Warmer Bedford Cottages

Guide for Residents | 2021

Energy use management and thermal improvements compatible with listed historic buildings for comfort, health, economy and value.

DEVON HISTORIC BUILDINGS TRUST since 1973

Tavistock

HERITAGE FUND

West Devon Borough Council

Tamar Energy Community

Contents

1. Introduction

West Devon Borough Council (WDBC) and Tamar Energy Community (TEC) are working with Bedford Cottage Residents to show how the cottages can be made healthier and more comfortable in cost effective ways.

Many of the Bedford Cottages are listed buildings which require listed building consents for alterations to their historic fabric or appearance. The study sought practical cost-effective solutions that can be implemented as good conservation practice. The solutions can also be technically appropriate and economic for many other listed and non-listed traditionally built homes in our area.

WDBC has agreed in principle to the recommended solutions as specified, which will in some cases require listed building consent.

This initiative is covering common issues that require ongoing building maintenance, plus good practice for the retrofit and insulation of Bedford Cottages.

This 'Guide for Residents' is a summary of the topics investigated and the resulting advice.

The TEC website has full technical information on each topic.

In 2020 the results of investigations and analysis by TEC were rigorously evaluated by a post graduate student at Plymouth University School of Building Sciences as a master's degree thesis. Sophisticated professional computer models were used to compare insulation options and identify which were most effective for a range of performance measures. The recommended insulation options were found to be the most cost effective compatible with traditional building fabric, and to provide the best comfort levels, contribution to low carbon targets, and long-term resilience to forecast climate changes.

2. Bedford Cottages: a history of heating

19th Century Origins

• Mill Hill Cottage

The Bedford Cottages were built in the mid-19th Century to house the influx of mining workers. The cottages were well-built homes designed to attract and retain foremen and skilled trades. At that time the rooms, facilities gardens and outbuildings would have been considered luxurious for working families.

The building materials were local brick, stone, slate, lime mortar, timber and clay floor tiles used in traditional ways. At that time walls were founded directly onto the underlying ground without separate foundations or damp-proof courses. Ground floor clay tiles were also laid directly onto the ground, probably on a lime sand screed. Brick or rubble stone walls were built using lime sand mortar. Externally walls were left bare, with lime plaster internally. The residents would have used lime wash on their walls to increase the reflection of light and for good hygiene. The windows and doors were well crafted and of good wood (indeed many survive 150 years on) but would have been draughty. The roofs were local Mill Hill slate fixed on battens across the rafters. In-roof room ceilings were lime plastered onto lathes fitted to the underside of the rafters.

There was no electricity or gas at that time. Water would have been drawn from communal standpipes nearby. Heating fuel was wood and coal in open hearths and range cookers used all day (and night) to keep everyone warm, dry clothes and cook food. These were hardy folk who would rise early and work long hours six days a week. They wrapped up against the cold and the fires would take a raw chill out the air (not create a fug).

However, those fires would also draw moist air up the chimney to ensure that the house was ventilated when closed-up in winter months. In summer and mild days windows would have been open much of the time. The lime mortar in the walls would absorb moisture when wet and humid and release moisture when dry, warm and draughty. This 'breathability' prevented the solid floors and walls from being permanently damp.

20th Century Changes

The Bedford Cottages were progressively adapted for new services and lifestyles throughout the 20th Century. Electricity and gas mains would bring power, light and convenient sources of heating. In the 1970s grants were available to build extensions with a kitchen and bathroom at the back of each cottage.

In Tavistock gas mains allowed many cottages to install gas fired boilers for heating and hot water, while in rural areas oil-fired heating was possible. Residents' expectations were that they could keep some or all rooms warm for much of the time. Cold draughts were sealed off.

These new systems did not use the old chimneys, and some were blocked, which significantly reduced the ventilation when the home was closed-up. Even unblocked chimneys became damp and therefore cold.

Room walls were often re-plastered with gypsum or cement and painted, often with impermeable materials. Often, external walls were re-pointed with cement-based mortar, or a cementatious render, and / or masonry paint, all of which are impermeable and prevent the walls from breathing as they should.

• **Parkwood Cottage (render removed)**

21st Century Requirements & Objectives

Energy prices have risen steeply in recent decades making heating a major household cost, and worldwide environmental concerns have demanded reductions in energy use. Building Regulations have responded with higher required standards for home insulation and heating system efficiencies, and the phasing out of fossil fuels. Governments are imposing energy performance standards to require progressive improvement of the existing housing stock.

Energy efficient homes that can be affordably kept warm, dry, and well ventilated are recognised as essential to health and wellbeing. The requirements of historic buildings are recognised in the Building Regulations and in the application of Energy Performance Certificates (EPCs).

3. Energy Management

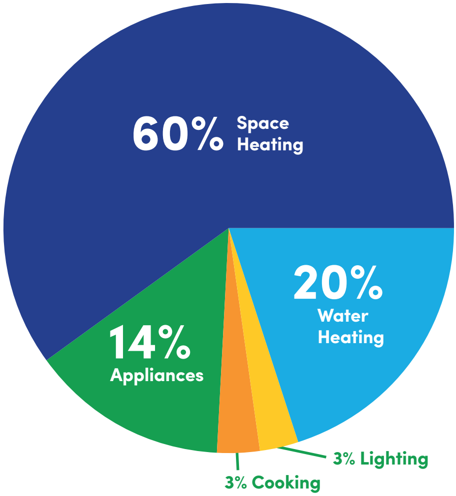
We use energy in our homes as electrical power and lighting, and various fuels (gas, oil, wood and electricity) for heating.

For typical households, space heating is about 60% and hot water about 20% of energy use (in kilowatt hours).

Appliances (fridges, washing machines, TV, computer, etc are about 14% with lighting 3% and cooking 3%.

Houses, households and lifestyles vary considerably so these are only indicative uses.

However, space and water heating are clearly the main use of energy and needs to be efficient for an affordable and comfortable home.



Electrical energy used in appliances and lighting are about three times more expensive per kilowatt than gas or oil used in heating. Electricity use is therefore typically about half of home energy costs making efficient use worthwhile.

Further, the environmental challenges of the 21st Century also require that we reduce all forms of energy use, and progressively transfer to renewable sources.

There are many ways to reduce energy use. Some are relatively easy to do while others require more effort and investment.

Tamar Energy Community's energy advisers can discuss residents' concerns and questions, including options on what can be done to reduce energy use. This can be a combination of a virtual, and where needed physical, home visit.

Visits will generally last one or two hours and include a review of:

- How the residents are using energy and energy saving tips
- Bills and suppliers and eligibility for Warm Home Discount and the Priority Services Register; and referrals for benefit checks

- Assistance with switching energy supplier where savings would result
- Easy energy saving measures including LED bulbs, radiator reflectors, draught stripping, hot water pipes and tank lagging
- Potential heating systems and controls for more efficient use
- A general survey of the home including insulation, any signs of damp, ventilation, hazard checks including smoke and carbon monoxide alarms

There are good online sources with comprehensive practical advice on many aspects of making homes more comfortable, reducing energy use and managing energy bills.

- Energy Savings Trust (EST): www.energysavingtrust.org.uk/home-energy-efficiency
- Centre for Sustainable Energy (CSE): www.cse.org.uk/resources/tag:energy-advice
- Historic England (HE): www.historicengland.org.uk/advice/your-home/saving-energy

The following sections cover the larger changes that require significant investment and professional services to make older homes more energy efficient.

• Parkwood Cottages

4. Heating Systems and Controls

Few homes now use open fires, but there is some use of wood burning stoves vented through the old chimney, either as main space heating, or only in a living room. In Tavistock where gas mains are available central heating gas boilers are common for hot water and space heating through radiators. Where there are no gas mains, central heating can be oil or LPG fired. The alternative is electric heating for hot water and room heating with night storage radiators. Single room or local comfort heating is sometimes by a plug-in convector or radiant heater.

While the Bedford Cottages are relatively small, they can be hard to heat due to:

- damp walls and floors
- uninsulated solid walls and uninsulated ceilings
- single glazed windows

The next section covers dealing with damp and later sections deal with insulation options.

Modern central heating boilers and wood burning stoves can be 20% or more efficient than older models. Replacement of old boilers reduces fuel use per kilowatt hour of heat and therefore the running costs.

Older heating systems have rather limited control options – often a single thermostat for the whole house, with some control over heating times the system is either on or off. Thermostatic radiator valves (TRVs) allow residents to control the temperature of each radiator. In practice few households actively manage the central or radiator controls, and they rely on turning the whole system on or off. Finding the resulting fuel bills expensive, they then resort to using individual electric heaters in the room they are using. This form of electric heating costs about three times more per kilowatt hour of heat than oil or gas heating.

Over time the UK is committed to phase out oil and gas domestic heating due to their CO2 impacts on the environment. The replacement systems will be largely renewable energy sources that generate electricity or heat. Photo Voltaic panels and wind turbines supply an increasing part of our electricity. The cost-effective use of this electricity will be through heat pumps which abstract heat from the air, water or ground, and deliver into the home

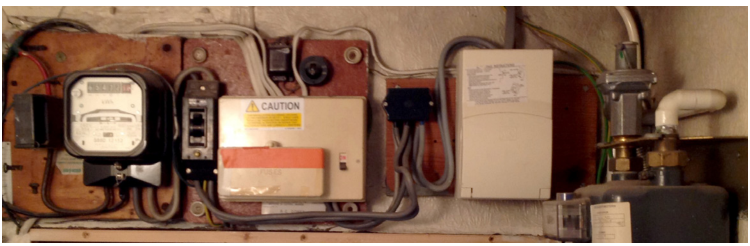
as hot water. (They work in the same way that a refrigerator extracts heat from inside the cold compartments). Heat pumps use about 1 kilowatt hour of electricity to produce 3 to 4 kilowatt hours of heat, which is cost effective and comparable with gas costs.
Modern heating controls allow residents to heat different rooms at different times so that each room is only heated to the desired level when required. This is more efficient than heating the whole house much of the time when rooms are not in use and provides better control of the required temperatures in each room.

Old night storage heaters (NSH) lose their stored heat through the day often requiring supplementary heating in the late afternoon and evenings. Modern high heat retention heaters have well insulated heat stores to allow the heat release only when required by the user. This more efficient energy use also avoids the need for more expensive supplementary heating. 'Economy 7' contracts offer lower overnight electricity rates, but that comes with higher daytime rates for other household electricity uses. Smart meters will allow half hourly metering and off-peak rates at various times of day and controls can avoid using peak rates.

The efficiency of home heating systems and controls are a significant part of the EPC rating. The improvement of heating systems will not normally require approval from WDBC planning unless new flues are proposed through walls.

A combination of a modern efficient heating system, and controls to maintain comfort levels only where required, can reduce energy use by up to 50% from an inefficient system without room-by-room controls, and will therefore payback the investment over a few years.

In the longer term, the Government plans to phase out carbon intensive heating, including gas, with efficient electrical heating such as heat pumps. For homes with gas connections this is not yet an economic option but will likely become more cost effective with policy incentives.



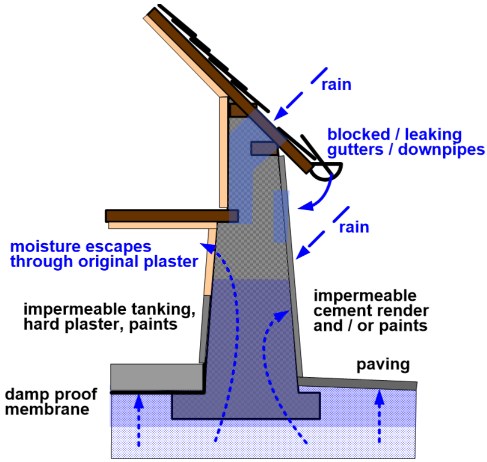
5. Dealing with Damp

Damp is the most common concern of Bedford Cottage residents. Dealing with damp is also an important first step to making a house healthy and more energy efficient. About 40% more heat is lost through damp than dry building materials. Historic stone walls can have effective thermal mass if they are kept as dry as possible, but dampness prevents that positive benefit.

Damp patches also host mould spores which rapidly multiply and create poor indoor air quality which affects those with respiratory conditions or poor immunity systems (young and old).

Causes may be penetrating damp, trapped moisture or rising damp, which are often misunderstood and sometimes made worse by wrong treatments.

Penetrating Damp arises from:



• Causes of damp

- leaking, broken or overflowing gutters and downpipes,
  slipped roof tiles, cracked render or failed pointing,
- low on walls due to high outside ground levels and/or splash zones,
- internal leaks from plumbing (eg joints or washing machine hoses) or wet room floor spills

Penetrating damp is due to poorly installed or maintained building parts releasing water into the building materials. Practical remedial works and regular maintenance are essential.

Trapped Moisture arises:

- within walls and chimneys due to impermeable pointing, external renders and paints
- in walls due to impermeable internal plasters and paints

Trapped moisture results from 20th Century builders using inappropriate impermeable materials on old buildings that relied on lime mortars and lime plaster to breathe. This is addressed in the external walls, render and paints sections.

Rising Damp is found:

- in solid floors laid on permanently damp or saturated soil
- in solid walls due to saturated foundations
- often caused by blocked or damaged drains

Rising damp requires the building fabric to breathe so that air movements can remove the moisture by evaporation. A plastic membrane below a solid floor traps moisture and tends to saturate the wall foundations. A better option is in the ground floor section 6.4. However, rising damp is often 'blamed' for conditions caused by raised ground levels, poor drainage outside the building, and impermeable finishes which block the building from breathing. This is addressed in the external walls and ground floors sections.

A further cause of damp is condensation on cold surfaces, covered in section 5.2.

5.1 Paints and Renders

The Bedford Cottages solid walls were built of brick or stone with lime mortar which absorbed moisture in wet periods but was then dried by sun and wind. Inside walls may have been lime plastered which also allowed indoor humidity to be absorbed and released by warm air movements. If external or internal walls were painted, a breathable lime wash was used.

• **Parkwood Cottage (render removed)**

The windows would be open in spring, summer, autumn and on mild winter days. Even closed doors and windows would have been draughty. In winter open fires would draw stale air up the chimney and draw fresh air into the room. The solid walls would have been cold, but their breathability would prevent the build-up of excessive damp.
In the 20th Century residents applied impermeable external and internal wall finishes, including:

- External cement pointing, cement renders and masonry paints
- Internal gypsum/cement pointing, tanking, plasters, and washable emulsion paints

These impermeable finishes trap moisture within the solid walls. Damp walls are thermally inefficient, and cause damp patches particularly near ground floors and wherever penetrating damp has entered through cracks in the finishes. The damp is also seen in patches of salts that have leached through internal plasters and paints.

The only remedies are removal of the impermeable finishes to reinstate breathability. Internally it is necessary to check behind the paint to see if it is lime or a 20th century impermeable plaster. Plaster removal is messy but fairly easy and can be replaced by an efficient lime thermal plaster that provides good insulation and is highly breathable. The walls can then be repainted with limewash, distemper, clay or silicate paints which are permeable.

Removing wall plaster may reveal other problems such as cement repointing of the stonework, or cement or bituminous tanking at the lower levels. These are harder to remove and will require lime mortar re-pointing of the areas affected before re-plastering.

Externally, cementatious renders were used in the 20th Century to make the wall impermeable to driven rain. It may originally have been effective, but over time cracks form and let in water that cannot escape. Cementatious renders are hard to remove and the chiselling off may damage the stone and old pointing (which may have been poor before the render) and require re-pointing with lime mortar. The render removal should be carried out with great care following a test on a small area., Where the stonework is found to be poor, using hand tools is preferred.

Where impermeable masonry paint has been applied directly over the stone or brickwork this can be removed by various methods, some chemical and others using gentle abrasive techniques. The options are being researched and will be added on the TEC website.

Silicate paints are breathable and can be used externally, but this would be subject to conservation approval on a case by case basis. The conservation preference would be to progressively restore the original external brick / stone and lime mortar character of the Bedford Cottages.

5.2 Chimneys

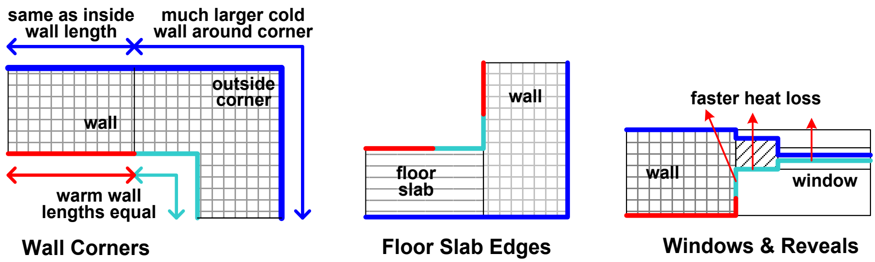
Chimneys are common sources of damp issues in Bedford Cottages. Rain penetration can arise from failed haunching or pointing or cracks in the chimney stack, or failed lead flashing between the chimney stack and roof. Some chimney stacks have been rendered. Over time the render develops cracks which let in water which is unable to evaporate away. Rain and downdraughts through the chimney can also cause the inside of the stack to be cold and damp. Birds, (particularly Jackdaws) nest in chimney stacks causing blocking ventilation and accumulating damp nesting materials, bird-waste and infestation.

Repair and maintenance of the chimney stack and roof are essential. Appropriate chimney cowls will prevent rainfall and bird entry. Where chimney stacks have deteriorated beyond repair, rebuild will be permitted to approved conservation details.

5.3 Cold Bridges

Moist warm indoor air condenses on cold surfaces in areas with faster heat losses through the building fabric known as cold bridges.

Common examples of cold bridge areas are wall corners, floor slab edges near outside walls and at window reveals. At corners and floor slab edges the cold thermal mass drains the warm surfaces. At windows the reveals and jambs have short heat loss paths to the outside cold surfaces.



Sufficient warm air movement will dry the condensation, but often these areas remain damp and mould forms. This can occur in under heated and low use rooms or where furniture blocks air circulation. Corners near ceilings and floors also tend to be still air pockets. These 'cold bridge' areas require special attention when insulating walls, floors, and windows.

5.4 Ventilation

The Bedford Cottages were built with open fires that were probably kept going throughout the day in winter months. Not only did they provide warmth, hot water and cooking, they also sent stale and moisture laden air up the chimney while drawing in fresh air through draughty doors and windows.

20th century central heating systems, draught proofing and lifestyles have increased indoor temperatures and the creation of excess moisture from showers, laundry and cooking. Warm air carries a higher moisture load than cooler air. Air temperature cools against cold surfaces condensing moisture as beads on hard surfaces or absorbed into the building materials as damp patches.

Excess moisture is also a sign that the air in living rooms is not being replaced by fresh air. Fresh air is required to replenish oxygen levels and to remove toxic gases such as carbon monoxide, dust, and the many microbial organisms that proliferate in humid conditions. Poor air quality has several adverse health impacts.

The Building Regulations require positive ventilation extractors from all 'wet' rooms (bathroom, kitchen and utility) to extract humid air and draw air from other rooms, thereby reducing high moisture spread into living areas and drawing fresh air in from outside.

In the West Country a common misunderstanding is that our humid outside air would bring more moisture in. However, the humidity measure is 'relative' humidity, which is the percentage of saturation 'at the air temperature'. Colder air saturates at a much lower moisture load than warm air – hence condensation as air cools.
Therefore, 80% humidity warm air carries far more moisture than 80% humidity outside cold air. Replacing stale warm air with fresh cold air significantly reduces the indoor moisture load.

Therefore, extractor fans should be installed (and used) in all wet rooms and set up to run at a high (purge) rate when wet rooms become humid to reduce the spread of moisture through the house. Even where extractor fans are installed it is common that residents do not use them because they remove expensive warmth. The Building Regulations requirement is based on evidence of the health risks of poor air quality and damp. Active control of when and for how long the extractor operates is a healthy compromise.

For new installations, modern extractor fans with variable ventilation rates and demand controls set the exhaust rate. A humidity sensor will increase the rate to purge high moisture loads (due to cooking or a shower for example) and reset to an efficient low background ventilation level when the moisture level falls back.

There are a few situations where extractor fans are not appropriate. For example, an oil Aga or other type of range cooker, draws in air through a grill into the exhaust flue, and an extractor fan could draw exhaust fumes back into the kitchen. Indeed, the range cooker functions as a continuous trickle (background) ventilator.

Moisture is not only from wet rooms, as all of us and our pets release moisture throughout the house. A low background ventilation rate in the wet rooms will continuously draw air from living rooms and bedrooms to ensure that fresh outside air is drawn in to maintain healthy air quality, and air movement will help to dry damp building areas. This is particularly important in cold months when windows are kept closed.

Some windows have trickle vents which only function where there is a positive pressure (wind) on that face of the building and drive stale air out the other side. Trickle vents should be left open except when they are causing a strong draught due to high winds. In all but the worst weather it is also sensible to open bedroom windows each morning for 15 to 20 minutes and sitting room windows once a day to purge stale air.

• **Westbridge Cottages (back)**

6. Renovating with Insulation

Generally, the topics in the preceding sections (heating and control systems, dealing with damp and ventilation) will be the highest priorities with the best returns on investment. Retrofit of the building fabric will generally involve significant costs with longer pay-back but can resolve problems of damp, reduce heat loss though effective insulation, and improve comfort levels.

To significantly improve the energy efficiency of a Bedford Cottage owners may chose:

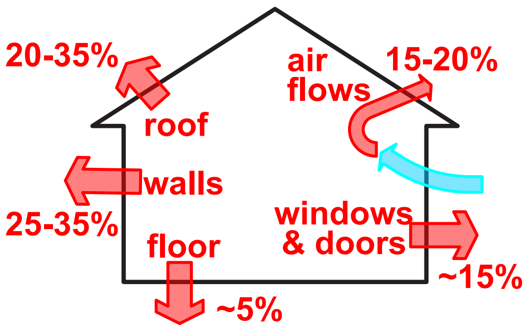
- whole house retrofit, normally soon after purchase and while living elsewhere, or
- progressive changes room by room over several years as they redecorate while in residence.

Whole House retrofit requires significant capital, but the building work would be more cost efficient due to unconstrained working conditions and economies of scale for each trade.

Progressive room by room working allows work to be done as funds permit but is disruptive and messy to family life in a small home.

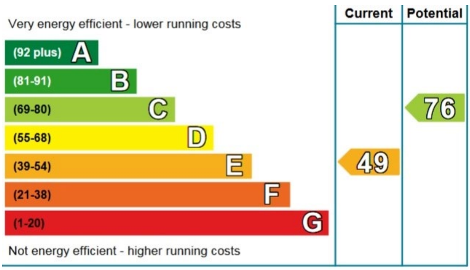
Where funds are limited, owners will want to prioritise work that gives the greatest benefit. The existing condition of the building fabric may dictate issues that need to be addressed. For example, wall insulation will only be effective if damp issues are resolved first, or as part of the work.

The diagram indicates the percentages of heat lost through each of the original uninsulated house elements: walls, roof, windows, floors, and air flows. While the walls and roof heat loss are similar, the cost of roof insulation may be significantly less, giving a better return on investment.



A popular measure for comparing return on investment is the pay-back years through savings in energy costs. However, the comparative costs and benefits depend on many aspects of the work and how it is done, therefore examples can only be indicative. Importantly, the primary reasons for the renovation work should be to make the home more comfortable, healthy, and enjoyable. The value of the property is also increased to offset the costs. Also, as energy costs continue to rise, the energy cost savings become greater.

Energy Performance Certificates (EPCs) recommend measures to improve thermal performance, but these works are not required for 'listed' Bedford Cottages where the work would harm historic character and would not be approved by the Council.
The Government Clean Growth Strategy for domestic housing is to "look at a long-term trajectory for energy performance standards across the private rented sector, with the aim of as many private rented homes as possible being upgraded to EPC Band C by 2030, where practical, cost effective and affordable."



The current legal requirement for the private rented sector is a minimum EPC E. This is planned to rise to EPC D in 2025 and to EPC C by 2030.

The direction of policy is for these requirements to be applicable to all private housing and this includes listed buildings "insofar as compliance with minimum energy performance requirements would not unacceptably alter their character or appearance".

The Warmer Bedford Cottages investigations have identified methods to improve the thermal performance of these homes to a good standard in a manner that is compatible with their historic character and fabric. The methods also offer potential to reverse much damage that has been done using inappropriate solutions in recent decades.

Insulation performance is compared using 'U-values' (in Watts per square meter per degree centigrade). It reflects the combined resistance to heat loss of all building layers from the thermal conductivity and thickness of each layer. Lower U-values are better insulated. In this Guide improvements are presented as percentage changes The actual U-values for different materials and specific product data are on the TEC website.

6.1 External Walls

Uninsulated external walls are the highest contribution to the cottage heat losses. Mid terrace cottages about 25% and end of terrace cottages with much higher external wall areas about 35% of their heat loss. The uninsulated solid walls will have a U-value of about 2.0 but will perform far worse if the wall fabric is damp.

Current regulations for new build require a wall U-value of 0.28 which is about 85% lower than the existing. For renovations, the minimum (threshold) U-value is 0.7 (about 65% below existing).

External Wall insulation will not normally be permitted for listed buildings, and/or buildings in a conservation / protected landscape area, particularly for primary facades. However, this may be an option on later rear extensions walls.
Internal insulation of external walls must meet several objectives:

- Breathability to allow moisture release from the wall (natural products)
- Avoid (interstitial) condensation risk within the wall. A minimum insulated U-value of 0.4 is advised but, to allow for material variability, a design value of 0.5 is recommended.
- Low impact on small room areas (deemed as less than 5% of a room area)
- Low / sympathetic impact on historic wall aesthetics (maintaining the character)
- Cost effective in reducing heat losses (deemed as payback in 15 years or less)
- Manageable disruption impact of the works (room by room)

The insulation option that can serve all these objectives is the use of a thermal lime plaster. There are several products, but their properties vary considerably. In particular, their thermal conductivity ranges threefold, limitations of their application thicknesses, and their cost.

A 50mm layer of the most efficient thermal lime plaster could give a 75% wall heat loss reduction. The existing wall plaster is likely to be 50 to 60mm thick, and it could be stripped and replaced to achieve the thermal improvement with no loss of space. The indicative payback is about 15 years. The pictures show a Fitzford cottage walls being insulated this way.

1. Stripping the existing plaster. 2. Repair structural cracks. 3. Harling to key and fill holes.
4. Scratch coat with key. 5. Float coat and final skim finish. 6. End view of layers with mesh.

Note that lime plastering is a specialist skilled job. Other considerations and options are discussed on the TEC website, particularly the breathability of existing external and internal finishes, and existing damp issues.
The payback assessment was at 2020 energy, material and labour cost estimates. Once the work is done, as energy costs rise the savings will be greater. An EPC will reflect the increased efficiency and enhance market value and ease of sale as the EPC requirements are raised.

Particular attention is required to window / door reveals, where condensation and mould are common. This occurs due to higher heat loss to the cold outside face of the wall, known as cold bridges. Often there is limited depth available for an overlay without covering the window or door frame. Removal of the existing plaster will be required to allow a thickness of the thermal plaster to sufficiently insulate these surfaces.

Extension Walls. Kitchens and bathrooms were added as ground floor extensions to most Bedford Cottages in the mid-20th century when grants were available for this specific purpose. The materials and build quality varied, and the level of insulation was significantly below current building standards.

Each extension will be different and therefore a typical heat loss has not been modelled. Where extension walls are poorly insulated the heat losses could be significant. Kitchens and bathrooms are areas of high humidity, and condensation mould will indicate both inadequate ventilation and cold surface areas.

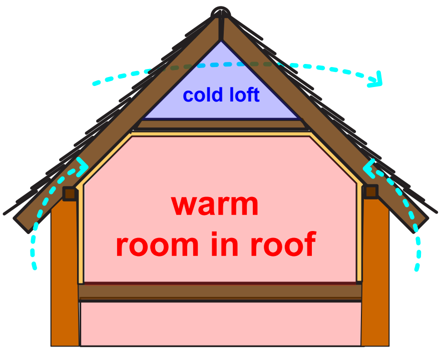
If the extensions are known to have cavity walls (which is likely in the 1970s) then cavity fill may be possible but requires careful investigation of the existing conditions and may not be appropriate.

Internal wall insulation is generally impractical in kitchens and bathrooms unless they are being stripped out and replaced as part of a whole house renovation. Even then, these are small room areas which would be reduced by added insulation.

The extensions are at the rear of the buildings, not part of the original historic fabric, use 20th century materials, and many are already rendered. If acceptable from a conservation perspective, a practical option would be to use external insulation to these walls. Cost effective options would depend on several aspects of the existing materials, condition, accessibility, roof overhang, alignment of gutters, downpipes etc.

6.2 In-roof Ceilings

Uninsulated sloping ceiling sections of rooms in the roof are the second highest contribution to the cottage heat losses. Model results indicated heat losses through these ceilings between 10% to 15% of the cottage total. Unable to heat these bedrooms some residents choose to sleep in ground floor living rooms during winter months.



The original ceilings were lathe and lime plaster onto the underside of the rafters, with no sarking fabric above the rafters. Draughts through the roof (eaves and tiles) chill the top surface on the lathe and plaster. An existing U-value will be 2.5 to 3.0. The current building regulations set a target roof U-value of 0.13, and a maximum 0.35 for refurbishments, 85% to 90% lower.

Insulation from above represents substantial works and associated costs which are only practical and economic when the roof needs to be re-slated. It would allow about 75mm of insulation between the rafters giving about 70% reduction, enhanced with insulated foil membranes. Over the rafter insulation boards would raise the roof line above neighbours and would not be approved.

Insulation from below fixed to the lathe and plaster over the existing sloping sections would reduce the ceiling height by whatever thickness is applied. With a limited thickness available, to achieve significant benefits, a high performing insulating material is required. A 20mm thickness would achieve about 60% saving and 30mm about 70% saving, but still above the Building Regulation refurbishment maximum U-value of 0.35. The pictures show a Fitzford cottage ceiling being insulated this way.

1. Fixing horizontal insulation boards 2. Insulation panels to slopes 3. Skim plastering

Removing the existing ceiling, insulation could be inserted between and below the rafters before reinstating the ceiling and would allow good insulation levels, an opportunity to check the condition of the rafters, battens and underside of slates and to install a vapour barrier. Normally removing existing historic fabric (original lathe and plaster) would not be permitted for listed buildings unless it has irreparably failed.

However, in the circumstances of the Bedford Cottages WDBC considers this to be a pragmatic compromise if sympathetic specifications are agreed.
With 75mm of insulation between the rafters and 40mm insulation board replacing the old ceiling, the U-value would meet the current Building Regulations, giving a 90% saving.

Horizontal sections of in-roof ceilings. Where loft hatches provide access, insulation may have been installed between the ceiling joists. To meet current standards this would need to be about 270mm of mineral wool between and over the joists. Often less than half of this thickness was installed and over the years it may have sagged or been compressed, significantly reducing effectiveness. As a low cost and relatively easy option it would generally be worthwhile to remove old mineral wool insulation and lay at full thickness. Insulation laid between the ceiling joists must not block the edge gap between rafters required to maintain ventilation to roof timbers.

Where the sloping sections of the ceiling are being refurbished, it would be practical and cost effective to include the flat ceiling to provide full continuity. This would leave the flat attic floor area available for storage without crushing insulation and avoids the risk of blocking airflow between the rafters.

Extension Roofs. Kitchens and bathrooms were added as ground level extensions to most Bedford Cottages in the mid-20th century when grants were available for this specific purpose. The materials and build quality varied, with the level of insulation significantly below current Building Regulation standards.

Where an extension roof is poorly insulated, then the heat losses could be significant. Kitchens and bathrooms are areas of high humidity and condensation mould will indicate both inadequate ventilation and cold surface areas.
Insulation options include:

- from above, by removing the existing roof covering (variously slates, tiles, felt or felt tiles) and insulation between and over the rafters (subject to the increased height not affecting the historic windowsill above).
- from below, by removing the existing ceiling and insulating between and below the rafters. This could achieve a high level of insulation with no loss of room height.
- from below, overlaying the existing ceiling with a thin high-performance insulation layer and plaster skim to significantly reduce the heat loss.

6.3 Windows and External Doors

Single glazed windows are the third highest contribution to the cottage heat losses at about 10%. Often old windows are also a significant source of cold draughts.
The original single glazed windows have a U-value of about 5. The building regulation for existing dwelling refurbishments is a maximum U-value of 3.3 and required U-values are 1.6 or lower.

Night covers (blinds, curtains, and shutters) are beneficial, but only when closed. In general, outside temperatures are lowest at night. Night covers also retain building fabric heat overnight when heating systems are off allowing a quicker warm up in the morning. They can also be left closed in unused rooms. Indicative savings when closed are:

Window Glazing	U-Value	Savings
Single	5.0	0%
Applied film	3.5	30%
Old Double	3.0	40%
Secondary	2.5	50%
Modern Double	1.2	75%
Triple	0.8	85%

Night Covers	Savings
Thermal Blind	20%
Heavy Curtains	50%
Fitted Shutters	60%

The effectiveness of secondary glazing and night covers depend on how well they fit and exclude draughts (ie trap an undisturbed layer of air against the glass). Well fitted secondary glazing plus curtains or shutters may be as effective as double glazing.

The grade 2 listing of Bedford Cottages was to preserve their historic streetscape as part of the regional mining heritage. Windows are an important part of period character. Remarkably some of the original windows have survived for over 150 years. However, in the last hundred years many were replaced with changes of material and style. This has degraded the character of some rows and WDBC requires that any replacements are sympathetic to the original styles.

The conservation principle for listed building original fabric, including windows and doors, is that they should be carefully maintained and repaired to preserve the historic character of the building. Therefore, replacement of original windows will only be approved if they are beyond economic repair. Replacement window consents will require matching the materials and style of the original windows.

For listed buildings, many local authorities will not give consent to double glazing which is considered to change the character of the heritage façade. However, WDBC is working with local craftsmen to define appropriate designs that would replicate the aesthetics of the original windows but provide the draught proofing and double glazing to meet current building standards. For replacement windows, double glazing does not cost significantly more than single glazing. These windows would also be approved as replacements for non-original windows to reinstate the building character.

The bespoke craftsmanship of such windows is more costly than (unapproved) mass produced standard units. However, as the joiners become familiar with the design, the cost difference will reduce. The cost of replacement windows is not justified by energy savings, but will enhance comfort, the property character and value.



6.4 Ground Floors

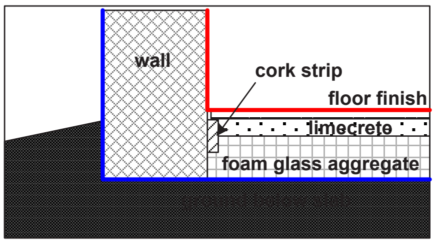
Ground floors are a relatively low proportion of the cottages heat losses.

The original ground floors were clay tiles probably with a lime screed on the soil below. A few cottages still have these tiles, in at least some rooms. In many cottages these tiles have been either taken up or overlain with new flooring and little is known about what is below and whether insulation was included. It is likely that some will have excavated soil to install a damp-proof membrane below a concrete screed. This may have exacerbated moisture (rising damp) in the base of walls.

Rear extension floors were mostly built in the 70's and are likely to be concrete slabs which would also have included a damp-proof membrane.

The mid-winter temperature of the ground below solid floors will remain about 10°C except around the outside edges; therefore, floor U-values (rate of heat loss) depend on the ratio of perimeter to area. Most of the ground floor rooms abut other rooms or party walls, and therefore have limited or no external walls. The extensions have a higher ratio of perimeter to areas giving poorer uninsulated U-values.

The regulation for floor renovations is a minimum (threshold) U-value of 0.7 and target of 0.25. The Bedford Cottage uninsulated original floor U-values are about 0.3 (mid terrace) to 0.5 (end terrace) and 0.5 to 1.0 for extensions. These relatively low U values and the 10°C below floor temperature limits the heat loss.



Therefore, works to insulate ground floors would not bring significant energy cost saving. Cold floors are uncomfortable and the use of carpets with underlays provides some insulation value.

However, if the existing ground floor is damp, it needs to be ventilated and carpets and other coverings will develop mould on the underside which is unhealthy. Damp floor tiles or screed indicate trapped moisture with no drainage or ventilation path to escape. Where unhealthy conditions exist the tiles / screed need to be removed and the underlying soil excavated to install a drainage layer – the best option is to use foam glass aggregate which also provides good insulation. A screed above should remain dry and support chosen floor finishes.

1. excavation 2. pour foam glass on breather membrane 3. spreading 4. tamping to compact & level 5. breather membrane 6. tamping limecrete slab 7. edge cork strip 8. tiling onto lime slab

The subfloor foam glass aggregate will not only benefit heat loss through the slab, but also insulate the cold bridge at the base of the wall and assist vapour movement (breathability). This method has recently been installed in a (previously damp) Fitzford end of terrace cottage.

The mid terrace cottages have very little external wall and therefore the mid slab heat loss is considerably less. However, the cold bridge / damp along the external walls can be an issue for the ground slab near the outside walls. A proportionate solution is a 0.5m wide strip of foam glass and screed along the wall to a similar design. Specification details are on the TEC website.

7. Renovation Planning

UK Government policy is that homes will be required to meet EPC ‘C’ standard by 2030. Without improvements, many Bedford Cottages would be at the low end of the scale. Various grant schemes will be available to help those of limited means to upgrade homes with low EPC ratings.

TEC’s survey of Bedford Cottage residents identified common concerns with damp, and the high costs of heating homes with solid walls, floors, and uninsulated roofs. Health issues arise due to cold, damp, and mould.

Few households will be able carry out a full home retrofit due to cost and disruption. However, with government grants becoming available, measures can be progressively made.

The condition of each house, and householder needs, are different. Each requires a considered plan of how to make the home more efficient, comfortable, healthy, and economic to heat.

This guide introduces the considerations that will inform your plan, in an order that leads from everyday energy management, heating and control systems, the importance of dealing with damp, and conservation compatible options for insulation to meet the home retrofit regulations.

Government grants will require the installers to demonstrate that measures are appropriate and meet good practice standards of installation.

This guide allows householders to make informed judgements on what measures they need and how effective they could be. In prioritising work:

- first adopt simple measures such as draught proofing, lagging hot water pipes and tanks, using LED light bulbs and efficient electrical goods, secondary glazing
- replace old inefficient boilers and heating controls
- deal with damp by identifying causes and doing required maintenance and repairs, and planning measures to resolve trapped moisture
- finally, major insulation measures, where they are cost effective. These will involve local authority approvals. Obtain professional advice and only use trusted tradesmen who understand traditional buildings

Further Information

Tamar Energy Community's (TEC) website provides access to the Warmer Bedford Cottages supporting information which show how the values presented were determined and the authoritative sources for the methods and input values.

The TEC website also includes information on the critical properties of retrofit materials and links to manufacturers and suppliers' data sheets and installation guides.
Contact TEC for advice and support with your retrofit planning.

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