Design Guide 16

Greener Traditional Buildings

16.1 UNDERSTANDING HISTORIC FABRIC

Historic buildings, like all existing buildings, have considerable embodied energy: the energy used in collection and preparation of materials and in construction. From the climate change perspective, it makes sense to prolong the life of such structures, which brings continuing returns from the energy originally invested, and which reduces the need to build anew.

However, historic buildings differ from modern buildings in various ways and, along with continued and evolving use, there can be pressure to make changes to address perceived deficiencies. Such changes can have profound implications for historic fabric: this advice seeks to help to resolve the tension between preservation and adaptation, giving guidance on practical matters, and on the statutory consents that may be required. Key to the planning of such change is to understand the nature of what is to be changed.

16.2 WALLS

Traditional walls are usually of thick, solid construction; of local limestone, or, from the C18 onwards, clay brickwork. Traditional walls have no cavity between the inner and outer faces, unlike most walls built since the early part of the C20. With a cavity wall, the outer face of the wall is separated from the inner face, and moisture soaking into the outer face is thus prevented from passing to the inner face.

Traditional walls, however, control moisture in other ways: they are usually much thicker than modern walls; and they are built with soft, porous lime mortar between the stones or bricks, which allows moisture passing into the wall to evaporate out again, when weather conditions change.

From the C19 onwards, walls have usually been built with a damp proof course – a continuous layer of some impervious material, such as lead, slate or bitumen, set just above external ground level. This separates the lowest part of the wall from the upper part, and prevents moisture from the ground passing up into the parts of the wall that are within the internal rooms.

Fig. 1 Local limestone and clay brick walling

Older traditional walls do not usually have damp proof courses of any kind – again, they rely on the breathable nature of the wall, which allows moisture to evaporate away. It is also notable that traditional walls are usually finished internally with porous lime plaster, which aids this process and which is able to withstand moisture in the wall.

Since the latter part of the C20, walls have tended to incorporate some form of insulation, usually of mineral wool or plastic foam, and usually set within the cavity (although occasionally fixed to the inner or outer face of the wall). Traditional walls have no such provision. They rely on the much greater mass of the wall acting as a heat store, tending to maintain a fairly steady temperature, and tending to feel warm in winter and cool in summer.

16.3 GROUND FLOORS

Traditional ground floors were usually of solid construction, with a stone slab or tile surface laid on the ground. The stones or tiles may be laid directly on earth, or on some form of lime, sand or ash base. Modern, solid ground floors are usually of concrete, with damp proof membranes (usually impermeable plastic sheeting) separating the floor surface from the ground; they may also have insulation beneath or within the floor structure. Traditional solid ground floors do not have insulation or damp proof membranes; as with traditional walls, they rely on their mass and the breathability of the construction to allow moisture to evaporate.

Fig. 2 Traditional stone flag flooring and elm boards

From the C19, suspended timber ground floors were also used (Fig. 4), with floorboards on timber joists set well above the ground. In such constructions there is usually ventilation beneath the floor, ideally with air vents in two opposite external walls, which is essential to control ground moisture and prevent timber decay.

16.4 ROOFING

There was a range of traditional roof coverings, including thatch, stone tiles, timber shingles, clay tiles and blue slate; all usually laid on timber battens, and fixed directly to the roof structure, with no form of underlay. The more irregular coverings (particularly stone slates) were sometimes pointed-up internally with porous lime mortar (a process known as 'torching'), to help prevent wind-driven rain entering the roof. Such roofs are breathable over the whole surface, and will allow moisture from the habitable spaces below to evaporate effectively.

Fig. 3 Welsh slate, stone slate, clay tile and thatch

Traditional roof coverings continue to be used, supplemented in more recent years by products such as concrete tiles and reconstituted stone tiles. Since the early part of the C20, roof coverings have usually been fixed over some form of underlay (and of course many traditional roofs have been re-covered using underlay). The first underlays were bitumastic and not permeable; although in more recent years breathable cloth underlays have been developed.

16.5 WINDOWS

There are three basic types of traditional window in our area: 1) side-hinged casement windows, which may be metal or timber framed, and which may include some areas of fixed glazing; 2) vertical sliding sash windows, which are usually timber-framed, and which have counterbalancing weights concealed in the side framing; 3) the much rarer horizontal sliding sash window (sometimes known as the 'Yorkshire window'), which is usually timber framed, and which slides in a grooved timber sill.

Fig. 4 Traditional casement and vertical sash windows

Earlier windows were originally glazed with handmade 'cylinder' or 'crown glass', both of which have an uneven and highly characteristic surface.

Earlier windows were also usually formed with relatively small individual panes of glass, joined together with a grid of grooved lead 'cames', which again are highly characteristic. Usually, there is just a single layer of glass. Heat loss through windows was commonly controlled with timber shutters, usually mounted internally, and folded back against the window reveals when not in use.

16.6 ALTERATIONS TO HISTORIC FABRIC

The previous paragraphs detail how historic buildings differ significantly from more recent buildings – especially in the way they control the internal environment. It is important to ensure that alterations intended to improve energy efficiency are sympathetic to the historic fabric, with particular regard to the way the fabric functions and to its appearance, whatever the status of the building.

If the building is Listed, any proposal potentially affecting the character or fabric of the structure is likely to require Listed Building Consent. Careful analysis of the building fabric should always be undertaken in order to determine whether the proposed changes are necessary and effective; and if they are, to ensure they can be carried out in a sympathetic manner. Evidence of this analysis and the part it has played in coming to an optimum design solution is an essential part of a Listed Building application.

16.7 INSTALLING INSULATION, GENERAL POINTS

As noted above, traditional buildings in West Oxfordshire have certain characteristics which mean modern methods of insulation may be impractical or inappropriate. The following notes on forms of insulation and methods of installation summarise key issues that home-owners should consider when instructing contractors or briefing professional advisers. They are not intended to be definitive advice for any specific circumstance.

16.8 SOLID STONE WALLS

These have poor insulating properties by modern standards. However, because of their high thermal capacity, they act as a useful temperature modulator: in summer, they tend to remain cool; in winter, once warmed, they retain heat. Although this does not save energy to the extent that a highly insulated modern enclosure would, in practice, acceptable comfort conditions can be achieved with lower air temperatures than in a house where heat is not stored by the structure.

As a consequence, boiler and radiator thermostats can be set significantly lower. Adding insulation as an internal lining to solid walls eliminates this effect because their thermal capacity can then have little if any impact on temperature or comfort inside the building.

16.9 SMALL WINDOWS

These often represent a significantly lower proportion of the external surface area than windows in typical modern buildings. Consequently, heat loss through the whole

Fig. 5 Small window area in traditional houses

enclosure needs to be considered before deciding whether double-glazing would necessarily be the best use of available resources. Also, especially in the countryside, vernacular buildings were

often built to take advantage of passive solar gain. Windows to habitable rooms tended to be grouped in southern elevations; whereas, when rear elevations were exposed to the prevailing wind (if windows were provided at all) they were invariably kept small. This intuitive but sensible approach should be respected when considering alterations or extensions to existing vernacular buildings. Having large windows to take advantage of a view is a modern concept.

16.10 STEEP ROOFS

Whether originally covered by thatch or stone slates, the attic storeys of most traditional houses were enclosed by steeply-pitched roofs supported by purlins on A-frame trusses. These attics were often used as habitable rooms, or may have been converted for such use at a later date. For this reason, it is unlikely home-owners will be able to benefit from insulation grants, which assume insulation is simply rolled out on ceiling joists within a roof void used only for storage. Nonetheless, increasing roof insulation is likely to be the most efficient and cost effective intervention it is possible to make to a traditional house: in many cases, it is likely to be much more effective than certain other interventions, such as double-glazing.

Roof voids are often home to bats and birds. Care will be needed to ensure that no undue harm comes to protected wildlife species, and a bat survey, for example, may be required.

16.11 INSTALLING INSULATION TO ROOFS

Adding roof insulation will not usually require planning permission, provided it can be added in such a way that it does not significantly raise the level or volume of the existing roof surface. However, whether adding roof insulation internally or externally, Listed Building Consent will probably be necessary, especially where:

- The roof surface would have to be raised by even a small amount – this often results in awkward details at eaves and verge which will certainly alter, and could detract from, the appearance of the building;
- Original ceiling finishes (often lath and plaster) have to be removed and/or replaced in order to facilitate the work;
- Main roof timbers (such as trusses or purlins) are likely to be affected.

The following notes relate to the main building elements where traditional construction is often judged to be inadequate by modern standards and where intervention is most frequently considered. Installing insulation to roofs is most likely to be undertaken in one of three ways:

Fig. 6 Insulation can be laid between joists or rafters

Method 1: within the ceiling void:

As noted above, many older traditional buildings in the District have steeply sloping roofs in which A-frame trusses create an attic, which may be used as habitable space. In this case, method 2 or 3 (*below*) must be adopted. However, where: a) the roof slope is so shallow that it is not feasible to use it for habitable accommodation; b) there is some form of impediment, such as a restricted means of escape; or c) the nature of alterations to trusses or original roof fabric necessary to allow habitable use is considered to be unacceptable, then it would be normal to consider the use of cheap and simple roll or granular insulation, laid over or between the ceiling joists.

Method 2: externally – usually during re-roofing:

When existing roof finishes are at, or nearing, the end of their life, it is often necessary to strip and re-roof; either with reclaimed materials (such as stone slates) or a modern replacement (such as artificial slate); on Listed Buildings, the latter alternative requires Listed Building Consent., and may not be deemed acceptable. Re-roofing can afford an opportunity to add an effective and efficient level of insulation in the most practicable way. There are many available products and several ways this could be achieved:

a) by inserting slab material (or occasionally, quilt) between rafters

This is a common approach; however, great care must be taken to cut the slabs so they fit snugly between the rafters (on older buildings, these are often at unequal centres and not always parallel one to another). Consequently, strict supervision is essential to ensure accurate cutting, so that there is the minimum of gap between insulation and rafter. It will usually be necessary to tape all junctions and joints to ensure the insulation is air tight, and a ventilated air gap is usually required above the insulation – all to prevent condensation forming within the roof structure.

b) by laying slab material or quilt over rafters

This is easier to apply and can thus be cheaper. However, it will invariably have the disadvantage that the finished roof surface will be significantly raised – especially where battens and counter-battens are required. This will create difficult (and often ugly) junctions at eaves and verge, and sometimes ridges and valleys. Traditional junctions with dormers, roof lights and other features may also be compromised. Consequently, this method of adding insulation may well be problematic in historic buildings – especially where the roof surface is a key element in the appearance of the building. Unless there are special circumstances (and carefully considered details) this would not usually be permitted with a Listed Building.

c) by fixing multi-layer, reflective foil beneath or above rafters

There are now several products of this type, and their range and performance is rapidly expanding. However, some Building Control officers do not accept that these products comply with Building Regulations, and it is advisable to check with the Building Control Department. Despite possible technical reservations, these products offer some significant advantages for retro-fitting to existing buildings: they are simply stapled to the bottom or top of existing rafters, and it is much easier to achieve an air-tight enclosure. A small air gap needs to be maintained either side of the foil (and this sometimes requires battens); despite this, they often achieve a reasonable level of insulation without a significant increase in the overall depth of the roof construction.

d) By a combination of the above

Where, for instance – as is often the case in older buildings – rafters are insufficiently deep to accommodate a good thickness of insulation, the optimum solution could be to use whatever slab material fits the joists, with multi-foil quilt beneath, using battens to maintain the required air gap before reinstating a ceiling finish. Whether used on their own or as the top part of a composite insulation package, thin, multi-layer foil-based insulation membranes have the further advantage that their reflective nature provides better protection against solar gain in the summer than insulation quilts and slabs.

Method 3: Internally – with roof finish left in situ

When the roof is not being stripped, there is little practical alternative to adding insulation on the underside of the roof covering, often between existing rafters. In this case, it is important to check what, if any, membrane may have been added beneath the slates and usually over the roof joists when the building was last re-roofed.

Until recently, it was usual for roofers to add bitumen-based or other waterproof felts. Unlike the modern breathable membranes now used, these can cause condensation to develop on the felt above the insulation. Where this form of construction remains, great care (and specialist advice) should be taken to ventilate the roof void, or otherwise detail the new construction to avoid condensation.

With Listed Buildings, or other buildings where some roof slopes are an important part of the building's appearance, any required vents should be carefully sited so as not to break the roof surface, or ideally to be integrated within existing features, such as eaves, ridges, and dormers. Also, where existing ceilings are predominantly lath and plaster, there may be a requirement for this to be replaced on a like for like basis.

NB Several companies offer a service entailing the spraying of foam insulation within the roof void; some implying their product 'repairs' old roof finishes in some way. Whilst some of these systems might be considered in very specific circumstances, in principle the application of a sprayed membrane to the underside of any slate or tiled finish is discouraged because it makes the roof surface (originally flexible and permeable) rigid and impermeable; it also makes the replacement or re-fixing of individual slates from time to time difficult, and could lead to other problems.

16.12 INSTALLING INSULATION TO WALLS

As with loft insulation, there are many specialist firms offering various forms of cavity insulation, with grants again available for the work. However, few if any traditional historic buildings have cavity walls, so the most common (and heavily promoted) form of wall insulation is seldom feasible.

Adding sheet insulation to the internal face of external walls of Listed Buildings is seldom appropriate (and will rarely be permitted) because it will cover existing stonework, plaster or other finishes, which are often an important part of the building's architectural interest. New internal lining can also affect other important details, such as window and door reveals, skirting boards, architraves and cornices.

Whilst these considerations may not always apply to un-Listed traditional buildings, it is still worth considering whether the loss of temperature modulation and increased comfort provided in rooms enclosed by walls with a high thermal capacity are worth the potential energy saving achieved by adding insulation on the inner face of a solid masonry wall.

However, in some forms of traditional building, such as non-Listed barns, where there are no or few internal details or finishes that would be affected, it may be appropriate to add insulation to the internal face of walls behind dry lining or other new internal finishes. In this case, it would be important to ensure that adequate ventilation was maintained behind the dry lining, so that the moisture always present in a solid stone wall could continue to dry out in the normal way.

Occasionally, the construction and finish of vernacular buildings may be of such poor quality or in such bad repair that it may be appropriate to add insulation externally. Slab insulation can be fixed to the outside of the wall, which is then protected by a new water-resistant external finish, such as render on expanded stainless steel mesh. This is a specialist area of work which needs to be carefully specified; there are often junctions (especially with the roof) where the relationship between the planes of existing and new materials will be difficult to resolve successfully.

Adding wall insulation internally will not require Planning Permission; however, it will normally require Listed Building Consent where the building is Listed – especially where the internal wall finish and/ or internal details around openings are integral to the character of the building. However, adding insulation externally (probably with some additional weathering coat) may require Planning Permission.

Where a building is Listed, such works will require Listed Building Consent – which would rarely be considered appropriate, except in exceptional circumstances, and where the altered appearance could be demonstrated to be an appropriate change to the Listed Building which did not detract from its character.

16.13 INSTALLING INSULATION TO GROUND FLOORS

As noted above, most traditional buildings in the District have a solid floor, effectively laid directly onto earth. In these circumstances owners may wish (and are often advised by surveyors or contractors) to take up the floor so that a new concrete floor can be laid on a damp-proof membrane; and, these days, a good layer of insulation – especially where under-floor heating (whether water or electric) is contemplated. Where old flagstones or other important fabric is not lost (and can be taken up and re-laid without significant physical damage or impact on its character) this is invariably sensible advice; however, on a Listed Building, where original fabric could be lost, Listed Building Consent would be required, and such work may be problematic.

Fig. 7 Care must be taken to avoid undermining footings

Adding insulation beneath existing raised timber floors is also viable. Again, with original or old boards it is important to make sure they can be carefully taken up and re-laid without significant damage or alteration of character. Great care should be taken to ensure existing ventilation

beneath the floor is not reduced or eliminated (and where no ventilation exists beneath the raised floor, it should be added as part of the works).
In either case, if excavation is required to accommodate the extra depth of concrete slab, insulation or ventilation gap, it is important to make sure that such excavations do not go lower than the footings of any load-bearing walls, whether external or internal. Unless the depth of foundations is already clearly understood, it would be wise to excavate a number of trial pits (externally if possible) to determine the safe level to which excavation could be carried out. If there is any doubt, a structural engineer, architect or surveyor experienced in working with traditional construction should be consulted.

Underpinning existing load bearing walls in order to allow deeper excavation (or for any other reason) should be avoided. Traditional stone buildings are usually built off modest foundations (if any) laid in lime mortar, which can accommodate the normal minor movement which often arises in old buildings. However, if underpinning is introduced beneath part of a traditionally-built wall, it creates an area of rigid construction; and when movement does occur, it can 'break the back' of that part of the building, leading to cracking at one or both sides of the underpinning.

16.14 IMPROVING THE THERMAL PERFORMANCE OF WINDOWS

Windows are one of the main elements that give character to a building: they are its eyes. Even apparently minor alterations to windows can have a major impact on the appearance of a building. For this reason, any proposed alterations must be carefully considered before being implemented, especially when a building is Listed (when change will require consent) or in a Conservation Area.

Partly as a result of advertising by window replacement companies, many people believe double-glazing is one of the most effective ways to save energy in their homes. However, as noted above, the proportion of heat lost through the small area of window openings in traditional buildings is often significantly smaller than that lost through other elements of construction – most notably the roof.

Fig. 8 Visually harmful double-glazing

The next most important element is air-tightness. Draughts and air circulation, including through ill-fitting windows and doors, up chimneys, probably accounts for a greater loss of energy than through the single-glazing of comparatively small windows in historic buildings. Air-tightness of the whole construction is more difficult to secure in renovation and conversion projects than in new buildings; however, reducing heat lost through chimneys (especially open fireplaces) and retro-fitting draught seals to existing windows and doors, is simple to achieve. Even with original windows in Listed Buildings it can usually be achieved without having an impact on the appearance of the building: consequently it is unlikely to require consent.

Fig. 9 Slim double-glazing with well detailed glazing bar

Government guidance used to hold that double-glazing was seldom if ever appropriate for a Listed Building. Current advice holds that the potential damage of such a change needs to be weighed against the potential to mitigate the impact of climate change. Whether single-glazed windows in a Listed Building should be replaced by double- or even triple-glazed windows, or whether some form of double-glazing should be added – will always need to be judged on a case-by-case basis; however, considerations will include:

A) The importance of the existing windows to the character and appearance of the building;

B) Whether an equivalent increase in insulation could be achieved by other means – such as increased roof insulation and/or more efficient heating equipment (*see below*) – which are likely to be less detrimental to the character and appearance of the building. It is worth noting such alternative methods can also be more cost effective;

C) The extent to which the design and appearance of the window relies upon the precise size and detail of frame and glazing bars. For instance: the narrow and finely-detailed glazing bars of C18 sash windows are one of the fundamental aspects of their design – features that cannot accommodate double-glazing of any thickness. On the other hand, replacement of traditionally detailed flush casements with minimum horizontal subdivision can sometimes accommodate double-glazing with only a limited impact on their appearance;

D) The skill and care with which a building owner or their design adviser has analysed the current situation, appraising alternatives and, where these demonstrate that a change of window form may be appropriate, the skill with which the change is designed and detailed to have the minimum impact on such matters as:

- designing the window to solve the actual technical and aesthetic issues;
- the proportions of the window and its subdivision;
- the size and detail of frame and glazing bar sections;
- the impact of flat reflective modern sheet glass replacing older glass types where some distortion is a key characteristic;
- the choice of spacer bars for double-glazing that match the colour of the frame (brilliant white and silver seldom being appropriate for traditional buildings);
- avoiding the use of fake elements, such as applied glazing bars or applied lead strips.

E) Adding shutters where none exist, or replacing existing shutters with better insulated and more air-tight versions could well be a cheaper alternative to double-glazing; it could also have a less damaging impact on the appearance of the building. On Listed Buildings, original shutters are usually an important part of the character of the building; in which case, as with windows, a carefully detailed alteration

Fig. 10 Traditional wooden shutters

to add draught seals could be considered. Where shutters are absent or not original, a good case could be made for the addition of modern highly insulated shutters (as part of a fully considered package of work) in preference to any alteration to the windows themselves – except the addition of draught seals if possible.

F) The form and appearance of uPVC windows is seldom appropriate for traditional buildings, and never appropriate for Listed Buildings. In addition to aesthetic considerations, uPVC windows utilise considerable energy in their manufacture; and whilst they require minimal initial maintenance, when they do degrade they usually cannot be repaired, and must be scrapped. In contrast, well-designed traditional windows, made with timber from sustainable sources, have a virtually unlimited life if properly maintained. Even if an ideal re-decoration schedule is not maintained, as a last resort it is always possible to piece in a new sill, an individual frame or even a whole sash or casement without discarding the whole window.

16.15 INSTALLING NEW SERVICES

The vast majority of traditional buildings already have electrical, heating and hot water services. However, the search for greater energy efficiency has led to new technologies and to changes in services equipment. Installation of such new services is likely to make a significant contribution to the energy efficiency of historic buildings, but may also have profound implications for historic fabric. The Council's Planning and Building Control Departments are happy to advise on the acceptability of specific proposals, and on the need for statutory consents; there is also guidance on the Government's Planning Portal.

NB these notes are intended for general guidance only; you will need to take specialist advice from suitable consultants with respect to technical feasibility, and you will need to use experienced and appropriately qualified contractors for installation.

Fig. 11 Combi-condenser boiler, and flue next to chimney

16.16 BOILERS AND FLUES

A new or replacement gas or oil fired boiler can give significant energy savings. The best condensing boilers are up to 90% efficient, using 30 or 40% less energy than older models. Installing such a boiler is unlikely to be problematic, as new boilers tend to be smaller, and fuel supply is unlikely to require significant openings to be made. Condensing boilers need a condensate drain, but this usually requires only small bore pipework. However, the provision of a new flue can be problematic, as it may require a sizeable new hole in walling, alterations to an existing vertical chimney flue, or even a completely new vertical flue. New flues can make a significant impact on the exterior, due to their appearance and also due to the white plumes of water vapour that they release. Such flues will need to be placed with great sensitivity to the building and to the setting, as will new or replacement oil tanks. Solid fuel boilers and their fuel stores tend to be more voluminous, and may be more difficult to accommodate within the main part of a typical traditional building.

Installing a new boiler in a Listed Building may require Listed Building Consent, particularly if it involves alteration to internal walls, significant fittings or fixtures. A new flue through an external wall, a new vertical flue, or the alteration or lining of an existing vertical chimney flue to a Listed Building will usually require Listed Building Consent.

New flues may also need Planning Permission under certain circumstances, whether the building is Listed or not, depending on form, height, position on the building and the location of the building. Similarly, new oil tanks may require Planning Permission, depending on size, position on the site, whether they are in the grounds of a Listed Building, and location of the building. Note also that gas or oil fired boilers and their flues and tanks will need to be certified by an appropriately accredited installer, whilst other types of boiler and their flues will require approval under The Building Regulations.

16.17 GROUND SOURCE, WATER SOURCE AND AIR SOURCE HEAT PUMPS

These devices harvest the sun's heat stored within the ground, water or air, usually giving a favourable energy return for the relatively modest amount of electricity needed to drive the system (typically three or four units of heat energy for each unit of electrical energy). The harvested heat can be used to provide hot water or warm air for space heating, and can also be used to provide hot water for domestic purposes.

Ground and water source heat pumps have two primary components: 1) the heat collecting pipework, which allows a mixture of water and anti-freeze to flow through the heat source; 2) the pump unit, which circulates this mixture and which collects heat from it. Pump units tend to be larger than typical heating boilers, although can usually be fitted into typical domestic spaces. With relatively small bore pipework, installation is unlikely to be problematic.

Fig. 12 Ground source pipework and air source heat pump

In ground source systems the heat collecting loop is buried in the ground around the building, in flat or vertical coils, or possibly in vertical bore holes where the site is restricted. Care must be taken not to undermine building or wall foundations, or to affect garden features of special interest. In water source systems the heat collecting loop is laid in a large volume of water – typically a deep lake, although it may be possible to use a river or other water source. Again, care needs to be taken not to affect significant garden or landscape features.

Installing a ground or water source pump in a Listed Building may require Listed Building Consent, particularly if it entails alteration to internal walls, significant fittings or fixtures. Heat collection loops will not normally require Listed Building Consent, unless directly affecting Listed fabric. Heat collection loops for domestic buildings do not require Planning Permission, although this is required for installations to other types of building. Ground and water source heat pump systems will require approval under The Building Regulations.

Air source heat pumps also have two primary components: 1) the air handling fan unit, usually placed on or against an external wall, which passes large volumes of external air over a small collecting pipe coil of water and anti-freeze; 2) the pump unit, usually located internally, which circulates the water and anti-freeze mixture and which collects heat from it.

Just as for standard boilers or ground or water source pump units, the internal equipment can usually be located in a traditional building without problem, although the external unit can be more problematic. The size of the external unit varies, depending on how much equipment is located externally; but there will usually need to be a significant cabinet to house the fan (a metre or so tall) and a sizeable clear space around it.

It may be possible to locate the external unit away from the building, although this may reduce efficiency. In any event, the external unit will need to be placed with great sensitivity in relation to the building and to the setting.

Installing an air source pump unit to a Listed Building may require Listed Building Consent, particularly if it involves alteration to internal walls, significant fittings or fixtures. An external air handling fan unit to a Listed building would usually require Listed Building Consent. Under current legislation, external air source heat pump equipment also requires Planning Permission in all circumstances, whatever the building type. Such systems will also require approval under The Building Regulations.

16.18 HEAT DISTRIBUTION AND EMISSION

Heat can be distributed around the building from the boiler, heat pump or other source in one of two main ways: 1) via hot water, in pipework; 2) via warm air, in duct-work. With water systems, the pipe diameter tends to be small, and it can usually be fitted around the building with minimal disruption of fabric.

Air systems can be more problematic: air is much less dense than water, and so a much greater cross-sectional area is needed to carry useful amounts of heat. Because of this, the ducts tend to be of large size, and are likely to be obtrusive when retrofitted to a building of traditional form. New hot water pipework systems to a Listed Building may need Listed Building Consent if significant internal fabric is affected; although in some cases, with careful planning and installation, the impact does not justify this. New air duct systems in a Listed Building would almost certainly need Listed Building Consent.

Warm air is usually released via grilles of some type. For hot water systems there are two main types of heat emitter: 1) wall-mounted or freestanding radiators; 2) underfloor heating pipework. Some early cast iron radiators in Listed buildings are significant features, and replacement with modern radiators may need Listed Building Consent and may not prove acceptable. However, the removal of thick paint layers from such early radiators, with cleaning out and general overhaul, can greatly improve their performance.

Modern pressed steel radiators in Listed Buildings are unlikely to be considered significant, and replacement with more efficient convector versions, or radiators of different proportions, may not require Listed Building Consent, subject to the impact on adjacent fabric.

Underfloor heating is becoming increasingly popular for two main reasons: 1) the emitters are unobtrusive; 2) the systems run at lower temperatures and are thus well suited to use with ground, water and air source heat pumps. However, underfloor systems require substantial building works and this can be problematic when retrofitting to traditional buildings.

In ground floors it is usually necessary to cast a new concrete slab and screed in which the pipes are embedded, entailing substantial excavation for the new floor structure and for the required insulation. There are three potential problems here: 1) excavation of the existing floor may undermine wall foundations; 2) significant early flooring, including stone slabs and tiles, may be lost; 3) the new floor structure will be less breathable than traditional flooring, and may cause moisture trapped beneath the floor to migrate to the walls. Underfloor pipework is also sometimes fitted in upper floors below floorboards.

Again, this may be problematic when retrofitting to traditional buildings, because: 1) early timber floorboards and ceiling plaster may be lost or damaged; 2) retained early timber floorboards may be affected by heat in such close proximity; 3) pipe holes or notches may need to be formed in spine beams and joists. Installing underfloor heating in a Listed Building will usually require Listed Building Consent, and if significant early fabric is adversely affected the proposal may be unacceptable.

16.19 RAINWATER HARVESTING

This entails the collection of rainwater from roofing and possibly the land, for various non-potable uses, including flushing WCs, clothes and car washing, and garden irrigation. It can offer significant savings in mains water consumption (around 50% for a typical house), and so, from a climate change perspective, is eminently supportable. A rainwater storage tank

Fig. 13 Water butt for rainwater harvesting

will be needed, and because of our variable climate this will need to be sizeable. Tanks are usually buried on site, though can be above ground. Filters and pumps are also needed, usually in or adjoining the tank, and control valves and pipework within the house.

In order to retrofit such systems to traditional buildings, there must be sufficient site area for the tank, and the pipework fitted around and through existing fabric. In Listed buildings, particular care must be taken to minimise the impact on historic fabric. Excavation for the tank must not undermine foundations or affect garden features of special interest.

If the tank is above ground, it must be sited with special regard to the building and its setting. The internal pipework must be fitted with special regard to internal fabric, fittings and fixtures. Listed Building Consent may be required for new pipework in a Listed Building if significant internal fabric is affected; although, with careful planning and installation, the impact may not justify this. If the storage tank is sited above ground, Planning

Permission may also be required, depending on size, position on the site, whether the tank is in the grounds of a Listed Building and the location of the building. Rainwater harvesting systems require approval under The Building Regulations.

16.20 GREY-WATER RECYCLING

This entails the collection of water from baths, showers and basins for flushing WCs. In a typical home it can save around 30% in mains water consumption; although grey-water requires sophisticated cleaning processes and detergents, which have environmental implications. The technology is still young, and the pros and cons need careful weighing. A storage tank will be required; however, as there is usually a fairly continual supply of grey-water, it need not be as large as that for rainwater harvesting. There will also be cleaning and filtering equipment, and connecting pipework and control valves.

Systems vary: tanks can be external and buried, or internal, or both. Internal equipment and pipework will need to be fitted with special regard to internal fabric, fittings and fixtures. Listed Building Consent may be required for installations to a Listed Building if significant internal fabric is affected. Again, however, careful planning and installation can do much to mitigate the impact. Grey-water recycling systems require approval under The Building Regulations.

16.21 SOLAR THERMAL PANELS

These are externally located panels containing fluid in tubes (usually water with antifreeze), designed to absorb heat from the sun. Typically, the heated fluid is circulated through a heat exchanger in an internally located water tank, to provide hot water for domestic uses. It is possible to use these systems for air heating; although in this country this is likely to require large expanses of panels. There are two main types of panel: 1) flat plane, where the fluid filled tubes are mounted in a glazed box; 2) evacuated tubes, where the fluid filled tubes are mounted within evacuated glass tubes. The latter are more efficient, but more expensive.

Fig. 14 Solar thermal panels (evacuated tube type)

The optimal orientation for solar thermal panels is south, south-west or south-east facing, mounted at an angle of 30 to 40 degrees. They may be mounted on a roof slope, a wall, a flat roof, or a freestanding structure on the ground, provided the panels will be exposed to sunlight for the majority of the day. It is also possible to mount some flat plane panels flush with the roof covering; although there will usually be a visual impact either way. So, for historic buildings it will usually be preferable to site such panels in less prominent positions, including on rear roof slopes, in roof valleys, behind parapets, within the perimeter of flat roofs, and on ancillary buildings.

Planning Permission is not usually needed for such installations, provided: the panels are not on a building in the grounds of a Listed Building; the panels are set lower than the highest part of the roof; and the panels do not project more than 200mm above the roof or wall surface. For freestanding arrays Planning Permission may not be needed either, depending on location, height and size.

Fig. 15 Conspicuous and concealed solar panels

Listed Building Consent will usually be needed for panels on a Listed Building – and as they can have a significant impact on historic character, this may be problematic. Great care must be taken with siting panels in such situations, and with some particularly sensitive buildings there may not be an acceptable solution. Listed Building Consent may also be needed for internal changes for new hot water tanks, and for connecting pipework. Installation of solar thermal panels will also require approval under The Building Regulations in respect of the increased roof loading, fixings, penetrations through the roof covering and changes to electrical, heating and hot water systems.

NB: Further guidance is given in the council's 'Solar Microgeneration' leaflet.

16.22 SOLAR PHOTOVOLTAIC PANELS

These are externally located panels of semi-conducting material, usually silicon-based, which convert the sun's light into electricity. The electricity generated can be used for domestic purposes, with any surplus sold back to the grid (with the agreement of the network operator and supplier). There are no pipes, just electrical connections to the internal system, so the physical installation can be simpler than for solar thermal panels. The panels vary in form and colour, and include translucent glazed types, and panels that imitate traditional roofing materials, such as slate.

The optimal orientation for solar photovoltaic panels is also south, south-west or south-east facing, mounted at an angle of 35-40 degrees. As with solar thermal panels, they may be mounted on a roof slope, a wall, a flat roof, or a freestanding structure on the ground, again provided the panels will be exposed to sunlight for the majority of the day. The panels that imitate traditional materials can be built into the roof covering, which can mitigate the visual impact. However, for historic buildings it is usually preferable to site the panels in the least obtrusive positions, as noted above.

Planning Permission is not usually needed for solar photovoltaic panels on buildings, and may not be for freestanding solar photovoltaic arrays, subject to the same considerations as solar thermal panels. Listed Building Consent will usually be needed for solar photovoltaic panels on a Listed Building; and, as with solar thermal panels, they have the potential to make a significant impact on the historic character, so great care must be taken. Again, with some particularly sensitive buildings there may not be an acceptable solution. Installation of solar photovoltaic panels will require approval under The Building Regulations in respect of increased roof loading, fixings, penetrations through roof covering and changes to electrical systems.

NB: Further guidance is given in the council's 'Solar Microgeneration' leaflet.

16.23 SMALL-SCALE WIND TURBINES

These devices convert the kinetic energy of the wind into electricity. They comprise rotating blades, on either a horizontal or vertical axis, driving a generator. As with solar photovoltaics, the electricity generated can be used for domestic purposes, and any surplus potentially sold back to the grid. Typical small scale turbines range from around 0.93 metres diameter, producing up to 0.1 kW, to around 15 metres diameter, producing up to 50 kW. Smaller turbines may be building-mounted; larger turbines are usually freestanding.

Fig. 16 Small scale wind turbine

Wind turbines are not the easiest devices to deploy in the domestic context, or on small-scale sites generally. They need to be exposed to the prevailing wind (usually from the south-west), and be clear of obstacles such as trees, other buildings and tall landscape features.

Careful assessment of wind speeds must be undertaken before pursuing this strategy, as local annual average wind speeds of below 4.5 meters per second will not produce enough electricity to justify the capital outlay. The Energy Saving Trust recommends that wind turbines are best considered when the local annual average wind speed is 6 metres per second or more.
If building-mounted, turbines generally need to be set well above the roof line, which has profound implications for the building, both in visual and structural terms. Planning Permission is usually needed for domestic wind turbines, whether building-mounted or freestanding.

If the turbine is to be attached to a Listed Building, it will also need Listed Building Consent, and such proposals will need to be carefully considered. With historic buildings the visual impact may be problematic because, in order to function efficiently, turbines are likely to need to be prominently located. Suitable structural fixings into old roofs or walls at high level are also likely to be difficult to achieve, both practically and in terms of the impact on historic fabric. Siting away from the main historic building, either on ancillary buildings or freestanding, is likely to be less problematic. Wind turbines also require approval under The Building Regulations in respect of the structural works and changes to the electrical systems.

16.24 FURTHER INFORMATION AND CONTACTS

http://www.historicengland.org.uk/advice/technical-advice/energy-efficiency-and-historic-buildings/
(*Historic England guidance on Energy Efficiency and Historic Buildings*);

http://www.oxford.gov.uk/PageRender/decP/HeritageEnergyEfficiencyTool.htm
(*Oxford Heritage Energy Efficiency Tool*)

For further information and useful contacts, see Design Guide 12: SUSTAINABLE BUILDING DESIGN