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Support to the Renovation Wave – Deep Energy Renovation of Historic Buildings in Ireland

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Final Report

Trinomics

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Support to the Renovation Wave – Deep Energy Renovation of Historic Buildings in Ireland

In association with:

Shaffrey Architects

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Acronyms

BAU	Business as usual
BCR	Benefit Cost Ratio
BER	Building energy rating
CAP	Climate Action Plan
CBA	Cost benefit analysis
CO_2	Carbon dioxide
DECC	Department of Energy and Climate Change
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EED	Energy Efficiency Directive
EIB	European Investment Bank
ENPV	Economic Net Present Value
EPBD	Energy Performance in Buildings Directive
ERR	Economic rate of return
ESCO	Energy Service Company
EU	European Union
EUI	Energy Use Intensity
IAQ	Indoor Air Quality
IEPHP	Improving the energy performance of heritage properties
IES	Integrated Environmental Solutions
LCCA	Life Cycle Cost Assessment
LCCC	Limerick City and Country Council
LCD	Liquid crystal display
LTRS	Long-term renovation strategy
NIAH	National Inventory of Architectural Heritage
OPW	Office of Public Works
SCP	Social Climate Plans
SEAI	Sustainable Energy Authority of Ireland
TSI	Technical Support Instrument
TUS	Technical University of Shannon

1. Introduction

This report is the final report of the '*Support to the Renovation Wave – Deep Energy Renovation of Historic Buildings in Ireland*' contract funded by the European Union *via* the Technical Support Instrument (TSI), managed by SG REFORM[1] of the European Commission (EC). The beneficiaries of the work were the Office of Public Works (OPW) and Limerick City and County Council (LCCC) of Ireland. The project was implemented by Trinomics, Technological University of the Shannon (TUS), Shaffrey Architects, RIAI Grade 1 Conservation Architects, and Passivate Building Energy Consultants, in cooperation with the European Commission.

Context

Accounting for approximately 15% of Ireland's building stock, historical buildings have a role to play in supporting Ireland's climate mitigation ambitions through the implementation of safe and effective energy efficiency improvements. While protected structures are exempt from building regulations related to the Conservation of Fuel and Energy (Part L), Ireland's Climate Action Plan 2023 (CAP) specifies that the entire public sector, including historical buildings, will need to improve energy efficiency by 50% by 2030. Ireland's Long-term Renovation Strategy (LTRS) 2020 sets out the strategy for meeting targets through the renovation of the existing building stock.

In a European context, the Energy Performance of Buildings Directive (EPBD) (2010/31/EU), and subsequent revised EPBD (EU/2024/1275), seeks to achieve a fully decarbonised building stock by 2050 by spurring renovations in each Member State (MS). MSs must apply minimum requirements as regards the energy performance of new and renovated buildings. For non-residential buildings, the revised EPBD includes the gradual introduction of minimum energy performance standards to trigger the renovation of buildings with the lowest energy performance, based on national thresholds. Although MSs can exempt various categories of buildings from the rules, such as protected structures, the EPBD highlights the need to address, where feasible, the renovation of historic properties.

In Ireland, and also across the EU, there is a significant gap in expertise, detailed case studies and empirical data on improving the energy efficiency of historical buildings. The renovation of historical buildings is more complex than the renovation of buildings of modern construction namely due to the heritage aspects of the building which require qualified conservational expertise to determine appropriate interventions. Furthermore, there are hygrothermal risks associated with the installation of insulation where it previously never existed, potentially leading to expedited building fabric deterioration if not done correctly. In addition to these technical barriers, access to finance and a skills and capacity shortage across the construction industry are challenging but not insurmountable barriers. Therefore, wide reaching knowledge dissemination and upskilling is required across the sector to address these challenges efficiently and professionally.

Objective

The specific objective of this service contract was to assist national authorities in improving their capacity to design, develop and implement reforms in line with Article 4 of the TSI Regulation. The project aimed to support the OPW and LCCC in developing best-practice, evidence-based, cost-effective approaches for the energy retrofitting of historic buildings while protecting their heritage significance, as well as establishing a sustainable funding model for this purpose. To achieve these aims, the project provided the following:

- Developed **technical energy renovation case study exemplars** of four historic buildings in Ireland to support the *OPW Approaches to Improving the Energy Performance of Heritage Properties in State Care*;

[1] Reform and Investment Task Force (SG REFORM) – previously DG REFORM.

- Performed **holistic cost-benefit analysis** of these case studies to demonstrate the value for money and multiple benefits of investments in renovating historical buildings for improved energy efficiency;
- **Training programme and material** for upskilling responsible persons in the OPW, LCCC and wider Irish public sector regarding the OPW 'Guidance for Deep Energy Renovation of Public Sector Historic Properties' and the new supporting case studies. The trainings ensured capacity building and knowledge transfer; and
- Developed **guidelines for establishing a sustainable local/regional investment fund** for the renovation of historical buildings.

Reading guide

The aim of this final report is to summarise the performed activities, present key findings from the project, and provide SG REFORM and the beneficiaries with recommendations. This report is structured as follows.

- **Section 1** (the current chapter) provides an **introduction**.
- **Section 2** summarises **project deliverables and results**.
- **Section 3** provides a summary of key **project recommendations** developed across deliverables.

2. Summary of project results

This section presents and summarises the main deliverables and results of this project.

2.1. Deliverable 1 – Inception report

The inception report served as the key outcome of this project's inception phase, which set the foundation for strong output throughout the project. The specific objective of Deliverable 1 was to fine-tune the understanding of the assignment and agree on the methodological approach for the various deliverables, the overall work plan, as well as communication and governance practices. Specifically, the inception report included the following:

- an update of the methodology and timing for Deliverables 2 to 5, following discussions between the project team, SG REFORM, and the project beneficiaries;
- agreements regarding the study project's governance and communication, as well as an updated timeline for the overall project.

The report also provided minutes from the kick-off meeting and other meetings, as well as additional relevant information.

2.2. Deliverable 2 - Case studies and upgrade of methodology for deep renovation of historic buildings

2.2.1. Introduction

Background

Using the OPW 'Approaches to Improving the Energy Performance of Heritage Properties in State Care' ('the OPW IEPHP guidance')[2] the TSI project Deliverable 2 aimed to develop four desk-based exemplars / case studies for the energy upgrade of different types of traditionally built historic buildings in the public sector (including 'protected structures'). Through the development of these four case studies, the strategies and workflows of the guidance were further tested to build on the knowledge base for improving the energy performance of historic properties.

The OPW IEPHP guidance largely follows the framework suggested in the European standard I.S. EN 16883:2017 Conservation of cultural heritage - Guidelines for improving the energy performance of historic buildings (European Committee for Standardisation, 2017).

At the outset the OPW provided a longlist of potential case study buildings for consideration. All potential case studies were in the ownership or care of the OPW. A review of the long list of case studies was carried out by the case study design team in conjunction with the OPW, at which point the following criteria were set for selecting the four case studies:

Selected case studies must:

- Provide a variety of building typologies;
- Provide a variety of wall construction types and external finishes, to include cut-stone, rubble stone, brick, and a combination of these which are typical of construction types both in Ireland and Europe;
- Provide a variety of scale of building ranging from relatively small to larger scale;
- Provide a range in complexity of construction and heritage value;
- Provide a range of different building uses, which can have a significant impact on the proposed energy improvement strategies; and,
- All buildings must be feasibly accessible to the design team throughout the duration of the project.

[2] Office of Public Works, OPW, Approaches to Improving the Energy Performance of Heritage Properties in State Care (Dublin, 2024)

Once the four preferred buildings were agreed with the OPW, the preparation of the case studies followed the sequence of steps and milestones set out in the OPW IEPHP guidance document. This provided a practical approach to applying the process set out in the European Standard I.S. EN 16883:2017 Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings (European Committee for Standardisation, 2017)[3].

The four case studies aimed to explore a range of potential solutions, in particular for material specifications and renewable energy options. The focus of the case studies was on energy efficiency measures. In the context of a real-life project, other parameters will likely influence final details and specifications. Other necessary investigations and assessments to those carried out for the case studies will inform the specific solutions appropriate for each project.

The four buildings selected for the case studies were:

- Block 11, Collins Barracks, Dublin 7;
- 88 Merrion Square, Dublin 2;
- Oldbridge House, Co. Meath;
- 23 Kildare Street, Dublin 2.

The Office of Public Works, Ireland supported the consultant team with the analysis of each building through providing measured surveys, arranging for localised opening up works of the building fabric for further investigation, facilitated carrying out in-situ testing, as well as coordinating inspection visits to the buildings. The OPW Heritage Services provided representatives to act as 'client' during development of proposals, as well as an in-house multi-disciplinary steering group for each of the case-study buildings.

Case Study Building Overview

Below is an overview of the four case study buildings selected. All case studies are protected structures and rated of Regional or National Importance value on the National Inventory of Architectural Heritage (NIAH).

Block 11, Collins Barracks, Dublin 7

Block 11 is part of the historic Collins Barracks, formerly Royal Barracks military complex. It was previously used as a stable and a gymnasium, and more recently as office and storage space for the OPW. The building was built between 1820-1840 with alterations between 1867 and 1884. It is a two-storey, simple institution-type, solid masonry structure, with a long rectangular form and natural slate pitched roof.

88 Merrion Square, Dublin 2

No. 88 is one of the earliest buildings on Merrion Square, dating to the mid-1750's. Located at the southern end of a terrace of 8 buildings, it was significantly altered externally and internally in 1859, with new brick facing and large windows introduced to the long southern façade. No. 88 was originally occupied as a house and is now used as ancillary office and archival storage space by the National Gallery of Ireland. No 88 is a four storey over basement building constructed of solid brick walls on a solid masonry basement.

Oldbridge House, Co. Meath

Oldbridge House is part of the Oldbridge Estate and is built on the site of the 1690 Battle of the Boyne. It is a large, detached country house that is part of a wider historic demesne, located in a rural setting. The present house was built in the 1750s on the grounds of an earlier post-medieval gabled house. It was originally constructed as a three-bay, three-storey over basement central block with two-bay, two-storey over basement wings to either side. The house was subsequently altered internally and externally in the 1830s with an additional storey added to the side wings giving the building its present form.

[3] European Committee for Standardisation, I.S. EN 16883:2017 Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings (2017)

23 Kildare Street, Dublin 2

23 Kildare Street is located in central Dublin and is part of the Leinster House complex of Government buildings. The result of an architectural competition, it is a purpose-built government building, developed to house the Department of Industry and Commerce. It was built between 1938 and 1942 as a concrete and steel frame building with brick cavity infill and faced with predominately ashlar granite and limestone for the string courses, cornices and carved panels. It is an example of 20th century architectural heritage that has stood the test of time due to the workmanship being of the highest quality. It remains in its original use as Departmental offices for two Government Ministries.

Approach

In line with the OPW IEPHB guidance document and I.S. EN 16883:2017 standard, the approach to the development of the four case studies followed the 5 stages as set out in the OPW IEPHB document.

Stage 1. Initiating the Process

Stage 1 established the context as well as the appointment of the design team.

Stage 2. Building Assessment

Stage 2 assessed the existing building to gain an understanding of the heritage significance, construction, local environment and energy performance to create the existing baseline model. This was also the stage where in-situ measurements were taken. Two models were developed for the existing baseline; one using default values and one using measured / calculated values.

Stage 3. Refining Objectives and Setting Targets

Stage 3 reviewed the original project targets and objectives against the information gathered in Stage 2 to assess if these targets seem achievable and revises these targets and objectives if required.

Stage 4. Design and Specification

Stage 4 identified the repair / maintenance issues to be addressed as well as developing the strategies and proposals for the building fabric and services interventions. These interventions were then tested in thermal modelling / hygrothermal models. The interventions were also assessed against their impact on the heritage significance of the building. Similarly to Stage 2, two final energy models were created, one using default values to provide an official Building Energy Rating (BER) and one using measured / calculated values to model a more accurate energy performance rating for the building.

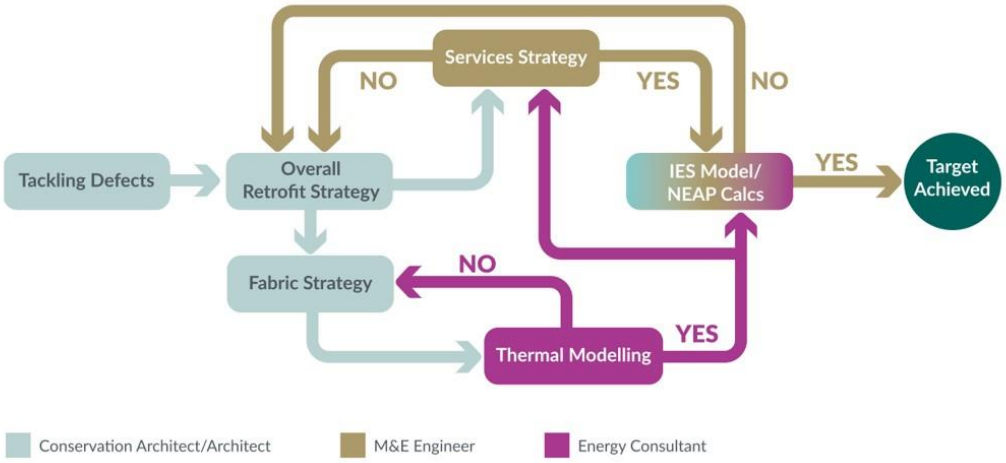
Stage 5. Implementation, Post-Occupancy Evaluation and Monitoring

Stage 5 recommended post-occupancy evaluation and monitoring that should be carried out.

Methodology

While not all projects followed the same process, these four case studies typically adopted a consistent approach in developing the proposed interventions as set out in Figure 2-1 below.

Figure 2-1. Stage 4 design process workflow diagram from the OPW IEPHB document.



After identifying the existing defects to be addressed, an overall retrofit strategy was developed. This typically involved establishing at a high-level what interventions would be feasible, such as, will an intervention to the walls be acceptable or not. Generally, the development of the overall fabric strategy was progressed first. This was followed by the services strategy development. The case studies underwent a cyclical process of identifying individual proposals and testing these in the relevant models. If the proposals did not meet the objectives set, it was necessary to review the overall strategy and test again. Once the proposals did achieve the objectives, they were fed into the proposed energy model (in the case of the four case studies this was an Integrated Environmental Solutions (IES) model) with the final outcome calculated.

Additional Considerations

Alongside the project brief, there were a number of other considerations that were particularly relevant for the development of the case studies.

Consideration of Heritage Impact

Throughout the process of developing the case studies, it was vitally important to constantly review the impact proposals would have on the building heritage. For instance, at Stage 2 it was necessary to identify the significance of the building. Later, each intervention was assessed against the heritage impact. Following the establishment of the final proposals another review of the impact on the architectural heritage was undertaken with any mitigation measures identified if necessary. This highlighted the importance of considering the impact on the building heritage at all stages of the project.

Default and Measured Values

As noted above, two models for the existing and proposed condition were prepared based on using either default values or measured / calculated values. Since measured in-situ values are currently not accepted for use in an official published BER in Ireland, it was necessary to calculate the official BER based on default values as well as the more accurate measured BER using the in-situ values. This was useful to identify if there was a difference between the two BERs and primary energy use. Using the BER based on the measured in-situ values ensures that any interventions are correctly designed and applied, however, this may mean that the official published BER will be lower than the actual BER.

Ventilation Requirements

As the case studies adopted a fabric first approach, attention was given to the impact on ventilation requirements, in particular with regard to meeting Part F of the Irish Building Regulations[4]. In some cases, the interventions necessary to meet ventilation requirements can have a greater impact on the architectural heritage than those required for energy efficiency and need to be carefully considered as part of the overall impact on the building.

2.2.2. Case Study Summaries

Case Study 1 – Block 11, Collins Barracks

Figure 2-2 Block 11, Collins Barracks south façade



Block 11 has simple interiors with limited decorative finishes and the height of the building only rises to two storeys with a generous attic space. As such it was possible to propose a number of interventions to both the fabric and services that may not have been possible in other scenarios, which resulted in a very significant improvement in the energy performance of the building from an existing BER of G to a proposed BER of B1.

However, there were several key challenges and opportunities that were highlighted during the development of the case study interventions.

Proposals for upgrading the thermal envelope initially included the first-floor red brick extension and the west gable lean-to structure. However, due to the limited benefit of upgrading the lean-to structure, it was decided to exclude this element from the thermal envelope, retaining it as an external covered space while providing low-level heating to manage condensation.

The plaster skirting and the upgrades to the first-floor extension floor presented particular challenges. The plaster skirting is an interesting surviving detail and there was a desire to retain this detail. However, this required a break in the thermal line, which needed to be tested in the thermal model to identify if there was a risk of surface condensation and mould growth before the proposal could be confirmed. Similarly, the floor upgrade solution to the first-floor extension presented some awkward junctions that had to be tested in the thermal modelling to identify the risk of surface condensation and mould growth.

The first-floor extension's concrete floor posed a challenge for upgrading due to the risk of interstitial condensation. The initial proposal to replace the screed with insulated material was deemed high risk. Instead, insulating below the slab was found to be a safer option, even though it resulted in a break in the thermal line.

The installation of the services interventions requires careful design, detailing and execution. However, the strategy benefits from the relatively simple building form and generous space within the attic to allow for the installation of a new heating system as well as a full mechanical ventilation and heat recovery system in a discrete and reversible solution.

[4] Part F of the Irish Building Regulations provides guidelines on ventilation, aiming to ensure that buildings have adequate ventilation to maintain healthy indoor air quality.

Case Study 2 – 88 Merrion Square, Dublin

This 18th century townhouse is a typical example of the iconic Dublin Georgian townhouse. The building is located in a very prominent and sensitive location within the South Georgian Dublin quarter. The building is a commonly found typology of 18th and 19th century urban buildings in Ireland and within Europe. It retains high level of historic fabric and is an end of terrace property with a characteristic multi-level internal layout. The type of construction and the challenges that face upgrading this type of property are very prevalent within Europe.

Figure 2-3 88 Merrion Square front façade



As such the solutions developed for 88 Merrion Square had to deal with regularly occurring issues, which make this case study a really useful example of how to work through proposals and problems to arrive at a set of robust solutions. Added to this was the less common feature of the rear conservatory extension which generated a creative solution to isolate it from the thermal envelope to avoid alterations which would have had adverse architectural heritage impacts. These solutions provided significant improvement in the energy performance of a building that is challenging with many constraints, resulting in bringing the building from an existing BER of D2 to a proposed BER of B3.

The focus of the approach and primary opportunities to install insulation to No. 88 Merrion Square was the roof and the basement floor, with minimal intervention to the walls, and limited/localised interventions to the windows. This minimised impact to the heritage values and historic characteristics of the building.

Also, of particular note in the solutions to 88 Merrion Square was the ventilation strategy. The existing building relies on the natural permeability of the building and openable windows. While this existing strategy works sufficiently, the proposed interventions to the fabric will improve the airtightness level, therefore a mechanical ventilation solution was more appropriate in this instance. The creative use of the existing chimney flues as the ductwork routes would avoid unacceptable interventions to the rooms, particularly to the decorative plasterwork.

Case Study 3 – Oldbridge House, Meath

Oldbridge House is located in a rural area of high historic and archaeological importance and retains a substantial amount of original, or historic fabric. As a detached property it also has a high percentage of thermal envelope, however, as a mostly rectangular building it has a relatively efficient form.

Figure 2-4 Oldbridge House front façade



The building is common / typical in many ways. It is a detached estate house similar to many historic house museums found throughout Ireland and across Europe. The type of construction is commonly found in buildings of this period and location, and the challenges that face upgrading this type of property are very prevalent.

The existing construction of the external walls with internal decorative features is a common typology and the solutions to address these in particular are worth noting. It is worth noting that the proposals have responded sensitively to the existing building historic fabric and avoided making interventions that would have had an unacceptable negative impact on the historic character.

Of particular note is the in-situ measured good thermal performance of the external walls. The wall build-up, with a lath and plaster internal finish, has a small air gap between the lath and internal brick leaf, which enhances the thermal performance. This aspect, again often found in Ireland and Europe, is important to highlight as it allowed for the walls to remain as existing and avoided the potential need for large scale wall insulation.

The proposed intervention solutions provided significant improvement in the energy performance of a historic building that is challenging with many constraints, resulting in bringing the building from an existing measured BER of E2 to a proposed BER of B3.

The final proposals omitted initial proposals to upgrade the existing windows with new double or vacuum glazing as it was preferable to retain the existing single glazing from a heritage point of view as it imparts a more authentic experience for the museum. The case study report identifies the testing that was carried out both on including or omitting the window upgrades to assist in the decision-making process.

The approach for Oldbridge House therefore focused on improving energy efficiency of the building roof and basement floor. The good thermal performance of the existing walls meant that energy upgrade interventions to the walls would not be required, with only localised insulation to the worst performing areas of the walls, such as in the window reveals where the wall thickness is reduced.

Case Study 4 – 23 Kildare Street, Dublin

23 Kildare Street, like all case studies, presented its own challenges in the development of the overall upgrade strategy proposals. The building is located in a prominent city centre location. The building was constructed in the late 1930's and retains a high level of original fabric in good condition. The building form also presents a high percentage of the thermal envelope.

Figure 2-5 Street façade of 23 Kildare Street



The building is a good example of early to mid-20th century construction that is similar to many buildings throughout Ireland and across Europe, and the challenges that face upgrading this type of property are very prevalent.

Although there were a number of challenges with upgrading 23 Kildare Street, particularly to the walls, proposals were worked through to arrive at a set of solutions to provide significant improvement in the energy performance of the building. This resulted in bringing the building from an existing BER of D2 to a proposed BER of B2.

The development of 23 Kildare Street benefitted greatly from the extensive historic drawings and specification documents available. The original drawings and specifications were instrumental in understanding the building's construction, providing reliable information that confirmed as-built conditions. Access to service risers within walls offered a non-invasive look at the wall build-up, to confirm the build-ups. This reduced the need for invasive exploratory work

Hygrothermal and thermal modelling of the existing external walls identified an existing risk of interstitial condensation between the granite layer and the outer brick leaf, as well as a risk of surface condensation and mould growth internally. Based on a visual inspection, the existing building does not appear to be showing any signs of issues due to this risk of interstitial condensation, though the proposals had to be cognisant of this existing condition.

One of the more challenging areas to address as part of the energy upgrades was the approach to the external walls. Original drawings confirmed the presence of a cavity wall system in 60-70% of the external walls. While using cavity insulation was initially considered to improve thermal performance with minimal disruption, it was not suitable overall due to the risk of surface condensation and mould growth. Thus, internal wall insulation was the preferred approach. Although this introduced a new

layer internally that would be more disruptive, it minimised the risk of surface condensation and mould growth compared to the cavity wall insulation option.

The ventilation strategy was also one of the most complex issues to address in 23 Kildare Street. Since introducing ductwork for a mechanical system would have caused significant disruption to the interior finishes and a natural ventilation solution that relied on holes in the external walls would not be acceptable, a bespoke managed solution had to be explored whereby ventilation is provided by the naturally occurring permeability of the building fabric as well as through openings (i.e. windows and doors). The indoor air quality would be monitored by sensors in each room which indicates to the occupants when it is necessary to introduce additional fresh air into a space. Trickle vents could be introduced into the frames of the timber window sliding sashes if additional background ventilation was deemed to be required.

The existing underfloor heating system is an original and innovative feature of the building. While the proposals in the case study look at a new heating output system (such as radiators) since reusing the underfloor heating may not be certifiable, this should be explored further as it would be much better from a heritage perspective to reuse the existing underfloor heating pipes. Alternatively, introducing radiators on the external walls can use the additional layer of internal wall insulation to run pipework in to minimise the visual clutter in the spaces.

The building is currently heated via connection to an energy centre location at Leinster House. There is currently no information available on the future decarbonisation or upgrade of that energy centre on which further studies could be carried out to examine the impact of that on future performance of the case study project. The roof-top air-source heat pump will have installed capacity to cater for the whole building as currently modelled, however the decentralised connection to the existing energy centre will be retained in a bi-valent manner to offer some redundancy or additional installed capacity for unusually cold periods.

2.2.3. Implementation, Post-Occupancy Evaluation and Monitoring Summary

As the case studies are essentially at a detailed feasibility stage, in line with the OPW IEPHB Stage 5, general recommendations were made on the evaluations that should be undertaken during and after completion of the renovation works. While these tests or monitoring are relevant to all the case studies, other tests may also be necessary once the works are developed in more detail.

Airtightness

An air pressurisation test should be carried out to confirm the airtightness level of the building following the energy upgrades. This should be undertaken prior to the completion of the works on site to allow for any areas of excessive air leakage identified to be address.

It is particularly important to calculate the proposed airtightness level as it may have an impact on the supply of ventilation required.

Indoor Air Quality

The use of Indoor Air Quality (IAQ) sensor technology provides building occupants with useful data on indoor temperature, relative humidity and CO_2 levels and provides them with the information needed to respond to changes in the indoor environment.

In some case studies the ventilation strategy relies on natural ventilation and openable windows, therefore, it is critical in these instances that indoor air quality monitors are used. Using IAQ sensor technology with data shown on a liquid crystal display (LCD), will inform occupants as to when it may be necessary to open windows to increase natural ventilation (albeit for short periods of time in cold or inclement weather).

Energy Use Intensity

Energy Use Intensity (EUI) is the delivered energy consumption per m2 that is required by the building over the course of a year. When assessing energy used by a building one needs to be careful

in comparing this to that predicted by the Building Energy Rating certificate. There will always be key differences between the two. The BER certificate does not include for 'plug' loads, i.e. all equipment connected to the general-purpose plug outlets, server rooms and power for data management systems, and catering functions. Also, the BER assessment is based on a standard set of operational hours, typically 10 hours a day, 5 days a week. Any deviations from the assumed hours of operation in the BER assessment will lead to differences in the energy used versus the predicted energy use. However, monitoring of the EUI can provide useful feedback on how the building is performing compared to the designed model.

Occupant Satisfaction Survey

Following occupation of the building an occupant satisfaction survey should be carried out to evaluate the buildings performance to check if the objectives have been met in practice and whether the strategies are performing as designed. This provides important information on the project and may highlight any shortfalls in the strategies.

An initial evaluation should be carried out soon after occupation of the building and focus on functionality and the need for any adjustments. A second evaluation should be carried out within 1-3 years.

Interstitial Moisture Monitoring

Interstitial moisture monitoring is used to determine the rate at which the fabric dries out post-construction, as well as to monitor moisture levels at points of interest in the façade over time post-occupancy. The analysis is carried out by inserting relative humidity probes into the wall at specific depths to arrive at a point of interest. Typically, the probes would be installed to monitor relative humidity at the interface of the newly installed insulation layer and the original substrate.

Due to the equipment costs and challenges in installing such equipment, as well as the knowledge required to carry out accurate data validation and comparison of the measured vs. calculated values, this is not a monitoring procedure that would be recommended on all building projects, but rather in situations where perhaps new methods are being employed, or a new material is being used for which not a lot of information is currently available.

Ideally, this monitoring would take place over a period of at least one year, with two-to-three years providing a more robust data set against which comparisons can be drawn, and under which the drying-out period should be complete. The continuous monitoring can then be used to ensure critical moisture levels are not reached, and examine the effects of severe weather events, be that excessive rain or indeed heat, may have on the performance and behaviour of the wall.

2.2.4. Conclusion

On review of four case studies of different building typologies, construction materials and uses, it is positive to see that there is an opportunity for appropriate sensitive energy upgrades to be carried out that can have a meaningful energy efficiency improvement impact whilst protecting the heritage significance of the buildings.

The development of the case studies will help to expand the knowledge base in the area of improvements to the thermal performance of heritage buildings. As more case studies are developed, they will also provide further useful insight that should be disseminated to the wider field.

Alongside this, in the future if the proposed interventions to the case studies are implemented the case study reports should also be updated to assess if the designed proposals reflect the actual implementation. This would also provide valuable insight into future energy performance improvement projects.

2.3. Deliverable 3 - Cost benefit analysis for energy efficiency renovation of historic structures

2.3.1. Introduction

Preserving historical buildings while improving their energy efficiency, presents a unique challenge. Deliverable 3 explored how a cost-benefit analysis (CBA) can be used to evaluate the energy renovation activities planned in Ireland. This method offers a framework for decision-making by considering not just the financial aspects, but also the environmental and social impacts of the project.

The objective of this deliverable was to analyse and demonstrate the value for money of energy efficiency renovation investments based on a holistic cost and benefit analysis using CBA methods. This involved assessing the total economic implications of the renovation project while simultaneously highlighting the broader environmental and societal benefits associated with improved energy efficiency.

CBA can provide a picture of the economic viability, environmental impacts, and potential societal gains associated with the renovation projects. This information will be valuable for decision-makers when weighing up the costs and benefits of the proposed renovation activities.

The CBA methodology employed in this deliverable followed a structured approach that included defining objectives, identifying and quantifying costs and benefits, determining the time horizon, discounting future values, calculating the Economic Net Present Value (ENPV), conducting sensitivity analysis, and evaluating risks. This framework ensured a comprehensive assessment of the energy efficiency renovation project's financial and socio-economic implications, facilitating informed decision-making.

Context

For decision-makers, navigating the complex landscape of historical building renovations requires a careful evaluation of the long-term economic and environmental impacts. Cost-Benefit Analysis plays a crucial role in this process. By comparing the costs of energy efficiency upgrades against the anticipated benefits—both direct and indirect—CBA provides decision-makers with a comprehensive understanding of the economic feasibility of renovation projects. It allows for a clearer picture of how public funds can be most effectively allocated to achieve both environmental and economic sustainability.

In the context of historical building renovations, a CBA is particularly valuable as it helps decision-makers balance the financial demands of preserving cultural heritage with the urgent need for energy improvements. This methodology not only supports the selection of cost-effective retrofit measures but also highlights the long-term benefits, such as reduced operational costs, improved energy efficiency, and enhanced heritage preservation, all of which contribute to the broader goals of sustainable development. Through the integration of CBA into the decision-making process, stakeholders can ensure that renovations align with national sustainability goals while safeguarding Ireland's architectural heritage for future generations.

CBA in Heritage Building Renovation

CBA is a widely used method for evaluating the economic feasibility of projects by comparing the total expected costs against the benefits derived from the project. In heritage conservation, CBA can be instrumental in determining whether the long-term benefits of preserving a historical building outweigh the initial and ongoing costs associated with its restoration.[5] This approach is particularly

[5] Hromada, E.; Macek, D.; Heralova, R.S.; Brožová, L.; Strelcová, I., Integrating Life Cycle Cost Analysis for Sustainable Maintenance of Historic Buildings. Buildings 2024, 14, 1479. https://doi.org/10.3390/buildings14051479

important when the costs of retrofitting historical buildings are high, but the benefits — such as cultural value, tourism, and local economic growth — are substantial.[6]

For instance, the energy efficiency improvements in historical buildings can have both direct and indirect benefits. Direct benefits include reduced energy consumption and maintenance costs, while indirect benefits might include enhanced property values and increased attractiveness for tourism or community engagement.[7] These benefits, though often intangible, are essential in the decision-making process, as they contribute to the cultural and social value that a preserved heritage site offers.[8]

2.3.2. Applied Methodologies

Cost Benefit Analysis

CBA is a critical analytical tool employed to evaluate the economic merits and drawbacks of investment projects. This methodology allows for a systematic assessment of costs and benefits, facilitating informed decision-making regarding resource allocation. As outlined in the "Guide to Cost-Benefit Analysis of Investment Projects" published by the Directorate-General for Regional and Urban Policy (DG REGIO), CBA serves to demonstrate the welfare changes attributable to a proposed intervention.[9]

Life Cycle Cost Assessment (LCCA)

Life Cycle Cost Assessment (LCCA) is another tool for evaluating the economic feasibility and sustainability of energy-efficient renovations of historical buildings. This methodology follows the ISO 15868-5:2017 standard, which ensures a systematic approach to assessing all costs across a building's life cycle, from design to demolition. LCCA combined with the CBA to present lifetime costs and benefits as part of the Deliverable 3.

Embodied Carbon Calculation

Embodied carbon calculation is used to evaluate and compare the carbon emissions associated with the renovation of historical buildings versus constructing new buildings. This method helps quantify the environmental impact of refurbishment projects by calculating the carbon emissions embedded in building materials and processes. By comparing the embodied carbon of retrofitting a historic building with that of new construction, the environmental benefits of preserving and upgrading existing structures were highlighted, thereby supporting sustainable building practices and contributing to carbon reduction goals in the context of energy-efficient renovations.

Operational Carbon Calculation

Operational carbon benefits are assessed by comparing the CO_2 emissions from energy consumption in the renovation scenario with those in the Business-as-Usual (BAU) scenario. This comparison helps quantify the environmental impact of energy-efficient renovations, showing how much carbon emissions are reduced by adopting energy-saving measures in the renovation process.

2.3.3. Case Study Selection

The case studies evaluated in this deliverable are the same as those selected for Deliverable 2. CBA and LCCA were conducted for the following case studies: Block 11 Collins Barracks, Oldbridge House, 88 Merrion Square, and 23 Kildare Street.

[6] Butkovic, L. L.; Mihic, M.; Nahod, M.; Sigmund, Z., The Benefits of Cost-Benefit Analysis in Construction Projects, 2022, 6th IPMA Senet Project Management Conference: Digital Transformation and Sustainable Development In Project Management.

[7] Yuming Liu, Tingting Liu, Sudong Ye, Yisheng Liu, Cost-Benefit Analysis for Energy Efficiency Retrofit of Existing Buildings: A Case Study in China, Journal of Cleaner Production (2017), DOI: 10.1016/j.jclepro.2017.12.225

[8] Wilkinson, S., Ying, F. J, The Application of Life Cycle Costing for Building Retrofit, 2007, CIB World Building Congress.

[9] European Commission (2021). Economic Appraisal Vademecum 2021-2027 - General Principles and Sector Applications.

For each case study, both costs and benefits were collected. Savings resulting from the renovations, including energy efficiency improvements and reduced emissions, were monetized, and a comprehensive economic analysis was conducted to assess the financial and environmental impacts of the renovations.

2.3.4. Results and conclusions

All case studies were evaluated economically from a limited perspective. Some cases are part of larger building complexes; however, the renovation scenario is only applied to certain parts of these complexes. Therefore, the results presented in this section may differ if the cost-benefit analysis is conducted with a wider scope.

Block 11 Collins Barracks

Based on the results of the economic and environmental analyses, the Collins Barracks renovation project is a highly recommended option for public investment. The positive net benefits, a high benefit-cost ratio, and an Economic Rate of Return (ERR) three times higher than the selected discount rate indicate that the project is economically viable and provides significant returns on investment. Additionally, the environmental savings further enhance the project's value by aligning with Ireland's sustainability targets.

The most sensitive parameter in this analysis was the renovation cost, which significantly affects the project's economic outcomes. A 20% increase in renovation costs could substantially reduce net benefits and ERR, emphasizing the need for accurate cost forecasting and effective project management. Therefore, it is essential that the renovation costs are closely monitored to ensure the economic viability of the project.

Given the strong economic indicators and environmental impact, this renovation project should proceed as a highly viable investment, contributing both to economic sustainability and carbon reduction goals. This case exemplifies how energy-efficient renovations can provide substantial returns on investment while preserving historical buildings for future generations.

Oldbridge House

The Oldbridge House renovation is a unique and complex case, due to the historical significance of the facility, which includes an important battlefield and museum central to Irish history. While the CBA focused solely on a section of the main building and its renovation, it is crucial to note that the full scope of the building's size and age significantly influenced the investment requirements. The renovation's economic feasibility was limited, as the potential benefits—primarily rent benefits for the OPW- did not outweigh the large investment required for the entire structure.

The economic analysis revealed that the net benefits over a 30-year period were substantially increased when compared to the business-as-usual scenario, and the renovation scenario itself did not produce a positive economic outlook but the operational and maintenance costs reduced significantly. The low Benefit-Cost Ratio (BCR), coupled with negative incremental and net benefits, indicated that the project would not meet the financial thresholds required for proceeding. Additionally, the ERR could not be calculated, reinforcing that the renovation failed to generate sufficient returns above the cost of capital.

However, it's important to recognize that Oldbridge House provides a range of qualitative benefits—social, cultural, and heritage-related—that were difficult to monetize in the analysis. These include its role in Irish heritage and its potential as a key historical and educational site. The renovation provides substantial environmental benefits, including reductions in operational carbon emissions and embodied carbon savings, making it a sustainable project when viewed from an environmental perspective. If sustainability or regulatory mandates are prioritized, these benefits might justify proceeding with the renovation, despite the negative financial results.

Given the lack of economic return and the negative incremental benefits, it is recommended to reassess the renovation project with a focus on controlling costs and exploring ways to monetize non-financial benefits such as heritage, tourism, etc. Should the costs be reduced and the overall benefits

increased, there may be an opportunity to improve the project's economic feasibility. Alternatively, if the project aligns with broader sustainability objectives, the environmental benefits could still serve as a valid reason to proceed with the renovation.

88 Merrion Square

The 88 Merrion Square renovation project is considered likely viable, with a high BCR and a positive ERR which is almost three times higher than the discount rate. While the project generates positive net benefits, the negative incremental benefit of suggests that, from a purely economic perspective, the renovation does not outperform the BAU scenario significantly. This highlights the need for further refinement of project assumptions, particularly renovation costs.

The most sensitive parameter in this analysis is renovation costs, which have a direct and significant impact on both net benefits and ERR. Increases in renovation costs would reduce the project's financial viability, while cost reductions would improve its outcomes. Therefore, effective cost forecasting and management are crucial for ensuring the project's success. The environmental savings in carbon emissions and the reduction in embodied carbon further enhance the project's value, but it is recommended that these benefits be considered in tandem with financial returns to ensure the full value of the renovation is captured.

In conclusion, while the 88 Merrion Square renovation is economically viable, it falls within a moderate return range and requires further evaluation. It is important to keep in mind that this evaluation was made only for the focused aspects of the renovation described in Deliverable 2. Therefore, if the scope of the renovation is extended to the entire building complex, these results may change and present a more positive picture. Given the environmental benefits and positive economic indicators, it is recommended to proceed with the renovation, particularly if cost management is closely monitored and further sensitivity analyses are conducted. The renovation aligns with sustainability goals and provides an opportunity to enhance the building's long-term value, but caution should be exercised due to the modest return on investment.

23 Kildare Street

23 Kildare Street renovation project is a highly viable investment, with a high Benefit-Cost Ratio, indicating a strong return on investment. The Economic Rate of Return five times higher than the selected discount rate, further reinforces the financial feasibility of the project, making it a profitable choice. However, the negative incremental benefit suggests that, from a purely financial standpoint, the renovation does not provide significantly more benefits than the Business-as-usual (BAU) scenario. This highlights the importance of considering non-financial benefits, such as environmental impact and heritage preservation, in the decision-making process.

The most sensitive parameter in this analysis is renovation costs. As shown in the sensitivity analysis, increases in renovation costs significantly reduce both net benefits and ERR, while cost reductions improve the project's financial viability. Effective cost management and accurate cost estimation will be crucial to ensure the project's success and maintain its positive financial performance.

Given the positive net benefits, the strong ERR, and the substantial environmental savings, it is recommended to proceed with the renovation, while ensuring that renovation costs are carefully monitored and controlled. The renovation offers both economic and environmental benefits, and it aligns with broader sustainability and public policy objectives, making it a strong candidate for public investment. As it's indicated in the previous case study, this evaluation was made only for the focused aspects of the renovation described in Deliverable 2. Therefore, if the scope of the renovation is extended to the entire building complex, these results may change and present a more positive picture.

Conclusion

The findings from the case studies suggest that energy-efficient renovations are a highly effective strategy for achieving both the economic sustainability and environmental preservation of heritage buildings in Ireland. The economic analyses indicate that these renovations provide strong net benefits, and the environmental impact is significantly reduced, contributing to national and EU climate goals. The CBA, LCCA, and carbon footprint methodologies provide clear and reliable metrics

that policymakers can use to guide decision-making and ensure that public funds are invested wisely. By adopting a holistic approach that incorporates both economic and environmental considerations, Ireland can meet its sustainability goals while preserving its architectural heritage for future generations.

Thus, it is recommended that energy-efficient renovations of heritage buildings be integrated into Ireland's broader sustainability and climate action strategies, ensuring that these projects continue to deliver long-term benefits for the economy, the environment, and society. Below, the insights from this analysis for economic, environmental, social and cultural benefits are described below.

Economic Benefits

The economic analysis of all the case studies consistently reveals that energy-efficient renovations provide positive net benefits, making them a financially viable option for preserving heritage buildings. Through energy-saving measures and improved operational efficiency, such as enhanced insulation, better heating and cooling systems, and renewable energy integration, these renovations lead to significant reductions in energy consumption and maintenance costs. In many cases, the long-term financial savings from these improvements outweigh the initial investment, demonstrating the viability of energy-efficient retrofits from an economic perspective. Moreover, the Life Cycle Cost Assessment confirms that these projects offer value over the entire lifecycle of the building, providing both short-term benefits and long-term cost reductions.

Environmental Benefits

One of the key findings from the analyses is the environmental impact of these renovations. The carbon footprint calculations clearly show that energy-efficient renovations significantly reduce the carbon emissions of heritage buildings, particularly in the operational phase. By lowering energy demand through modern technologies, these projects contribute to Ireland's broader sustainability targets and the European Union's commitment to reducing carbon emissions. The reduction in embodied carbon, through more sustainable materials and conservation-focused approaches, further strengthens the argument for prioritizing energy-efficient renovations in heritage building projects. These renovations align with Ireland's climate action goals by helping to reduce the overall environmental footprint of the built heritage sector.

When considering the full life cycle carbon of a building, it is crucial to adopt a long-term view of both embodied and operational carbon emissions and costs. The energy-efficient renovations discussed across the case studies clearly show that while operational carbon savings, achieved through improved insulation, heating, and cooling systems, significantly reduce ongoing emissions, the embodied carbon—which includes emissions associated with construction, renovation materials, and demolition—also plays a major role. A key takeaway from these renovations is the importance of reducing embodied carbon, not only through the choice of sustainable materials but also by retaining as much of the existing structure as possible, preserving historical value while minimizing resource extraction and waste generation. This long-term perspective allows stakeholders to assess carbon impacts over the full lifespan of a building, from its construction phase to operation and eventual end of life, supporting the case for renovations over new construction, especially in heritage contexts where circularity can be maximized.

The renovation of heritage buildings can be greatly enhanced by applying the 9R principles of circularity, which provide a framework for improving sustainability in the built environment. These principles—refuse, reduce, reuse, repair, refurbish, recycle, recover, rethink, and redesign—are essential for guiding decisions throughout the renovation process. For example, the principles of reuse and refurbish allow for preserving original materials and structures, while repairing rather than replacing elements can reduce the environmental footprint. The focus on reducing energy consumption and recycling materials further enhances sustainability, while the ideas of rethink and redesign ensure that future renovations consider both energy efficiency and circularity in their planning stages. Incorporating these principles into energy-efficient renovations of heritage buildings aligns with Ireland's climate action goals, fostering a circular economy in which buildings remain useful and sustainable throughout their lifespans, contributing to long-term environmental benefits and resource conservation.

Social and Cultural Benefits

In addition to the economic and environmental advantages, energy-efficient renovations offer broader societal benefits. These renovations contribute to cultural preservation, maintaining and enhancing the architectural heritage that defines Ireland's cultural identity. They also offer social benefits, such as improved comfort for the building's occupants, reduced energy poverty, and the creation of a more sustainable built environment for future generations. Additionally, the preservation of heritage sites often boosts local economies by increasing tourism and fostering a greater sense of community pride. These social and cultural benefits are often more difficult to quantify but are significant in reinforcing the case for energy-efficient renovations.

Limitations, Scope, Assumptions, and Theoretical Nature of the Analysis

It is important to acknowledge the limitations and scope of the economic and environmental analyses conducted. The study primarily focused on certain aspects of the renovations, and due to the complexity of heritage buildings, a number of qualitative benefits—such as cultural significance, community engagement, and long-term societal impacts—could not be directly quantified. Additionally, monetary values for non-financial benefits (such as social and heritage value) were not fully incorporated into the economic model, which may affect the comprehensiveness of the analysis.

The assumptions made in the models are based on general projections for energy savings, operational costs, and environmental impacts, which may vary depending on specific circumstances, construction materials, and renovation techniques. These projections also assume consistent energy prices, which may fluctuate over time. Finally, the analysis should be seen as theoretical in nature, offering insights based on available data, but without definitive predictions for each individual building renovation project.

The recommendations provided should be considered with these factors in mind, particularly the need for further refinement in accounting for all the qualitative and non-financial benefits that energy-efficient renovations of heritage buildings can offer. As such, this analysis serves as a foundation for making informed decisions and further studies should refine the assumptions to reflect local context and priorities.

2.4. Deliverable 4 - Training programme and material

This deliverable encompassed the development of training content and the delivery of a 3-day training event at OPW's Dublin Castle conference facility and online.

Attendees included architects, engineers, surveyors, specifiers, historic building managers, and architectural conservation officers from the OPW and Local Authorities, as well as representatives from relevant government departmental bodies, and stakeholders from architectural conservation NGOs across Ireland.

The training included presentations by 35 eminent speakers across a range of topics under the themes of policy, practice and wider benefits.

Figure 2-6 The TSI project team at the Training Event in Dublin Castle.



2.4.1. Training Day 1: Policy

The first day of the trainings was held on the 17th of January 2025 in Dublin, consisting of four sessions:

- Welcome and introductions
- Session 1: The Big Picture
- Session 2: TSI project: Context of Deep Energy Renovation of Historic Buildings in Ireland
- Session 3: How Policy Affects Us
- Session 4: Social and Cultural Influence of Heritage Buildings.

The first day training had 117 in-person attendees and 243 online attendees. Most attendees were architects (196), followed by engineers (42) and managers (27).

The moderator was Eileen Dunne, a well-known TV presenter on the National Television.

Figure 2-7 Day 1 Training in Dublin



Welcome and introductions

The welcome and introductions of the first day training included short introductions from: John Conlon (Chair of OPW), Kaspar Richter (Directorate-General for Structural Reform Support, European Commission) and Prof. Vincent Cunnane (President of TUS). The introduction session was moderated by Eileen Dunne.

Session 1: The Big Picture

The first session of the day included presentations from three speakers, which provided the attendees with a broader context of the reasons for initiating this training on energy renovation of historic buildings.:

- *Climate Change: Impacts and Responses from an Irish Perspective* by Conor Murphy (ICARUS);
- Historical buildings under the recast EPBD and recast EED by Nina Neuman (European Commission); and
- *How the EPBD leads to significant changes to the renovation of our traditional buildings in Ireland* by Georgina Molloy (SEAI).

Session 2: TSI project: Context of Deep Energy Renovation of Historic Buildings in Ireland

The second session of the day provided an overview of the TSI project which the training programme is a part of. The session included three presentations:

- *Support to the Renovation Wave – EU Technical Support Instrument* by Jovana Jović Komnenić (European Commission);
- *Origins of the Project* by Audrey Farrell (OPW) and Kieran Reeves (LCCC); and
- *Overview of the Project Results* by Koen Rademaekers (Trinomics).

The second session was closed with a discussion panel with the presenters from the first two sessions, focusing on Energy and Carbon Performance for Historical Buildings.

Session 3: How policy affects us

The third session of the day delved deeper into the legislation and various policy elements within Ireland, with emphasis on how they affect traditional and heritage buildings. in particular in relation to the importance of circularity, decarbonisation and Building Information Modelling, these included presentations from:

- *Sustainability and Circular Requirements Impacting on Traditional and Heritage Buildings* by Charles Mitchell (Office of Government Procurement);
- *Energy Upgrading of Traditional Buildings for Low Embodied and Life Cycle Emissions* by Jacqui Donnelly (National Built Heritage Service); and
- *What the BIM Mandate means in terms of Traditional and Historical buildings* by Stephan Lynam (Office of Government Procurement).

Session 4: Social and Cultural influence of heritage buildings

The last session of the day comprised of a keynote speech from former President of Ireland Mary Robinson with an inspirational speech on the social and cultural influence of heritage buildings.

The final discussion panel: Changes Influencing the Renovation of Historical Buildings enabled the attendees to ask questions to the speakers via the Vevox tool.

2.4.2. Training Day 2: Practice

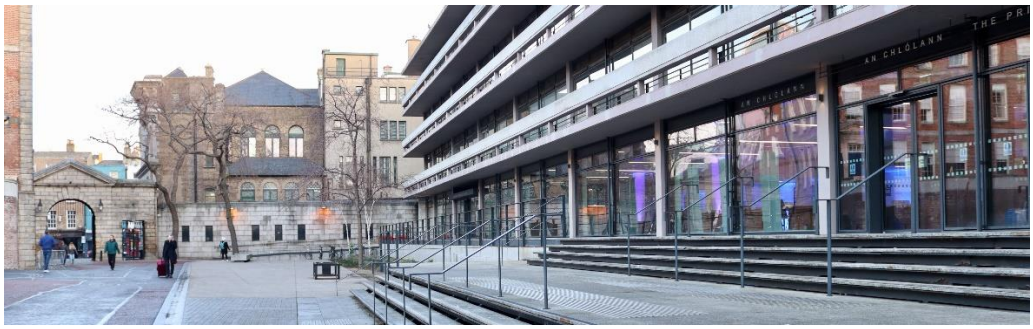
The second day of the trainings was held on the 25th of February 2025 in Dublin (rescheduled due to extreme weather conditions and a nationwide Status Red weather warning), which consisted of four sessions:

- Session 1: Building Assessment
- Session 2: TSI Project: Approaches to Deep Energy Renovation of Historic Buildings - Case Studies
- Session 3: Decarbonisation of Buildings
- Session 4: Futureproofing Renovation

The second day of training had 143 in-person attendees and 269 online attendees. Most attendees were architects (223), followed by engineers (49) and managers (31).

The Training Day was moderated by Tomás O'Connor from the Office of Public Works.

Figure 2-8 Day 2 Training at the Print Works, Dublin Castle



Session 1: Building Assessment

The first session included three presentations detailing the importance of assessing the building fabric condition before commencing renovation:

- *Traditional buildings – characteristics and condition* by Frank Keohane (Building Surveyor),
- *FabTrads Project* by Dr. Rosanne Walker (UCD) and
- *Scan to BIM and Defect Investigations – BIM case study for Heuston Station* by Robert Bartley (Murphy Geospatial).

Session 2: TSI Project: Approaches to Deep Energy Renovation of Historic Buildings - Case Studies

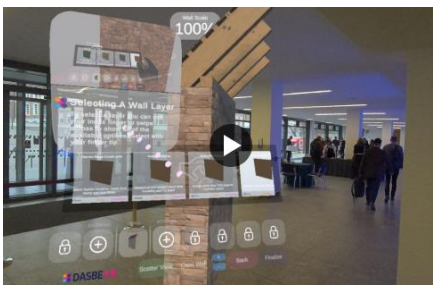
The second session comprised of a joint presentation by the project team of the case studies from Deliverable 2 by Grainne Shaffrey, Jonathan Buckley (Shaffrey Architects) and Andrew Lundberg (Passivate).

This followed with a discussion panel which covered questions not only on the TSI project, but also factors related to building fabric, hygroscopicity and importance of digital tools to assess buildings efficiently.

During lunchtime, attendees were able to network and gather advice from a number of specialized exhibitors working within the conservation industry - Leica Geosystems, Murphy Geospatial, Ecological Building Systems, Contec Specialist Building Products, Roundtower Lime, Partel, and Grants Ireland Heating Solutions. Additionally, two demonstrations outside the Printworks in the courtyard, gathered a lot of interest with a lime and lath plaster demo form Nolans Group and handmade brick moulds with Calx Restoration. Passivate also demonstrated how to set up a heat flux installation during the coffee breaks.

Figure 2-9 Demonstrations at the Day 2 Training Event







Session 3: Decarbonisation of Buildings

The third session focused on integrating low-carbon and renewable energy systems into historic buildings. Simon Jones completed the session with a talk on the importance of appropriate ventilation:

- *Heating from the Ceiling: Evaluating Electric Wallpaper in Scottish Housing Association Tenements via a Sensor-based System* by Dr. Ahmad Taha (University of Glascow),
- *Integrating Geothermal Systems* by Ric Pasquali (GeoServ)
- *The future of RES PV and historic buildings with MorphoColor film technology - Herisol Case study* by Dr Jan-Bleicke Eggers (Fraunhofer Institute) and
- *Ventilation and Indoor Environmental Quality in Buildings* by Simon Jones (Air Quality Matters).

Session 4: Futureproofing renovation

The last session of the second training session included a presentation by Adrian Joyce from Efficient Buildings Europe on the policy developments in the EU and their impact on Irish traditional buildings.

2.4.3. Training Day 3: Impact

The third day of the trainings was held on the 7th of February 2025 in Dublin, which consisted of four sessions:

- Session 1: TSI Project: The Wider Benefits of Renovation
- Session 2: Informed Decision Making
- Session 3: Learning from Practice
- Session 4: Benefits to Society

The training day had 139 in-person attendees and 257 online attendees. Most attendees were architects (214), followed by engineers (48) and managers (30).

The Moderator was Pat Barry from the Irish Green building Council.

Figure 2-10 Day 3 Training at the Print Works, Dublin Castle



Session 1: TSI Project: The Wider Benefits of Renovation

The first session included three presentations relating to Deliverables 3 and 5 of this study:

- *What's the difference? Carbon and Cost Benefit Analysis, TSI Case Studies* by Afrodit Adsal (Trinomics)
- Sustainable investment and financial models by Jessica Glicker (Trinomics)
- *Limerick City Xchange – Positive Energy Block Limerick* by Kieran Reeves (LCCC).

Session 2: Informed Decision Making

The second session of the day focused on informed decision making, including three presentations:

- *The Deep Retrofit of Tom Johnson House* by Dan Costelloe (OPW)
- *WUfI and building a database* by Joseph Little (TU Dublin)
- *IES Decarbonisation Digital Twins Dublin City – Operational Energy and Whole Life Carbon* by Dr. Niall Buckley (IES)

The second session was closed with a discussion panel with the presenters from the first two sessions, focusing on the wider benefits of decarbonisation.

During the lunch break the attendees were able to test out the Virtual Reality (VR) education tool, developed within TUS a spart of the DASBE (Digital academy of the Sustainable Built Environment) project. This VR tool allowed attendees to detect defects within a traditional thatch cottage, learn about heat pumps and assess the U-value of different compositions of a stone wall.

Session 3: Learning from Practice

The third session included three presentations concerning the wider aspects of renovating historical buildings through monitoring the energy performance after completion, repurposing and reusing demolition materials, and a final presentation outlining a number of relevant trainings available across Ireland to encourage further upskilling:

- *Dublin Castle Offices – post-renovation monitoring by* Audrey Farrell (OPW) and Andrew Lundberg (Passivate)
- *Adaptive Re-use of LSE project* by Laura Burley (Chipperfields UK) and
- *Upskilling opportunities for Historic Renovations and Decarbonisation* by Lis O'Brien (TUS)

Session 4: Benefits to Society

The last session of the Day 3 training included a keynote speech by Adala Leeson from Historic England on *Heritage in use: towards a more holistic understanding and valuation*. Evaluating the importance of historical value, incorporating all aspects socially, environmentally and economically.

The third day ended with a discussion panel including session 3 and 4 presenters on *Are we all together in the Decarbonisation of our Buildings?*.

2.4.1. Dissemination of training material

To ensure that all attendees availed of as much information the three training days were recorded and made available to all registered attendees over an online TUS SDRI Moodle e-learning platform (Moodle), along with a pdf copy of lecture slides. This allowed any attendee who missed a part of the training an opportunity to 'catch up'. The demonstrations were also recorded to allow the online attendees to review the content and experience the learnings.

Within a period of time after the training days, attendees were asked to complete a number of questions on the platform. Once completed, TUS provided a CPD certificate to confirm certificate of attendance.

Figure 2-11 TUS SDRI Moodle e-learning platform



2.5. Deliverable 5 - Guidelines for the establishment of a sustainable local/regional investment fund for the renovation of historic buildings

This deliverable, developed with input from the beneficiary Limerick City and County Council (LCCC), focused on developing a **replicable funding model for the renovation of historic buildings in Ireland**, with a focus on the city of Limerick.

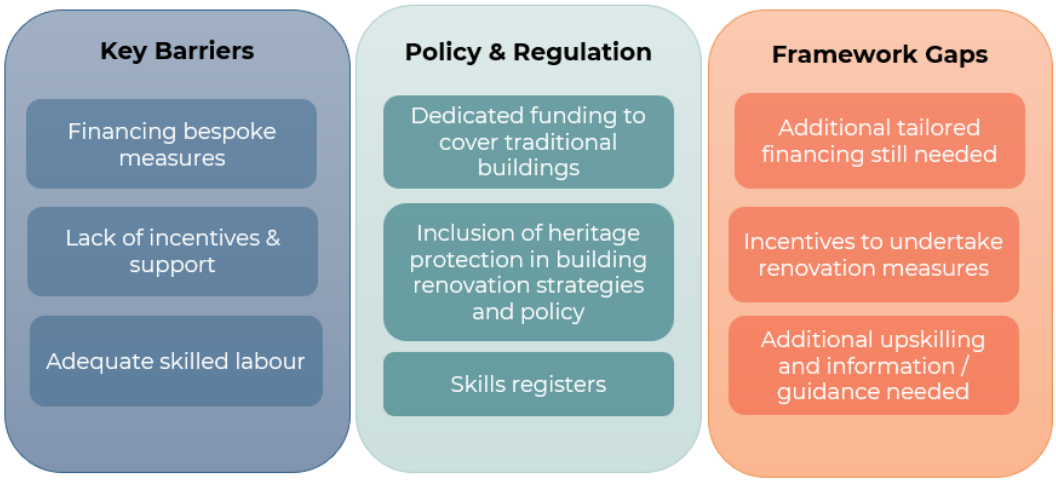
In this deliverable, a major component was the proposal of a **business plan for a revolving fund**, which included an assessment of a range of funding sources—including grants, loans, tax incentives, and private-sector investment—alongside potential repayment mechanisms such as Energy Performance Contracting (EPC), on-bill financing, and crowdfunding. The proposed business plan was informed by an analysis of the existing legislative and regulatory landscape in Ireland to identify possible barriers to implementation, as well as an assessment of best practices from other regions.

The final report of the deliverable outlines the **legal structure, governance, investment strategy, and financial sustainability of the proposed fund**, incorporating climate action goals and aligning with Ireland's public expenditure framework. The outcome is a comprehensive set of guidelines that can be used by local and regional authorities across Ireland to establish similar funding mechanisms, supporting large-scale, sustainable energy renovations of historic buildings nationwide.

2.5.1. Legislative/regulatory framework

This section summarises the **key barriers, current relevant policy and regulation, and remaining gaps** related to the renovation of historic buildings in Ireland (Figure 2-12). The findings were derived from a desk review of key national legislative and policy documents and supplemented by semi-structured interviews gathering insights from key stakeholders, including representatives from national and local government and stakeholders working on building perseveration at the national level.

Figure 2-12 Key barriers, current relevant policy and regulation, and remaining gaps related to the renovation of historic buildings in Ireland



Based on the research, it can be concluded that there exists a **strong interplay between legislation, plans, guidance, and funding mechanisms** in Ireland's efforts to retrofit buildings and protect architectural heritage. Multiple stakeholders contribute to achieving this objective, including government departments, local authorities, and heritage organisations. This is an evolving landscape, continuously incorporating new programmes and regulations to advance Ireland's national decarbonisation goals. Together, these elements form an integrated and dynamic approach to balancing Ireland's climate action priorities with heritage conservation goals.

Against this regulatory background, the following key findings were derived from the research.

Key barriers

The key regulatory barriers to financing the renovation of historic buildings in Ireland include the following:

- **Financing bespoke measures:** The main financial barriers to building renovations are well known and include long payback periods and risks associated with failing to achieve projected energy and financial savings. A significant barrier to renovating historic buildings in Ireland specifically is the high upfront cost associated with these often bespoke renovation measures, particularly those addressing energy efficiency improvements, as renovating historic buildings often requires specialised materials and skilled labour to maintain their heritage value, significantly increasing costs compared to modern structures.
- **Lack of incentives and support:** A lack of clear financial incentives and programmes specifically tailored to encouraging the renovation of historic buildings. Many potential renovators struggle to navigate a complex landscape of subsidies and grants and receive little to no guidance regarding available funding opportunities. Additionally, historic buildings are often not eligible for the funding opportunities available for building renovations due to stringent eligibility criteria.
- **Insufficient skilled labour:** A shortage of skilled professionals familiar with the needs of historic buildings and how to integrate modern energy efficiency practices with heritage conservation has also been identified as a significant barrier.

Current policy and regulation

The following policies, measures and programmes have been developed in Ireland to address the barriers identified above:

- **Dedicated funding:** Specific grant schemes from the Sustainable Energy Authority of Ireland (SEAI) offer financial assistance for retrofitting buildings, though these are not always tailored to the unique needs of historic buildings. SEAI primarily supports retrofitting under the National Retrofit Plan and the newly developed Traditional Homes Pilot. Furthermore, the Department of Housing focuses on heritage conservation through programmes like the Built Heritage Investment Scheme for protected structures and the Historic Structures Fund for community and public buildings. Additionally, the Heritage Council's Community Heritage Grant Scheme and Living City Initiative were emphasised in the interviews as key relevant funding programmes.
- **Heritage protection and national guidance:** There are several guidance documents, plans, and regulations addressing national decarbonisation, building decarbonisation, and the renovation of historic buildings (Table 2-1).

Table 2-1 Key guidance documents, plans, and regulations addressing national decarbonisation, building decarbonisation, and the renovation of historic buildings

Document/plan/regulation	Relevance to the renovation of historic buildings
Climate Action and Low Carbon Development (Amendment) Act	Overarching frameworks for promoting energy efficiency across sectors, including the built environment
Climate Action Plan	
Planning and Development Act 2000	Lays the groundwork for protecting historic buildings but can sometimes complicate efforts to align conservation needs with energy efficiency improvements.
National Retrofit Plan	Central to renovation planning, setting targets and outlining strategies to enhance building energy performance.
Long-term Renovation Strategy	

Document/plan/regulation	Relevance to the renovation of historic buildings
Irish Standard IS EN 16883:2017	Provides essential guidance on improving energy performance in historic buildings on a more technical level.
Climate Change Sectoral Adaptation Plan for Built and Archaeological Heritage	Emphasises adapting historic buildings to climate change, integrating resilience with energy efficiency.
Department of Housing, Local Government, and Heritage (DHLGH) Advice Series	Offers practical recommendations for retrofitting in alignment with conservation principles.
Architectural Heritage Protection Guidelines	Provide methodologies for energy renovations while safeguarding heritage values.

- **Skills registers:** Further support for historic building renovation is supplied heritage organisations and public bodies through skills registers. The Heritage Council supports a network of conservation officers aiding in the protecting of built heritage, while the Irish Georgian Society offers training and maintains an informal skills register – the Traditional Building Skills Register – which provides access to skilled tradespeople experienced in traditional building techniques. While this particular register is not accredited, there are various accredited registers available to homeowners, including the Royal Institute of Architects of Ireland and Conservation Accreditation Register for Engineers, which provide formal accreditation for professionals with expertise in conservation work, thereby ensuring that professionals in heritage conservation are adequately equipped.

Framework gaps

While the measures discussed above offer substantial technical and regulatory support for historic building renovations in Ireland, the following regulatory gaps remain:

- **Lack of tailored financing:** While programmes like the SEAI's grants and subsidies aim to promote energy efficiency improvements, they often do not address the unique requirements of historic building owners. Furthermore, existing national and regional initiatives tend to prioritise large-scale renovations, leaving smaller historic buildings and individual property owners underserved. Finally, funding is sometimes only available on a small scale (e.g., EURO 2 000), which is insufficient for more comprehensive renovations.
- **Unclear information and guidance:** Many of the existing policy and regulatory documents fall short of providing actionable, on-the-ground guidance marrying energy efficiency measures and preservation, leaving property owners uncertain about how to navigate the complex balance between heritage protection and energy efficiency. For example, key terms (e.g., "vulnerable buildings" or "adequate renovation") lack clear criteria and therefore create difficulties in policy implementation. Furthermore, the integration of heritage considerations into broader climate policies, such as the Climate Action and Low Carbon Development (Amendment) Act, remains limited. Additionally, specific guidelines bridging the gap between energy performance and heritage conservation remain incomplete in some areas, creating uncertainty and limiting progress.
- **Insufficient upskilling opportunities:** Currently, there is a notable gap in training programmes tailored to professionals and contractors navigating the unique challenges of energy renovations for historic properties. Greater investment is required in professional training and workforce development to build the necessary skills for this niche area.

2.5.2. Best practices for financing building energy renovations

This section presents key takeaways from a review of nine best practice examples of financing building energy renovations across the EU and the US (Table 2-2), which was conducted in order to inform the establishment of a revolving fund for energy renovation of historic buildings in Ireland.

Table 2-2 Overview of best practices, including type of funding, implementing body, and budget

No.	Programme	Country	Type of funding	Implementing body	Budget
1	Renovation Bonus	Austria	Grant	Kommunal Kredit Public Consulting	€ 2.4 million for 2023-2027
2	Energy Efficiency and Renewable Sources Fund	Bulgaria	Revolving fund	EEE Consortium (Econoler-EnEffect-Elana)	€ 11.2 million for 2004-2008
3	National Energy Savings Fund	Netherlands	Revolving fund	Warmtefonds is run by Zanders Treasury & Finance Solutions . The fund executor is Polestar Bemiddeling .	€ 300 million
4	Renovation Loan Programme	Estonia	Revolving fund	KredEx (public financing institution)	€ 175 million
5	Energy Renovation in Buildings Plan	France	Mixture of policy and financing packages/programmes	Minister for Energy and the Minister for Housing	€ 14 billion in public support
6	+CityxChange Project	Ireland	Grant	Limerick City and County Council	€ 6.5 million
7	Federal Historic Preservation Tax Incentives	United States	Tax incentive	National Park Service (Technical Preservation Services division), Internal Revenue Service, and the State Historic Preservation Offices	N/A
8	Renovation of Historic Campus Buildings	United States	Performance based repayment	Johnson Controls (ESCO)	USD 5.9 million (Approx € 5.5 million)
9	Green mortgages	Ireland	Mortgage	Bank of Ireland	€ 5 billion

Based on the review of best practices for building energy renovation, the following lessons can be drawn for setting up a revolving fund:

- **Combine initial grants with revolving funds for long-term fund sustainability:** Start by offering a combination of grants or subsidies to encourage early participation and uptake, especially in markets unfamiliar with energy efficiency financing. As the programme matures, transition to a revolving fund model to ensure long-term financial sustainability of the fund. This approach mirrors successful programmes that have evolved from grant-based support to self-sustaining revolving funds. Alternatively, establish or utilise multiple funding sources to cover the costs of renovation, such as a loan with a complimentary grant.
- **Establish fund size in relation to other available/complementary funding sources:** When establishing the programme budget, consider the availability of complementary funding sources, ensuring the fund can effectively leverage additional resources. A comprehensive evaluation of these factors allows for a more strategic allocation of resources, ensuring that the fund is adequately sized to meet project needs while complementing other available financial programs, thus maximising impact across the target area.
    - **Scope of the programme:** Programmes with a focus on deep renovation (e.g., Austria, France) typically require larger budgets because of the higher cost per project. In contrast, programmes targeting medium renovations (e.g., Estonia, Bulgaria) can have smaller budgets but must be supported by complementary funding sources to cover total project costs.
    - **Type and number of stakeholders:** The budget should be determined based on the number of buildings and stakeholders involved. For example, homeowner-based programmes (Netherlands, Ireland) may need smaller, more focused budgets

compared to programmes addressing public or multi-unit buildings (France, Austria, USA), which involve more complex financing and coordination.
    - **Complementary funding sources:** Many programs (e.g., Bulgaria's Energy Efficiency Fund) rely on complementary sources, such as development banks (EBRD, World Bank) and private investors, to supplement smaller government funds. In cases where the fund does not cover the full cost of a project, technical assistance plays a key role in guiding stakeholders to additional funding.
- **Offer complementary technical assistance to enhance fund attractiveness:** A valuable complementary component offered by many implementing bodies, is technical assistance**.** This support, often provided by development banks or public financial institutions (as seen in the Bulgarian case with EBRD), enhances the fund's effectiveness. With a comprehensive understanding of complementary available funding programs, the fund size can be smaller and strategically deployed to supplement other resources. This added layer of guidance makes the fund more appealing to recipients, as it maximises its usefulness by offering expertise on integrating other financial tools, thus facilitating the completion of energy efficiency projects.
- **Involve a range of implementing bodies for broader expertise:** Consider a diverse range of implementing bodies, including public institutions, local authorities, and private entities like Energy Service Companies (ESCOs). Public financing institutions can manage the fund, while private entities and local governments could help with outreach, implementation, and technical support.
    - **Public financial institutions** (e.g., Bulgaria's Energy Efficiency and Renewable Sources Fund) provide credibility, access to large-scale financing, and can offer technical assistance, which is key for projects requiring complex energy efficiency improvements. These institutions are effective when they coordinate with other sources like development banks or private investors.
    - **Government agencies** (e.g., Austria's Renovation Bonus, France's Energy Renovation Plan) are well-positioned to manage large-scale renovation efforts, particularly when there's significant public funding involved. Their ability to set clear policy frameworks and coordinate across different sectors (e.g., construction, financial institutions, local governments) enhances the programme's reach and scalability.
    - **Private financial institutions** (e.g., Ireland's Green Mortgages) can be successful in implementing energy efficiency programmes when market-driven incentives, such as lower interest rates for energy-efficient homes, align well with homeowners' interests.
- **Ensure regular monitoring and reporting:** Implement robust monitoring and reporting mechanisms to track the performance of projects funded by the revolving fund. Require periodic energy audits post-renovation to verify that savings targets are met. This will help improve accountability, refine the eligibility criteria over time, and provide data to adjust fund terms and conditions to maximize energy efficiency outcomes.

2.5.3. Options for the appropriate framework to facilitate the establishment of a revolving funding mechanism

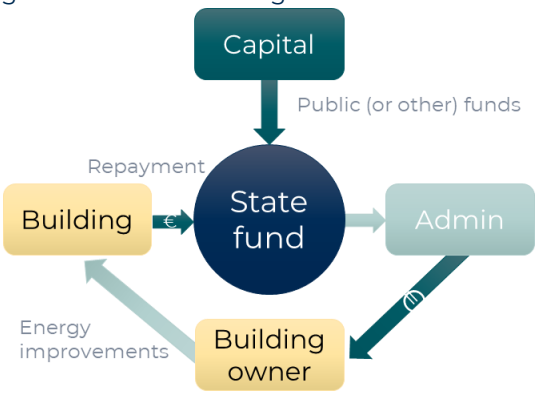
The task team presented a detailed analysis of the potential frameworks for establishing a revolving funding mechanism during the January 23rd monthly progress meeting. This session, attended by the steering committee, project team, and key beneficiaries, provided an opportunity to review and evaluate the most suitable financial and legal structures for implementation. The presentation outlined various options, highlighting their feasibility, regulatory considerations, and potential impact.

For the financial structure of the fund, two primary frameworks were selected: **direct lending and co-lending**. In addition, a national-level **energy service company (ESCO)** model was considered, which would entail a combination of a financing structure *and* an implementation model. The legal structure of the fund is dependent on the type of framework chosen. Each framework has advantages and disadvantages in terms of flexibility, complexity, ability to leverage capital, and other factors.

2.5.3.1.Direct Lending

Direct lending (see Figure 2-13 for an example) involves the state, directly providing loans to borrowers at a low interest rate. This approach is fully funded by Limerick, allowing for the possibility of highly competitive interest rates. The administration of these loans can either be managed in-house or outsourced to an external administrator. While this model ensures full control over the fund and loan terms, it also comes with a significant financial and administrative burden.

Figure 2-13 Direct lending financial framework

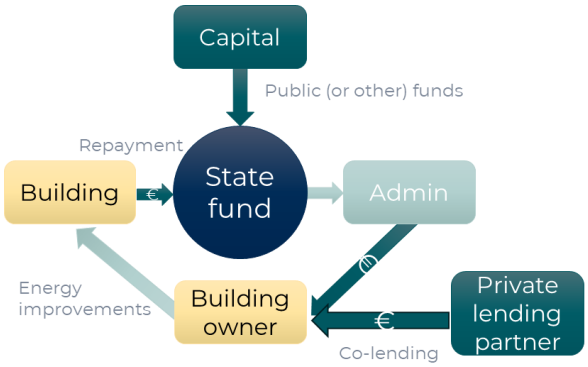


Source: Adapted from US DOE, Better Buildings

2.5.3.2.Co-Lending

Co-lending is a model where Limerick partially funds the loans alongside a co-lender, such as SEAI or a private funder. This structure allows for a low overall interest rate while ensuring that the private lender receives all the interest, making it financially attractive for them. Limerick provides a portion of the loan capital at a reduced interest rate, while the co-lender earns a typical interest rate on their share, further incentivising private sector participation. The co-lender, particularly a bank or an institution experienced in lending, can handle all administrative aspects, including underwriting and determining loan terms. Both Limerick and the lender share the risk in case of loan defaults. This approach balances public and private roles, reducing costs for the city while limiting its direct control over loan terms.

Figure 2-14 Co-financing financial framework



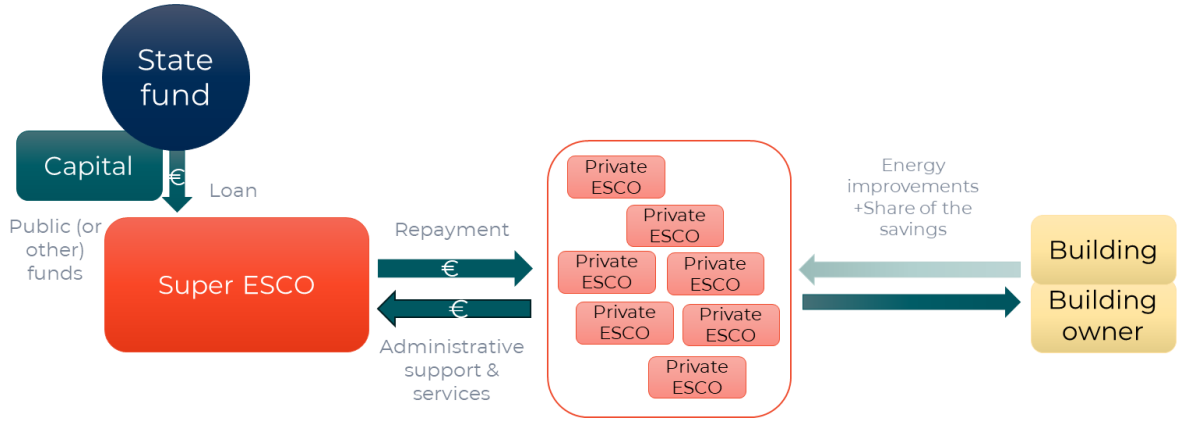
Source: Adapted from US DOE, Better Buildings

2.5.3.3.Super ESCO Model

An **Energy Service Company (ESCO)**[10] model for financing and implementing energy renovations differs from traditional models like direct lending and co-lending because it combines both financing and project execution under a single entity. In a traditional ESCO model, the ESCO finances, implements, and manages the renovation, with repayment tied to the actual energy savings achieved over time. This contrasts with direct lending and co-lending, where the fund is administered to cover the renovation, and building owners separately contract service providers to execute the works, assuming full financial and performance risk.

[10] The Super ESCO concept was developed in the 1990s as a potential solution to address not only the limitations of the Energy Performance Contracting (EPC) scheme, but also the Energy Service Company (ESCO) sector's lack of capacity, willingness, or interest to get involved in project financing (Econoler,series - super ESCO).

Figure 2-15 Super ESCO model



In the context of setting up a national revolving fund, a **Super ESCO** can be particularly interesting. A Super ESCO differs from a traditional ESCO in that it operates at a national level, aggregating and financing multiple energy efficiency projects, while also providing technical support and market development. While a traditional ESCO typically focuses on implementing individual projects for clients, often with limited resources and smaller-scale operations, a Super ESCO acts as a facilitator, de-risking investments and attracting funding.

A Super ESCO secures initial capital from government budgets, development banks, green funds, or international institutions. This funding is then used to finance energy efficiency projects through energy performance contracts where repayments are made based on the actual energy savings achieved, similar to a traditional ESCO.

A Super ESCO is particularly well-suited for the management of a national-level revolving fund, especially in countries with a nascent or non-existent ESCO market. Unlike individual ESCOs, which may lack the scale or financial capacity to take on multiple projects, a Super ESCO can pool resources, spread risks, and ensure a steady flow of reinvestment into new projects. By acting as a trusted intermediary, it can also attract investment, secure concessional financing, and ensure project quality and accountability, which is crucial for a self-sustaining revolving fund.

2.5.4. Discussions with potential contributors to the fund

Discussions with potential contributors were integrated into the interviews conducted and further explored during the workshop. By engaging stakeholders consistently across these tasks, we ensured a more cohesive and informed dialogue throughout the project. This approach allowed us to gather valuable insights while fostering collaboration, making it more effective to address key issues in a structured and interconnected manner. Combining these discussions within the broader stakeholder engagement process also maximized efficiency, ensuring that feedback and contributions were aligned with the project's objectives and evolving findings.

2.5.5. Business plan

The business plan provided a more in-depth analysis of the proposed financing frameworks, including direct lending, co-lending, and the ESCO model (which was originally introduced as a standard ESCO structure). Additionally, it expanded on the legal structure based on feedback from the beneficiary, presenting an overview of various potential models such as a public trust or nonprofit foundation, public-private partnership, municipal or government-backed fund, green investment fund, or a super ESCO.

Furthermore, the business plan incorporated climate action outcomes, an investment strategy, and financial forecasting to ensure long-term sustainability and impact. Lastly, the report outlined clear guidelines for local and regional authorities, providing actionable next steps to support implementation.

2.5.6. Workshop with stakeholders

The task team organized a hybrid workshop to present and discuss the feasibility and next steps for establishing a potential fund. Held as a side event on Day 3 of the Dublin training (Task 4) on February 7th, the workshop featured a comprehensive presentation of the business plan, regulatory review, and best practices. Additionally, an external expert shared insights from an established revolving fund in Bulgaria, fostering in-depth discussions among stakeholders.

Participants included public authorities from Cork, Galway, Dublin, and Limerick, along with representatives from the European Investment Bank, National Treasury Management Agency, and Strategic Banking Corporation of Ireland. The workshop provided valuable input, significantly contributing to the development of the final report under Task 5.

3. Project recommendations of key priority actions

This section provides a summary of key project recommendations developed across deliverables to provide a quick overview of recommended priority actions to be carried out by the beneficiary authorities.

3.1. General points of note and recommendations to strengthen OPW guidance based on the case study findings

While each of the case studies presented its own challenges unique to each building, there were some key points of note across all or multiple case studies. Below are some reflections and recommendations that could be incorporated or further emphasised in a future edit of the OPW 'Approaches to Improving the Energy Performance of Heritage Properties in State Care' ('the OPW IEPHP guidance'). Some of these points exist in the guidance already, but after the case studies put them into practice, their importance in contribution to an informed energy renovation design process has been highlighted here. The step-by-step approach set out in the in OPW Guidance document provided a really valuable roadmap in producing the case studies. And while there are a number of recommendations below to further develop the guide, this is more a case of refinement than wholescale changes.

3.1.1. Performing in-situ testing of existing wall fabric

In-situ U-value and Karsten tube tests were carried out on all the case studies. While some results confirmed the accuracy of the default values (as in 23 Kildare Street), others provided more surprising, positive results. In particular at Oldbridge House the in-situ U-value tests confirmed the walls have a very good thermal performance. The importance of in-situ testing is most obvious in Oldbridge House since the results showed that it was not necessary to introduce insulation to the build-up since the walls were already at an acceptable level. Had the in-situ tests not been carried out and a default value used for the existing wall, this would have suggested the need to introduce IWI to the external walls to improve the thermal performance, which would have impacted the heritage value / historic character through a potential loss of historic fabric and decorative plasterwork, as well as additional unnecessary material used.

3.1.2. Investigation works to confirm assumptions

The level of investigation works will depend on the complexity of each building; however, it is necessary to confirm assumptions made regarding the existing construction during the early stages of the design process. It might not always be possible to carry out invasive opening up works, especially if the building is occupied and of a sensitive nature. However, there may be discrete locations where localised opening up can occur, or if opening up works coincide with other maintenance works these can be less disruptive. Nevertheless, through investigative works should be undertaken prior to proposing interventions to the building fabric.

3.1.3. Using default and measured values to calculate BER and intervention proposals

Using both the default and measured values to calculate the BER and building energy performance can provide an insight into different results between the official BER (using default values) and the actual performance of the building (using measured or calculated values). As noted in the OPW IEPHP guide using measured values is important to ensure that the appropriate interventions are proposed, however, using default values to also create the official BER is useful throughout to identify if the official BER will be different than the actual performance. It may identify that the official BER is lower than the target BER rating set out in the project brief (for instance the official BER as a C1 but the actual performance as a B3).

3.1.4. Recognising the building's heritage value and important of an architectural heritage impact assessment

Understanding the importance of the building's heritage cannot be overstated. This is a fundamental element in assessing whether a proposal will be suitable or not. This will typically happen as part of a project, as part of the Architectural Heritage Impact Assessment, by a recognised heritage professional relating to heritage buildings regardless of whether the project is for energy upgrades or not. However, it is worth restating the importance as it will have an essential impact on the final proposal.

The initial stages of the case studies examined the building in terms of heritage significance and identified the categories of special interest. This formed the basis for proposing suitable interventions and for assessing the impact on the building. It is important that the energy upgrade works are conceived as opportunities to enhance architectural and heritage aspects where feasible. It is beneficial to reflect on the proposals with an Architectural Heritage Impact Assessment at the end of Stage 4. This holistic review of the proposals considers potential for both adverse and positive impacts. It is also an opportunity to reflect on the reasoning for such proposals.

3.1.5. Identifying the values to be applied

After assessing the existing building in Stage 1 and 2, in Stage 3, it is necessary to review at high-level the targets and objectives to identify any challenges in achieving these early on. It is useful at this stage to identify specific values against which the existing building performance can be assessed. For the four case studies these values were taken from Building Regulations technical guidance document Part L, and this will likely be the route in most case studies, however, in other instances they may come from different external sources, such as similar projects or case studies, or professional experience.

3.1.6. Identifying the thermal envelope

The thermal envelope will often be fixed from the outset of a project. However, it is worth assessing this at a high level to determine whether the existing thermal line is the most efficient solution. In both Collins Barracks and 88 Merrion Square the thermal line was altered to provide a more efficient solution to the upgrades, by excluding a relatively small 'addition' to the main building. In both instances maintaining the existing thermal line would have involved interventions that would have resulted in either excessive upgrades for minimal gain, such as in Collins Barracks, or loss of historic fabric, such as in 88 Merrion Square. It was preferable in these cases to alter the thermal line to make a more efficient proposal, while still retaining use of these existing spaces.

3.1.7. Investigating multiple solutions and acceptable materials via assessment tables

In all the case studies, a wide range of solutions and materials have been proposed. In some instances, it is clear that a particular solution or material is the right, or only, choice for that intervention. In other instances, there may be multiple suitable solutions or materials. The case studies aim to give a wide range of material solutions while using the assessment tables to identify the preferred proposal. However, across the four case studies it may be possible to swap out one solution or material for another and still achieve the same objective. This would be developed as part of the detailed design development stage where further assessment of the proposals would be undertaken. We would recommend that the assessment tables be used as a live document to be updated as more information becomes available, such as installation costs.

3.1.8. Consultation with Statutory Bodies

As noted in all the case studies, the overall proposals in the case studies would require planning permission and building control compliance. Early consultation with the Planning Authority Conservation Officer and Building Control department would be necessary to address any concerns which may impact on the overall upgrade strategy.

3.2. Recommendations for cost benefit analysis for energy efficiency renovation of historic buildings

The following recommendations are based on the work conducted under Deliverable 3. These recommendations are aimed to further guide OPW with cost benefit analysis for energy efficiency renovation of historic buildings.

3.2.1. Incorporation of CBA and LCCA in the decision-making process

Decision-making processes should include comprehensive cost-benefit analyses and life cycle cost assessments to ensure that public investments in heritage buildings are financially sound, environmentally responsible, and socially beneficial. These methodologies provide a transparent and structured approach to evaluating potential renovation projects, ensuring that public funds are effectively allocated.

3.2.2. Focus on long-term value when considering energy-efficient renovations

Energy-efficient renovations are not only about short-term cost savings but also about creating long-term value. Therefore, policymakers should adopt regulations and incentives that encourage building owners and developers to focus on the long-term sustainability of historical buildings through energy-efficient retrofits. This will help ensure that the benefits of these projects are realized over time, both for the environment and the economy.

3.2.1. Promote Broader Awareness and Engagement

Stakeholders, including local governments, heritage organizations, and the public, could be engaged in promoting the importance of energy efficiency in heritage building renovations. Public awareness campaigns that highlight the environmental, financial, and cultural benefits of these projects can encourage broader acceptance and participation.

3.2.2. Encourage Financial Support for Heritage Renovations

As part of wider public sector review, the beneficiaries of this TSI, OPW and LCCC, could bring to the relevant government department the findings of the TSI and the recommendation that: given the higher upfront costs of energy-efficient renovations compared to standard retrofits, it is crucial to offer financial incentives or subsidies to make these projects more accessible to public and private owners of heritage buildings. This could include tax breaks, grants, or low-interest loans specifically aimed at supporting energy-efficient renovation projects.

3.3. Recommendations for training

The following recommendations are based on the work conducted under Deliverable 4. These recommendations are aimed to further guide OPW and LCCC to use the training materials provided.

3.3.1. Use training materials to train new colleagues, and upskill new and existing employees

Building on the training content and materials developed under Deliverable 4, these resources could be actively utilised to train new colleagues and provide upskilling opportunities for existing employees who were not able to take part in the training course. The materials should be reviewed and, if necessary, repackaged into structured training modules tailored to different levels of expertise, ensuring accessibility and relevance for a wide range of professionals.

For new colleagues, the materials could be integrated into onboarding programmes, providing foundational knowledge on key topics covered in Deliverable 4. This would ensure that new team members are equipped with the necessary competencies from the outset, fostering consistency and efficiency across the workforce.

For existing employees, the training materials could be adapted into specialised upskilling workshops, focusing on emerging best practices, new regulatory requirements, or advanced techniques relevant to their roles. These workshops could be delivered through a combination of in-person training sessions, interactive webinars, and self-paced e-learning modules, allowing for flexible participation.

To maximise impact, it is also recommended that these training resources be continuously updated to reflect the latest industry demands and feedback from participants. Additionally, establishing a knowledge-sharing platform or an internal resource hub would facilitate ongoing learning and provide employees with easy access to training materials, case studies, and expert insights.

By repurposing and expanding upon the existing training materials, organisations can enhance workforce capabilities, improve performance, and ensure alignment with industry standards and evolving best practices.

3.4. Recommendations for establishing a sustainable local/ regional fund for renovation of historic buildings

The following recommendations are based on the work conducted under Deliverable 5. These recommendations are aimed to further guide the establishment of a sustainable local/regional fund for renovation of historic buildings.

3.4.1. Engage Local authorities and finance experts to select legal and financial framework

Based on the work conducted under Deliverable 5, to build on the preliminary analysis, it is crucial to further engage local authorities, including finance representatives, to determine the next steps and address any gaps identified in the initial phase.

This process should involve selecting the optimal financial and legal framework from the options presented. Key national authorities, including those responsible for the development of the Irish Social Climate Plan (SCP) – the Department of the Environment, Climate and Communications, should also be involved especially as the SCP could be a potential source of funding. This engagement will set the stage for a more detailed analysis and will help finalise the framework for the fund's establishment.

In the short term, LCCC, can engage stakeholders through workshops/meetings with local authorities and finance teams. Once the optimal financial and legal framework for the fund is selected, LCCC and engaged stakeholders can review the preliminary analysis and identify gaps/areas which need further clarification. Further Irish authorities responsible for the Social Climate Plan (DECC, SEAI) can be engaged to discuss potential funding opportunities and alignment. Afterward, a thorough analysis should be conducted of the chosen financial and legal framework, followed by a finalisation of the detailed operational structure of the fund. Lastly, it should be ensured that the fund aligns with the goals of the Social Climate Plan.

3.4.2. Establish an advisory board with national and international financial experts/potential contributors

To drive the in-depth analysis and ensure expert input, it is essential to establish an advisory board comprising national and international financial experts. The board should include key stakeholders such as the Sustainable Energy Authority of Ireland (SEAI) and the European Investment Bank (EIB), as well as other relevant experts in financing mechanisms for energy-efficient projects.

The advisory board's role would be to guide the project forward, offering insights into financial structuring, investment strategies, and potential barriers to implementation. Additionally, ensuring the participation of stakeholders involved in the development of the Irish Social Climate Plan will help align the work with national climate goals and secure relevant funding and policy support.

In the short term, national and international financial experts should be identified and invited to form the advisory board. Thereafter, initial meetings should be organised by LCCC to set priorities and review the preliminary analysis. SEAI, EIB and stakeholders involved in the Social Climate Plan should

be engaged. Further, the long-term financial strategy for the fund should be finalised, incorporating the advice from the board. Lastly, the advisory board's role can be expanded in monitoring and overseeing the implementation phase.

Annexes

A. Monitoring indicators

This section presents a brief overview and analysis of the project monitoring indicators as outlined in the inception report. Furthermore, indicators are proposed for the European Commission and the beneficiary authorities to monitor the outcome and impact of the project after the conclusion of the contract.

Project monitoring indicators

The monitoring of the project implementation is based on the following indicators, categorised according to the work completion status for each deliverable (Table 3-1).

Table 3-1 Overview of project monitoring indicators, including deliverable submission dates.

Project monitoring indicator	% of work completed	Draft report	Final report	Current status / Remarks
Deliverable 1 - Inception report	100%	27/02/2023 30/06/2023	14/12/2023	
Deliverable 2 - Case studies and upgrade of methodology for deep renovation of historic buildings	100%	27/10/24	28/11/2024	
Deliverable 3 - CBA for energy efficiency renovation of historic structures	90%	10/10/2024 15/1/2025 (revised) 10/03/2025 (revised) 24/03/2024 (revised)	29/04/2025	Awaiting approval
Deliverable 4 - Training programme and material	100%	n/a	n/a	Trainings conducted and materials sent on 14/03/2025
Deliverable 5 - Guidelines for the establishment of a sustainable local/regional investment fund for the renovation of historic buildings	90%	12/02/2025 26/02/2025 (revised)	19/03/2025	
Final report	80%	28/02/2025 24/03/2025	01/05/2025	Awaiting approval

Impact monitoring indicators (post-project)

We propose organising the indicators for monitoring project impacts according to the intended outcomes indicated in Chapter 1.3 of the Request for Service, which are the following:

1. adoption of methodologies/guidelines for the acceleration of historic building renovations;
2. capacity strengthening for energy renovation of historic buildings;

3. establishment of a sustainable local/regional investment fund.

For each of these outcomes, qualitative indicators can be used to measure both short- and medium-to-long-term impacts (Table 3-2).

Table 3-2 Proposed impact monitoring indicators for intended project outcomes

Intended outcome	Monitoring indicators for short-term impacts	Monitoring indicators for medium-to-long-term impacts
Adoption of methodologies/guidelines for the acceleration of historic building renovations.	The recommendations developed in the proposals of the four-case study historic buildings are adopted and implemented, leading to the renovation of the case study buildings.	Replication of deep renovation of other historic buildings based on the improved OPW guidance and the process and results of the case studies.
	The recommendations for post-works monitoring and data capture of energy usage are implemented for the four case study buildings.	The methodology developed and implemented on the case studies for a holistic cost-benefit analysis is replicated for other historic buildings.
	The recommendations developed in the proposal to improve the OPW guidance are adopted by OPW.	
	The methodology and guidelines for the holistic cost-benefit analysis are adopted by OPW and LCCC.	
Capacity strengthening for energy renovation of historic buildings.	The trainings on energy renovation for traditional buildings result in increasing the capacity and knowledge transfer, ultimately leading to CPD accreditation of the participants.	The capacity building and knowledge transfer from the training programme developed further for future learning across Ireland.
Establishment of a sustainable local/regional investment fund.	The business plan for establishing a revolving fund for Limerick is adopted and implemented by LCCC.	The implementation of the revolving fund leads to higher renovation rates of historic buildings in Limerick and the funding mechanism is replicated in other regions.

B. Challenges, lessons learnt, and recommendations for future projects

This section provides a brief summary of lessons learnt during the project implementation, which could be used by the European Commission and the beneficiary authorities for future projects on deep renovation of historic buildings in Ireland or other EU Member States.

Challenges and lessons learnt

This section describes the challenges and lesson learnt for each project deliverable.

Challenge 1: Delays in the case study selection in Deliverable 2

A key challenge for this project was the time required to finalise the case study selection in Deliverable 2. The original plan was to already start working on the case studies at the beginning of the project, however, the testing required during the studies needs to be done during the winter period to get accurate results. The selection of the case studies was an iterative process and required input from both the OPW in terms of ensuring the buildings were accessible and representative of a typology found across the EU and from the technical team to ensure that the buildings met the requirements for their on-site testing and analysis. Because of the time required to select case studies, the testing for the case studies was delayed for several months. Since the results of the case studies were consequential for the following deliverables, this delay had a cascading effect on the timeline of the rest of the deliverables, particularly Deliverable 3. To manage this delay, extra time was required to deliver Deliverable 3.

Challenge 2: Lack of necessary economic data for the case studies for Deliverable 3

A significant challenge in conducting the CBA and LCCA for the case study in Deliverable 3 was the absence of critical economic data. Accurate financial information, such as the costs for renovation activities (e.g., materials, labour, energy-efficient technologies), long-term operational expenses, and maintenance costs, was either incomplete or unavailable. Without these essential data points, it was difficult to conduct a comprehensive CBA and LCCA that compared the total costs of renovation with the expected savings in energy consumption and emissions reduction.

This lack of economic data hindered the ability to assess the financial viability of the renovations, making it challenging to determine economic rate of return (ERR), payback periods, and overall cost-effectiveness. To overcome this challenge, missing data will need to be gathered from relevant stakeholders, including project managers, contractors, and building owners. In some cases, reasonable assumptions based on similar projects may be necessary, and transparency in these assumptions will be crucial to ensure the reliability and accuracy of the economic analysis.

Challenge 3: Difficulty in Monetizing Social, Cultural, and Heritage-Related Benefits of Renovation for Deliverable 3

A key challenge in evaluating the impact of historical building renovations was the difficulty in monetizing the social, cultural, and heritage-related benefits. While economic and environmental benefits like energy savings are easier to quantify, the intangible value derived from preserving cultural heritage, such as community well-being and cultural identity, is much harder to express in financial terms. These benefits, such as increased tourism, improved neighbourhood aesthetics, and enhanced social cohesion, are often long-term and influenced by external factors, making them complex to measure and standardize across different case studies. To address this challenge, a qualitative approach was employed to capture and describe these intangible benefits.

Challenge 4: Extreme weather event requiring the cancellation of the rescheduling of Day 2 of the training for Deliverable 4

Speakers and exhibitors were notified at the last minute that the second day of training had to be rescheduled at a later date due to an extreme weather event (Storm Éowyn) as soon as a national Red Level Warning was announced. The storm developed suddenly and resulted in the cancellation of all public transport, flights into Ireland and a national warning to shelter in place due to the severity of the storm. Although a new date was quickly agreed, it was not possible for some international speakers to attend on the new date. This cancellation and rescheduling required some changes to the agenda and involved a time-consuming process of contacting all speakers, exhibitors and attendees. The rescheduling of the training day was non-negotiable though and TUS was swift to put the changes into action working with the OPW management team and sub-contractors who willingly agreed to reschedule.

Challenge 5: Difficulty in budgeting the training event for Deliverable 4

The initial budget presented within the TSI project was to provide training to 150 in-person and 200 online. The venue was provided by OPW. Due to public procurement procedures, TUS was limited to companies who could only be contracted by OPW, this reduced the pool of contractors. After securing contracts for video online streaming and catering services, the budget was reduced significantly leaving no room for other services or costs. Fortunately, many of the speakers did not request payment, however hotels costs were still required, and TUS slightly over-spent on the budget due to the unforeseen costs of using a streaming service and Dublin prices for catering.

Challenge 6: Sub-task alignment in Deliverable 5

A challenge encountered during Deliverable 5 was the need for clearer alignment across the subtasks, as well as the presence of several smaller tasks that were not always linked to clearly defined outputs. This resulted in some confusion in terms of how to structure the work, as certain expectations outlined in the ToR didn't entirely align with the typical components found in a business plan. For instance, some elements that were suggested for inclusion in the business plan didn't follow the usual structure, which created some uncertainty around the scope and content of the deliverable. This

required the project team to dedicate additional time to clarifying and adjusting the components to ensure they fit the necessary framework.

Additionally, some subtasks lacked a clear, cohesive structure, making it a bit challenging to coordinate efforts effectively. To address this, the team worked on realigning certain aspects of the business plan and making sure that all tasks were connected to clear, tangible outcomes. Moving forward, a stronger focus on alignment and clearer guidance in the ToR will help streamline the work and enhance the overall efficiency of the project.

Challenge 7: Lack of key stakeholder engagement in Deliverable 5

A challenge in DLV 5, especially in regard to the high level of stakeholder participation necessary was securing participation from key stakeholders like financial authorities and SEAI. Their busy schedules and differing priorities sometimes delayed involvement, while aligning their expertise with project goals proved difficult. It was unclear if this was due to lack of interest, or lack of access to correct contacts.

To overcome this, the project team made efforts to engage stakeholders through targeted outreach and clear communication. However, consistent input remained a challenge.

Recommendations for future projects

The following recommendations are provided based on the challenges/lessons learned from this project which may inform the structuring and development of future projects.

Pre-selection of case studies before project implementation or more time allotted for case study selection during the project implementation

An unexpected delay in Deliverable 2 was the length of time required to make a selection of case studies for the analysis. To potentially address this issue, case studies could potentially be pre-selected before the implementation of the project, which would also assist tendering teams in the development of their proposals and allow for questions to be posed to the beneficiaries at this stage. However, it is recommended to allow more time at the outset of the project for appointed experts to advise beneficiaries on the case study selection and timings and requirements of any on-site testing, surveys and analysis.

However, OPW would note that a risk is that the pre-selected case-studies are deemed not suitable, as the TSI provides the 'experts' to the beneficiaries, and the beneficiaries may not select the most appropriate case-studies without the TSI provider expertise.

Build upon new training material to create annual / bi-annual training in sector

Building on the work conducted in Deliverable 4, an annual training program can be developed to expand the reach and deepen the expertise of practitioners involved in the renovation of historic buildings across Ireland. The program would serve two key objectives:

1. Broadening Access – Extending training opportunities to a wider range of practitioners throughout the country.
2. Enhancing Skills – Providing continuous upskilling for professionals already working in historic building renovation.

Key Components

1. Developing and Expanding Online Resources & Tools
    - Building on the resources established during the project, ensuring they are accessible online and continually updated.
    - Developing interactive online training modules that complement in-person sessions.
    - Exploring certification options to enhance professional recognition of the training.
2. Scaling the Training Program Nationally and Beyond
    - Engaging stakeholders to assess interest in conducting the training in additional regions across Ireland.
    - Exploring opportunities to expand the training to EU-level partners, leveraging best practices developed under Deliverable 4.

- Strengthening collaborations with universities, trade organizations, and heritage groups to integrate training into existing education and professional development programs.

While it is not in OPW or LCCC remit to provide training to the public sector, the beneficiaries could bring recommendations to wider government bodies to investigate the potential for creating annual / bi-annual training in sector.

Establish a revolving fund

Building on the work conducted under Deliverable 5, a potential next step / project would take the initial research and analysis conducted in Deliverable 5 to establish a revolving fund in Ireland. As Deliverable 5 was a component of the overall work, a full project would further delve into the potential of a revolving fund.

The project would focus on:

1. Selecting the Optimal Fund Framework – Evaluating and finalising the most suitable structure for the revolving fund based on expert recommendations.
2. Linking the Fund to Ireland's Social Climate Plan (SCP) – Exploring how the fund can leverage SCP as a key funding source.
3. Strengthening Partnerships for Data-Driven Analysis – Collaborating with local energy agencies and one-stop shops to access more robust financial and energy data for a deeper scalability assessment.
4. Securing Additional Funding Beyond SCP – Identifying and engaging alternative funding sources, including EU funds, private sector investment, and green finance initiatives.

C. List of meetings

Throughout the project, there have been several meetings between the project team and steering committee for the implementation of the deliverables the table below provides an overview of the key meetings which fulfil the requirements of the Terms of Reference

Table 3-3 Overview all meetings that took place throughout project implementation

Type of meeting	Deliverable	Date
Preparatory call for Kick-off meeting	*DLV 1: meeting(s) with beneficiaries and SG REFORM to discuss the requirements for the inception report*	16 January 2023
Kick-off meeting	*DLV1: Kick-off meeting*	30 January 2023
Inception meeting	*DLV 1: meeting(s) with beneficiaries and SG REFORM to discuss the requirements for the inception report*	28 February 2023
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	13 June 2023
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	17 August 2023
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	28 September 2023
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	23 November 2023
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	21 December 2023

Type of meeting	Deliverable	Date
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	1 February 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	29 February 2024
Block 11 Collins Barracks workshop #1	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	11 March 2024
Block 11 Collins Barracks workshop #2	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	27 March 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	28 March 2024
DLV3 Workshop #1	*DLV 3: Organise workshop with stakeholders to present the methodology and guidelines.*	25 April 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	25 April 2024
88 Merrion Square workshop #1	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	2 May 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	23 May 2024
Interim meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	5 June 2024
88 Merrion Square workshop #2	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	6 June 2024
Oldbridge House workshop #1	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	13 June 2024
Oldbridge House workshop #2	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	4 July 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	25 July 2024
23 Kildare Street workshop #1	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	15 August 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	21 August 2024
23 Kildare Street workshop #2	*DLV2: Organise stakeholder workshops for each case study to present and collect feedback on assessment and proposals for energy efficiency upgrade works*	29 August 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	19 September 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	17 October 2024

Type of meeting	Deliverable	Date
DLV3 Workshop #2	*DLV3: Organise workshop(s) with stakeholders to present and collect feedback on the findings/analysis of the case studies.*	24 October 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	28 November 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	19 December 2024
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	9 January 2025
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	27 February 2025
DLV4 Training Day 1	*DLV4: Provide training of at least 3 full-day training sessions to take place in Dublin*	17 January 2025
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	23 January 2025
DLV4 Training Day 3	*DLV4: Provide training of at least 3 full-day training sessions to take place in Dublin*	7 February 2025
Deliverable 5.8 workshop	*DLV 5: Organise workshop(s) with stakeholders*	7 February 2025
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	10 February 2025
DLV4 Training Day 2	*DLV4: Provide training of at least 3 full-day training sessions to take place in Dublin*	25 February 2025
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	27 February 2025
DLV3 Workshop #3	*DLV3: Organise workshop(s) with stakeholders to present and collect feedback on the findings/analysis of the case studies.*	18 March 2025
Progress meeting	*Across deliverables: Convene meeting(s) with the beneficiaries and SG REFORM to understand and define requirements for this deliverable, discuss tasks, timetable and milestones, methodology, needs for data and information from beneficiaries*	3 April 2025
Final meeting	*Not required by ToR*	4 April 2025

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