Approaching Near Zero Energy in Historic Buildings

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Introduction

This report describes the baseline energy performance characteristics of the Energy Pathfinder demonstrator buildings. For most of the sites included this reflects their energy performance at the project outset in late 2019. The exception to this is the Viðareiði Vicarage where an extensive energy efficiency retrofit of the building fabric had already been completed prior to this date. For this reason, the description of the Vicarage is of an earlier baseline reflective of its pre-retrofit condition in the mid-late 2010s.

The building characteristics described by this report include building fabric, HVAC[1] systems, microgeneration technologies, energy storage and control systems, and building occupancy. In some cases, energy assessments have been carried out both during and prior to the commencement of Energy Pathfinder. These range from relatively basic surveys using national calculation methodologies such as the United Kingdom's SAP[2] and Ireland's BER[3], to more detailed investigations of building energy performance generally carried out by specialist consultants. Where available the results of these past energy assessments have been included with sources clearly indicated. For those demonstrators with available data, a review of their overall energy consumption while in baseline condition has also been included.

It should be noted that the dimensions and other details of the demonstrator buildings included herein are for illustrative purposes only and Historic Environment Scotland cannot and does not guarantee their accuracy. They should not therefore be relied upon for the purposes of planning any future retrofit or other building work as may take place.

This report is the second in a series as below:

- *T3.1.1 Demonstrator Buildings and Energy Assessment Strategies*
- ***T3.2.1 Initial Energy Performance Assessments***
- *T3.3.1/T4.2.1 Energy Assessment Results and Retrofit Outcomes*
- *T3.4.1 Embodied Carbon and Sustainable Retrofit Approaches*

Where retrofit work has been undertaken during or immediately prior to the Energy Pathfinder project taking place the impact of this is related by the subsequent report. All of these may be read together for a comprehensive overview of all energy and carbon assessment activities undertaken at Energy Pathfinder demonstrator buildings during the project lifetime.

[1] Heating, Ventilation, and Air Conditioning.
[2] Standard Assessment Procedure (https://bregroup.com/sap/standard-assessment-procedure-sap-2012/).
[3] Building Energy Rating (https://www.seai.ie/home-energy/building-energy-rating-ber/).

Bayview (formerly the Old Harbourmaster's House)

Pierowall Harbour, Gill Pier, Pierowall, Westray, Orkney Islands, KW17 2DL, Scotland

Figure 1: Bayview, pre-conversion in late 2019, seen from the southwest – Image © Historic Environment Scotland – Photographer: Carsten Hermann

Prior to conversion works commenced by the Westray Development Trust in 2021, Bayview was a detached 7-bedroom dwelling house. The conversion works, which are ongoing at time of writing and expected to conclude during summer of 2022, will see the building renovated and enlarged to form four new flats. Because the baseline energy performance of the structure was poor, and because the new units will be constructed to current Scottish building regulations for renovations, the expected improvement in overall energy performance and operational carbon emissions is considerable. The improvements resulting from the conversion project (and the results of Energy Pathfinder assessments) are discussed in the subsequent report *Energy Assessment Results and Retrofit Outcomes.* For Bayview, this report explores the baseline energy performance of the building as it was during late 2019.

Geometry:

Dimensions	
Gross internal floor area*	222.0m^2
Heat loss perimeter (internal)	111.5m

**Not including attached unheated garage and shed*

From an energy efficiency perspective, Bayview's geometry presents no particular problems as the structure is a relatively compact T-plan with a low form factor for a detached building[4]. The structure also features large windows on the primary south-facing elevation which open into the main living spaces, maximising solar gain. The only negative aspect from this point of view is a lack of attachment to adjoining buildings, meaning that the building envelope is entirely exposed to the external environment in every direction. This is reflected by a long heat loss perimeter on each floor relative to floor area, though again, this is not unusual for a detached building.

Fabric:

	Fabric	Insulation
Walls	Mass masonry, mainly sandstone with some whinstone, external cement render and internal dry-lining	Presumed uninsulated
Floor	Mix of solid and suspended floors at ground level	Presumed uninsulated
Roof	Pitched roof with a timber structure; slate covering mounted on sarking boards; second floor of the building forms a room-in-roof[5] with a small apex loft	150mm mineral wool insulation in apex loft; coomb ceilings are presumed uninsulated; no loft space at eaves
Openings	Windows and main external door are PVC-framed double glazing, main door has an external draught lobby	Condition of glazing is known to be poor; airtightness of openings is unknown

Overall, the current thermal performance of building fabric at Bayview is poor, virtually the entire envelope is composed of elements with a likely thermal transmittance well in excess of $1W/m^2K$. The only likely exception to this is the insulated apex loft which will have limited benefit due to the uninsulated coomb ceilings to which it is immediately adjacent. Somewhat unexpectedly (based on the poor condition of the pre-existing cement render) contractors working on the building during the renovation works have reported that the masonry of the external walls is dry and in good condition.

Services:

	System
Space heating	Non-condensing oil-fired combination boiler and system of radiators
Hot water	Instant hot water from combination boiler
Space cooling	None present
Microgeneration	None present
Energy storage	None present

[4] The ratio of internal volume to surface area.
[5] An additional storey wherein the habitable volume is principally contained within the roof structure of the building rather than the external walls.

The relatively basic set of building services at Bayview prior to the renovation project remains typical of a property of this type in a Scottish island setting at present. The main problem with this services configuration is that it relies entirely on a comparatively inefficient oil-fired boiler to provide for the entire heat demand of the property. Considering the high space heating demand of the building, the relative inefficiency of the boiler, and the high carbon factor of heating oil (298gCO_2e/kWh[6]), the operational carbon emissions of the building would have been very high if occupied as a dwelling in its 2019 condition.

Ventilation and Moisture Management:

Passive ventilation remains the norm in traditionally constructed properties in Scotland and in a property such as Bayview this would originally have been provided by air movement via underfloor voids, open flues, and via sash-and-case windows. With the introduction of double-glazing and the sealing of open flues two of these three principal routes have since been blocked off, combined with the introduction of indoor plumbing, impermeable materials (such as the external cement render) and wet appliances this creates a substantial risk of poor indoor air quality and potentially building fabric degradation. This is frequently the result in similar situations where ventilation and fabric permeability have been reduced and internal vapour loading has been increased.

Prior Energy Assessments:

	Date	**Key Findings**
RdSAP* Energy Performance Certificate (EPC)	August 2017	Primary energy indicator = 305 kWh/m2/year Energy efficiency score = E43 Environmental score = F37

**RdSAP stands for Reduced data Standard Assessment Procedure and is the UK's national calculation methodology for existing buildings under the Energy Performance of Buildings Directive (EPBD)[7].*

The results of this survey indicate a property performing well below average across all three of the relevant metrics listed above, this is fully expected due to limited insulation and the presence of an inefficient, high carbon heating system. It should be noted that there is a significant discrepancy between the floor area listed on the EPC and the area listed earlier. This is because the RdSAP assessment has entirely disregarded the 2nd floor, treating it as a loft insulated to a depth of 150mm. This is most likely because the assessor has deemed the 2nd floor not to constitute a habitable storey as per the RdSAP conventions.

Occupancy:

The property has been unoccupied since 2018, prior to which it was occupied as a single dwelling and also previously occupied as a guest house. Originally it served as the residence of the Pierowall harbourmaster, most likely tied to the position.

[6] As estimated by the Energy Saving Trust in April 2022 (https://energysavingtrust.org.uk/about-us/our-data/).
[7] https://bregroup.com/sap/.

Keepers' Cottages, North Ronaldsay Lighthouse

Dennis Ness / Versa Breck, North Ronaldsay, Orkney Islands, Scotland

Figure 2: The lighthouse complex – Image © Historic Environment Scotland – Photographer: Kenneth Easson
The south-eastern block is partially obscured behind the lighthouse, while the north-western block is in clear view to the right. Also notable are the four wind turbines standing to the west of the complex.

The Keeper's Cottages at the Dennis Ness lighthouse complex[8] are situated at the northeastern tip of the Orkney Islands, on the remote island of North Ronaldsay. This location presents multiple challenges from an energy perspective, including high exposure and salt spray, limited vehicular access, and highly constrained electrical infrastructure. Amongst these challenges lie opportunities however, such as high average windspeed which already powers four 6kWp wind turbines. The Energy Pathfinder demonstrator buildings are the two accommodation blocks constructed in the 19th century alongside the lighthouse to provide workshop space and dwellings for the lighthouse keepers. The south-eastern block is the earlier of the two (1850s) and is of solid brick construction, while the north-western block was constructed later (probably late 19th to early 20th century) and is of poured concrete construction.

[8] https://canmore.org.uk/site/3645/north-ronaldsay-dennis-ness-lighthouse.

Geometry:

Dimensions	
Gross internal floor area (SE block)*	166.9m^2
Heat loss perimeter (SE block)*	53.2m
Gross internal floor area (NW block)**	243.6m^2
Heat loss perimeter (NW block)**	85.8m

**does not include the adjacent unheated storehouses or attached public toilet*
***does not include the unheated boiler room situated between the café/visitor centre and the workshop*

The keeper's cottages at North Ronaldsay are two buildings (each pictured below, see figures 3 and 4) which stand on a rectangular plan, each housing a pair of semi-detached units. Originally, in the south-eastern block this was a pair of accommodation units while the north-western block housed an additional, larger accommodation unit and a workshop. Today their use is similar and the two dwellings in the south-eastern block benefit somewhat from being attached to each other, sharing a common envelope. The third dwelling in the north-western block, currently serving as a café and visitor centre, on the other hand is essentially detached as the workshop unit and boiler house to which it is attached are entirely unheated though this may change in the future.

Overall, the geometry of the structure is reflective of traditional buildings well adapted to their local environment, with each unit individually presenting a low form factor. Meanwhile, both south and north facing windows feature reasonably-sized windows, reflecting a compromise between thermal efficiency and the wellbeing of occupants.

Fabric:

Figure 3: The south-eastern block – Image © Historic Environment Scotland – Photographer: Carsten Hermann

South-Eastern Block

	Fabric	Insulation
Walls	Solid masonry, 600mm~ brick with sandstone details and an external render on brick elements, internally plaster on the hard	Uninsulated
Floor	Suspended timber	Uninsulated
Roof	Flat platform roof, structural timber deck with lead covering	200mm mineral wool insulation within the roof void (cold roof)
Openings	Windows are timber sash-and-case single glazing with timber shutters and thermal curtains, external doors are two-leaf timber	All windows and doors have some draught-proofing and are well fitted to their openings

The earlier south-eastern block is unusual for a domestic structure of its time in Scotland, in that the external walls are constructed of brick rather than stone. These are also unusual for being 600mm in depth, typically a solid brick external wall in 19th century Scotland or elsewhere in the UK would be approximately 200 to 300mm, this is likely to be a design adaptation to the building's northerly location, high exposure, and comparatively extreme local environment.

Also of note is an additional 600mm brick wall located in the middle of the building, dividing it lengthwise. This appears to be an original feature and was likely designed to function as a thermal mass, drawing heat from the flues contained within it while the building's open fires were burning and so acting to thermally moderate the indoor environment.

Shutters and heavy curtains remain a feature of the building that can be used by occupants to minimise heat losses through openings during night-time.

Figure 4: The north-western block – Image © Historic Environment Scotland – Photographer: Carsten Hermann

North-Western Block

	Fabric	Insulation
Walls	600mm concrete	Uninsulated
Floor	Concrete slab	Uninsulated
Roof	Concrete flat platform with roofing felt external covering	Uninsulated in the workshop, 200mm mineral wool insulation is believed to be present above a false ceiling in the café/visitor centre
Openings	Windows are primarily timber sash-and-case single glazing, with some aluminium framed double glazing and some formed of glass bricks, external doors are two-leaf timber	All windows and doors have some draught-proofing and are well fitted to their openings

The exact construction date for the north-western block is unknown, conceivably it may have been original (1850s) or could be as late as the early 20th century. Some sources do suggest it is original however this is somewhat counter-indicated by its very different construction technique which would have been highly unusual, though not unknown, in mid-19th century Scotland.

Little has been done thus far by way of energy efficiency improvements, with mineral wool roof insulation and some draught proofing in both blocks representing the only meaningful upgrade from their as-built form. From a maintenance perspective however, the building fabric is in good condition, especially considering the local environment which is characterised by high winds, driving rain, and salt spray from the nearby shoreline. This has been assisted by a major restoration project undertaken by the North Ronaldsay Trust in the 2000s and grant-funded by Historic Scotland.

Services:

	System
Space heating	*Main heating installed configuration:* Small scale community heating consisting of an oil boiler providing heat to a thermal store which provides heat to a system of radiators in each unit, individual radiator systems are controlled by a timer and by thermostatic radiators valves *Main heating actual configuration (time of writing):* Oil boiler has since become defunct and been removed, communal thermal store provides some inadequate space heating to the two cottages in the south-eastern block, a dual-immersion cylinder has been configured to heat the radiator circuit in the café/visitor centre, the workshop is unheated
Hot water	Cottages and café/visitor centre have individual immersion cylinders which are capable of receiving heat from the communal system, these also have backup electric immersion elements, 25mm~ foam insulation, and cylinder thermostats
Space cooling	None present
Microgeneration	4x 6kWp wind turbines,
Energy storage	Communal thermal store

The heating system at the keepers' cottages represents a key area in need of improvement as it was previously a high carbon heating system in its installed configuration and is now inadequate to the heat demand of the buildings following the failure and removal of the oil boiler. In addition, fuel transport to the island has been a longstanding problem as heating oil must be transported by ferry and craned onto the island. Future upgrade options, especially low carbon options, are likely to be constrained by relatively poor fabric performance however.

The four wind turbines present are highly productive as a result of high average windflow, producing in excess of 45,000kWh/yr. Use of this energy is currently suboptimal however as the electricity metering configuration on site means that three of the four turbines export energy directly to the island's electricity grid, bypassing local electrical loads.

Ventilation and Moisture Management:

This aspect of a building's design was, and remains, an especially important consideration for traditional buildings in Scotland due to the local climate which is characterised by driving rain, and by high rainfall and humidity generally. This is important for the health of both building fabric and occupants.

The keepers' cottages represent a good example of a traditional Scottish approach to passive ventilation, principally utilising a ventilated underfloor void, sash-and-case windows, and open flues as primary ventilation routes. These are intact at the cottages and have been slightly augmented by intermittent extract fans in kitchens, bathrooms, and WCs. This is a standard adaptation in modern Scotland to the additional moisture loading resulting from modern conveniences such as indoor plumbing and wet appliances.

Occupancy:

At time of writing dwellings 1 and 2 (south-east block) are short-term lets, while dwelling 3 (north-west block) serves as a café, shop, and exhibition centre for the lighthouse complex, all of these have lately been almost entirely unoccupied due to the coronavirus pandemic. As mentioned above, the fourth unit in the complex currently houses a woollen mill.

Going forward, the North Ronaldsay Trust currently intends to move the mill offsite and repurpose the workshop unit it resides in as a new home for the café, shop, and exhibition centre. They hope to then convert dwelling three into a caretaker flat for the complex tied to a permanent caretaker post, to be funded by the trust. Dwellings 1 and 2 are to principally continue as short-term holiday rentals, an important source of income for the NRT, but may from time-to-time serve as gateway accommodation to help new residents move to the island. The trust hopes, in the immediate future, to recruit a nurse practitioner for the island and to offer this person one of the lighthouse cottages for exactly this purpose.

Cathedral of Saint Mary and Saint Anne

Roman Street, Blackpool, Cork City, Ireland

Figure 5: Cathedral of Saint Mary and Saint Anne in the city of Cork, Ireland, viewed from the south.

The Cathedral of St Mary and St Anne, otherwise known as the North Cathedral, is an architectural palimpsest composed of various parts completed during multiple phases of building across the 19th and 20th centuries. Indeed, there remains uncertainty as to the precise construction of much of the cathedral and a full survey of the building was recommended in 2020 to establish a more comprehensive overview of the building as it stands today. Like many ecclesiastical buildings, especially those of traditional construction, the cathedral is a challenging structure from an energy perspective, with a large internal floor area, high form factor, and low airtightness.

Geometry:

Dimensions	
Gross internal floor area*	1936.4m^2
Heat loss perimeter*	346.7m

**excludes the unheated bell tower*

Despite the challenge of the Cathedral's size, it should be noted that the vast majority of this internal volume is composed of the nave itself. In addition to this main space dedicated to communal worship, the structure also features a lower ground level beneath the altar at the eastern end of the cathedral and an annex to the north of the nave which both contain community spaces of differing construction and more modest proportions. The dual nature of the building could thus lend itself to a hybrid approach in both energy management and in upgrading the energy performance of the structure as different interventions are likely to be advisable for these two parts of the building.

Fabric:

	Fabric	Insulation
Walls	Predominantly solid masonry, sandstone and limestone, some walls are dry-lined with a 50-60mm airspace	Uninsulated
Floor	A mix of solid stone, vaulted stone, and suspended timber floors*	Presumed to be uninsulated
Roof	Main roof over the nave is a pitched timber structure finished with slate; other roofs are timber platforms finished with felt	Main roof has some older degraded insulation; flat roofs are uninsulated
Openings	Windows are single glazed; external doors are solid timber	No thermal upgrades or draught proofing

**there is currently some uncertainty regarding details of the fabric construction, a full survey has been recommended by JCA Architects*

Typical of structures dating to the 19th century, the overall fabric performance of the cathedral is currently poor by modern standards. It should be noted however that air tightness has been identified as a key issue and fabric upgrades are unlikely to impart significant benefit without this first being addressed. This was recommended as a first step to improving overall performance by an outline feasibility study commissioned by NCE and completed by JCA Architects in early 2020. This study also identified a number of pressing maintenance issues of which the most urgent was repair of deteriorating flat roof membranes over the altar area which had exceeded their design life by a considerable margin. Replacement of these was completed by NCE during the course of 2020.

Services:

	System
Space heating	Primary heating is a mains gas boiler; additional heating provided by an air-to-air heat pump (installed 2018)
Hot water	Mains gas boiler
Space cooling	None present
Microgeneration	Solar photovoltaic system, ~4kWp (installed 2016)
Energy storage	None present
Other	Electric vehicle chargers (x2, installed 2018)

As outlined above, some initial progress has been made over the past five years in modernising the cathedral's technical services. Ongoing issues exist however, the 2018 air-to-air heat pump has had a limited impact on internal temperature and comfort, most likely due to low levels of air tightness which may be somewhat remedied by prospective draught sealing under consideration by NCE. Functionality and performance of the PV system installed in 2016 is unknown as output of the system has not been monitored in spite of a monitoring system being in situ.

Consumption of electricity and mains gas over three years (2018 – 2020) has been reviewed by NCE for Energy Pathfinder, the results of this review will be detailed in the following report. At time of writing there are also plans to shortly install a Wattrics monitoring system to collect higher resolution use data.

Outline Feasibility Study, JCA Architects:

Date	Key Findings
January 2020	• Injected insulation behind existing wall linings could be considered however this is inadvisable as such insulation could compromise the breathability of the structure • Roof spaces should be insulated with a mix of blown cellulose and mineral wool insulation • Draught-sealing of windows and doors should be undertaken prior to consideration of more costly and invasive measures

This study was commissioned by NCE Insulation in 2019, the full text of this study can be found by following the link at the bottom of this section.

Occupancy:

Recent use of the cathedral itself and the indoor spaces available in the annex portion of the building have been very limited due to restrictions put in place during the coronavirus pandemic. It is anticipated that as restrictions lesson the building will revert to a more normal occupancy pattern and resume its functions as a place of worship and a venue for various community activities.

Further Reading:

- Outline Feasibility Study by JCA Architects (2020)

Myross Wood House

Parish Ardagh, County Cork, Ireland

Figure 6: Myross Wood House, principal elevation of original Georgian house with early side extensions – Image © Historic Environment Scotland – photographer: Carsten Hermann

Figure 7: Courtyard with 20th century extension left of centre; the original building with older extensions right of centre – Image © Historic Environment Scotland – photographer: Carsten Hermann

The second of Energy Pathfinder's Irish demonstrator sites also presents a range of challenges and opportunities from an energy perspective. These have already been the subject of a number of reports which the information below is principally drawn from, specifically an energy upgrade study completed in 2021 by Akiboye Conolly Architects, and a retrofit strategy report completed in 2020 by Carrig Conservation International. Some building information was also provided to Historic Environment Scotland directly by our Energy Pathfinder project partners, NCE Insulation and University College Cork in June 2020. Consequently, the baseline condition reflected in this report is reasonably accurate to the real world condition of Myross Wood House in mid-2020.

The structure itself was originally the country residence of an aristocrat dating to 1817, with various additions during the 19th and 20th centuries, the latest of which was the south wing, added in 1959. During this period the building also changed function, serving as a seminary and as a venue for religious gatherings, most recently under the care of the Missionaries of the Sacred Heart. Going forward, the house will shortly be occupied by local climate action group Green Skibbereen with the intention of converting it into a Centre of Excellence for Climate Action and Sustainability. The structure is included on the Republic of Ireland's national inventory of heritage but is not subject to statutory protection.

Geometry:

Dimensions	
Gross internal floor area (total)	2205m^2
Original house	594m^2
South wing	630m^2
North wing	650m^2
West wing	331m^2

Even in the category of 19th century country houses, which typically contains expansive buildings with often unusual built form, Myross Wood House is of considerable size with a floor area well in excess of 2000m^2. The house also features high ceilings, especially in the original part of the building, ranging from 3.2 to 4.3m. Later additions are of slightly more modest vertical proportions with an internal floor-to-ceiling height ranging from 3 to 3.4m.

By virtue also of its courtyard layout, the building also has a high form factor. As such, upgrades to the building fabric are likely to be expensive due to the large surface area of the external envelope but also highly beneficial for the same reason. Indeed, such upgrades may be a precondition of successfully upgrading and decarbonising the building services depending on the precise technology options pursued.

Fabric:

	Fabric	Insulation
Walls	*East, west, and north wings:* Solid masonry, approximately 600 to 700mm thick with an external cement render, lime plaster on interior face *South wing:* Cavity masonry of concrete block construction and is 450mm thick with an external cement render	*East, west, and north wings:* Most walls uninsulated, some have been relined in modern plasterboard with a thin layer of polystyrene insulation *South wing:* Presumed uninsulated (as-built)
Floor	A mix of solid concrete slabs and suspended timber floors	Presumed uninsulated (as-built)
Roof	Pitched timber roofs finished with slate mounted on battens	100mm mineral wool insulation above ceilings, known to be in poor condition, effective thickness estimated to be ~75mm
Openings	There are a total of ninety-seven windows in the house, all of which are uPVC double-glazing dating to around 2000	U-value of main windows = ~1.8 W/m^{2}K

Three 0.9m^2 double-glazed rooflights in south wing, U-value approx 2.2	U-value of roof windows = ~2.2 W/m^{2}K
Six external doors across all wings, of which three timber and three uPVC	U-value of external doors (both timber and uPVC) = ~2.5W/m^{2}K

Although fairly typical by the standards of traditional building fabric in Scotland and Ireland, the thermal fabric performance of Myross Wood House is poor by modern standards. The exception to this is external windows and doors which have almost entirely been replaced with modern units which have an estimated thermal performance well within the normal range of performance for current products of this type. Openings generally remain in acceptable condition and are reasonably airtight, excepting two timber external doors in the east wing which are in poor condition.

The condition of fabric elements is highly variable and prior to undertaking any upgrade works a number of outstanding maintenance issues will need to be addressed. Solid masonry walls in the older wings of the house are suffering dampness due to moisture within the building fabric becoming trapped behind the impermeable cement render, with lower parts of the north and west wing also suffering rising and laterally penetrating damp due to encroaching ground levels. It is also worth noting that the solid floors in the property derive little benefit from thermal inertia due to comparatively high perimeter to area ratios.

Services:

	System
Space heating	Two oil boilers installed 1993 (estimated combustion efficiency 70 to 75%), of which one is defunct, the functional boiler has a rated output of 365kW
Hot water	Provided by oil boilers
Space cooling	None present
Microgeneration	None present
Energy storage	None present

The house presently has a large carbon footprint principally due to its high space heating energy demand (see below) which is currently met by its 1993 oil-fired boiler. Heating for the building is currently controlled by timers across three zones, however there is no thermostatic control of the system at present. There is also a liquified petroleum gas (LPG) tank present which supplies gas for cooking. Annual consumption of heating oil prior to the outbreak of the coronavirus pandemic in 2020 was approximately 78,000 litres, equating to approximately 780,000kWh. Annual electrical demand for the building during the same period varied within a range of approximately 36,000 to 44,000 kWh/year.

Ventilation and Moisture Management:

Ventilation of the property is currently provided passively, principally via underfloor voids, openings, and open flues as per the original design. Considering the potentially high level of occupancy which may result from Green Skibbereen's planned use of the building, Akiboye Conolly Architects have recommended against any reduction of ventilation rates that does not incorporate analysis and control of internal humidity levels as under these conditions internal vapour loading is likely to far exceed the design capability of the structure, especially considering the reduction in fabric permeability compared to the original design resulting from the modern cement render.

Building Energy Report (BER) estimate:

Date	Key Findings
March 2020	• Building Energy Rating (BER) = E2 • Annual primary energy usage = 377,383kWh/yr • Annual carbon emissions = 93,140kgCO2/yr

Completed as part of Carrig (2020) retrofit strategy report, this estimated BER refers only to the traditionally constructed portions of the house, excluding the 1959 south wing.

The BER is the Republic of Ireland's national calculation methodology per the requirements of the Energy Performance of Buildings Directive (EPBD). This estimated report by Carrig reflects the relatively low fabric performance and high carbon technical services of Myross Wood House at present as discussed above.

Occupancy:

Recent occupancy of the house has been very limited, with fewer than ten individuals in residence throughout the period of the upgrade study conducted by Akiboye Conolly Architects. For context, the south and west wings alone house in excess of fifty bedrooms. Going forward, it is difficult to predict what the precise occupancy of the house will be. It may be reasonable to assume however, that average occupancy of the house is likely to increase dramatically as Green Skibbereen intend to pursue both daytime and residential uses, in addition to occupying the building as a base for their organisation.

Further Reading:

- Energy Upgrade Study by Akiboye Conolly Architects (2021)
- Retrofit Strategy Study by Carrig Conservation International (2020)

Rector’s House

Rantakatu 7, 92100 Raahe, Northern Ostrobothni, Finland

Figure 8: The Rector’s House – Image © Historic Environment Scotland – photographer: Kenneth Easson

The Rector’s House is a two-storey timber house originally constructed in 1900 as a residence for the headmistress of the local teacher’s college by the State of Finland’s National Board for Public Housing. The building has seen multiple uses and some modification over the course of the 20th century, most recently and significantly a complete renovation in 1991. Although currently vacant, the most recent use of the building was as part of the school of engineering and as an office for the Oulu University of Applied Sciences from 1999 to 2014. The exterior of the building is in the protected S2 category under the Finnish system of heritage management.

Geometry:

Dimensions	
Gross internal floor area	553m^2
Total volume	1,980m^3
Room heights	Basement = 2.2m Ground floor = 3.4m 1st floor = 2.4m

Fabric:

Figure 9: Modern semi-circular concrete ring added to protect an original ventilation opening, which has itself been modified to serve as a basement window – Image © Historic Environment Scotland – photographer: Kenneth Easson

	Fabric	Insulation
Walls	Log walls with timber panelling on the exterior face, foundations and base of the wall are granite	Some limited internal insulation on the main elevations, consisting of mineral wool dating to the most recent renovation in 1991
Floor	Suspended timber over an unheated cellar, this extends under part of the structure with a solum void underlying the remainder	Underfloor insulation, wood wool between floor joists
Roof	Seam-welded sheet iron	350mm mineral wool insulation in attics
Openings	Openings are largely original windows in timber frames, upstairs windows were replaced like-for-like during the 1991 renovation; external doors are original timber	Box windows: a pair of single-glazed windows (inner and outer) in each window opening separated by an air gap

The base of the external walls is grey granite, which includes ventilation openings to the cellar and other underfloor spaces. However, all of these are now positioned too low and some are blocked entirely due to encroaching ground levels, with ventilation needs of the building fabric having been largely ignored in recent years. Some ventilation openings have been protected by a semi-circular concrete ring with a wooden door.

The windows are also timber, and largely original, with only windows on the upper storey having been replaced during the 1990s renovation. There is an urgent need for maintenance however and the windows are in need of stripping, fronting, and weatherproofing. There is also some water damage to ceilings internally and it was noted during an inspection that the internal environment is noticeably humid but further investigation of the extent of any water damage has not yet been undertaken.

Services:

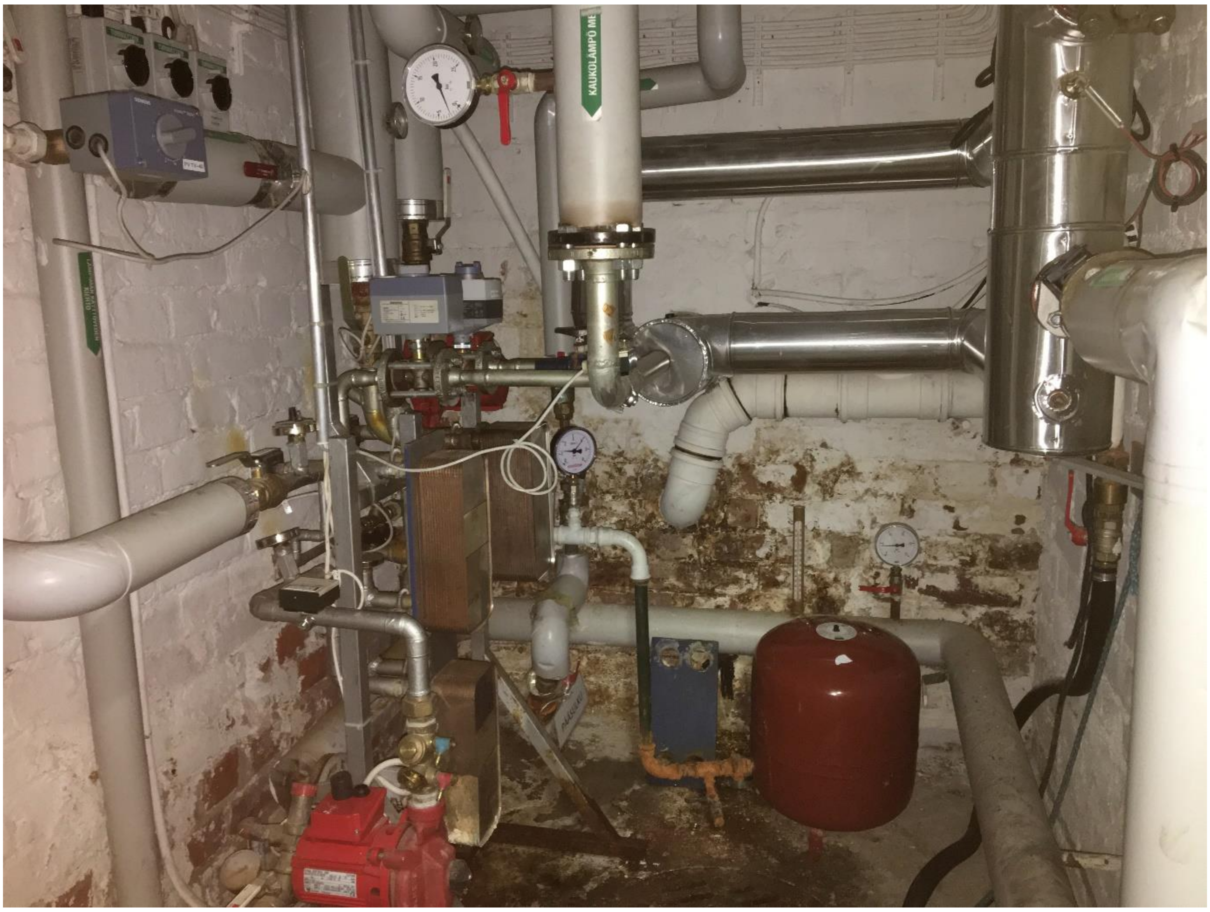

Figure 10: Basement room housing district heating plant equipment, note in particular the heat exchangers (three rounded metal cuboids to left of centre showing visible corrosion) – Image © Historic Environment Scotland – photographer: Kenneth Easson

	System
Space heating	Heat exchanger from the district heating system supplying heat via insulated pipework to a system of radiators (flow temperature 60 to 80°C)
Hot water	Heat exchanger from the district heating system
Space cooling	None present
Microgeneration	None present
Energy storage	None present

The local sub-assembly which provides heat to the house from Raahe's district heating system, and the associated switchboard, was renewed in 1992. It is worth noting that this system is already excellent in environmental terms as it is powered by waste heat from the local SSAB steel plant. A visual survey in early 2020 has found that the internal pipework within the house is well insulated and that both pipework and radiators are in good condition, the heat exchangers themselves however were found to be in poor condition. The radiators are individually controlled by thermostatic valves and the presence of room or zone thermostats is presumed based on the degree of precise control noted in the 2020 HVAC report undertaken by staff from the Oulu University of Applied Sciences.

Ventilation and Moisture Management:

Ventilation of the internal spaces is provided by a balanced supply-extract mechanical ventilation system. Supply air for this system is pre-heated by a dedicated heat exchanger powered by the district heating system. This system was installed in 1992.

Energy reports and surveys:

	DATE	**RELEVANT FINDINGS**
ENERGY PATHFINDER HVAC REPORT	February 2020	• HVAC systems surveyed as described above (see technical services) • Monitored energy consumption in 2019 was ~58MWh, building unoccupied and room temperatures set to 15C with ventilation reduced to minimal levels* • Monitored energy consumption for the period 2015 to 2017 was ~95 to ~105MWh, building unoccupied but specific energy saving actions not yet taken to reflect this condition*

**these measurements were possible because the Rector's House is equipped with an energy meter which can be read remotely*

In addition to the HVAC survey noted above, a condition survey of the building is planned to take place during 2021 in order to gain a greater overall understanding of both the general health of the building fabric and the extent of issues which are already known to exist (see building fabric).

Occupancy:

The Rector's House has been unoccupied since 2014 and remains vacant at time of writing. At present the intention of the building owners is to explore a further renovation and change of use to create a residence, studio, and exhibition space for visiting international artists. Prior to this the building has previously served in various different roles including both domestic and non-domestic functions as a residence, office, home to the Raahe Institute of Computer Engineering, and home to the Oulu University of Applied Sciences School of Engineering.

Tegs Kyrka

[Jägarvägen 16, 904 20 Umeå, Västerbotten County, Sweden]

Figure 11: Tegs Kyrka exterior, seen from the northwest in June 2022 – Image © Historic Environment Scotland – Photographer: Kenneth Easson

The Tegs Kyrka is a place of worship for the Church of Sweden and belongs to the Tegs Parish in the Lulea diocese. It is located in the residential area of Tegs in the southern part of the city of Umea. The building's expressive design was conceived in 1963 by the Stockholm architect Carl Hampus Bergma who won an architectural competition in that year. Hampus worked for Le Corbusier and Alvar Aalto, two of the most internationally-important architects of the 20th century. The influence of Le Corbusier and Aalto is clear to see in the use of exposed shuttered concrete (as at Le Corbusier's convent, La Tourette) and the freestanding campanile (bell tower) favoured by Aalto at his churches and civic buildings.

Construction of the church began in 1967 and it was inaugurated in 1969. The functional form of the church was executed in concrete which provides the surface finish both internally and externally. It is oriented on a NW-SE axis from the entrance to the chancel. The chancel overlooks a garden enclosed to the east and north by the church offices. The garden was originally intended to be enclosed in cloister form but is open to the SW. The bell tower is in the form of a slender concrete tower located next to the entrance front.

The church has been painted in recent years in a yellow-pink colour both internally and externally. It has had an acoustic coating applied to the ceiling and some changes have been made to the windows, but the building is otherwise largely unaltered from its original design. It was designated a listed building in 2011 and is on the building register of the Swedish National Heritage Board, Riksantikvarieambetet. Any changes to the church would require the permission of the county administrative board.

Geometry:

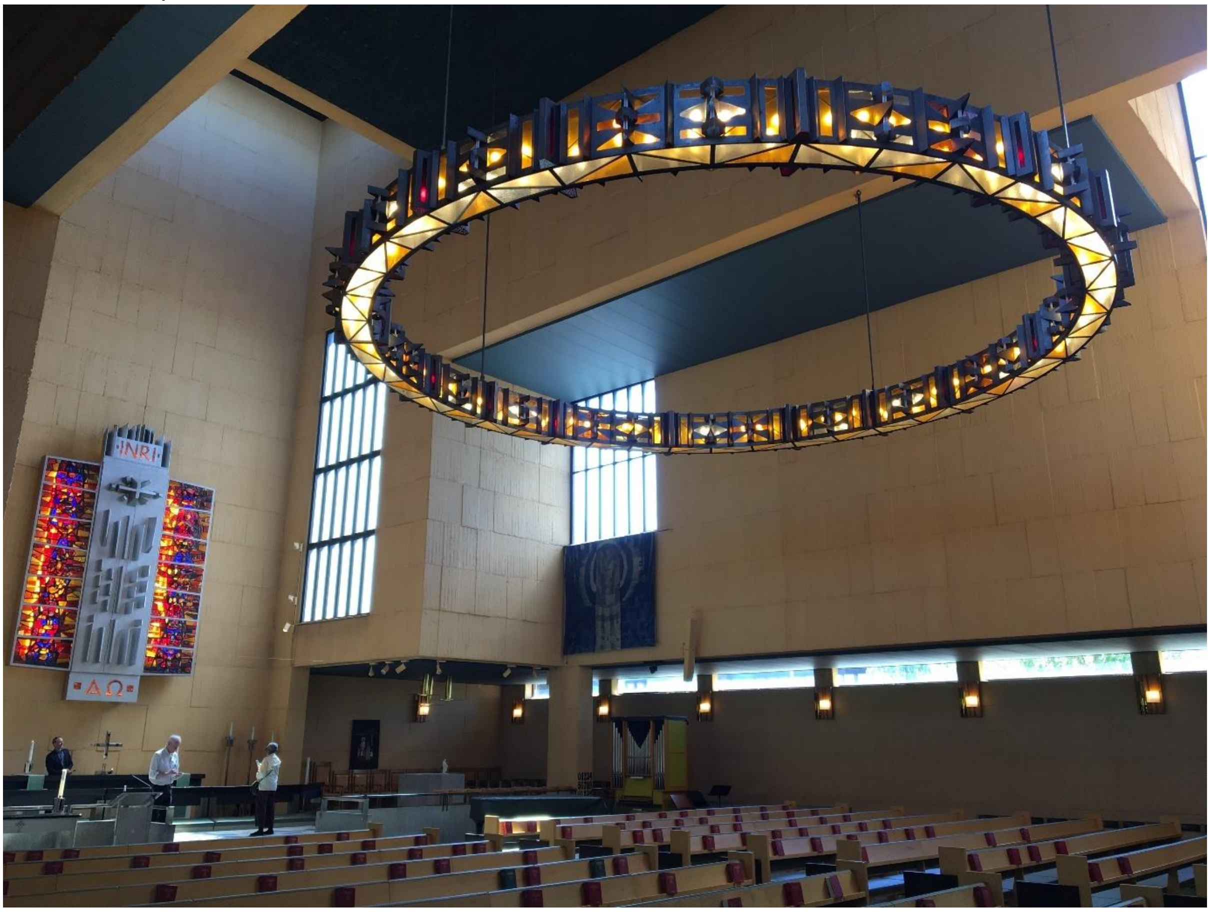

Figure 12: Main internal space at Tegs Kyrka, seen from the northern corner – Image © Historic Environment Scotland – Photographer: Kenneth Easson

Dimensions	
Gross internal floor area*	688m^2
Heat loss perimeter (internal)	Approximately 102m*

**At ground floor level,*

Internally, the church is laid out in basilica form and can accommodate up to 500 worshippers. The design of the nave reflects the overall architectural concept of the church as a series of interconnecting cubes oriented around a principal volume. The nave is of almost square plan, divided into a main hall with side aisles and a secondary seating area contained in a gallery at second floor level.

The ceiling of the nave is 16m high, increasing to 20m in height over the altar. Hanging at the centre of the nave is a very large chandelier called Christ's Crown of Thorns created by the artist Harald Garmland, made of metal and coloured glass and completed on site.

Fabric:

Figure 13: Interior face of external concrete walls, showing the distinctive pattern created by the original shutterwork formed from logs – Image © Historic Environment Scotland – Photographer: Kenneth Easson

	Fabric	Insulation
Walls	100mm concrete and 250mm concrete (with insulation between)	150mm mineral wool
Floor	Concrete 200mm	150mm wood wool insulation
Roof	Steel exterior on a 35mm timber deck, 500mm air gap, 250mm concrete and 100mm acoustic plates	300mm mineral wool
Openings	Aluminium-framed double glazed windows.	Argon-filled glazing cavity, average U-value of 2.0

The church is constructed from shuttered concrete and the imprint of the timber formwork is a distinctive feature of the exposed concrete finish. The concrete panels of the church are precast with insulation enclosed between them. The roof is a concrete slab with no insulation or roof void. An acoustic coating has been applied to underside of the ceiling of the nave which may have a marginal thermal impact.

The windows are aluminium framed and double-glazed with an argon fill. There are large windows on three elevations but none on the south east elevation where the chancel is located. The window to wall ratio is 8.4%.

There are three external doors which are made from timber faced in copper. The main entrance door is in the NW elevation and is the largest in size. Smaller doors enter the building from the SW and NE. Draughts are recognised as an issue with this arrangement.

Services:

	System
Space heating	Electric underfloor heating supplemented with local district heating supplied through mechanical ventilation system
Space cooling	Not present
Microgeneration	Not present
Energy storage	Not present

Heating is provided by electric underfloor heating wires laid within the original concrete floor slab. The church and annex also receive heat input from a local district heating network. In the church, this can be used to pre-heat the external air input for the mechanical ventilation system. The building's setpoint is a constant 20°C, controlled by wall-mounted sensors and maintained for 24 hours per day.

It is notable that all lighting in the church and offices is now in the form of LED units. This is approximately 260 fittings, of which most are 12W and about 30 are 35W fittings. Lighting is manually controlled as required. Energy costs for the church are high with metered usage being recorded at 121.0MWh/yr.

Ventilation and Moisture Management:

Figure 14: Heat recovery ventilation unit in the plant room at Tegs Church – Image © Historic Environment Scotland – Photographer: Kenneth Easson

The church has a mechanical ventilation system that works on the basis of a heat recovery system. A significant issue for the church is the presence of asbestos in the lining of the system's ductwork. Ventilation of the church has not proven to be an issue because the nave has a very large internal volume and it is only generally occupied for short periods. There is likely to be some degree of passive ventilation via the doorways, and there is also intermittent air extraction in the WCs. Air tightness of the building is unknown.

Figure 15: Input vent from the mechanical ventilation system adjacent to the northeastern external wall – Image © Historic Environment Scotland – Photographer: Kenneth Easson

Occupancy:

The Tegs Kyrka is still actively used as a church and its annex building contains community spaces which are used frequently. Religious functions take place principally on Fridays, Saturdays and Sundays, with typical attendance of 30 to 40 people. A smaller mass takes place on Thursday evenings, attended by 10 to 15 people. The church also experiences a steady flow of visitors in the region of 1 to 5 per day in winter and 10-20 per day in summer.

The main space of the church has capacity for 500 and occasionally it will host large events such as concerts where the attendance will range from 100 to 500 people.

Viðareiði Vicarage

[Viðareiði, Viðoy island, Faroe Islands]

Figure 16: Viðareiði Vicarage seen from the northeast in August 2022 – Image © Historic Environment Scotland

Figure 17: Viðareiði Vicarage seen from southwest in August 2022 – Image © Historic Environment Scotland

The Vicarage at Viðareiði is the northernmost vicarage on the Faroe Islands and in a location that has been occupied for approximately 500 years. The building that stands today was built in 1854 and was originally a farmhouse and vicarage. The building is now fully used as a vicarage for the adjacent church operated by the Church of the Faroe Islands (Fólkakirkjan).

The Vicarage is an excellent example of vernacular Faroese building practices which developed over centuries in a context where all building materials except turf and stone were scarce and expensive.

The house originally had two entrances, one for the workmen in the farm and one for the priest. The entrances were located at each end of the building. This was later changed to a common entrance in the middle of the building. Previously, the attic was mainly used as storage space for farm implements but was converted to domestic accommodation in the 1960s, at which time other small internal changes were made. The house was originally accompanied by agricultural buildings but these were all demolished and a garage erected in the 1980s. Electricity came to Viðareiði in 1956 and a central heating system was also installed in the Vicarage around this time. The Vicarage is of great cultural and sentimental significance to both the Faroe Islands and local community.

Geometry:

Dimensions	
Gross internal floor area*	272.5m^2*
Floor area of heated rooms	243m^2*
Heat loss perimeter (internal)	42.82 (main house ground) + 41.70 (main house 1st (RiR)) + 23.13 (smokeroom and other heated parts of barn)

**Cold basement of approximately 50m^2 not included*

As can be seen in Figure 16 (above) the Vicarage sits on a site which slopes to the north. The (south) entrance frontage is single storey in height with an upper floor contained in the roof, but the house sits on a stone-walled part-basement which is accessible externally from the north side.

Ground floor ceiling height is 2.18m. The smokeroom has an open timber roof which has a ridge height of 4.5m. The first floor rooms have a ceiling height of 2.05m but wall heights are approximately 1.5m at the foot of the coombs.

Fabric:

	Fabric	**Insulation**
Walls	Rubble at ground/basement level with timber construction above	100mm rockwool
Floor	Suspended timber boarded floor with later coverings over	None
Roof	Approximately 150-175mm turf over 21mm plywood and a synthetic weatherproofing layer	100mm mineral wool insulation to house
Openings	26 windows of predominantly side hung timber casement design	Timber-framed double glazing

The main building is timber construction on a rubblework part-basement and foundations. The external timber walls have 1" vertical boarding and batten cladding, 1" battens, 12mm plywood, 100mm rockwool, 5x5"(125mm) posts, inner vertical boards in note.

The smokeroom is identical in construction to the main walls but with 50mm insulation in 75mm posts instead of 100mm in 125mm posts. Insulation at the Vicarage dates to the last major renovation carried out in 1992. The cowshelter has stone walls in the region of 700 to 900mm thick.

In the time period of this reporting it was noted that regular condition surveys had been carried out and the main fabric was found to be in good condition with no signs of any major defects or dampness. However, the windows were found to be in poor condition showing considerable amounts of rotten timber even though they had been mostly renewed in 1992.

The Vicarage has a total of 26 windows. 18 of these are in the walls of the main building, 6 are in the roof's dormerheads, a ridge-light in the smokeroom, and a small window in the cowshelter gable. The windows in the main building are timber-framed with double glazing and have internal timber shutters. Their U-value was unknown. The external doors are timber but were found to be in poor condition with poor airtightness

The roof construction comprised approximately 150-175mm turf over 21mm plywood with a synthetic weatherproofing layer. The roof of the main building has 100mm mineral wool insulation but the cowshelter and smokeroom are uninsulated.

Services:

	System
Space heating	Heating is an oil boiler heating a system of radiators with TRVs
Hot water	Assume hot water is provided by oil boiler
Space cooling	None present
Microgeneration	None present
Energy storage	None present

Heating was originally provided by stoves fired with coal or peat. Modern heating is provided by an oil boiler heating a system of radiators with thermostatic valves, the design flow of the radiators being 65C. Heating is on demand without much consistent pattern, the main building being heated to about 22C. The smoking room is heated only occasionally and the cowshelter and basement are both unheated. It is assumed that this system also provides domestic hot water.

Ventilation and Moisture Management:

Ventilation of the Vicarage is largely passive and controlled by its occupants through opening of windows and doors. There is intermittent extract ventilation in the kitchen and bathrooms. Landsverk has said it is not well disposed to the idea of mechanical ventilation as they believe it would not be possible to sufficiently disguise the system components and would adversely affect the traditional Faroese farmhouse character.

Occupancy:

The Vicarage is in use and serves the church in being the home of the vicar and his wife. Some smaller community and ecclesiastical functions take place in the building which also receives regular visits by parishioners. The Vicarage is known to have a high turnover of occupants which has in part been ascribed to the poor comfort levels in the building, although no change of use is being considered at this time