

Lit & Phil Library: Decarbonisation Plan

Cultural & Heritage Sector Decarbonisation
Historic England & Arts Council Pilot Study
January 2026

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Executive Summary

The following report presents a Decarbonisation Plan for the Grade II* listed Lit & Phil Library, Newcastle. Founded in 1793, the Literary and Philosophical Society of Newcastle upon Tyne (Lit & Phil) occupies a purpose-built library opened in 1825. It is the largest independent library outside London, and is open to all and free to explore. Alongside its historic and contemporary collection, the Lit & Phil hosts a range of public events including talks, concerts, readings, discussions and book launches.

The Lit & Phil is currently in the early stages of a major capital project aimed at transforming the organisation's inclusivity, ensuring the building is structurally sound, sustainable, and accessible, while strengthening its relevance and engagement with the wider community.

The Decarbonisation Plan has been commissioned by Historic England and Arts Council England, as part of a pilot study focussing on decarbonisation of buildings within the cultural & heritage sector.

The report has been prepared collaboratively by architects Haworth Tompkins and MEP engineers Skelly & Couch, with input from cost consultants Gardiner & Theobald and historic building surveyors Conisbee.

The Decarbonisation Plan is underpinned by Historic England's 'Whole Building Approach', and includes recommendations for targeted improvements to building fabric, services, and operations, as well as the development of a costed and prioritised roadmap to decarbonisation.

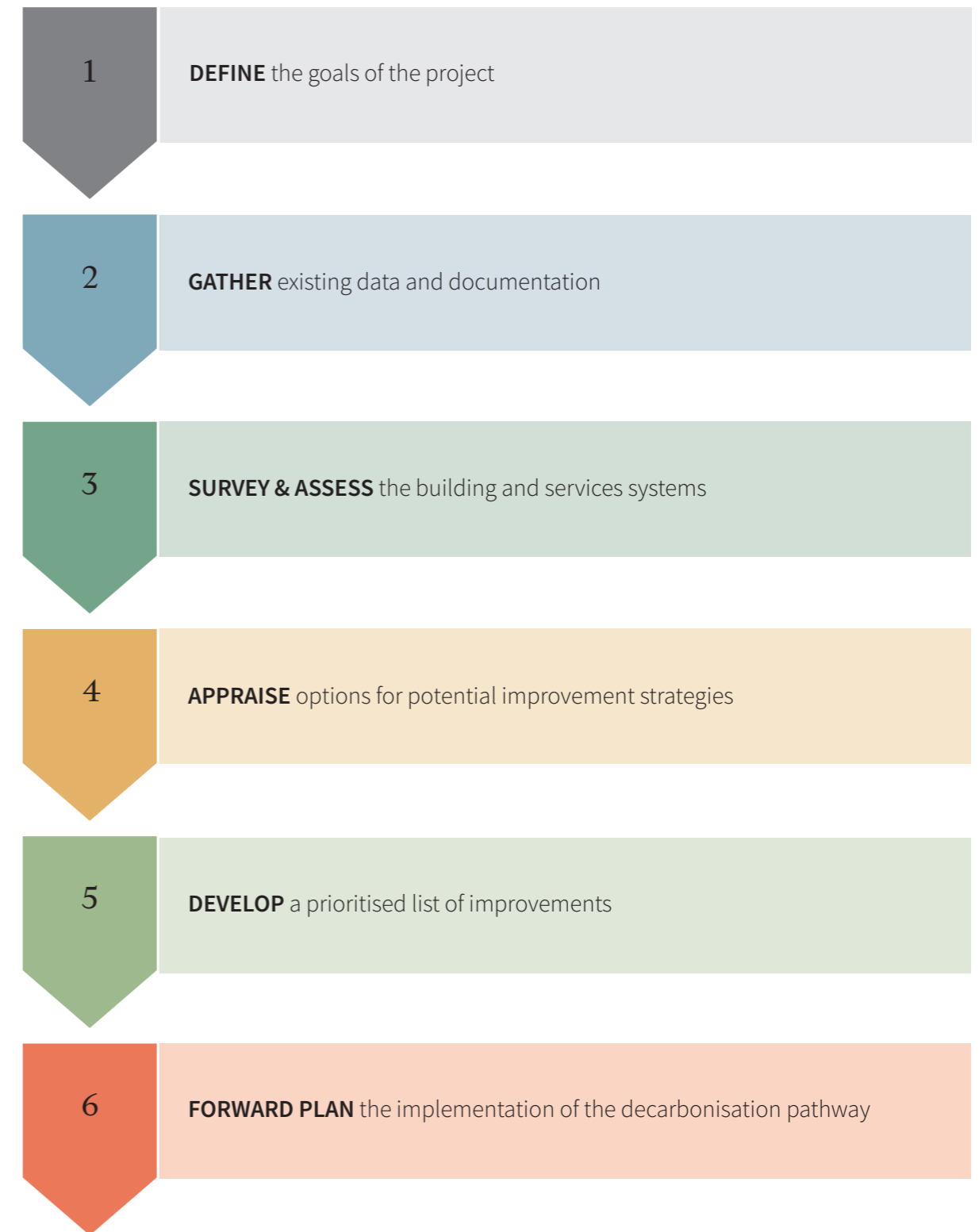
The development of the Plan has followed a six-step process, which corresponds to Stages 1 and 2 of the Historic England Whole Building Approach.

The report has been developed in consultation with the Board of Trustees at the Lit & Phil, based on information collected through:

- Initial briefing workshops carried out with staff at Lit & Phil and with the incumbent design team.
- A building site visit attended by Haworth Tompkins and Skelly & Couch.
- A visual services inspection and thermal imaging survey, carried out during the site visit.
- Online information records including the planning portal, and Historic England Listing register.

Building information was also provided directly by Lit & Phil including:

- A Design, Access Heritage and Planning statement and proposed architectural drawings prepared by xsite architecture as part of the current capital works.
- An MEP Stage 2 report and proposed layouts provided by Clark Degnan services engineers.
- Utility electricity and gas meter readings provided by building management for the period December 2022 – November 2024.

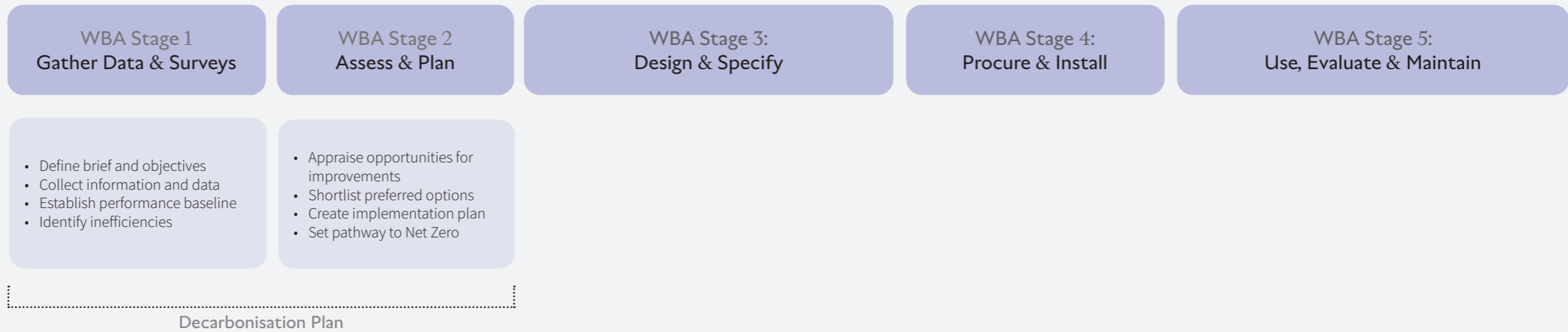


The six-step process of developing a Decarbonisation Plan

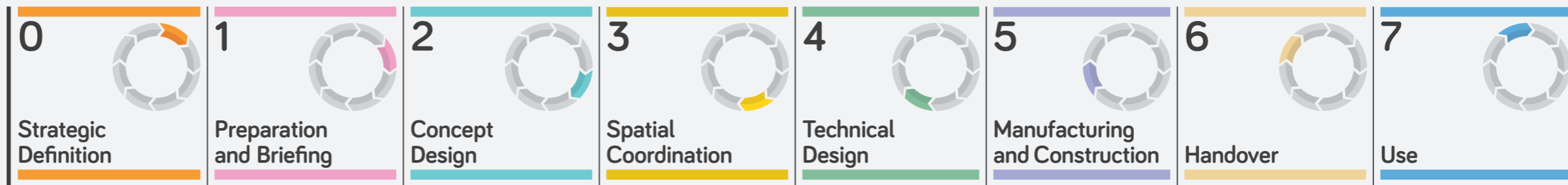
Decarbonisation Plan



Whole Building Approach



RIBA Plan of Work 2020



PROJECT DEFINITION

1.1 Introduction

Decarbonisation Context

UK Government carbon targets

The built environment accounts for around 25% of the UK's total carbon footprint.¹

Decarbonisation of the built environment is therefore a key factor in achieving overall UK carbon reduction targets, such as the UK Government's target to achieve net zero carbon emissions in the UK by 2050.

New buildings and planned refurbishments

Statutory measures exist that require new buildings to achieve high levels of energy efficiency and carbon performance, and energy efficiency to be introduced when work is carried out on existing buildings. This includes Part L of the Building Regulations, which was updated in 2021 with higher efficiency standards. There are also measures set through the planning system.

These statutory measures are relatively demanding and mean that many new and refurbished buildings should meet high levels of energy and carbon performance. Furthermore, industry guidance such as that developed by the UK Green Building Council (UK-GBC), the London Energy Transformation Initiative (LETI), and the UK Net Zero Carbon Building Standard (UK NZCBS) recommends that all new buildings (domestic and non-domestic) should be planned to be Net Zero by 2030 to meet broader climate change targets. Such targets, along with similar targets set by the Royal Institute for British Architects (RIBA) in their 2030 Climate Challenge, are being voluntarily adopted by clients as an enhancement to statutory requirements.

¹ Source: UK Green Building Council (UKGBC), Net Zero Whole Life Carbon Roadmap Technical Report (November 2021) p 10. Note: This figure includes buildings and infrastructure and relates to consumption emissions (i.e. the figure includes emissions from imported materials)

Existing buildings

It is projected that 80% of existing buildings are expected to remain in use until at least 2050,² meaning that statutory or voluntary measures for new buildings alone will not sufficiently reduce carbon emissions from the built environment in line with overall targets. There are however currently no direct statutory requirements to make energy and carbon performance improvements to existing buildings where no work is planned, or indeed where only minor works are carried out (e.g. decorative) or where such improvements would affect the nature of historic and listed buildings.

There are some indirect statutory measures that would promote higher carbon efficiency, and grant schemes to promote new systems such as heat pumps.

To meet national carbon reduction targets, voluntary measures to decarbonise existing buildings will therefore be required. It is hoped that the findings and proposals in this report will allow the Lit & Phil Library to set objectives for a decarbonisation pathway accordingly.

By upgrading energy and carbon performance, other benefits for the library could include:

- Reduced energy costs
- Enhanced occupant comfort
- Higher resilience in services where loads are reduced
- Potential promotional benefits

² Source: <https://post.parliament.uk/net-zero-and-the-uk-his-toric-building-stock/>

Net Zero Carbon

The concept of net zero carbon, where buildings are fully decarbonised in terms of Scope 1 and 2 carbon emissions³, is gaining increasing attention as a means to bring buildings in line with the wider UK and international targets for decarbonisation.

Interim targets for lower degrees of carbon reductions may also be appropriate, particularly for existing buildings where steep reductions in carbon emissions are technically and economically challenging. Regardless of the target set, it is important that key principles of net zero are applied to ensure consistency.

The UK Net Zero Carbon Building Standard

Pilot Version was published in 2024 and creates a unified definition for 'Net Zero Carbon Aligned Buildings' in the UK, underpinned by an evidence-based reporting methodology. The guidance provides set energy use intensity targets, which are compatible with the availability of renewable energy sources expected to be available in 2040, the deadline which the standard sets.

As part of the development of the UKNZCB standard, a working group was convened to look at the specific challenge of applying a Net Zero Carbon Building Standard to historic buildings or those with heritage significance. After extensive consultation and analysis, heritage buildings do not currently form part of the Standard.

³ Scope 1 emissions are those from on-site fuel use; Scope 2 emissions are indirect emissions from purchased electricity use. Refer to Appendix "Net Zero Carbon Glossary"

There is consequently a need for specific guidance to support the progressive decarbonisation of listed and historic buildings, which offers a more practical and proportionate pathway than achieving absolute net zero carbon. These buildings face unique constraints including heritage significance, structural limitations, and construction typologies that make full decarbonisation technically challenging or inappropriate.

A progressive approach prioritises measurable, incremental emissions reductions through targeted efficiency improvements, system upgrades, and low/zero carbon technology integration, while respecting conservation requirements. This enables steady performance gains aligned with technological progress, funding cycles, and grid decarbonisation.

Crucially, it supports a balance between climate action and heritage preservation, recognising that historic buildings can lead by example in sustainable management and adaptive reuse.

1.1 Introduction

The term “net zero” is often used incorrectly. To better define the concept and parameters, a group of construction organisations including LETI and CIBSE produced the following definitions.

	A 'Net Zero (whole life) Carbon' Asset is one where the sum total of all asset related GHG emissions, both operational and embodied, over an asset's life cycle (Modules A0-A5, B1-B8, C1-C4) are minimized, which meets local carbon, energy and water targets or limits, and with residual 'offsets', equals zero ¹ .
NET ZERO EMBODIED CARBON OR NET ZERO LIFE CYCLE EMBODIED CARBON	A 'Net Zero Embodied Carbon' asset is one where the sum total of GHG emissions and removals over an asset's life cycle (Modules A0-A5, B1-B5 and C1-C4) are minimized, which meets local carbon targets or limits (e.g. kgCO2e/m2), and with additional 'offsets', equals zero.
NET ZERO UPFRONT CARBON	A 'Net Zero Upfront Carbon' asset is one where the sum total of GHG emissions, excluding 'biogenic carbon', from Modules A0-A5 is minimized, which meets local carbon targets or limits (e.g. kgCO2e/m2), and with additional 'offsets', equals zero.
NET ZERO CAPITAL CARBON - INFRASTRUCTURE	A 'Net Zero Capital Carbon' infrastructure asset is one where the sum total of GHG emissions, as aligned with the scope of Capital Expenditure (or Capex) as determined by the asset owner's preference but always including Module A and C, is minimized, meets local carbon targets or limits (e.g. kgCO2e/m2), and with additional 'offsets', equals zero.
NET ZERO OPERATIONAL CARBON – ENERGY	A 'Net Zero Operational Carbon – Energy' asset is one where no fossil fuels are used, all energy use (Module B6) has been minimized, meets the local energy use target or limit (e.g. kWh/m2/a) and all energy use is generated on- or off- site using renewables that demonstrate additionality. Direct emissions from renewables and any upstream emissions are 'offset' ² .
NET ZERO OPERATIONAL CARBON - INFRASTRUCTURE	A 'Net Zero Operational Carbon' infrastructure asset is one where the sum total of GHG emissions, as aligned with the scope of Operational Expenditure (or Opex) as determined by the asset owner's preference, has been minimised and meets local carbon, energy and water targets or limits, and where no fossil fuels have been used for operational energy use (Module B6), and which, with additional 'offsets', equals zero.

1 To meet the requirements of 'Net Zero (whole life) Carbon' the definitions for 'Net Zero Upfront Carbon', Net Zero Embodied Carbon', 'Net Zero Capital Carbon', Net Zero Operational Carbon – Energy', 'Net Zero Operational Carbon – Infrastructure', 'Net Zero In-Use Carbon Asset' and 'Net Zero Operational Carbon – Water' must also be individually met as applicable.

2 Note: Direct emissions must include CH4 and N2O emissions from the combustion of biomass and biodiesel fuels. Upstream emissions include: direct and indirect emissions from energy generation and distribution, WTT emissions for energy consumed in the building and from energy generation and distribution.

1.2 Project Context

1.2.1 The Capital Project

The Lit & Phil is in the early design stages of a significant capital project aimed at transforming the organisation's inclusivity, ensuring the building is structurally sound, sustainable, and accessible, while strengthening its relevance and engagement with the wider community. The project also aims to enhance and diversify use of the building in order to generate income and secure the long-term financial sustainability of the organisation.

The appointed design team, led by xSite Architecture, has recently completed RIBA Stage 3 on a scheme that aims to 'sensitively reconcile functional requirements with improved accessibility and upgraded environmental performance in the context of this Grade II* listed building to ensure a viable future for the Society and its long-standing home.' The Stage 3 report sets out a series of proposals to meet the brief in terms of spatial co-ordination and compliance with all of the core statutory processes. These include:

Entrance & Accessibility Upgrades

- New internal lift to serve basement, ground and first floor levels.
- Secure Ground Floor access (to prevent non-issued books being removed)
- Reconfiguration and operation of existing entrance doors in relation to accessibility, energy conservation / draft prevention, and visual connectivity with the external streetscape
- New external lighting

New Event Spaces/Staff & Visitor Facilities

- Reconfiguration of the existing events space, staff and visitor facilities
- New events space for seminars, spoken word performances, acoustic musical performances

- Women's WC facility (off library) to be replaced & refurbished
- Additional WCs and accessible WC to be provided
- A dedicated and serviced staff room to be incorporated in the building at an easy and convenient location.
- Reconfiguration of book binding storage and workshop spaces
- Provide meeting rooms for external hire, or smaller events

Storage

- New high-density roller racking in the basement

Building Services (phased)

- New mechanical ventilation with heat recovery to ground floor spaces
- New ventilation to new WCs and kitchens
- New air handling unit to first floor Library and reading room
- Replacement of radiators and pipework
- New ASHP
- Modifications to domestic hot water
- New controls and metering
- New lighting

Listed Building Consent has been granted for the proposed internal alterations, including installation of a vertical lift from basement to first floor level; new archiving shelving and WCs at basement level; reconfiguration of ground floor event rooms and associated facilities; and new first floor WC's.

Submission of the Planning Application is outstanding as the extent of replacement/repair works, in particular to the roof lanterns, remains under review. A combined Listed Building Consent and Planning Application

will be required in Stage 4, which addresses all of the modifications made to the scheme since the original submission along with the external alteration works.

The anticipated external works include:

- Replacement of the single glazing in windows without secondary glazing (blind windows left unaltered)
- New external lighting
- Replacement of the external platform lift
- Introduction of PVs and ASHPs at roof level
- Inlet and extract vents through the building fabric to support MEP upgrades
- Replacement of the failing roof covering over the new platform lift enclosure between the Collections Gallery and Silence Room
- Any roof works (scope to be agreed), including replacement/repair of roof lanterns and replacement of roof coverings

Roof works under consideration:

- Repairs to roof glasshouses and improved maintenance access
- Repairs to roof above 1880s entrance
- New roofs to areas within lightwell

Funding

In the early stages of the project, the Lit & Phil was granted £1m capital funding by the Barbour Foundation specifically to support improvements to accessibility, such as the new lift and improved WC facilities. These will be carried out in August 2026.

The Society has also recently secured £247,000 development phase funding from NLHF to progress the wider scheme, in anticipation of a £4.5m application for delivery funding in due course.

Additional fundraising may also be required to support some of the more complex elements of refurbishment, such as repair or replacement of the roof lanterns, which are also subject to further investigations and asbestos surveys.

As a result, the capital project is likely to be delivered in a number of phases in response to funding limitations and logistical constraints.

The surveys and options appraisal within this report have been undertaken separately from the design development of the capital project, but in consideration of the overall objectives and funding context of the wider ambitions.

1.2 Project Context

1.2.2 Decarbonisation Aims and Objectives

The Lit & Phil has long been a hub for inventors, pioneers, and visionaries; a key institution during the Industrial Revolution.

Today, the Board of Trustees is committed to continuing that legacy by leading the way in decarbonising their historic building. This commitment also acknowledges the building's origins: when it opened in 1825, coal (now known as a major driver of climate change) was its primary heat source. In re-imagining the building's future, the Trustees believe the same spirit of innovation and expansive thinking that the Lit & Phil has always fostered can now contribute to solving broader environmental challenges, as well as guiding the practical decisions behind the wider capital project.

This Decarbonisation plan for the Lit & Phil sits outside of the main capital works project, having been instructed separately and led by a different design team.

The key aims of this Decarbonisation study are as follows:

- To establish the library's baseline operational energy and carbon performance.
- To compare this performance against industry benchmarks and standards.
- To propose suitable targets for enhanced performance, taking into account local planning and listed building requirements.
- To appraise options available in order to achieve these targets including energy use reductions and low/zero carbon technologies (LZCs).
- To agree a prioritised strategy for implementation, both within and beyond the capital project.

The Lit & Phil aims to integrate the Decarbonisation Plan into their main capital project, ensuring that recommended adaptations are either included in the primary scope of work or planned for seamless incorporation in the future.

This plan will need to factor in the aims, ambitions and proposals set by the capital works project, whilst making objective recommendations for energy saving interventions and low and zero carbon technologies, guided by independent analysis of the existing building.

Some of the recommended options for improvement may already been proposed as part of the capital works, however the options will be presented as standalone works, and will be able to be implemented independently, in the event that the wider capital project works do not go ahead.

BACKGROUND INFORMATION

2.1 The Existing Site

2.1.1 The Building

The Literary and Philosophical Society of Newcastle upon Tyne (Lit & Phil) was initially founded in 1793 by members who would meet in various locations around the city to discuss and debate matters of the day. In 1825, a purpose-designed library was opened on Westgate Road to house the Society's growing collection of books and artefacts. The Lit & Phil, as it is now known, became a hub of learning and enlightenment before the establishment of the city's universities.

By the early 19th century it had become a home for inventors, pioneers and visionaries and a focal point for the industrial revolution. George Stephenson demonstrated his 'miners safety lamp' to the Society in 1815, and Joseph Swan lit a public room with electric light for the first time here in 1881. It has also hosted a range of literary figures and intellectuals including Oscar Wilde, E.M. Forster and Gertrude Bell.

Today, the Lit & Phil continues to inspire minds, stimulate imaginations and confer a wealth of knowledge to young and old alike. It is the largest independent library outside London, with a collection of more than 200,000 books, from 16th century tomes to modern fiction. It also houses the largest music collection in the North of England and hosts a varied events programme including jazz, folk and classical music, author evenings, theatre including bookbinding, Latin, fine art and creative writing.

The Lit & Phil has recently secured Development funding of £274,263 by the National Lottery Heritage Fund to help progress plans for repairs and enhancements to the building, in preparation for an application for delivery funding of £4.5m.

Additional funding has been awarded by benefactors including the Barbour Foundation, towards a project that aims for completion towards the end of 2028.

The proposed interventions will provide:

- Improved accessibility, so everyone can use the building regardless of mobility.
- Digitisation, opening parts of the collection to a global audience.
- New learning spaces, for schools, universities, and creative projects.
- Expanded cultural programming, reaching new and under-represented communities.



Image source: Newcastle Castle



Image source: Google streetview

Year of construction	1825
Architect	John Green, stone mason
Listing status	II*
Year of listing	1954
Primary function	Members library and public reference Library
Other uses	Cultural hub Hosts variety of events – lectures, concerts, meetings Book binding workshop
Location	Newcastle upon Tyne
GIA	2,043m ²
Significant later construction works / alterations	1885 – Addition of rear wing at right angle to main building 1866-1957 – addition and then removal of raked lecture theatre
Neighbouring buildings	<ul style="list-style-type: none"> • Bolbec Hall (1907) – currently empty • Neville Hall (1872) - The North of England Institute of Mining and Mechanical Engineers (archive and heritage venue) • National Rail car park to the rear with vaults beneath

2.2 Heritage Significance

2.2.1 Heritage Designations

The Lit & Phil is a Grade II* listed building, situated within Newcastle city centre.

Official list entry:

- Heritage Category: Listed Building
- Grade: II*
- List Entry Number: 1121954
- Date first listed: 14-Jun-1954
- List Entry Name: Literary and Philosophical Society
- Statutory Address 1: Literary and Philosophical Society, Westgate Road

Location:

- Statutory Address: Literary and Philosophical Society, Westgate Road
- District: Newcastle upon Tyne (Metropolitan Authority)
- Parish: Non Civil Parish
- National Grid Reference: NZ 24813 63925

List description:

Literary and Philosophical Society GV II*

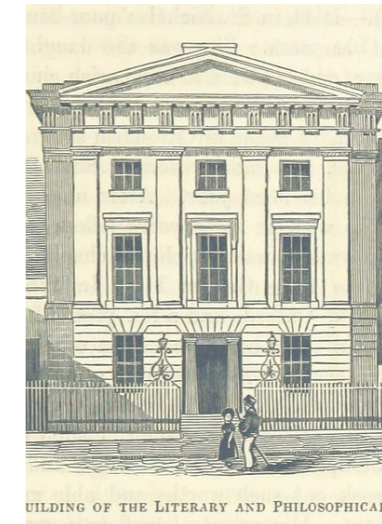
Private library and society rooms. 1822 by John Green; stone mason John Ions of Gateshead. Sandstone ashlar; roof not visible. Greek revival style. 3 storeys, 3 bays under pediment. Moulded plinths; rusticated ground floor with wide square stone steps to double door recessed behind fluted Ionic columns; Voussoirs to this and to flanking aproned sashes. First-floor sashes in architraves, with cornices, the central bracketed; projecting sills to square second-floor sashes; all windows have glazing bars. Top entablature with triglyphs and guttae. Ends set back and entablature follows. 1885 addition of rear wing at right-angles obscured by Bolbec Hall (q.v.). Interior shows much classical stucco ornament on friezes; wrought-iron balconies and spiral stair to library gallery; low-domed roof lights with glazing bars. Extension at rear with similar-style interior 1888/9 by A.B. Gibson. Sculpture collection includes busts of Bewick 1825 by Bailey, of Rev. Turner 1829 by Bailey; of George Stephenson 1832 by Moore; of Robert Stephenson 1855 by Wyon; and statue of James Losh 1836 by Lough.

Images courtesy of Lit & Phil

Top mid image taken from page 339 of 'The Local Historian's Table Book of remarkable occurrences, historical facts, traditions, legendary and descriptive ballads, connected with the Counties of Newcastle-upon-Tyne, Northumberland, and Durham. Historical Division.



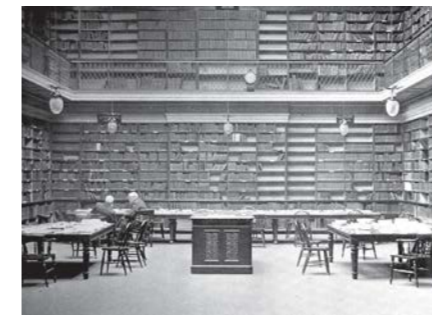
Competition winning scheme by John Green



The new building illustrated in 1836



Photo c. 1915 before & after arrival of Bolbec Hall



New reading room c.1890



Library Interiors in the early 20th century



The lecture theatre 1866-1967, shortly before its removal

2.2 Heritage Significance

2.2.2 Building Significance

The following section provides a summary of the overall Significance of the Lit & Phil Library. As a collective term for the sum of all the heritage values attached to a place, Significance can be understood through a series of inter-related themes. For further information on the assessment of heritage values, please refer to the following Historic England document: 'Conservation Principles, Policies and Guidance', 2008.

Evidential Value

The potential of a place to yield evidence about past human activity, or the potential for new knowledge about the fabric or history of the asset.

The Lit & Phil Library holds exceptional evidential value due to its layered architectural history and its position on a historically significant site.

Archaeological Evidence: The building sits within the buffer zone of Hadrian's Wall, a UNESCO World Heritage Site. Remnants of the Roman period, such as sections of the Wall and the vallum (ditch and bank), are believed to run underneath or near the building, providing archaeological significance. Excavations have confirmed the proximity of Roman remains, making the site a vital component in understanding Newcastle's development from the Roman era onward.

Architectural Evolution: The building, designed in 1825 by architect John Green, showcases the Greek Revival style, which symbolises the Society's intellectual aspirations. This structure has undergone significant changes, such as the construction of the lecture theatre in 1859, the 1889 library extension, and the later removal of the original barrel-vaulted ceilings. These changes document shifts in usage, design trends, and societal needs over time.

Material Evidence: Surviving architectural details like the original ashlar stonework, the timber coffered ceilings, and the modifications to create the 1889 reading room contribute to the site's ability to provide tangible evidence of its layered history

Historical Value

The ways in which past people, events and aspects of life can be connected through a place to the present; or the way in which a place supports a narrative of the past. This tends to be illustrative or associative.

Association with Intellectual Movements: Founded in 1793, the Literary and Philosophical Society became a driving force in the region's cultural development. It provided an essential forum for debate, learning, and innovation. The Society's fostering of ideas helped shape significant industrial advancements, particularly in mining and engineering, with figures like George and Robert Stephenson closely associated with its legacy.

Connection to Key Events and Figures: The library was home to early gas lighting experiments, and in 1880, its lecture theatre became the first public room in the world to be lit by electric light, courtesy of Sir Joseph Swan. This moment in technological history reflects the building's central role in innovation.

Societal Impact: The building hosted societies advocating for the abolition of slavery and the promotion of scientific, historical, and literary pursuits. This engagement with key national and regional issues highlights its broader historical significance.

Aesthetic Value

The ways in which people draw sensory and intellectual stimulation from a place, and how they engage with it emotionally.

The Lit & Phil Library is a distinguished example of the Greek Revival style, reflecting the cultural aspirations of its founders and their emphasis on education and enlightenment.

The building's neo-classical design, modelled on a Greek Doric temple, conveys the intellectual gravitas and democratic ideals central to the Society's purpose.

The library's original coffered barrel vault (now replaced) and the gallery-lined reading room with its carefully arranged busts of prominent figures illustrate its early commitment to creating an inspiring scholarly environment. Later additions, like the reading room extension, sought to preserve this aesthetic coherence while adapting to new needs.

The Lit & Phil's presence along Westgate Road and its proximity to other historic buildings, such as Neville Hall and Bolbec Hall, make it a key element of Newcastle's historic townscape. Its monumental style contrasts with adjacent Victorian structures, enhancing its visual prominence and civic importance.

Communal Value

The meanings of a place for the people who relate to it, or for whom it figures in their collective experience or memory, as well as how the place brings people together as a community.

The Lit & Phil Library remains an active and cherished cultural institution, underlining its communal value.

Cultural Hub: For over two centuries, the Lit & Phil has served as a meeting place for intellectual discourse, literary pursuits, and public lectures. This role as a cultural hub has helped foster a shared sense of identity among Newcastle's residents.

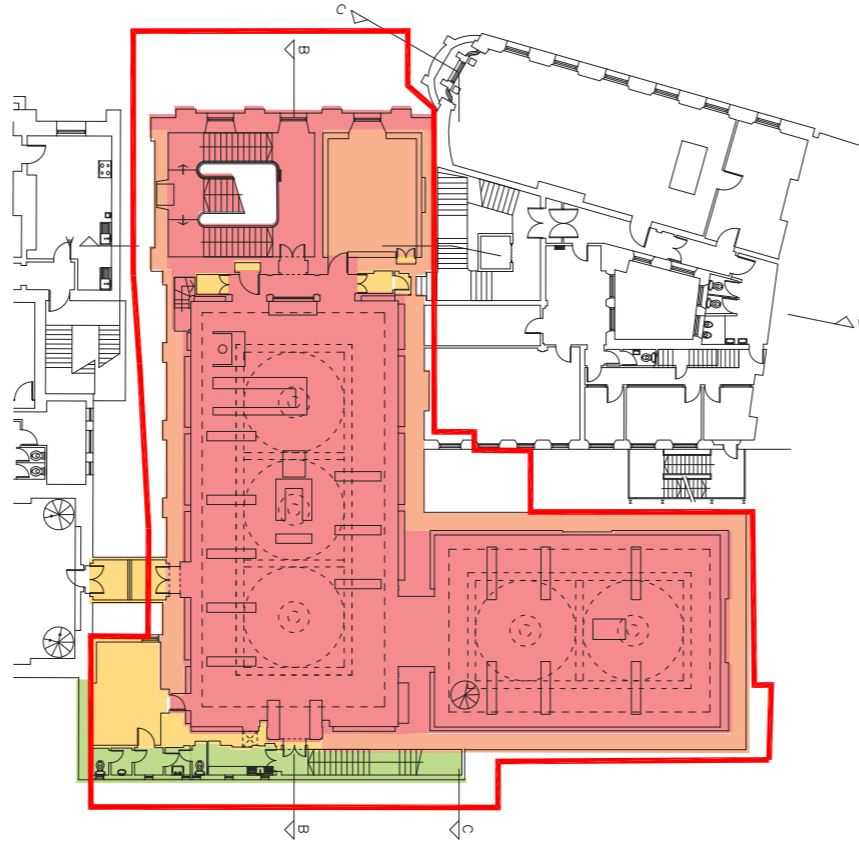
Adaptation for Modern Use: The Society has successfully adapted its mission to modern times, maintaining a public lending library and hosting events that engage diverse audiences. Its openness and inclusivity enhance its significance as a community space.

Educational and Social Impact: The Lit & Phil continues to attract visitors interested in its history, collections, and programs. The library's collections, including rare books and art, serve as a resource for education and scholarship, ensuring its continued relevance to both local and academic communities.

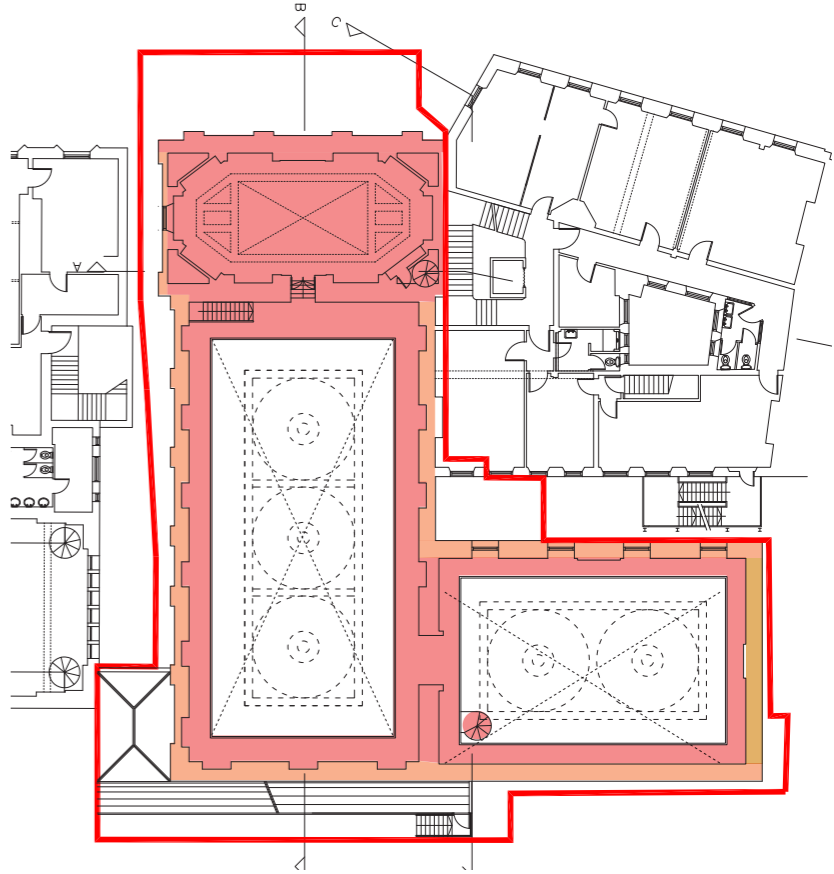
Summary

The Lit & Phil Library's evidential, historical, aesthetic, and communal values make it a vital asset in understanding Newcastle's history and cultural evolution. Each layer of its development tells a story of intellectual growth, societal change, and architectural adaptation, warranting its careful preservation for future generations.

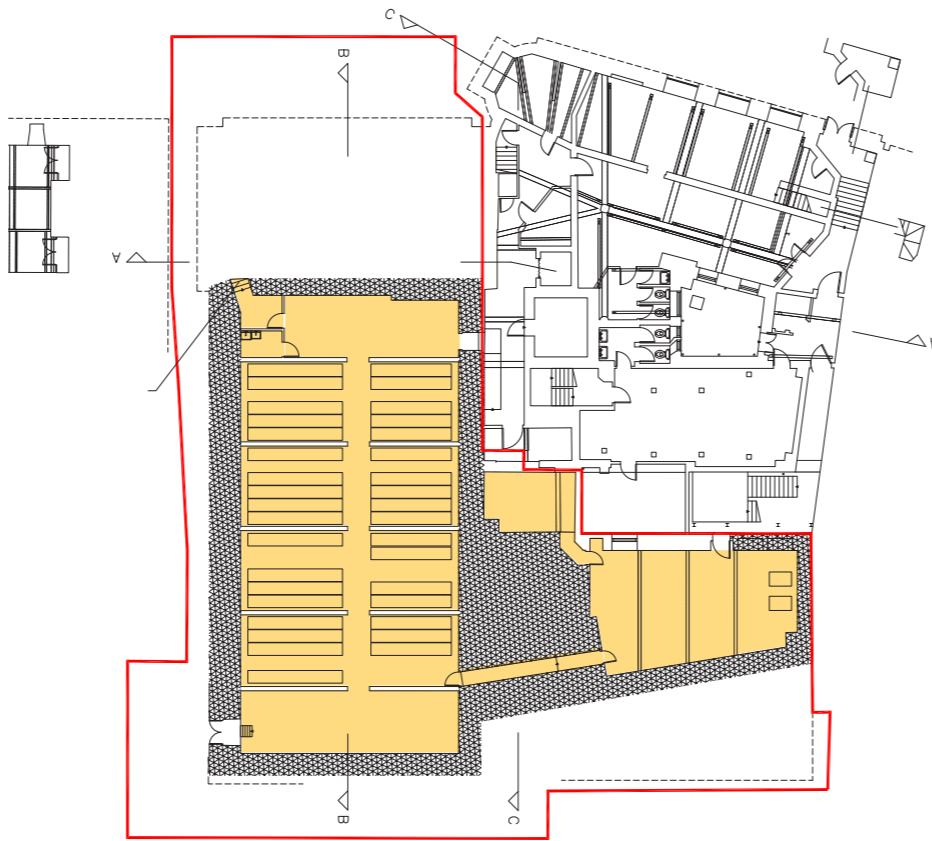
2.2 Heritage Significance



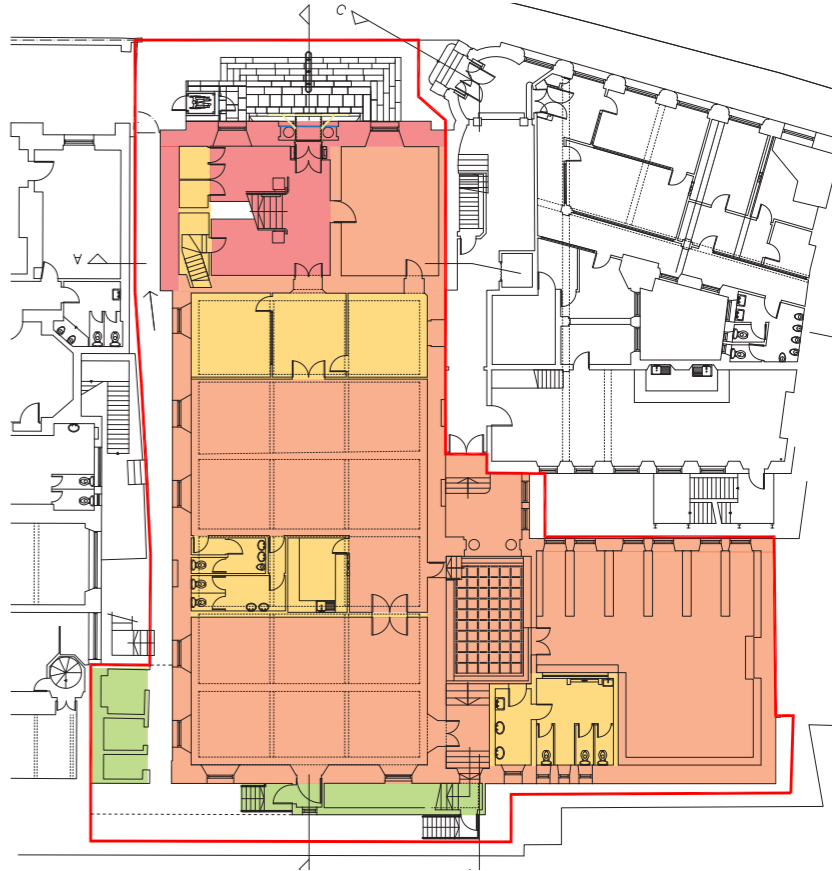
Existing First Floor Plan



Existing Second Floor Plan



Existing Basement Plan



Existing Ground Floor Plan

- Key
- Exceptionally Significant
 - Highly Significant
 - Significant
 - Neutral
 - Detrimental



2.2 Heritage Significance

2.2.3 Historic phasing

The following diagrams, extracted from the 2006 Conservation Management Plan, illustrate the key phases of construction on the site.

Key to Phasing

Pre-existing

Lit & Phil Building

Phase 1: 1825

Phase 2: 1834

Phase 3: 1837

Phase 4: 1860

Phase 5: 1866

Little physical evidence remaining

Phase 6: 1889

Phase 7: 1894

Phase 8: 1898

Phase 9: 1931

Phase 10: 1964

Phase 11: 1967

Neville & Wood Memorial Halls

Phase 1: 1872

Phase 2: 1902

Phase 3: 1972?

Bolbec Hall

Phase 1: 1909

Phase 2: 1949

Phase 3: 1972?

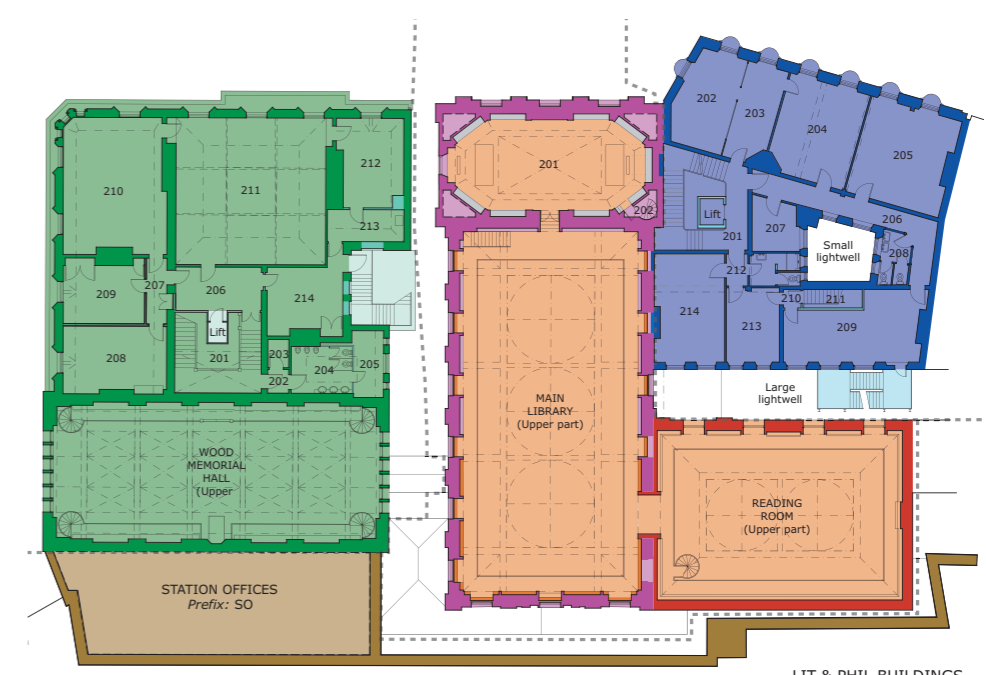
Station Offices

Phase 1: 1886?

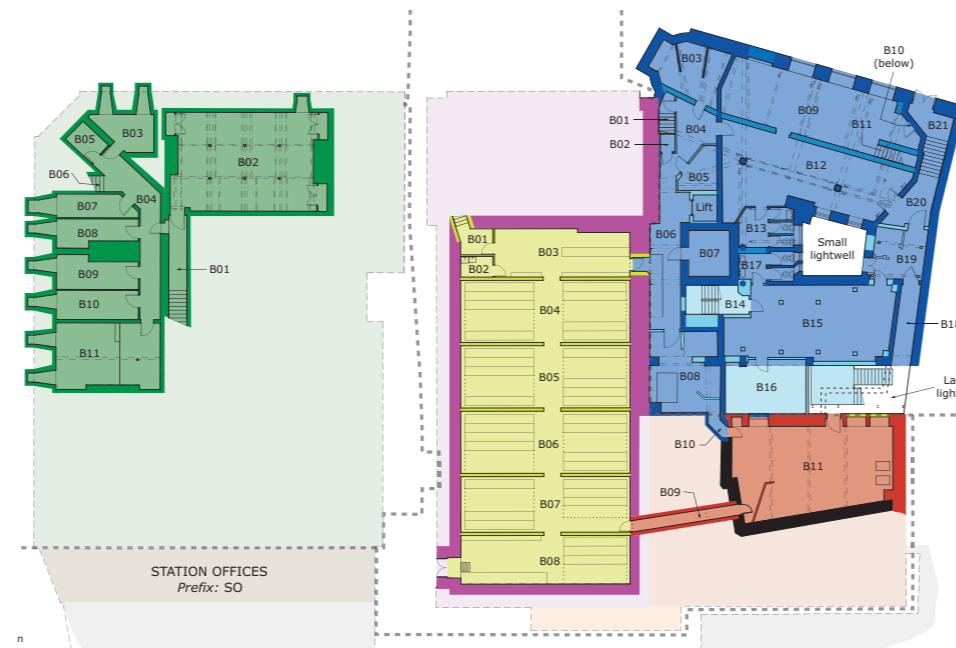
Phase 2: 1893?



First Floor Plan



Second Floor Plan



Basement Plan



Ground Floor Plan



Plans source: Lit & Phil Conservation Management Plan, PLB Consulting, 2006

2.3 Site Constraints

2.3.1 Site Location

The Lit&Phil is located on Westgate Road, close to Newcastle Central Station within the Newcastle Central Conservation Area. Westgate Road originally followed the line of Hadrian's Wall, a scheduled ancient monument that runs to the north-west of the site.

The building is enclosed on two sides by neighbouring buildings and to the rear by a high retaining wall to the edge of the station car park.

It forms part of a group of civic buildings, including the Grade II listed Bolbec Hall (1907) to the east, and the Grade II* listed Neville Hall (1872) to the West.

For further information on the history of the site and adjacent buildings, refer to the Conservation Management Plan for The North-East Institute, prepared for the North East Civic Trust by Ian Brocklebank RIBA IHBC & PLB Consulting Ltd October 2006.

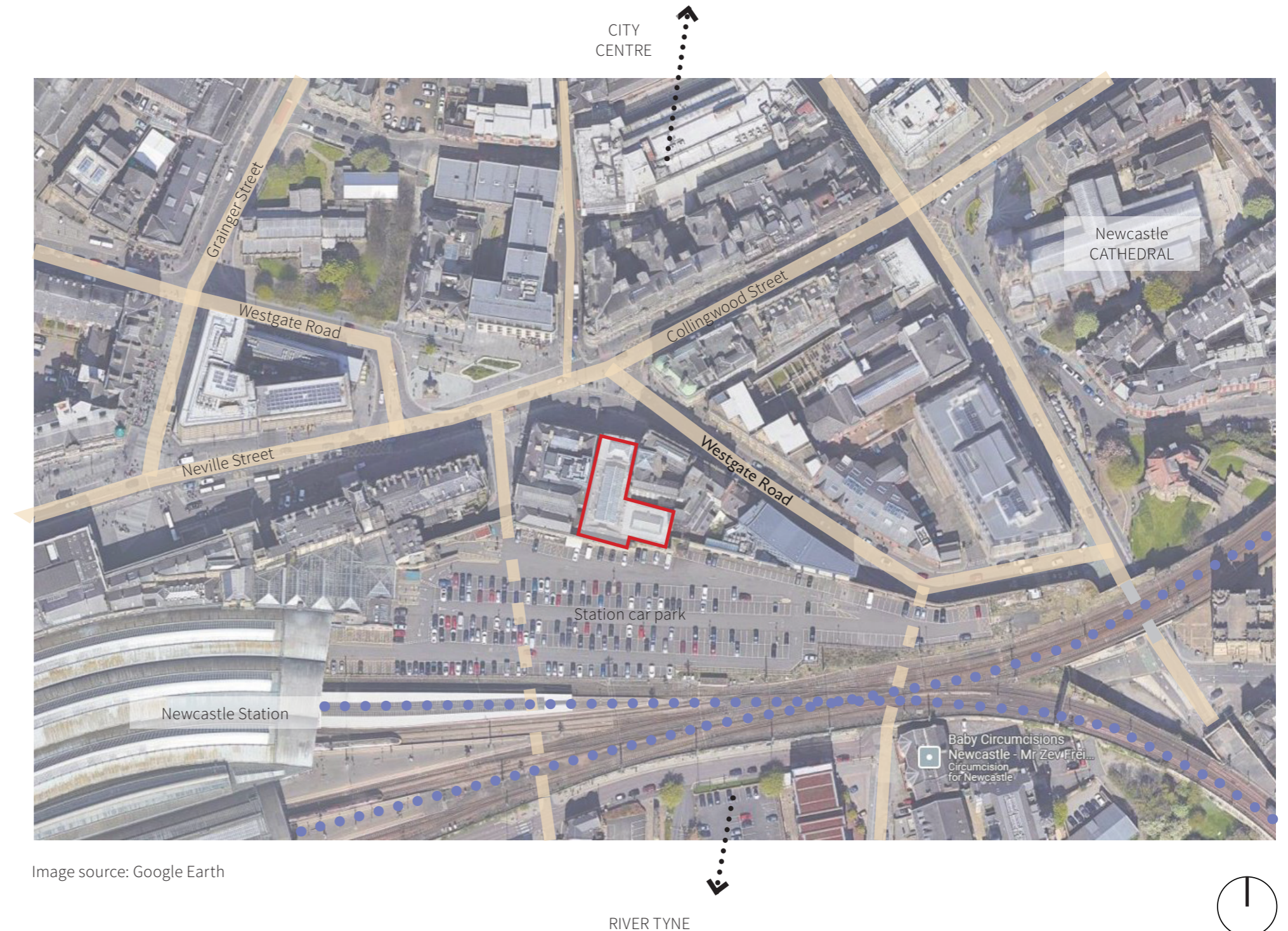


Image source: Google Earth

2.3 Site Constraints



Image source: Google Earth



Orchard Street runs beneath car park

Station car park with vaults beneath

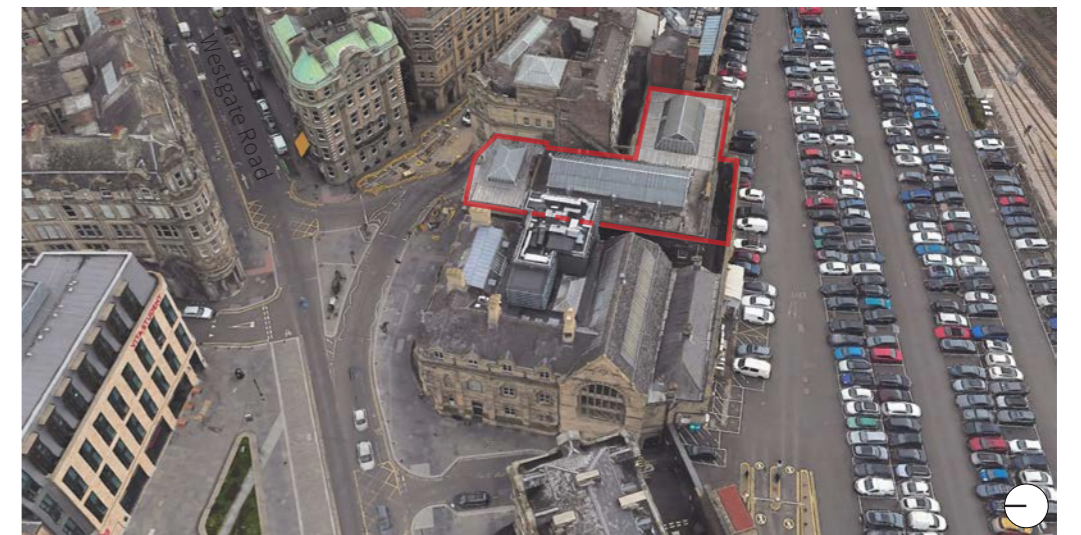
Retaining wall to car park

KEY

- Site boundary
- ▲ Entrances
- ▲ 3d View
- Number of storeys



A



B



C

2.4 Occupancy & Management

2.4.1 Use, Occupancy & Management

The Lit & Phil is managed by a core team, guided by a Board of Trustees.

Key personnel include:

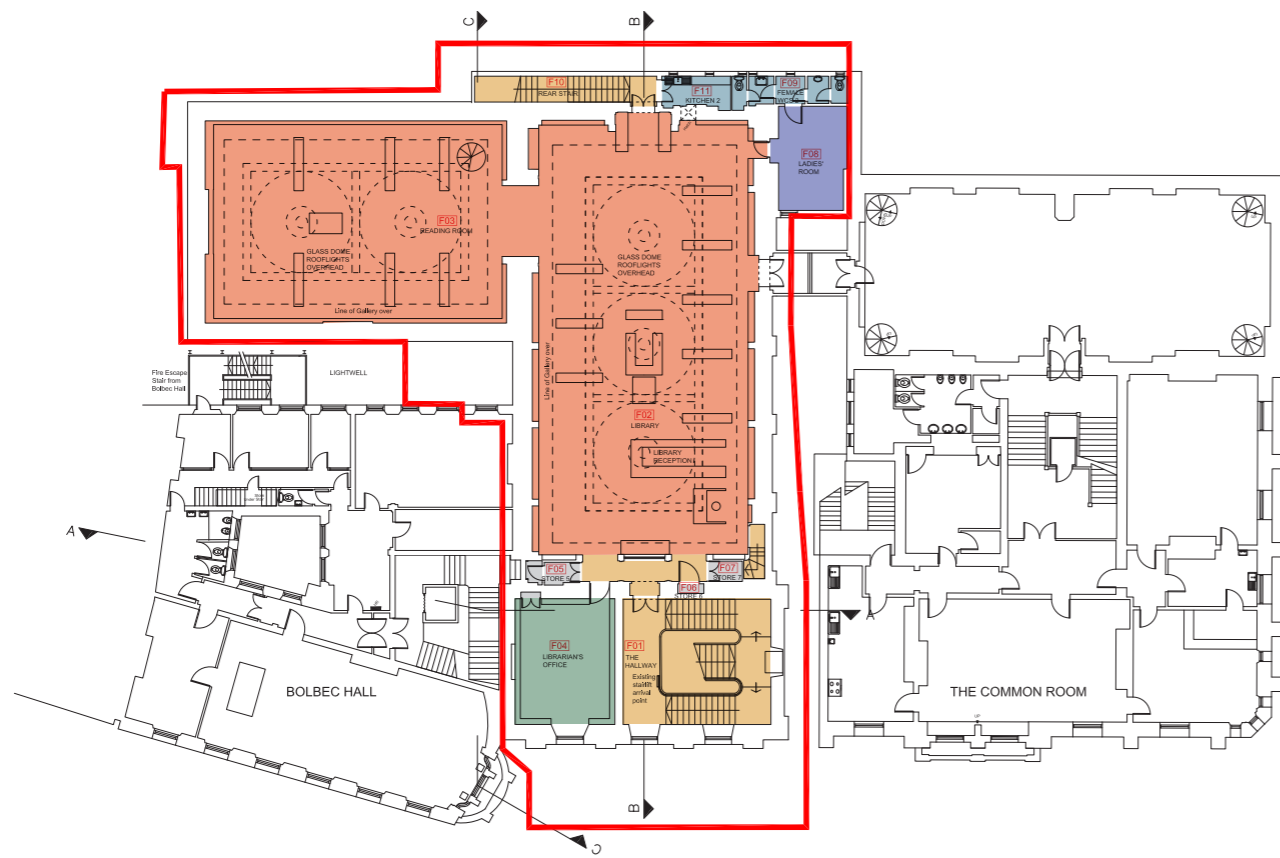
- Trustee leading the capital works project
- Chair of the board of Trustees
- Head Librarian
- Accountant
- Facilities manager

The building is cleaned daily and the heating is switched on in the early hours of the morning to bring the building up to temperature for the cleaner’s arrival.

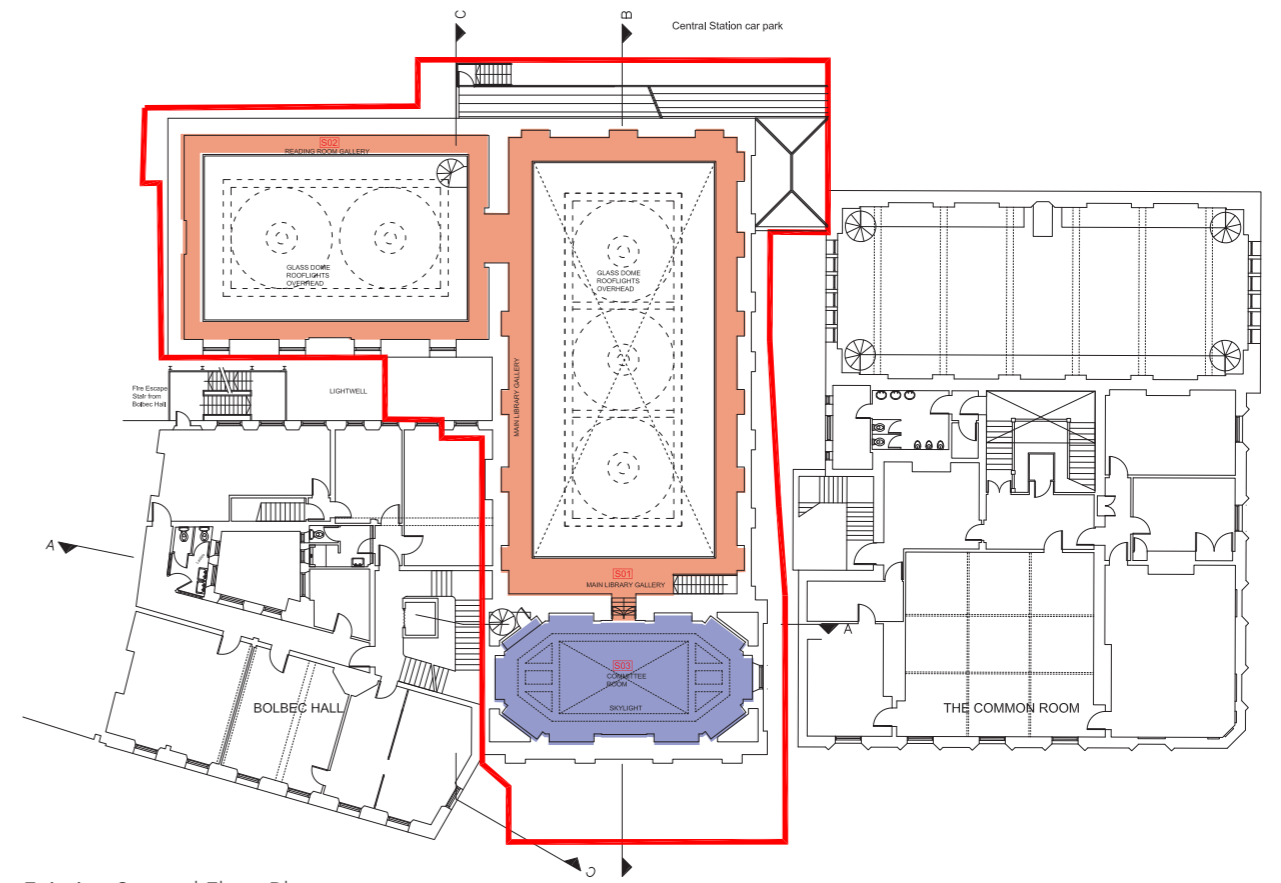
The library is used by a broad range of people, from younger students and families, to older members and visitors for evening events.

The existing plans are shown on the following pages, in addition to the reconfigured plans proposed under the current capital project. The overall use of the building will not change significantly, however occupancy and intensity of use may increase within the Loftus and multipurpose rooms, once the works have been carried out.

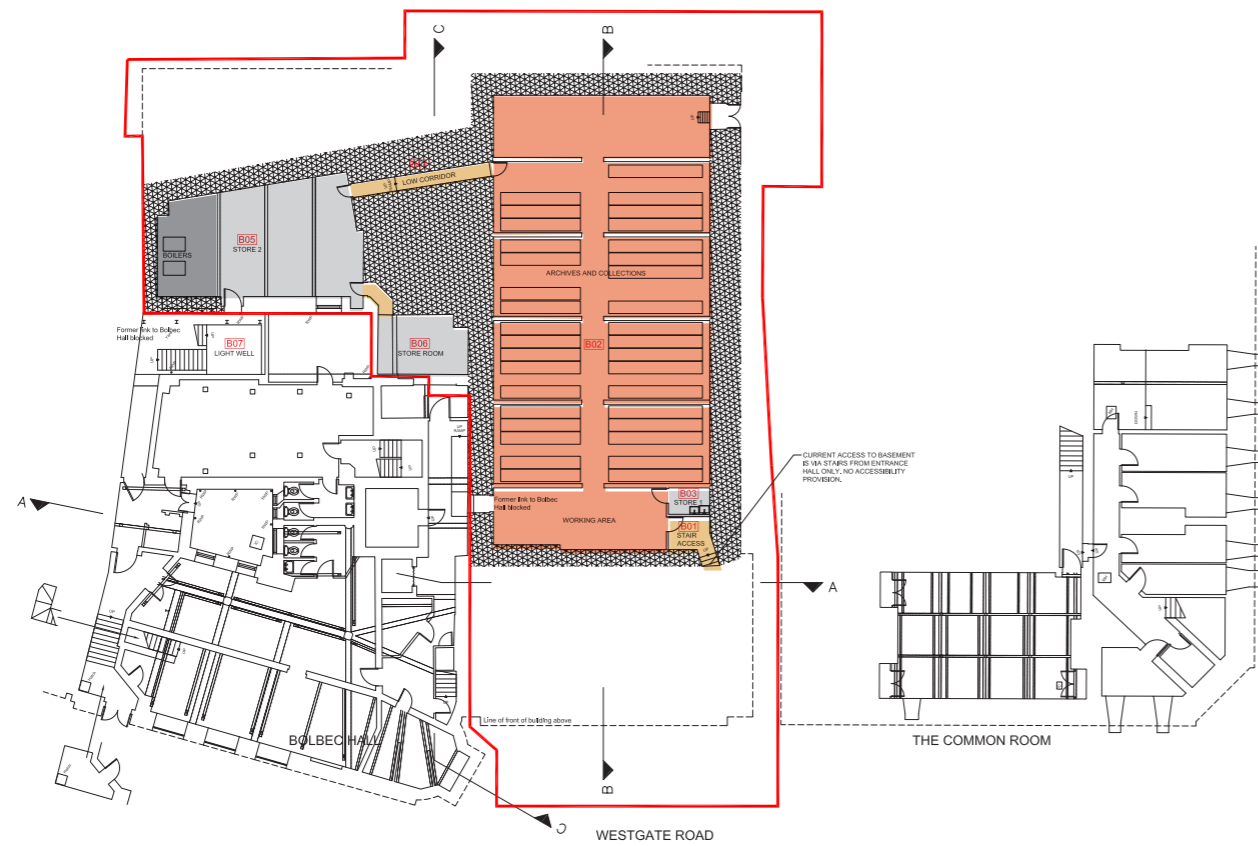
Building Ownership	Owned outright by Lit & Phil
Management	Member owned charity overseen by Board of Trustees Active and involved membership
Days of opening	Monday - Saturday
Typical hours of operation	9:30am - 7/8pm, or 1pm on Saturdays
Out of hours use	Cleaning staff arrive at 7am Events can go on until 10pm
Occupancy	Loftus/ multipurpose rooms - 95 people Joseph Swan Room - 20 people - most used Committee Room - 20 people
Usage fluctuations	Families at weekends, students during the week Quieter during summer and university holidays
Users	Members demographic is predominantly older but not representative of the typical building users. Post grad students and families use the library
Uses	Quiet individual study Language, writing, bookbinding and art classes Jazz and classical music concerts



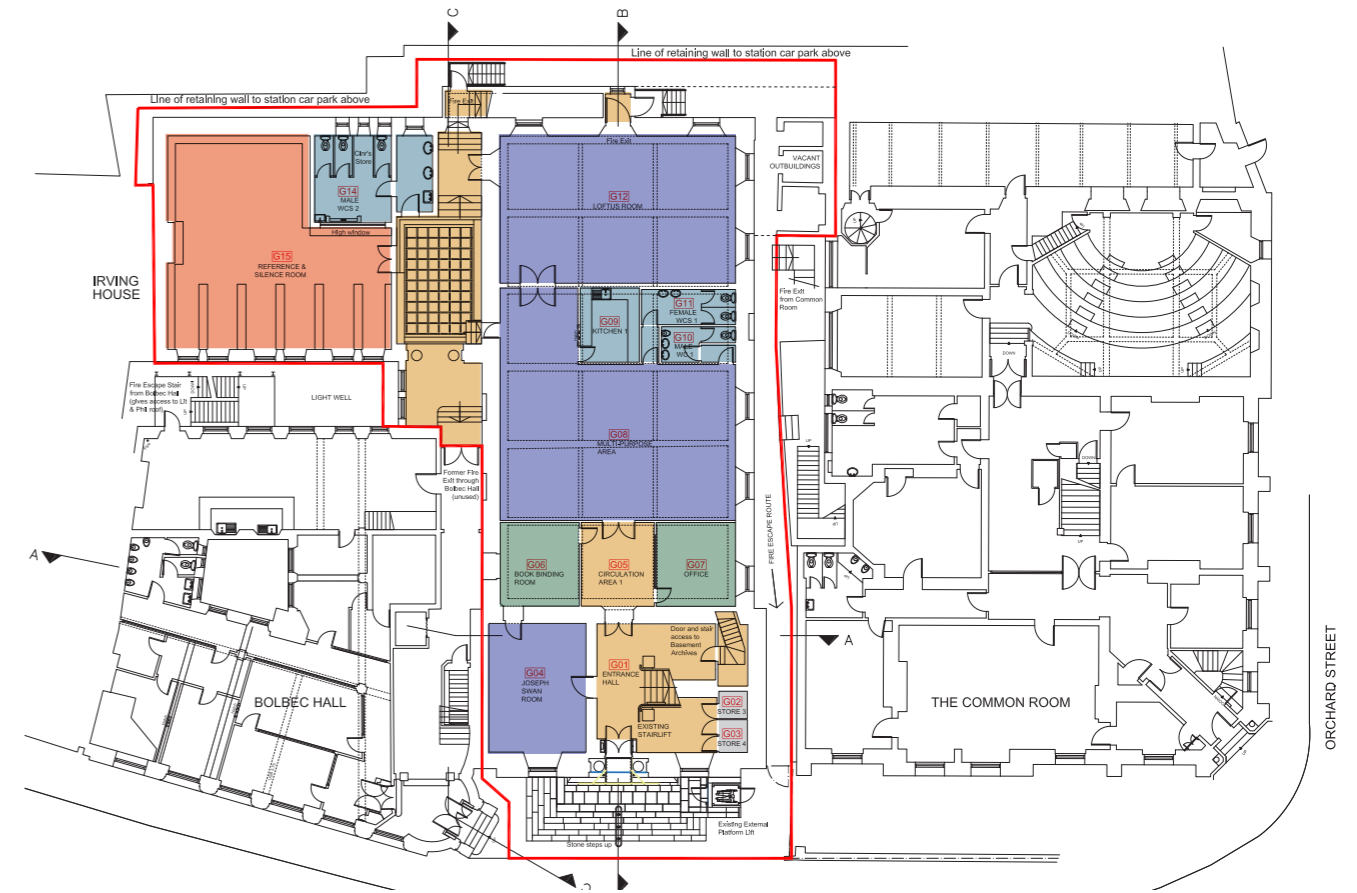
Existing First Floor Plan



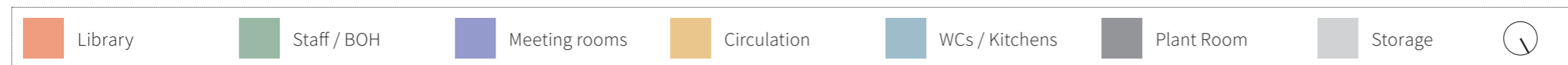
Existing Second Floor Plan



Existing Basement Plan



Existing Ground Floor Plan



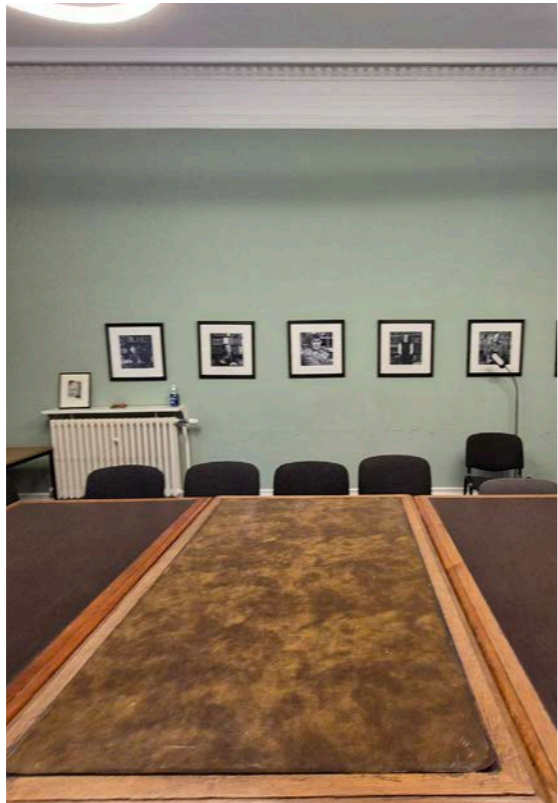
2.4 Occupancy & Management



Main Library - second floor gallery
Image source: Photo by Sally Ann Norman, courtesy of Lit & Phil



Reading Room - second floor gallery



Joseph Swan Room - ground floor



Main Library - first floor



Committee Room - second floor

2.4 Occupancy & Management



Loftus Room - ground floor
Image source: Lit & Phil



Multipurpose Room - ground floor



Reference & Silence Room - ground floor



Archive - basement

SURVEYS & ASSESSMENTS

3.1 Building Surveys

3.1.2 Building Services Condition Survey

Skelly & Couch undertook a visual inspection of the building services on 28th January 2025.

The building was open and occupied to staff and the public throughout the survey.

The purpose of the report was to identify M&E equipment energy use that could be addressed with a decarbonisation strategy and the capacity of the existing infrastructure to establish a base point for energy reduction measures and the introduction of decarbonised plant.

The report also describes the principle of the non-energy using M&E services identified incidentally as part of the inspection.

Key issues identified:

- Building is entirely naturally ventilated - no heat recovery systems are present.
- Windows are generally sealed shut.
- Building is heated under a single zone.
- Radiators do not have individual TRVs.
- Pipework is generally uninsulated.
- Many fluorescent fittings are present, however the organisation has a rolling programme to replace with LED.

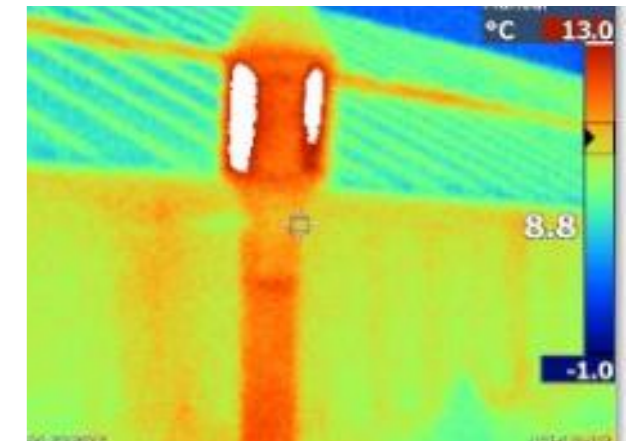
Recommendations for further analysis:

1. Temperature monitoring in peak season to assess performance of control
2. CO₂ monitoring in heavily occupied spaces to assess performance of control
3. Detailed survey to identify outputs of the heat emitters in each space.

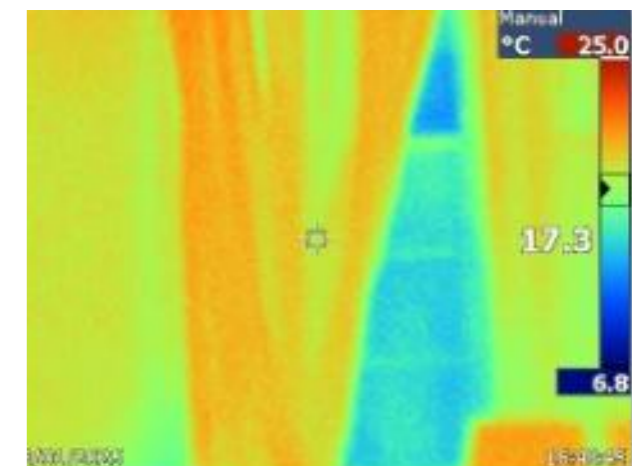
3.1.3 Thermal Imaging Survey

As part of the visual inspection, a Thermal Imaging Survey was undertaken.

- Glass lanterns over library domes give good performance in library spaces.
- Exposed pipework with heat loss is unfavourable but they are in heated areas.
- Thermal imaging showed that glazing with coverings (curtains, shutters) had better performance than solely glazing when in good condition and utilised effectively. Coverings were generally used permanently if present, improving performance of rooms.
- Natural ventilation in library space located at high level had large heat losses as open to external air.
- Heat loss is evident from the front façade glazing.



Thermal imaging showing heat loss through rooftop vents to library



Thermal imaging showing the difference in heat loss between glazed areas and areas covered with curtains

3.2 Fabric Performance

Little information is available on the building's original construction as no intrusive inspection into the building fabric has been carried out. Existing U-values have been based on the information provided by Haworth Tompkins. Typical building practices of the time have also been considered. Proposed U-values have been either calculated using the wall build ups detailed below or estimated using tabulated CIBSE guidance.

Current knowledge or assumptions of the building fabric have been summarised in the table below. The satellite view on the following page details the main spaces of the building, as well as external element types.

	Fabric Element	Construction	Fabric Condition	U-Value (W/m ² K)	Notes / Assumptions
EXTERNAL WALLS	Front façade	1000mm sandstone ashlar assuming 5% lime mortar 20mm plasterboard internally		1.10	Uninsulated Assumed the full thickness as sandstone ashlar with internal plaster finish.
	East / west façades	900mm sandstone ashlar assuming 5% lime mortar 20mm plasterboard internally	Tightly enclosed by neighbouring buildings limiting access for maintenance, leading to deterioration.	1.20	As above
	South fire exit	250mm sandstone ashlar assuming 5% lime mortar 20mm plasterboard internally	Tightly enclosed by railway arches limiting access for maintenance, leading to deterioration.	2.30	As above
	Right wing south/east façade	250mm brick assuming 5% lime mortar 20mm plasterboard internally	Internal deterioration around the chimney breast in the Silence room from rainwater ingress.	1.80	Uninsulated Assumed the full thickness as red brick with internal plaster finish.
	Basement walls (plant space)	Internal finish red brick		1.70	U-value estimated using CIBSE Guide A table 3.22 detailing basement walls based on depth
	Basement walls (archive space)	Internal finish plaster		0.81	As above
FLOORS	Entrance hall ground floor	Ornate stone finish		0.82	Estimated using CIBSE Guide A table 3.16 detailing uninsulated solid ground floors based on the perimeter/area ratio
	Silence room ground floor	Ornate herringbone flooring finish		0.82	As above
	South fire exit ground floor	Not witnessed		1.30	As above
	Archive basement floor			0.35	Estimated using CIBSE Guide A table 3.21 detailing uninsulated basement floors based on the perimeter/area ratio
	Plant basement floor			0.53	As above
ROOF	2-domed flat roof	20mm lath and plaster internally 200mm timber joists and boards 5mm lead finish	Lead finish appears to be in sound condition, subject to further investigation.	1.35	Uninsulated
	3-domed flat roof	20mm lath and plaster internally 200mm timber joists and boards 5mm bitumen felt finish	Bitumen finish appears to be in sound condition, subject to further investigation.	1.30	Uninsulated
GLAZING	Roof glasshouses	Opaque Georgian wired glass panes mounted on metal frames Single-glazed	Glasshouses appear to be largely dirty reducing transparency. Structural concerns have been raised around the glazing bars being undersized which causes them to flex.	6.50	Estimated using CIBSE Guide A table 3.29 for metal-framed rooflights with roof adjustments in table 3.30 and 31
	Decorative rooflight lanterns	Single-glazed metal-framed		6.50	As above
	Façade windows	Single-glazed timber-framed sash windows	Windows are mostly sealed shut	4.80	Estimated using CIBSE Guide A table 3.29

3.2 Fabric Performance



Satellite view of Lit & Phil Library with key zones indicated and external fabric
Image Source: Google Earth

3.3 Building Services

3.3.1 Overview

Generally, services are well maintained and there is good knowledge of the existing infrastructure within the Facilities Management personnel. There has been no major refurbishment or upgrade of services in recent history, therefore the MEP is generally inefficient by modern standards.

A number of issues with the building were raised during briefing workshops and site visit. These include:

Accessibility

The main stair is fitted with a chair-lift but this is not satisfactory, and there are other areas of the building which do not have level access. These issues are proposed to be addressed by the capital project, including the installation of a new lift from Basement to First Floor level and a platform lift within the Ground Floor.

Layout

The arrangement of the main lettable spaces prevent and the lack of accessible corridors prevents their full occupancy.

Capacity

The book collection is growing at a rate of 7-1000 per year. The archive in the basement has specialist storage requirements, which are not currently met.

Other

- Acoustics is of concern
- Book alarm will be considered with installation of new lift
- Welcome desk for merchandise desirable
- Income generation is an important factor

A number of issues with the building services were also raised by the staff which are summarised below. A more in-depth review of the systems follows.

Heating

- The 2no gas boilers are about 10 yrs old, are well looked after and serviced annually but staff believe they could be more efficient.
- There is a thermostat in the gallery and valves on rads but not active valves
- There is 1 heating zone for the whole building. Staff would like zoning of heating to have more control.
- Temperature wise, control is difficult. Thermal comfort is not ideal; the building is often too hot or too cold. The Committee room in particular is often cold.
- Lit & Phil have been quoted £7-8k per boiler for replacement.

Cooling

- There is no active cooling in the building.
- It can get hot in summer but not stifling.
- Staff do open doors to improve ventilation, but many are fire doors.

Ventilation

- There is an original system of Victorian air ducts for natural ventilation, serving ground to second floor. It is unclear if this is still working as intended or if it has been partially sealed.
- Many windows are painted closed.

Lighting

A roll out of LED fittings is in progress

3.3.2 Building Utilities & Meters

The gas supply and utility meter for the library is located in the basement of the Bolbec Hall, which can be accessed via the Lit & Phil basement plant room. The gas meter is U40.

Utility mains water meter and stop cock located in basement plant room, on the wall to the lightwell.

Incoming telecoms could not be identified on site; however, may be a combination of BT copper lines and new fibre lines.

No fire-fighting supplies have been identified or are known about.

3.3 Building Services

3.3.3 Heating

Heating is served by 2no. ~87kW floor-mounted Ideal Concord CXA condensing gas boilers located in the basement plantroom. The boilers are approximately 10 years old, serviced annually and well looked after.

The system includes:

- Pressurisation and 500L expansion set.
- 2" gas feed pipe.
- Twin head pumps with two traceable branches. One travels adjacent to chimney, the other travels exposed through the store.
- Horstmann controller.
- Staff have indicated there is a thermostat in library balcony but was not witnessed during the survey.

Control

Temperature control is overall difficult. There is 1 heating zone for the whole building. Some radiators have valves but they are not active.

The heating is turned on in the early hours to bring the building up to temperature for the cleaners' arrival.

Pipework

Pipework is 65mm flow steel. Pipework not easily traceable out of the basement as a large proportion is embedded within the building fabric, and it is not visible where it drops below floors.

No insulation outside of the basement store was witnessed.

Some sections have foil faced insulation within the basement.

Where visible condition appears reasonable however, there may be internal corrosion which is not apparent.

Testing can be carried out to ascertain wall thicknesses etc if required.

Heat emitters

- Ornate cast iron radiators within the Silence Room, Committee Room and Entrance Hall.
- Column radiators in the multi-purpose ground floor, Loftus Room and Ladies Room.
- Concealed finned pipes in the library.
- Exposed heating pipe running throughout library space.
- Fan assisted heater in the basement.

Thermal comfort

Staff feedback on thermal comfort is that the building is either too hot or too cold, particularly in the library. The basement temperature was not noticeably different from the rest of the building during the survey.



2x gas boilers, expansion set, twin head pumps in basement



Ornate radiator in Silence Room



Column radiator in multi-purpose area



Exposed pipe throughout library space



Fan assisted heater in basement archives

3.3 Building Services

3.3.4 Ventilation

There is only natural ventilation throughout the whole building.

Windows are largely sealed, with facility managers unable to confirm when they were last opened.

WCs are unventilated and have labelled windows to be kept shut.

There are ventilation air ducts integral to the fabric, with openings built into beams in some locations. Grilles are visible in the library space and the ground floor multi-purpose area.

There are Victorian turrets on the roof, connected to air ducts with high level openings in the library ornate ceiling space. These turrets evidenced high heat losses during the thermal imaging survey.



Ventilation air ducts integral to beams



Air ducts integral to Library ornate plaster ceiling (left) connected to Victorian turrets on roof (right)

3.3 Building Services

3.3.5 Domestic Hot Water

The locations requiring domestic hot water are:

- Basement store sinks
- Ground floor female/male WCs
- Ground floor male WCs
- Ground floor kitchenette
- First floor female WCs

All DHW is provided by local electric water heaters.

One is visible in the basement store. None are present in the female WCs. There was no access to the male WCs or kitchenette during the survey.

There are controls on an adjustable timer located outside the basement archives.

3.3.6 Cold water

The cold water is incoming into the basement plant room and is present in the spaces as for foul drainage.

The distribution is uninsulated copper pipework. This is able to be traced in the basement and is demonstrating good condition.

3.3.7 Drainage

The pipework appears much older in WCs and is painted

Rainwater drainage

The rainwater drainage is fed from the flat roof sections sloped to a perimeter channel. The channel has regular downpipes with leaf guards. The downpipes appear to drain internally to the building, concealed within the building fabric.

The downpipes appear free of debris.

Foul drainage

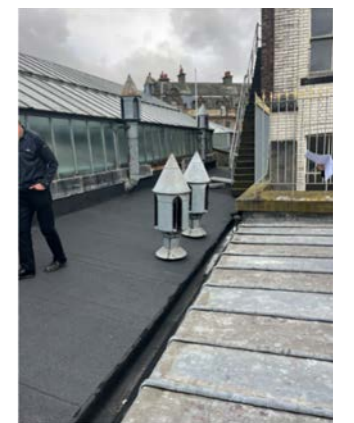
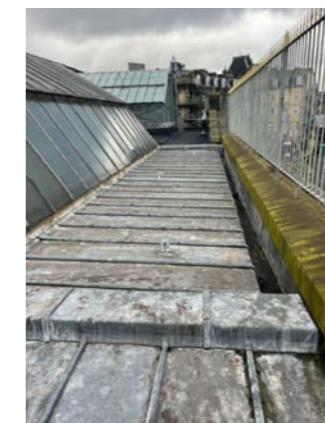
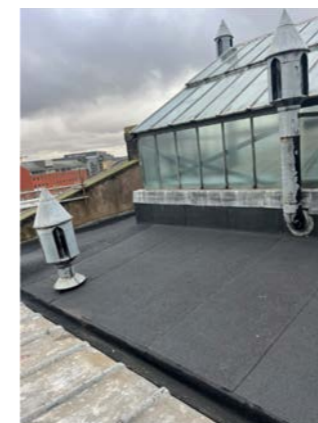
Foul drainage is a mix of plastic and metal above ground branches. Pipework is exposed in WCs and stores.

Routes through the building have not been determined.

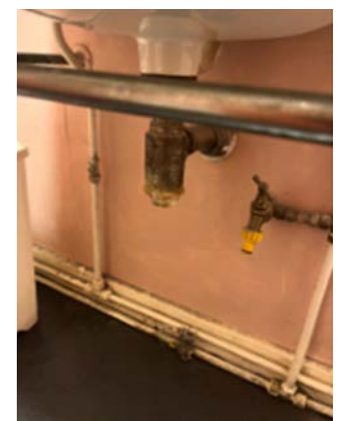
Foul drainage is present in basement level store, ground floor female and male WCs, ground floor kitchen, and first floor female WCs and kitchenette. It is assumed this is functional and connected to sewer.



Local electric water heater visible in basement store



Channel for rainwater drainage on the roof



Exposed foul drainage pipework in WCs and stores

3.3 Building Services

3.3.8 Electrical

The incoming mains enters the store room 3 within the Entrance Hall on the ground floor.

The main panel board is located in the same room with RCD protection, also with isolator and meter.

The incoming supply is 100A TPN.

The condition is good, last tested in March 2023 by Lewis-Harvey Ltd.

There are ways available on the board for spare capacity. The incumbent M&E consultant has requested a quote for an upgraded supply to support the future installation of heat pumps as part of the capital project.

There are CCTV cameras throughout the public spaces with the control panel located in store room 5 on the first floor.

There is a Honeywell Galaxy intruder alarm system with sensors throughout the building. The panel is located within store room 4 on the ground floor.

There are no WC alarms, disable refuge or induction loops. There is a stair lift present on the main staircase.

There is a book alarm present in the main entrance for alerting staff for books taken without being checked out.

3.3.9 Lighting

There are many fluorescent fittings present throughout the building, all with manual control.

The organisation currently has a rolling programme to replace these with LED although the details of this has not been confirmed.

4.1 Energy & Carbon Assessment

The following section investigates the existing energy and carbon performance of the library. An estimated heating demand has been calculated in order to set a carbon baseline, based on the available building information and reasonable assumptions.

Industry benchmarks and standards are used for a comparison as well as metered data for the observed use of the building.

4.1.1 Collection of Data

The Lit & Phil Library was subject to a building services survey and a qualitative thermal imaging survey performed by Skelly & Couch on 28th January 2025. During this, information on the library was witnessed and discussed with management.

The following applies:

- The building was open and occupied to staff and public throughout the survey.
- Record information including surveys and utility bills was collected.
- Heating provision identified by observation of plant equipment, zones, thermostatic controls and heat emitters throughout building. Verbal feedback on general comfort acquired.
- Ventilation availability noted from existing openings and use of windows during the time of survey.
- Photographs taken to guide building fabric estimations.
- No invasive surveys were carried out.

Energy data

Utility electricity and gas meter readings have been provided by the library's management for a two year period; December 2022 to November 2024.

The library's space heating system is fed by gas boilers and the domestic hot water uses local electric heaters. The gas meter readings therefore relate to the heating consumption of the building over the provided period.

Building information

Building floor, external walls, roof and glazing areas have been determined from existing building layouts provided by XSite Architecture. These include basement, ground floor, first floor and second floor plans, elevations and sections based on a measured survey completed in 2007 with spot checked measurements.

Little information is available on the building's original construction. Fabric for u-calculations have been based on historic examples. The calculated u-values and assumptions used are listed in section 3.2.

Air tightness testing

Envelope air tightness testing was performed by BSRIA on 16th August 2025 to determine the air permeability of the existing Lit & Phil whole building.

The air permeability rate with all vents unsealed was found to be 11.0 m³h⁻¹m⁻² @ 50 Pa.

This value represents the air leakage rate of the Lit & Phil under its normal operating conditions.

Carbon conversion factors

The annual carbon emissions have been calculated based on conversion factors for natural gas and electricity from The National Calculation Methodology modelling guide – 2021 Edition, see table below.

FUELTYPE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Electricity emissions (kgCO ₂ /kWh)	0.163	0.160	0.153	0.143	0.132	0.120	0.111	0.112	0.122	0.136	0.151	0.163
Gas emissions (kgCO ₂ /kWh)	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21

Gas and electricity CO₂ emission and primary energy factors for buildings other than dwellings. Extracted from the National Calculation Methodology 2021

FUEL TYPE	P/ KWH	
Natural gas	9.7	
Electricity	Day rate	35.9
	Night rate	28.9

Lit & Phil Library's utility rate per fuel type excluding standing charges

4.2 Heat Energy Usage Estimate

4.2.1 Design temperature assumptions

The yearly heat energy usage of the existing Lit & Phil Library has been calculated as an estimate to provide a comparison with metered data for the library's operational energy and carbon performance before interventions are investigated.

The baseline is for space heating energy usage, which allows comparison to metered gas data and apportionment of the heating energy use to different aspects of the building.

A number of methodologies are available to estimate the expected heating energy requirement in a building. In this case, due to the limited building information available, a simple heating degree days calculation was carried out, where heating degree days were applied to output a yearly consumption estimate for heating usage only.

The degree days method allows a peak load to be converted into a yearly heating consumption rate, accounting for the local climate.

A brief overview of the assumptions made within this methodology are included below:

- Newcastle heating degree days with a base temperature of 16°C.
- An internal design temperature of 20°C throughout the whole building has been assumed, with the exception of the basement at 18°C. Based on the internal temperatures observed during the site survey.
- Peak load calculation using external temperature of -4°C based on the CIBSE tabulated extreme temperature for Newcastle.
- Walls shared with the unoccupied Bolbec Hall treated to have an external temperature of 10°C.

4.2.2 Infiltration assumptions

Air tightness testing carried out on the Lit & Phil Library found the air permeability rate to be 11.0 m³h⁻¹m⁻² @ 50 Pa, with all vents unsealed as representative of standard building operation.

This has been converted into an average annual air infiltration rate using two methods for validation:

- Conversion via empirical data in CIBSE guide A, figure 4.15, based on the Lit & Phil building volume.
- Conversion via tabular data in CIBSE guide A, table 4.16 for partially exposed buildings.

Both methods found an air infiltration rate of 0.30 ACH.

Where improvements are made to building openings in the interventions section, an estimated improvement to this infiltration value is made to account for reduced heat losses via infiltration

4.2.3 Ventilation assumptions

The building is known to only have natural ventilation throughout. The calculations assume the spaces are appropriately ventilated by the infiltration of the building fabric, thus no account is made for additional ventilation. Anecdotally there may be inadequate ventilation during the summer.

The existing natural ventilation system consists of high level turrets through and around rooflights and roofs. It is assumed that opening doors and windows provided the low level fresh air ventilation based on a stack system, exhausting through the roof. As this is uncontrolled it leads to unwanted ventilation during unoccupied periods and heating season.

4.2 Heat Energy Usage Estimate

4.2.4 Baseline results

Based on these assumptions, the steady state heat losses throughout the library could be estimated for a peak load scenario. The adjacent pie chart illustrates these by loss type and fabric type as a proportion.

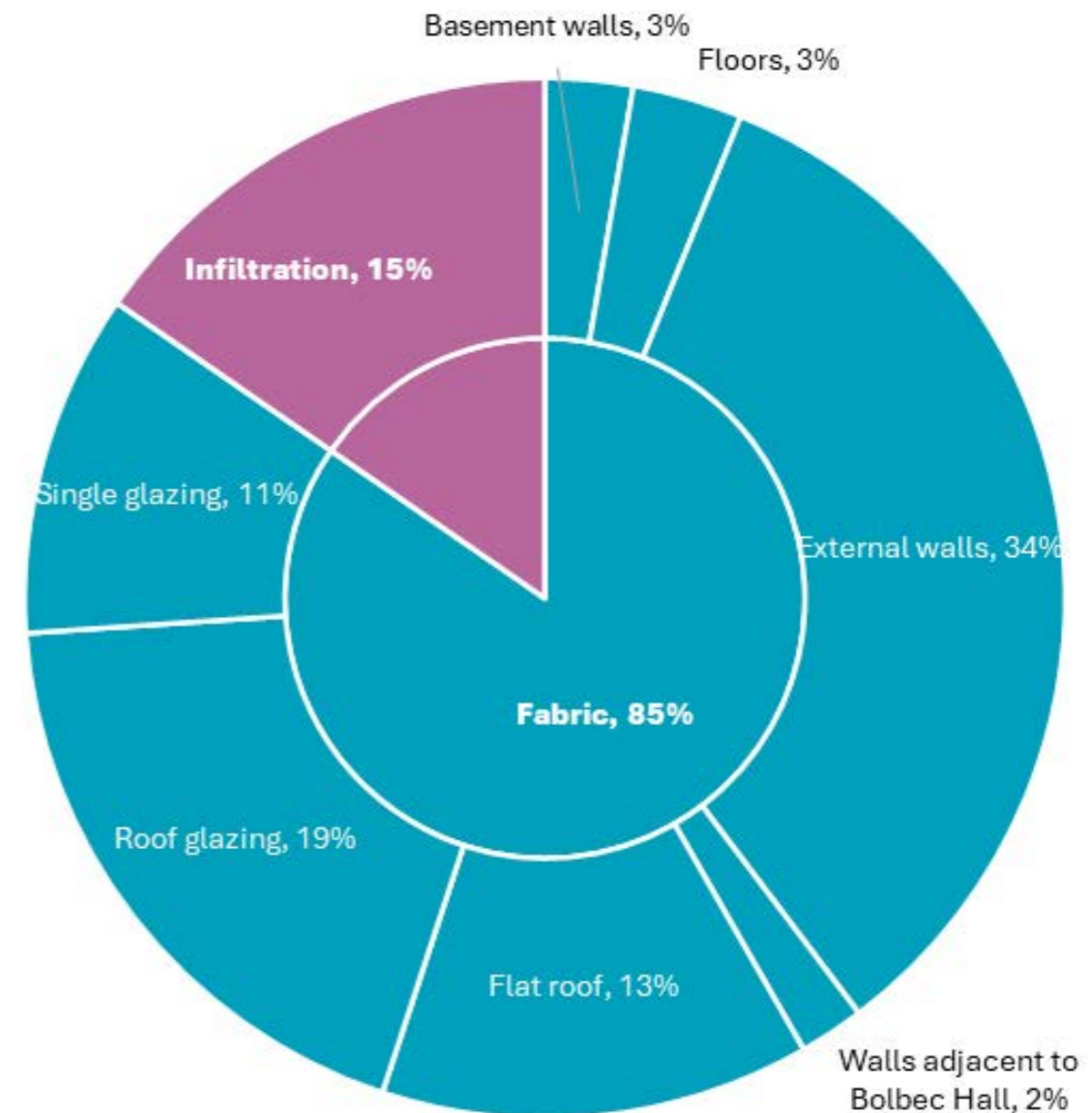
Key observations are as follows:

- Fabric losses account for a significant proportion of the building's heat loss at 85%.
- 15% of the overall losses arise from infiltration of the building envelope. This is based on air tightness testing of the Lit & Phil.
- External walls are the element type with the largest heat loss, at 40% of all fabric losses, however see note below.
- Heat loss through glazing is almost double from the decorative lanterns and glasshouse system on the roof than the façade sash windows.
- Heat loss through the multiple roof elements makes up 38% of all fabric heat losses.
- The basement and ground floor have low heat losses compared to the other element types, due to being in contact with the ground rather than the air.
- The main library walls are largely lined with bookshelves which have not been considered in the building fabric losses. As reasonably good insulators, these would reduce heat losses through the external walls.

It should be noted that, due to the thick, heavy stone walls, the steady state calculation for heat loss through walls is unlikely to reflect reality as the building will rarely be in a steady state, with the internal surfaces either heating up or cooling down depending on whether the heating is on or not.

This also makes it difficult to heat the space to a comfortable temperature as there will usually be significant radiant losses to the walls.

A dynamic thermal model would provide more accurate results.



Estimated steady state heat losses from existing Lit & Phil library, expressed as a proportion of the total building heat loss based on the type of loss and the individual fabric type

4.3 Metered Data

4.3.1 Metered annual energy use & carbon emissions

The adjacent graphs show the total metered carbon emissions, energy use and utility cost respectively for the Library by fuel type for December 2022-November 2024.

Key observations are as follows:

Energy

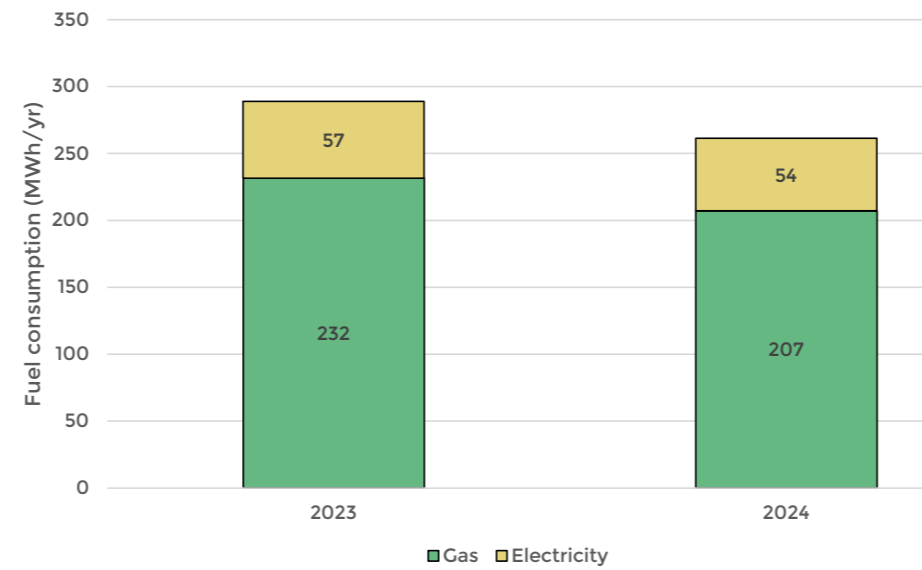
- The average total energy use across the two year period was 275 MWh/yr.
- Of the total energy use, 80% related to gas and 20% to electricity across both years.
- This is to be expected as the space heating is served by gas, whilst the domestic hot water is from electric heaters where the demand is small.
- There was a reduction in energy consumption for both fuel types from 2023 to 2024; 11% and 5% for gas and electric respectively.

Carbon

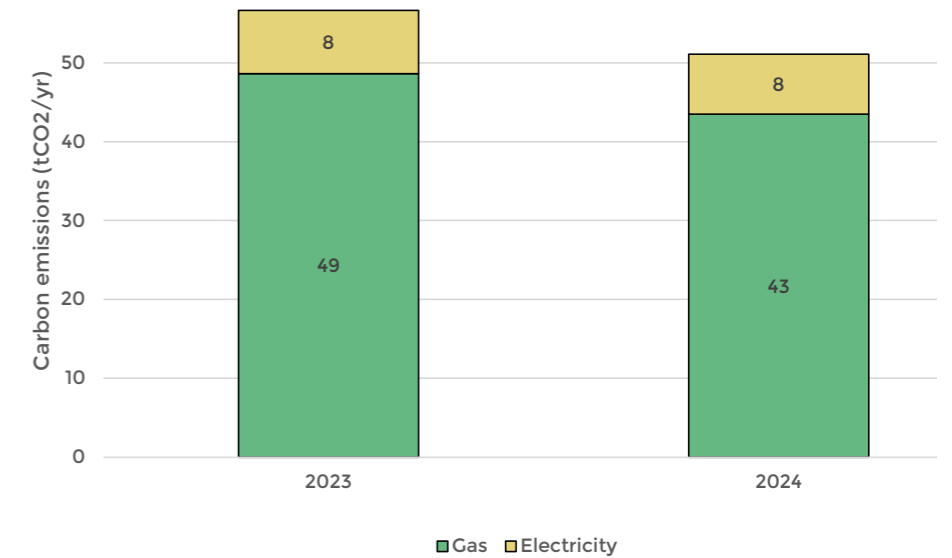
- The average total carbon emissions across the two year period was 54 tCO₂/kg
- Of the total carbon emissions, 85% related to gas and 15% to electricity on average.

Cost

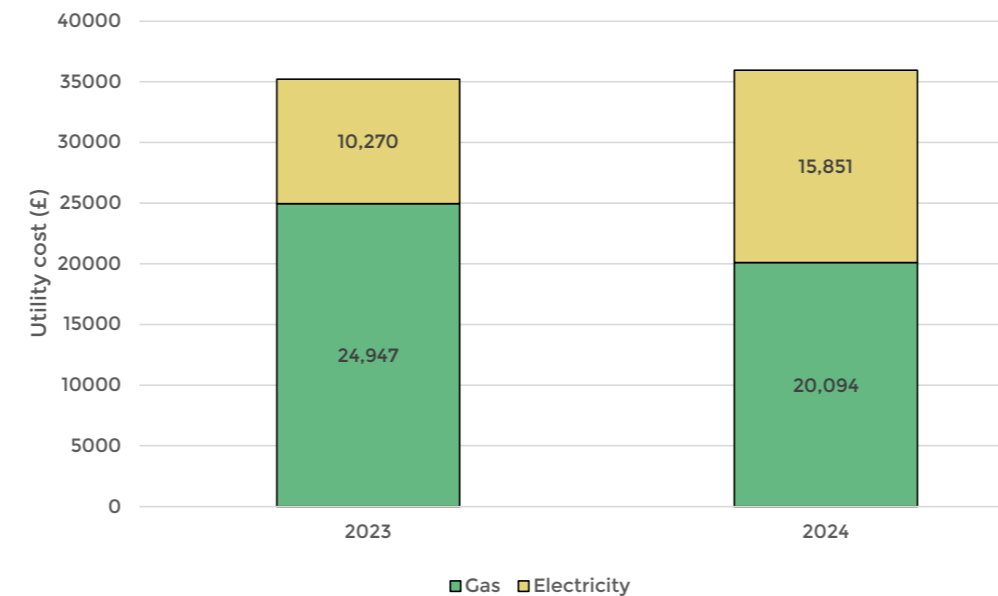
- The average total annual cost was £35,600.
- The total electricity cost increased in 2024 despite its reduced consumption.



Total annual MWh consumption by fuel based on meter readings (Dec 2023 to Nov 2024)



Total annual carbon emissions by fuel in tCO₂ based on meter readings (Dec 2023 to Nov 2024).



Total annual utility cost by fuel based on current energy rates (Dec 2023 to Nov 2024), excluding standing charges

4.3 Metered Data

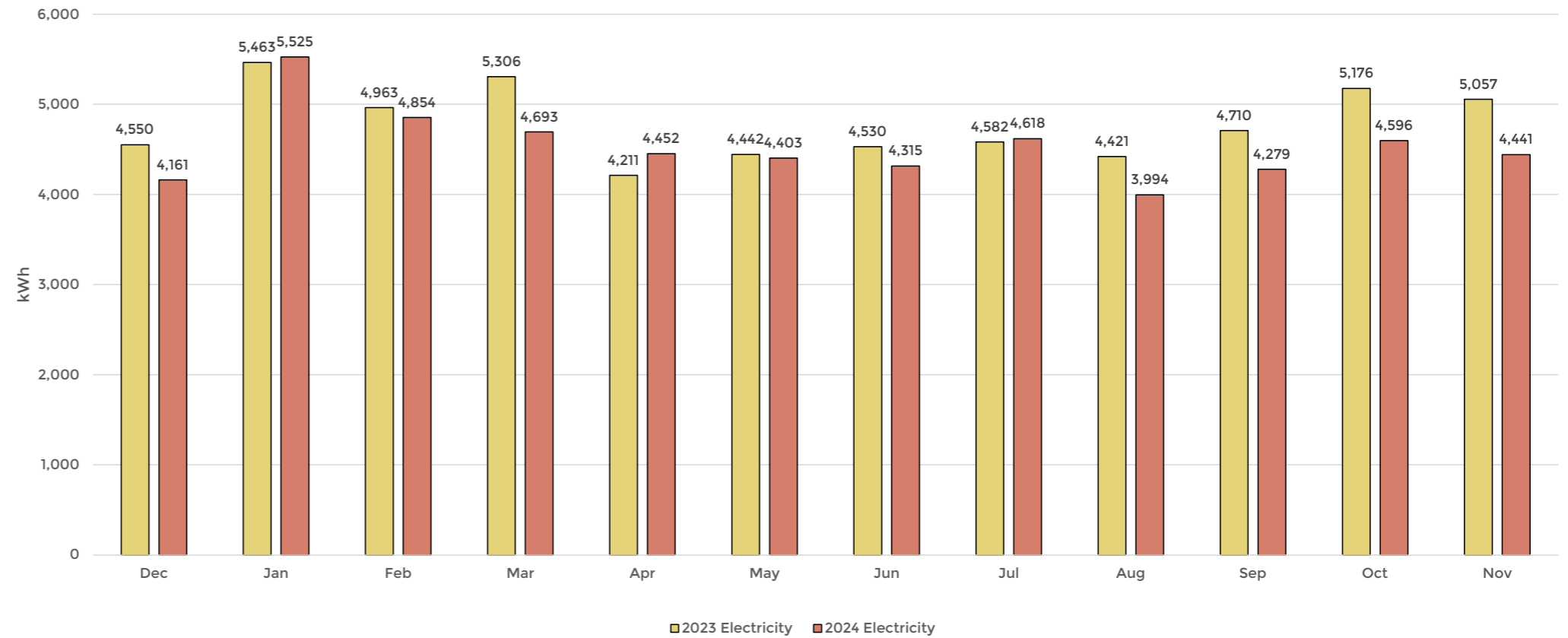
4.3.2 Metered monthly energy use

Electricity

The adjacent graph shows the library's metered electricity consumption by month for the same period.

Key observations across the figure are as follows:

- Electricity consumption has stayed relatively consistent throughout the period; the lowest monthly consumption in August 2024 is 28% lower than the highest consumption in January 2024.
- The highest consumption was in January of both years, likely due to high lighting use during these winter months.
- Electricity consumption in December 2023 and 2024 were relatively low despite also being winter months, which could be a result of lower library usage due to periods such as the university and school Christmas holidays, or being closed for a period.
- There is generally a slight reduction in electricity usage from 2023 to 2024.



Lit & Phil Library metered electricity use per month (kWh) in the period Dec 2023-Nov 2024.

4.3 Metered Data

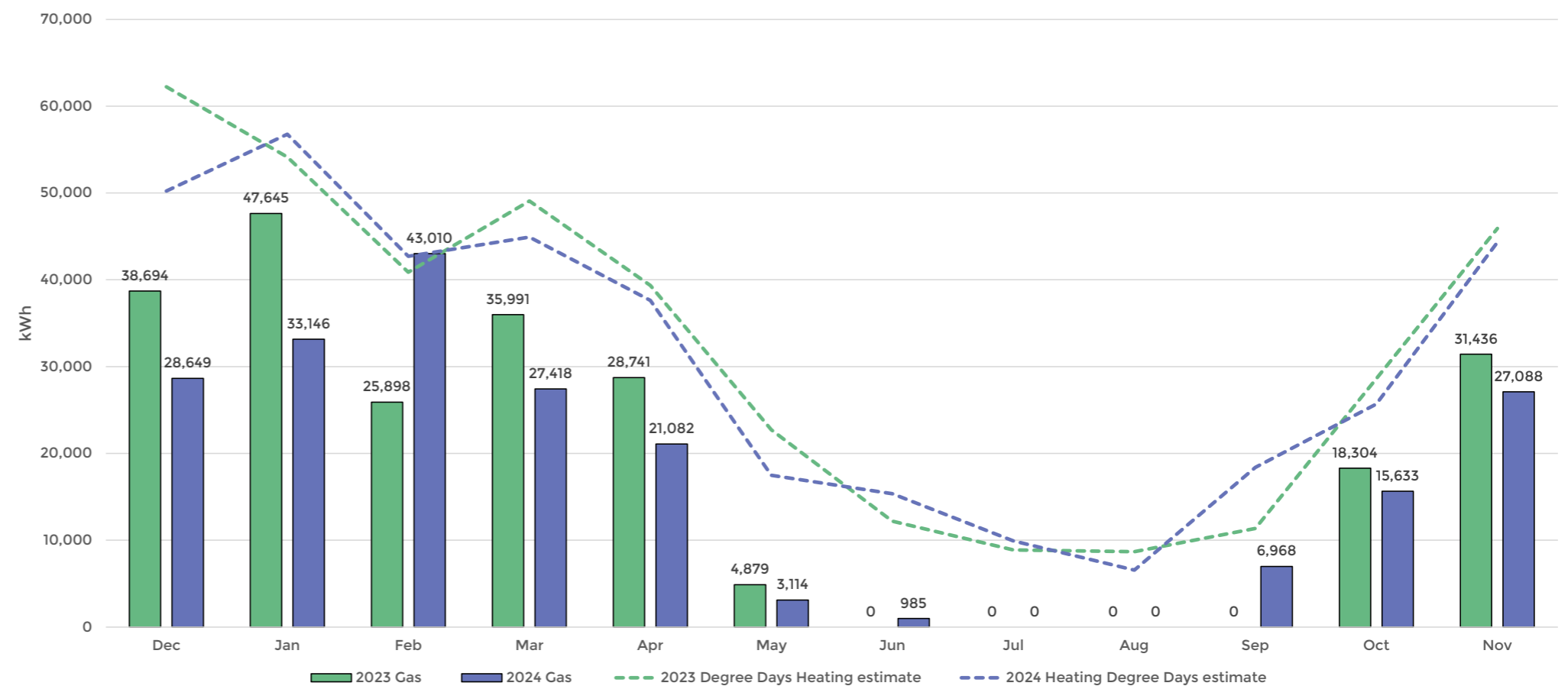
Gas (Space Heating)

The adjacent graph shows the metered gas consumption for the library across the same period. For comparison, the estimated heating loads calculated with Heating Degree Days for Newcastle (base temperature 16°C) from section 4.2.4 have been included as monthly totals (kWh).

Key observations are as follows:

- The monthly gas consumption appears to follow a seasonal profile tracking the heating degree days estimates.
- The highest metered consumption in the period was found to be January 2023.
- The consumption was 0 across June - September 2023 showing the heating was off for these summer months. This was only the case for July and August in 2024.
- Metered consumption across December 2023 and 2024 were especially low relative to the degree days estimate for these months. This could be a reflection of lower library activity during the Christmas holiday periods.
- The metered heating energy use is lower than the estimated (calculated) usage. This is likely due to uncertainties in the estimated calculations. See below:
 1. The degree days method considers a constantly heated model, meaning out of hours, building closures and lack of heating at weekends are not considered. This should result in an over-estimate in the calculations. This may be relevant for the summer months also, as where the heating was off in the metered data, there is notably more usage in the estimated data. There appears to be a higher tolerance in terms of comfort for when heating is required in reality than the degree days predicts.

2. There are extensive bookshelves in the main library which have not been considered in the building fabric losses. These would be reasonably good insulators and reduce the heat losses through the external walls, further contributing to the metered and predicted differences.



Lit & Phil Library metered gas use per month (kWh) in the period Dec 2022-Nov 2024 with comparison between 2023 and 2024. Plotted against the estimated monthly heating loads based on Heating Degree Days for Newcastle with a base temperature of 16°C.

4.4 Building Benchmarking

The difference between the metered gas consumption and the estimated heating energy usage suggests that estimated calculations contain some inaccuracies. These include the fabric build ups excluding inherent insulators like bookshelves, and the degree day constant heating application neglecting no heating over the weekend.

However, the estimated heating consumption is a useful measure as it includes detailed fabric breakdowns which allows specific building interventions to be individually assessed. For this reason, the operational baseline of the heating use has been based on the estimated calculations.

The application of heating degree days only applies to the space heating gas consumption, and so the averaged metered value has been assumed for the operational baseline of the electrical energy.

The graph adjacent shows this operational baseline, as well as the Lit & Phil's metered data from December 2022 – November 2024 presented as kWh/m² gross internal floor area. Industry benchmarks are also based on the comfortable temperatures typical of this building type.

These have been included in the graph for comparison, covering the below:

- CIBSE benchmarking 25th percentile – For public buildings, libraries. Stated source DEC. Aligns with good practice buildings.
- CIBSE benchmarking 50th percentile – For public buildings, libraries. Stated source

DEC. Aligns with typical practice buildings.

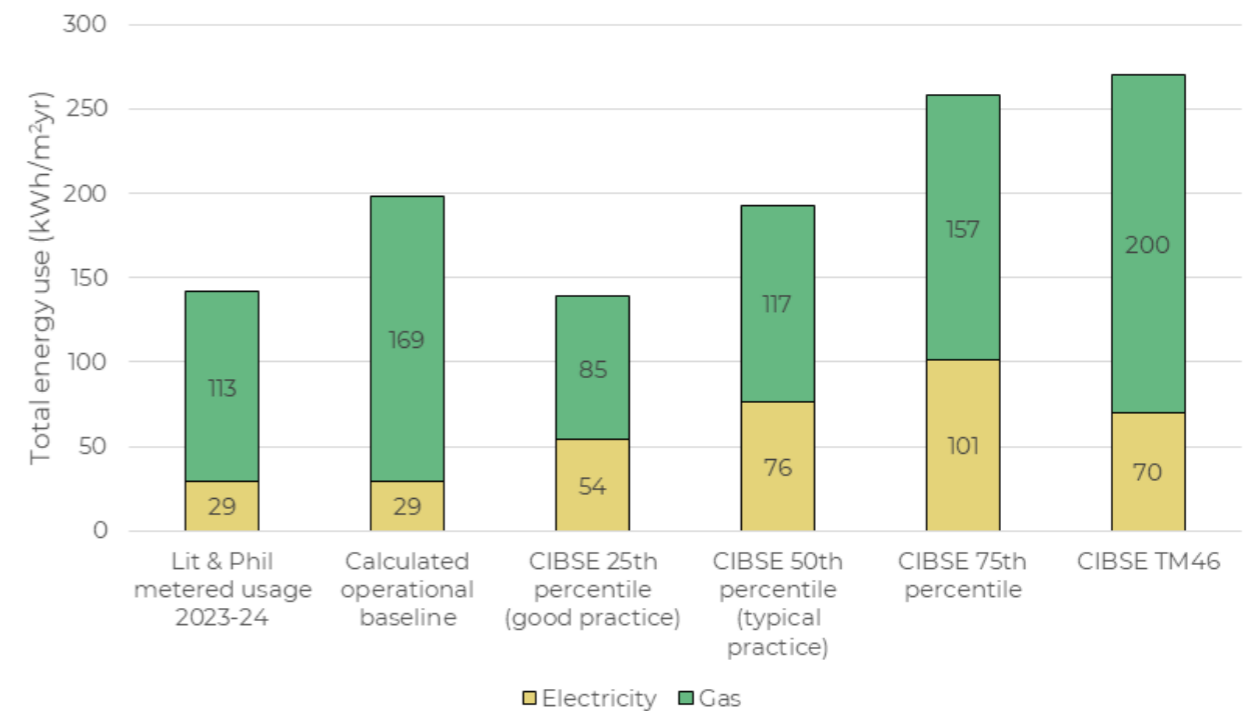
- CIBSE benchmarking 75th percentile – For public buildings, libraries. Stated source DEC.
- CIBSE TM46 – A 2008 technical memorandum on building benchmarks. Value for public building in cultural activities observed.

Benchmarks are based on buildings of a similar use, and do not take into account the age or anything else that may affect the energy use, so are useful only to give a vague comparison of what might be expected.

Key observations are as follows:

- The metered electricity usage, and thus the electricity baseline, was less than all the industry benchmarks. This may be due to the fact that the lighting is undergoing a replacement scheme from fluorescent fittings to LED. Due to the age of most of the benchmarks LED lighting will not be included in these values. It may also reflect lower computer use compared with similar buildings.
- It should be noted that ventilation does not currently meet building regulations, and in complying with this through the provision of mechanical ventilation, electricity use is likely to increase.
- The current heating use is similar to typical practice benchmarks, so similar to how other buildings of its type are performing.

Annual energy use intensities compared to industry benchmarks



Annual energy use intensities (kWh/m²yr) comparison between the Lit & Phil metered usage 2023-24, the calculated operational baseline, CIBSE library benchmarks by percentile, and CIBSE TM46 benchmark.

5.1 Objectives

The purpose of the Options Appraisal is to assess the range of potential measures that could be implemented to reduce the energy use and carbon intensity of the Lit & Phil.

As part of the Whole Building Approach, Historic England recommends that interventions should be implemented according to the 'Energy Efficiency Hierarchy'.

This order of priority reflects the relative benefits, costs, and technical risks of interventions as well as the 'three pillars of energy transition' - sufficiency, efficiency, and generation:

- Firstly, reduce energy consumption in real terms (sufficiency)
- Secondly, minimise unavoidable energy use (efficiency)
- Lastly, generate energy from 'renewables', also known as low and zero carbon technologies, where possible (generation)

There are a number of benefits to reducing the buildings energy consumption:

1. Reduced CO₂ emissions to align with net zero aims.
2. Reduced strain on utility infrastructure e.g. electricity grid.
3. Reduced running costs.
4. Improved occupant comfort
5. Reduced capital cost for new plant e.g. reduction in heat pump size.

A strategic approach to decarbonisation ensures that the most effective and beneficial measures are implemented first, providing a clear roadmap for energy-efficient retrofitting.

The Lit & Phil's established aims and objectives for the decarbonisation strategy include:

1. Gain a better understanding of the performance of the existing building and its service systems.
2. Address defects and deficiencies in the existing systems and fabric.
3. Identify opportunities to reduce energy demand; improve energy efficiency and transition towards low or net zero carbon services.
4. Improve thermal comfort and indoor environmental quality, including increased control of environmental conditions for occupants.
5. Reduce energy bills wherever possible, to help with ongoing financial constraints
6. Increase the diversity of uses within the building in order to widen access and generate further revenue to secure the long-term resilience of the organisation.

Increasing the use and occupancy of the building may increase energy consumption, therefore improving the control and efficiency of building services and improving fabric performance are key priorities to avoid an increase in running costs.

Repair and maintenance of existing systems should be prioritised as a starting point, in order to ensure the existing building is running as efficiently as intended.

5.2 Energy Use Intensity Targets

The UK Net Zero Carbon Building Standard (UKNZCBS) Pilot Version was published in 2024 with the aim of providing a clear framework for achieving net zero carbon in the built environment. The guidance provides set energy use intensity targets as part of the Net Zero Operational Carbon definition.

These targets measure the total energy use (excluding on-site renewables) to achieve an energy use intensity compatible with the expected availability of renewables in 2040, the deadline which the standard sets.

The standard gives guidance for a “stepped” and “one-go” retrofit. In the stepped retrofit, guidance is given for the progressive reduction of energy use intensity year-on-year.

The “one-go” retrofit assumes all the improvement works will be carried out in one go, and no improvements will be made following this. The targets are more lenient for earlier starting dates, under the assumption that technology and knowledge will improve which will make carbon reduction easier.

For the purposes of this exercise, the “one-go” EUI target has been applied.

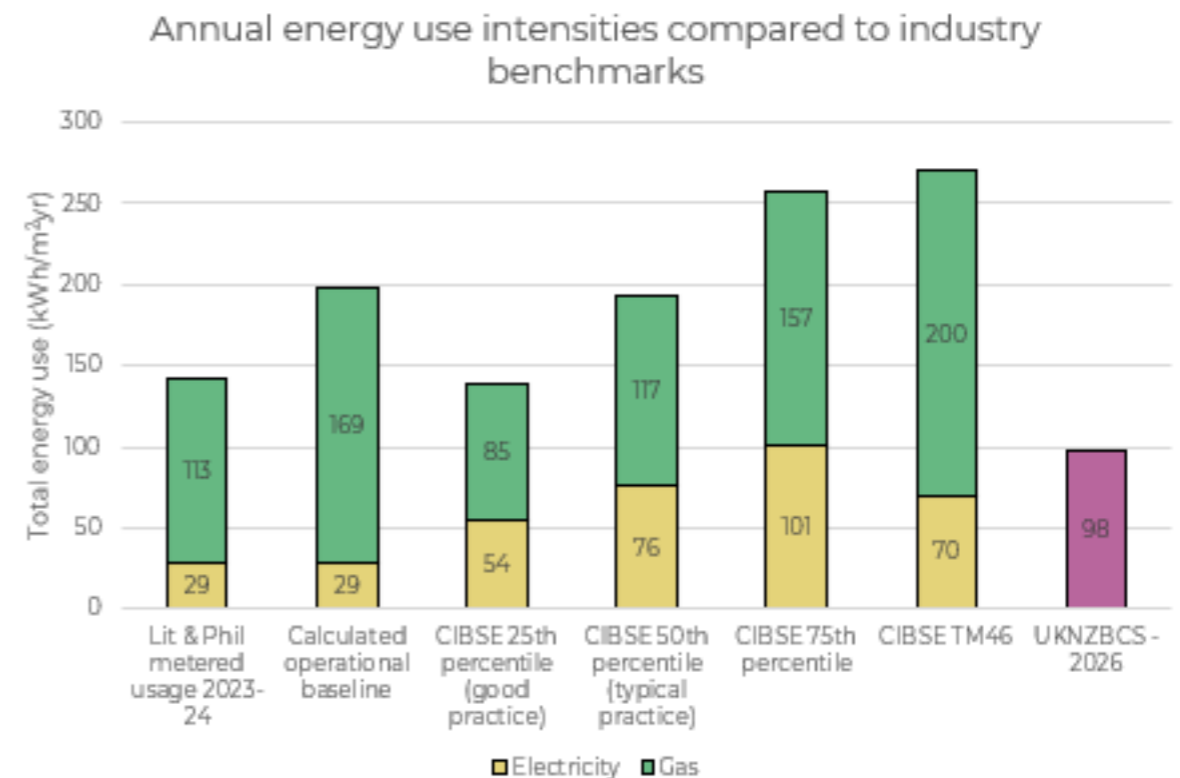
Based on a 2026 start, the energy use intensity for a “Cultural & Heritage – Collection” building is: 98 kWh/m²yr.

If demand can be reduced sufficiently to meet these emissions and the remaining energy for operations is supplied by on or off-site renewable, zero carbon sources, the building can be considered Net Zero Operational Carbon according to these definitions.

The adjacent graph adds the UKNZCBS 2026 target to the previous figure comparing the calculated operational baseline and industry benchmarks.

Key observations for Lit & Phil are as follows:

- The metered data requires 31% reduction to meet the UKNZCB target.
- The calculated operational baseline requires a 51% overall energy reduction to meet the UKNZCB target. However as discussed, this estimate is likely too high through the constant heating assumptions, therefore the metered data has been used in the calculations throughout the rest of this report.
- Changing the heating system to an electric system, ideally a heat pump, and ensuring all electricity is purchased through a renewable only tariff, the building could meet the net zero definitions



Annual energy use intensities (kWh/m²yr) comparison between Lit & Phil metered usage 2023-24, the calculated operational baseline, CIBSE benchmarks and the UKNZCBS

5.3 Reducing Energy Consumption

A broad range of opportunities to reduce energy consumption have been explored, including building fabric improvements, services upgrades, system efficiencies, metering and controls.

5.3.1 Building fabric

Owing to the historic and listed nature of the building fabric there is limited opportunity for internally or externally insulating existing walls or insulating the existing floors. The build-up of the main roof areas is unknown but they are not believed to be insulated.

Insulation to the main roof may be possible, particularly in areas where essential repairs need to be carried out, though this should be carefully considered in the context of other roof works e.g.. rooftop plant, works to glasshouses etc.

The area of building fabric that appears most straightforward to address is the glazing, as many of the existing windows are single glazed, though the frames appear in reasonable condition. This could either be done through adding secondary glazing, replacing with double glazing or by re-glazing the existing frames.

5.3.2 System efficiencies

Heat recovery ventilation could be added to the library area to reduce and control the air flow through the main library. This is understood to be under-ventilated during the summer, and is uncontrolled.

We understand that provision is being made for this, making use of the existing openings in the rooflights, through the current capital project works.

5.3.3 Metering

Metering is an effective method to reduce consumption and is often relatively low cost to implement. Lit & Phil's current metering system could not give detailed data to interrogate its energy usage.

Metering of individual systems can help determine the separate usages within the building, allowing savings to be made within those areas.

5.3.4 Monitoring services

There are a number of organisations which provide a contract based monitoring services whereby sensors are distributed throughout buildings and building services and are fed into a monitoring system which they then review on a regular basis. This is useful for larger buildings with complex BMS systems however it does not appear suitable in this case.

5.3.5 Controls

There are a number of opportunities to improve building system control and reduce energy consumption. Use of local controls can reduce the unwanted use of energy in unoccupied rooms and smarter controls such as PIRs and temperature sensors can further improve this. A more sophisticated but costly method would be to implement a BMS system to monitor and control the entire building independently.

Improving the controls of the heating system would provide several benefits to the library. Technologies such as smart radiator valves will allow for more zonal controls of the heating, reducing usage within unoccupied rooms. Additionally, this can provide more comfort to spaces as they can be programmed to heat rooms to comforting temperature in advance of occupancy.

5.4 Low/Zero Carbon Technologies

Along with the building fabric improvements, services upgrades, and energy saving measures discussed in the previous section, the implementation of low/zero carbon (LZC) technologies will play a key role within the carbon reduction strategy.

Key recommendations for the LZC technologies to implement on site at Lit & Phil Library are given below. The remaining subsections provide additional information on the individual LZC technologies and a comparison of these options.

The following LZCs have been reviewed for their suitability:

- Photovoltaics
- Thin film photovoltaics
- Air source heat pumps
- Decentralised air source heat pumps
- Exhaust air source heat pumps
- Domestic hot water air source heat pumps
- Solar thermal
- Biofuels
- Ground source heat pumps
- Surface water source heat pump
- Variable refrigerant flow

5.4.1 Photovoltaics

Photovoltaic (PV) panels use photons in sunlight to create an electrical current. They are typically placed in an exposed location where they have access to bright, unshaded sunlight. Based on current developments in this technology, the maximum efficiency of panels is around 25%. In the UK, the optimal position for a panel is south facing and pitched between 20-35° to the horizontal. Panels should be arranged to avoid shading from adjacent buildings, trees etc.

5.4.2 Solar thermal

The Lit & Phil Library does not house a centralised DHW system as all hot water is currently provided by local electric heaters. In order to effectively utilise solar thermal technology, a new DHW system would need to be implemented throughout the library.

Considering the low DHW demand of the library only covering the WCs and small kitchenette, solar thermal technology would not be a feasible route to decarbonising the Lit & Phil due to the infrastructure that would be required for its implementation.

It is also not possible to export unused hot water from solar thermal panels, unlike surplus electricity with PVs which overall offer a more simple solution to generating power effectively.

5.4.3 Air-source heat pumps (ASHP)

Air Source Heat Pumps (ASHPs) are low-carbon heating systems that extract heat from the outside air—even at low temperatures—and use it for internal heating. They operate using electricity only. ASHPs typically have efficiencies of 2.5 to 4, meaning they can produce 2.5 to 4 units of heat for every unit of electricity used. This high efficiency, combined with the ability to pair ASHPs with renewable electricity (e.g. from solar panels or green tariffs), makes them a key technology in the push to decarbonise buildings and meet climate targets.

As the Lit & Phil currently uses gas heating, switching to an ASHP heating system would significantly reduce carbon emissions as ASHPs produce no on-site emissions. The carbon footprint will depend solely on the electricity source, but as power grids become increasingly renewable, ASHPs become cleaner over time.

Decentralised ASHP

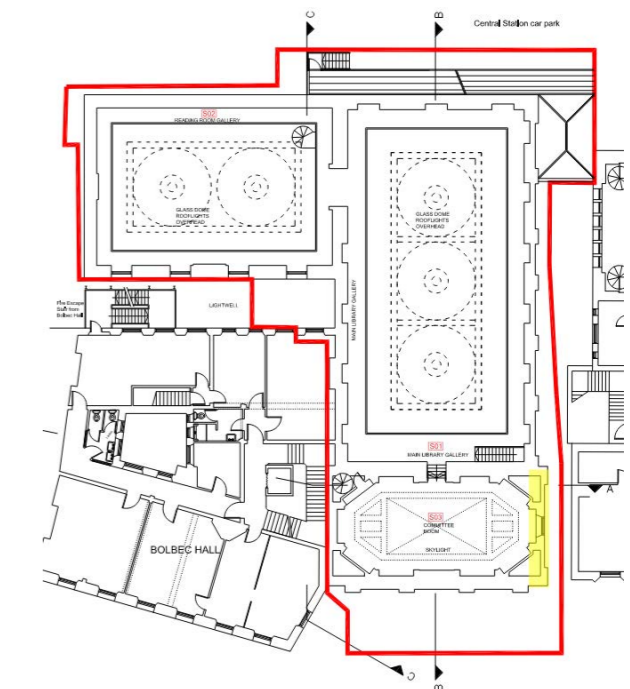
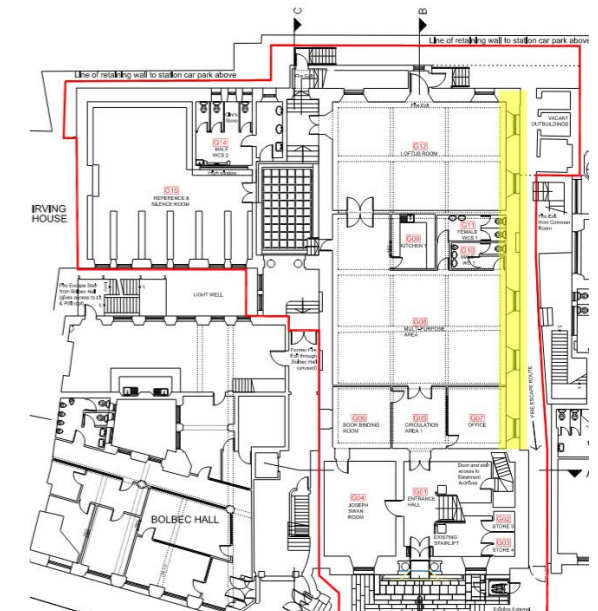
Decentralised air-source heat pumps are self-contained ASHPs that serve individual rooms. Rather than having units centralised in a plant space with distribution pipework throughout the building, these decentralised units are situated directly on the wall of each space to be served

Given the various constraints of the Lit & Phil roof, decentralised air-source heat pumps could be beneficial as they remove the need for locating plant around the roof glasshouses. However, they require direct access to external walls. The library spaces in the Lit & Phil are lined with book shelving around the room perimeters, making these spaces unfeasible for this technology. This includes the Silence Room, and the main Library including in the west Wing.

The Librarian's office and Joseph Swan room are also unlikely locations as these share walls with Bolbec Hall and are situated on the front façade, where visible equipment would not be feasible. However, the regularly used lecture spaces on the ground floor, and the Committee Room on the second floor could be suitable locations for this heating method. These all have exposed external walls available on the less significant west façade where decentralised units could be installed.



Powrmatic AIRCO290 packaged wall-mounted twin duct heat pump



Indicative external walls where decentralised heat pumps could be used, highlighted yellow. Note these walls are still in close proximity to neighbouring buildings where maintenance access is currently limited, so the feasibility of this technology would be dependent on a review of this.

Top image: Ground Floor, Bottom image: Second Floor

5.4 Low/Zero Carbon Technologies

Exhaust air ASHP

Exhaust air-source heat pumps provide mechanical ventilation to a space, but also extract heat from its exhaust air stream in order to supply space heating.

This technology is beneficial as the exhaust air stream is cooled further to provide more additional heating than in standard mechanical ventilation with heat recovery (MVHR). However, as it is a heat pump integrated into MVHR, ventilation will always be provided alongside space heating, even if the ventilation is not needed. – i.e. when the building is preheated but not yet occupied.

If the Lit & Phil were to install air-source heat pumps on the roof to provide the building's space heating, this exhaust air technology would not be necessary as an additional. In this case, the provision of ASHPs would be recommended alongside MVHR technology in the main library space. However, if ASHPs were not installed and the gas boilers were retained, exhaust air-source pumps would be a beneficial way to provide heating and ventilation to the main library space, whilst offsetting the gas boiler use.

ASHP – domestic hot water heating

The domestic hot water of the Lit & Phil is currently all supplied by local electric water heaters. The demand is low, as it is currently only required in WCs and the small kitchenette.

Using air-source heat pump water heaters has been deemed unnecessary since replacing the electric heaters would not help offset the gas boilers, and the DHW demand is so small.

5.4.4 GSHP: open or closed loop

The requirement of a large space for ground source heat pump (GSHP) boreholes makes this technology inaccessible for the Lit & Phil Library as it does not have external grounds to utilise.

5.4.5 Surface water-source heat pump

The Lit & Phil is positioned in excess of 350m from the River Tyne, with a highly obstructed route by industrial and railway infrastructure.

Surface water-source heat pumps have therefore been assumed as a not feasible technology due to this proximity.

5.4.6 Biofuels

The extent of storage and delivery requirements for biofuel technology is deemed not feasible for the Lit & Phil given its city centre industrial location, as woodchips and pellets would need to be sourced locally.

The combustion of biofuels also contributes to poor air quality, particularly in urban areas.

5.4.6 Variable refrigerant flow (VRF)

Variable refrigerant flow uses the refrigerant as the primary medium for heating and cooling. The technology is well-controlled as it is one proprietary system, improving maintenance.

They provide good coefficient of performance values, however, similar performances can be obtained from alternatives with much lower embodied carbon due to the amount of refrigerant in VRF.

For this reason, the technology has not been considered as suitable for decarbonising the Lit & Phil Library.

5.5 Option Evaluation

Evaluation methodology

The potential measures to reduce energy consumption and carbon emissions have been assessed against a range of criteria and considerations including:

1. Implementation
2. Heritage sensitivity
3. Indicative capital cost
4. Estimated energy /carbon reduction
5. Cost per tonne CO₂ saved ('energy cost effectiveness')

Implementation

This considers the challenges of implementing the proposed measure within the context of the specific building or site. These will vary from building to building but may include:

- Logistical challenges such as impact on occupation or decant requirements.
- Interfaces with adjacent fabric, both internally and externally.
- Impact on existing retained building services and systems.

Heritage sensitivity

Informed by the hierarchy of significance, this assesses the relative sensitivity of the proposed measure with respect to heritage values, including visual / aesthetic, evidential and historic.

It does not include a full impact assessment as required for planning and listed building consent, nor identify the potential public benefits. It is intended to provide a preliminary consideration of heritage sensitivity in order to guide further investigation at the next design stage.

Indicative capital cost

The cost assessment represents indicative estimates of the likely costs to implement the carbon reduction improvements as described in this study, as a starting point for decision making. It is important to recognise the assessments are based on the limited information currently available. As with all construction works it is advised that further cost checks are carried out at each design stage. The current costs should be viewed as at RIBA stage 0/1.

The allowances currently assume each item is carried out via a direct contract with the supplier, rather than delivered through a Main Contractor. Appointing a main contractor to undertake a work item will lead to additional costs through management and profit layering. Conversely if the works are linked to a wider scope and form part of a larger scope economies of scale may arise.

Note that all costs are current day, 3rd quarter 2025. An adjustment for inflation will be needed once a delivery programme is established. Contingencies should also be considered; design, construction and client contingencies are recommended.

Estimated energy / carbon reduction

This provides an estimate of the potential energy savings and carbon reduction associated with the proposed measure, compared to the baseline developed during the survey and assessment process.

It provides a high-level guide as to the relative scale of reductions achievable with each measure under consideration.

Energy-Cost effectiveness

This provides an indication of the scale of carbon reduction relative to the capital investment required to implement each measure.

It provides a more consistent method of evaluating the relative cost effectiveness of different measures than payback periods, which are influenced by changing energy prices and tariff types.

The costs identified in the table represent indicative estimates of the likely costs to implement the carbon reduction improvements as described in this study.

The costs form a starting point for decision making. It is important to recognise the assessments are based on the limited information currently available. As with all construction works it is advised that further cost checks are carried out at each design stage. The current costs should be viewed as at RIBA stage 0/1.

The allowances currently assume each item is carried out via a direct contract with the supplier, rather than delivered through a Main Contractor. Appointing a main contractor to undertake a work item will lead to additional costs through management and profit layering. Conversely if the works are linked to a wider scope and form part of a larger scope economies of scale may arise.

Please note all costs are current day, 3rd quarter 2025. An adjustment for inflation will be needed once a delivery programme is established. Contingencies should also be considered; design, construction and client contingencies are recommended.

General exclusions

- Removal and reinstatement of furniture and fittings to enable works to be completed
- Structural enhancements to the existing building to accommodate decarbonisation proposal
- Professional Fees
- Contingencies: design, construction, client
- Inflation
- Finance Charges
- VAT
- Client direct costs including loss of earnings, operating costs etc.

5.5 Option Evaluation

NOTE: Cost scale values are high-level estimates and should only be taken as indicative for comparison purposes. Specific figures should be confirmed with a Quantity Surveyor before implementation.

Low: < £100k

Medium: £100k £1m

High: > £1m

Element	Energy saving opportunities	Difficulty of implementation	Heritage sensitivity	Indicative capital cost	Estimated energy/ carbon reduction	£ spent per ton of Carbon saved	Maintenance and Repair requirements	Other considerations
BUILDING FABRIC								
Windows <ul style="list-style-type: none"> Historic single-glazed timber sash windows are present throughout Windows are largely sealed and labelled in WCs to be kept shut Historic shutters are present on many windows. 	Option 1 <ul style="list-style-type: none"> Replace the existing windows with new double-glazed timber sash windows to match existing. Assumed U-value improved from 4.8 to 1.8 	Medium Frames can be removed and replaced simultaneously, reducing need for temporary weather protection	High Loss of original windows may detract from significance due to loss of evidential value and individual significance of any original glazing. May alter external appearance of listed building	£441,000	-10% of heating energy and carbon emissions from gas 4.6 tCO ₂ /yr	£95,900	Low Single glazed timber box sash windows are in reasonably good order and without signs of any extensive decay. Redecoration and limited timber repairs anticipated within 3 years	<ul style="list-style-type: none"> Replacing the windows would improve thermal performance and air tightness, reducing heat loss by building infiltration. Entire replacement of the existing windows is intrusive for a heritage building and only offers 1% improvement over the secondary glazing and reglazing alternatives below.
	Option 2 <ul style="list-style-type: none"> Add secondary glazing to the façade windows. Consider glazing fitting within staff bead to avoid obstructing shutters. Assumed u-value improved from 4.8 to 2.4 	Medium May be difficult to achieve on windows with shutters	Medium	£300,000	-9% of heating energy and carbon emissions from gas 4.0 tCO ₂ /yr	£75,000		<ul style="list-style-type: none"> Secondary glazing would benefit the thermal performance and air tightness similarly to the double glazing upgrades. Although it has slightly reduced energy savings, it would be a lower cost alternative. Less disruptive than other options, although may be challenging to integrate with existing shutters.
	Option 3 <ul style="list-style-type: none"> Refurbish and re-glaze the existing single-glazed sash windows with slim-line double glazed units or vacuum glazing. Assumed single glazing U-value improved from 4.8 to 2.1 	Medium Windows would need to be removed and taken offsite, requiring temporary weather protection of openings	Medium The significance of the glazing may vary across the building. Replacement glazing may be more suitable for rear-facing windows	£385,000	-9% of heating energy and carbon emissions from gas 4.3 tCO ₂ /yr	£89,500		<ul style="list-style-type: none"> Offsite work required to refurbish existing frames. Existing frames must be suitable for the additional weight and sash weights will require rebalancing.

5.5 Option Evaluation

Element	Energy saving opportunities	Difficulty of implementation	Heritage sensitivity	Indicative capital cost	Estimated energy/ carbon reduction	£ spent per ton of Carbon saved	Maintenance and Repair requirements	Other considerations
<p>Glazed roof lanterns</p> <ul style="list-style-type: none"> • Metal framed roof lantern above ornate glass laylight. • Concerns around the glazing bars being undersized which causes them to flex. • Roof glasshouses have been modelled as buffer spaces which raise the external temperature of the roof glass lanterns • Due to the assessment method heat gains are not included therefore savings may be lower than expected. 	<ul style="list-style-type: none"> • Replace the existing single-glazed roof lanterns with new double-glazed lanterns over the existing decorative laylights. • Potential structural implications on roof. • Could allow better control of ventilation within the lanterns through actuated windows • Assumed lantern glazing u-value improved from 6.5 to 2.1 (note that these figures do not account for the overall performance of the lantern and laylight) • Ornate glass laylights beneath glasshouses to be protected and remain as existing. 	High May be structural implications, eg scaffolding required within the building to protect the laylights.	Medium	£1,382,000	-13% of heating energy and carbon emissions from gas 5.9 tCO2/yr	£234,200	High Various cracked glass panels Lead flashings and cappings in poor condition, requiring full replacement Evidence of water ingress and plaster damage around perimeter of glasshouses in rooms below. Asbestos rope possibly present in glazing bars, which could decay, causing a health hazard. Issues should be addressed within 1 year	<ul style="list-style-type: none"> • Replacing the lanterns offers large reductions to heat loss and infiltration through roof glazing elements. • Structural and fabric condition issues could be addressed by this intervention. • Additional mechanical ventilation may be required if airtightness is improved
	<ul style="list-style-type: none"> • Add insulation to the solid roof areas inside the glasshouses, surrounding the laylights • Existing flat roofs assumed to be uninsulated with 1.30 u-value for felt areas and 1.35 for lead areas. Improved to 0.18 with insulation. 	Medium Would need to be detailed carefully around existing access route and ornate laylights	Low	£128,000	-2% of heating energy and carbon emissions from gas 1.0 tCO2/yr	£128,000	Low Could be carried out in conjunction with repairs to glasshouses	<ul style="list-style-type: none"> • The area of flat roof is quite minimal and offers little improvements to heating energy. • Implementation would be difficult and would not help address fabric condition issues
<p>Flat roofs</p> <ul style="list-style-type: none"> • 3 x dome roof finished in bitumen felt • 2 x dome roof spaces finished in lead • All assumed as uninsulated • Ornate plasterwork on the internal ceilings 	<ul style="list-style-type: none"> • Add insulation to the lead and bitumen flat roof areas. • Existing flat roofs assumed to be uninsulated with 1.30 u-value for felt areas and 1.35 for lead areas. Improved to 0.18 with insulation. 	Medium Assumes insulation from above, requiring full strip-out of existing finishes	Low	£361,000	-9.4% of heating energy and carbon emissions from gas 4.3 tCO2/yr	£84,000	Medium Felt finishes have been recently installed and remain in good overall condition. Lead sheet flat roof finishes and perimeter details appear to be in acceptable condition No widespread water ingress is reported currently	<ul style="list-style-type: none"> • Thermal performance of the solid roof areas would improve but would not benefit air tightness. • Ornate plasterwork on the internal ceilings means insulation would have to be added from the outside, therefore external finishes would need renewing. • Works should be carried out prior to installation of new rooftop plant

5.5 Option Evaluation

Element	Energy saving opportunities	Difficulty of implementation	Heritage sensitivity	Indicative capital cost	Estimated energy/ carbon reduction	£ spent per ton of Carbon saved	Maintenance and Repair requirements	Other considerations
External walls <ul style="list-style-type: none"> Largely assumed as solid construction with sandstone ashlar externally and plasterboard internally Right Wing rear facades assumed as red brick externally and plasterboard finish Thicknesses based on existing layout drawings All walls assumed to be uninsulated Ornate joinery bookshelves lining the walls in the library spaces 	<ul style="list-style-type: none"> Add vapour permeable internal insulation to the external walls in the main library spaces, silence room, entrance hall including the committee room. Assumed external wall u-value 1.2 in the main library spaces and ground floor, 1.80 in the right wing, 2.3 in the south fire exit, improved to 0.30 throughout. 	<p>High</p> <p>Would require temporary decant of collection</p>	<p>High</p> <p>Ornate nature of these spaces makes insulating these walls unlikely to be feasible or appropriate</p>	£478,000	<p>-19% of heating energy and carbon emissions from gas</p> <p>8.9 tCO₂/yr</p>	£53,700	<p>Medium</p> <p>Internal walls generally in fair condition or concealed by bookcases</p> <p>Local plaster repair and redecoration required where water ingress has occurred, most significantly in Silence Room</p>	<ul style="list-style-type: none"> A large proportion of heat loss is predicted to occur through the external walls so internally insulating these offers good energy improvements. The specification and detailing of the internal insulation would need to be carefully designed to mitigate risk of interstitial condensation and cold bridging. Due to the ornate nature of the library space, silence room and committee room, adding insulation does seem not feasible within listed building constraints The bookshelves may already be providing some additional insulation which has not been accounted for in these calculations.
	<ul style="list-style-type: none"> Add vapour permeable internal insulation to the external walls in the ground floor multi-purpose area, including the Loftus room and book binding space, and back fire exit stairwell. Assumed external wall u-value 1.2 in the main library spaces and ground floor, 1.80 in the right wing, 2.3 in the south fire exit, improved to 0.30 throughout. 	<p>Medium</p> <p>Would require alterations to window architraves and corncing</p>	<p>Medium</p> <p>Intervention proposed in less sensitive spaces</p>	£154,000	<p>-8% of heating energy and carbon emissions from gas</p> <p>3.6 tCO₂/yr</p>	£42,800	<p>Medium</p>	<ul style="list-style-type: none"> The spaces with less critical historic significance are the ground floor back of house areas and lecture rooms. Insulating these spaces internally would reduce heating consumption, however their area of external walls are much less than the library zones so the savings are not as significant. These rooms will be refurbished and redecorated as part of the current capital project, so internal insulation could be considered within this scope. The specification and detailing of the internal insulation would need to be carefully designed to mitigate risk of interstitial condensation and cold bridging.
Ground floors + basement <ul style="list-style-type: none"> All floors and walls assumed as uninsulated Basement archive currently heated (observed during survey) with no clear differentiation of controls with other building spaces 	<ul style="list-style-type: none"> Implement minimal heating in basement archive in accordance with latest standard. Recommend the use of this space as archive only, reading of this material to occur only in library spaces in above. Insulate the floor between archive basement and ground floor above. 	<p>Low</p>	<p>Low</p> <p>Insulation would have to be added from the basement as ground floor finishes appear to be have heritage significance</p>	£49,000	<p>-2% of heating energy and carbon emissions from gas</p> <p>1.0 tCO₂/yr</p>	£49,000	<p>Low</p>	<ul style="list-style-type: none"> The heat loss through the basement and ground floors is estimated to be a small percentage of the total peak heat loss calculation. This means improving the basement conditions offers little savings to the heating energy. However, it may offer more benefits regarding the expectations of archive storage.

5.5 Option Evaluation

Element	Energy saving opportunities	Difficulty of implementation	Heritage sensitivity	Indicative capital cost	Estimated energy/ carbon reduction	£ spent per ton of Carbon saved	Maintenance and Repair requirements	Other considerations
LIGHTING								
<ul style="list-style-type: none"> Existing lighting includes LED fittings although many fluorescent lamps are still present. There appears to be manual control of lighting throughout. 	<ul style="list-style-type: none"> Replace any remaining fluorescent lamps for more efficient LED bulbs/ fittings with improved lighting controls e.g. presence detection-based dimming in circulation areas and areas not in regular use 	Low	Low	N/A	-	-	-	A roll out of LED fittings is already in progress
VENTILATION								
<ul style="list-style-type: none"> The existing building is currently naturally ventilated throughout. Victorian air ducts are present in the Library and large lecture rooms, linked to uncontrolled ventilation turrets on the roof. Many windows are painted shut WCs are not ventilated and windows are labelled to keep shut. 	<ul style="list-style-type: none"> Provide extract fans to toilet facilities with occupancy sensing. 	Low	Low	£32,000	-	-	-	These works have already been included as part of the current capital works project
	<ul style="list-style-type: none"> Install mechanical ventilation with heat recovery to lecture rooms which can become densely occupied. 	High	Medium Careful detailed design required to conceal new services within historic fabric	N/A	-	-	-	These works have already been included as part of the current capital works project
	<ul style="list-style-type: none"> Install new demand-controlled mechanical ventilation system, eg through CO2 sensors in the main library space and lecture rooms Heat loss through infiltration assumed to be reduced to zero. (?) Mechanical ventilation sized to cover the natural ventilation the infiltration is currently providing in the main library. 	High Victorian air ducts either to be reused or sealed up to prevent infiltration. Significant space required for MVHR and ducts.	High	High	£236,000	There would be a 0.3% saving of heat energy for a 0.1% increase in electricity consumption.	-	<p>Low Condition of existing uncontrolled air vents is satisfactory, though CO2 monitoring has not been carried out to assess whether ventilation is sufficient for maximum occupancies.</p> <p>The building is not suffering from condensation or mould issues</p> <ul style="list-style-type: none"> Low energy savings in installing demand-controlled mechanical ventilation to replace the natural ventilation in the library space. This is based off the assumed infiltration rate in the estimated heat loss calculation. Mechanical ventilation would provide more control, better thermal comfort and potentially improved air quality throughout the year as there has been some reports of stuffiness in the summer. If replacement of the Glasshouses is intended then the provision of mechanical ventilation should be carried out alongside or following these works so that the system is sized on current infiltration rates.

5.5 Option Evaluation

Element	Energy saving opportunities	Difficulty of implementation	Heritage sensitivity	Indicative capital cost	Estimated energy/ carbon reduction	£ spent per ton of Carbon saved	Maintenance and Repair requirements	Other considerations
HEATING DISTRIBUTION AND CONTROLS								
<ul style="list-style-type: none"> 2x 90kW condensing gas boilers in basement stores Single heating zone Thermostat in library indicated Some uninsulated pipes Large bore exposed pipe running through library 	<ul style="list-style-type: none"> Add zoning valves, heat meters, and variable speed pumps to the primary boiler room heating circuits. Implement zonal heating for occupied zones only, with unoccupied zones at a setback temperature 	Medium Detailed design required	Low	£141,000	Detailed design required in order to understand potential improvement.	-	-	<ul style="list-style-type: none"> Low cost and straightforward solution which facilitates future energy reductions and monitoring benefits.

5.5 Option Evaluation

NOTE: Capital cost values are high-level estimates and should only be taken as indicative for comparison purposes. These values do not allow for energy centre infrastructure, controls, or other ancillary equipment which would be common to all options.

LZCT Opportunities	Difficulty of implementation	Heritage sensitivity	Indicative capital cost	Operational cost	Total energy output (relative to total site demand)	Estimated energy/carbon reduction	£ spent per ton of carbon saved	Maintenance and Repair requirements	Other considerations
Photovoltaics	Medium May be integrated onto the existing roof structure, around the south perimeter of the glasshouses. Subject to structural investigations. Refer to further design investigations in Section 6	Low Rooftop PVs unlikely to be visible from ground level	£42,000 - £50,000	Low Minimal running cost and periodic maintenance only	4% of current total energy usage 22% of current electrical demand (best case)	-3% of current total carbon -20% of current electricity carbon emissions 1.5 tCO ₂ /yr	£28,000 - £33,300	Medium Renewal of roof coverings and addition of insulation to be considered prior to installation of rooftop plant	New meter will be required but unlikely to be problematic. Planning and listed building consent will be required however the south perimeter location appears to be feasible PVs are included as part of the current capital works project
Air-source heat pumps	Medium Space on roof and clear zones required Potential structural implications. Space for buffer vessels required within building.	Low - Medium View of rooftop plant enclosure from ground level to be considered - low impact if can be concealed from street level.	£226,000 - £267,000	Medium/high Subject to electricity tariffs, CoP and seasonal variation	100% of heating demand	-67% of current total carbon -79% of current heating carbon emissions 36 tCO ₂ /yr	£6,270 - £7,400	Medium Renewal of roof coverings and addition of insulation to be considered prior to installation of rooftop plant	Additional electrical load may increase site beyond existing capacity, requiring substation. Existing heat emitters may require upgrades to provide the same outputs. Refer to Energy saving measures table. Pipework routes will be required to buffer vessel Heat pump redundancy needs to be considered, Planning and listed building consent will be required ASHPs to serve new Lecture Rooms are included as part of the current capital works project
Decentralised ASHPs	Medium Proximity of west-facing external walls to neighbouring buildings may make installation and maintenance of this technology difficult.	Medium/high Locations would need to be limited to side elevations	£53,000 - £63,000	Medium/high Subject to electricity tariffs, CoP and seasonal variation	Subject to detailed design	Subject to detailed design		N/A	Additional electrical load may increase site beyond existing capacity, requiring substation. Existing heat emitters may require upgrades to provide the same outputs. Refer to Energy saving measures table. Pipework routes will be required to buffer vessel Planning and listed building consent will be required
Exhaust air ASHPs			£33,000 - £39,000	Medium/high Subject to electricity tariffs, CoP and seasonal variation	Subject to detailed design	Subject to detailed design			Only beneficial if the gas boilers are retained. The exhaust-air air source heat pumps can then be used to provide heating and ventilation to the main library space to offset the boilers

DESIGN DEVELOPMENT

6.1 Key Recommendations

The recommended options for the Lit & Phil to implement to reduce energy consumption and introduce low and zero carbon technologies are listed below.

These have been selected by the consultant team, in discussion with the client, as the options with the most favourable outcomes when assessed against the appraisal criteria. Some of these measures have already been identified by the capital works project design team as possible areas for improvement.

Building Fabric

- Upgrade the thermal performance of the windows.
- Replace or re-glaze the existing single-glazed roof lanterns.
- Insulate the flat roof areas.
- Internally insulate the external walls of less significant spaces; such as the ground floor multipurpose area and rear fire exit.

Service Systems

- Replace non-LED light fittings
- Introduce lighting controls to allow automatic dimming and/or absence detection.
- Add zoning valves and controls to the heating system to enable zonal and scheduled heating.
- Establish effective sub-metering

Low/Zero Carbon Technologies

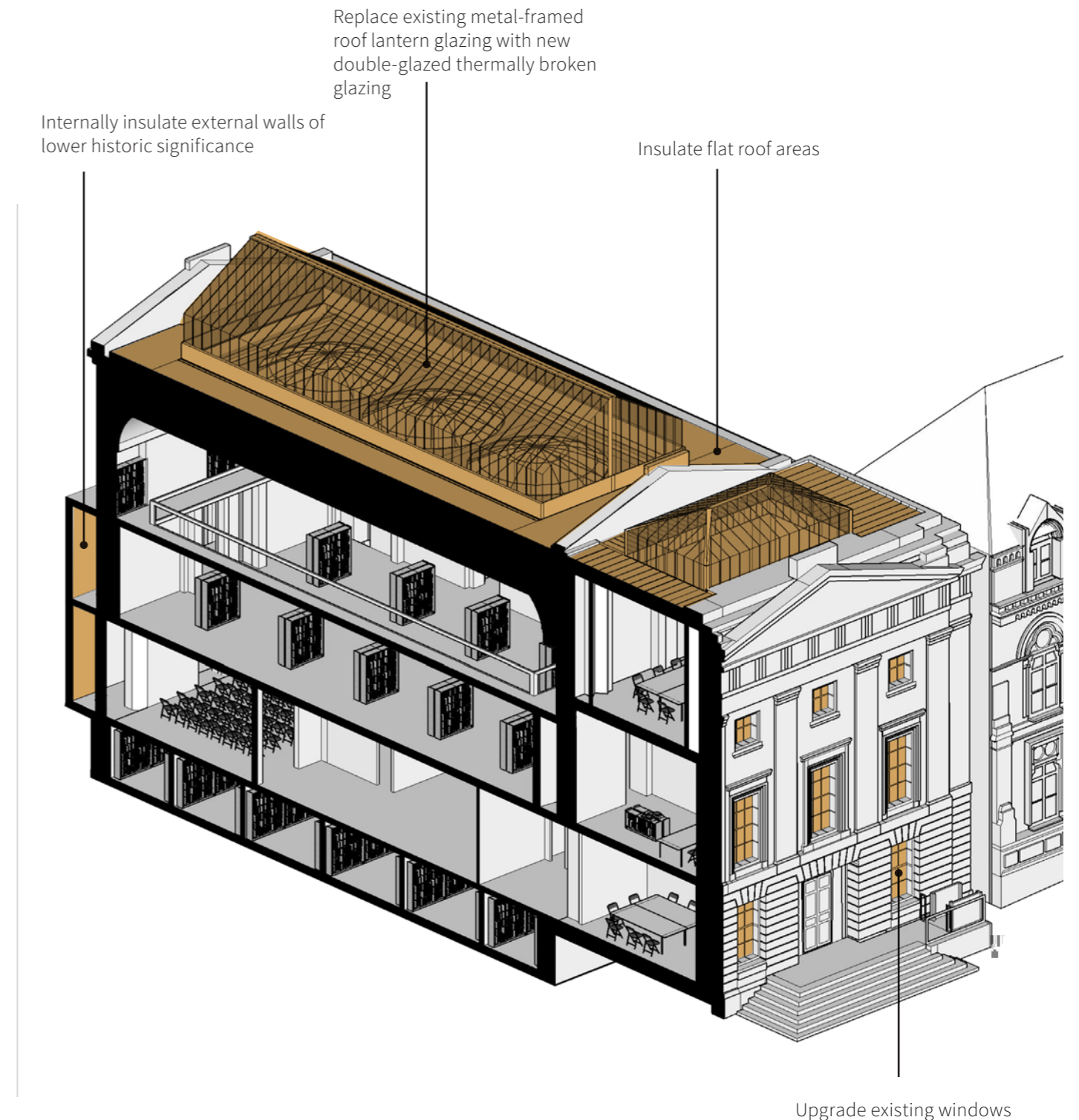
- Introduce Photovoltaics
- Air Source Heat Pumps

Maintenance & Repair

In addition to implementing new improvement measures identified through the appraisal process, it is equally important to ensure that the existing building fabric is in good repair, to minimise unintentional heat loss, and to facilitate new interventions.

The following relevant recommendations were identified during the Condition Survey of the building:

- Undertake urgent structural repairs to the basement boiler room tunnel roof.
- Replace defective leadwork and repair corroded steel frames in roof glasshouses.
- Investigate potential replacement of lantern glazing; review frame capacity for double glazing.
- Repoint and repair masonry copings, cornices and pediments; remove vegetation.
- Improve surface water drainage, especially at the rear elevation; carry out CCTV survey of pipework.
- Redecorate and repair timber sash windows; consider secondary glazing for thermal upgrade.



6.2 Building Fabric

6.2.1 Facade Glazing

The existing windows are timber-framed, single-glazed sash windows, consistent with the building's historic fabric and assumed to be original. During the site visit, many windows were observed to be covered by shutters or curtains, which thermal imaging confirmed provided a measurable improvement in thermal performance. However, this also limited natural light and outward views.

The condition survey found the windows to be generally in sound working order, requiring only redecoration and minor localised repairs.

Improving the thermal performance of the windows could deliver an estimated 9 - 10% reduction in overall building energy use—a significant saving relative to other measures considered.

Options for upgrading the windows include:

- Installation of secondary glazing
- Re-glazing within the existing frames, with slim-line double-glazed units or vacuum glazing. To include full overhaul with new draught sealing and adjustment of sash weights.
- Replacement of existing windows with new double-glazed timber sash windows to match the existing.

Each of these options would give a similar improvement in performance but the cost and technical implications vary.

Given the heritage value and reasonable condition of the existing joinery, secondary glazing may appear the most straightforward intervention. However, in many locations the

presence of original timber shutters would make this difficult to implement.

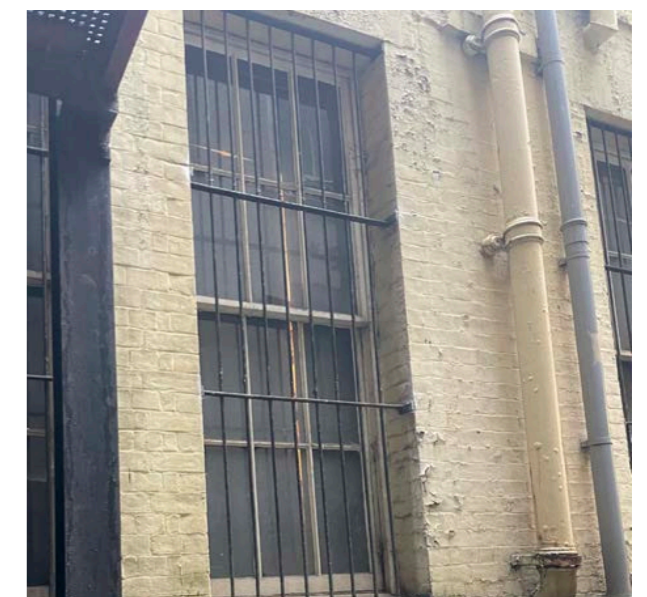
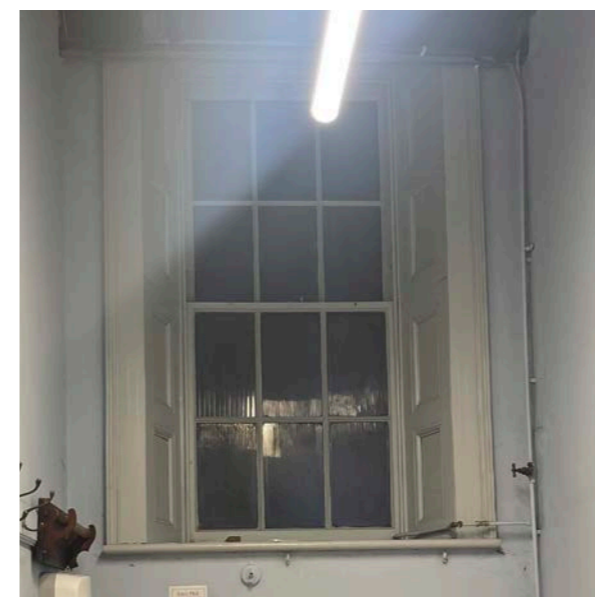
Re-glazing within the original frames, or full replacement with new double-glazed timber sash windows designed to replicate the historic appearance, may therefore prove more suitable in this context, particularly for windows that do not form part of the primary street-facing facade.

A detailed feasibility study should be undertaken to test these options and identify the most appropriate solution.

Any upgrade works to the windows will require Listed Building Consent, and planning permission may also be required for re-glazing or replacement.

As scaffolding access is likely to be necessary for any significant works to the windows, it would be most efficient to undertake the works comprehensively across the building rather than on a room-by-room basis.

Note that repair and re-glazing of the existing windows would likely be carried out off-site, requiring temporary boarding of the openings.



Original timber sash windows with internal shutters and external security bars

6.2 Building Fabric

6.2.2 Roof Lanterns

There are three glazed lanterns on the roof of the Lit & Phil, all single-glazed steel-frame construction, over decorative laylights. The lanterns and laylights are assumed to date from the early twentieth century, following a significant fire, although the external wired glazing may have been replaced more recently.

The condition survey noted that the Main Library lantern is in poor condition, with corroded steel frames, cracked glazing, and defective leadwork causing active leaks. The use of asbestos rope is also suspected. The Reading Room and Committee Room lanterns are in better condition but still require replacement of leadwork.

The thermal imaging survey showed that the lanterns and laylights provide relatively good thermal performance in the library spaces, however analysis also indicated that replacing upgrading the lanterns with double-glazing could provide up to 13% reduction in overall building energy use.

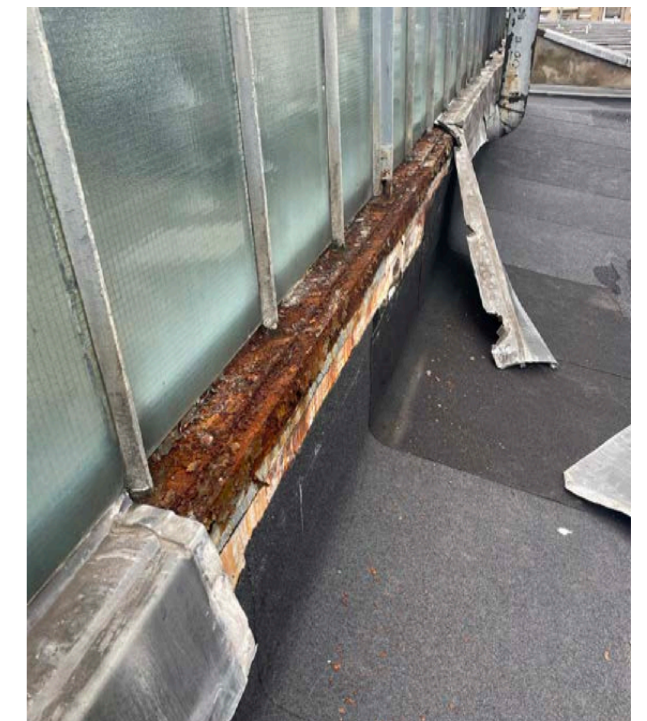
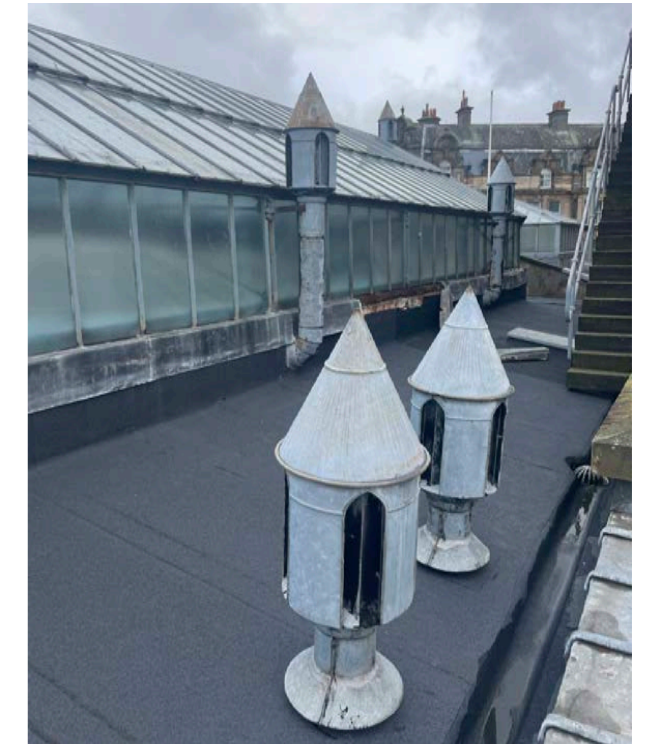
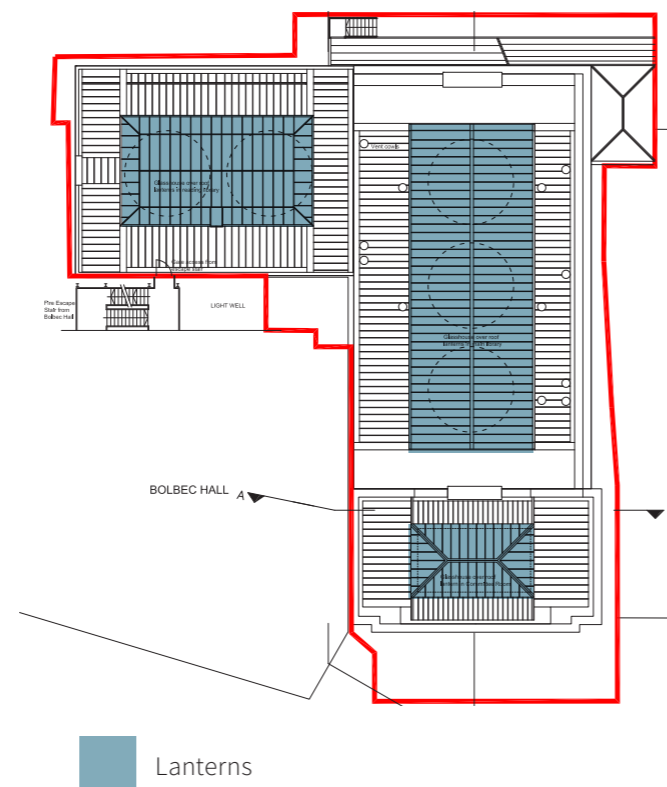
In light of their poor condition and possible asbestos issues, it may be desirable to replace the glazing of the lanterns entirely, to avoid further maintenance issues.

There are number of connected implications to consider:

1. New double-glazed units will be heavier than the existing, so structural reinforcement of the internal steel frame may be required.
2. Replacement of lanterns would ideally take place prior to installation of new rooftop plant to avoid additional constraints during construction.

3. Renewal of roof finishes and insulation should also be considered in conjunction with lantern replacement. Ideally the works would be carried out at the same time for better coordination and cost efficiency in contractor overheads and preliminaries.
4. The existing lanterns may be acting as a thermal buffer and contributing to the passive natural ventilation of the building.

The ventilation strategy for the building needs to be considered in designs for replacement lanterns, perhaps incorporating automatic opening panes to provide better ventilation and reduce overheating in hot weather.



Single-glazed roof lanterns over decorative laylights

6.2 Building Fabric

6.2.3 Insulation

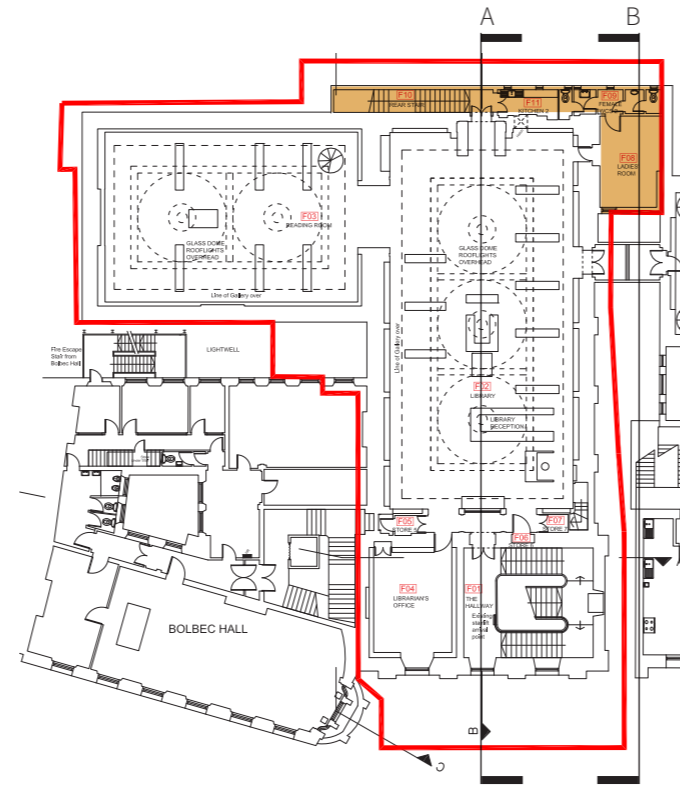
There is limited opportunity to introduce insulation to the existing walls, given the heritage significance of both their internal and external fabric. However, the later additions to the south and west elevations may offer scope to incorporate insulation to the walls, floors and/or roof. All elevations are assumed to be of solid brick and stone masonry, in generally good condition.

The roofs are very low pitched and set out around three steel framed lanterns over the laylights within the Main Library, Reading Room and Committee Room. Roof finishes comprise modern bituminous mineral felt over the Main Library (recently applied) and traditional lead sheet with timber rolls in the other areas, all assumed to be uninsulated.

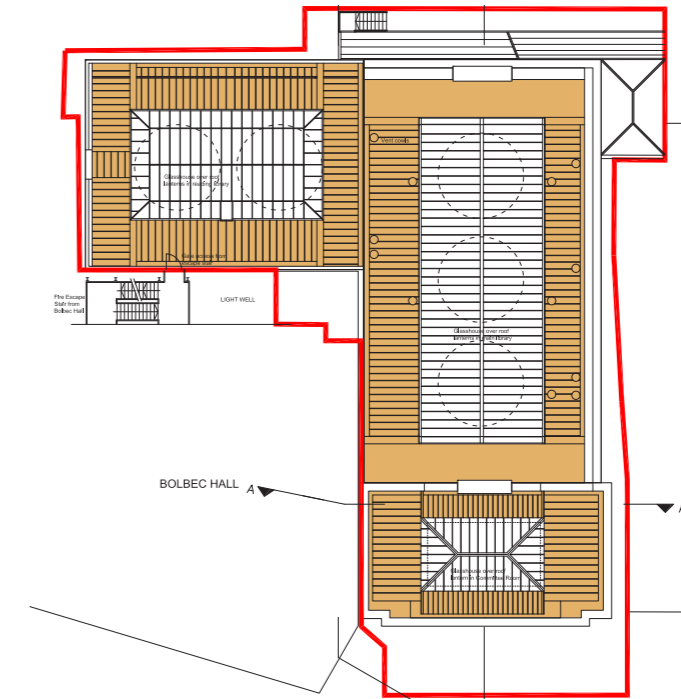
Overall, the roof is in fair condition, requiring only localised repairs to lead flashings and masonry copings.

Introducing insulation at roof level could deliver an estimated 9% reduction in overall building energy use. While this measure would be most appropriate when the roof coverings are due for full renewal, their current condition suggests this will not be necessary in the short term.

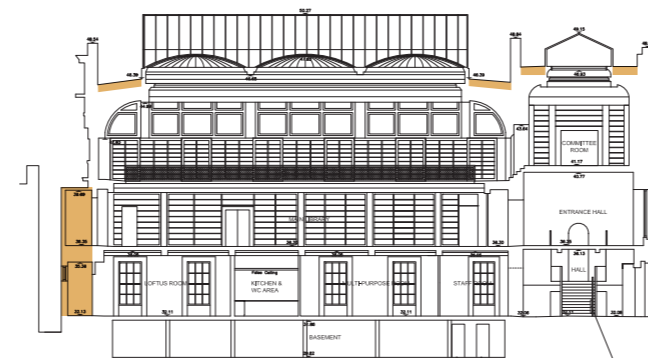
Any roof insulation strategy should also be considered alongside other potential rooftop works, such as the replacement of the glasshouses and the installation of new plant, as undertaking these interventions simultaneously would likely prove more cost-effective.



Ground Floor Plan




Roof Plan



Section A



Section B

 Potential for new insulation

6.3 Service Systems

6.3.1 Metering, Lighting and Controls

The alterations to metering, lighting and controls systems outlined in section 5.3 could be carried out independently as part of an ongoing programme of routine maintenance and repairs.

LED lighting could be rolled out as existing fluorescent lighting needs replacing or as budget becomes available.

Improved metering of systems could be explored with energy suppliers, replaced alongside other works to existing systems of implemented if budget is available.

Zonal heating controls or individual radiator valves could also be added to the existing system or implemented as part of a wider updated to a new LZCT heating system.

Metering & Controls

Existing metering is very limited throughout the library, meaning it is hard to assign energy consumptions to specific end uses. By metering data more specifically, evaluating and optimising energy usage becomes easier, such as sub-metering to improve visibility of specific energy use patterns. Lit & Phil's meter data was limited to the total values per month which meant the building's energy could only be evaluated as a whole.

Ideally any metering system installed would collect data and provide reporting on these items. This would allow monitoring, analysis, and corrective actions to be taken. CIBSE Guide F indicates that savings of around 5-10% are typically possible with effective metering. This figure depends on the existing setup and ensuring actions to optimise energy are undertaken when identified. There are a number of metering systems on the market which provide easy to use interfaces to log and monitor energy use.

Local controls

If not already in place, local control improvements such as weather compensation and detailed time scheduling could be applied to the existing boiler system. This will improve the efficiency of the boilers without the expense of a BMS dealing with this system only. The boiler manufacturers are likely to provide this type of system.

BMS controls

A centralised management system for the library's services may allow more efficient use of the building's heating and ventilation. A BMS can facilitate a timed or occupancy-based approach for Lit & Phil's heating and ventilation use, and provide centralised control. This would improve comfort within the library and avoid unnecessary heat loss through over heating or over ventilating.

Improved zonal heating system

The library is not often at maximum capacity as the rooms for hire - Loftus, Joseph Swan and Committee Rooms - can be left empty for periods of time. As the library only features one heating zone, these spaces will often be heated whilst empty. These clashing zones will account for some wasted energy.

With improvements to the structure and control of the heating system, heating zones could be established and only zones with occupied rooms could be heated. It is recommended that the other zones are kept at a lower setback temperature, rather than being completely unheated. This intervention would require some rationalisation of the booking process of the hire rooms to ensure comfort for occupants and efficiency for the heating system.

The use of LoRaWAN smart radiator valves would allow this by providing centralised control to individual radiators with a range of programmable features. This could allow the library to begin using occupancy based heating.



MClimate Vicki LoraWAN TRV

Ventilation

Heat recovery ventilation could be added to the library area to reduce and control the air flow through the main library. This is understood to be under-ventilated during the summer, and is uncontrolled.

We understand that provision is being made for this, making use of the existing openings in the rooflights, by the design team.

6.4 Low & Zero Carbon Technologies

6.4.1 Photovoltaics

The roof of the Lit & Phil provides an opportunity to install solar PV panels, however, careful coordination would be required with the rooftop lanterns above the glazed laylights. The PVs would have to be installed with sufficient space for maintenance and access to other areas of the roof.

The PVs will also impose additional load on the existing roof, the capacity of which will need to be checked by a structural engineer.

The following considerations have been made:

- The lead roof above the building entrance has been deemed an unfeasible PV location due to its limited access, and its largely north-facing position which would heavily reduce PV output.
- The south-facing perimeter around the right wing lead roof and main library bitumen roof may be a feasible location to install PV panels, however sight lines would need checking. See array 1 and 2 in the markup adjacent.
- The south end of these glasshouse pitched roofs could be utilised to increase PV area. This would only be possible if the glasshouse structures were replaced from the existing. See array 3 and 4 in the markup adjacent.
- Note all the above would also likely be subject to planning and listed building approval, and a structural inspection to ensure PVs can be supported to the existing building without damage.

These possible locations have been divided into 4 arrays, as demonstrated in the diagram adjacent.

The table below compiles the yearly energy production estimated from each of these arrays, considering a 25° to the horizontal. It is also expressed as a percentage of the existing electricity consumption at the Lit & Phil.

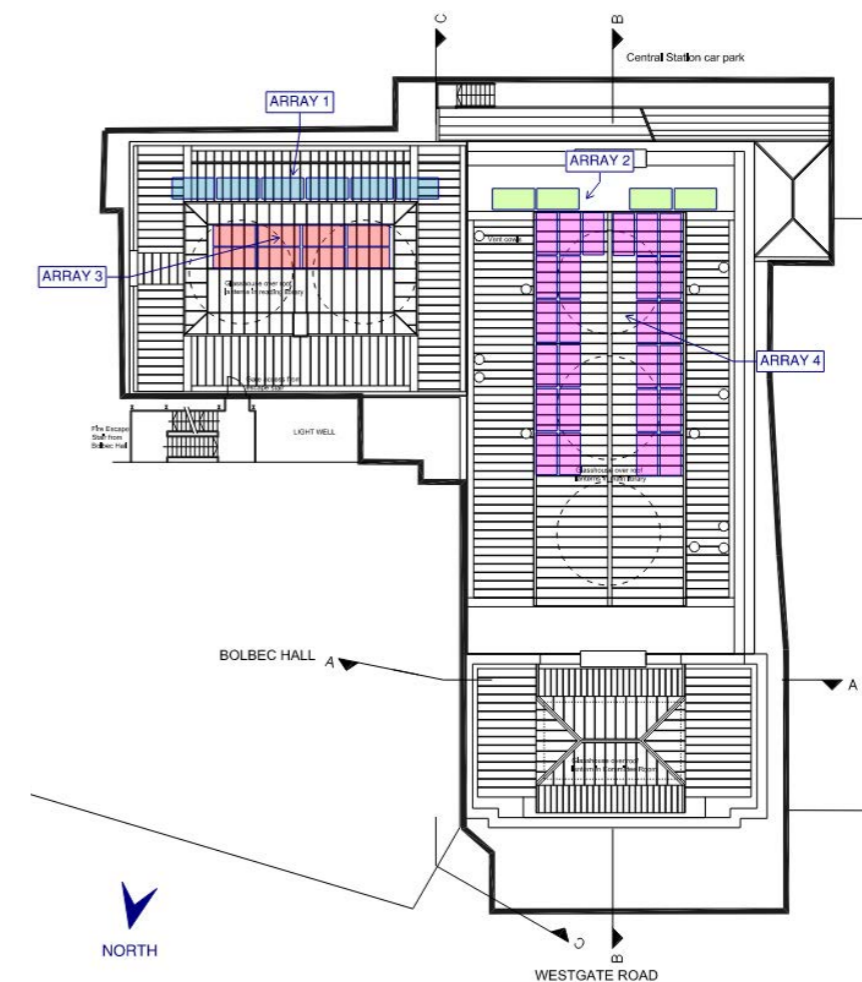
It is estimated that installing all the arrays indicated would cover 1/5 - 1/4 of the Lit & Phil's annual electricity usage.

6.4.2 Thin film Photovoltaics

Thin film PVs are transparent panels which appear as glass interfaces whilst yielding onsite generation of electricity. This could be used for the glasshouse structures above the rooflight lanterns, particularly if they are to be entirely replaced due to their structural concerns. Thin film PVs are available in varying transparencies, with lower transparencies maximising visible light transmission but reducing electrical output. The existing roof glasshouses appear to be largely dirty, meaning replacing the glazing with semi-transparent thin film PVs may not reduce the daylighting currently experienced in the library spaces below.

A detailed design would be required to identify the transparency acceptable for replacing the glasshouses, however, they only offer approximately 1/6th of the peak output that the opaque PV panels above provide, for the same area of coverage.

A larger percentage of the glasshouses area could be utilised as there would not be the same consideration of available daylight for the glass lanterns, however, the panels would lose efficacy the further north along the glasshouses. The impact on internal daylighting would also need to be carefully considered in relation to significance and architectural character.



Possible locations for solar PV panels from array 1 to 4.

ARRAY	AREA OF PANELS (M ²)	YEARLY ENERGY PRODUCTION (KWH)	PERCENTAGE OF EXISTING ELECTRICITY CONSUMPTION
Array 1	13.2	1420	2.6%
Array 2	8.8	950	1.7%
Array 3	17.6	1900	3.5%
Array 4	57.3	8000	14.3%
Total	70.5	12,300	22%

Estimated outputs from possible PV arrays

6.4 Low & Zero Carbon Technologies

6.4.3 Air Source Heat Pumps

Air-source heat pumps extract heat from atmospheric air and transfer it to heat the building. The system uses fans to draw air across a heat exchanger containing water or a refrigerant which is warmed up. This is circulated to the heat pump system which upgrades the heat to feed into the building heating circuit. Reversible units are also able to provide cooling.

The heat pump shown below is a Clade ACER high-temperature CO₂ refrigerant low noise ASHP. These can generate higher temperatures up to 80°C, which is beneficial for heritage buildings with inherently high heat losses like the Lit & Phil. These have been chosen for their low GWP refrigerant, low noise and high flow temperature.



Clade ACER high-temperature CO₂ refrigerant low noise air-source heat pump

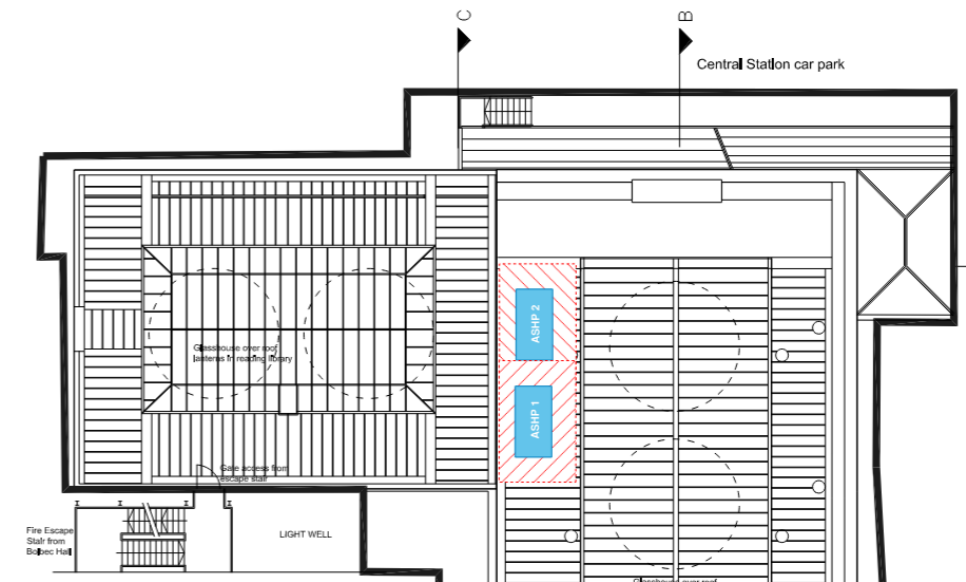
As shown in on the adjacent diagram there is availability to install 2no. new air-source heat pumps externally on the Library roof. The most viable location would be on the frame between the two glasshouses. This could be within a screened area for acoustics if required.

Each ASHP supports a load of 100kW which covers the existing heating demand of the Lit & Phil. This is also approximately 70% duty of the estimated (calculated) peak load of heat loss. 2no. ASHPs enables redundancy in the system.

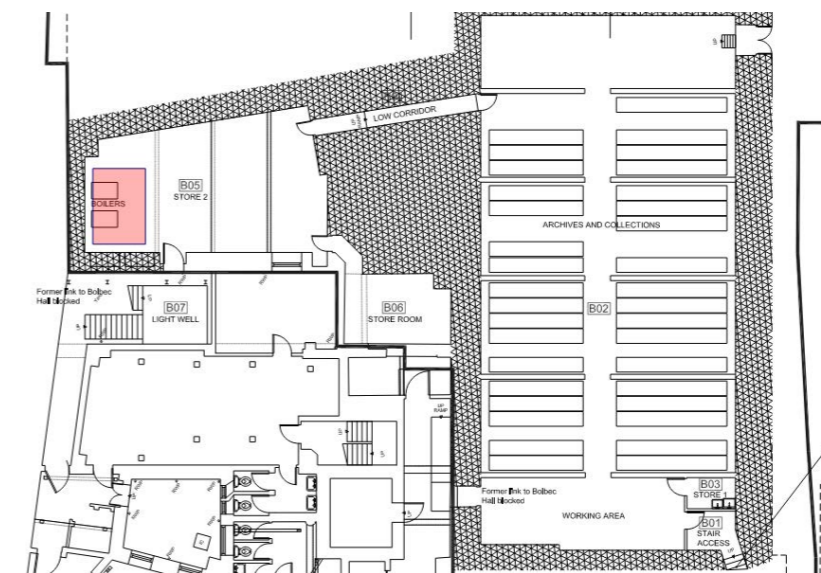
This arrangement would enable the space heating to be provided entirely with air-source heating, which would provide a long-term low carbon solution, particularly as imported electricity carbon factors reduce with grid decarbonisation.

The following considerations would be required in a full detailed design on this technology:

- 2no. ASHPs would result in an additional electrical load which may increase site loading beyond existing electrical capacity. Electrical infrastructure upgrades may be required and would be reviewed if this option were proposed. A quote for an upgraded supply to support heat pumps has already been requested as part of the capital works.
- Noise to sensitive areas would need to be checked.
- Existing heat emitters may require upgrades to provide the same outputs with the new flow/return temperatures.
- Heritage implications of external heat pumps.
- Structural implications of the roof safely supporting the heat pumps.
- Large buffer vessels required. These could be located in the existing basement plant space, as indicated in the adjacent diagram. It may be possible to retain existing pipework routes throughout the building from this location.



Possible roof location for 2no. Clade ASHPs with required clearance zones indicated



Possible location in the existing basement plant space for buffer vessels.

FORWARD PLAN

7.1 Decarbonisation Pathway

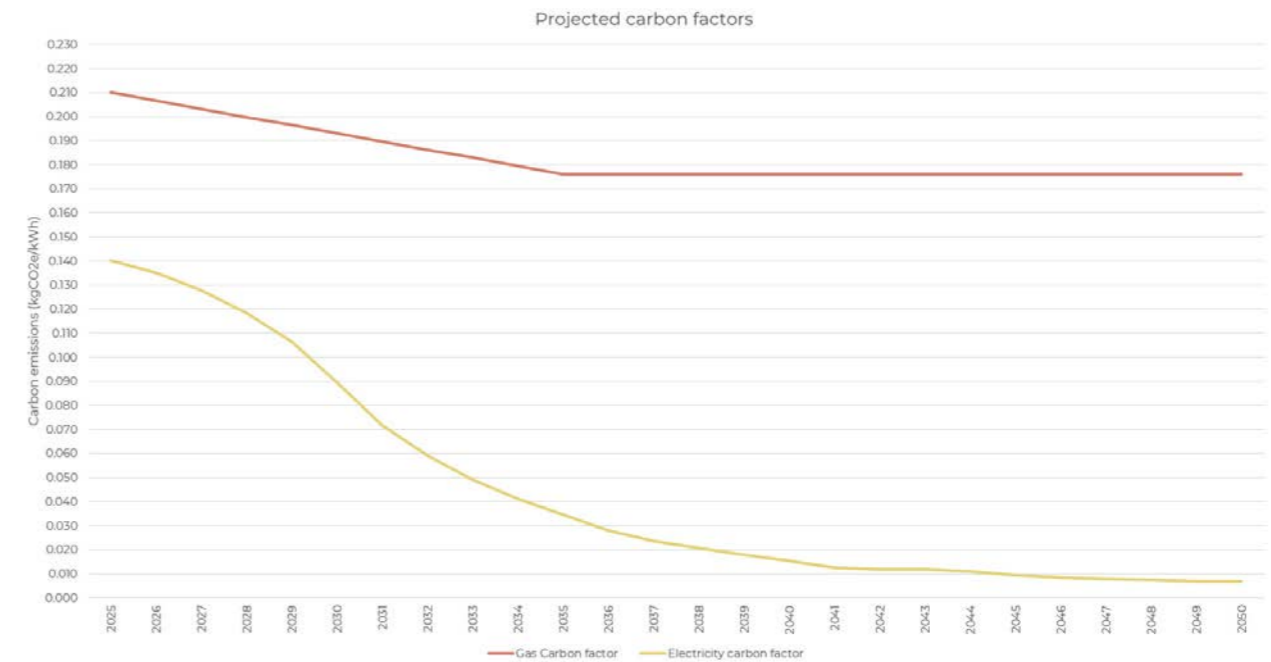
The Options Appraisal has identified a number of potential measures to improve energy efficiency and reduce carbon emissions associated with operation of the building.

The prioritisation and timing of implementation will be informed by practical and logistical considerations, such as the availability of funding and alignment with existing or planned projects, as well as the energy-saving potential of individual measures.

The current capital project has already considered a number of the proposed interventions and outlined a preliminary strategy for phased implementation in response to funding streams.

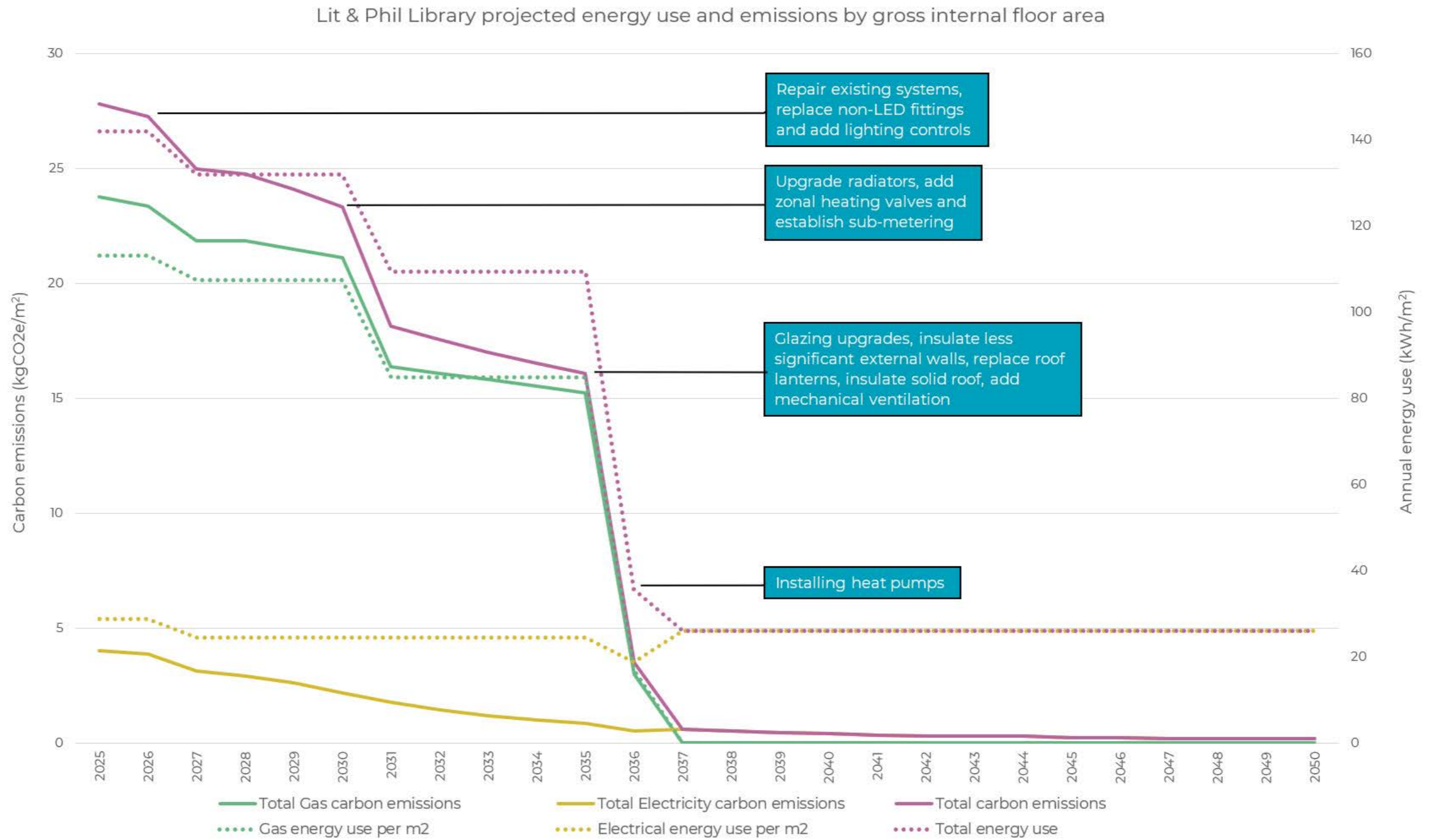
Where possible, the proposed decarbonisation pathway responds to the strategic approach to the capital project, while acknowledging that uncertainties remain around the technical and cost feasibility of the more significant measures, such as works to the roof lanterns and air source heat pumps.

1. Repair and maintain any existing systems to be retained.
2. Replace non-LED light fittings throughout the building and introduce lighting controls to allow automatic dimming/switch off when unoccupied.
3. Replace radiators and pipework with new heat emitters suitable for low-temperature heating.
4. Add zoning valves and controls to the existing heating system to enable zonal and scheduled heating
5. Establish effective sub-metering
6. Undertake works to the existing single-glazed windows to improve thermal performance and air tightness.
7. Internally insulate the external walls of less significant spaces; such as the ground floor multipurpose area and back fire exit as part of internal refurbishment work.
8. Replace the existing single-glazed roof lanterns.
9. Insulate the solid roof sections outside the glasshouses.
10. Introduce mechanical ventilation with heat reclaim to replace the existing uncontrolled natural ventilation.
11. Introduce solar photovoltaics, dependent on nature of lantern upgrade or replacement.
12. Install air source heat pumps



Graph of predicted future carbon factors for gas and electricity emissions up to 2050.

7.1 Decarbonisation Pathway



Graph of predicted future energy use and carbon emissions for the Lit & Phil Library up to 2050, based on the proposed decarbonisation pathway from the options appraisal

7.2 Next Steps

The Lit & Phil is already engaged in planning for the future refurbishment and enhancement of the building, including works to decarbonise operations.

The next steps to further integrate the findings of this study into their strategic planning of the capital project include:

1. Identify funding opportunities

In addition to the capital funding secured from the Barbour Foundation and development-phase support from NLHF, further funding streams should be identified to support the wider ambitions of the Trust.

If funding is sought for specific elements of scope, such as repairs to roof lanterns, technical feasibility and costing studies are likely to be required to inform the case for support.

2. Additional surveys and assessments

Further investigation of the existing building will be required to develop some of the improvement measures in more detail, including:

- Detailed condition survey of the glazed roof lanterns, to identify the structural capacity of the existing frames and patent glazing system and their suitability for re-glazing or replacement. This should be preceded by an asbestos survey.
- Technical options appraisal for upgrade works to windows.
- CO₂ monitoring within the Library and other spaces.
- Survey of the size / capacity and routes of the existing natural ventilation ducts to inform design development of any new mechanical ventilation system.

Front cover image: Photograph by Sally Ann Norman, courtesy of Lit & Phil

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