Northern Periphery and Arctic Programme 2014–2020

EUROPEAN UNION
Investing in your future
European Regional Development Fund

ENERGY PATHFINDER

Approaching Near Zero Energy in Historic Buildings

Deliverable No: T3.1.1

Deliverable Title: Demonstrator Buildings and Energy Assessment Strategies

Submission date:

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Deliverable Type: R (Report)
Dissemination Level: PU (Public)

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NCE Insulation IDENTIFYING & DELIVERING ENERGY REDUCTION MEASURES

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

Introduction

This report introduces each of the Energy Pathfinder demonstrator buildings in which project partners have supported or directly commissioned energy monitoring, simulation, or survey activity to take place. It also provides an overview of the energy assessment strategy and specific activities undertaken at each site. Originally, assessment strategies for the demonstrator buildings were devised during late 2019, however these were subject to considerable disruption resulting from the coronavirus pandemic throughout 2020 and much of 2021. Scottish demonstrator sites were impacted especially severely by this due to their relative remoteness which made them inaccessible to HES staff for much of the period. Consequently, the strategies outlines in this report have been revised multiple times during the lifetime of the project in response to developing circumstances.

In consultation with project partners, significant redrafts took place in late 2021 and early 2022 to reflect those activities which had already been successfully completed and which partners remained confident could be undertaken during the remaining run of the project. This final draft relates the overall assessment strategy and specific activities which were ultimately implemented at each of the demonstrator sites. The results produced are presented in subsequent reports.

This report is the first 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*

These reports may be read together for a comprehensive overview of all energy and carbon assessment activities undertaken at Energy Pathfinder demonstrator buildings.

Historic Environment Scotland (HES) has compiled this report as the work package coordinator for energy management and monitoring as part of the Energy Pathfinder project however HES does not necessarily endorse or recommend the assessment strategies outlined herein.

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 southeast – Image © Historic Environment Scotland – Photographer: Carsten Hermann

Overlooking the harbour of Pierowall, the largest settlement on the island of Westray, Bayview is a two-and-a-half storey detached house constructed in the late 19th century. Originally the building was the house of the Pierowall harbourmaster before being used more recently as a family home and guest house. Unoccupied since 2018, the Westray Development Trust has since purchased the building with the aim of converting the building to house four flats which are to be let by the Trust to residents of the island. It is hoped this will contribute to resolving a longstanding shortage of affordable housing. These works are ongoing at time of writing and are expected to be completed during summer of 2022. Energy efficiency upgrades specified as part of this are described in detail in our subsequent report.

The external walls at Bayview are mass masonry built from a mixture of local stone types, chiefly sandstone with some whinstone[1], and cement-based harling[2] on the exterior face. This harling was in poor condition and has been replaced like-for-like during the conversion. The existing roof in 2019 was of timber construction finished in slate and has also since been replaced like-for-like. The existing windows were of relatively modern PVC-framed double-glazing but have also been replaced with similar units as the existing ones were in very poor condition. The gross internal floor area of the building prior to conversion works was 222m^2 of which the ground floor was mixed solid and suspended timber construction, and internal floors were all of suspended timber. This internal floor area has been increased during the conversion by the expansion of the building envelope to the rear, chiefly to accommodate a common stairwell. The external walls and ground floor were previously uninsulated, as was most of the roof structure with the exception of a small apex loft insulated with mineral wool to a depth of approximately 150mm. The building does not carry any statutory heritage

[1] Whinstone is a term generally used to describe hard, dark-coloured igneous and metamorphic rocks such as basalt or dolerite.

[2] A Scots term for an external rough-cast render, traditionally consisting of lime and aggregate.

designation. Space heating and domestic hot water prior to conversion was provided by an oil-fired combination boiler and system of radiators.

The Energy Pathfinder assessment strategy at Bayview focuses on achieving an in-depth understanding of the hygrothermal risk and embodied carbon impact of the fabric retrofit undertaken as part of the conversion project. An outline understanding of the overall energy performance impact of the conversion will also be achieved using the comparatively simple RdSAP methodology to provide pre-and-post retrofit estimates thereof.

Coordinating project partner: ***Historic Environment Scotland***

Local contact: ***Westray Development Trust***

Assessment Methods:

Method:	**Aim:**	**Notes:**
Fabric retrofit embodied carbon and hygrothermal risk comparative analysis*	Evaluate the carbon impact and hygrothermal risk of two approaches to fabric retrofit, one representing a standard vapour-closed approach and the other a vapour-open approach using biogenic materials.	This will be a detailed study using bespoke software called the Green Building Calculator (GBC) recently developed for the UK's Sustainable Traditional Buildings Alliance (STBA)
Pre and post retrofit assessment using RdSAP	Produce a reliable estimate of building energy performance before and after the Westray Development Trust retrofit project.	RdSAP is the UK's national assessment methodology for existing buildings under the EPBD

**This study, covering the demonstrators at both North Ronaldsay and Westray, will form the content of deliverable T3.4.1Embodied Carbon and Sustainable Retrofit Approaches.*

Keepers’ Cottages, North Ronaldsay Lighthouse

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

Figure 2: Lighthouse with north-western block, housing the café/visitor centre and woollen mill – Image © Historic Environment Scotland – Photographer: Carsten Hermann

Figure 3: South-eastern block, housing two holiday apartments – Image © Historic Environment Scotland – Photographer: Carsten Hermann

The complex at Dennis Ness, also known as Versa Breck, is composed principally of the lighthouse itself and two accommodation buildings. Of these, the southeast block was built alongside the lighthouse in 1852 while the northwest block is of different construction and was added later, most likely in the late 19th or early 20th century. At 42.3 metres high, the beacon itself is Britain's tallest land-based lighthouse. The complex is statutorily designated as cultural heritage through listing at category B, Scotland’s second highest designation (reference: LB5892).

Standing on a rectangular plan, the symmetrical southeast keepers' accommodation block is of solid brick construction with sandstone quoins at corners and windows. This block houses two cottages originally built for the lighthouse keepers’ and which are now holiday lets operated by the North Ronaldsay Trust. The northwest block, of poured concrete construction, was originally built to provide a third keepers’ cottage and a machine workshop for the complex. The third cottage

currently serves as a café and exhibition centre while the workshop hosts a woollen mill processing locally produced fleece from the North Ronaldsay herd. The Energy Pathfinder demonstrator buildings are the two accommodation blocks which are owned by the North Ronaldsay Trust. The UK's Northern Lighthouse Board continues to own, operate, and maintain the lighthouse itself which is consequently outside the scope of Energy Pathfinder.

An existing oil boiler and thermal store, which also receives some limited input from the complex's four wind turbines, functioned as a communal heating system for the complex until recently. The boiler has since been removed and the remaining space and water heating provision on site is inadequate. The woollen mill is planning to relocate within the next few years, which will provide the opportunity to reconfigure the northwest block substantially. As part of this, the trust hopes to reinstate the third cottage as a caretaker's flat tied to a permanent post at the complex, with the café and visitor centre relocating into the vacated workshop.

The energy assessment strategy of Energy Pathfinder at the Keeper's Cottages is a detailed investigation of the fabric performance and services configuration at the buildings. Through this, the project hopes to assist the North Ronaldsay Trust in developing a logical and feasible plan for energy performance improvements at the complex. There is also the potential for co-design activity to take place in support of this.

Coordinating project partner: ***Historic Environment Scotland***

Local contact: ***North Ronaldsay Trust***

Assessment Methods:

Method:	**Aim:**	**Notes:**
Energy upgrade study	Identify and evaluate options for improving HVAC, energy storage, control, and microgeneration systems, including both changes to hardware and energy management approaches.	This study will incorporate a detailed energy model of the north-western block and a slightly simpler model of the south-eastern block.
Fabric retrofit embodied carbon and hygrothermal risk comparative analysis*	Evaluate the carbon impact and hygrothermal risk of two approaches to fabric retrofit, one representing a standard vapour-closed approach and the other a vapour-open approach using biogenic materials.	This will be a detailed study using bespoke software called the Green Building Calculator (GBC) recently developed for the UK's Sustainable Traditional Buildings Alliance (STBA).
Indoor air quality monitoring	Monitor and evaluate indoor air quality.	
Air tightness testing	Determine overall air tightness and estimate passive ventilation rate.	

RdSAP assessment	Estimate current energy performance and SAP rating.	
DE HRA assessment	Estimate energy performance and model both technical and fabric improvement options.	DE HRA (Dynamic Engine Home Renewables Advice) is bespoke software used by Scotland's national energy efficiency advice service, Home Energy Scotland.
Thermal imaging	Assess the in-situ performance of existing building fabric.	

**This study, covering the demonstrators at both North Ronaldsay and Westray, will form the content of deliverable T3.4.1Embodied Carbon and Sustainable Retrofit Approaches.*

Cathedral of Saint Mary and Saint Anne

Roman Street, Blackpool, Cork City, Ireland

Figure 4: Cathedral of Saint Mary and Saint Anne in the city of Cork, Ireland, viewed from the north.
Image © Sebastian "sebrem" B… via Wikimedia Commons [CC BY-SA 3.0]

Built between 1805-1810, with a tower added in 1869, this cathedral is built in the Gothic Revival style and is located to the north of the river Lee in Cork, southern Ireland. It is on the National Inventory of Architectural Heritage under the category 'National'. It is one of two cathedrals in Cork and is the seat of the bishop of Cork and Ross. The original construction consists of solid wall construction with limestone quoins and string courses and rubble sandstone walls. The principal roof is pitched and slated with terracotta tiles at the ridge. The building has numerous additions from different ages, mostly of modern construction with cavity walls. This now creates a loose T-plan with a five-bay nave and a three-bay chancel to the east.

The building is heated using air to air heat pumps installed in 2018. Electricity is partially supplied by solar panels installed on a hidden part of the roof. This system is currently inefficient and does not provide the required heat for the building. The building is in frequent use, so zoning of the space and providing comfort heat only when necessary might not be the most efficient way forward.

As part of the Energy Pathfinder project, energy monitoring will look at the efficiency of the current heating system. This will include the metered use of electricity as well as the electricity generated by the solar panels. A short-term contract will be awarded to create a baseline energy value. An analysis of the comfort of the building users will be made to identify areas of discomfort in the church. At this point, we are waiting for more information and the results from this survey before of finalising the monitoring strategies.

It is worth noting that locally and in some sources the building is also known as Saint Mary's Cathedral, The North Cathedral, or The North Chapel.

Coordinating Project Partner: ***NCE Insulation***

Assessment Methods:

Method:	Aim:	Notes:
Energy management study	Optimise operation of existing heating systems to minimise overall energy spend whilst maintaining a comfortable indoor environment for users.	Undertaken during early 2022 by local energy consultants DCSix Technologies

Myross Wood House

Parish Ardagh, County Cork, Ireland

Figure 5: Myross Wood House, principal elevation of original Georgian house with early side extensions – Image © Historic Environment Scotland – photographer: Carsten Hermann

Figure 6: Courtyard with 20th century extension left of centre; the original building with older extensions right of centre – Image © Historic Environment Scotland – photographer: Carsten Hermann

Located within 100 acres of Myross Wood, approximately 80km southwest of the city of Cork, the origins of this historic manor house are contested. The current owners of the building, the Missionaries of the Sacred Heart, claim that the vicar of Myross at the time, the Reverend Arthur Herbert "built an elegant and commodious residence of five bays, which now forms the centre of Myross Wood House" [3] at some point prior to his death in 1760. Said building was then later, around 1819, "extensively enlarged […] around a courtyard" by the Earl of Kingston, who had become the owner of the building by that time.

The current owners purchased the house in 1946 and used the building as a religious study house, making some adaptations to suit the new purpose of the building, including total rebuilding of the south wing in 1959. Over the years the interior of the house has also been gradually adapted to suit the needs of this religious community and since 1970 it has served primarily as a retreat centre, with

[3] https://www.myrosswood.ie/history

the west wing being extensively renovated and refurbished in 1987[4]. After a period of very limited occupancy the building has now been leased to local environmental group Green Skibbereen and is in the initial stages of being set up as the West Cork Centre of Excellence for Climate Action and Sustainability (CECAS).

The building today still stands amidst an extensive estate, on the western shore of a tidal sea loch. The main building is constructed of stone masonry with an external render. There is also a large modern extension in cavity masonry construction. Space and water heating are provided by a pair of oil boilers. Further details regarding the building fabric and technical systems can be found in the subsequent T3.2.1 baseline energy performance report.

The entry in Ireland's National Inventory of Architectural Heritage (registration number: 20914210) describes it as a "detached five-bay two-storey over basement former country house, built c.1820, with pair of two-bay two-storey flanking pavilions. Central porch addition to front and project bay window to south, c.1930."[5] The inventory describes the house as "(a)n imposing early nineteenth century house, retaining its classical portions and style. … The hipped roof, large windows and fine doorcase are typical features of its time. The flanking end pavilions create a scale and grandeur which elevate it above more modest country houses."

This demonstrator study would benefit from a desk assessment of overall building energy performance using a variety of tools, in addition to a study of renewable energy potential at the site.

Coordinating Project Partner: ***University College Cork***

Assessment Methods:

Method:	Aim:	Notes:
Energy upgrade study	Identify potential for upgrade of the building fabric and potential renewable sources of heat and electricity	
Retrofit strategy study	Develop a detailed strategy for energy retrofit which is compatible with the health of the building fabric and preservation of built heritage at the site	
Energy audit	Estimate the current energy performance and environmental footprint of the building	This is an audit carried out using a standard methodology designed by Ireland's SEAI to assist SMEs in reducing their energy consumption and carbon footprint

[4] Missionaries of the Sacred Cross, 2020. *Myross Wood Retreat: History*. https://www.myrosswood.ie/history

[5] https://www.buildingsofireland.ie/buildings-search/building/20914210/myross-wood-house-ardagh-county-cork

The Rector’s House

Rantakatu 7, 92100 Raahe, Northern Ostrobothnia, Finland

Figure 7: The Rector’s House – Image © Historic Environment Scotland – photographer: Kenneth Easson

The Raahe Rector’s House is a building of moderate cultural significance on Raahe’s university campus. This traditionally constructed, timber-boarded log structure is currently unoccupied due to chronic dampness issues which have caused considerable mould growth. Fungal investigations have been commenced to inform the planning of a suitable renovation journey which can restore the building to active use. This process has been delayed considerably however due to staff changes at Oulu University and due to the ongoing coronavirus pandemic. Current plans for the building intend it to become a residence for visiting artists following renovation.

Energy Pathfinder support of this project and any activities to be undertaken will be determined once the results of the aforementioned fungal investigations are available.

Coordinating Project Partner: ***Oulu University of Applied Sciences***

Assessment Methods:

Method:	Aim:	Notes:
Energy upgrade study	Explore potential energy upgrade options as part of upcoming change of use	This has been undertaken by engineering students at OAMK and forms part of a masters level thesis in architecture
Thermal imaging	Assess the in-situ performance of existing building fabric.	

Tegs Kyrka (Tegs Church)

Jägarvägen 16, 904 20 Umeå, Västerbotten County, Sweden

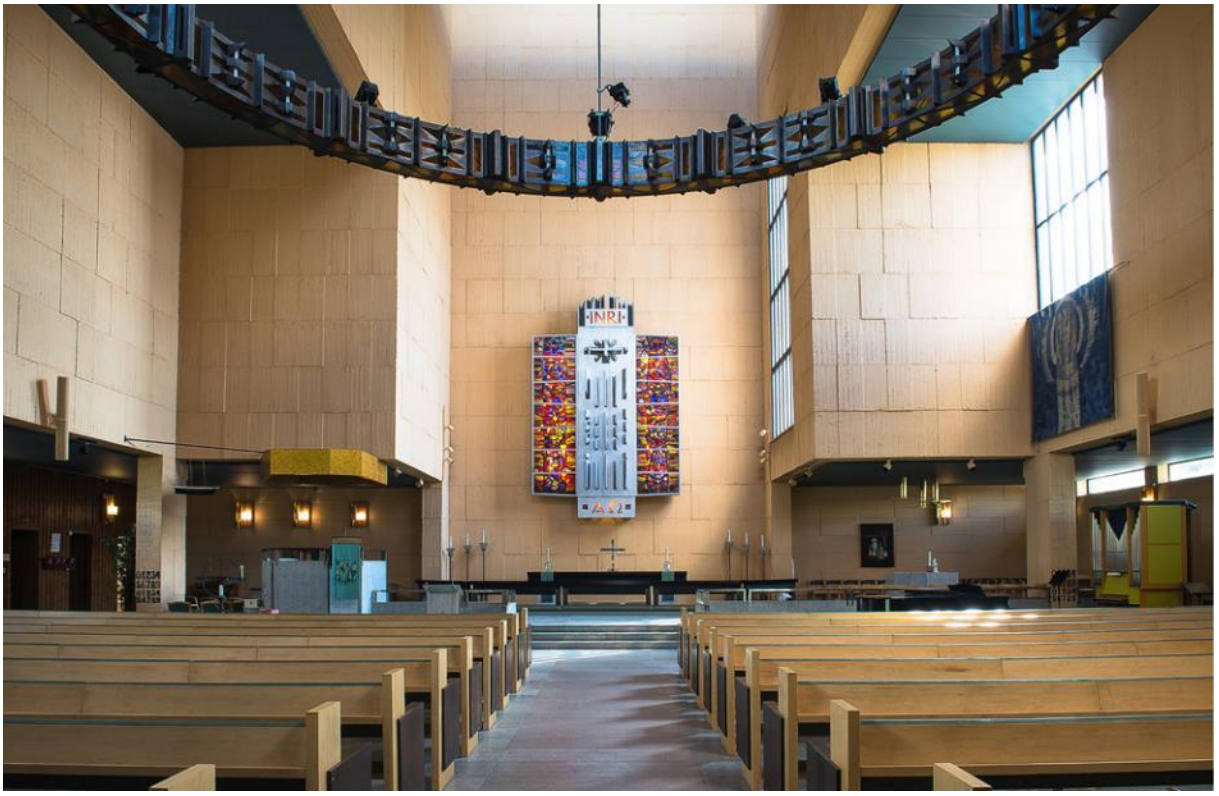

Figure 8: Interior view of Tegs Kyrka – Image © Anders Säderlund via Orgelanders.se

Tegs Kyrka is the place of worship for the Church of Sweden in the residential neighbour of Tegs, south of Umeå's city centre. The building's expressive design in exposed concrete was developed between 1963 and 1965 by the architect Carl Hampus Bergma. Construction of the building then began in 1967 and was completed in 1969. Largely unaltered from its original design, the church has been a listed building since 2011, appearing on the buildings register of the Swedish National Heritage Board, Riksantikvarieämbetet[6,7].

Accommodating 500 persons, "Tegs Kyrka […] is a modernist concrete church, which forms the northern part of a building complex with parish halls in the eastern and southern regions."[8] A detached bell tower, also in concrete, stands immediately to the northwest. The parish offices, to the southeast, were built at the same time and contain several meeting spaces.

The focus of this building as a case study in the project Energy Pathfinder will be investigation of air movement within the church building; a large, and tall, volume of space, and thereby its impact on both energy use and occupants' thermal comfort. The heating and ventilation systems of the building will also be studied in detail and suggestions provided to improve the technical building systems. For

[6] Riksantikvarieämbetet, 2011. *Bebyggelseregistret [Buildings Register]: Tegs Kyrka*. http://www.bebyggelseregistret.raa.se/bbr2/byggnad/visaHistorik.raa?page=historik&visaHistorik=true&byggnadId=21400000440517

[7] Riksantikvarieämbetet, 2011. *Bebyggelseregistret [Buildings Register]: Tegs Kyrka*. http://www.bebyggelseregistret.raa.se/bbr2/byggnad/visaHistorikText.raa;jsessionid=5A943A4CA3267BEF8FCBE789160B924B?byggnadBeskrivningId=21720000130845&byggnadId=21400000440517&historikId=21000001916162

[8] Svenska kyrkan [Swedish Church], n.d. *Om Tegs kyrka [About Tegs Church]*. https://www.svenskakyrkan.se/umea/om-tegs-kyrka

this, equipment will be installed to monitor the ambient indoor environment at different heights within the indoor volume. Environmental modelling will also be investigated, including simulations using computational fluid dynamics. This will look in particular at how lowering the set point of the heating system during parts of the day and night might improve energy performance, and how thermal zoning can lead to a more energy efficient heating model.

Coordinating Project Partner: ***Umea University***

Local Contact: ***Umea Vicarage, Church of Sweden***

Assessment Methods:

Method:	Aim:	Notes:
Energy simulation including computational fluid dynamics (CFD)	Analyse thermal zoning and patterns of air movement within the internal volume	This will also form the research component of a PhD project at Umea University and utilise IDA-ICE commercial energy simulation software (www.equa.se/en/ida-ice).
Thermal imaging	Assess the in-situ performance of existing building fabric and services	

Viðareiði Vicarage

Viðareiði, Viðoy island, Faroe Islands

Figure 9: Viðareiði Vicarage seen from the immediate northwest – Image © Historic Environment Scotland – photographer: Carsten Hermann

Built in 1854 in the village Viðareiði, this wooden vicarage building is an ongoing pilot project of Landsverk, the Faroes department of public works and a partner organisation in Energy Pathfinder. The building is being renovated by Landsverk which will include removal of most modern materials, installation of Optoglas windows, extensive insulation works, and replacement of the existing fossil fuel heating system with a ground source heat pump. These renovation works will be completed by the end of 2019.

The Energy Pathfinder project will support the monitoring of appliances and technical building systems, principally to inform the occupants of their energy use and extrapolate transferable guidance from this process. Monitoring activities will also include infrared thermography after the refurbishment is completed in order to assess the effectiveness of retrofitted insulation, identify areas to be improved and assess overall patterns of heat loss across the structure. The pilot will also serve as an example of conservation-focused energy performance improvements to a historic building of traditional construction.

Coordinating Project Partner: ***Landsverk***

Local Contact: ***Diocesan Authorities of the Faroe Islands***

Assessment Methods:

Method:	Aim:	Notes:
Meter readings	Determine energy consumption pre-refurbishment	5 years of energy consumption data available in the form of oil purchases and electricity bills
Review of energy consumption data from Energy Key system	Determine energy consumption post-refurbishment	Energy Key is a monitoring system developed in Denmark
Infrared thermography	Assess and analyse overall patterns of heat loss	Equipment used: Elma Instruments FLIR
Monitoring of CO2, relative humidity, and temperature	Monitor and evaluate post-retrofit indoor air quality	