9 Aquamac seal fitted by hand into top corner of door frame

Figure 7.10 Seal fits behind striker plate

If it is decided to put the groove in the door frame, two problems arise. The first is to check for small nails, used to fix sealing strips in the past, which must be removed before routing can begin. The second is that the router cannot get into the corners or the door frame. The groove here must be made by hand with a chisel (Figure 7.9). The brass or steel striker plate, which accepts the Yale or mortice lock, should be removed to allow a grove to be made behind it (Figure 7.10). On balance, I have always routed the door frame in preference to the door.

To rout the door frame, the distance between the door and the frame must be measured. If it is wider than the height of the seal, (i.e. 6 mm), then a filler piece of wood of a similar colour to the door frame should be installed. The width of this filler should leave a gap of 3 mm between it and the door to allow the door to close. With external doors, the gap should be wider in summer than if the job is done in winter to allow for the door frame swelling in damp weather. This filler piece will need to be glued to the door frame with PVA glue or similar, as the groove will probably cut through it.

Figure 7.11 Timber batten with Aquamac seal fitted in trough under door

To seal the base of the door, a timber batten should be made, to fit under the door in the drainage channel. Once its thickness is determined, it will be routed, and a seal inserted (Figure 7.11). A hardwood batten should be used as this batten could be wet for much of its life and would otherwise rot. The batten needs to be fixed to the door step with Rawlplugs and screws or one of a variety of modern fixings that are now available.

The strip is located so that the leading edge or “hinge” of the strip faces the door as it closes (Figure 7.6 & 7.10).

d. Sealing internal doors

Internal pitch pine doors are easier to remove and are lighter than front doors, though still heavy. There is also less likelihood for small nails to be left in the door frame. Grooving them is like the main front door. The router creates a lot of dust so if routing the door frame in situ it is worth hanging dust sheets, one on either side of the door, to contain the dust. If the door is removed the routing can be done outside or in a workshop, which avoids the mess in the room. If carpets are fitted either side of the door, they must be trimmed back to allow space for a timber batten, already grooved to take a seal, to be fixed to the floor. (Figure 7.12).

Figure 7.12 Carpet cur back in internal doors to accept the under door seal

e. Sealing skirting boards

Sealing skirting boards and filling in gaps in cupboard linings is best done with a sealing gun (Figure 7.13). For varnished wood Everbuild Crystal Clear Sealant is best. It comes out as a white bead, but over time dries to a hard, translucent glass like plastic. Translucent silicon can be used, but is sticky, so attracts dust. For painted surfaces, cheaper painters' caulk can be used. With the double skirting as we have in our house, there can be a gaps between floor and skirting, lower skirting and first moulding, first moulding and the second (higher) skirting, the second skirting and top moulding and the top moulding and wall, five gaps in all! Old houses are hard to seal!

Figure 7.13 Using a sealant gun to fill gaps in skirting boards

8. Heating system

a. Zoning the heating system

When traditional houses were converted from coal fires, to gas and electric fires and then again to central heating, the initial concept of only heating the rooms being occupied was replaced with heating the whole house. In these traditional houses, where even with refurbishment, relatively high heat losses cannot be avoided, this is a wasteful energy policy. It is therefore worth reviewing the central heating system, to see if it can be re-plumbed into zones, which can be switched on at different times of the day. An alternative solution is to fit wireless operated radiator valves, so individual radiators can be instructed to come on at different times and at different temperatures.

The previous owner had already separated the heating system into two zones, downstairs and upstairs. By re-routing and extending the pipe leaving the main valve to a central point in the heating system, and fitting two additional motorised valves, three zones are created. These are:-

1. The bathroom and hall are always on when the heating is on.
2. Zone 1: - The kitchen, and dining room are switched on 7-9 a.m., 5.30 -6.30 p.m.
3. Zone 2: - The lounge is switched on 6 p.m. – 11.00 p.m.
4. Zone 3: - Upstairs is switched on 6.30-8.00 am and 8-11 p.m.

Figure 8.1 Control boxes, top one for zones 1 & 2, and bottom for zone 3

The problem with such a system is that occasionally the dining room will be needed on some evenings and the lounge on some mornings. A little forethought is therefore required to manually switch the heating to on for these rooms before they are needed. If zones can be very simply switched on and off, possibly by using a mobile phone app., then switching on and off the different zones is more likely to be used. If this is difficult, this may result in home owners having all the heating on in the house, resulting in higher, wasteful energy use.

b. Controller

A typical control box is shown in Figure 8.1. Most control boxes are not easy to set. The more options they have, the more difficulty people have in setting them. Usually only one person in the family knows how to set the control box, with others fearful of changing settings. Some people choose simple timers that use pins to switch on and off the heating, as these are visually easy to understand. These, however, do not allow for weekend heating to be different from during the week, or different days having different requirements. The desire for a simple controller usually results in having heating on for longer than is needed. To minimise heat use in practice therefore, the control box should be easy to understand and alter, while offering all the options the user wants.

c. Control of individual radiators

All the radiators in our house were fitted with thermostatic valves by the previous owner. This is superior to having radiators brought on by a single thermostat located in the hall or lounge. If a fire is lit in the lounge, or sun streams into the dining room, the radiators in that room will shut down if the temperature in the room rises above the radiator valve’s set point. There are however some problems that should be avoided.

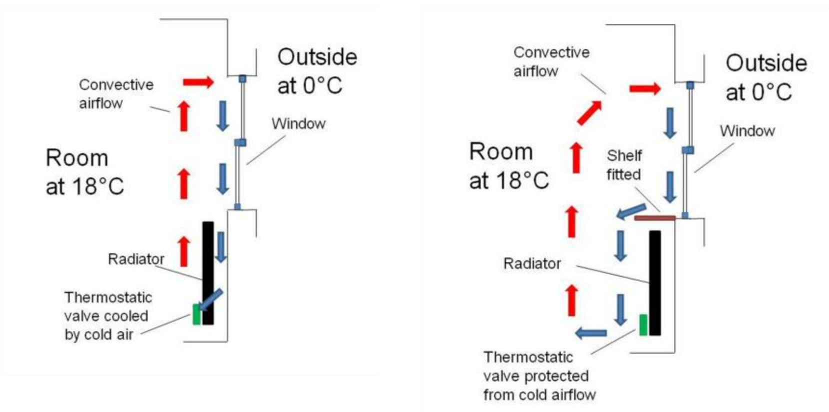

Figure 8.2 Convection airflow if radiator located under window without shelf (left) and with shelf (right)

Radiators are often fitted under windows, to free up walls where furniture or bookcases are located. In cold weather, a convective airstream develops, whereby air, cooled by heat loss through the window, will drop vertically downwards over the radiator (Figure 8.2). The valve on the radiator is therefore cooled by the cold airstream, so that the radiator keeps pumping out heat regardless of the temperature in the room. In such a situation the radiator valve should be controlled by a remote sensor on the wall, which is not affected by this cold downward airflow.

Radiators under windows can also be behind curtains, when these are shut at night. The area behind the curtain therefore becomes warm, resulting in greater heat loss than if the radiator were on the inner side of the curtain. By widening the shelf in the dining room, and cutting the length of the curtains so they stopped at the shelf (Figure 8.2 & 8.3), this downward cold flow of air is diverted away from the radiator valve, and the insulation value of the curtains maintained, so that the room air warmed by the radiator is kept on the room side of the curtains. To avoid these problems, it is best to keep radiators away from windows.

Figure 8.3 Shelf fitted to allow curtains to be shut and to deflect downward cold convective airstream away from radiator valve

Children and many adults do not appreciate that radiator valves do not control room temperature if they are turned full on. If the occupants of the room are cold one day, they turn the valve full on, then find the room too hot in normal weather. This is where windows tend to be opened to cool the room rather than turning down the valve.

d. Smart phone operated heating controls

The ability to switch heating remotely using a mobile phone when away from home avoids the need to leave heating on, just so the house is warm when you come home. Equipment now available to do this depends on how your heating system is controlled. If you have a single thermostat in your hall or lounge, that controls the whole house, this can be replaced by wireless thermostat that communicates with your house Wi-Fi router (modem). The HIVE, Nest, or Tado systems work on this principle and cost £200 – 250, plus a relatively small installation charge.

If you have thermostatically controlled radiators, and want to control the temperature of rooms individually, you need to have a system that uses Wi-Fi connected radiator valves that communicate to a central hub. The Honeywell Evohome system that does this cost £250 for the base unit plus £50 per radiator valve. In our house, with 12 radiators, this would cost £850 plus the fitting charge. Now the link between the hub and a smart phone is on/off, but this is likely to be improved to give greater remote control. By adopting this system, the need to split the heating system into zones using motorized valves is unnecessary, as the individual control of radiators provides any zoning required.

e. What to do with open fires

As discussed at the start, the chimneys of open fires provide a continuing escape route for air warmed by radiators. The efficiency of fires is often quoted as in table 8.1 below.

Table 8.1 Approximate efficiencies of fires (Ref: Manufacturers leaflets and Features fireplaces)

Type of fire	Efficiency (%)	Chimney or ventilation required	Vent sealed when fire off
Coal fire, with restricted throat	10-25	Yes	No
Coal effect gas fire with heat exchanger	35%	Yes	No
Gas fire, glass fronted	75-85	Yes, but restricted to feed combustion only	No
Flue-less catalytic gas fire	70-80	Requires large room, or some air leakage into room	No
Multifuel/wood stove	78	Yes	Chimney can be closed when not in use
Electric fire[3]	100	No	Yes

[3] Electric fire is 100% efficient in that it converts all the electricity in to heat, but electricity generation from gas or coal is about 35%

The efficiencies may well be true when the fire is operating but if the chimney remains open when the radiators are on, or even when the fire has gone out, there will be a continuing heat loss up the chimney if an open chimney is required.

Figure 8.4 Inserting a slide into a coal fire to block off the chimney when the fire is off

After much deliberation as to what to do with our coal effect gas fire, our eventual choice was to install an electric 2 kW convector fire with a coal-effect light, to give cheer on dark days and a focus to sit around. It obviously will use electricity at 14 p per kWh, rather than gas at 4 p per kWh[4], but we rarely use any but the coal-effect light, as radiators heat the room. Despite my asking the installer to seal both the chimney and hearth, a significant draught came from this new fireplace in windy weather. On calling back the installer, he apologised and said that he had forgotten to fill the gap between the lath and plaster and the stonework. When he had gone after doing this sealing, I found he had used porous glass fibre to fill this gap, so this is another source of leakage that I had to fix.

In the lounge, I fitted a removable slide (Figure 8.4) to seal the chimney when the fire is off. This slides in and out well, with the only problem being that of forgetting to remove the slide prior to lighting the fire. A room full of smoke provides early indication of this but is obviously a risk with such a system. Unless this approach is somehow made failsafe, this is not a long term solution.

Again, after much debate and concern about changing the character of our lounge, we decided to install a 5 kW multi-fuel stove (Figure 8.5), as it seals the chimney when it is not in use and is more efficient than an open coal fire. It was hoped that the stove would be less dusty than the open coal fire. While a back boiler connected to the hot water tank was considered, it was felt that this would add an unnecessary complication to the stove installation. The stove requires anthracite “ovoids” if a coal fuel is to be burned[5].

---

[4] The 4p per kWh assumes a gas boiler is 75 % efficient

[5] While not mentioned by the salesman, the handbook that came with the stove advised that it should be used with anthracite smokeless ovoids rather than house coal, as the latter could cause explosions within the stove and smoke up the glass. The term multi-fuel is therefore somewhat misleading.

Figure 8.5 Old coal fire on left with new wood/anthracite stove on right

The concern about the appearance turned out to be a non-issue, as we like the appearance of the stove. It always looks smart, as you cannot see the ash. We took the opportunity of the refurbishment to change the marble fireplace and mica tile surround to a wooden fireplace with maroon tiles. The stove works well using either the ovoids or the wood off-cuts left over from the house modifications, and I suspect coal, free of stones, would be suitable to burn, though this would have to be approved by the supplier. It is much less dusty than the open fire. It can be allowed to go out an hour and a half before bedtime as it retains its heat for a considerable time after all the fuel is burnt. Once the stove warms up and starts giving out heat, the thermostatically controlled radiators switch off. The ovoids produce a continuous low-level heat with less need for re-stoking compared to when using wood alone. Solid fuel use, in the past using only coal in our coal fire, but now ovoids and wood, has decreased from 1000 kg per annum to a coal equivalent of 340 kg, a reduction from £340/annum to £115. In practice the actual cost is very much less as we have so much old wood cuttings plus logs from friends with land, our use of ovoids is just enough to keep the wood burning constantly. Converting from an open fire to a stove should have been one of the first things we did.

f. Managing a house with a zoned heating system

When central heating systems were originally installed, homeowners tended to leave many of the doors between rooms open. From a psychological point of view, this allows light into the whole house through the windows from the various rooms and gives a feeling of brightness within the house. The whole house is at approximately the same temperature.

A zoned house in contrast, has rooms at different temperatures. With doors left open, air from the kitchen, for example, will rise due to its buoyancy upstairs to bedrooms. Cold air from the bedroom will sink downstairs, due to being denser than the warmer air, and create a draught and cool the kitchen. This results in a circulation of air between the two rooms, with the cold air flowing along the floor, cooling the radiator thermostats in the warm rooms and thereby keeping the radiators pumping out heat. Zoned houses therefore require that doors of rooms are kept shut in winter. We now therefore keep our bathroom and kitchen doors shut, as the hall with its large expanse of lath and plaster wall, tends to be cold.

A further problem with leaving doors open occurred with our bedroom. With the bedroom heating off until 8 pm, and the kitchen door open, warm humid air from the kitchen would float upstairs to the bedroom. As the bedroom was cold, the inner pane of the double-glazed windows was also cold, so the warm humid air from the kitchen condensed on the glass and wet the window sill. If the room were kept warm, this would be less likely to happen, but more energy would be used. By shutting the bedroom door, the warm humid air from the kitchen cannot enter the bedroom, so this not only solves the condensation problem but also saves energy.

9. Refurbishment of individual items and rooms

In the following section I relate my experiences in refurbishing the various rooms in the house, to illustrate what I did and what problems were encountered along the way. The order of sequence was partly based on doing the coldest rooms first, but also by which rooms were in greatest need of redecoration or refurbishment.

a. Windows, doors and roof

On moving into the house, we replaced the leaky wooden back door with a uPVC door, the timber windows with uPVC sash and casement or pivot windows and sorted the damp patches in the upper rooms by getting the skews, where the roof meets the gable and the party wall of our semi-detached house, sorted. With the external fabric of the building relatively well sealed we could then start on the rooms.

b. Conversion of dressing room to an en-suite

A dressing room off our main bedroom provided the opportunity to convert this room to an en-suite shower, hand basin and toilet. As the roof needed to be repaired anyway, we decided to replace the small skylight window with a Velux window. The room being in the corner of the house, with two of the walls being external, we decided to replace the lath and plaster of these outer walls with composite insulation panels. This development required a building warrant, so a building's surveyor was employed to draw the proposed changes and a warrant was subsequently obtained.

Figure 9.1 Removing lath and plaster in slabs

Having taken down a lath and plaster wall in a previous house and being overwhelmed by the dust in the air and the volume of plaster needing to be dug out, I decided to minimise the amount of dust by cutting the plaster out in slabs (Figure 9.1) using a powered jig saw.

It is critical to check for any cables or pipes behind the lath and plaster, and to know where the studs are, so that the jig saw does not cut or hit these items. By using a stud and metal detector (Figure 9.2), the position of these can be marked on the plaster and the jig saw operated to avoid them.

Figure 9.2 Using a Bosch detector to find the location of studs and electric cables

Taking out slabs of plaster in this way really cuts down the dust that must be dealt with. They can be immediately put into heavy duty rubble sacks, for easy disposal to landfill. However, the jig saw blades rapidly wore out, due to fine stones mixed in with the plaster. Changing to (more expensive) tungsten carbide blades solved this problem.

Figure 9.3 Sealing the en-suite toilet waste pipe from air ingress

Once the lath and plaster from the coombe ceiling and the two external walls had been removed, the slaterers installed the new Velux window. The plumber fitted the water pipes and waste pipes for the shower, sink and toilet. I then fitted a new 6 mm waterproof (WPB) plywood floor and sealed round the base of the toilet waste pipe (Figure 9.3) to ensure that there were no draughts (This was seen by the plumber as unnecessary).

I then fitted a composite panel of 25 mm Styrofoam glued to 12.5 mm plasterboard (Figure 9.4). The latter is used to delay the spread of fire if a fire occurs. As glass fibre was to be installed in the rest of the combs, it was put in the roof above the combs.

Skirting boards were fitted along the base of the walls and the gap between them and the floor sealed with a filler from a sealant gun. The walls and roof of the en-suite was then plastered. The plumber and electrician returned to fit the shower and connect the electrics. To get the shower tray to fit closely to the wall, the plumber removed part of the skirting board. This undid my efforts to seal the room from draughts and resulted in an exchange of views between me and the plumber and required my having to seal the whole perimeter of the tray.

Figure 9.4 Fitting composite panel to studs in en-suite

Assessment of the en-suite

The en-suite is now completely draught free. My sealing on the toilet waste pipe and shower tray has been effective and the Velux window seals exceptionally well. We fitted an electric heated shower, with a pump to compensate for the low head between the shower and the tank. We should (and subsequently did), have gone for a pressurised water system that used gas heated water from the water tank. This would have given us hot water for about a third of the cost of water heated by electricity. The main mistake we made was to bring the water pipe to the shower down between the wall and lath and plaster (Figure 9.4) and the piping to the sink down the roof comb. Both freeze regularly, but luckily do not burst as they are plastic pipes. I retro fitted a thermostatic controlled trace heater (Thermotex, www.thermotex.co.uk) cable to the pipe to the shower, so this no longer freezes.

Figure 9.5 Skirting board fitted where fireplace had once been

c. Redecoration of bedroom

Figure 9.6 Sealing the floor and skirting board (left) prior to fitting the carpet underlay (right)

Once the en-suite was completed, we redecorated the adjoining bedroom. A skirting board was installed along the wall which used to have a fireplace (Figure 9.5). The moulding on top of the skirting board was retrieved from another old house. The gaps between the skirting and moulding were sealed prior to being fixed to the board. As we were replacing the carpet, I took up the carpet myself and sealed the gap between the skirting board and the floor with 75 mm wide, silver coloured, fabric tape (Figure 9.6). I then asked the carpet supplier if his fitter would seal the carpet underlay at its edges and where the sections of underlay met. The supplier said this was not possible. However, when I explained my requirement to the fitter when he arrived, he willingly agreed. He taped the underlay around all its edges, then fitted his gripper bars over the tape (Figure 9.6, right). He said that this was no trouble. The carpet was laid in the normal way.

Assessment of bedroom

On a windy, cold day the bedroom was still cold. The seals on the 10-year-old uPVC pivot windows leaked in places. We temporarily taped up the windows with white tape, which reduced the draughts. The room was still cold on cold nights and I suspected that the heat loss on both sides of the dormer exceeded what the radiator could supply. We called in the window installers, who checked the windows and adjusted the small cams that allow the seals to be more compressed. This modification failed to improve the situation, so the bedroom remained cold. This has now been rectified as described in page 45.

d. Refurbishment of the kitchen

We wanted to refurbish the kitchen for several reasons. It was cold. It had draughts coming from behind the kitchen units that we could not access to seal. The carcasses of the kitchen units were starting to break up. The electric hob was old and there was a large chest freezer with a damaged seal that we were unable to replace. The external wall was part stone and part brick, and the lath and plaster had been replaced by 12.5 mm plaster board.

We wanted to remove the kitchen units, take out the plaster board, insulate the walls and install a new fitted kitchen. When I asked the foreman of a joinery company to assess the job, he thought we were mad to undertake such a major refurbishment. We decided to go ahead despite this. In order to make the joiners feel that they were not removing perfectly good kitchen units and plaster board, I moved the best parts of the kitchen units upstairs to my workshop, so when the joiners arrived the room looked in need of refurbishment. Some

Figure 9.7 (a) Hammer punctured plasterboard, (b) cut skirting to board to allow kitchen unit to fit snug against wall and (c) unsealed hole for wiring

of the sources of the draughts were now clearly visible (Figure 9.7). The joiner nailing the plaster board into position many years ago had missed the nail and punctured the plasterboard. (This is why screws rather than nails should be used to secure plasterboard). Holes at the base of the wall, where the skirting board was removed to allow the kitchen units to fit flush to the wall, allowed draughts as did access holes for cables and pipes.

A team of three joiners then removed the plasterboard, installed 50 mm Kingspan insulation board between the studs in the outer wall and 25 mm Kingspan in the party wall, where our semi-detached house joins our neighbour’s house. There was less space to take the insulation while leaving a 50 mm airspace in this wall and as it was a party wall, the temperature difference was not as great as on the outer wall. The Kingspan was kept in position using 75 mm aluminium tape to join the board to the studs (Figure 9.8). Once this

Figure 9.8 Plasterboard removed leaving studs, Kingspan inserted between studs, with composite panel on top, and final result prior to the sealing of windows.

insulation was in place, sheets of composite Styrofoam/plasterboard were put in place and screwed to the studs. Screwing plasterboard into place prevents the damage to plasterboard if nails are miss hit. The room was effectively reduced in width by 50 mm, due to this addition, but the reduction was hardly noticeable. The company’s foreman suggested we replace the double glazed, 6mm airspace, timber pivot windows with new uPVC windows, with 20 mm airspace between panes, as the timber windows were well through their life. This we did. The room was then skim plastered throughout.

The fitted kitchen supplier was instructed to avoid making any holes in the kitchen wall linings, with the threat that we were going to pressure test the kitchen following installation, and any leaks were to be made good. He eventually agreed that he would make every effort to ensure the installer kept the kitchen as sealed as possible. The result has been an almost completely sealed kitchen, where the only significant air leakage is through the closed (!) trickle ventilators on the pivot windows, which moan and groan in windy conditions. These trickle ventilators are required by building standards, and while they are a point of leakage, they do have a safety role in ensuring some ventilation in very well sealed houses.

Figure 9.9 Airing cupboard

Figure 9.10 Kitchen with new units installed

The previous owner had made an airing cupboard around the central heating boiler. This was recreated (Figure 9.9), and the hot water tank given extra insulation by surrounding it with glass fibre. The final installation is pleasing to the eye (Figure 9.10).

The roof space above the kitchen had had 100 mm glass fibre installed, but this had slumped to 50 mm. A large galvanised water tank in the roof space had to be cut into pieces using a jigsaw and then removed to gain access to the roof space. The roof height was so low that it was only possible to crawl across the joists. Crawling boards made from old chipboard were installed to enable access. The first layers of insulation went below the crawling boards. Once all the boards were laid and screwed into position, an additional layer of glass fibre was laid above the crawling boards, while retreating towards the roof hatch. Over the course of this work, a mobile phone was kept to hand in case I became totally stuck and needed help to escape!

Working in such confined conditions full of glass fibre dust, wearing a face respirator, steamed up glasses and a bump hat, and hardly any room to move is unpleasant and may be unacceptable for employed insulation fitters or joiners. Because it is my house, I was prepared to put up with these unpleasant conditions, for the long-term benefit from the improved insulation.

Assessment of Kitchen modifications

All modifications to the kitchen have been very successful. The leaks from behind the kitchen units have gone, the room is warm, and the airing cupboard was used in preference to the tumble drier, saving considerable electricity. Only in the strongest of winds is there enough air leakage through the trickle ventilators to blow the kitchen door shut.

Fitment of a new boiler

In 2013, our 12-year-old condensing boiler, which had needed regular repairs, finally failed. Its aluminium heat exchanger had corroded away. We were persuaded by the plumber to fit a Glow worm condensing combi boiler with a 35 litre hot water tank within it. This allowed us to dispense with the gas heated 140 litre hot water tank. The boiler came with a pressurized water system enclosed, so that the water supply and central heating header tanks in the loft could be dispensed with. The results have in all but one aspect been very worthwhile. The 35-l hot water tank means a bath is filled just as quickly as before. The absence of the external hot water tank gives up more room in the kitchen cupboards. The attic cupboard is now free of water tanks, giving more room for storage. And there is now greater water pressure in the en-suite. The heat lost from the boiler and hot water tank has been reduced so much that the airing cupboard has become no longer effective. Clothes now took days to dry and started to smell. While this is a positive in terms of energy conservation, it has reduced the merit of the airing cupboard. A dehumidifier has now been purchased for £150 (2014) and is switched on for two hours whenever a new batch of wet clothes is put in the cupboard. This uses about a third the power of the tumble drier and has brought the airing cupboard back to its old effectiveness.

e. Refurbishment of the attic room

The previous house owner had either created, or at least improved, the attic space above the upstairs bedrooms. However, the insulation that had been installed had slumped to about 25mm thick in places, and the areas over the dormer windows were very difficult to enter.

Figure 9.11 Pitch pine doors not tested to BS476

A timely letter in March 2008 from Aberdeen City Council, saying they were working in close partnership with Scottish Power, to provide subsidized loft insulation encouraged me to ask for a quotation. Scottish Power's insulation contractor, Miller Pattison Ltd, duly came, spent two minutes inspecting the loft space, said the work could not be done, and left. I was left on the doorstep wondering what to do next.

This room posed several dilemmas, which even today I have failed to resolve. These are listed below: -

- To comply with building warrant, if we were to use the attic room as a living room, office or bedroom, we would need to make the doors on the first floor fireproof. As such, doors need to be designed to withstand a fire for 30 minutes and to be tested to BS 476 standard. This would require removing the beautiful pitch pine panel doors (Figure 9.11) and replacing them with manufactured doors that are designed to pass the fire resistance test.
- Access to the attic room is by a steep set of steps, which is neither a safe escape route in an emergency nor suitable for people nervous of heights (Figure 9.12)
- A stair with a turn in it could be fitted, but this would mean the employment of a structural engineer, cutting through the main roof joists and the installation of structural reinforcement
- Not engaging a structural engineer would be likely to cause problems when the house is eventually sold, as the building survey would require evidence that any modification conformed to building standards.
- The attic room became excessively hot in warm sunny summer weather, while in winter it became cold
- The presence of the floor in the loft meant that only insulation of a thickness less than the recommended 270 mm could be fitted
- The attic room was surplus to our living requirements but would provide valuable space for filing cabinets for storage

Figure 9.12 Steep steps to attic

We decided therefore only to use the attic as a storeroom. The next decision was whether to leave the loft space as it was or to refurbish it

A previous owner had laid glass fibre insulation between the joists, then put down a tongue and grooved chipboard floor on top of the joists. The glass fibre had slumped from what was probably originally 100 mm to about 25 mm in thickness, so needed to be either added to or replaced. As the side walls sat on top of the flooring, the floor could not be lifted without first removing the side walls. Their removal would allow insulation to be fed down the coombes. It was therefore decided to remove the side walls, which meant a total refurbishment of the attic.

The refurbishment chosen is as shown in Figure 9.13. The existing plasterboard was sawn into pieces that fitted into refuse sacks. The glass fibre that had backed the plasterboard was stacked up ready for spreading later over the loft space.

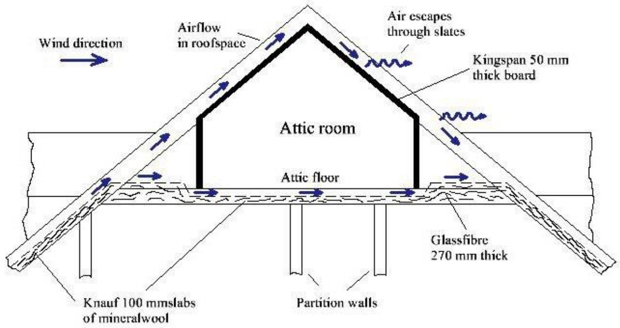

Figure 9.13 Cross section of attic room after modification

Installing insulation under the floor

A portable circular saw was purchased to saw the chipboard floor so that sections could be removed to allow insulation to be inserted below the floor and to allow the frames for the side

Figure 9.14 Left, Knauf 100 mm mineral wood slab with 100 mm glass fibre to the right; centre, brick compresses glass fibre, but does not compress mineral wool slab

walls to be fixed directly to the timber joists. A section of flooring 300 mm wide was removed from the centre of the floor, to allow insulation to be fed in under the flooring. The insulation chosen to insert under the floor was 100 mm thick Knauf mineral wool slab, as this was much less likely to slump, (i.e. reduce in depth) over time compared with conventional glass fibre wool (Figure 9.14). Feeding insulation under the floor was not easy so I felt it important that it should not have to be repeated for a very long time.

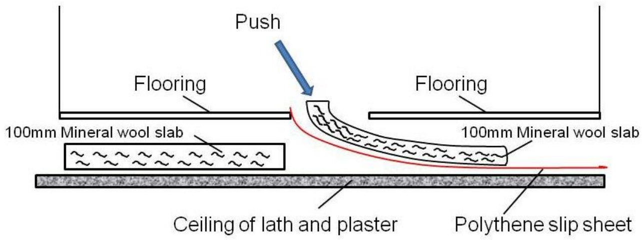

Figure 9.15 Feeding mineral wool slabs under the flooring

To insert the insulation under the floor, the 1.2 m by 600 mm slabs were cut so that they would fit between the joists. A three-metre-long by 350 mm wide piece of robust polythene was fed under the floor using draining rods. This was inserted to help the insulation slide over the rough lath and plaster fixed to the roof joists (Figure 9.15). A 1.2 m long section of insulation was then fed into the 300 mm gap that had been made in the centre of floor and slid along the polythene as far as it would go. Similar sized slabs of insulation were slid under the floor from the far end of the floor until they met the first slab. The polythene slip sheet was then removed, and a final section of slab was then inserted in the space between the two 1.2 m slabs and a section of 300 mm section of flooring screwed into position. As the joists were 150 mm deep, the space between the top of the insulation and the floor was 50 mm, which allows air to flow over the slabs and remove any condensation that occurs in the mineral wool insulation.

Inserting insulation down the combs

Figure 9.16 Rake in up position (left) and down position (right)

Some glass fibre insulation had been put down the combs but this had slumped to 25 mm. This was pulled up and replaced by the Knauf mineral wool 100 mm thick slabs. The slabs were cut to a size that would slide down between the joists. As the spacing between roof joists sometimes tapers between the apex of the roof and the eaves, this sometimes required the material to be forced into position. To cope with this, a rake type device was made (Figure 9.16). The slabs of Knauf insulation were laid on top of the thick polythene sheet used previously, and the spikes on the rake spiked through the polythene and sheet as shown in Figure 9.17. The rake was pushed down the coombe using the drainage rods, until the wall head was reached. The rake was then pulled back up, causing the prongs to go into the "down" position, which left the slabs of insulation behind[6].

[6] The rake bracket should be a Vee, to avoid it catching on projections, nailed to the roof trusses, during withdrawal

By using the Knauf rockwool slabs rather than glass fibre, it is hoped that the material will not slump over time and therefore will not require reinstalling.

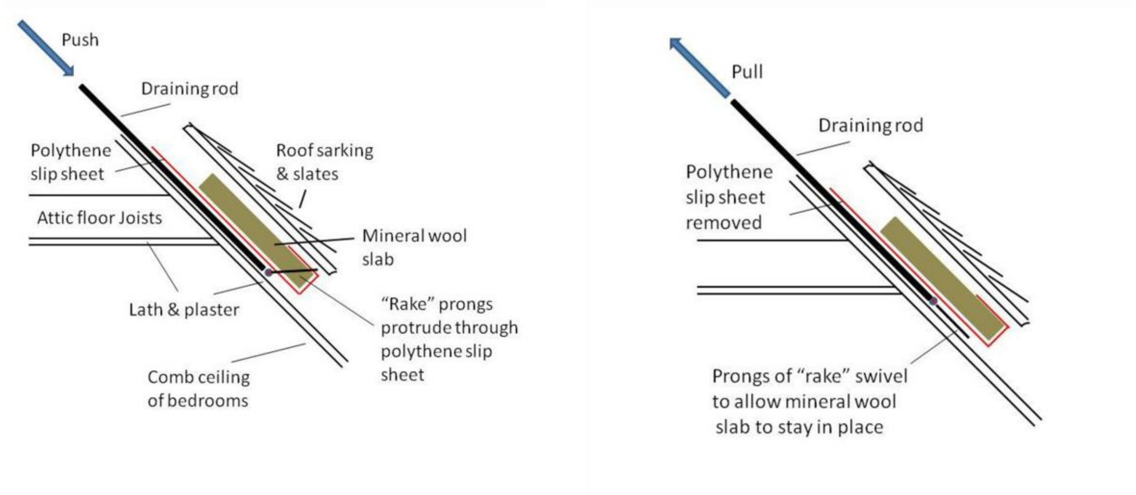

Figure 9.17 Pushing the mineral wool into position using the rake (left) and withdrawing the rake (right)

Once the coombes had the slabs of insulation inserted, the glass fibre insulation, recovered when the plasterboard from the original attic was removed, was spread over the loft floor and the loft spaces above the dormer windows, to a thickness of 270 mm.

Building the attic walls and roof

A framework to form the side walls was fixed directly to the timber joists, rather than to the timber floor as had been done previously. The framework allowed for fixing the plasterboard on all four sides with screws. Kingspan sheet insulation, 50 mm thick, was inset into the frames, and fixed to the frames using 75 mm aluminium tape (Figure 9.18). This tape stuck well on to the framework and Kingspan/Celotex and was therefore much preferable to a slightly cheaper tape with poor adhesive quality. (As with suppliers of many faulty materials, the person at the trade counter said, "We have never had any complaints about this tape before", and seemed uninterested when I stated that it simply did not stick to the Kingspan).

My delivery of aluminium foil backed plasterboard came with no foil backing, so had to be redelivered with the correct material. Having foil on both the plasterboard and the Kingspan is perhaps overdoing the vapour barrier, but as it is so easy to tear the aluminium foil during installation, this saves having to patch up holes or tears in either the Kingspan or the plasterboard. The plasterboard was then fixed to the framework and roof trusses with galvanised screws, which prevent the screws rusting, and staining the plaster, wallpaper or paintwork.

Figure 9.18 Kingspan or Celotex fixed in between trusses with tape (left); insulation covered with plasterboard (right)

Doors in the walls of the attic

Large doors sealed with AQ21 Aquamac seal (Figure 9.19) were put in the vertical walls of the attic. These allowed access to the loft space surrounding the attic and will allow topping up of the glass fibre when this is needed. They also allowed access to the shower fan, electric wiring and water pipes. An area housing the water tanks for the fresh water and central heating system was left insulated above, but not below the floor. This allowed warmth to come through from the house into this airspace to keep the tanks from freezing. Following the removal of the water header tanks, this cupboard now only stores sails and lifejackets.

The whole attic was then skim plastered to provide a uniform finish and to allow the loft to be painted with emulsion. The steep access ladder had adhesive treads fitted to the steps hand rails to hold on to when ascending and descending (Figure 9.12). Seals were put in the attic door to further seal the attic and prevent warm air rising into the attic when it was not in use.

Figure 9.19 Attic doors fitted with Aquamac AQ21 seals

Assessment of attic refurbishment

The attic room is in effect a sealed insulated box sitting on top of the house roof joists. While the ceiling of the first-floor bedrooms rooms are insulated with a mixture of 100 mm mineral wool slabs under the loft floor and 270 mm fibreglass over the rest of the loft, wind through the roof space can flow between the insulated attic and the mineral wool slabs. The thermal benefit of having the attic room over the 100 mm mineral wool is probably small. While I am tempted to seal the air access under the attic floor to ensure air does not flow over the 100 mm wool slabs, if condensation does occur here, there will be no airflow to dry it off. If I was able to prevent the migration of vapour from the first-floor rooms through the ceiling lath and plaster, I would not hesitate to do this, but I do not think this is possible without removing the lath and plaster and replacing it with plasterboard, aluminium foil and possibly 12 – 15 mm insulation board. The insulation seems to be helping to keep the attic warmer than before, so that our filed papers do not become mouldy, but the refurbishment took over a year of part time effort for a relatively small thermal gain. The job is well done, looks good and is an improvement on what was before.

f. Walk in cupboard

Our walk-in cupboard where coats and boots are stored has always been the warmest room in the house, in spite of being able to see if the basement light had been left on through holes in the floor. To seal up these holes, a 6 mm sheet or WPB plywood was laid over the floor and screwed down with 25 mm screws. The join with the skirting board was then sealed with a sealant gun. Other holes in the lath and plaster were filled with plaster. This eliminated most of the draughts. The heat was coming from the uninsulated hot water pipes running through the cupboard to the upstairs radiators. These pipes have therefore been insulated with foam tubing from B&Q, as far as is possible, since they are hard up against the wall.

Figure 9.20 Sealed cupboard round meter and consumer unit

Assessment

The cupboard is still warm but less so than before. I should have gone for EPS tubular foam piping insulation available from Sheffield Insulation, rather than the poorer insulation value grey foam.

g. Vestibule

A flood of water entering our vestibule from above the front door, demolishing some lath and plaster and exposed a rotten lintel. As we thought the lintel would have to be replaced, we decided to insulate the external walls of the vestibule at the same time. I removed the lath and plaster and then called the joiner to replace the lintel. The rot was less extensive than we thought so the lintel was left in place and we only insulated the external walls with 25 mm of Kingspan board fitted between the studs with another 25 mm sheet of Kingspan on top followed by plasterboard. The total thickness of the modified wall, between the face of the studs and the face of the plasterboard came to 25 mm + 12.5 mm = 37.5 mm in total. This kept the width of the wall within the roof frieze so even with an additional coat of plaster this refurbishment did not change the appearance of the vestibule.

The electricity consumer unit is situated within a cupboard in the vestibule. As sealing the wires passing thought the lath and plaster into the consumer unit would have required a major disturbance of the box, I decided to seal the doors of the cupboard with AQ21 Aquamac seals instead. This required fitting some extra framing and routing the doors to take the seals (Figure 9.20). This was relatively easy to do.

The major other problem was sealing the perimeter of the house front door. I fitted the letterbox with an airtight flap. A hardwood batten was routed, fitted with an AQ21 Aquamac seal, and fixed into the channel of the granite step with rawlplugs. The top and side frames of the door were routed and fitted with AQ21 Aquamac seals. The hinged side of the door was fitted with a 6 mm wide foam strip stuck on the frame. The inner door to the vestibule was sealed in the same way.

Assessment of vestibule refurbishment

Had it not been for the rotten lintel I would probably not have insulated the external walls of the vestibule, as it tends to be at a lower temperature than the hall. I would however have inserted the seals in the front and inner doors and the doors of the consumer unit cupboard. The vestibule is now well sealed, so closing of the front door must be done slowly to let the air escape past the seals. The door sealing took a lot of work, but I think it was worth it. Over the following winter, some condensation and mould became evident in the cupboard. This was probably due to warm air leaking into the cupboard. I have subsequently made two holes in the lath and plaster, to get more air movement in the cupboard and painted the wet area with bleach. No further mould has been seen.

h. **Bathroom**

Soon after we moved in to our new house, we noticed that the bathroom seemed very draughty. Using a combination of painters' caulk sealer, translucent silicone and expanding foam, I sealed gaps between the skirting boards and the floor, the timber rail and the plastered wall and where the pipes came into the sink and toilet cistern. Despite this draughts were still evident. The removal of the panel surrounding the bath revealed that the lath and plaster on the inside of the external wall had crumbled (Figure 9.21). Wind was entering via this hole. By fitting seals around this removable bath panel, the majority of this draught was sealed. I suspected however that similar crumbling of plaster had occurred behind the sink or toilet, as the bathroom still felt cold.

In 2012 we decided to redo the bathroom. The lath and plaster on the south and west walls adjacent to outside was removed. During this process a couples of holes, behind the cistern that I had failed to find, and seal were discovered (Figure 9.23). This showed just how difficult it is to seal existing fittings fixed to lath and plaster walls.

Figure 9.21 Lath and plaster crumbled by bath

Figure 9.22 Bathroom frieze

As there seemed to be a considerable cold air movement within the partition wall, between the bathroom and the dining room, I decided to insulate this wall too. All walls were insulated with Celotex EPS insulation board, followed by 12 mm Celotex sheet and foil backed plasterboard. Where there was room, 50 mm Celotex board was used between studs and where there was not room, 25 mm Celotex was used. Timber fixings (dwangs) for the toilet holder, towel rails, etc., were put in behind the insulation to provide a firm fixing for these items. The whole surface was skim plastered. Horizontal framing was installed to lower the ceiling and vertical framing erected to house the pipework for the shower. The false ceiling was lined with plasterboard, and glass fibre 200 mm piled on top. The vertical framing was insulated with Celotex and covered in foil-based plasterboard. A bath was installed with its water taps and shower fed from the gas boiler. A musty smell coming from a cupboard in the bathroom encouraged me to insulate this cupboard internally. In removing the framing for the cupboard shelving, I discovered mould growth on the unpainted wood

Figure 9.23 Why sealing with foam failed to seal holes in the lath and plaster behind the toilet cistern

where it adjoined the lath and plaster wall. This was obviously the source of the musty smell and was impossible to treat in situ. In high humidity areas such as bathrooms and kitchens, cupboards need to be insulated when the room is insulated.

Assessment of bathroom refurbishment

The bathroom is now the cosiest room in the house. The draughts have now been eliminated and the radiator has now sufficient output to more than meet the requirements of the room. The cupboard now does not smell.

i. Spare & master bedrooms

The spare and master bedrooms were treated the same way. Both have dormer windows, the sides of which were uninsulated. A cross section of the wall has lath-and-plaster on the inside, a 100 mm air gap, and sarking on the outside, on to which slates are nailed. In each room, this lath and plaster was removed together with the lath and plaster below and around the windows. The lath and plaster were replaced with Celotex sheeting between the studs, followed by 12 mm Celotex sheeting, (Fig 9.24) followed by 12 mm foil backed plasterboard. A final skim of plaster provided a smooth finish to paint on emulsion and seals the gap between the skirting boards and the wall.

In the master bedroom only, a Danish manufactured Velfac window (Fig 9.25), made with a timber frame, with external anodized aluminium sheeting was installed. Its construction is similar to Velux windows, and while expensive compared to uPVC windows, it was fitted because we knew it would be a top-class seal that would cope with the wind pressure on this very exposed part of the building.

Figure 9.24 Insulation of external wall, sides of dormer and party wall in spare bedroom

Figure 9.25 Velfac timber framed window In master bedroom

Assessment of bedroom refurbishment

The master bedroom, which was very exposed to SW winds, and which had the Velfac timber framed window fitted, has shown the most improvement, due primarily to the quality of sealing against wind. That and the improved insulation, means that the bedroom is relatively warm when we go to bed. The cold-feet-in-bed syndrome of the previous years is now a distant memory. I did think that we might have to replace the existing single plate radiator with a double unit, but the reduced heat loss by reduced air leakage and improved insulation has made this unnecessary. Perhaps as we age, we will do this. The spare bedroom in the east (normally leeward) side of the building was never as cold as the master bedroom, so the benefit from the improved insulation is less marked.

j. Hall, stairs and landing

Figure 9.26 Gaps in stair treads hidden under carpet

Figure 9.27 Secondary “Save and Glaze” plastic sheeting in front of leaky sash and single glazed feature window

A cold draught used to cascade down the stairs from the landing to the hall, in spite of all doors upstairs being closed. The removal of the stair and landing carpet revealed cracks in both the treads and in the woodwork of the stairs themselves (Figure 9.26). Some required fillets of wood to be inserted while others were narrow enough to be sealed with a sealing gun. The carpet effectively hid the gaps but did not seal them.

The feature single glazed sash and case windows, despite being “sealed” by Ventrolla, were draughty. As they would have cost over £3,000 plus each to remake as double-glazed units, we fitted Save and Glaze Ltd, Perth, Poly Carbonate secondary glazing (Fig 9.27). Apart from the darker colour of the magnetic strip that holds the sheet to the window frame, it is difficult during the day to see the glazing. At night it reflects a little so it is slightly more obvious. It does seal any draughts and looks smart.

k. Insulation of hallway gable wall

A decision to paint our hallway in November 2015 led to us to remove the lath and plaster and insulate our hallway's gable wall. The new paint showed 4-5 circles of moist plaster at different points in the original wall. This, we speculated, was due to loose plaster from the rear of the lath falling down the wall cavity and accumulating on the pegs attaching the studs to the granite wall. The accumulated plaster then acted as a cold bridge between the granite wall and the lath and plaster lining, causing condensation to occur on the paintwork.

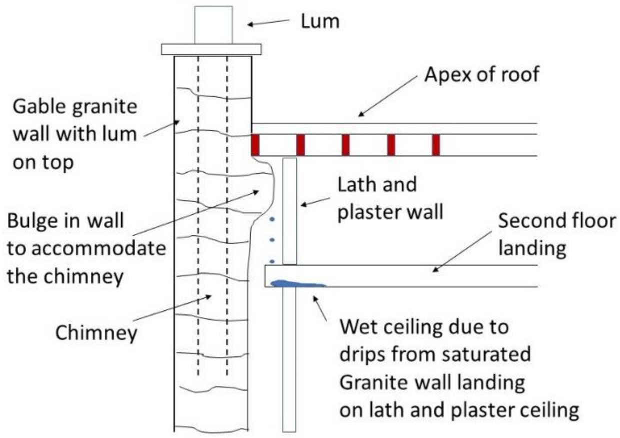

Figure 9.27 Rainwater flowing down inside of gable wall

We had known for some time that rainwater in wet periods entered the gable chimney, saturated the chimney breast and granite wall and flowed down the inside of the wall. Repeated efforts to point the chimney breast, seal the lums (chimney pots) and gable, had not stopped this happening. (See Appendix 2, p 76, for more details). This water flow may have made the loose plaster accumulating on the pegs wet, making cold bridging worse.

Instead of spending more money on slaters, we decided to strip out the lath and plaster and line the wall with foil backed insulation and plaster board. By doing this, water could flow down the wall unimpeded by fallen plaster. The cost for the joiner and materials to do this was £5,000 in total. The hallway is now warmer than before but reductions in the gas bill are not evident.

This solved the problem of damp patches at a stroke, except for one issue. As the chimney breast protrudes out from the wall, water dripped from it on to the ceiling of the first-floor landing, causing a wet patch to form (Figure 9.27). I have now inserted a heavy plastic film sheet at an angle of 45 ° in the loft space ventilated cavity, to divert the drips back down the wall. Time will tell if this works.

Our new neighbour Grant Tiarney solved the problem a different way. He kept the lath and plaster, but poked drainage rods up the cavity from his basement, knocking any loose plaster off the pegs. A lot of plaster came down and now he has only one patch where there is a problem. He may insulate the gable like we did some time in the future.

Connecting the chimney fireplace to the ventilated cavity ensures air movement within the chimney. (There should not be a vent in the plasterboard blocking off the chimney. This will simply allow warm room air to escape up the chimney).

I. Building leakage test

Figure 9.28 Air leakage test equiment

A chance offer of a building air leakage test, costing normally £180, occurred in August 2013. This involved the fitment of a canvas curtain in the front door frame (Figure 9.28), with a computer-controlled fan in its center. The test is done by running the fan, so it produces a vacuum in the house of 50 Pascal (Pa). The result was a leakage of 9 air changes per hour compared to 5-7 for a normal modern home. The test was done after fitting the multi-fuel stove, but before the spare room and master bedroom were insulated and sealed, and the hall, stairs and landing were sealed. The airflow through the fan was 26.2 $m^3/h.m^2$ floor area. In carrying out this test, leaks could be identified by the inrush of air. A leakage test at the start of a refurbishment would help identify potential draughts and help decide on refurbishment strategy.

10. Insulation under the whole house floor

The last improvement was to redo the under-floor insulation. This had been partially done using low density glass fibre, supported by a combination of pieces of wood and string by the previous owner. I decided to completely remove this as the glass fibre was projecting below the floor joists and was being pulled out when people rubbed against it as they walked through the basement.

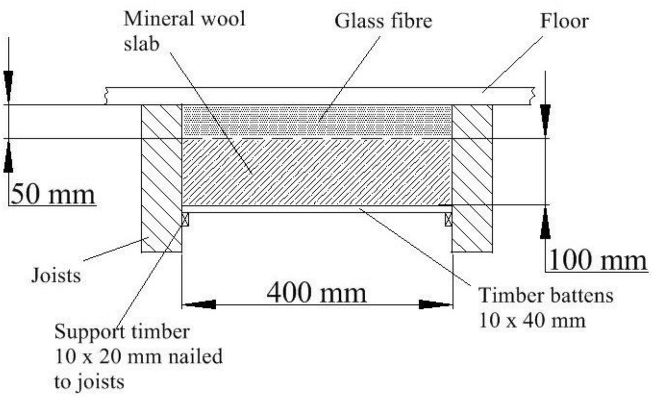

Figure 10.1 Cross section of floor joists showing how insulation is held in place

Strips of pressure treated wood 10 x 20 mm cross section were nailed to the floor joists 170 mm below the floor board (Figure 10.1), and a sandwich of glass fibre on top and Knauf mineral wool slab, cut to size, inserted between the joists. Pieces of pressure treated wood, 10 x 40 mm, were cut the width between the joists, and slid in above the strips of wood nailed to the joists, to support the Knauf wool slab. This both made use of the glass fibre that had been used previously and gave a pleasant uniform

Figure 10.2 Mineral wool installed on left, still-to-be insulated section of floor on right

appearance of the wool slab (Figure 10.2). As this material holds together well, supports are needed only every 300 mm. It is also much less dusty than glass fibre but is more expensive (See table 12.1).

11. Energy use prior to and over the period of modifications

When we purchased the house, the previous owner had kept a log of electricity and gas use over a period of years. This provided a very useful baseline for any subsequent changes in energy use, shown in the adjoining graph (Figure 11.1). The units used are kilo Watt hours (kWh) of electricity and kWh of gas. At today's (2015) prices one kWh of electricity costs us 14.225 pence and one kWh of gas 3.933 pence, approximately 14 and 4 pence respectively. These costs **exclude** the electric and gas standing charges, each costing £190.46 / annum (2014), or £380.92 in total. The graph also excludes the heat energy supplied by the stove, costing £121 for 342 kg of ovoids (Smokeless coal, costing £354 per tonne, 2015), and having an effective heat output of 2,330 kWh per annum assuming a stove efficiency of 78% and ovoid calorific value of 31.4 MJ/kg. The stove therefore provided 15 % of the total heating with gas providing the rest.

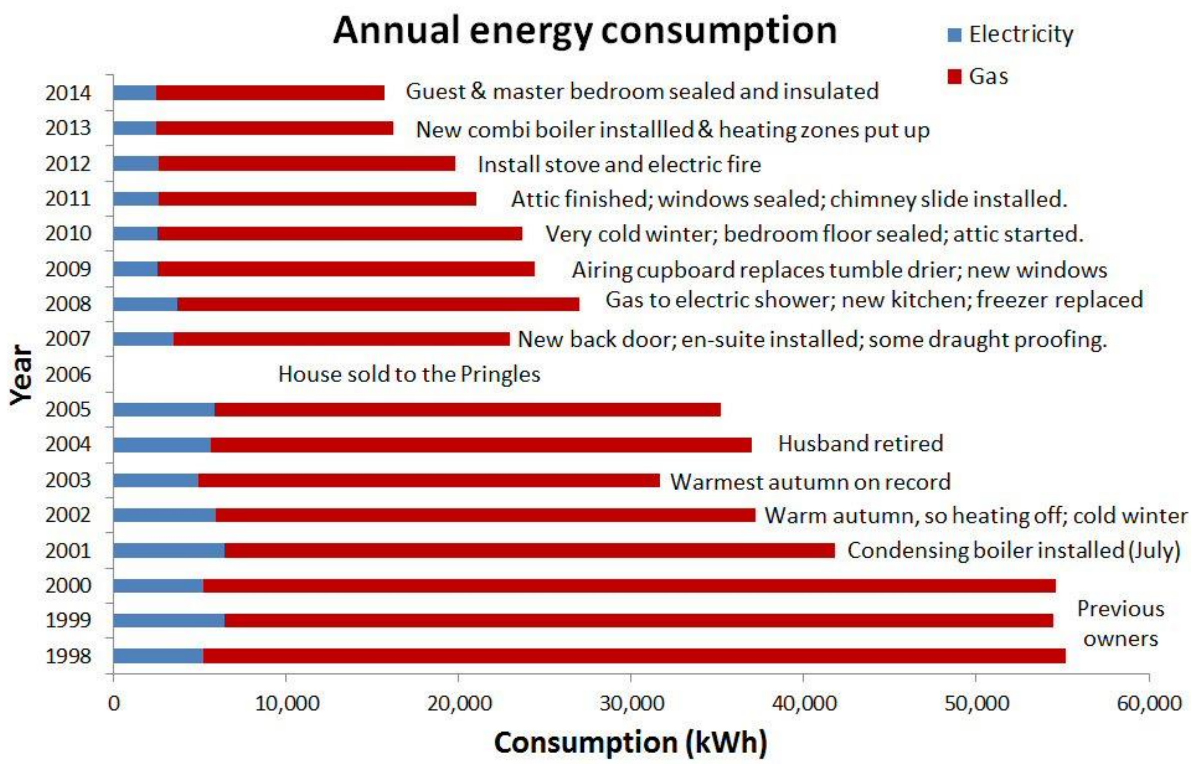

Figure 11.1 Effect of changes in house ownership and home modifications on gas and electricity consumption @ 2015 energy costs. (N.B. Any savings due to sealing or insulation follow modifications)

a. Lighting

While lighting is not dealt with in detail in this report, the previous owner changed from incandescent lighting to compact fluorescent bulbs as these bulbs became commercially available during their period of occupancy Some of their electricity reductions were therefore due to savings in power for lighting

When we bought the house in 2006, candle type compact fluorescent bulbs were just becoming available on the internet. The first thing we did therefore was to change to these bulbs from the original incandescent candle bulbs. Some of our early reductions in electricity use would therefore have been due to these changes. In 2008, when we refurbished our kitchen, we removed the lighting bar fitted with halogen lights and replaced it with two three-bulb arrays of spotlights (Figure 11.2). We avoided recessed lights as their holes allow heat to escape from the kitchen into the airspace above.

Since 2009, the whole house has been fitted with fluorescent lighting. When they fail, we will replace them, where possible, with LEDs.

Figure 11.2 Three-bulb array of compact fluorescent spotlights

b. *Past changes*

Explaining the changes in energy use is complicated in that two sets of occupants, with different lifestyles and preferences, occupied the house over the 1998 to 2012 period. To provide more detailed changes of electricity use, the more expensive of the types of energy used, Figure 11.3 shows the same information as Figure 11.1, but at a smaller scale.

The differences in electricity consumption between 2005 and 2007 was probably mainly due to the previous occupants' use of a 2kW electric heater to supplement the radiators. The reduction in electricity use between 2008 and 2009 was likely to be due to changing from an

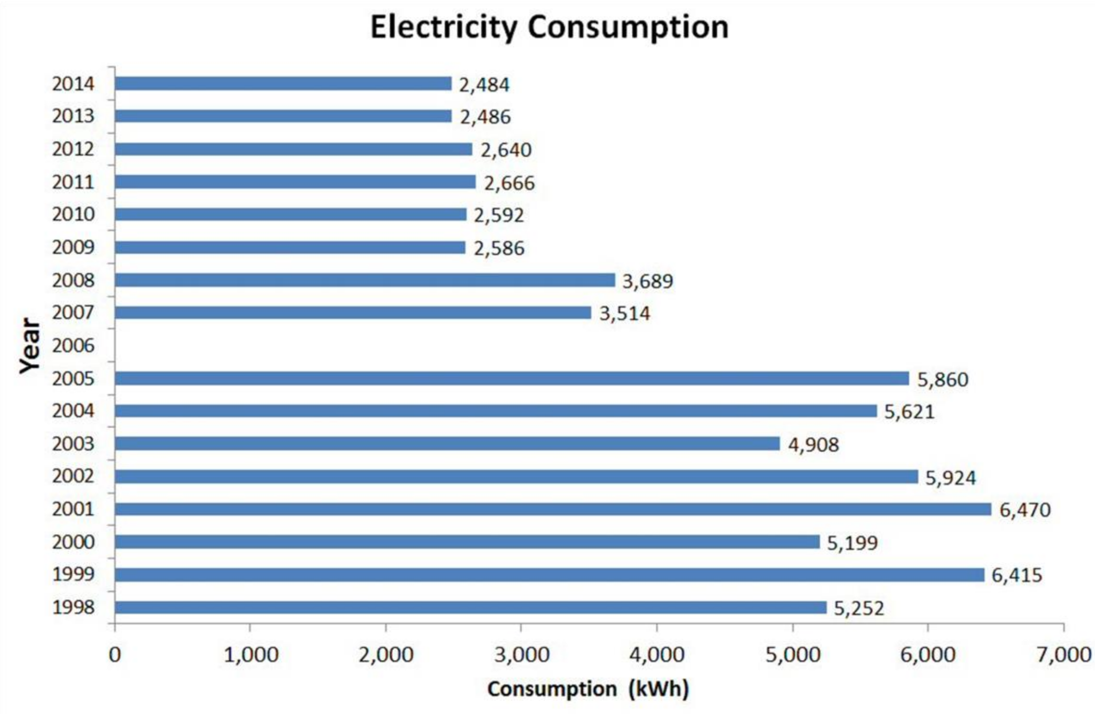

Figure 11.3 Electricity consumption in kWh (units) for 1998 – 2014, using a smaller scale than in Figure 11.1.

electric hob to gas, and the replacement of an old, leaky and probably less efficient chest freezer with two small but more efficient freezers.

The owners prior to August 2006, kept the back living room, where they normally sat, near 20°C during winter evenings. They used the 35% efficient coal-effect gas fire as a back-up to the radiators to boost the temperature when it was cold and to give cheer. The use of the

coal effect gas fire plus the ventilation due to the chimney, will account for some of high gas use prior to the change of owners. The coal fire in the front room was only used by the previous owners on 20-30 occasions per year, so coal use was low. Solar gain was significant in helping keep the house warm, due to the rear of the house facing south.

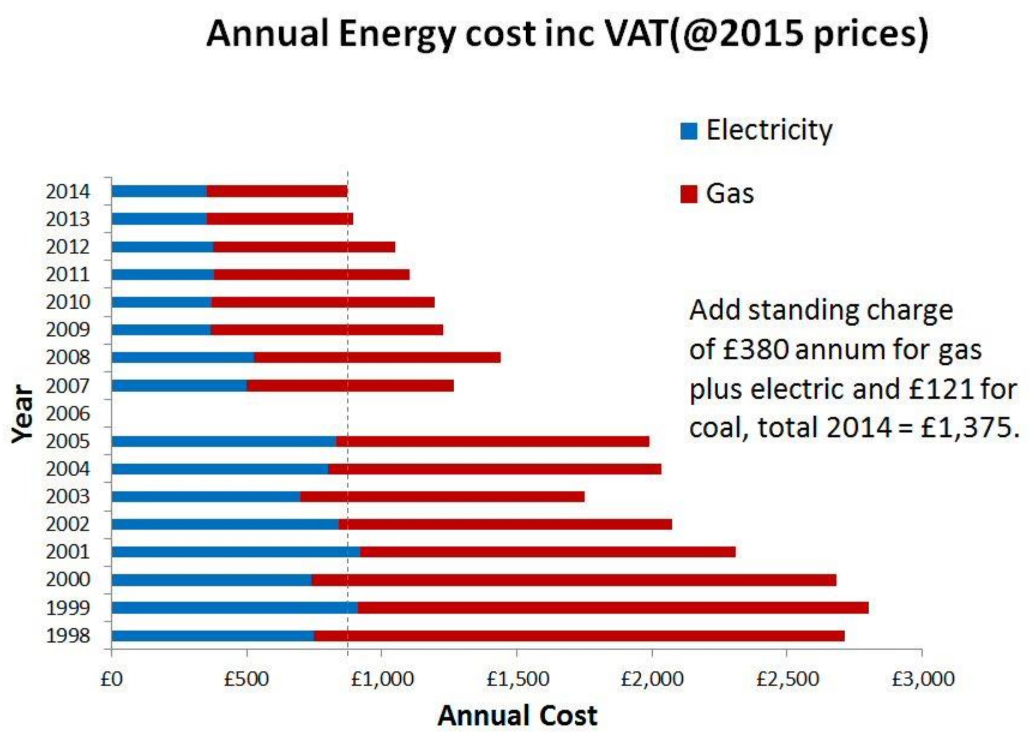

Figure 11.4 Energy use between 1998 and 2014 shown as an annual cost, excluding combined electric and gas standing charge of £380

The reduction in gas use between 2000 and 2002 by 39% (Figures 11.1 and 11.4) was primarily due to the installation of the condensing boiler and the fitting of the motorized valve that allowed the upstairs to come on later than the downstairs heating. This reduction was spectacular and shows just why fitting a condensing boiler is such a good investment.

The reduced consumption of energy after we bought the house is probably partly lifestyle differences and partly my improvements. In contrast to the previous owners we kept our living rooms at about 17°C. The lifestyle differences and our initial energy saving measures had the effect of reducing the gas used by 44% and the electricity used by 47%. Between 2006 and 2012 we used the coal fire in our lounge on 120 evenings per year, consuming about one tonne of coal in the process. We never used the coal-effect gas fire. Our heating was on between 6.30 – 8.30 a.m. and 5 - 11 p.m. during the winter. My wife showers daily using an electrically heated shower installed in 2006 and I bath three times per week using gas heated water. On mornings when I am at home, I tend to put on an extra fleece if I feel cold, and often put the heating on for an hour at lunch time to warm the house a little. The temperature in the hall and dining room would be nearer 16°C than 18 - 20°C. By 2007 I had done a lot of draught proofing on rooms and windows, so this may explain some of the reduced gas use compared with 2005.

In 2008 we used more heating as I was ill, and the kitchen was being gutted. Electricity use in 2009 reduced mainly as the refurbished airing cupboard was used to dry clothes rather than the tumble drier. The newly insulated and sealed kitchen in late 2008 may have been the reason for slightly reduced gas use. In 2010 and 2011 the newly insulated attic, the sealing of windows and the chimney slides may have helped reduce the gas use a little.

While not showing up on the graph, the reduction in coal use by moving from the coal fire to the stove was dramatic, a reduction from 1000 kg coal per year to 340 kg. The conversion of the heating system into three zones and changing to the new Combi condensing boiler has reduced gas use a little. As the sealing of the stairs, hall and gable windows has only just been completed, so their effect has still to be assessed. The house is however considerably more cosy than in the past.

c. Checking on base level electricity use

In 2010 I bought an electricity monitor, with a transducer-cum-transmitter located beside the mains electricity supply and a receiver with a LED display, which we keep in the kitchen (Figure 11.5). This shows the power used when various appliances such as the oven, washing machine, toaster, etc. are switched on. It gives useful feedback on just how much power these items use and deters switching on ovens for too long or using the tumble drier on sunny days.

Figure 11.5 Electricity monitor reading in kilo Watts (kW)

The meter can be used to check how much power is being used to power equipment on standby. In this house, power use never goes below 0.14 kW, or 140 Watts. This costs us £174 per year. While I have traced half this power use to equipment being on standby, I have been unable to trace the other half. (With the fitment of a smart meter in 2016, I found this meter was reading 80 W higher than the smart meter. This explains why I could not trace the "missing" power.

d. Checking cost of heating water

We had a hot water tank heated by the gas boiler. When we moved into the house in 2006, in order to ascertain the cost of keeping the water hot, whether we used the water or not, I set the hot water controls to heat the water morning and evening over a period of three days when we were away from home and when no hot water was being used. The gas used over the period was therefore solely to keep the hot water up to temperature. The heat used was 14.5 kWh per day, which costs £0.57 per day at today's rates (2015). Over the whole year this represented a cost of £208 per annum. In the winter, some of this heat would have contributed to keeping the house warm, but in summer such heat is wasted.

An examination of the water tank showed that the plumber had removed a 50 mm wide by 800 m high section of the 50mm spray foam insulation surrounding the tank, to allow room for a pipe to pass between the tank and the wall. (Had he moved the pipe 250 mm to left or right this would not have been necessary!) I therefore packed glass fibre around this area as well as round the whole tank. By reading the gas meter over the last three years at the start and end of August, when gas is used only for heating water and cooking on the hob, the cost of gas used averaged £0.28 or 7.08 kWh/day. This included using the hot water for baths and washing dishes, and the gas used for cooking, which the £0.57 figure in the previous paragraph did not. This relatively low cost of heating water has implications when considering solar panels to heat water, discussed in section 12.a below.

e. Future improvements

I perhaps should have installed a heat recovery system to continually ventilate the house, and so keep the air in the house fresh. This would have allowed us to seal up the trickle vents in the windows that cause over ventilation in windy weather. I always assumed that the house would be too leaky to make this a sensible investment, but it would allow sealing of rooms without any anxiety that they may become too well sealed for human safety or result in condensation in cupboards or cold areas.

The potential for renewable energy developments is discussed in section 12 below.

12. Renewable energy

In undertaking this refurbishment, I concentrated on making the house as energy efficient as possible without too much disturbance. As the insulation work has come to an end, we are now considering whether to embark on producing renewable energy.

a. Solar heating for hot water

In August, the gas in our house is only used for heating the water and for cooking food on the gas hob. The average use of gas used in the month of August in the three years 2009 – 2011 was 225 kWh. If two thirds (0.667) was used for water heating, the cost of gas would be 225 (kWh) x 3.933 (p/kWh) x 0.667 = £5.90 per month. If solar heating were to provide all our hot water needs over the six summer months, this would save £5.90 x 6 = £35.40 in gas bills per annum.

If the cost of the installation of a solar water heater were £1,500, and it was depreciated over 20 years, paid for by a loan costing 7% interest, with an annual maintenance cost of 3% of capital, the annual cost would be £186. We would therefore be £186 – 35.40 = £150.60 worse off.

I checked our washing machine to see if it would could increase our need for hot water. While it has hot and cold feeder pipes, the service engineer confirmed my findings that it only takes in cold water. Most modern machines are now cold fill, with the water being heated using electricity, though it is apparently possible to get machines which do take in hot water. For people with large families having lots of showers, fitting a solar hot water system may be justified. For the two of us with our low use of hot water this investment is simply not at all worthwhile.

b. Photo Voltaic panels on our kitchen roof

As our kitchen roof faces 140 degrees, approximately southeast, we can install solar panels and gain a Feed-in-tariff (F.I.T.) of 13.88 p/kWh of electricity generated, with an extra 4.77 p/kWh of income on each kWh we export to the grid. This rate FIT requires a “D” Energy performance certificate for the house. I hope to get a “C” but will certainly get a “D”. A near neighbour has a south facing, unshaded, rear roof with 10 solar panels giving a maximum of 2.1 kW electricity in total. Its averaged output over 2010 to 2012 was1707 kWh / annum. Our kitchen is slightly overshadowed by a neighbouring building and can only take 7 panels. If the overshadowing had only a minimal effect, we could produce 1195 kWh. The income we could get annually would therefore be 1195 x 0.1388 = £165.87 FIT. Any of this energy that we can use ourselves would save us 14.225 p/kWh. The energy that we could not use is exported to the grid and gains a further 4.77 p/kWh. If we utilized a third of the energy generated, the total value would = FIT + (0.67 electricity generated x export value) + (0.33 x electricity generated x value) = £165.87 + (0.67 x 1195 x 0.0477) + (0.33 x 1195 x 0.14225) = £260.15. This compares with the actual cost of electricity used in this house during 2014 of £353.32. The quotation for the solar panels and inverter in 2012 was £9,340, and would now be about £6,000, as the cost of panels has come down. The return would therefore be £260 per annum for an investment of £6,000, giving a pay back in 35 years assuming an interest rate on capital of 2.5%. As the FIT guaranteed payment only lasts 20 years, this investment looks unattractive. At 5 and 7.5% interest rates, the payback exceeds 60 years.

Other renewable systems

As the area where we live is surrounded by trees and other houses, I believe that any wind turbine would be unlikely to pay for itself or produce any meaningful amount of power. We would be better to put any capital that we might have thought of spending on a home wind turbine into a wind farm development on a moor.

c. Heat pumps

Heat pumps are powered by electricity, which at 14.225 p/kWh compared to 3.933 p/kWh for gas, is 3.6 times the cost. The best ground source heat pumps have a coefficient of performance (COP) of 3.5 – 4.0, that is, one kWh of electricity produces 3.5 to four kWh of heat energy. At these figures, the cost of running a heat pump to produce heat is similar to getting natural gas from the mains supply and burning it to produce heat, but you still have to pay the cost of installing the heat pump in the house, burying the pipework in the garden or in deep holes, and on maintenance on what is basically a refrigerator working in reverse. Where natural gas is available therefore, it is unlikely that a heat pump would be a sensible investment on either a financial, or reduction in carbon footprint, basis.

Had we been on an oil based or LPG heating system, both considerably more expensive than natural gas, I would have costed out a ground source, or possibly air source, heat pump, to see if one was justified.

13. Cost of modifications

Placing a precise cost on the modifications to improve the energy efficiency of the house is difficult, as almost all the work to improve the energy efficiency of the house was carried out in conjunction with improvements made to the rooms refurbished. I have therefore costed out the entire improvements, using 1) “Spons’ Architects’ and builders’ price book, 2010”, 2) my own estimates using the Spons system of costing, or 3) actual invoices from companies where tradesmen were used. I have charged my own work time at £16.88/hour, again from Spons, to assume all the work was done by tradesmen. Where there were fiddly jobs, with minimal materials used, I have for simplicity just given these jobs a labour cost.

I have then separated which modifications were to improve the energy efficiency of the house and totaled these for each job. As much of the work was done in confined places like the attic and cellar, the Spons’ figures may well be an underestimate.

a. Basis of costs

In calculating the costs of renovations for the various rooms, I have used the materials costs shown in table A.1 in the appendix. These were actual prices I either paid, or was quoted for, buying material as a cash sale. All costs are exclusive of VAT, as VAT changed from 17.5 %, to 15 % to 20% during the modifications. VAT on energy saving materials or grant funded heating systems installed into existing buildings (e.g. Ventrolla’s draught proofing of our windows) may be charged at 5 % by building contractors, joiners, plumbers or electricians, but contractors should confirm this with HMRC (HMRC, Notice 708/6, 2011). The detailed calculations are shown in the Appendices

b. Summary of modifications

I have summarised the costs involved in carrying out the house improvements together with the estimated cost which relates to the energy saving aspects to the job. These are shown in table 13.1.

Table 13.1 Total costs of modifications exc. VAT

Room or area	Total cost of improvement	Extra cost of improvement to improve energy efficiency
	£	£
Doors and windows	7,208	7,208
En-suite	5,944	803
Bedroom	916	73
Kitchen	22,783	7,034
Attic	3,882	3,882
Vestibule	1,693	1,254

Guest bedroom	1,809	1,508
Master bedroom	5,380	5,380
Sealing hall, stairs and fitment of secondary glazing	666	666
Below floor insulation	1,239	1,188
Fire replacements	4,618	4,618
Total	**£56,138**	**£33,614**
Total + VAT at 17.5%	**£65,962**	**£39,496**

The changes in fuel use between 2005, when the house was owned by the previous occupants to 2014 are shown in Table 13.2. I have costed out the fuel used in the multifuel stove, with wood converted to the equivalent calorific value of ovoids. The weight of ovoids used was 342 kg, costing £121 in total for the year.

Table 13.2 Fuel use comparison between 2005 and 2014, at 2014 prices. (These exclude combined electric/gas standing charge of £380)

Energy type	**2005**	**2014**
	£	£
Electricity	834	353
Gas	1158	520
Coal	82	121
Total	**2074**	**994**

The total annual saving in energy costs between 2005 and 2014 was therefore £2074 - £994 = **£1080**. As a proportion of this saving was probably down to lifestyle differences, rather than as a result of sealing and insulating the house, this may be an overstatement of the savings achieved through house modifications. However, I have used this figure to estimate the payback period on capital invested at three rates of interest, Table 13.3. The capital costs include VAT at 17.5% as this was the average rate over the period of the modifications. The capital cost of energy efficiency improvements, but excluding labour, is 54% of the total cost. This figure was obtained from table A.2, appendix, and is the average of the ratio of material cost to labour cost for the measured rates of work.

Table 13.3 Payback period for investment in energy conservation[7]

Total cost of modifications	Cost inc VAT at 17.5 % (£)	7%	5%	2.5%
Including labour charge	39,496	>60 yrs	>60 yrs	>60 yrs
Excluding labour charge	21,327	>60 yrs	>60 yrs	27 years

The payback periods for the £39,496 work done, including the labour charge, to improve the energy efficiency of the house, is always in excess of 60 years whether the money is borrowed at 7, 5, or 2.5%. If the cost of labour is excluded, the refurbishment cost of £21,327 has a payback period always in excess of 60 years except for the borrowing rate of 2.5% when the payback period is 27 years. When making investments, payback times of between 5 to 20 years would be expected if an investment was to be considered as worthwhile. To expect to pay back the cost of the refurbishment work in energy costs saved is not therefore met. The government Green deal's Golden rule would therefore have ruled out all these modifications.

c. Comment on value of refurbishment work

In the period prior to this project, when the previous couple owned the house, the gas and electricity costs were reduced (at 2014 prices) from £2,712 to £1,988, i.e. £724 by replacing the traditional gas boiler with a condensing boiler, splitting the house into two heating zones, replacing incandescent bulbs with compact fluorescent bulbs and insulating part of the attic. In jargon terms this could be the "low hanging fruit" which was rightly tackled first.

In conventional economic terms, the subsequent draught proofing, fitting of new windows, installation of insulation materials and refurbishing the attic, to reduce the cost of gas and electric energy used to £873, for an expenditure of £39,496 (Inc. VAT) would not be judged as financially worthwhile. Some aspects of the work may well have been worthwhile, but as it was not possible to link any one modification with a reduction in energy use, particular worthwhile improvements are not possible to identify.

For DIY enthusiasts who are willing to give their labour free and with money sitting in deposit accounts yielding interest rates of 2.5% or less, the payback period is 27 years.

Another way of looking at the financial benefits from the work is to see the refurbishment in terms of the value of the house. This house cost £350,000 in 2006 and is now worth £570,000, as a neighbouring house sold for this value in February 2015. The refurbishment cost of £39,496 to reduce energy bills is only 7% of the value of the house. If the house is more comfortable, the windows and internal décor improved, and the annual energy bill reduced, the cost may be acceptable.

[7] Amortization equation used is $C \times ((r(1+r)^n)/(1+r)^n-1))$ where C is capital investment, r is rate of interest, and n is years of repayment. NB. If rate of interest is 7%, r = 0.07.

Part of the idea behind the Scottish government's "Home Reports" for houses which are for sale is that it gives an A-G style energy rating. This is supposed to reward people like ourselves for draught sealing and insulation work when it comes to selling. The price obtained for the property should reflect the work done. Since these properties are very sought after and each house is unique in situation and character, these visual impacts are likely to have more effect on price paid than a good energy rating or the presence of insulation, the majority of which is hidden from view.

In practice, many people in similar houses buy the house for their looks and their "old world" feel. After several years, or as the owner's age, they start to suffer from the cold and move to warmer, better insulated properties. While they solve their problem, the footprint of UK plc, however, stays high as the new owner moves in and uses excessive amounts of fuel to keep warm.

Our own view is that the house is very much more comfortable than when we first moved in. I would do the same improvements again if I were to buy a similar house, but ensure the windows were BBA accredited and put in the multi-fuel stove much earlier in the refurbishment.

14. Comments for future Government aid for hard to treat homes

This project has highlighted several dilemmas relating to hard to treat homes with single solid walls: -

- Apart from the installation of condensing boilers, fluorescent or LED lighting, loft insulation in empty loft spaces and simple draught proofing, other renovations to improve the energy efficiency of these homes may have paybacks in excess of 30 years
- Owners of an old cold, draughty house may well decide to move to a warmer, more modern, house, especially as they age, rather than bother to refurbish the house to make it more energy efficient
- While such a move will solve the owner's need for comfort and energy efficiency, UK plc is left with the high carbon footprint of an energy inefficient house and a requirement to invest in power generation to supply energy which is subsequently needlessly wasted
- Because of the previous point, the government has a stake in encouraging owners of thermally inefficient houses to refurbish these and so should either make loans available to pay for refurbishment or provide grants to contribute to this cost
- The government's plan for their Green Deal, with its Golden Rule that refurbishments aimed to conserve energy should pay for themselves within five years is certain to fail for solid walled traditional housing as sealing and insulation of such properties is very labour intensive and therefore expensive
- The only reliable way of ensuring that refurbishments have been effective is by checking subsequent reductions in meter readings and purchases of oil or coal.

Reliance on tradesmen, certificated or not, to undertake the work and building surveyors, council staff and energy performance certificates, to assess the work, is likely to give results that bear little relation to actual energy saved.

- Sealing of rooms and the installation of insulation can involve dirty, unpleasant work that commercial firms may wish to avoid from both health and safety reasons and the difficulty of recruiting and keeping staff. DIY house owners like myself in contrast may be willing to undertake such work on a one-off basis to improve their own property and subsequent thermal comfort

- Any grants that are restricted only to refurbishment work done by contractors, rather than by home owners, is likely to significantly reduce the number of householders willing to carry out such refurbishment due to the high cost of contract work

- If loans are to be provided to pay for a proportion of the refurbishment work, the annual repayment of the loan should be paid out of the energy savings made. This will encourage the home owner to get the job done in a way that will ensure energy savings.

- To minimise the cost of refurbishment work, it is better undertaken when home or room modifications are being carried out anyway; the period taken for a full energy efficiency refurbishment may therefore last many years

- To both ensure that homeowners doing work themselves or engaging contractors carry out the refurbishment in a sensible order and to an effective standard, local authority staff or designated contractors should draw up a staged development plan, whereby interim payment of grants could be made as each milestone is reached.

- To encourage tradesmen to take the sealing up of rooms seriously, assessment of modifications should include the pressure testing of the house after work has been completed.

Bibliography & references, including titles of publications supplied by Prof Branka Dimitrijevic, CIC Start Online, GCU

AECB forums. Moisture Risks of Wall Upgrade 2 - Insulation in Old House Walls. http://www.aecb.net/forum

Aquamac21 Weatherseal, Marches Architectural Hardware Ltd, £21.95 ex VAT per 25 m roll, or £0.88/m.

Building Research Establishment (BRE) - Refurbishing pre-1920's Solid Wall Properties. www.BRE.co.uk

Building Research Establishment (BRE). Moisture Risks of Upgrade - BRE262 - Thermal Insulation, avoiding Risks.

Changeworks. Edinburgh Tenement Upgrades 1 - Renewable Microgeneration in Traditional Buildings.

Changeworks. Edinburgh Tenement Upgrades 1 - Energy Efficiency in Traditional Buildings.

Changeworks. Edinburgh Tenement Upgrades 3 - Fact Sheets Guidelines for Tenement Renovations. pp 24 www.changeworks.org.uk (V Good overall guidance. BP)

CIBSE, (2005). Heating, ventilating, air conditioning and refrigeration. Pp 429. ISBN 1903287588

DECC, (2012) Green deal, a summary of the government's proposals. DECC. http://www.decc.gov.uk/assets/decc/legislation/energybill/1010-green-deal-summary-proposals.pdf

CICStart online, prounounced **"**Kickstart", aims to embed sustainable building design and refurbishment into practice. Based at Glasgow Caledonian University, Glasgow, it delivers web-based seminars (webinars) on research work and building refurbishment issues. http://www.cicstart.org

Energy savings trust (EST), (2004) Internal wall insulation in existing housing- a guide for specifiers and contractors. Energy efficiency best practice in housing good practice guide No 138. pp12 www.est.org.uk/bestpractice

English Heritage - Building Regs, Interim Guidance for Historic Buildings.

English Heritage - Upgrading Traditional Buildings.

English Heritage. Moisture Risks of Wall Upgrades 3 -. Wall Insulation Risks in Historic Buildings.

ESRU (2010). Improving Energy and Carbon Performance of Housing - A Glasgow Case Study. pp 38 http://www.cicstart.org/userfiles/file/FS-7-REPORT.PDF

EST - Energy Efficient Historic Homes. CE138

EST - Internal Wall Insulation. CE17

EST - Practical Refurbishment of Solid Walled Houses. CE184

EST - Sustainable Refurbishment. CE309

EST - Energy Refurb Existing Homes. CE83

EST, (2004) Refurbishing dwellings with solid walls- a summary of best practice. Energy efficiency best practice in housing good practice guide. Pp 8. www.est.org.uk/bestpractice

GCU /Historic Scotland - U Value Measurements in Traditional Buildings.

Glasgow Caledonian University (GCU)/ Historic Scotland - Performance of Windows, Shutters and Curtains.

Historic Scotland - Energy Efficiency.

Historic Scotland (2007) Indoor air quality and energy efficiency in traditional buildings. pp40

Scottish Building Standards - Traditional Buildings Improvements 1 and 2.

Spons' Architects' and builders' price book (2010)

Straub, J (2007) Moisture Risks of Wall Upgrade 1 - BSD114 Masonry Retrofit. Building science digest. http://www.buildingscience.com

SPAB Society for the protection of ancient buildings. www.spab.org.uk

Sustainable Traditional Building Alliance (STBA) An organization set up to actively promote and deliver a more traditional built environment http://www.sdfoundation.org.uk

Appendix 1 Costing of refurbishments

Table A.1 provides the costs (2012) of the materials used in the work carried out to improve the energy efficiency of the house. Table A.2 provides measured rates, defined as the combination of material cost plus the labour input, for installing unit length or unit area of material into the house. The remaining tables A.3 to A.12, calculate the total cost of refurbishing each room.

Table A.1 Insulation and related material unit costs exc. VAT (February 2012)

Description	Specification	Size	Cost per sheet or length exc VAT	Cost per unit area or m exc VAT	Supplier
Celotex sheet	EPS Foam between aluminium foil	20mm thick 2.4m x 1.2m sheet	£11.25	£3.91/m^2	Condell Ltd website
Celotex sheet	EPS Foam between aluminium foil	12 mm thick 2.4 x 1.2 m sheet	£9.91	£3.44/m^2	Condell Ltd website
Kingspan sheet	EPS Foam between aluminium foil	25mm thick 2.4 x 1.2m sheet	£11.81	£4.10/m^2	Sheffield Insulation
Kingspan sheet	EPS Foam between aluminium foil	50mm thick 2.4 x 2.4m sheet	£18.29	£6.35/m^2	Sheffield Insulation
Kingspan K18	Styrofoam and plasterboard composite panel	25 mm thick insulation glued to 12.5 mm plasterboard	£35.86	£12.45/m^2	Sheffield Insulation
Knauf glass wool (Calc density 9.35 kg/m^3)	Glass fibre roll Lambda (λ) value 0.044 W/m°C	100 mm thick 12.18 m x 1.140 m	£23.47/roll	£1.69/m^2	Sheffield Insulation
Knauf slabs (Calc density 36.1 kg/m^3)	Mineral wool Lambda (λ) value 0.037 W/m°C	100mm thick 1.2 x 0.6 m, 5/pack 3.6m^2	£34.55	£9.60/m^2	Sheffield Insulation

Plasterboard	Aluminium foil backed	12.5mm thick 2.4 x 1.2 m	£6.62	£2.30/m^2	Sheffield Insulation
Spacetherm on plasterboard	9.5 mm insulation glued to 11.5 mm plasterboard	20 mm x 1.2m x 2.4 m sheet	£230	£80/m^2	Proctors of Blairgowrie
Spacetherm on Fermacel board	9.5 mm insulation glued to 10.5 mm board	20 mm x 1.2m x 2.4 m sheet	£242	£84/m^2	Proctors of Blairgowrie
CW Venture tape	Aluminium adhesive tape	75 mm wide by 50 m long	£9.77	£0.20/m	Sheffield Insulation
White wood strapping	Off saw white wood, treated	10mm x 38mm x 4.8 m	£0.86	£0.18/m	Buildbase
White wood framing	Treated 47x50 mm Off saw	4.8 m lengths	£ 2.50	£0.52/m	Buildbase
White wood framing	Treated 47x100 mm Off saw	4.8 m lengths	£ 4.80	£1.00/m	Buildbase
Screws	Nickel coated Philips head	80 mm	£3.00	£0.03/unit	John Smith, Aberdeen

Table A.2 below gives measured rates, the cost of materials plus the labour cost per unit (usually m or m^2) of material erected.

Table A.2. Installation costs exc VAT (Spons' rates of work; figures in red are my guestimates)

Job	Material	Labour hours	Labour £	Material £	Unit	Total rate
Removal of lath and plaster & disposal	Labour and disposal cost of plaster and timber to landfill	*0.9*	15.19	2.60	m^2	17.80
Removal of plasterboard	Labour and disposal cost of old plasterboard	*0.1*	1.7	0.91	m^2	2.61
Composite panel insulation	Attach panel to existing studs using screws	*0.8*	13.50	12.45	m^2	25.95
Loft insulation	Glass fibre to a depth of 250 mm in cramped loft space	0.2	3.38	4.22	m^2	7.60
Insulation down coombes	Feeding 100 mm thick Knauf mineral wool slabs down combs or under floor	0.24	4.05	9.60	m^2	13.65
Under-floor insulation in basement	100 mm mineral wool slab + 100 mm glass fibre	0.34^{++}	5.74	9.61	m^2	15.35
Erecting framing to take insulation	47 mm x 50 mm rough sawn treated timber	0.13	2.19	0.52	m	2.71
Erecting 38 x 100 mm framing	38 x 100 mm rough sawn treated timber	0.25	4.22	1.00	m	5.22
Inserting sheet insulation between framing	Cutting 50 mm EPS (Kingspan) sheets to fit between studs or framing and taping it to the frames	0.40	6.75	6.35	m^2	13.10

Erecting 12 mm insulation	Putting 12 mm insulation over studs and 25-50 mm insulation	0.25	4.22	3.44	M^2	7.66
Erecting plasterboard	12.5 mm foil backed plasterboard	0.44	7.42	3.22	m^2	10.64
Erecting aqua-panel	8 mm plastic coated WPB plywood	0.44	7.42	33	m^2	40.4
Tiling	Applying tiles	1.0	16.88	30	m^2	46.88
Sealing gaps with gun	Sealing narrow gaps in skirting boards and cupboards	0.02	0.34	0.3	m	0.64
Laying plywood flooring	6.5 mm WPB plywood	0.41	6.92	4.8	m^2	11.72
Painting walls with emulsion	Painting walls with four coats of emulsion	0.33	5.57	1.25	m^2	6.82
Ave % labour & materials			46%	54%		

+ Charge for carpenter/ joiner gang =£16.88/hr/person (Spons)
++ My own work rate monitored

a. Replacement door and windows

The cost of sealing the exterior of the building is shown in Table A.3. This was done sequentially, when room renovations were being carried out. First was the replacement of an ill-fitting timber door with a new uPVC door, which cost £610. All prices quoted below exclude VAT.

We asked Ventrolla, the company which specializes in sealing old windows, to seal the timber lounge sash-and-case bay window, the upstairs sash and case bay window, the workshop sash and case window, and the two feature windows in the gable. To keep their quote to a minimum, only the centre windows in the three window bays were fitted with new counterweights, so at least one window per room could be opened in summer.

As stated on page 20, the new counterweights on the sash and case windows did not work reliably, so we still could not open any windows. We therefore redid the upstairs windows and installed uPVC windows instead. The workshop sash-and-case window was installed later.

We then decided to replace the lounge timber sash-and-case bay windows with similar but double-glazed uPVC windows. We also replaced the dining room sash-and-case window and a tilt and turn window for the bathroom.

The replacement of all the windows, other than the ones fitted in the kitchen and two existing feature gable windows which we are leaving, came in total to £7,208. In fairness to Ventrolla, the sealing did help reduce the draughts until we were ready to install new uPVC windows.

Table A.3 Cost of sealing house exterior with new door, new seals and replacement windows exc. VAT

Item	Area m^2	Unit cost (£)	Total excluding Ventrolla work (£)
Kitchen uPVC back door	1.90	610	
Ventrolla window sealing for all sash-and-case windows plus fitting additional sash weights		1648	
Upstairs bedroom bay sash-and-case window	3.80	2444	
Workshop sash-and-case window	1.54	650	
Lounge sash and case windows	4.91	2440	
Dining room sash-and- case plus tilt and turn bathroom window	2.00 & 1.20	1064	
		Total	£7,208

b. En- suite

The en-suite area was just under 2 m x 2 m square, yet converting it to a shower room, and installing a toilet and sink unit was high (Table A.4).

Table A.4 Cost of converting dressing room into en-suite exc. VAT. (Unit rates from table A.2)

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1	Design of en-suite by building surveyor (invoice)	1	250	250
2+	Removal of lath and plaster from two exterior walls and ceiling (m^2)	10.6	17.60	186.5
3	Purchase of Velux window (invoice)	1	200	200
4	Installation of Velux inc slater work (invoice)	1	390	390
5+	Fit composite insulated panel to existing studs (m^2)	10.6	15.95	169.1
6	Fit sealed, insulated “box” between Velux & ceiling (hrs)	4	16.88	67.52
7+	Lay plywood floor (m^2)	4	11.72	46.9
7+	Sealing round toilet waste pipe (hrs)	3	16.88	50.64
9	Framework for bulkhead and cistern (m)	20	1.77	35.4
10	Fitment of Aqua-panel face to bulkhead (m^2)	2.88	40.4	116.35
11	Cupboard and bulkhead top (invoice)	1	270	270
12	Shower tray, shower, towel rail, extract fan (invoice)	1	1850	1850
13	Fitment of shower tray (hrs)	3	16.88	50.6
14	Tiling two sides of shower wall (m^2)	3.04	36.88	112.1
15	Fitting shower framework (hrs)	2	16.88	33.8
16	Plumber work (invoice)	1	1410	1410
17	Electrical work (invoice)	1	255	255
18+	Plastering walls and ceiling (invoice)	1	350	350
19	Painting walls and ceiling (invoice)	1	100	100

	Total			£5,943.91
	Cost relating to energy conservation improvement			£803.1

+ Indicates items that relate to energy saving improvements

c. Master bedroom

The master bedroom adjoining the en-suite had what seemed a good double-glazed window and only needed a skirting board added and the floor sealed prior to laying a new carpet. Table A.5 details the costs involved. In 2014 we decided to replace the window and insulate the external wall as the room was so cold. Cost for this extra work is shown in table A.9.

Table A.5 Cost of upgrading 4.5 x 4.0 x 2.8 m high master bedroom exc. VAT (Unit rates from table A.2)

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1	Fit “missing” skirting board (hrs)	4	16.88	67.52
2+	Seal holes in cupboards and skirting boards with sealing gun (m)	22	0.64	14.00
3+	Lift carpet (hrs)	2	16.88	33.76
4 +	Seal gap between floor and skirting with 75 mm tape (hrs)	1.5	16.88	25.32
5+	New underlay (sealed) and carpet	1	776	776.00
	Total			£916.60
	Cost relating to energy conservation improvement			£73.00

d. Kitchen

The work on the kitchen involved removing the old kitchen units to the workshop upstairs, stripping the plasterboard, installing insulation board between studs, fitting composite panels to the studs, and purchasing and fitting four new windows, refurbishment of an existing airing cupboard, installing glass fibre above the kitchen ceiling, and tiling and decoration of the walls. The insulation and fitting of the new windows was done by tradesmen.

Table A.5 Cost exc. VAT of refurbishing 8.2 x 2.0 x 2.5 m high kitchen and fitting new units

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1	Preparation of room for joiners by removal of existing kitchen units (hrs)	4	16.88	67.52
2+	Labour charge to strip plasterboard & replace with insulation new plasterboard (invoice)	1	3,775	3,775.00
3+	Insulation materials (invoice)	1	872	872.00
4+	uPVC Windows (invoice)	4	280	1120.00
5	Plumber to reroute water supply and some central heating pipework (invoice)	1	700	700.00
6	Electrical equipment and lighting for kitchen and fitted units (invoice)	1	1567	1567.00
7	New kitchen units, fitted (invoice)	1	11,700	11,700.00
8+	Refurbishment of airing cupboard (hrs)	15	16.88	243.00
9	Doors for airing cupboard (invoice)	4	96	384.00
10	Additional insulation for existing hot water tank (hrs)	2	16.88	33.76
11+	Plastering of kitchen (Invoice)	1	900.00	900.00
12+	Installing glass fibre above kitchen (m^2)	16.4	7.60	124.64
13	Tiling of walls between upper and lower wall cabinets (m^2)	2.56	46.88	120.01
14	Painting of walls (m^2)	24	6.82	163.70
15	Laying of Malmolium (Invoice)	1	1012.17	1012.17
	Total			£22,782.80
	Cost relating to energy conservation improvement			£7,034.64

e. Attic

As explained previously it was decided to strip out the existing attic store room and reinstall it. This would allow insulation to be inserted down the combs of the upper rooms, would allow renewal of glass fibre insulation that had slumped to 25 mm, and would result in a properly sealed room.

Table A.6 Cost exc. VAT of refurbishing the 10 x 3 x 2.00 m high (apex) attic storeroom

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1^+	Removal of existing plasterboard (m^2)	42.37	2.61	110.59
2^+	Removal of wall and comb roof framework and stacking of glass fibre (hrs)	14	16.88	236.32
3^+	Sawing trough in perimeter of room floor to allow framework to be nailed to roof joists and removal of access trough in centre of room to allow insulation to be fed under floor (hrs)	2	16.88	33.76
4^+	Install Knauf mineral wool into combs of rooms below using special “rake” and slip sheet (m^2)	25.16	13.65	343.43
5^+	Spread of glass fibre removed from previous room to loftspace above dormers and between attic room and eaves (m^2)	16.12	7.60	122.51
6^+	Installation of Knauf 100 mm mineral wool slabs under the floor using slip sheets (m^2)	18	13.65	245.7
7^+	Fit chipboard panels in centre of floor made from surplus chipboard (hrs)	2.5	16.88	42.20
8^+	Fitment of 47x100 horizontal framing to roof trusses for fixing wall framing to (m^2)	16	5.22	83.52
9^+	Fitment of four 47 x 100 mm corner posts for wall framing	3.2	5.22	16.70
10^+	Framing of 47 x 47 mm rough sawn treated timber for two side walls of room	16.0	2.71	43.00
11^+	Additional time to install “cupboard” surrounding fresh water tank and central heating header tank (hrs)	10	16.88	168.80
12^+	Framing for gable walls of room	13.2	2.71	35.80

13^{+}	Installation 50 mm insulated panels between studs and taped to studs	42.37	13.10	555.04
14^{+}	Fitting of foil-based plasterboard, over the insulated panels	42.37	10.64	450.82
15^{+}	Fitting frames to access doors in room walls (hrs)	5	16.88	84.40
16^{+}	Timber doors, fitted with Aquamac seals (hrs)	8	16.88	135.00
17^{+}	Fitting boxes to two Velux windows and sealing (hrs)	6	16.88	101.28
18^{+}	Timber flashings to four doors (hrs)	5	16.88	84.4
19^{+}	Plaster attic walls and ceiling (Invoice)		700	700.00
20^{+}	Paint attic walls and ceiling with four coats emulsion and varnish woodwork	42.37	6.82	288.96
	Total			£3,881.95
	Cost relating to energy conservation improvement			£3,881.95

f. Vestibule

As stated previously, the decision to insulate the vestibule resulted from a water flood that broke through plasterboard to expose a rotten lintel above the door. Had it not been for this we would have left the vestibule uninsulated and concentrated in sealing the outer front door instead.

Table A.7 Cost exc. VAT of repairing, sealing and insulating 1.5 x 1.5 x 3.2 m high vestibule

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1^{+}	Remove lath and plaster on the exposed outer wall and around the front door (m^2)	2.47	17.8	44.00
2^{+}	Replacement of single glazed window above the front door with a double-glazed unit (Invoice)	1	60.00	60.00
3^{+}	Insulation between studs with 25 mm Kingspan EPS sheet, taped to studs, fitting of spacers and plasterboard lining (Invoice)	1	550.00	650.00
4^{+}	Replacement of skirting boards and dado rail (Invoice)	1	100.00	100.00

5⁺	Plaster skim of whole vestibule (Invoice)	1	150.00	150.00
6⁺	Wall paper for Vestibule (Invoice)	1	82.00	82.00
7	Painting and decoration of vestibule (hrs)	14	16.88	236.32
8⁺	Fitting Aquamac 21 seal around door and in trough below door (hrs)	10	16.88	168.80
9	Preparation and painting of front door with four coats of paint (hrs)	12	16.88	202.56
	Total			£1,693.36
	Cost relating to energy conservation improvement			£1,254.00

Table A.8 Cost exc. VAT of insulating and sealing guest bedroom, 5.4 x 3.04, 2.8 m high

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1⁺	Remove lath and plaster on the exposed outer wall, chimney breast and sides of dormer (m^2)	11.80	17.8	210.04
2⁺	Disposal of lath and plaster to HWRC, 2 trips	3.5	16.88	59.08
3⁺	Framing up of sides of party wall (m)	25.64	2.71	69.48
4⁺	Insulation between studs with 50 mm Kingspan EPS sheet, taped to studs, fitting of spacers and plasterboard lining (m^2)	6.45	13.10	84.49
5⁺	Insulation between studs with 25 mm Kingspan EPS sheet, taped to studs, fitting of spacers and plasterboard lining (m^2)	3.87	10.85	41.99
6⁺	Insulation over studs of 12 mm Ecotherm insulation board (m^2)	18.25	7.66	139.79
7⁺	Fit plaster board over whole area	18.25	10.64	194.18
8⁺	Replacement of skirting boards (m)	8.9	12.35	109.91
9⁺	Plaster skim of whole room (Invoice)	1	380.00	380.00
10	Wall paper for party wall (Invoice)	1	64.00	64.00
11	Painting and decoration of room (hrs)	14	16.88	236.32
12⁺	Fitting Aquamac 21 seal around door and in trough below door (hrs)	7	16.88	118.16

13+	Sealing floor and skirting board	6	16.88	101.28
	Total			£1,808.72
	Cost relating to energy conservation improvement			£1,508.40

Table A.9 Cost exc. VAT of insulating and sealing master bedroom, 4.25 x 3.82, by 2.8 m high

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1+	Removal of furniture and fixing of plastic sheet to protect the new carpet (hrs)	3	16.88	50.64
2+	Remove lath and plaster on the exposed outer wall, sides of dormer and one coombe (m^2)	9.35	17.8	166.43
3+	Disposal of lath and plaster, two trips to HWRC	3.5	16.88	59.08
4+	Purchase of Velfac window, 3.22 m^2 (Invoice)	1	2291.87	2291.87
5+	Installation of Velfac window by joiners (Invoice)	1	1500.00	1500.00
6+	Framing and ceiling round window	7	16.88	118.16
7+	Manufacture of book case/access panel to pipework behind wall lining (hrs)	14.0	16.88	236.32
8+	Insulation between studs with 25-50 mm Kingspan EPS sheet, taped to studs,	11.94	13.10	156.41
9+	Insulation with 12 mm Celotex insulation over all the insulation	11.94	7.66	91.46
10+	Plasterboard over all newly installed insulation	11.94	10.64	127.04
11+	Plaster skim of whole bedroom (Invoice)	1	380.00	380.00
12+	Painting and decoration of bedroom (hrs)	9	16.88	151.92
13+	Removal of plastic sheet and reinstatement of furniture	3	16.88	50.64
	Total			£5379.97
	Cost relating to energy conservation improvement			£5379.97

Table A.10 Cost of fitting secondary glazing in hall and landing plus sealing of staircase, exc. VAT. (No VAT on secondary glazing)

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1^+	Removal of carpet from hall, stairs and landing (hrs)	3.5	16.88	59.08
2^+	Sealing of flooring and stair case	15.25	16.88	257.42
3^+	Temporary replacement of carpet	2.0	16.88	33.76
4^+	Prepare sash and case coloured glass windows for secondary glazing	3.5	16.88	59.08
5^+	Two secondary glazing windows with magnetic strip attached			257.00
	Total			£666.34
	Cost relating to energy conservation improvement			£666.34

g. Below floor insulation

Table A.11 Cost of installing below floor insulation

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1	Removal of existing insulation (hrs)	3	16.88	50.64
2^+	Installation of insulation over whole floor area	77.4	15.35	1188.10
	Total			£1,238.73
	Cost relating to energy conservation improvement			£ 1188.10

i. Replacing fires

Table A.12 Cost exc. VAT of installing new fires

Item no	Activity or purchase	No	Unit cost or rate £	Total £
1+	Replace coal effect fire with 2kW electric fire	1	904.00	904.00
2+	Replace coal fire with 5kW multi (?) - fuel stove	1	3,700.00	3,700
3+	Tiling of fire recess and front of fireplace (m^2)	1.41	46.88	66.10
	Total			£4618.10
	Cost relating to energy conservation improvement			£4618.10

Appendix 2. Possible reasons for saturated gable walls

While not strictly related to building refurbishment, almost every semi-detached house down our street suffers from water stains on the lath and plaster of their gable walls. Slaters are regularly at work pointing chimneys and sealing chimney pots (lums), mostly with little success. As I worked on the insulation in our attic, I would occasionally see water running like a river down the inside of the granite wall, in both the gable and the partition wall. This always seemed to come from the chimney itself, rather than lower down in the gable. At the time I did not think of checking the weather prior to this happening, but it was wintertime, which is often wet and very windy.

Granite walls are 500-600 mm thick, so one would think that rain would not be able to penetrate to the inside of the wall, however windy or wet it was. However, while the chimneys are also 500 – 600 mm wide, they have the chimney flue going through them. The sides of the flue may be only 150 – 200 mm thick. Wind driven rain may indeed penetrate the flue itself, then run vertically down the flue, travel sideways at an angle of 40 ° to the horizontal, to where the fireplace was located. Since the inside of the wall and base of the flue are not normally repointed, the water will then seep out the wall here and flow downwards.

In the past when fires were lit, the heat from the chimneys would dry out the flues daily, reducing the likelihood of walls becoming saturated. Without the fires, the walls get more and more saturated.

Another possibility is that the “hats” on the lums are not effective and rain penetrates the flue from above. I think the former idea is the more likely.