Approaching Near Zero Energy In Historic Buildings

Deliverable No.: DT 2.4.1

Deliverable Title: Specification and design for historic buildings retrofitting

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Deliverable Type: R

R = Document, report
DEM = Demonstrator, pilot, prototype, plan designs
DEC = Websites, patent filing, press & media actions, videos, etc.

Dissemination Level: PU

PU = Public
CO = Confidential, only for members of the consortium, including the Commission Services

This project has received funding from the European Union's Northern Periphery and Arctic Programme (2016-2020) under Grant Offer Letter 304_1175_20194.

CONTENTS

1.0 SCOPE

The Pathfinder project has used a number of demonstration projects in developing its methodology:-

Bayview, Orkney Islands, Lighthouse keepers' cottages, North Ronaldsay, Scotland, North Cathedral, Cork and Myross Wood House, Co. Cork, Ireland, Vicarage of Onageroi Vidareidi, Faroe Islands, Rector's House, Raahe Finland, Tegs Kyrka, Umea, Sweden.

Detailed reports are available on the website for these.

This document focuses on the detailed recommendations for Myross Wood House.

It is worth noting typical traditional construction types within the Northern Periphery area: solid masonry predominates in Ireland and Scotland, but to a lesser extent in Sweden and Finland, whereas timber or solid log construction is more typical in Sweden, the Faroe Islands and Finland.

There are some differences in recommended treatment for improving the thermal performance of the built fabric, which are crucial to avoiding problems of dampness, humidity and poor air quality. The use of modern materials of low vapour permeability in solid masonry construction is fraught with risks, especially when internal insulation is applied, reducing the temperature of the structure with attendant condensation risk. Many of these modern materials are also liable to have a high embodied carbon footprint, especially if derived from petrochemicals. It is advisable to address ventilation and reduction of internal humidity as a priority before significantly upgrading insulation.

Traditional timber construction, on the other hand, may be intrinsically more vapour-permeable; provided this vapour-openness is maintained, higher levels of insulation can be achieved with diminished risk of interstitial condensation.

(Completion certificates - listed as DT2.6.1 - are only relevant to a few of the projects, those which have reached completion.

2.0 REFERENCE DOCUMENTS

Refer to links for other project reports in the Pathfinder website

3.0 MYROSS WOOD HOUSE DEMONSTRATION PROJECT DESIGN AND SPECIFICATION

Recommendations are given in several detailed reports; the reference documents listed below can be found here:

Akiboye Conolly Architects' Myross Wood House Energy Upgrade Study, 2020

includes analyses of historical energy use, fabric performance, upgrading recommendations including description of recommended materials and techniques, and projected energy savings

Liam McLaughlin's Energy Action Plan for Green Skibbereen - Myross Wood House, June 2022

incudes energy audits, based partly on the above, and recommended improvements

BMA Architects' Retrofit Strategy for BEC Grant Application with outline costs 2022

this looks in generic terms at improvement works, with material descriptions, including preparatory works to aid drying and weathertightness

P J Barrett & Co quotation for preparatory buildings works to aid drying and weathertightness, based on the above, 2022

Carrig Conservation Retrofit Strategy Report on the condition, conservation and retrofitting of the historic fabric, 2020

The present document includes many of the recommendations in all of these reports, draws largely on, and incorporates the analyses and recommendations of first report listed above.

Each element of the building is examined in terms of generic principles of methods of upgrading energy performance, setting out existing construction alongside potential improvements.

The building as a whole is then considered in terms of appropriate degrees of alteration, taking into account the relative historic value of the different wings, and optimum recommendations given for three different levels of upgrading, element by element.

In conclusion, the potential reductions in energy performance is calculated for each wing, and for the whole building.

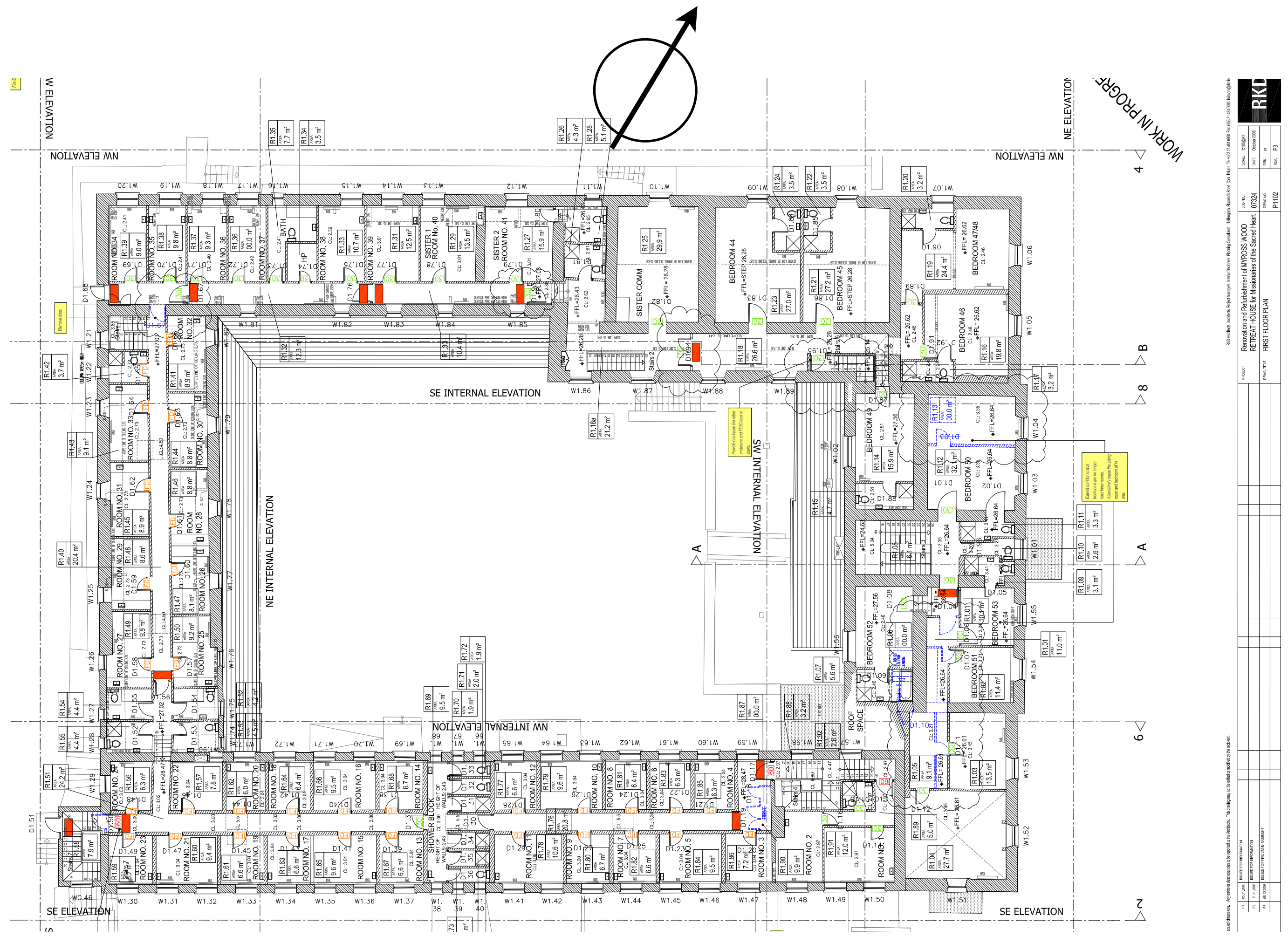
The existing building

The existing building has been studied in some detail in other reports, including by Carrig, and their recommendations should be followed in advance of any energy upgrading work, especially, for example, in drying out the existing structure. This is particularly significant in the east wing, where opportunities to change the construction are liable to be constrained, and to some extent in the north and west wings, which are of partly similar construction, susceptible to damp from the ground, although perhaps less constrained architecturally.
The south wing is of much more recent construction, with minimal architectural features warranting conservation, but it is unlikely to have a significantly better thermal performance.
Most roof spaces have been insulated with a nominal 100mm layer of mineral fibre insulation; its condition should be checked.
Doors and windows throughout all wings are relatively recent replacements, mostly upvc with double glazing.

Existing energy performance compared with upgrade options

Digital survey drawings from RKD have been interrogated to measure all building surfaces - walls, windows, doors, ground floor, internal floor areas and effective roof area where generally insulated at ceiling level. Default U values have been estimated from on-site and digital plan measurements of wall thicknesses and window and door constructions, and air leakage rates assumed, based on typical figures for comparable construction using generic and characteristic values for properties of the assumed construction based on drawings provided.
The area and U value measurements are tabulated in spreadsheets to examine overall performance of each wing of the building.

There are two contrasting ways of assessing the existing building performance: we have been given various fuel costs for the years 2012 up to July 2019. The records are not consistent in that they only partly distinguish expenditure on different energy sources, but the most detailed information relates to three complete years, 2016, 2017 and 2018. At these times the building was, as far as we can assess, only partly occupied; there were six novitiates occupying the "retreat wing" (out of more than 50 bedrooms) from August 2016 - August 2017. A drop in energy use for 2018 suggests further reduced occupancy, and this is consistent with observed occupancy during early site visits, with just 4 people in residence. However, it has been reported that some background heating was maintained in less occupied areas.
The crude energy use calculated from fuel bills works out at around 180 KWh per sq m per annum for this period of partial occupancy. It is difficult to relate this to an energy rating, as the BER procedure assumes full and regular occupancy. We have, therefore, analysed the building elements to assess their performance with normal occupancy, heating, hot water and other energy use, such as lighting.



Myross Wood House Fuel consumption	2012	2013	2014	2015	2016 3rd quarter	2016 4th quarter	2016 total	2017	2018	2019 to July
							6 novitiates in residence****			
Heating oil *	Fuels not distinguished 2012-2015**									
OIL cost €							15,421.82	18,251.32	17,532.85	9,910.00
Average oil price €/1000 l.	1104.20	1069.20	974.30	677.40			582.70	632.20	692.60	714.30
Volume, 1000 litres**	34.611	30.695	32.369	32.132			26.466	28.870	25.315	13.874
Calorific value KWh/l	14.925	14.925	14.925	14.925			14.925	14.925	14.925	14.925
Oil energy used MWh	516.563	458.122	483.106	479.565			395.007	430.878	377.820	207.065
Overall light & heat**	38,217	32,819	31,537	21,766						
GAS - for cooking only										
Cost €					418.92	545.00	1,908.40	1363.40	1,363.40	681.70
Gas cost lpg €/litre, ave							0.62	0.66	0.72	0.79
Calorific value lpg KWh/l***							7.2	7.2	7.2	7.2
Gas energy used MWh							22.162	14.873	13.634	6.213
ELECTRICITY incl outbuildings										
Electricity cost €							6237.00	7,048.48	5,798.72	1,618.86
c/KWh ex vat (SEAI)				13.8	12.9	12.5	12.7	12.5	13.5	14.2
€/KWh inc vat @ 13.5%				0.157	0.146	0.142	0.144	0.142	0.153	0.161
Electricity consumed MWh							43.269	49.681	37.844	10.044
Overall cost "light & heat" €**	38,217	32,819	31,537	21,766			22,342	25,556	26,431	
				Note drop in oil price						
TOTAL ENERGY USE MWh							460.438	495.432	429.298	223.323
Energy KWh/m2 floor area, typical years, part occupancy							170.155	183.087		

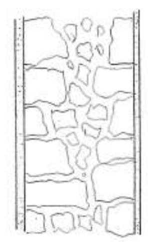
Notes: figures based on expenditure records
Heating and hot water predominantly by oil; a small amount of supplementary heat from solid fuel (not accounted) & electricity
* 2 tanks: large for large boiler for general central heating for 2/3 of house Oct-April + small boiler for washing in one wing of retreat house; small tank for kitchen & "house" (presumed E wing)
Heating oil calorific value taken as 43 MJ/Kg or 11.94 KWh/Kg, specific gravity 0.8; 1.25 l/Kg (kerosene)
** Assuming dominated by oil, as no separate data for electricity
*** Flogas state 26MJ/l = 7.2KWh/l
**** A smaller number (unspecified) in residence the following year
Based on data from Fr Michael Curran MSC 08.07.19 AkiboyeConollyArchitects Oct 2020

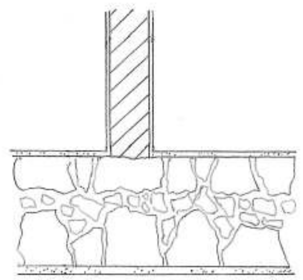
Generic analysis of individual building elements

Walls
Existing

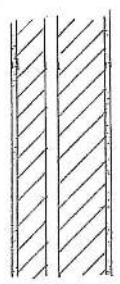
Solid masonry
These wall are generally around 600-700mm thick. One measurement of wall U value was made on the older, east wing in February 2019. The resulting readings were unreliable as the external sensor was removed for much of the recording period. A resulting figure of 4.95 W/m2K was questionable, and a figure of 2.1 W/m2K was deduced from a small, more consistent part of the recording as more likely correct. This is close to the theoretical figure calculated using iSBEM software. The external concrete render is likely to have trapped a significant amount of water in the wall, raising the U value by 30%.
Walls in the older wings should be stripped of external render in spring and allowed to dry out over a summer, ideally with some protection from wind-driven rain if the weather is exceptionally wet. Such drying out, even without other measures, could bring the U value closer to 1.3 W/m2K, as shown in measurements by HES, amongst others.

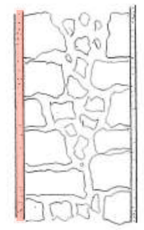
The lower parts of the north wing in particular, and to some extent the west wing, have suffered damp from rising and laterally penetrating ground water due to relatively high and encroaching ground levels; these levels need to be reduced and reshaped to aid air movement, possibly occasional sun penetration, so that they can be allowed to dry out.



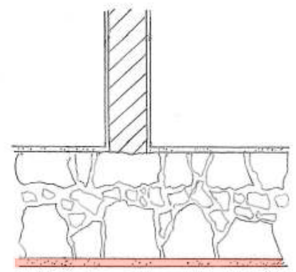


Cavity blockwork
The south wing is of more modern construction, and the 450mm thickness suggests concrete block construction, with a 50mm cavity, probably with cement render externally and gypsum plaster internally. Given its age, it is unlikely to include any insulation.

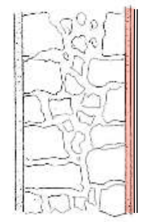




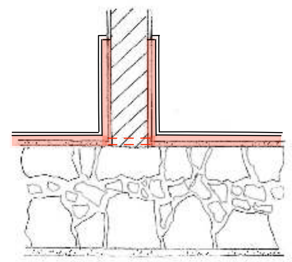
External wall insulation
e.g. cork lime render



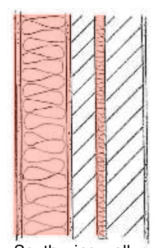
External wall insulation
e.g. cork lime render



Internal wall insulation -
requires condensation check!



Internal wall insulation - condensation check!
requires thermal break on return



South wing wall
external insulation
render + cavity fill

Improved

Solid masonry
In choosing between internal or external wall insulation several issues should be carefully considered:
Moisture movement, both rain and internal humidity/condensation
External insulation: valued architectural features may be compromised with thick added layers; continuity with roof level and ground floor insulation should be ensured; exposure to driving rain may be mitigated by suitable external layers, but opportunities for any trapped water to evaporate must be ensured, generally by the selection of vapour-open materials and finishes. Depending on the thickness of external insulation, insulated extensions to sills will be required; these can also eliminate cold bridges. Ideally doors and windows of improved performance should be refitted in this added insulation layer. If not, care should be taken to maximize the performance of relatively thinner insulation in reveals of openings. If an existing external cement render of 38 - 50mm is replaced by a cork-lime mix, existing features can be reproduced, vapour permeability ensured (any paints should be porous) and insulation further improved.
Where external features demanding preservation are not present, a ventilated rainscreen cladding can protect external insulation and deal effectively with driving rain.

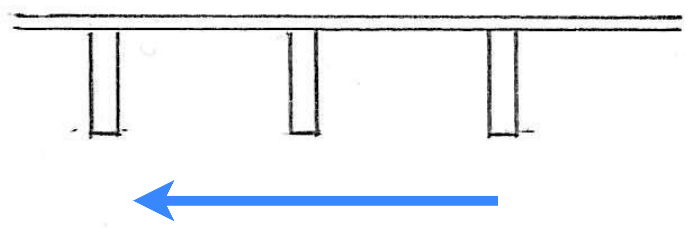
Internal insulation: if materials of high vapour resistance are used, the risks of vapour entering, and becoming trapped in colder parts of the wall, especially through gaps or joints, poses more serious risks of interstitial condensation; installation will be disruptive and space will be lost; where internal walls/floors meet external walls, thermal breaks should be introduced, or insulation should be returned, typically 500-1000mm on both sides; this is especially necessary where internal partition walls are of solid construction, and wall thicknesses suggest that this applies throughout most of the east and south wings. If vapour-open materials are used, checks (e.g. hygrothermal probes) need to be made on dynamic behaviour, often over at least a full heating season, to verify risk of condensation build-up in the wall; some alkaline materials, such as calcium silicate, can reduce the risk of mould growth where condensation or high humidity do occur, provided walls can dry out at regular intervals;

Cavity blockwork
These walls can be upgraded with external insulation where there are no historic architectural features to constrain alterations. The cavity must be filled at the same time to prevent thermal looping (note that all cavity wall insulation products with Irish Agrement Board certificates are not certified for use outside a relatively sheltered region around Dublin. The protection from driving rain provided by external insulation and render is critical.)

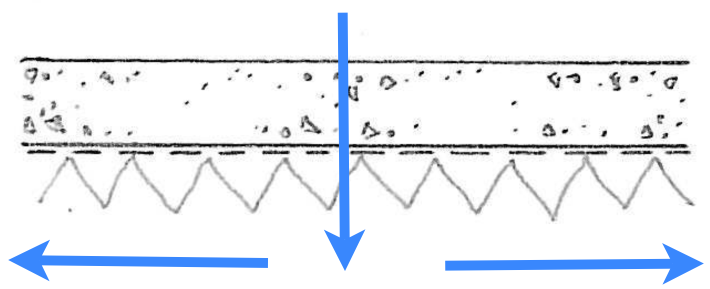
Generic analysis of individual building elements

Ground floor
Existing

Suspended timber floors will offer very little thermal insulation, and sit over unheated voids which should be well ventilated, and are, therefore, close to external air temperature. The free air movement through under floor voids is important to keep floor timbers dry, so should be checked, and any obstructions cleared before any other works are undertaken.

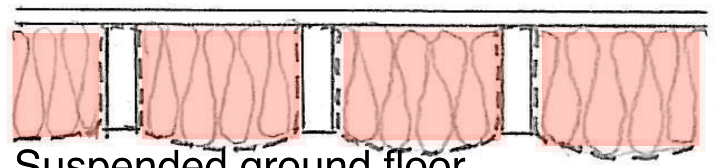


Solid floor concrete slabs, present to some extent in all wings, including the whole south wing, are similarly likely to be lacking insulation, given their dates of construction. Although large areas of solid floor with relatively lower proportional perimeter lengths can exploit the thermal inertia of the ground beneath the slab, the proportions of ground floors in Myross Wood House offer only moderate benefits in this way (typical perimeter P/A area ratios are well over the preferred ratio of 0.25 for domestic, or 0.3 for non-domestic, even by criteria of around 15 years ago), and much heat will be lost through lateral transfer in the ground.



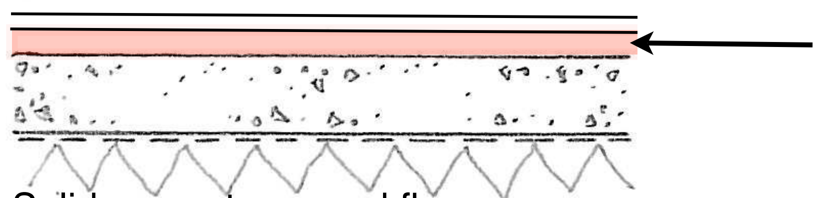
Improved

Suspended timber floors may be lifted and insulation fitted tightly between joists. Under floor ventilation must be maintained. Moisture movement needs to be carefully considered: there is a risk that a vapour barrier at floor level may allow the passage of vapour at joints or peripheral junctions; there is less risk of condensation if insulation is vapour-open, such as wood fibre or cellulose fibre, which can also facilitate complete filling of awkward spaces; these can be supported on a breather membrane or, if in the form of batts, on an open mesh or netting.

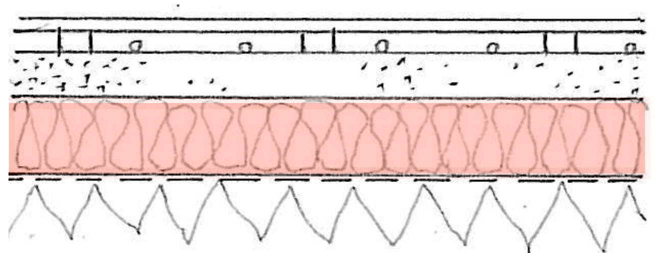


Suspended ground floor
~250mm fibre insulation

Solid floors may be overlaid with thin insulation (e.g. vacuum insulation panels, which are very expensive but have very high thermal resistance), but care needs to be taken to check moisture movement through gaps or joints condensing on colder surfaces. If ceiling heights permit, thicker alternatives are cork- or hemp-lime, or insulation and a new finish can be laid on top of the structural floor; these options can incorporate heating coils.
A more disruptive alternative is to dig up the floor, excavate and lay a new floor on insulation (shallow stepped foundations may limit this approach). There are several options for construction of such lowered floors with improved insulation:
the slab may be laid on compression-resistant insulation on a radon barrier/damp proof membrane. Under floor heating pipes may be run through a slab or screed in this position, offering more efficient heating (comfort is achieved with a favourable thermal gradient and lower air temperatures, hence lower fabric losses). Under floor coils may also be run in a small air space over slab or insulation and under a thin floor finish of moderate or low thermal resistance (such as 22mm timber); this offers a faster response if intermittent heating is called for.



Solid concrete ground floor
vacuum insulation + new floor finish

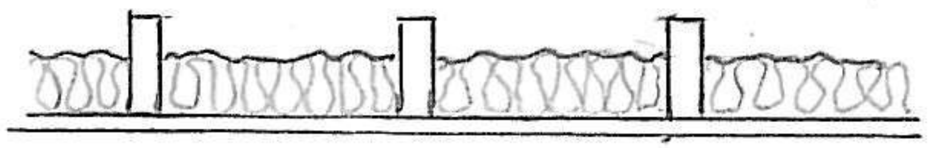


Excavated & new ground floor slab
with underfloor heating & floor finish

Generic analysis of individual building elements

Ceilings under unheated roof voids
Existing

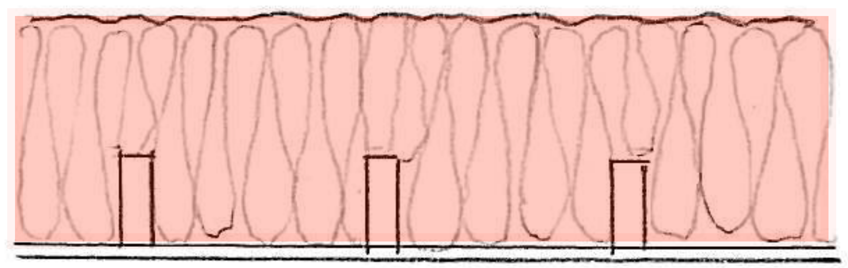
Most of the roof voids have been insulated with ~100mm of mineral fibre some years ago. This is either glass fibre or rockwool, some in batts, some blown fibre. The condition of the material should be assessed (given the poor condition, contamination and compression over the years, this has been taken as effectively 75mm); bear in mind that these materials are irritants, and although not currently treated as presenting hazards comparable to asbestos, it may only be a matter of time before such health hazards are recognized. Internal water vapour can generally migrate through such ceiling constructions, whether of plasterboard (without foil backing) with skim plaster finish, or lath and plaster, so the ventilation of roof spaces is important to disperse this moisture and protect roof timbers. Foil backed plasterboard will increase the vapour resistance of the ceiling layer, but the fibrous insulation above remains vapour open.



Ceiling to roof space

Improved

If the existing fibre insulation is contaminated it should be removed, and this may be a prudent measure to eliminate an irritant material of poor performance.
A new, vapour-open insulation layer of around 400mm thickness should be installed. This may be in the form of batts or blown. If batts are used, the thicknesses of layers should be matched to joist depths to minimize voids and ensure close fitting. Materials of low carbon footprint can be selected by examining environmental performance declarations - EPDs - of materials suppliers, and cellulose materials such as recycled newspaper or wood fibre, as well as wool, will have carbon footprints which are either negative or close to zero. They should also be fire retardant, and this is often achieved by suitable additives.
If there is a risk of debris falling from roof coverings or linings (some early slate roofs may be lined with lime plaster) a breather membrane may be laid over the insulation to keep it free of contaminants; similarly, if access is required, a floor may be laid on raised joists.
If the ceiling requires replacement, or a service cavity is to be formed under the existing ceiling, then a variable permeability "intelligent" breather membrane can be fitted. These materials will act as a vapour check in cold weather to resist the passage of moisture, and are vapour open to aid drying of any moisture within the construction above during warm weather.



Ceiling to roof space
400mm fibre insulation

If the attic space is occupied, or where ceilings follow roof slope (as partly occurs in the North wing), insulation would have to follow the roof slope, and maintenance of ventilation to roof timbers becomes relatively more critical.
Although there are no flat roofs, such roof forms can be insulated by an inverted roof construction.

Generic analysis of individual building elements

Air infiltration and humidity control

Existing

A typical rate of air infiltration for the existing construction allows for leaky window and door frames, gaps in ground floor boards over ventilated voids, some open fireplaces in the east wing, services penetrations, wall vents, attic access hatches and the like.

The high air-change rate has helped keep the fabric relatively free of moisture, and no reduction in ventilation rates should be countenanced without careful analysis and control of internal humidity.

Despite existing relatively high infiltration and air movement rates, some areas have suffered continuing dampness, especially at ground level in the north wing. The degree of dampness is also dependent on occupancy, activities and heating. During high levels of occupancy, with frequent use of showers, washing facilities, laundry and cooking, the risk of condensation is dramatically increased.

Improved

Uncontrolled infiltration of cold outside air, and leakage of warm air should be minimized, and an appropriate volume of fresh, filtered and warmed air supplied, to suit levels of occupancy and activities inside the building. Detailed, dynamic hygrothermal analyses should be carried out to assess condensation risk after renovation. To reduce condensation risk, adequate ventilation should be treated as a first priority, even when thermal upgrading is limited.

The optimum recommendation is to instal mechanical ventilation with heat recovery. Air extract should be targeted at areas of moisture-generating activities, primarily showers, cooking, laundry and areas of high occupancy. Ideally each room should have a supply of fresh warmed air at 40 - 50% relative humidity. Such an installation would be quite disruptive to instal, although in top floors insulated ducting could be run through roof spaces. Such systems should be carefully balanced when installed and commissioned, and filters should be replaced regularly. Note the updated requirements of the revised TGD Part F regulations on design, installation and commissioning.

An intermediate solution, still with heat recovery, is to focus extract on the principal moisture-generating areas, and allow warm, drier air to percolate with small transfer openings under doors from strategically located inputs.
An alternative is to instal separate mechanical wall vents with heat reclamation in individual rooms; the amount of heat reclaimed is limited according to the activities and heat generated in that room.

A further alternative is to drive extract with carefully designed stack effect and wind-driven extract. It is especially important to limit the effects of wind pressure which can easily overwhelm the much smaller (typically by an order of magnitude) pressure differentials generated by stack effect.

A simpler installation, without heat recovery, is to instal mechanical extract in the principal moisture-generating areas, and introduce outside air through humidity-sensing slot vents (even with relatively high humidity external air in winter, its relative humidity will reduce if it is warmed when it enters the building). This system is less efficient, will not reclaim heat, but is potentially much more economical, and can run at lower overall air-change rates. Ventilation rates should be maintained, with a normal minimum rate of 0.5 air changes per hour, increased with higher occupancy, which can be controlled with CO_2 and humidity sensors.

It is, incidentally, recommended that CO_2 sensors be used as a proxy for viral load in occupied internal environments; in order to reduce risk of cross-infection to acceptable levels, a limit in the range of 600 - 1000ppm should be applied, subject to occupant activities and density (Passive House + issue 35 Sept/Oct 2020, p14 quoting work by Prof John Wenger, UCC),

Quite apart from risk of condensation and mould, it should be noted that radon levels, in the absence of floor barrier membranes, are also dependent on ventilation rates. Myross Wood House sits in an area of low risk according to the EPA radon map (https://www.epa.ie/radiation/radonmap/) but it would be prudent to make measurements before any reduction in ventilation rates.

Generic analysis of individual building elements

Services

Services runs - Existing
The locations, condition and function of all services runs should be recorded to identify those which can be retained and those to be replaced.

Lighting - Existing

Existing lighting is predominantly T8 fluorescent tubes in what appear to be fairly old fittings with wire-wound control gear and compact fluorescent lamps; we assume an overall average luminous efficacy of around 50 lumens per circuit watt.

Heating controls - Existing

The existing heating system has minimal controls; details have not been confirmed, and should be verified by the occupants. It has been described as being in three zones, and running on a time clock. The presence of any thermostatic controls should be checked.

Water - Existing
The existing cold water supply should be checked for the presence of any lead piping, which should be replaced. Depending on the source, water services may involve some pumping energy.

Effluent - Existing
The existing system is presumed to be a septic tank and traditional soil percolation. B.O.D. of effluent should be tested

Services runs - Improved
The locations of all services runs require careful thought and planning in relation to upgrading of the building fabric. Accessibility should be ensured, especially where services may run through or behind added insulation or vapour control or breather membranes.
It is always good practice to remove redundant services, to record and label all services and control systems, and to provide clear operating instructions for building owners and managers; unless these personnel are technically trained, the simpler and more intuitive they are the better. Drawn, digital, or ideally BIM records should be kept for building managers.

Lighting - Improved

If all these were to be replaced with high efficiency led fittings, an overall luminous efficacy of ~90 - 100 lumens per circuit watt could be achieved. Benefits would include extended life expectancy of lamps to around 80,000 hours, allowing recovery of capital costs multiple times within the life of fittings. Occupancy sensors can avoid unnecessary operation of lighting in unoccupied areas.

Heating controls - Improved

A number of control systems offer major savings. These include room thermostats, occupancy sensors, weather-sensing or weather-forecasting optimum start controls, along with local zone control programmers, to cut heating to minimum temperatures to protect the fabric of the building, but minimize heating of unoccupied areas. In the absence of dedicated technically trained building systems managers, the simplicity of interface, together with user training, is essential to realize potential savings.

Water - Improved
The use of low flow fittings, such as spray taps and the avoidance of power showers, can achieve useful reductions in hot water use.
Rainwater harvesting can offer very significant reduction in consumption of treated potable water. It would require separate circuits to wcs and, depending on the degree of filtration and treatment, any other appliances such as washing machines. The amount of pumping energy, will depend on tank location, whether at high level for gravity supply (with associated costs of supporting structure), or ground level for a pumped supply. Possible energy in water treatment such as high pressure filtration, filter backwashing, reverse osmosis or u.v. sterilization, will depend on the methods used.

Effluent - Improved
The use of anaerobic digestion could be considered for generating methane as a fuel source which could be stored for use when other renewable energy sources are not available.
Digested residue can be used as fertiliser.
A reed bed system could also be considered to clean effluent.

Generic analysis of individual building elements

Heating system

Existing

There are two existing oil boilers, dating from 1993. One of these is out of action. The other is rated at 365KW output (401KW input), and, given its age and condition, is likely to achieve a combustion efficiency of around 70-75%

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Average oil price €/1000 l.	1104.20	1069.20	974.30	677.40			582.70	632.20	692.60	714.30
Volume, 1000 litres**	34.611	30.695	32.369	32.132			26.466	28.870	25.315	13.874
Calorific value KWh/l	14.925	14.925	14.925	14.925			14.925	14.925	14.925	14.925
Oil energy used MWh	516.563	458.122	483.106	479.565			395.007	430.878	377.820	207.065
Overall light & heat**	38,217	32,819	31,537	21,766						
GAS - for cooking only										
Cost €					418.92	545.00	1,908.40	1363.40	1,363.40	681.70
Gas cost lpg €/litre, ave							0.62	0.66	0.72	0.79
Calorific value lpg KWh/l***							7.2	7.2	7.2	7.2
Gas energy used MWh							22.162	14.873	13.634	6.213
ELECTRICITY incl outbuildings										
Electricity cost €							6237.00	7,048.48	5,798.72	1,618.86
c/KWh ex vat (SEAI)				13.8	12.9	12.5	12.7	12.5	13.5	14.2
€/KWh inc vat @ 13.5%				0.157	0.146	0.142	0.144	0.142	0.153	0.161
Electricity consumed MWh							43.269	49.681	37.844	10.044
Overall cost "light & heat" €**	38,217	32,819	31,537	21,766			22,342	25,556	26,431	
				Note drop in oil price						
TOTAL ENERGY USE MWh							460.438	495.432	429.298	223.323
Energy KWh/m2 floor area, typical years, part occupancy							170.155	183.087		

Notes: figures based on expenditure records

Heating and hot water predominantly by oil; a small amount of supplementary heat from solid fuel (not accounted) & electricity

* 2 tanks: large for large boiler for general central heating for 2/3 of house Oct-April + small boiler for washing in one wing of retreat house; small tank for kitchen & "house" (presumed E wing)

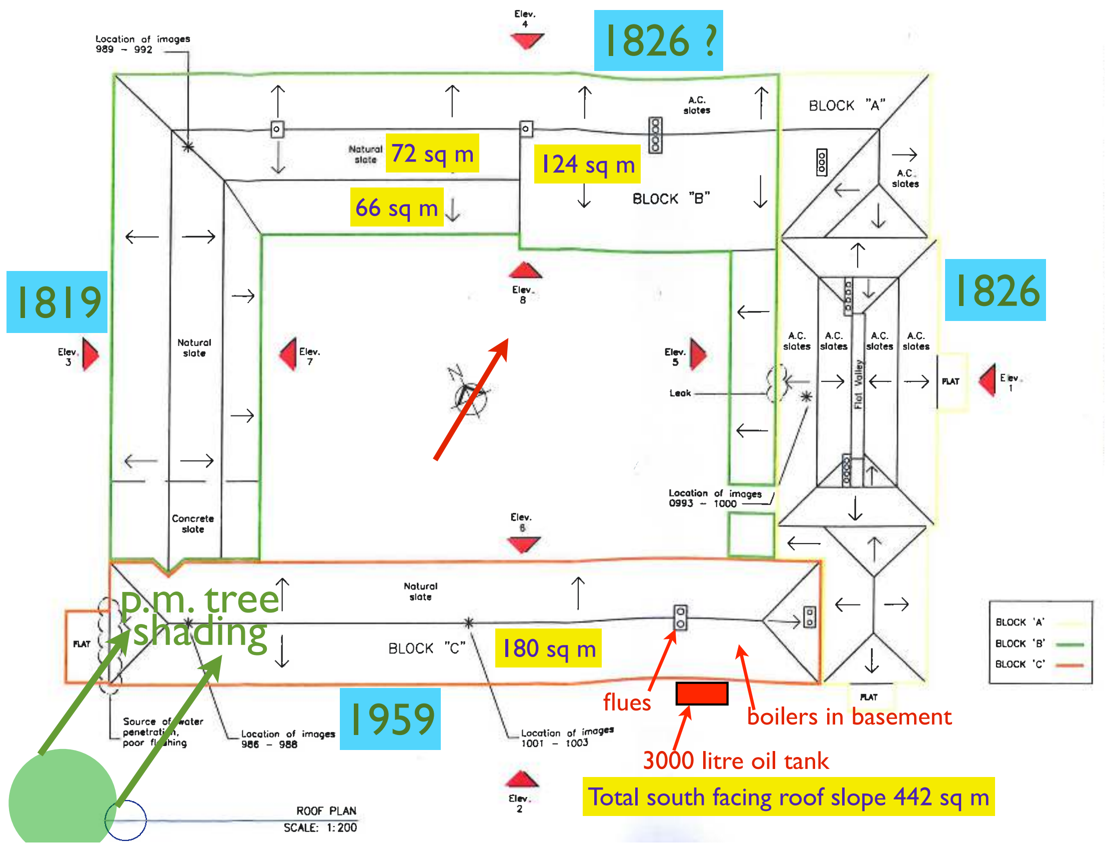
Heating oil calorific value taken as 43 MJ/Kg or 11.94 KWh/Kg, specific gravity 0.8; 1.25 l/Kg (kerosene)

** Assuming dominated by oil, as no separate data for electricity

*** Flogas state 26MJ/l = 7.2KWh/l

**** A smaller number (unspecified) in residence the following year

Based on data from Fr Michael Curran MSC 08.07.19 AkiboyeConollyArchitects Oct 2020



Improved

We recommend the following options, each of which has differing environmental impacts, which are also discussed below under Renewable Energy Options (see p.17).

Biomass boiler
This may run on wood chip, pellets or as a log burner. The first two are easier to automate. If biomass is grown locally, the carbon footprint of this fuel source can be relatively low, as well as providing local employment (which, in turn, may obviate the emissions associated with commuting to employment elsewhere).

Air-to-water heat pump
Depending on the heat emitters used, this can achieve a seasonal coefficient of performance (c.o.p.) of ~3.5 - 4. If underfloor heating is used, this can be run at a temperature of 30 - 35°, promoting a much higher coefficient of performance. If domestic hot water is provided by a heat pump, this will have to run hotter, reducing c.o.p., and up to 60° periodically to prevent the growth of Legionella.

Ground source heat pump
A survey of ground conditions would be required to assess the suitability of soil conditions for a horizontal array, or the presence of sub-surface aquifers for deep boreholes. Potentially high coefficients of performance may be achieved with optimum conditions.
Because of the sensitivity of heat pump c.o.p. to output temperature, there are gains to be made by using the maximum amount of low temperature heat emitters, especially under floor.

Solar hot water
In periods of high occupancy there could be a large demand for domestic hot water for washing, laundry and kitchen. In summer this can easily be provided almost entirely by solar hot water panels or evacuated tubes. (If evacuated tubes are selected, the type and warranty of vacuum maintenance should be carefully examined; there have been problems maintaining the vacuum seal in glass-to-metal connections through a 10 year warranty.)

Waste water heat reclamation
If large numbers of occupants are likely to be using showers, especially if at the same times, useful heat can be reclaimed by heat exchangers on shower drains, feeding pre-warmed water to the hot water heating source, since the heat reclaimed coincides, with just a short delay, with the heat demand.

Some of these technologies are illustrated on the following pages

Three levels of intervention

Because of the diverse character and architectural quality of the various wings of the building, as described elsewhere, we have adopted three levels of proposed improvements.

The original east wing has the most obvious historical architectural quality, and although not protected, it does feature in the record of architectural heritage.

The north and west wings appear to be of similar age (there is a dated stone in the west cloister which suggests it is at least as old as the east wing, although of a more utilitarian construction (it may have been built originally as a stable or other out house) their quality is much more mixed, and compromised by later additions such as the cloister.

The south wing was built in 1959 and has little architectural merit; it is, therefore, proposed as suitable for much more drastic intervention.

Further variants of the basic upgrades proposed here are included as element U value calculations in a technical appendix.

Renewable energy options
Solar photovoltaic

Any or all of the following options can bridge the gap between overall performance of the upgraded building and Near Zero levels.

Building fabric upgrading proposals specific to each wing
(Services upgrades are as set out above)

East wing
Existing energy performance

Walls are liable to be damp, partly due to cement render and some areas where internal finishes have impeded drying of the walls.

Calculation of U-value from standard EN ISO 6946
including 1 thermal bridge, air gap and fixing corrections

U=2.03

Reference:	External Wall Existing East Wing	Calculated U-Value
Job:	Myross Wood House	2.03
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Render	50.0	1.000	0.050	1000	1800	90.000
2	Sandstone Rubble	560.0	2.510	0.223	790	2300	1017.520
3	Plaster	25.0	0.510	0.049	960	1120	26.880
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.130	-	-	-

Upgraded U values

with significant drying + render U=0.74

Reference:	External Wall East Wing Improved	Calculated U-Value
Job:	Myross Wood House	0.74
Client:	Pathfinder / NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Cork Lime Render Base Coat	30.0	0.080	0.375	1000	1230	36.900
2	Cork Lime Render Top Coat	20.0	0.037	0.541	1000	250	5.000
3	Sandstone Rubble	560.0	2.510	0.223	790	2300	1017.520
4	Plaster	25.0	0.510	0.049	960	1120	26.880
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.130	-	-	-
	Thermal bridge:						
Insulation				0.000			
Bridge				0.000			

Ground floors are either suspended timber over cold, ventilated voids, or solid slab; neither is insulated.

Suspended timber U=2.49

Reference:	Suspended Timber Floor - Existing	Calculated U-Value
Job:	Myross Wood House	2.49
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	25.0	0.130	0.192	1600	500	20.000
2				0.000			
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

suspended +250mm insulation U=0.15

Reference:	Suspended Timber Floor Improved	Calculated U-Value
Job:	Myross Wood House	0.15
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	25.0	0.130	0.192	1600	500	20.000
2	Ecocel Insulation Dry	250.0	0.040	6.250	2020	35	17.675
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

Solid slab U=2.84

Reference:	Solid Ground Floor	Calculated U-Value
Job:	Myross Wood House	2.84
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Screed	75.0	1.400	0.054	650	2100	102.375
2	Concrete (dense reinforced)	150.0	1.700	0.088	840	2200	277.200
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

solid + cork lime + timber U=0.58

Reference:	Solid Ground Floor Lime & Timber	Calculated U-Value
Job:	Myross Wood House	0.58
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	22.0	0.130	0.169	1600	500	17.600
2	Cork Lime Render Base Coat	100.0	0.080	1.250	1000	1230	123.000
3	Concrete (dense reinforced)	150.0	1.700	0.088	840	2200	277.200
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

Attic insulation is of minimal thickness. U=2.84

Reference:	Ceilings - Existing	Calculated U-Value
Job:	Myross Wood House	0.51
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Plasterboard (fire-rated)	12.7	0.250	0.051	1000	900	11.430
2	Mineral wool (quilt)	75.0	0.042	1.786	1030	12	0.927
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.100	-	-	-

attic insulation 400mm U=0.10

Reference:	Ceilings - Improved	Calculated U-Value
Job:	Myross Wood House	0.10
Client:	Pathfinder and NCE	

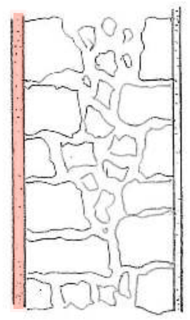
Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Plasterboard (fire-rated)	12.7	0.250	0.051	1000	900	11.430
2	Ecocel Insulation Dry	400.0	0.040	10.000	2020	35	28.280
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.100	-	-	-

Doors and windows are mostly upvc replacements of the originals, so lack historic authenticity. Some shutters to windows are still in place.
U values are taken as being in a nominal range of 1.8 to 2.2, based on fairly old replacements generally with double glazing, and allowing for poor draught stripping; see the tabulated values on p.11 above.

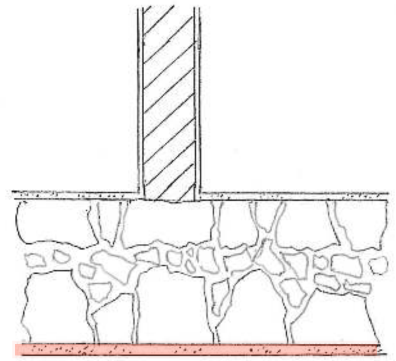
Assuming use of shutters, draught stripping etc.
U reduced to ~1.5 average

Upgrades constrained by minimizing architectural impact

Walls
The walls should be dried out by removal of render as recommended under Generic Analysis of Building Elements above. When dry, a vapour-open insulating render, such as cork-lime, may be reapplied to restore the original features. A thickness of around 50mm, or more if possible, will provide some useful insulation.



External wall insulation
e.g. cork lime render

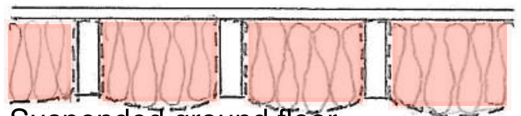


External wall insulation
e.g. cork lime render

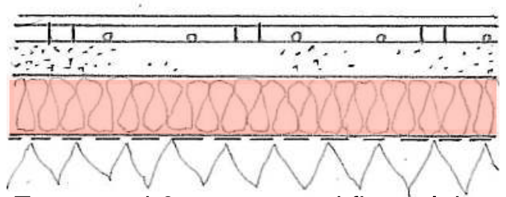
Ground floors
Recommended improvements are as detailed above

Solid concrete ground floor

heated
insulating screed or vacuum insulation + new floor finish

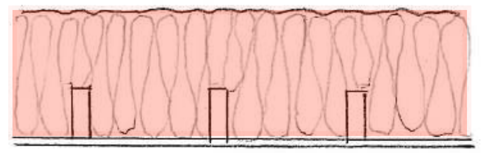


Suspended ground floor
~250mm fibre insulation



Excavated & new ground floor slab
with underfloor heating & floor finish

Ceilings under roof void
Recommended improvements are as detailed above



Ceiling to roof space
400mm fibre insulation

Doors and windows
Ideally these should be replaced with well draught-stripped triple glazed units, although pay-back in energy savings would be over a long period. If more historically appropriate timber sashes are considered, it may be difficult to accommodate the thickness of triple glazing. Slim vacuum-insulated double glazed units can be accommodated in traditional thin timber glazing beads. Shutters should be restored and could also be insulated.

North and west wings

Existing energy performance

Whilst the proposals presented in this report concentrate on the two more extreme cases of east wing, where conservation is taken as the default for external appearance, and the south wing where there is little of architectural value to inhibit fairly comprehensive alteration. Although the construction is similar to the east wing, there are relatively fewer architectural features that might warrant preservation, so an intermediate level of upgrade alterations is examined here.

Walls

U=2.03

Reference:	External Walls - Existing	Calculated U-Value
Job:	Myross Wood House	2.03
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Render	50.0	1.000	0.050	1000	1800	90.000
2	Sandstone Rubble	560.0	2.510	0.223	790	2300	1017.520
3	Plaster	25.0	0.510	0.049	960	1120	26.880
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.130	-	-	-

Ground floors suspended

U=2.49

Reference:	Suspended Timber Floor - Existing	Calculated U-Value
Job:	Myross Wood House	2.49
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	25.0	0.130	0.192	1600	500	20.000
2				0.000			
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

solid slab

U=2.84

Reference:	Solid Ground Floor	Calculated U-Value
Job:	Myross Wood House	2.84
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Screed	75.0	1.400	0.054	650	2100	102.375
2	Concrete (dense reinforced)	150.0	1.700	0.088	840	2200	277.200
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

Ceilings under roof

U=0.51

Reference:	Ceilings - Existing	Calculated U-Value
Job:	Myross Wood House	0.51
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Plasterboard (fire-rated)	12.7	0.250	0.051	1000	900	11.430
2	Mineral wool (quilt)	75.0	0.042	1.786	1030	12	0.927
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.100	-	-	-

Doors and windows

U values are taken as being in a nominal range of 1.8 to 2.2, based on fairly old replacements generally with double glazing, and allowing for poor draught stripping; see the tabulated values on p.11 above.

Upgraded U values

+ 100mm external insulation

U=0.33

Reference:	External Walls- North & West Improved	Calculated U-Value
Job:	Myross Wood House	0.33
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Cork Lime Render Top Coat	20.0	0.037	0.541	1000	250	5.000
2	Woodfibre Insulation Board	80.0	0.039	2.051	2100	140	23.520
3	Sandstone Rubble	560.0	2.510	0.223	790	2300	1017.520
4	Plaster	25.0	0.510	0.049	960	1120	26.880
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.130	-	-	-

suspended +250mm insulation

U=0.15

Reference:	Suspended Timber Floor Improved	Calculated U-Value
Job:	Myross Wood House	0.15
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	25.0	0.130	0.192	1600	500	20.000
2	Ecocel Insulation Dry	250.0	0.040	6.250	2020	35	17.675
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

solid + cork lime + timber

U=0.58

Reference:	Solid Ground Floor Lime & Timber	Calculated U-Value
Job:	Myross Wood House	0.58
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	22.0	0.130	0.169	1600	500	17.600
2	Cork Lime Render Base Coat	100.0	0.080	1.250	1000	1230	123.000
3	Concrete (dense reinforced)	150.0	1.700	0.088	840	2200	277.200
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

attic insulation 400mm

U=0.10

Reference:	Ceilings - Improved	Calculated U-Value
Job:	Myross Wood House	0.10
Client:	Pathfinder and NCE	

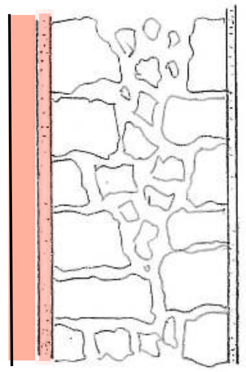
Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ $(Wm^{-1}K^{-1})$	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity $(Jkg^{-1}K^{-1})$	Density (kgm^{-3})	Heat capacity $(kJm^{-2}K^{-1})$
	External surface	-	-	0.040	-	-	-
1	Plasterboard (fire-rated)	12.7	0.250	0.051	1000	900	11.430
2	Ecocel Insulation Dry	400.0	0.040	10.000	2020	35	28.280
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.100	-	-	-

Assuming use of shutters, draught stripping etc.
U reduced to ~1.5 average

Intermediate upgrade options - relatively less constrained

Walls

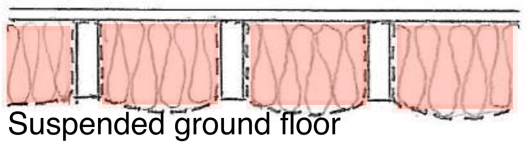
Eaves overhangs are relatively limited, so would require extending for the addition of a useful amount of external insulation - ideally 200mm or more. In this case an intermediate level of improvement is adopted, adding just 100mm externally.
Ensure continuity with attic insulation
Attic ventilation routes should be maintained at eaves.



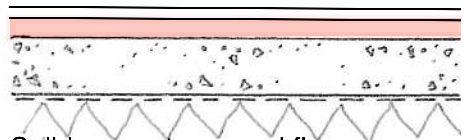
External wall insulation
e.g. cork lime render

Ground floors

Some are suspended timber, but with suspected very poor ventilation and dampness, hence susceptible to decay. Some areas are of solid slabs. Both the recommendations proposed for east and south wings are relevant.

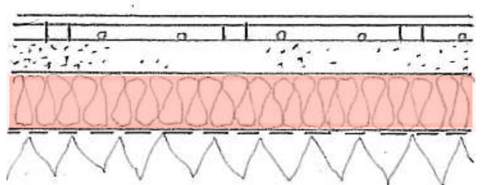


Suspended ground floor
~250mm fibre insulation



heated insulating screed or

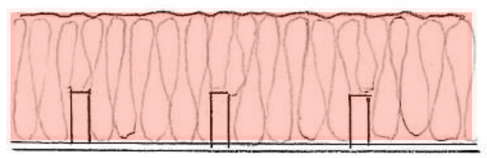
Solid concrete ground floor
vacuum insulation + new floor finish



Excavated & new ground floor slab
with underfloor heating & floor finish

Ceilings under roof space

Again, the recommended improvements are the same as elsewhere. It is worth noting some unusual vaulted ceilings in this area which are suitable candidates for retention. Some measures to stabilise any attic insulation would be appropriate, depending on the insulation materials used. If loose fill or blown insulants are used, these could be overlaid with a breather membrane to inhibit movement towards the eaves, and maintain eaves ventilation.



Ceiling to roof space
400mm fibre insulation

Doors and windows

These are candidates for replacement, although the pay-back period is liable to be fairly long.

South wing

Existing energy performance

Upgraded U values

Upgrade options - unconstrained

Walls

Calculation of U-value from standard EN ISO 6946
including 1 thermal bridge, air gap and fixing corrections

U=1.18

Reference:	External Wall South Wing - Existing 1950s	Calculated U-Value
Job:	Myross Wood House	1.18
Client:	Pathfinder & NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Render	25.0	1.000	0.025	1000	1800	45.000
2	Block (heavy)	190.0	0.900	0.211	840	1850	295.260
3	Air 50mm	50.0	0.278	0.180	1	1	0.000
4	Block (heavy)	190.0	0.900	0.211	840	1850	295.260
5	Plaster	25.0	0.510	0.049	960	1120	26.880
6				0.000			
7				0.000			
	Internal surface	-	-	0.130	-	-	-

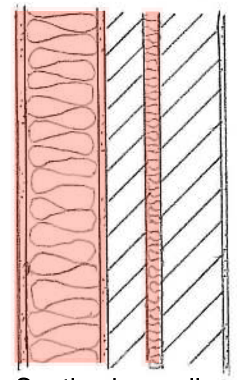
+ external wood fibre +cavity insulation

U=0.11

Reference:	External Walls 1950 - Improved & Cavity Filled	Calculated U-Value
Job:	Myross Wood House	0.11
Client:	Pathfinder & NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Cork Lime Render Top Coat	15.0	0.037	0.405	1000	250	3.750
2	Cork Lime Render Base Coat	35.0	0.080	0.438	1000	1230	43.050
3	Woodfibre Insulation Board	250.0	0.039	6.410	2100	140	73.500
4	Block (heavy)	190.0	0.900	0.211	840	1850	295.260
5	Rockwool Blown Fibre	50.0	0.039	1.282	1030	40	2.060
6	Block (heavy)	190.0	0.900	0.211	840	1850	295.260
7	Plaster	25.0	0.510	0.049	960	1120	26.880
	Internal surface	-	-	0.130	-	-	-

We recommend a thick layer, ~250-300mm, of external wall insulation, which must run from well below floor level up to eaves, and be connected continuously with loft insulation, whilst retaining ventilation routes to the attic space. The eaves overhang is reasonably generous on this wing to allow for this. Some vapour permeability in the insulation will be beneficial, in case of any water penetration, either from wind-driven rain, unintended discontinuities in external finish, or from internal water vapour, which will be driven by partial vapour pressure from the warmer interior. An external render, which should also be vapour permeable (in order to release any rain-driven water penetration through cracks, for example) can greatly mitigate the effects of any dampness. It should be borne in mind that climate change predictions highlight significant increases in both the quantity of rain and also its association with high wind speeds, resulting in much increased driving rain indices, especially in the south west of Ireland, and facing prevailing winds.



South wing wall
external insulation
render + cavity fill

Floor
Solid slab

U=2.84

Reference:	Solid Ground Floor	Calculated U-Value
Job:	Myross Wood House	2.84
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Screed	75.0	1.400	0.054	650	2100	102.375
2	Concrete (dense reinforced)	150.0	1.700	0.088	840	2200	277.200
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

solid + cork lime + timber

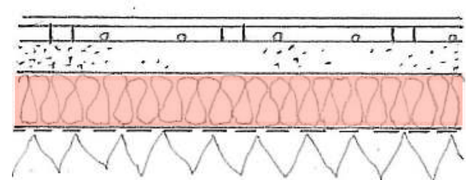
U=0.58

Reference:	Solid Ground Floor Lime & Timber	Calculated U-Value
Job:	Myross Wood House	0.58
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Timber (Softwood)	22.0	0.130	0.169	1600	500	17.600
2	Cork Lime Render Base Coat	100.0	0.080	1.250	1000	1230	123.000
3	Concrete (dense reinforced)	150.0	1.700	0.088	840	2200	277.200
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.170	-	-	-

The ground floor appears to be a ground-bearing concrete slab; given its date of construction it is quite likely that this is uninsulated. An optimum upgrade would be excavation and relaying a new floor on dense waterproof insulation on a radon barrier/damp proof membrane. A less disruptive alternative would be to lay a high performance compression-resistant insulation layer on the existing slab with a new floor finish on top. Access points would need to be ramped.

Solid concrete ground floor
vacuum insulation + new floor finish



Excavated & new ground floor slab
with underfloor heating & floor finish

Roof

U=0.51

Reference:	Ceilings - Existing	Calculated U-Value
Job:	Myross Wood House	0.51
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Plasterboard (fire-rated)	12.7	0.250	0.051	1000	900	11.430
2	Mineral wool (quilt)	75.0	0.042	1.786	1030	12	0.927
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.100	-	-	-

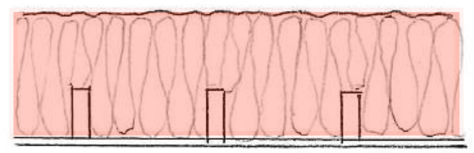
attic insulation 400mm

U=0.10

Reference:	Ceilings - Improved	Calculated U-Value
Job:	Myross Wood House	0.10
Client:	Pathfinder and NCE	

Layer	Material	Layer thickness, d (mm)	Thermal conductivity, λ ($Wm^{-1}K^{-1}$)	Thermal resistance, R (m^2KW^{-1})	Specific heat capacity ($Jkg^{-1}K^{-1}$)	Density (kgm^{-3})	Heat capacity ($kJm^{-2}K^{-1}$)
	External surface	-	-	0.040	-	-	-
1	Plasterboard (fire-rated)	12.7	0.250	0.051	1000	900	11.430
2	Ecocel Insulation Dry	400.0	0.040	10.000	2020	35	28.280
3				0.000			
4				0.000			
5				0.000			
6				0.000			
7				0.000			
	Internal surface	-	-	0.100	-	-	-

The loft space should have 400mm of fibrous insulation laid over a breather membrane with intelligent variable vapour permeability to ensure drying out of any penetrating moisture in warm weather. Insulation should run out over the top of wall to meet external wall insulation, and eaves ventilation maintained by profiled semi-rigid sheeting to contain the insulation.



Ceiling to roof space
400mm fibre insulation

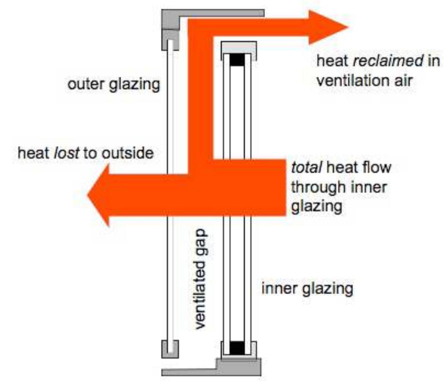
Openings

Given the absence of historic features to be retained, it is assumed that windows and doors can be replaced with PassivHaus approved triple glazed highly insulated units, with average U values of ~0.7 W/m2K. Similar values can be achieved with supply air windows, subject to manufacturers re-entering the market.

U reduced to ~0.7 average

Doors and windows should ideally be replaced with new argon-filled, warm-edge, triple glazing with insulated frames and extended sills, or supply air windows (right); frames should be repositioned within the external insulation layer. (If the costs are considered excessive, and existing doors and windows are retained, care will be required to detail higher performance insulation in reveals to counteract the inevitable cold bridges.)

Ventilation and lighting recommendations are as set out above.



heat flows through the Supply Air Window

Renewable energy options

Solar photovoltaic

Any or all of the following options can bridge the gap between overall performance of the upgraded building and Near Zero levels. There are large areas of south-facing roofs where solar pv and hot water panels can be fitted. They can, of course, be ground mounted away from buildings.
The areas with reasonable orientation, slightly east of south, amount to ~260 sq m on the north wing, 180 sq m on the south wing, totalling ~440 sq m. At a rate of ~170Wp per sq m, achievable with high efficiency monocrystalline cells, this could generate a peak of ~75 KW.
Typical performance in west Cork would suggest an annual output of 60 MWh (current values are around €5,400 or ~€10,000 for feed-in or import tariffs respectively).
Our own experience shows that pv generation in winter will be around 5 - 10% or less of typical summer rates, so whilst energy overall may be balanced annually, there will be large imports in winter, and especially at night. This mismatch between peak supply and peak demand, can be mitigated with energy storage - see below.
Although Electric Ireland terminated new connections to its original micro-generation feed in tariff in 2014, they extended the 9c/KWh feed in tariff to existing customers up to the end of 2020; however, under EU legislation, the government is obliged to introduce feed in tariffs in mid 2021.

PV: Monocrystalline large panels 260Wp   GB Sol slate effect above, Tesla glass tiles below

Energy storage

Energy storage is one of the least developed areas of renewable technologies. Battery storage of electrical energy is liable to be limited to hours, or at most, a day or two, bearing in mind the current costs (if the normally-quoted 1000 charge cycles is taken as a realistic life expectancy, the costs may not cover the differential value between current import and export tariffs).
A promising technology which may come to market shortly is storage of electrolysed hydrogen in solid state at normal temperature and pressure, using nanoparticle powders; the process is not revealed, but likely to rely on forming metal hydrides. Hydrogen is released with slight heating for use in a fuel cell. Long term storage offers energy densities double those of lithium ion batteries, with 5 times life expectancy.

Hot water storage should be carefully sized to suit patterns of use and available energy (our own experience suggests it is possible to avoid any imported energy for hot water for at least 9 or 10 months of the year, but this is just for two people with 5 sq m of panels and 300 litres of highly insulated tank; extrapolating the storage volume to likely occupancy numbers is liable to imply a rather large tank).
Phase change thermal storage chemicals, encapsulated in a large water tank, can be exploited to provide an order of magnitude increase in energy storage density.

Biomass

The extended estate includes old woodland, much of which was lost in storms a few years ago, and may be regarded as suitable for re-forestation or replanting. Depending on the planting species, and bearing in mind the benefits of selection to favour biodiversity, short- or medium-rotation coppicing may offer a fuel source that would be close to carbon neutral. It also offers the benefits of local employment.
The extent of the estate has been requested; pending definition, we have used an assumed boundary, amounting to approximately 62 Ha, of which roughly 35-40% is woodland.
We understand pasture has been leased to local farmers, and this, with its herd and their associated slurry, could help feed an anaerobic methane digester.
The woodland area could be replanted where lost to storm damage. Data from Coford (Coford Connects Environment No 3, Kenneth A Byrne & Kevin Black) suggests carbon sequestration rates of 1.8 - 2.4 T/Ha/yr for broadleaf species (we would not recommend conifers such as spruce; despite faster sequestration, they offer poor biodiversity).

Assuming 24 Ha planted with a mixture of broadleaf species, averaging 2.1 TC/yr, this could offset around 50T carbon per year.

Short rotation coppicing can be a much more efficient carbon sink, but is liable to offer poorer biodiversity benefits.

Average rate of C sequestration in forest plantations during a single rotation (after Dewar and Cannell 1992).

	Yield Class	C Sequestration Rate (t C/ha/yr)
Sitka spruce	24	4.4
	22	4.3
	20	4.1
	18	3.8
	16	3.6
Beech	6	2.4
Oak	4	1.8

Biogas generation may exploit sewage, waste or by-products from other agricultural and horticultural activities on the estate, and possibly kitchen waste. The resulting methane, scrubbed of CO and CO_2, may be stored for running a gas engine driven combined heat and power system or fuel cell, for example. This can be one instance of an established technology which offers viable energy storage.

Right: Anaerobic digester generating biogas image from Agriland.ie

Ground source heat pump

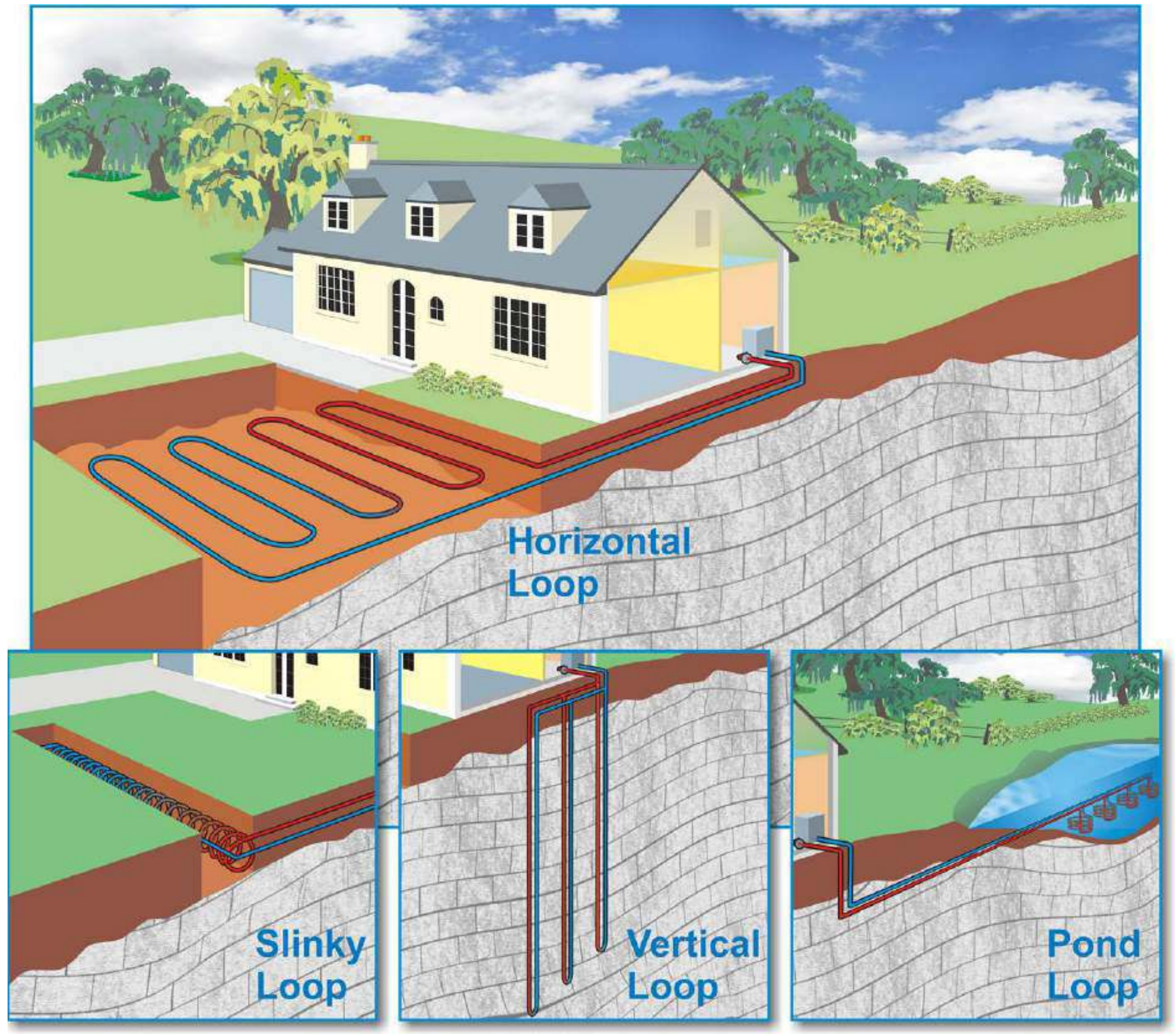
The suitability of the site for a ground source heat pump can be assessed with guidance from the Geological Survey of Ireland guide "Ground Source Heat & Shallow Geothermal Energy" GSI March 2015. In very brief summary, a soil depth of at least 3m is recommended, and good water content and/or flow aids thermal recharging for horizontal arrays, which should be a minimum of 1.2m deep. Vertical boreholes require sub-surface aquifers to recharge.
The bay bordering the site to the east might be considered as a source for a heat pump, but the exposure of mud at low tide is likely to render this challenging; corrosion and fouling of coils in seawater would also need to be contended with.

Right: GSI guide ground source arrays

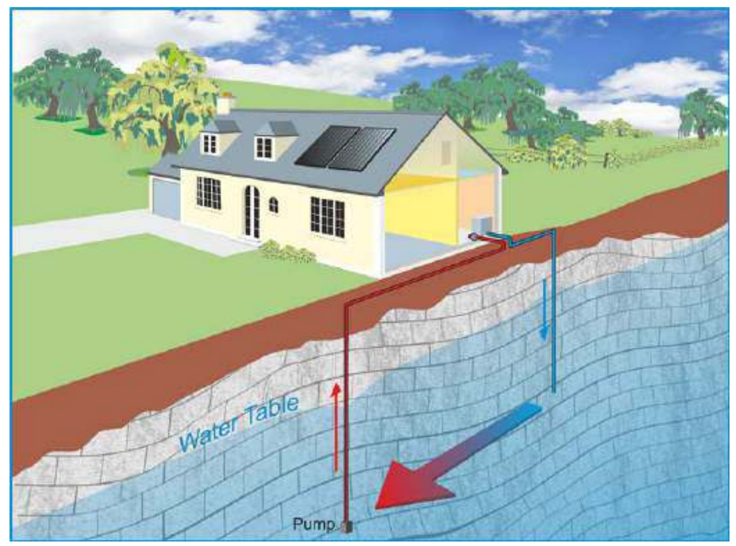
Wind turbine

The local topography offers a possible site to the south west for wind generation; the likely maintenance costs of medium size turbines would require careful consideration. A possible advantage of wind is the potential availability when solar is at a minimum.

As described on previous page, closed loop systems can be installed in your home in vertical or horizontal arrangements. The diagram below illustrates this.



An open loop collector obtains energy directly from the water by pumping it through a heat exchanger (in most cases there is a heat exchanger before the heat pump itself). These collectors are vertical systems where water is most commonly sourced by pumping groundwater from a borehole or a well. Once the heat energy has been extracted, the groundwater can then be either injected back into the ground using a re-injection well or discharged to a surface water body or a drain.



Discharging water to groundwater or surface water may have environmental impacts if the groundwater chemistry has been altered, or the heat pump has been used in cooling mode and the discharged water is warm. The relevant discharge permits should be sought from your Local Authority.

Environmental footprint

The environmental / carbon footprint of all materials specified should be assessed, as these will assume greater significance in the overall impact in the building's lifetime; initial embodied carbon becomes a greater proportion of lifetime carbon emissions as energy in use is progressively reduced - construction-embodied carbon emissions can amount to decades of near-zero operational emissions.

Materials manufacturers and suppliers should be asked for their Environmental Product Declarations, EPDs. If manufacturers have not yet had these independent assessments carried out, the more they are requested, the greater the motivation to undertake the assessments. Many manufacturers may make claims which have to be scrutinised carefully to detect "greenwash" especially where carbon offsetting is claimed.
Where EPDs are not available, simple strategies such as selection of recycled or wood-based materials, locally manufactured or derived products, those resulting from simple manufacturing processes, and the avoidance of petrochemical-based products can reduce embodied carbon and environmental footprints.
Some materials with apparently high embodied energy calculated in MJ/Kg may in fact be of relatively low impact where they are of low density or, applied in thin layers to cover large surface areas.
As an illustration, we include here a comparison of sprayed polyurethane under floor insulations for part of a small community building, applied by a small wheeled robot (which can be introduced into the sub-floor void through an air brick) with cellulose fibre from recycled newsprint, which has a slightly carbon negative footprint (taken as zero here). The embodied carbon in the petrochemical based spray is equivalent to the emissions from heating over about 17 years. As energy efficiency increases, embodied carbon will dominate further.

The activities supported by the renovation and re-occupation of Myross Wood House could offer local employment. Compared with just providing housing for people who commute elsewhere for employment, the emissions of frequent commuting can easily eclipse any savings in emissions of reduced building energy use.

As an illustration, we include an analysis for a small 248 sq m community building in Cork, with its existing gas heating and improved levels of insulation, comparing its carbon footprint for heating the building over a typical day, with the carbon footprint of just eight building users' travel, assuming as an example an average commute of 10 miles or 16 Km; travel emits more than 5 times the building emissions.

FRIENDS' MEETING HOUSE: CARBON FOOTPRINT OF FLOOR INSULATION OPTIONS: Q-BOT vs FIBRE

ROOM / SPACE	Approx area m2	U val Existing	U value fibre	U value p.u.
Library, corridor	38.0	2.0	0.16	0.167
Meeting Room	62.0			
Total floor areas A m2, nominal	100.0			
UA		200.00	16.00	16.70
Degree hrs @ 1200ºd p.a.		28,800	28,800	28,800
Heat loss per year KWh		5,760.00	460.80	480.96
Cost gas @ 6c/KWh, € p.a.		345.60	27.65	28.86
Annual CO2 emissions, gas heating, Kg		1,094.40	87.55	91.38
over 60 years:-				
Heat loss 60 years KWh		345,600.00	27,648.00	28,857.60
Carbon budget:-				
weight of 100m2 insulation, Kg		0.00	450.00	525.00
embodied carbon		0.00	0.00	1,575.00
17y CO2 emissions T @ 0.19Kg/KWh		17,510.40	1,488.38	1,553.50
total CO2 embodied + emissions 17y		17,510.40	1,488.38	3,128.50

Notes: all figures, insulation thickness, density, etc. are orders of magnitude for comparison purposes only
Met Eireann degree days <15.5º Cork Airport = 2167 mean; actual partial usage reduced to 1200
U value Existing floor (revised) ~2, assuming low air leakage
U value 250mm natural fibre, k= 0.04, U = 0.16
U value 150mm p.u., k= 0.025, U = 0.167
Embodied carbon, natural fibre: claimed to be carbon negative, but taken as carbon neutral
Embodied carbon, polyurethane from Inventory of Carbon V1 = 3.0 Kg/Kg
CO2 emissions for gas taken as 0.19 Kg/KWh (very small allowance for losses/inefficiencies)
Energy costs taken at lowest current domestic tariffs, without inflation ACA 264 19.12.17
Revision B: floor U value, low air leakage & predominantly stagnant air under revC 31.10.20
floor heat loss % of current total heating 16.5

FRIENDS MEETING HOUSE, ASSUMED TYPICAL DAY ENERGY USE

Carbon Calculator			
	Enter energy used…	**…multiplied by…**	**to give …kgs of CO2**
Gas: (Cubic metres)		2.009	0
… or kilowatt hours (kWh)	40	0.185	7.4
Oil: (Litres)		3.179	0
Electricity (kWh)	3	0.537	1.611
Total CO2 emissions from buildings (kilograms)			**9.011**

FRIENDS MEETING ASSUMED TYPICAL DAY

Carbon Calculator : Car Travel			
	Fuel used	**multiplied by**	**…kg of CO2**
Litres of petrol	12	2.315	27.78
(4 cars, 10 miles each way, 30mpg)			
Litres of diesel	9	2.63	23.67
(4 cars, 10 miles each way, 40mpg)			
Total CO2 emissions from car travel (kilograms)			**51.45**

Potential upgraded fabric energy performance

The potential overall energy performance of each wing is tabulated in the totals derived from the detailed measurements for each wing, assuming ALL the recommended optimum improvements are implemented; these may not all be economically justified, but indicate the maximum potential reduction in total heat loss through the building fabric.
The notional figures for unintended ventilation losses are still included here, but can be further reduced. This should be subject to a detailed pressure test and leak tracing survey on site. It would be reasonable to expect air change rates at 50Pa could be brought close to a range of 1 - 1.5 ac/hr; actual ventilation losses could in practice be based on much lower air change rates, even if only by leak sealing, but especially with controlled mechanical ventilation with heat recovery. (Note that the standard air leakage pressure test is carried out at 50Pa, which corresponds, without adjusting for local building shape factors, to a wind speed of 9 m/s. Average wind speeds at this west Cork coastal site are likely to be around 5 - 6m/s at standard measuring height of 10m, so average ground level wind pressures will be significantly lower.)

Myross Wood House Window & wall areas	Window 1	No	ΣA	U gen	Window 2	No	ΣA	Window 3	No	ΣA	Window 4	No	ΣA	Window special	No	ΣA	U spec	ΣUA	Door 1	No	ΣA	U	Door 2	No	ΣA	U	ΣUA	ΣUA all opes	ΣA All opes	Total wall area	Wall area less opes	Wall U value	UA	Opes % of wall area	Ground floor area	Solid slab floor area	Suspended floor area	Roof area at ceiling	U value ceiling	UA ceiling	Totals all UxA	Total MWh per year
Wing / face	AREA A				AREA A			AREA A			AREA A			AREA A					AREA A				AREA A									all			mezzanin	Areas A 25:75%						
E WING																																faces			158.33	95.58	286.75					
E face	1.78	4	7.12	1.50	2.53	5	12.65	3.54	4	14.16	3.10	4	12.40					69.50	6.60	1	6.60	1.50					9.90	79.40	52.93	277.60	224.67			19.07								
W face	2.53	2	5.06	1.50	0.61	4	2.43	1.76	3	5.28	1.84	7	12.86	1.04	2	2.08	1.50	41.56	2.12	1	2.12	1.50	2.33	1	2.33	1.50	6.68	48.24	32.16	159.70	127.54			20.14		U floor	U floor					
N face	1.55	1	1.55	1.50														2.33										2.33	1.55	50.60	49.05			3.06		0.58	0.15					
S face	1.78	1	1.78	1.50	8.08	1	8.08											14.79										14.79	9.86	45.60	35.74			21.62		U x A	U x A			E WING		
TOTAL FOR E WING																		128.17		2	8.72			1	2.33		16.58	144.75	96.50	533.50	437.00	0.74	323	18.09	382.33	55.44	43.01	382.33	0.10	38	605	99
S WING	note W wall : add porte cochere							24.77																												100% solid slab						
E face	mostly = E wing,+ 11.74 above roof + porte cochere							24.77																						36.51	36.51			0.00		339.10	m2 area					
W face	1.06	1	1.06	0.70														0.74	2.51	1	2.51	0.70					1.76	2.50	3.57	62.57	59.00			5.71		U value						
N face	1.67	16	26.66	0.70	1.83	9	16.43							rooflight				30.16	3.36	1	3.36	0.70	3.27	1	3.27	0.70	4.64	34.80	49.71	223.40	173.69			22.25		0.58						
S face	1.67	19	31.73	0.70	0.85	3	2.55	1.85	11	20.35	2.81	4	11.24	0.99	3	2.97	0.70	48.19	3.30	2	6.60	0.70					4.62	52.81	75.44	317.30	241.86			23.78		U x A				S WING		
TOTAL FOR S WING																		79.09		4	12.47			1	3.27		11.02	90.10	128.72	639.78	511.06	0.11	56	20.12	339.10	197		362.98	0.10	36	379	62
N WING	Floor area includes W end Lounge + cloister																																			Areas A 70:30%						
E face	none = E wing																													28.46						293.91	125.96					
W face	none = W wing																													28.46						U floor	U floor					
N face	1.71	4	6.84	1.50	1.09	1	1.09	1.57	13	20.41	0.81	1	0.81	2.70	2	5.40	1.50	51.83	4.52	1	4.52	1.50	2.87	1	2.87	1.50	11.09	62.91	41.94	259.10	217.16	0.33		16.19		0.58	0.15					
S face	1.06	5	5.30	1.50	2.48	6	14.88	1.27	5	6.35				1.40	1	1.40	1.50	41.90	2.20	1		1.50	2.32	1	2.32	1.50	3.48	45.38	30.25	160.70	130.45	0.33		18.82		U x A	U x A			N WING		
TOTAL FOR N WING																		93.72		2	4.52			2	5.19		14.57	108.29	72.19	476.72	347.61	0.33	115	15.14	419.87	170.47	18.89	419.87	0.51	214	626	103
W WING	excludes new S wing W end, N wing; includes cloister																																			100% solid slab						
E face	0.56	1	0.56	1.50	1.07	6	6.42	2.48	8	19.84				rooflight				40.23	2.02	1	2.02	1.50					3.03	43.26	28.84	114.40	85.56	0.33		25.21		214.54	m2 area					
W face	1.10	6	6.60	1.50	0.65	5	3.25	1.19	2	2.38	1.93	2	3.86	1.05	2	2.10	1.50	27.29	1.71	1	1.71	1.50	1.88	1	1.88	1.50	5.39	32.67	21.78	149.20	127.42	0.33		14.60		U floor						
N face	none = N wing																																			0.58						
S face	none = S wing																																			U x A				W WING		
TOTAL FOR W WING																		67.52		2	3.73						8.42	75.93	50.62	263.60	212.98	0.33	70.28	19.20	214.54	124.43		214.54	0.51	109	380	62
				Approx ave. overall heights				Internal volumes m3			Airchange/hr @50 Pa			Volume/hr			Airchange @ ave winds				Heat loss MWh/yr																					
NB: N & W wings are				N + W wings		7	m	N + W		8882	4			35527	m3			3553	m3/hr		30	MWh/yr			First floor area N & W wings				634.41	Total floor area N + W wings					1268.82			WHOLE BUILDING TOTALS				
taken together				E wing		9	m	E wing		8307	5			41535	m3			4153	m3/hr		35	MWh/yr								Total flr area E wing incl mezz					922.99			All fabric losses		ΣUA	1991	
				S wing		7	m	S wing		4915	3			14744	m3			1474	m3/hr		12	MWh/yr								Total floor area South wing					702.08			Heat loss MWh per year				
								Total		22103				91805	m3			9181	m3/hr		77	MWh/yr								Total floor area all wings					2893.89			@ 1900 degree days			327	
				NB 50Pa = ~9m/s wind. Actual air change rates will be significantly reduced (~90%) owing to average wind speeds in open landscape at 10m height of ~6m/s																																	KWh/m2 per annum			113	
				Heat load based on 1900 degree days (Cork Airport = 2252°days) allowing for climate change & local microclimate																										AkiboyeConollyArchitects October 2020 revised Jan 2021												

Conclusion - overall energy performance of fabric heat losses comparing existing with potential achievable with ALL the recommended improvements applied:

Building wing	existing (p.4)	upgraded (p.18) with ALL improvements
The whole building - 2899m2 equivalent to	1263 MWh pa 436 KWh/m2 pa	327 MWh pa 113 KWh/m2 pa
East wing - 923 m2 equivalent to	368 MWh pa 399.7 KWh/m2 pa	99 MWh pa 107 KWh/m2 pa
North and west wings - 1269 m2 equivalent to	567 MWh pa 447 KWh/m2 pa	165 MWh pa 130 KWh/m2 pa
South wing 702 m2 equivalent to	327 MWh pa 466 KWh/m2 pa	62 MWh pa 88 KWh/m2 pa

Note that overall energy use needs to include other inputs/losses such as ventilation and lighting. Lighting use per day or year is highly dependent on the type of use and activities, and can vary from under 2 to about 10 hours per average day, around 700 - 3500 hours p.a; typical residential consumption could be in the range of 5 -15 KWh/m2 pa. Typical existing assembly or educational buildings can have an installed wattage of around 10-20 W/m2 and use 7 - 25 KWh/m2 pa (25 KWh/m2 pa is the ISBEM default for community buildings). The uses envisaged need to be defined, but consumption can be halved by replacing the existing with efficient led fittings.
Ventilation similarly needs to be designed in response to the activities and occupation envisaged.

Commentary

None of the wings treated separately, nor the whole building, can achieve near zero energy levels without renewable inputs. Current regulations do, in any case, require a significant proportion of energy input to come from renewables.
If the building is treated as a whole, substantial renewable energy inputs would be required. However, if each wing can be treated separately, mimicking to some extent terraced or semi-detached buildings, then the differences due to the assumed permissible extent of alterations, and the varying proportions, that is surface to floor area ratios, become more evident.

The east wing, despite being the most constrained in the scope of improvements, does benefit from a relatively more efficient surface to floor area ratio, being wider, and partly three storey.

The north and west wings are disadvantaged by their relatively large surface areas, with long, narrow floor plans. They are also assumed to allow only relatively "shallower" retrofit works within their historic fabric.

The south wing, which allows the greatest scope of alterations, is disadvantaged by its relatively long thin proportions and consequently less favourable surface to floor area ratio. Nevertheless, with its relatively unconstrained alterations, it can come closest to near zero energy rating standards - roughly equivalent to a B1 rating .
Renewable energy inputs would be required to reduce its energy input requirements to near zero levels.