Short guide to improving the energy efficiency of a traditional stone houses

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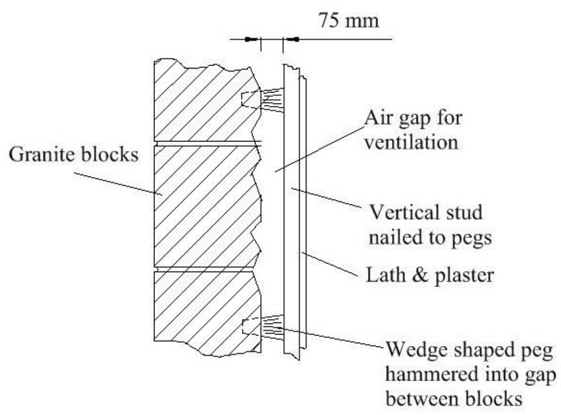
1. Introduction

Homeowners living in traditional stone houses are often daunted by the complexity of refurbishing their homes to improve their energy efficiency and comfort. Between 2006 and 2014 I refurbished our own house, logging what I did in a 72 page pdf document "Improving the energy efficiency of a traditional stone house", listed under "Topics" in the Website http://www.sustainability-in-practice.org.uk, That document provides information for the building trade and capable DIY home owners. As a result of my experience I have produced this second, shorter guide, for homeowners to give them an overview of what to consider, followed by a recommended step by step strategy for action.

2. Characteristics of traditional granite stone buildings

a. Structure

Traditional granite stone buildings have 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 is very rough, the studs have to 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 25 mm in cross section 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 on to the lath (Figure 2.2).



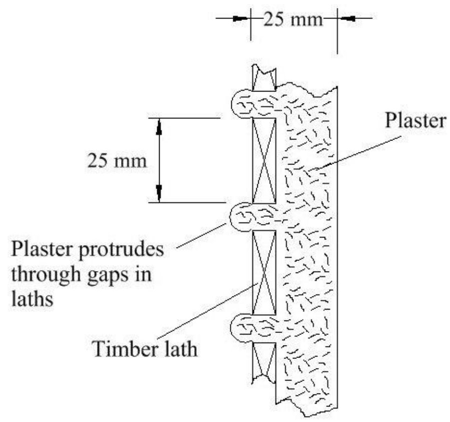


Figure 2.1 Granite blocks, left, with internal lath and plaster, right

Figure 2.2. Magnified side view cross section of lath and plaster

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.

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 wiring or pipe work and partly through boards shrinking due to the warmer room temperatures when central heating is installed. Ceilings are also lath and plaster which is applied to the underside of the floor joists. The gap between the ceiling and floor boards above is also ventilated by wind and convection (Figure 2.3).

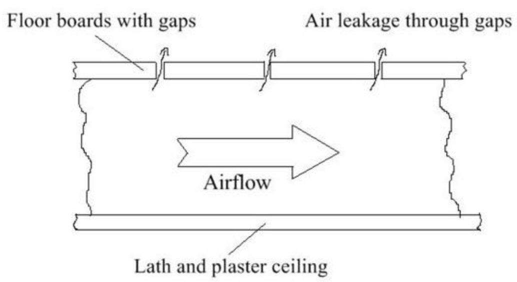


Figure 2.3 Wind induced airflow under floors

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 made in the top and base of partition walls for wiring and pipe work do mean that partition walls do get some ventilation with outside air.

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. This fostered the philosophy that "these houses needed a good supply of natural ventilation to keep them dry", which is often quoted by today's tradesman.

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 escapes up chimneys. Most chimneys in bedrooms and some public rooms were therefore closed off. With the warmer room temperatures, the need for "a good supply of natural ventilation through the rooms" is no longer needed. Instead, the requirement is to seal the rooms as best as possible while ensuring that the spaces between the granite walls and the lath and plaster is kept well ventilated to minimise any risk of condensation and associated wet or dry rot. This is the approach that is recommended by me and others for 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 the wind 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 then 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.

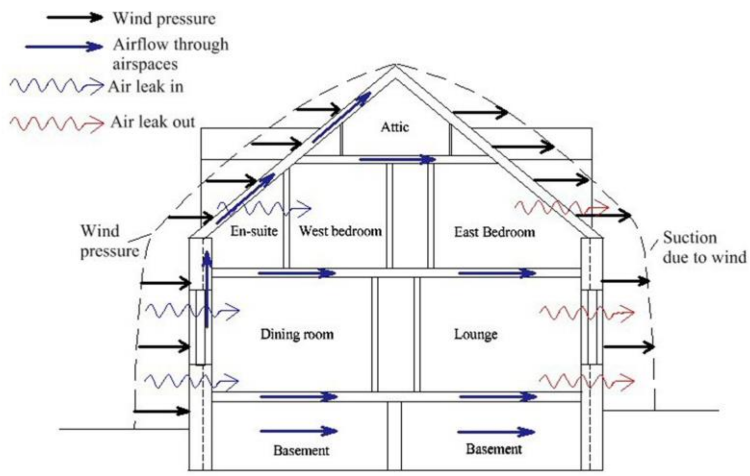


Figure 3.1. Airflows within a granite building due to wind

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 floors 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 of heat from a warm space to one that is cooler. The greatest temperature differences are between the upstairs rooms and the loft roof space, including either side of dormers. The next greatest difference 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 usually at a similar temperature to the rooms themselves.

5. Strategy for improving energy efficiency of traditional stone buildings

The statements made below come in part from the well documented science of building environment, combined with my recent experiences of making our granite home more energy efficient. The information gained in this exercise has formed the basis for the following recommendations.

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, where warm internal air escapes up chimneys, 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. This is highest in exposed farm houses and least in houses sheltered by other houses or trees.

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 cold draught of ambient air can only get in if there are leaks to escape through.

b. Reducing heat loss by conduction through room wall linings

Insulation is used to reduce the rate of flow of heat through the linings of room walls. The figure given to walls to indicate their insulation value is their U-value, which is the rate of heat per second they let through the insulation material. A low U-value (e.g. 0.2 W/m^2 °C) relates to a very well insulated wall, while lath and plaster, excluding the granite wall, has a U- value of 3.0 W/m^2 °C, very poor insulation.

Warm air can hold more moisture as invisible vapour than cold air. The vapour pressure in a warm room is therefore usually higher than outside the house, so there is a continuous flow of vapour from inside the house to 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. With lath and plaster walls, this vapour will flow through the plaster into the ventilated airspace between it and the stonework. Were insulation material such as glass fibre put behind the lath and plaster, this vapour can cause the insulation to get wet. This leads to two basic rules for installing insulation:-

1) If lath and plaster is left in place in ceilings, only lay porous materials such as glass fibre or rock wool on top of the ceiling, where air circulation in the loft will dry off any condensation that occurs in the insulation
2) If lath and plaster is replaced with aluminium foil backed plasterboard, which prevents almost all vapour movement, either insulation board or porous insulation materials can be used.

c. Insulation arrangements compared

Insulation of lofts is usually carried out using rolls of porous materials such as glass fibre or rock wool. More dense materials like slabs of rock wool, which do not slump like glass fibre, may be used in areas difficult to access to allow topping up, like under attic floors or down coombs.

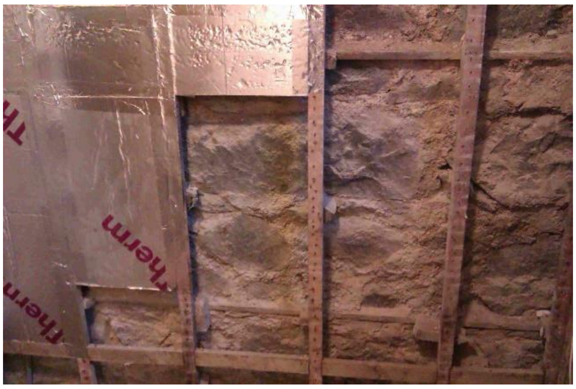


Figure 5.1 Sheets of 50-25 mm insulation fixed between studs with foil tape, leaving 50mm air space between sheet and wall

Figure 5.2 Insulation and studs covered with second 12 mm sheet insulation prior to installing foil backed plasterboard

If lath and plaster adjacent to outside walls is to be insulated, it should be replaced with insulated board material (Figure 5.1), which is subsequently covered with foil backed plasterboard. Where the rooms have ceiling friezes, decorative skirting boards, pillars, and fireplace surrounds, the projection from the studs must be restricted to 25 mm, the same thickness as the lath and plaster that has been removed. Sheets of 50 - 25 mm board are fitted between the studs, followed by a 12 mm sheet (Figure 5.2) over this sheeting and the studs, subsequently covered by aluminium foil backed plasterboard. The plasterboard can be slipped down behind the existing skirting boards. A final 3 mm skim of plaster applied to the plasterboard provides a flat surface for painting and seals any gaps between the skirting boards and the wall.

By insulating the linings of external walls, the heat loss is minimised and the likelihood of condensation on the walls is reduced. The only problem occurs in cupboards. If the doors are taken off, they will usually stay condensation and mould free. If they have doors, the cupboard internal walls and contents can become cold and suffer condensation and mould. It is best if they are insulated, even just with a 12mm sheet of insulation followed by plasterboard. If the cupboard houses the consumer unit, behind which wires go through the lath and plaster, the doors of the cupboard should be sealed and additional holes made in the lath and plaster to ensure the cupboard is kept well ventilated and dry.

d. Windows and doors

Windows and doors often leak around their periphery, so either should be fitted with new seals or replaced. New windows or doors should come with a British Board of Agrément (BBA) certificate quoting their performance in practice, particularly, stating how well sealed they are. Avoid purchasing windows, especially sash and case windows that do not have this rating. Double glazed windows, preferably with a 20 mm gap or more between panes, will avoid condensation forming on the glass. Internal secondary glazing, while not as attractive as new double glazed units, is highly effective in both sealing draughts and preventing misting up of windows. Double or secondary glazing also goes some way to improving the overall insulation value of the house.

e. Forms of energy for heating

In choosing what form of energy to use in what situation I have based my decisions on the following rationale. Electricity is a highly versatile, but expensive, energy source in the home and should be kept primarily for powering fridges, washing machines, TVs, sound systems and lighting. Gas is almost a quarter the cost, and so should be used for heating and cooking when available. Heating oil and LPG is slightly more expensive than gas but cheaper than electricity (Table 5.1). Sawn waste wood, logs, wood chip and pellets are useful for fueling stoves, with the first two helping to keep you fit. As more renewables come on stream and fossil fuels become rationed, are more heavily taxed, or simply increase in cost, there will be a move from fossil fuels to electricity for heating.

An incentive is available from government, the domestic renewable heat incentive (RHI), to encourage a change from fossil fuels to renewables. Payments are made on the basis of the amount of heat your are likely to use, based on the EPC for your house, so require that you have had an assessment carried out and have had a Green deal assessment (See p. 10). While not renewable systems, air source heat pumps (ASHP) systems also gain an incentive. These are for a maximum of 20 years, so stop after that. These subsidies are in addition to the value of the heat produced.

Table 5.1 Costs of fuels compared with electricity (Costs from Scottish Power and various web sources)

Fuel	**Cost per unit**	**Calorific value**	**Efficiency in boiler of stove (%)**	**Cost per kWh of heat produced**
Electricity for comparision	14.22 p/kWh		100	14.22
Natural gas boiler	3.93 p/kWh	37.53 MJ/m^3	89	4.41
Diesel oil (28 sec) boiler	46 p / litre	40.5 MJ/litre	89	4.60
Coal in stove	35.4 p / kg	31.4 MJ/kg	78	5.20
Firewood in stove	10.5 p / kg	16.0 MJ/kg	78	3.03
Wood chips (30%)	11.0 p/kg	12.6 MJ/kg	78	4.02

f. Boiler heating systems

Boiler type heating systems are universally popular for heating radiators and hot water. Condensing boilers are now both reliable and of all the changes that were made in our house, provided the most dramatic reduction in energy use. Heating water only when needed for washing, showering or baths, makes more sense than keeping a tank of hot water continuously above 65 °C. This is why combi boilers are popular. The addition of a small 35 litre hot water tank within our boiler, sufficient to rapidly fill a bath or sink, makes this an attractive option. If houses have many occupants, or are fitted with solar hot water systems or back boilers, a conventional condensing boiler together with a hot water tank may be the more logical choice.

If changing a boiler, it can be an opportunity to change from a header tank system to a pressurised water system. We did this on the recommendation of our plumber and are delighted with the result. Pressure is maintained in the house's pipework by a small pressure vessel, kept at a constant pressure by a small pump. This not only keeps the pressure relatively uniform over the whole house, regardless of what floor you are on, but dispenses with the need for water tanks in the loft, which take up room and may freeze.

g. Open fires, gas fires, ranges and stoves

Open coal, wood and gas fires need a chimney to carry away smoke and fumes. Open chimneys also allow room heat to escape, reducing the warmth obtained from the fire. When the fire is not lit, the chimney still provides a route for any heat to escape. Sealing a chimney with a slide or balloon poses the risk of the homeowner forgetting the seal is in place, and smoking out the room. Ranges and stoves have flues attached, which can be closed down or shut when not in use. Our change from an open fire to a stove, due to its greater efficiency, reduced coal/wood use by two thirds. Open fires should therefore be replaced by stoves. Ranges, like Aga's or Raeburn's, greatly loved by their owners, and often converted from solid fuel to oil, have a huge heat transfer area. While the hot plates for cooking are insulated by hinged lids, heat is radiated from the whole range winter and summer. The heat in summer is unnecessary and a waste of energy. For an energy efficient house, these should go.

h. Heating control

Figure 5.3 Honeywell wireless controlled radiator

Control systems for home heating are going through an interesting change, with smart phone control apps, home wireless modems and wireless operated wall and radiator thermostats entering the market. The easiest to control remotely is the wall thermostat that is located in the hall or lounge and controls the whole house. This is simple and satisfactory for small flats, but for larger houses with a number of rooms, radiators with thermostatic valves allow different temperature settings for lounges and bedrooms with the ability to turn down the settings in unused rooms. Further energy savings can be made by splitting central heating systems into zones, as I did, such as the kitchen, lounge and bedrooms. This is now made easier by fitting wireless valves to radiators, so that they can be switched on remotely at different times of the day. This is the system I would use today. Being able to operate wireless operated wall thermostats when away from home using a smart phone is now available using (HIVE, Nest or Tado) systems. Controlling a number of wireless radiator valve systems from a distance is still to come.

A zoned house, which has rooms at different temperatures, requires room doors to be shut. If doors are 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 so create a draught that cools 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, often unnecessarily, pumping out heat. Zoned houses therefore requires that doors of rooms are kept shut in winter.

i. Passive solar heating

If your house has a south facing aspect, this is a real asset. If a conservatory is built, the roof should be insulated in my experience, with glass only in the walls; otherwise the conservatory becomes too hot in summer and too cold in winter. A stone wall between the conservatory and house can act as a heat sink, or the solar heat can simply warm the room behind the glass. Blinds, thick curtains or a door can insulate, or shut off, the windows at night.

j. Connecting stove and solar hot water panels to a hot water tank

An appealing scenario I considered was to have a highly insulated hot water tank which is heated in summer using a solar collector and in winter by a stove. The problem here is not that hot water can be generated this way, but whether the heated water can be utilized. There are only so many showers one needs. To ascertain how worthwhile an installation like this will be, read the gas meter (more difficult with oil heating) and check how much gas is used in summer to heat water for showers, washing and baths. This may only be a few pounds per month. Will the saving in gas pay for the solar panels, the new tank, the pipework and pump, bearing in mind the panels only heat in summer, and heating varies depending on cloud cover. The heat provided by the stove is probably more consistent, but it will only be on during the winter. Having done the sums, discussed in the 72 page companion to this publication, I decided against this approach. Just heating water when you need it has its merits.

k. Monitoring energy consumption

If you ask people how much energy they use a year, few can tell you. Keeping track of energy use when trying to cut down is both interesting and fun. Actions to reduce energy use can be assessed for effectiveness if meters are read regularly. The reduction of energy use for our house between 1998, when it was owned by another couple, and 2014, when most of the refurbishment was complete is shown in Figure 5.3.

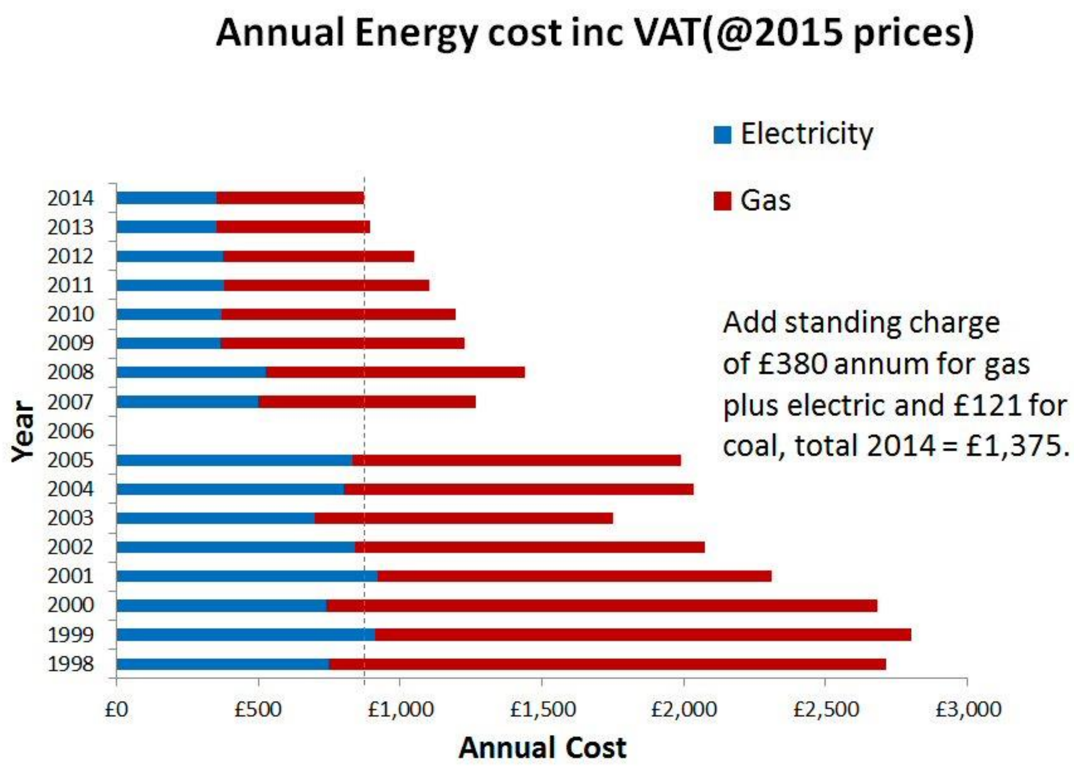


Figure 5.3 Annual energy cost for our three bedroom, two story home, between 1998 to 2014, the period when measures to make the house more energy efficient were made

However, in constantly checking energy use, conflict can occur with house occupants if one is altering controls to minimise energy use while the other is feeling cold. The approach my wife and I use is for me to do all the draught proofing, insulating, fitting of control equipment, etc., while she decides when the heating is to come on, what the thermostats should be set at and which rooms should be heated and when. So far this approach has worked well and we are still together.

6. Checking the house with using pressure checks and infrared cameras

Pressure tests on a house involve the fitment of a canvas curtain in the front door frame (Figure 6.1), with a computer controlled fan in its center. The test is done by running the fan so that it produces a vacuum in the house of 50 Pascal (Pa). In carrying out this test, leaks can be identified by the inrush of air coming through room doors kept just ajar, through holes in cupboards and gaps in skirting boards, or gaps in floors. A leakage test at the start of any refurbishment helps identify potential draughts and will aid the development of a refurbishment strategy.

Figure 6.1 Pressure test kit installed in front door of house

A further test on the building can be carried out using an infra red camera. While the pressure test can be carried out regardess of external weather conditions, the infrared test needs to be done in winter when the house is warm and the external temperature is cold. The different colours in the test show the areas where most heat is being lost. If you know how the building is constructed, the results will come as no surprise and may be of little benefit. Where it will be useful is where insulation, such as injected foam in cavities walls is missing, leading to greater heat loss in these areas. Of the two tests, the pressure test is much the more important. A second test after refurbishment is complete, ensures that tradesmen have sealed all wiring and piping access holes, and that kitchen fitters have sealed walls behind their units.

7. The Green deal, the Energy Companies Obligation (ECO)

The Green Deal is a Government policy initiative led by the Department of Energy and Climate Change (DECC). It is a framework enabling private companies to offer consumers energy efficiency improvements at no up-front costs. The payments are recouped over time through charges on the energy bill. The Green Deal can be accessed by owner-occupiers, the private and social rented sectors and the commercial sector.

The Green Deal process has four stages:

1) ***Assessment*** - carried out on home or business premises by a Green Deal Advisor or assessor for which there is a charge (current quotes of £95-£100). They will use standardized software to identify what energy improvements can be made and what the financial savings would be. A Green Deal advice report is produced outlining options.

2) ***Finance*** **–** The report can be taken to one or more Green Deal Providers who can arrange and fund the improvements. If you decide to take up a Green Deal offer, you will sign a Green Deal plan, the contract between you and the Green Deal Provider.

3) ***Installation*** –The Green Deal Provider will arrange for a Green Deal vetted Installer to carry out the work agreed.

4) ***Repayment*** –This is made over time through your energy bill which in turn passes on payments to the Green Deal Provider. The amount borrowed is set such that the measures, plus the interest should be affordable out of average bill savings as predicted by RdSAP – the so-called ***Golden Rule***.

   This is not a conventional personal loan as the charge is attached to the house. If you move house, the new occupant will pick up the charge while benefiting from a more energy efficient property.

   Interest will be charged on these payments but the rate will be fixed. It is up to the Green Deal Providers to decide on the interest rates, so it is a case of shopping around for the best deal (6.9-7% has been quoted).

The finance is provided by a private sector consortium seeking to provide Green Deal finance to a wide customer base. The interest adds a substantial amount to the overall repayments and this has led to the criticism that for many of the measures theoretically available in the Green Deal, the return on investment in fuel bill terms is simply too low to cover the costs of finance in a reasonable time or even within the predicted lifetime of the measure itself. This is why most green deal assessments end up with no further action.

With my modifications, payback time in terms of energy savings alone exceeded 60 years, even at an interest rate as low as 2.5%. The Golden Rule is therefore unlikely to have supported any of the modifications carried out. Had the increase in value to the house and the value of its greater thermal comfort been added to the value of energy cost savings, a truer cost benefit would have been obtained. Alternatively, a grant towards the work could have tipped homeowners into funding work that they might not otherwise have undertaken.

The Energy Obligation (ECO) is the successor to the Carbon Emission Reduction Target (CERT) which offered subsidized cavity wall and loft insulation. ECO obliges the big six energy companies to deliver a certain amount of carbon saving by paying towards energy efficiency measures. The Government has decided that it wants to use the ECO to boost the market for solid wall insulation so around half of the spending will have to be on energy efficiency improvements to houses with solid walls or hard-to-treat cavities. ECOs overcome the basic hurdles of the Green Deal by offering substantial subsidies. Customers will only be able to access ECO funding if they have a Green Deal Assessment done and then secure an offer from a Green Deal Provider or direct from an energy company and crucially if they use a contractor who is Green Deal accredited.

Whether this will deliver in practice is yet to be seen.

8. Standard Assessment Procedure (SAP) and Energy Performance Certificates (EPCs)

SAP measures the energy efficiency of the house on a scale of 1-100 with 1 being the least efficient. The calculation is done using specially designed software and is simplified for existing buildings, where certain assumptions may have to be made regarding the construction and materials, by using Reduced Data Standard Assessment Procedure (RdSAP). The SAP/RdSAP methodology has been amended to enable local weather data to be used in calculating energy saving benefits or measures.

Energy performance Certificates (EPCs) indicate how energy efficient a house is on a scale of A-G with A being the most efficient with the lowest fuel bills. The certificate also tells you on a scale of A-G about the impact the home has on the environment. Better rated homes should have less impact through reduced CO_2 emissions. The calculation methodology used is SAP for new build and RdSAP for existing houses.

9. Step by step guide to making the house more energy efficient

Having carried out a complete refurbishment of our house, if I were to start again I would do some things in a different order. The following step by step guide is therefore based on my experiences.

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

- A pressure test should be carried out on the building before deciding on strategy. Thus will identify how porous the building is, which rooms are most leaky, and the areas of inrushing air can be used to identify where leaks are coming from in individual rooms.

- Once the scale of the leakage has been established, a plan of action can be formulated. Leakage holes may be behind kitchen units, in cupboards, along skirting boards, through the floor, through windows and doors. Often it is better to remove whole kitchen units or cupboards, than fiddle with finding and sealing up a host of holes in the units themselves.

- This energy saving exercise is a chance to simplify your house, to remove added cupboards, fitted wardrobes, and glory holes. Their removal may well expose holes that you never knew existed.

- Every time new wiring, plumbing, or computer cables are installed, new holes are punched in the room linings. In an energy refurbishment, it is best to carry out any rewiring, boiler or central heating changes, before you start sealing the house. Items to consider are whether to install a solid fuel stove rather than keeping traditional fireplaces, whether to replace the existing hot water tank and boiler with a combi boiler, whether to remove water header tanks and replace them with a pressurised water system, 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.

- External doors and windows should be sealed or replaced to ensure the building is airtight. If new, they should come with a BBA certificate to prove that they are well sealed and perform as stated.
- 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[1] should be fitted to a number of internal doors to both stop draughts within rooms, especially these with open fires of stoves 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.
- The schedule of energy refurbishment work should be undertaken at the same time rooms are being redecorated. If feasible the lath and plaster adjacent to external walls should be insulated, especially 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[1]. The present vogue for exposing and sanding leaky timber floors should not be considered unless there is some way of sealing between the boards.
- Installers of bathrooms, shower rooms, fitted kitchens, etc. should be instructed to seal[1] any holes they make when fitting their equipment.
- Once all the refurbishment has been completed, a second pressure test should be carried out to check the house is sealed and that tradesmen have not left holes in the room linings. A penalty by the home owner may be incorporated in any contracts requiring rooms to be sealed after work has been done in them.

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