ENERGY EFFICIENCY IN TRADITIONAL BUILDINGS
RECENT DEVELOPMENTS IN IRELAND

Jacqui Donnelly
Architectural Conservation Advisor
Department of the Environment, Heritage and Local Government, Ireland
Email: jacqui.donnelly@environ.ie

ABSTRACT

Historic buildings deal with climatic conditions differently to modern structures and ill-considered alterations to improve energy efficiency can cause irreparable damage to the architectural heritage. In transposing the EU Energy Performance of Buildings Directive into Irish law, protected structures were exempted from the new requirements. Nonetheless, many owners understandably wish to reduce energy consumption and increase comfort levels in their historic buildings. This paper looks at the steps taken in Ireland to provide guidance on best practice. The Department of the Environment, Heritage and Local Government, which legislates for heritage protection and building standards, recently published '*Energy Efficiency in Traditional Buildings'* to provide practical advice on appropriate upgrading measures. The guidelines support conservation practitioners and decision-makers in meeting standards for retro-fitting while protecting the heritage.

Keywords: Energy efficiency; architectural heritage; traditional buildings; guidelines; upgrading

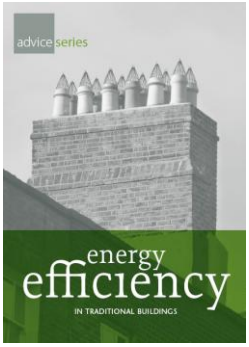
LEGAL REQUIREMENTS FOR ENERGY PERFORMANCE IN IRELAND

In transposing the EU Energy Performance of Buildings Directive into Irish law, all national monuments and protected structures were exempted from the requirements to have Building Energy Rating certification when offered for sale or to let. The conservation of fuel and energy by buildings is regulated in Ireland by the Building Regulations Part L. However Part L does not apply to works, including extensions, to protected structures. Nonetheless, despite these exemptions, many owners understandably wish to reduce energy consumption and increase comfort levels in their historic buildings. This paper looks at the steps taken in Ireland to provide guidance on best practice.

'ENERGY EFFICIENCY IN TRADITIONAL BUILDINGS' GUIDELINES (2010)

The perception exists that 'old means cold,' that is, that older buildings perform poorly in terms of energy efficiency and offer low levels of comfort to their occupants. In recent years we have seen many proposed developments where the developers have tried to justify the demolition of historic buildings on the grounds that they would be replaced with more energy-efficient ones.

It was decided to publish guidance to counteract such misconceptions; to make a case for the contribution of older buildings to sustainability; and to provide advice on how best such buildings could be thermally upgraded. These Guidelines, entitled '*Energy Efficiency in Traditional Buildings*' were published in November 2010 by the Department of the Environment, Heritage and Local Government. They are aimed primarily at building owners and give advice on how they can maximise comfort levels and reduce energy usage in a building while avoiding damage to its historic qualities and the condition of its fabric. The Guidelines are accepted as supplementary guidance to meeting the requirements of the Building Regulations for buildings of architectural and historical interest.

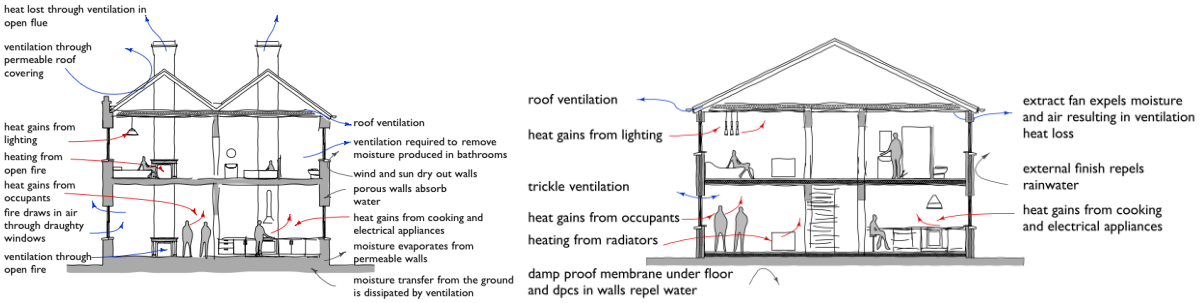


Publication cover


A typical Irish traditional farmhouse

Firstly, for the purposes of these Guidelines, we have defined 'traditional buildings' as those with solid masonry walls of stone or brick often with a lime render finish, with single-glazed timber or metal framed windows and a timber-framed roof; usually clad with slate but often with tiles, copper or lead. This was the dominant form of construction in Ireland from medieval times until the mid-twentieth century. In fact virtually all buildings constructed in Ireland before 1940 were built in this manner.

As all of us who deal with the conservation of historic buildings know, traditional buildings with solid masonry walls perform in a different way to modern construction. They are built of relatively soft, absorbent materials such as lime mortars and timber that absorb moisture from the atmosphere when the weather is wet - which is very often in Ireland – and allow this water to evaporate out when the weather is dry. This method of construction relies on the fact that walls were built of a sufficient thickness that the moisture rarely penetrates to the full depth of the wall and so the interior of the building remains dry. Altering this delicate balance can have detrimental effects of the well-being of the building fabric. Applying thermal upgrading techniques to historic buildings, which were designed primarily for modern construction, can cause damage not only to the building fabric itself but can seriously reduce the quality of life, and even the health, of the occupants of the buildings. Condensation on wall and window surfaces or within the depth of the construction, mould growth, lack of necessary ventilation to prevent insect and fungal attack of timber are among the adverse effects.



A comparison of the ventilation and heating requirements for a traditional (left) and a modern building (right)

EMBODIED ENERGY AND WHOLE-LIFE COSTING

To begin, it is important to make the case for the retention of older buildings, not only for their architectural and historical values. Demolishing an old building to replace it with a new, more energy efficient one does not always make environmental sense and does not take account of the value of the embodied energy present in the existing building and other factors. The reuse or continued use of older buildings is a key component of sustainable development and energy conservation practice. Making use of an existing building before building anew saves on demolition waste, which accounts for a large percentage of landfill, while the production and/or importation of new building materials accounts for a significant amount of energy use.

Before and after images of a restored stableyard insulated to modern standards

For traditional buildings, it can be shown that non-intrusive upgrading measures such as draught proofing, attic insulation and boiler replacement can ensure that a traditional building has the potential to out-perform a newly built building over a lifetime of one hundred years.

UNDERSTANDING THE INNATE ADVANTAGES OF THE BUILDING

Many early builders were aware of the advantages of practices such as building in sheltered locations and of planting trees to form shelter belts. Buildings were often aligned to maximise solar gain and minimise exposure to prevailing winds. The thermal mass of thick masonry walls was exploited to retain heat gained during the day from the sun. It is therefore important to acknowledge the impacts of exposure to both wind and sun, and of latitude and altitude on an existing building, and to assess

how the immediate setting of the building might be changed to improve the microclimate in which a building exists.

Now-ruinous vernacular houses on Great Blasket Island in the lee of the hill with their gables turned towards the prevailing winds from the Atlantic

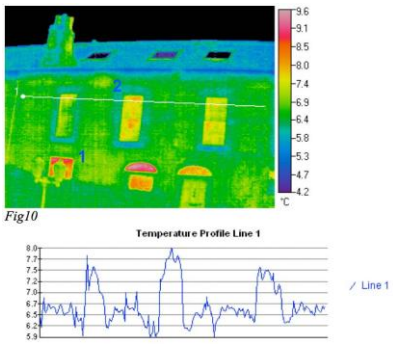
PRELIMINARIES TO UPGRADING

Before undertaking major, invasive, and often expensive works, there are several steps that can be taken that will have little or no impact on the architectural heritage of the building:

The first step is to consider how the building is used and managed. The greatest savings in energy consumption often come from changing the way a building is used and the behaviour of its occupants. This is an area which it is difficult, if not impossible, to regulate and yet can show the greatest savings in energy use. Some relatively simple measures can result in immediate benefits including:

- Turning down thermostats by as little as 1ºC (this can result in potential savings of 5-10% on a fuel bill)
- Having shorter or more efficient running times for the heating system
- Heating unused or seldom-used rooms only to a level sufficient to avoid mustiness and mould growth and keeping the doors to such rooms closed
- Using energy-efficient light bulbs
- Placing fridges and freezers in cooler rooms where they will consume less electricity
- Closing shutters and curtains at night
- Fitting smart meters to provide information on electricity usage and raise awareness of energy consumption
- Ensuring that the correct use of heating controls is understood by the occupants on completion of any upgrading works and that instructions are passed over to the new owner when the building changes hands. A lack of understanding of the controls for a heating system can lead to significant inefficiencies in the use of fuel and energy
- Using daylight for lighting rather than artificial lighting

The next step is to ensure that the building is in good repair, well-maintained and dry. There is often little point in insulating or draught-proofing a building if it is not. High moisture levels in the fabric of a building seriously reduce a building's thermal efficiency. A wet wall transfers heat from the interior of a building about 40% more quickly than a dry wall. It is therefore important to ensure that roofs, gutters and downpipes are functioning well; that there is no soil banked up against a wall and to avoid the use of dense, impermeable cement renders that can trap moisture in walls.



Assessment methods such as thermography can be used to identify areas of a building that are losing most heat possibly because they are damp

Reducing draughts

In traditional buildings, heat loss commonly occurs as a result of excessive ventilation or draughts. Over time buildings move, settle and shrink causing gaps to open up in locations where there were none originally. This often happens at the junction between windows and their surrounding masonry, or between sashes and window frames. Previous alterations to the building and works to install or remove services may have left gaps and cracks that were never properly sealed. Localised decay may have resulted in gaps particularly around doors and windows. All these factors invariably result in increased levels of draughts, resulting in discomfort for the building users as well as the loss of heat.

Insulation options

Before undertaking any upgrading works, the Guidelines advise owners to do some preliminary investigation as follows:

- Assess which elements of the building require upgrading works and complete a list of proposed works. Estimate the cost of upgrading and the potential energy savings that will result on completion of the works.
- Consider the effect of any proposed works on the appearance of the exterior and interior of a building and ensure that no works will interfere with, or damage, important elements or finishes or the historic character of the building as a whole
- Bear in mind that the cheapest works with the greatest energy savings are draught proofing, attic insulation and upgrading the boiler and heating controls. These can often be carried out with a minimal impact on the appearance of a building or its historic fabric
- If works are to be undertaken on a phased basis consider targeting colder rooms first, such as north-facing rooms
- Don’t reduce ventilation too much; it is needed for human comfort and to dispel moisture within a traditionally built building
- Research all proposed insulation materials. Before any new materials are introduced into a historic building, they should be proven to work, ideally having been in use in Ireland for 25 years or more and be known to perform well and not to have any damaging effects on historic fabric. Take account of the expected lifespan of the materials; any health aspects related to off-gassing, compaction of the material over time and the ‘breathability’ of the insulation.

UPGRADING THE THERMAL EFFICIENCY OF THE BUILDING

Roofs

An estimated 25% of heat loss occurs through a building's roof. Fitting insulation at roof level can be one of the most cost-effective and least-intrusive measures for improving thermal performance in a traditional building and should have no adverse effects on provided that ventilation and moisture control are properly addressed. Ventilation is very important in roof spaces to protect the roof timbers by moderating humidity and the moisture content. Prior to commencing any attic insulation, it is important to establish the location of any existing vents and to ensure that they will not become blocked by any addition of insulation.

Walls

An estimated 35% of heat lost from a building is through the walls. However, wall insulation (whether internal or external) is the most potentially problematic upgrading measure for a traditional building. Traditionally built masonry walls in Ireland were generally constructed of varying combinations of stone, brick and lime-based mortar, of solid construction, sometimes with a core of lime mortar and rubble filling. These materials are porous, allowing moisture to be absorbed by the wall and later released, depending on the weather conditions. They are soft and flexible and can accommodate small amounts of movement within the fabric. Walls often have timbers embedded in them and high levels of moisture, from whatever source, can lead to decay. Modifications to traditional walls should ensure that the breathability and flexibility of the structure are maintained.

A lime-rendered finish in good condition improves the insulating values of a wall and prevents damp penetration to the interior

External insulation of walls. External insulation has certain advantages over internal insulation: the benefits of the high thermal mass of a solid masonry wall are retained; there is a reduced risk of condensation between the insulation layer and the masonry wall; the building fabric remains dry and heated from the interior and there is no impact on internal finishes and room sizes. Among the drawbacks is the fact that these materials are relatively untried and untested in Irish climatic conditions. In order to fully exploit the benefits of its thermal mass, a solid masonry wall would ideally be insulated on the exterior face. However, as many external façades would be completely altered by the addition of external insulation, it is likely to be an inappropriate solution for most traditional and historic buildings. Even on buildings with plain rendered façades, external insulation is problematic as the thickness of the insulation affects details at all junctions around windows and sills, eaves and gutters,

doorways and any items fixed to the walls, at junctions where the building meets the ground and with neighbouring houses in terraced and semi-detached buildings.

Internal insulation of walls. Insulating the internal face of an existing wall will alter an internal room to varying degrees depending on the level of finish. It can be very intrusive and is rarely appropriate for buildings with interiors of architectural significance. Any addition of insulation will add to the wall depth, reducing the size of the room, interfering with the historic finishes and requiring the relocation of all electrical points and switches, wall lights and radiators. An increase in wall depth will adversely affect all decorative finishes such as plasterwork cornices, architraves, shutters and skirtings. A plain room with no cornice and minimal joinery may be easier to insulate but requires careful consideration in relation to maintaining the breathability of the building fabric. As well as the aesthetic and architectural conservation considerations, there are other potential technical difficulties in lining the interior of existing walls. Unlined masonry walls benefit from interior heat that keeps them dry. When the walls are lined, moisture ingress from the exterior and low external temperatures may result in a problematic build-up of moisture within the wall. There is also a possibility that condensation may occur between the insulation and the wall fabric, resulting in further moisture build up. The addition of insulation to the interior also alters the ability of the building to moderate temperature through its thermal mass. If an interior is to be thermally upgraded the insulation must be applied to every surface to avoid any possibility of thermal bridging which could result in mould growth. This may be hard to achieve, expensive, and extremely disruptive to the historic interior.

Windows, doors and rooflights.

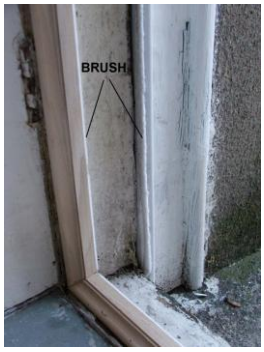
Traditional windows are an intrinsic part of the character of our historic and vernacular buildings. In Ireland, most surviving traditional windows are timber-framed, vertically sliding sash windows with single glazing. The quality of the timber and workmanship found in older windows is generally far superior to that found in modern ones and, when properly repaired and maintained, traditional windows will commonly outlast modern replacements. Between 10-15% of the heat lost from a building can be through its windows, by a combination of radiant heat loss through the glass, conductive heat loss though the glass and frame and ventilation heat loss through gaps in the window construction. This is low compared with the estimated average 25% heat loss through the roof and 35% through external walls. Yet windows are most often the first target of energy efficiency works.

In terms of heat retention within a building, older windows may appear to perform poorly when compared to some modern windows. It is, however, possible to repair and upgrade traditional windows to bring them up to a similar standard to modern double-glazed windows. Prior to considering works, the actual heat loss through the windows should be considered. In buildings where windows are small compared to the overall wall area, upgrading the windows may not result in a significant improvement in comfort levels or in energy savings. When considering the replacement of windows, a number of factors should be taken into consideration. First and foremost is the potential effect on the character of the building and the architectural heritage value of the existing windows. Also to be considered are the financial cost, the energy required to produce a new window, its embodied energy,

and the environmental cost related to disposal of waste. Modern double-glazed window units are expensive and high in embodied energy. The initial financial cost and embodied energy consumption may never be recouped by cost and energy savings on heating bills within the serviceable life of such windows. Instead, simple upgrading of existing historic windows can eliminate draughts and reduce heat loss.

Draught proofing of windows. Draughts may result in heat loss and are also uncomfortable, resulting in a perception that a room is cooler than it actually is. Draught proofing of a window will not improve its rate of heat transfer but stopping draughts will reduce heat loss and improve the thermal comfort of the occupants. The first step in reducing draughts is to overhaul the windows by carrying out any necessary repairs and ensuring that the sashes or opening lights operate properly within the frame. A window that is in good working order can be fitted with draught-proofing strips. However, with some particular old, delicate or valuable window frames, cutting grooves to insert draught proofing will not be appropriate.

Using existing shutters and curtains. Many Irish buildings of the 18th and 19th centuries were originally constructed with internal timber shutters to the windows. The best way to reduce heat loss in the evenings and at night is to use such shutters. Blinds or heavy curtains, which could be given an insulated inter-lining, when used with the shutters will further improve heat retention; there are specially designed thermal blinds available which can improve on this again. There may be some scope for upgrading shutters using a thermal lining applied to the rear of the shutter panels. The shutter box, into which the shutters fold when not in use, is often a source of draughts that is overlooked and should be sealed around the edges to eliminate unwanted air movement.



Simple unobtrusive measures can be used to upgrade historic windows and shutters

Secondary glazing. For buildings that are primarily used during the day it may be appropriate to consider secondary glazing, that is, a full-sized window panel fitted directly inside the existing window, which acts in a similar way to double glazing. Secondary glazing should be sealed to the interior but the original windows should be ventilated to the exterior to prevent condensation forming between the two windows, which is not only unsightly but is potentially damaging to the historic building fabric. Therefore, if secondary glazing is to be fitted, the original windows should not also be draught proofed. The combination of secondary glazing, shutters and curtains has the potential to match the insulation properties of triple-glazed windows. Secondary glazing alone can result in better overall thermal performance than a standard double-glazed window.

Double glazing. Original or early-replacement windows in a traditional building should not be replaced with double-glazed windows while the fitting of double-glazed units into historic timber frames is rarely appropriate or achievable. Historic sash frames are generally finely crafted from slim sections of timber, the depth and strength of which would not be adequate to support double-glazed units. Double-glazing technology is constantly improving and the use of slim-line double-glazed units may be appropriate in situations where single-pane sash windows require replacement but not where the historic glass survives or where the new units would be too heavy for the historic window frames. As with all double-glazed units, the cost of these high-tech components is unlikely ever to be recouped over their lifespan, while the gases used to fill the cavity can have a high embodied energy.

Floors

The ground or lowest floor in a building is the most important floor to consider for effective thermal upgrading. An estimated 15% of the heat within a traditional building is lost through its ground floor. Both ventilated and unventilated suspended timber floors are particularly common at ground floor level in Irish buildings. Stone flags, tiles or brick paving laid on solid floors (often bare earth) are also common, particularly within basements. Improving the thermal performance of the ground floor can significantly improve comfort levels by providing a warm floor underfoot. In a historically important building it may, however, be difficult to upgrade a floor without loss or disturbance of significant finishes such as tiles or brick paving and therefore particular care needs to be taken.

Suspended timber floors. Suspended timber floors were constructed both as ventilated floors with vent grilles in the exterior walls and as unventilated floors. Where vents are provided it is important to ensure that these remain unobstructed as they ensure that moisture levels do not build up in the space beneath the floorboards. If any vents have been blocked up in the past, it is important to reopen them. Floor coverings such as rugs or carpets will eliminate draughts and the underside of the floor can be upgraded with insulation.

Solid floors. The easiest way to upgrade an existing solid floor is to add a layer of insulating material above it with a new floor finish on top. The covering of an existing floor should only be considered if it is of no architectural or historical interest. Floor finishes such as decorative tiles, brick, wood block or stone flags should not be covered over although in some cases it may be possible to carefully lift these to allow for re-laying over the new, insulated floor. Floors which have previously been interfered with and have modern finishes are the most appropriate for covering with insulation. However, this will increase the height of the finished floor level and affect internal features such as skirting boards, window linings, doors and architraves and cause difficulty at the foot of stairs.

Services

As the opportunities to increase insulation in a traditional building are relatively limited, building services and their controls can play a large part in improving energy efficiency. In most traditional buildings, building services such as heating systems, plumbing and electrical installations are not original to the building and there may

therefore be some flexibility in altering them. The properties of historic buildings (high thermal mass and slower response time), together with issues related to the installation of services mean that systems which are not usually considered for use in modern buildings can be most appropriate in historic buildings. Solutions are not always as simple as they may seem and a holistic approach should be taken to looking at the benefits as well as the future consequences of any given system. Technology in this area is constantly evolving and new products are regularly becoming available.

Plumbed heating systems. Designers of older buildings were sometimes surprisingly sophisticated in understanding buildings, their ventilation and heating. Heavy cast-iron radiators were an important invention of the 19th century, and are durable and efficient. Their moderately slow response time is particularly suited to avoiding thermal shock, that is, an abrupt change in temperature, in older buildings. In Ireland, most older buildings were originally heated with open fires but it is likely that this form of heating is now superseded in many houses. In most buildings open fires will be supplemented or have been replaced by a central heating system fuelled by oil, gas or timber fired boilers. While boilers are more efficient than open fires, significant improvements in efficiency have been made in recent years with 95% efficiency boilers now available. The upgrading of standard boiler systems and associated controls in traditional buildings can be a relatively straightforward process with little negative impact on historic fabric.

Wood burning. Many traditional buildings have chimney flues that can be used to advantage with wood burning stoves. A stand-alone stove as a replacement for an open fire would not normally have a boiler but there are a limited number of small stand-alone room stoves available with integrated boilers that can be connected to radiators and a hot water system.

An electrical storage heater fitted in an 18th century house. The low height allows for the continued use of the timber shutters at night

Electrical services. The use of electricity as a source of energy for heating is generally inefficient due to losses in generation, in distribution and in the appliance itself, with high resultant carbon dioxide emissions per unit of heating output when compared to oil or gas heating systems. The use of electric heating will also have a negative impact on a building's Building Energy Rating, as it is deemed to be inefficient and carbon-intensive: this may change in the future with increased use of wind and hydro-power. However, in the context of a historic building or a protected structure, the installation of wiring for an electrical heating system may be much less intrusive than a piped water-heating system, with no risk of damage to the fabric of the building from water leaks.

Heat recovery. Most heat recovery systems for domestic situations rely on a managed ventilation system in the context of tightly sealed new buildings. There is concern that significantly reducing ventilation within a traditionally built building may cause moisture problems within the fabric and in rooms. It seems unlikely that a heat recovery system in a predominantly naturally ventilated building would be either cost- or energy-efficient. In addition, any mechanical system that relies on ductwork will probably encounter difficulty as the relatively large ductwork would inevitably entail unacceptable levels of disturbance or loss of historic fabric or give rise to visual impacts.

Water conservation. Many historic buildings, particularly those in isolated rural locations, had systems for collecting and storing rainwater. Where old collection systems survive, such as lead or copper tanks in the upper reaches of buildings, water butts or water barrels, it may be possible to bring them back into use as a water conservation measure and for use in activities such as watering the garden or washing cars.

Renewable energy technologies. Upgrading the fabric and services of an existing building are usually the most cost-effective means of improving its energy efficiency. However, there are instances where, to achieve greater energy savings and reduce carbon dioxide emissions, the use of renewable energy technologies could be considered for small-scale generation of electricity. Using simple solar-powered water heaters for domestic hot water is probably the most effective way to actively exploit solar power. The location of solar panels or photo-voltaic arrays mounted on the roof of a traditional building will require careful consideration. It should be remembered that solar panels require an enlarged water cylinder which must be accommodated within the building. Small-scale wind-turbines are unlikely to offer any benefit in an urban environment although well-located installations, with a good exposure to wind, may be worthwhile in a rural situation. Power from such an installation could be used for water heating or background space heating. Wind turbines generate a large amount of vibration in use and are subject to high wind loadings and these must be taken into account if considering attaching one to an older, possibly fragile, building. Also, the visual impact of a wind turbine on a historic building may be unacceptable.

Heat pumps. Heat pumps work best serving as a source of heat for underfloor heating, where the water temperature required is lower than for radiators. If properly designed and installed, heat pumps may represent a carbon-efficient form of space heating. As heat pumps are usually only appropriate for use with underfloor heating the retrofitting of this type of system is difficult. This type of upgrading should usually only be considered in the context of large-scale refurbishment works.

Lighting. Many traditional buildings were designed for optimum use of daylight; effective use of day-lighting can reduce the need for artificial lighting. Careful design of switching arrangements and other controls for lighting such as occupancy detectors together with energy-saving light-bulbs are effective ways of reducing energy use in buildings.

•