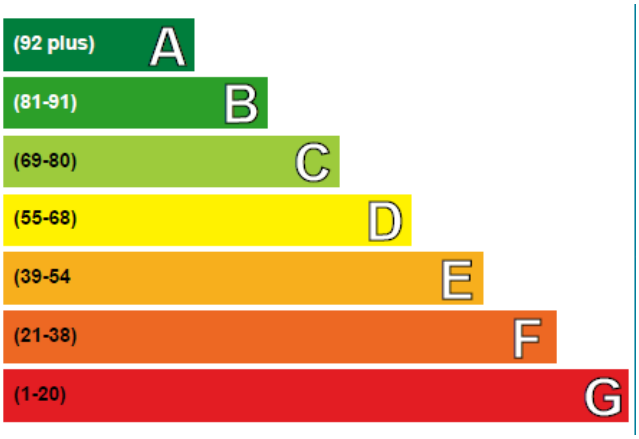

Whole Tenement Retrofit Case Study

July 2024

Loco Home Retrofit CIC

Loco Home is helping end Glasgow's contribution to climate change. It provides expert advice to households, local authorities and businesses. It is a co-operative, led by over 200 voluntary members.

www.locohome.coop

Under One Roof

Under One Roof is Scotland's only charity dedicated to providing free and impartial information to the more than half a million tenement flat owners, and housing professionals, on issues related to tenement maintenance, common repair management, and retrofit.

www.underoneroof.scot

Executive Summary

Decarbonising home heating through the retrospective fitting ('retrofit') of insulation and clean heating is a key sustainability goal. However, owners face significant challenges due to cost, complexity and risk. These issues are compounded in traditional buildings and, moreover, those in multiple ownership such as tenements.

This project, a strand within Loco Home's wider project funded by the Pilot Climate Engagement Fund[1], developed a holistic view of retrofit options for a whole privately-owned tenement building. The project took place between January and March 2024 which coincided with the consultation period for the Scottish Government's Heat in Buildings Bill (HIBB) which proposed minimum standards for energy efficiency and clean heating. These legislative proposals were considered in the scenarios analysed in this project.

Surveys of the building fabric and services were carried out. Owners were consulted through questionnaires and in-person meetings. The current focus of the owners is on overdue stonework repairs, insurance and an unsupportive factor. Maintenance needs in the years ahead include replacing roof tiles.

Scenarios were analysed for their impact on running costs and capital costs. These scenarios comprised combinations of three different insulation scenarios: no change; HIBB compliance plus double glazing (HIBB+); and deep retrofit approaching the Association for Environment Conscious Building's Retrofit Standard[2] '(AECB-). It considered three heating scenarios: gas boilers, air source heat pumps and networked ground source heat pumps.

Energy bills with a ground source heat pump would reduce by 25% without adding insulation, equating to a saving of £318 to £526 per year for flats maintained at 20°C. The HIBB scenario requires the addition of ground floor insulation, reducing annual heat requirements (kWh) by 30%. The AECB deep retrofit scenario gives energy savings of around 80% as well as significant comfort and air quality benefits. Capital costs per flat in the HIBB+ scenario, including anticipated repair and maintenance requirements and heat pump range from £39k for a mid floor flat to £47k for a ground floor flat. The AECB deep retrofit adds at least £40k capital cost per flat.

The analysis highlights issues with Energy Performance Certificates, particularly that advanced draught-proofing is not reflected in the scoring. Furthermore, heat recovery ventilation makes EPC scores worse rather than better.

The combination of high costs with technical and cooperation issues as well as poor support from factors and regulation creates a huge challenge for tenement owners. In the view of Loco Home, since there is no technical requirement for insulation or draught proofing to be introduced for the efficient operation of a heat pump, the most achievable decarbonisation plan may be one that involves relatively few changes to the common parts of the building. Such a plan should enable additional measures to be adopted on a flat-by-flat basis depending on the preferences of the individual owners. That would mean avoiding external wall insulation, ground source heat pumps and solar PV and instead focusing on draught proofing and controlled ventilation. Those owners wishing to decarbonise without waiting for clarity on a local authority-led heat network can opt now to install air source heat pumps.

[1] "Climate Engagement Fund, Approved Bids 2023-24", Scottish Government, 2023
[2] 'AECB Carbonlite Retrofit', AECB, 2023

Implementation of the 2019 recommendations from the Scottish Parliamentary Working Group on Tenement Maintenance would provide the necessary basis for decision making, contracting and financial planning[3]. Those recommendations were for owners associations, building reserve funds and five-yearly building surveys. Provided that funding can be arranged, this governance structure would also provide the conditions for deeper retrofit, such as wall insulation and solar PV.

Independent, holistic, specialist advice is also needed which goes beyond that currently provided by central and local government.

The financial burden addressing overdue maintenance, which is of intergenerational benefit, should not be placed solely on the existing owners. New forms of finance are required to fund repairs, maintenance and green retrofit.

[3] 'Working Group on Maintenance of Tenement Scheme Property Interim Recommendations Report', RICS, 2019

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Notes

Loco Home Retrofit and Under One Roof were the project partners.

John Gilbert Architects, Lùths Services and NBM Construction Cost Consultants were subcontractors.

This report provides information, not professional advice.

Contact Chris Carus at Loco Home Retrofit for more information about this report: info@locohome.coop

1. Introduction

Decarbonising home heating through the retrospective fitting ('retrofit') of insulation and clean heating is a key sustainability goal. The Climate Change Act (Scotland) 2009 requires that emissions be reduced by 75% by 2030, compared to the 1990 baseline[4]. This is expected to require 22% of buildings to be heated with renewable sources by 2030, up from 4% in 2021[5]. Retrofit can also provide significant additional benefits including improved comfort, health and wellbeing and reduced energy bills.

However, property owners face significant barriers to retrofit including the capital cost as well as the complexity and risks associated with making plans and procuring works. Traditional solid-walled buildings, generally built before 1919, face additional technical challenges such as the risk of condensation forming behind wall insulation. In shared buildings, such as traditional tenements, these problems are compounded by the challenges of synchronising the interests and financial capacities of all owners. Indeed, many tenements already have an overhang of overdue repairs and maintenance which may amount to £2.9 billion across the City of Glasgow alone[6] before insulation and clean heating are considered.

This project, a strand within Loco Home's wider project funded by Climate Engagement Fund[7], developed a holistic view of retrofit needs and options for a whole privately-owned tenement building. The project had the following objectives:

- Take input from owners in two workshops
- Take feedback and report lessons learnt to inform future tenement engagement.
- Contribute content to an overarching series of films about retrofit.
- Deliver a report (this report) outlining retrofit feasibility for this building.

Under One Roof was a project partner. John Gilbert Architects, Lùths Services (building services consultancy) and NBM (construction cost consultants) were consultants.

The project took place between January and March 2024 which coincided with the consultation period for the Heat in Buildings Bill (HIBB). The consultation outlined the Scottish Government's proposals for a Heat in Building Standard, comprising minimum energy efficiency standard (MEES) and a clean heating standard. These legislative proposals were considered in the scenarios analysed in this project.

The building studied was in Dennistoun, Glasgow. It is a four storey pre-1919 sandstone mid-terrace tenement. It has eight flats, five of which are owner-occupied and three have private landlords. It was selected because it is of a typical tenement design; there is a mix of tenure types; and because the owners are facing common challenges with repairs and maintenance. Recruitment was achieved through pre-existing contact with one of the owners.

[4] 'Climate Change Act (Scotland), 2009', legislation.gov.uk
[5] Heat in Buildings Strategy, Scottish Government, 2021
[6] "Repairs bill for Glasgow tenements 'could run into billions'", Scottish Housing News, 2018
[7] "Climate Engagement Fund, Approved Bids 2023-24", Scottish Government, 2023

PROJECT METHOD

The project team executed the following steps:

January 2024	Recruit tenement. Initial information to owners by email and WhatsApp 29th - Information letter drop to occupants 29th - site survey
February	1st - first workshop with owners 8th - Info sheet, video, owners questionnaire Reviewing policy context Site survey reports Reviewing Deeds and Factoring arrangements Energy modelling, scenario planning and analysis 29th - second workshop with owners
March	3rd - Owners update letter and video Technical reports on retrofit plans. Share draft analysis with owners.
April - July	Finalise report with stakeholders

NAVIGATING THIS REPORT

This report is structured as follows. Section 2 summarises relevant regulatory and best practice considerations. Section 3 reports key findings from owner engagement. Section 4 summarises key findings from building surveys. Section 5 describes the retrofit scenarios which are then analysed in section 7 according to methods set out in section 6. Conclusions are drawn in section 8.

The full technical reports from consultants are provided as attachments - see the list in Appendix A.

2. Regulation, Policy and Best Practices

2.1 TENEMENT REGULATION

This section borrows heavily from information resources provided by Under One Roof, the charity for Scotland's tenements and tenement owners. Further information is provided in Attachment 1.

2.1.1 Property Managers (aka Factor)

Property managers are employed by the owners to manage the common property on their behalf. It is the owners' responsibility to make sure the common parts of their building are kept up to standard and the factor is there to help owners do this effectively.

Factors must comply with the Property Factors (Scotland) Act 2011, which requires Factors to be registered and work to a Code of Conduct. It also provides a dispute resolution process.

More information here: https://underoneroof.scot/articles/1108

2.1.2 Property Management Rules

Rules applying to all flats are set out in the Tenements (Scotland) Act 2004. These include the obligation to have common building insurance (see below) and a duty to maintain.

The land certificate for each flat (formerly known as title deeds) sets out the specific rules around the owner's responsibilities - including their share of costs - for common, mutual or individual repairs. Where the certificate is inadequate the Tenements Act applies.

It may be necessary to consult a solicitor to interpret land certificates accurately.

More information: https://underoneroof.scot/articles/1352

2.1.3 Maintenance

Regular inspections and preventative maintenance are less costly than reactive repairs. However the challenges of organising pro-actively can be too much for many owners.

A Scottish Parliamentary Working Group on Tenement Maintenance[8] made three key recommendations:

- Mandatory owners' associations to support decision-making.
- Mandatory five-yearly property inspections,
- Mandatory building reserve funds with monthly owners' contributions to support future maintenance,

Legislation that responds to the Working Group recommendations is expected to be introduced over the next few years. In the meantime, these recommendations represent best practice.

[8] Working Group on Maintenance of Tenement Scheme Property Interim Recommendations Report', RICS, 2019

2.1.4 Insurance

It is a legal obligation on owners to have adequate building insurance in place to cover the whole building, including common areas. This can be through a single common insurance policy or through individual insurance policies.

See more information here: https://underoneroof.scot/articles/1138/

2.1.5 Repairs

From the Under One Roof website:

> *"Every owner has a duty to maintain the parts of the tenement that provide support and shelter. This would apply to leaking roofs, rot in structural timbers, leaks around individuals' windows etc.. This duty can be enforced by other affected owners and does not require majority agreement, though this should be sought wherever possible."*

More information here: https://underoneroof.scot/articles/987/

2.2 HEAT IN BUILDINGS BILL CONSULTATION

As part of its Climate Change Plan, the Scottish Government's recently consulted the public on proposals to introduce two important measures affecting buildings[9]: Minimum Energy Efficiency Standards and a Clean Heating Standard.

2.2.1 Minimum Energy Efficiency Standard (proposed)

The proposed Minimum Energy Efficiency Standard is proposed as a checklist of measures, where these are applicable to the building:

- 270 mm loft insulation;
- suspended ground floor insulation;
- cavity wall insulation (not applicable to solid-walled tenements);
- draught-proofing;
- heating controls;
- 80 mm hot water cylinder insulation.

Note that double glazing is not a proposed requirement.

Alternatively, compliance can be achieved by demonstrating a specific space heating demand (SSHD) of not more than 120 kWh of heat being needed to maintain comfortable temperatures, per square metre of floor area per year.

The Scottish Government proposes that owner occupiers must comply by 2033. Private landlords are to meet the standard by 2028, or they will be prevented from letting to a new tenant from this date.

Owner occupiers, but not landlords, that meet the Clean Heat Standard would be exempt from the Minimum Energy Efficiency Standard.

[9] 'Delivering net zero for Scotland's buildings - Heat in Buildings Bill: consultation', Scottish Government, 2023

2.2.2 Clean Heating Standard (proposed)

Polluting heating, such as gas boilers, are proposed to be prohibited as a main heating system by 2045. This means that clean heating systems such as heat pumps, electric storage heaters or heat networks must be installed by then.

In addition to the 2045 deadline, the Scottish Government proposes two further situations for the prohibition of polluting heating, such as gas boilers.

1. After a grace period of two to five years following the purchase of a property.
2. Following notice from a local authority that a district heating network has been established in the area.

2.2.3 Local Heat And Energy Efficiency Strategy

Local Authorities are required to publish Local Heat and Energy Efficiency Strategies (LHEES) which provide an area-based approach to heat and energy efficiency planning and delivery.

Glasgow's strategy[10] outlines areas of the city that may be suitable for developing heat networks, in which heat is sourced from a centralised facility and then distributed to buildings through pipes. However, it does not indicate whether or when these heat networks will be built, only their feasibility.

The tenement studied in this project is in an area considered to be of secondary suitability for a heat network. This is primarily due to its distance from renewable heat sources such as the River Clyde.

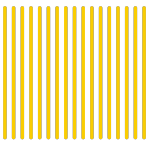
[10] 'Glasgow Local Heat and Energy Efficiency Strategy', Glasgow City Council, 2023

2.3 ENERGY EFFICIENCY BEST PRACTICE

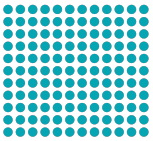
Loco Home always recommends taking a holistic approach to planning retrofit.

First, make a holistic plan for the whole building with the help of an expert advisor who is free of conflicts of interest.

Address repairs and maintenance, such as a leaky roof, before anything else.



Aim for a continuous layer of insulation. That means, for example, wall insulation meeting or overlapping with floor and roof insulation.



Aim to achieve a continuous airtightness layer. Replace uncontrolled ventilation (draughts) with controlled ventilation (fans) to maintain sufficient fresh air.

Install a zero emissions heating system such as a heat pump as early as can be achieved without regrets - this is mainly about upgrading radiators to achieve efficient operation.

Install renewable generation, such as solar panels, and smart technology.

The Scottish Government's advisor, the Climate Change Committee, foresees that emissions targets for 2050 can be met with a 12% reduction in heat demand in its Balanced Pathway[11] - a relatively light intervention that it estimates will cost £10,000 per household. Some building experts disagree and advise that homes should be much-improved with insulation and draught-proofing, reducing required investments in grid upgrades and renewable generation such as wind farms while also providing health and economic benefits.

While the Scottish Government is setting its Minimum Energy Efficiency Standard at around 120 kWh of space heating demand per square metre of floor area per year (kWh/m^2.a), the Association for Environment Conscious Building and LETI recommends a much lower energy demand of 50 kWh/m^2.a, representing much more insulation and draught-proofing. Furthermore this Standard is calculated using the more stringent Passive House method[12], rather than the RdSAP method used by the Governments. Debate around these issues continues.

In solid-walled buildings such as Glasgow's traditional tenements, there are significant technical constraints to greater levels of energy efficiency. While attaching insulation to the outside of the

[11] 'The Sixth Carbon Budget | The UK's path to Net Zero', Climate Change Committee, 2020 (see p113)
[12] 'Climate Emergency Retrofit Guide', LETI, 2021,

walls would be highly effective, heritage constraints promote the preservation of the external appearance. An acceptable compromise may be to externally insulate only rear and gable walls.

Insulating the external walls on the *internal* surface can be highly disruptive and creates elevated risks of moisture accumulating in the wall. In the worst case, that moisture may cause floor joists to rot and collapse, although it may take several years for problems to develop. Loco Home has produced materials to promote understanding such as this video. It is critical to maintain and treat walls with suitable materials. This means gutters and downpipes must be in good condition and walls must be pointed externally using lime mortars rather than cement mortars. Furthermore, insulation must be vapour permeable such as woodfibre rather than rigid foam boards.

2.4 CLEAN HEATING

The options for clean heating are a heat network, individual air source heat pumps or direct electric heating.

2.4.1 Heat Networks

As mentioned above, the building is in an area considered by Glasgow City Council to be of secondary suitability for a district heat network. If one were to be developed it would be of either a 4th or 5th generation type network.

A '4th generation' district heating system would involve the least disruption for owners. Insulated pipes buried under the road bring heat to the building. Two pipes circulate hot water to and from a small wall-mounted 'heat interface unit' (HIU) in each flat. The HIU will meter the amount of heat transferred to the flat's radiator circuit and to the hot water taps. No hot water cylinder is required. However, these schemes are very large infrastructure projects that are expected to take some years to build. Necessary consumer protection legislation is being developed[13].

Alternatively, a '5th generation' heat network brings renewable heat at around 5 to 20C, usually from a network of boreholes in nearby roads and green spaces. Individual heat pumps in each flat bring the heat to a higher temperature for radiators and hot water storage. One network provider proposes to cover the capital cost by requiring connected homes to pay a monthly charge which would be comparable with a gas standing charge. The majority of the running cost would be for electricity for the heat pump, charged in the normal way. This option is referred to as ground source heat pump in this report (GSHP).

2.4.2 Individual Air Source Heat Pumps

Individual air source heat pumps (ASHP) could be considered if a heat network development is not forthcoming. Households wishing to decarbonise early can choose to install a heat pump now.

It is not necessary to install insulation for a heat pump to perform at top efficiency. What matters is system design, which usually includes upgrades to radiators and pipework. However, increased insulation will reduce the size and cost of the heat pump and radiators. AECB and other experts in sustainable buildings advise that installing heat pumps or clean heat networks will make a rapid reduction to carbon emissions and further insulation can be completed later[14].

[13] 'Heat networks regulation: consumer protection', UK Government, 2023
[14] 'AECB launches two levels of retrofit standards', Passive House Plus Magazine, 2023

If care is given to the design and operation of heat pump systems, running costs will reduce for most households compared with a gas boiler. Some households, especially those that are fuel poor and heat intermittently may see an increase in running costs without improvements in insulation.

Heat pumps reduce emissions by around 70% compared with a modern gas boiler. The reduction will increase over time as the energy grid becomes cleaner.

Various forms of air source heat pump exist. Air source fan units can be located on the ground or hung from the wall. Innovative roof- and attic-mounted applications are also emerging. In some circumstances the heat pump can be located internally with no external equipment other than vents.

Another form of ASHP is air-to-air heat pumps, where heat is distributed internally by blowing recirculated indoor air over a heat exchanger, instead of using a water-filled radiator. Despite being a lower cost option, air-to-air was not considered in this report since no independent certification scheme or government funding is available for this technology.

2.4.3 Direct Electric Heating

Direct electric heating - including storage heaters, panel heaters, electric wallpaper, electric boilers and infrared heating - would cause heating bills to increase compared with the existing gas boilers and were not considered further in this project.

3. Owner Engagement, Governance

This section describes the existing governance and cooperation between owners of the case study building. Then it describes the process through which owners and tenants were engaged to consider energy improvements.

3.1 GOVERNANCE

There is evidence of good relations between most of the owners but this does not appear to be sufficient to enable timely repairs and maintenance. A WhatsApp group enables easy communication between the owners. In addition, several of the owners and tenants occasionally meet in a social context, including as a pub quiz team.

A property manager, or factor, is engaged by the owners as their agent in repairing and maintaining the building. The Factor arranges periodic cleaning of the common areas. Owners reported dissatisfaction with the factor as it does not take a proactive approach to identifying and addressing issues.

Diverse abilities and willingness to pay are barriers to building maintenance. For example, in recent years, agreement could not be achieved concerning contributions to repair rainwater goods and one owner had to step in and pay additional shares so that the work could proceed. Also, one owner is in dispute with the factor concerning the management fee.

Perhaps most significantly, the owners did not have full confidence that there was sufficient building insurance in place to cover reinstatement of the building in the event of a fire or other major problem. At least some owners have individual building insurance policies in place, but the owners do not have visibility to confirm that current policies add up to sufficient cover for the whole building. The factor explained that no common insurance is in place because it has not been instructed by the owners to procure such a policy. The Factor says that such an instruction must have unanimous agreement between the owners. In law, such a decision requires only a majority agreement. However the factor may be arguing that while one owner is already in dispute over fees it is not confident it would be able to recover the costs of a common insurance policy.

3.2 ENGAGEMENT

Of the eight flats in the building, five have owner-occupiers and three have private landlords. The project started by seeking the participation of the owners and tenants in defining the retrofit proposal. An information sheet, a questionnaire and a meeting held in one of the flats sought to elicit input from owners on goals and priorities for maintaining or improving the building. Contact was made by posting letters through flat doors and by asking for information to be shared through the owners' WhatsApp group.

3.2.1 Questionnaire

Responses were received from three out of five owner occupiers, one out of three landlords and one out of three tenants. Table 3.1 summarises their responses to the prioritisation of retrofit benefits. Energy bills and maintaining home value are the most important motivators for retrofit.

Table 3.1: Owner and tenant prioritisation of retrofit benefits. Each letter represents one owner or tenant. (O = Owner-occupier, L = Landlord; T = Tenant)

Which of these potential home improvement benefits would you prioritise for your home?	Importance				
	1 Low	2	3	4	5 High
Reducing energy bills			L	O O	O O T
Improving comfort			O L		O T
Reducing environmental impact			O L	O	T
Eliminating damp issues (moulds, condensation, rising damp)	O		O L	O	T
Improving indoor air quality (pollutants, viral load, humidity)		O	O L	O	T
Maintain or improve the value of my home			L	O O O	T

- Three respondents noted the importance of required stonework repairs.
- One flat indicated intentions to renovate, including addressing an off-level floor due to historic settling of the walls.
- Most respondents did not provide clear input on their current gas and electricity usage.
- There was some dissatisfaction with the service provided by the factor.

Most respondents have high confidence in still being in their properties five years hence, but much less confidence in being there 10 or more years from now - see Table 3.2.

Table 3.2: Owner and tenant responses to "How confident are you that you will still be in the property on the following timelines?"

Insert 'X'	Not confident	Somewhat confident	Highly confident
5 years		O: 2	O: 1 L: 1 T: 1
10 years	O: 2 T: 1	O: 1 L: 1	
20 years	O: 3 T: 1	L: 1	

3.2.2 Owner Consultation

Information sheets were distributed on 29th January, 8th February, 29th February, 4th March 2024. These sheets preceded or followed on from meetings with owners. To broaden accessibility, these sheets were supplemented with short video explanations.

In addition, Loco Home met with owners in one owner's living room on 1st February and 29th February. At the first of these meetings, experts from Luths Services and John Gilberts presented short explanations of available retrofit options and their benefits. Video summaries were provided to those owners unable to attend.

While owners were interested to hear about the options for energy improvements, most conversations centred on the owners' long standing difficulties in addressing some overdue stonework repairs.

Figure 3.1: Owners' meeting with Loco Home to discuss retrofit options on 29th February, 2024.

4. Building Surveys

Surveys of the building fabric and building services were made by the sub-contracted consultants on 29th of January 2024. The survey was carried out via drone video, external inspection and internal inspection of four flats, including ground, mid and top-floor flats, which were assumed to be representative of the other flats.

The full reports from the consultants are provided as attachments to this report. The key highlights are summarised below. Note that these survey reports do not constitute specifications for works.

4.1 FABRIC SURVEY

4.1.1 External Condition

Roof

- Roof slates were replaced with concrete tiles, probably in the 1980s or 1990s. The tiles may be at the end of their service life, which is typically specified as 25 or 30 years.
- The roofs on the two bay windows and rear outshot are finished with slate.

Figure 4.1: Drone photograph of rear elevation and roof.

Rainwater goods

- It is worth noting that all rainwater goods are likely to be too small in the future as rainfall episodes become more intense with further climate change. If any works are envisaged at

roof level, it is recommended to enlarge the gutters and downpipes, including for easy access at ground level and changing all to a lightweight metal if possible.

Figure 4.2: Front bay window and guttering.

Chimney stacks and wallheads

- Render, flashings and chimney pot haunching is in varying conditions but generally good.
- Most chimney pots are not covered and it is recommended that they be covered while remaining ventilated to reduce water build up in the chimney. Cowls can be used, or elephant's foot cowl for disused chimneys.

Figure 4.3: Chimney pots on the east wallhead.

Stonework

- Many areas have been repointed with unsuitable cement mortar and several areas have been patched with unsuitable cement render. There is some delamination and loss of surface finishes which is severe in places.
- In the rear wall various services have been drilled through the wall and have not been sealed.
- There are several cables draped over the walls from more recent cable and satellite installations. Cables can draw rainwater onto the wall.

Figure 4.4: inappropriate cement repairs and ensuing surface delamination on the front wall.

Windows

- From a maintenance point of view there is a reasonable case for upgrading the timber single glazing, but less reason for upgrading the more modern PVCu double glazing. From a heritage point of view all should ideally be replaced as none are original and none match the original forms or patterning.

Rear court

- It would be good to replace the hard landscaping with one with porous surfaces, always allowing for drainage away from the building and court generally.

4.1.2 Internal Condition

Close

- At the upper levels, the condition of the curved stairwell walls drops and the upper floor wall finish is in poor condition with widespread peeling paint and discolouration. This would appear to be linked to moisture damage.

Figure 4.5: moisture damage in the stairwell at top floor.

4.1.3 Energy efficiency

Roof

- Roof insulation is 150mm between joists and 120 to 150mm across joists. However there are several areas where insulation is missing, such as around the boardwalk and at the wall head.
- The owner of flat 3/1 noted that he had recently insulated the ceiling space of the bay window in his flat, but the other bay was not checked.

Figure 4.6: Incomplete 270mm insulation in the roof

Ground floor

- The ground floor flats have suspended timber floors. We were not able to inspect under the floor. We assume these floors are uninsulated.
- There are air bricks externally to front and rear although at the rear these are located above floor level and would need to be ducted below any future insulation.
- The external ground level at rear is non porous and relatively high compared with floor joist position. There is some risk that floor joists may become wet and rot and this would be exacerbated by floor insulation which makes the joists colder. This risk is mitigated by the slope away from the wall towards a gutter and drain.
- Note that the suspended ground floors are a significant source of draughts entering the building.
- The close has a solid floor.

Figure 4.7: View of rear wall showing that the ground level is non porous and relatively high compared with floor joist position. There is some risk that floor joists may become wet and rot and this would be exacerbated by floor insulation. This risk is mitigated by the slope away from the wall towards a gutter and drain.

Walls

- The external walls, to front and rear are both of solid sandstone with lath and plaster finishes internally, some of which may have been replaced with a more modern equivalent such as plasterboard.

4.2 SERVICES SURVEY

4.2.1 Heating

All flats have gas boilers. In the surveyed flats these were all combination boilers. EPCs indicate that one property (3/2) has an older and less efficient non-condensing boiler.

Heating is provided by radiators which are a mix of double panel convectors and some lower output single panel convectors and towel rails. While these likely provide sufficient heat from gas boilers operating at high temperatures, they are likely undersized for efficient operation of a heat pump with the current levels of insulation.

Some flats surveyed had 15mm radiator connection pipes but some microbore 8mm was present in others. 8mm often needs to be upgraded to 15mm for operation with a heat pump, depending on the heating requirement of each room.

4.2.2 Ventilation

The flats are ventilated through natural ventilation (uncontrolled draughts and opening windows), with half of the flats having trickle vents installed on the windows. No mechanical ventilation, such as extract fans, was observed.

4.2.3 Electrics

Some consumer units (fuse boxes) were not compliant with current standards.

Some flats do not have DNO cut outs (main fuses), which presents a barrier to the installation of smart meters, upgrading consumer units and installing larger loads such as heat pumps.

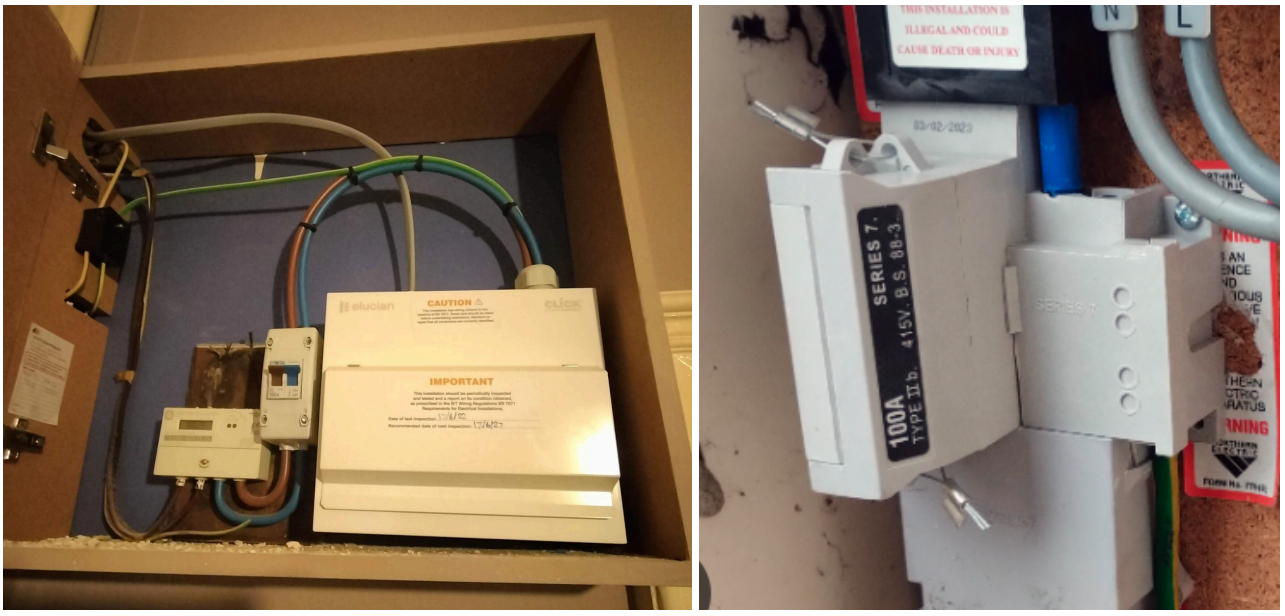


Figure 4.8: Left: an unusual electrical supply in one of the flats with 100A isolator but no DNO cut out fuse. Right: an example cut out fuse.

5. Improvement Scenarios

Improvement options for insulation, heating and solar PV are described. Then the scenarios to be analysed are set out.

5.1 OPTIONS FOR HEATING DEMAND REDUCTION

Three heating demand scenarios (insulation levels) were considered. These are specified in Attachment 4 and summarised in Table 5.1.

1. **No change**
    a. 2 flats have single glazing.
2. **HIBB+**

    Compliance with the Minimum Energy Efficiency Standard proposed in the Heat in Buildings Bill consultation plus double glazing. This means

    - Topping up loft insulation for a consistent 270mm layer
    - Ground floor insulation. While access via hatches may be possible towards the front of the building, the ground slope makes it necessary to lift floorboards in at least the rear parts of the ground floor flats. This is reflected in the assumed costs.
    - Minimal draught proofing such as windows.

    Double glazing was added to this scenario because no heritage constraints apply to the case study building and it is already installed in most flats.

3. **AECB-**

    A deep retrofit specification for the whole building broadly in line with the Association for Environment Conscious Building's (AECB) Retrofit Standard Step Two, mentioned in Section 2.

    The scenario deviates from the AECB Standard in two main areas. The modelled airtightness does not reach the AECB target due to cost and feasibility. Also the ground floor common area (the close) is left uninsulated.

Table 5.1: Summary of demand reduction (i.e. insulation) scenarios.

	Existing	HIBB+	AECB-
Thermal envelope	Stairwell is uninsulated	As existing, uninsulated	Stairwell is insulated and unheated. Front and rear external doors are airtight.
Roof	Patchy 270 mm	Even 270 mm	450 mm
Ground floor	None	150mm insulation	210mm
Windows	6 flats double glazed 2 flats single glazed	All double glazed	Double glazed
Front wall	Uninsulated	As existing, uninsulated	Polyurethane injected behind lath & plaster
Rear wall	Uninsulated	As existing, uninsulated	100mm stone wool with silicone render
Airtightness	As existing, assumed to be Permeability 15 $m^3/m^2.h$	Draught-proofing on windows, i.e. as existing. Permeability 15 $m^3/m^2.h$	Extensive draught proofing interventions. Permeability 5 $m^3/m^2.h$
Ventilation	'Natural' ventilation, i.e. draughts and window opening	'Natural' ventilation, i.e. draughts and window opening	Ducted mechanical ventilation with heat recovery (MVHR)

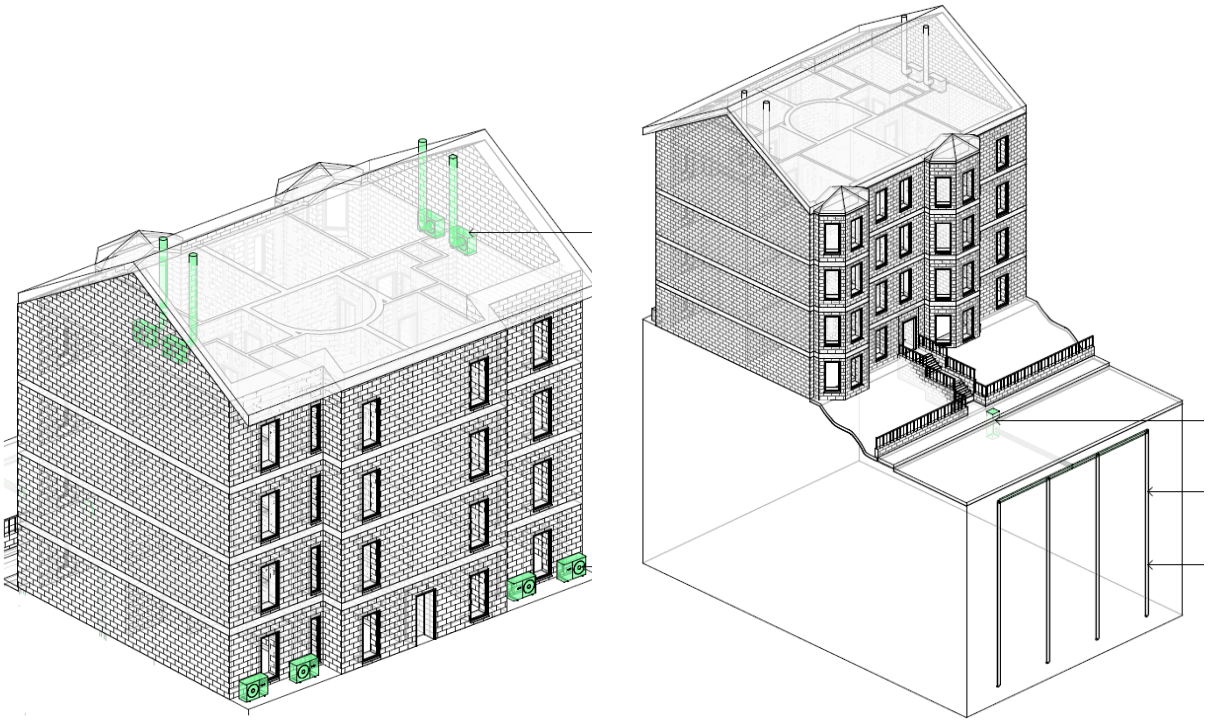
5.2 CLEAN HEATING OPTIONS

For each insulation scenario, three scenarios for decarbonised heat were considered. These are described in detail in Attachment 5.

1. **No change:** condensing gas boiler with thermostatic radiator valves (TRVs) and programmable thermostat
2. **ASHP**: Individual air source heat pump
    a. Outdoor fan units could be ground-mounted for the bottom four flats.
    b. The top four flats could have attic-mounted heat pumps. While this would be unusual it is not unprecedented.
    c. ASHPs would be 'split' type systems with refrigerant running from the outdoor units in narrow insulated pipes to heat exchangers in each property.
    d. Hot water storage would be required. This could be a cylinder in the storage cupboard or a heat battery in a kitchen cabinet.
    e. Other ASHP options such as internally-located exhaust air heat pumps were not considered in this project.
3. **GSHP**: Individual ground source heat pumps supplied by a network of boreholes. In other words, a fifth generation heat network.
    a. Compact ground source heat pumps inside each flat.
    b. Hot water storage would be required. This could be a smaller wall-mounted cylinder.
    c. An array of boreholes in the back court or in the street would be networked with uninsulated pipes and supplied to each flat on a loop. Construction of a ground source is not viable for this building alone as there is no access for a drilling rig to the back court. Instead it would be necessary to drill in the street.
    d. One system provider said that a project of as few as 50 homes may be economically viable. This would require support from the local authority. Owners would not need to pay up front for network construction. Instead current and future owners would be required to pay a connection charge, comparable with a gas standing charge, for an extended period of time.

An additional scenario, a fourth generation district heat network, is a possibility for this building, dependent on local government decisions and private investment. This option was not modelled due to a lack of information on expected costs.

Figure 5.1 illustrates potential installations. Detail diagrams are provided in Attachment 6.



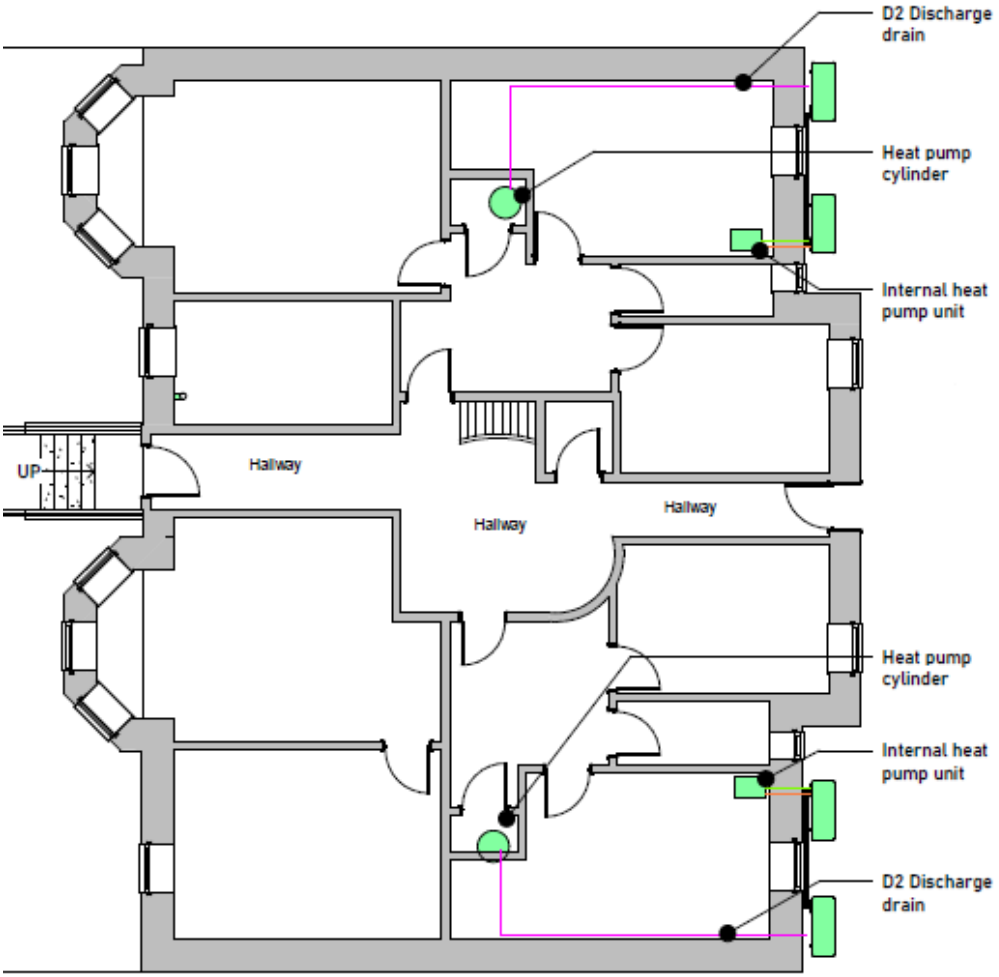


Figure 5.1: Visualisations of potential ASHP and GSHP and internal installations. See more detailed drawings in Attachment 6.

5.3 SOLAR PV

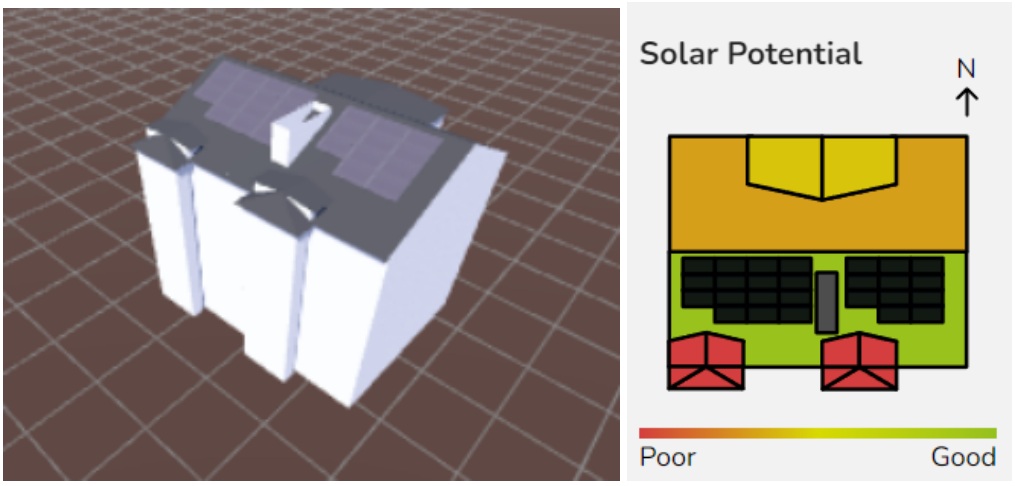


Figure 5.2: Output from solar potential calculations.

There is space for 20 solar PV panels with a rated output of 8kWp on the front, south facing roof. Despite some shading from the chimney stack, this could be attractive to owners, providing issues around co-ownership could be navigated. The roof tiles may need to be replaced before installation. Alternatively, roof tiles could be replaced with integrated solar panels.

Cost would be around £3-4k per flat, not including scaffolding. A Solshare system that maximises on site consumption and financial returns would cost around £1k more per flat.

The impact of solar PV on bills and EPC was not included in the analysis.

5.4 SCENARIOS

Three heating demand reduction (insulation) options and three heating options were considered. Each combination of options varies for top floor, mid-floor and ground-floor flats. These options combine to give 3 x 3 x 3 = 27 scenarios, although not all were evaluated.

6. Evaluation Method

Options were evaluated considering their impact on energy demand, running cost, capital cost and practicality.

Running costs were calculated for a scenario of constant 18C in bedrooms and 21C in other rooms. This is not realistic for most households, but adjustments can be made on a pro-rata basis to align with current bills. Current typical energy prices were used: 28.6p/kWh for electricity, and 7.4p/kWh for gas.

Indicative capital costs were also estimated by an independent cost consultant.

Three common measures were used to assess building energy performance:

- **Specific space heating demand (SSHD)** is the heat energy required to heat the dwelling over a year, under standardised conditions, normalised per square metre of floor area. (kWh/m^2.a). This was calculated by two methods:
    - **RdSAP.** The simple checklist-based method used for EPCs, RdSAP. This is the simplified version of the Standard Assessment Procedure (SAP) which is the basis of government regulation including the proposed Heat in Buildings Standard. It assumes a limited number of heating hours per day.
    - **Passive House method.** Design PH, a more accurate tool used for Certified Passive House building design, was also used. It takes account of solar and internal gains and assumes indoor temperature of 20C, 24 hours per day through the whole heating season. Due to the higher average indoor temperature it generally leads to a higher estimate of energy requirements than RdSAP.

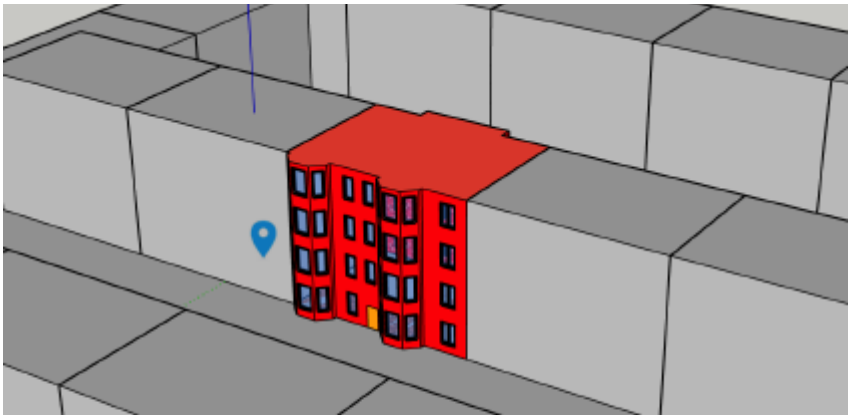


Figure 6.1: 3D model used in Design PH energy modelling

- **Peak heat load (kW)**. This measure is used by heating engineers to determine the size of heat sources and radiators. It is the rate at which heat is lost from the dwelling, and must be replaced by the heating system, under design conditions of -4C outside, 18C in bedrooms and 21C in living spaces. Sometimes reported per square metre of floor area (W/m^2). This was calculated using heat loss modelling conforming to BS12831.
- **Energy Performance Certificate/ Energy Efficiency Rating score (EER).** EER is a score out of 100 indicating the ***cost*** to heat and light a dwelling under standardised conditions, based on a simple checklist survey. EERs were extracted from the existing Energy Performance Certificates (EPC) taken from the public register. Scenarios were calculated using software conforming to the latest standard, RdSAP v9.94.

7. Analysis

The impact of each scenario on operating costs are examined in 7.1. Section 7.2 reviews estimates of capital costs.

7.1 ENERGY AND RUNNING COSTS

Table 7.1 summarises the measures for each scenario. It shows that in the HIBB+ scenario, using the more accurate Passive House method, the heat demand of the whole building reduces by 31% due to the installation of ground floor insulation and double glazing in the remaining two flats. This is reflected in an improvement in the EPCs for ground floor flats from 60 (D) to 69 (C) while retaining gas boilers.

Replacing boilers with GSHPs in HIBB+ scenario increases the heat demand because SAP assumes that heat pumped dwellings are on average warmer. This is because heat pumps operate more efficiently if indoor temperatures are maintained in a narrower band than is typically found in UK homes with gas boilers. However the EER (an indication of running cost) improves due to the efficiency of the GSHP.

Between current and AECB- scenarios there is a 78% reduction in heating demand by PH method. However, EPC ratings get worse not better. This is because improved airtightness cannot be input to EPCs. Furthermore, RdSAP assumes that heat recovery ventilation increases heating demand which is incorrect.

The running costs (based on constant 18-21C indoor temperatures) show significant reductions due to both improved insulation and switching to heat pumps. Simply replacing boilers with ASHP achieves a small annual saving of between £47 and £72 without adding any insulation. For a ground floor flat, there is an 83% bill saving going from current situation to AECB- with GSHP.

*Table 7.1: Summary of scenario impacts: * whole building evaluated by Passive House method; ** EPC calculations (RdSAP v9.94); *** heat engineers method following BS12831 and assuming continuous 18°C in bedrooms and 21°C in all other rooms.*

	Existing			HIBB+			AECB-		
Whole building									
Specific space heating demand (PH)*	206 kWh/m2.year			142 (-31% vs current)			50 (-78% vs current)		
Heating system	**Gas boiler**	**ASHP**	**GSHP**	**Gas boiler**	**ASHP**	**GSHP**	**Gas boiler**	**ASHP**	**GSHP**
Top floor flats									
Specific space heating demand (EPC)**	70	-	-	70	-	74	58	-	76
EPC Energy Efficiency Rating**	70 (C)	-	-	70 (C)	-	81 (B)	77 (C)	-	(72B)
Peak heat load (kW)***		5.56			5.56			2.70	
Annual heating load (kWh/ year)***	15,225			15,222			4,329		
Annual heating cost (£)***	£1,408	£1,361	£1,062	£1,408	£1,360	£1,062	£400	£387	£302
Mid floor flats									
Specific space heating demand (EPC)**	81 to 96	-	-	54	-	57	58	-	61
EPC Energy Efficiency Rating**	73 (C)	-	-	72 (C)	-	81 (B)	77 (C)	-	82 (B)
Peak heat load (kW)***		5.29			5.26				
Annual heating load (kWh/ year)***	14,015			13,890			3,671		
Annual heating cost (£)***	£1,296	£1,253	£978	£1,285	£1,241	£969	£340	£328	£256
Ground floor flats									
Specific space heating demand (EPC)**	152	-	-	77	-	82	78	-	83
EPC Energy Efficiency Rating**	60 (D)	-	-	69 (C)	-	81 (B)	74 (C)	-	81 (B)
Peak heat load (kW)***		7.47			5.69			2.86	
Annual heating load (kWh/ year)***	23,126			16,127			5,162		
Annual heating cost (£)***	£2,139	£2,067	£1,613	£1,492	£1,441	£1,125	£477	£461	£360

7.2 PROJECT COSTS, INCLUDING MAINTENANCE

Indicative capital costs for both building maintenance and energy-related retrofit were prepared by NBM Construction Cost Consultants and their report is provided in Attachment 7 along with details of assumptions and exclusions. It must be stressed that these costs were prepared on basic outline descriptions, not detailed specifications.

The analysis includes the cost maintenance measures reasonably expected to be incurred in the next ten years, including periodic roof replacement, repairs to chimneys and flashings, rainwater goods upgrades and rear wall repointing. For comparison, the average cost of comprehensive tenement repair packages supported by Glasgow City Council under its Scheme of Assistance over the last 5 years has been £313,000[15].

In addition to the capital costs, revenue costs were added in this report. This includes solicitor's fees to establish an owners association (as a legal body as per a Development Management Scheme under Title Conditions Act 2003) as well as a sinking fund. Additional revenue costs include architect and planning application fees.

A third scenario was added, HIBB++, positioned between HIBB+ and AECB-. Modelled scenarios:

1. HIBB+, with ASHP
2. AECB-, with ASHP
3. HIBB++ with ASHP
    a. Addition of internal wall insulation to front and back, plus additional draught-proofing and decentralised mechanical extract ventilation (dMEV).
    b. Addition of solar PV - integrated panels in lieu of full roof covering replacement.

Costs are summarised in figure 7.2 with and without double glazing, as two flats do not have double glazing.

The full analysis is available here (Google Sheet). Notes on the analysis are included in Appendix C.

[15] Data on Glasgow City Council Scheme of Assistance by private correspondence.

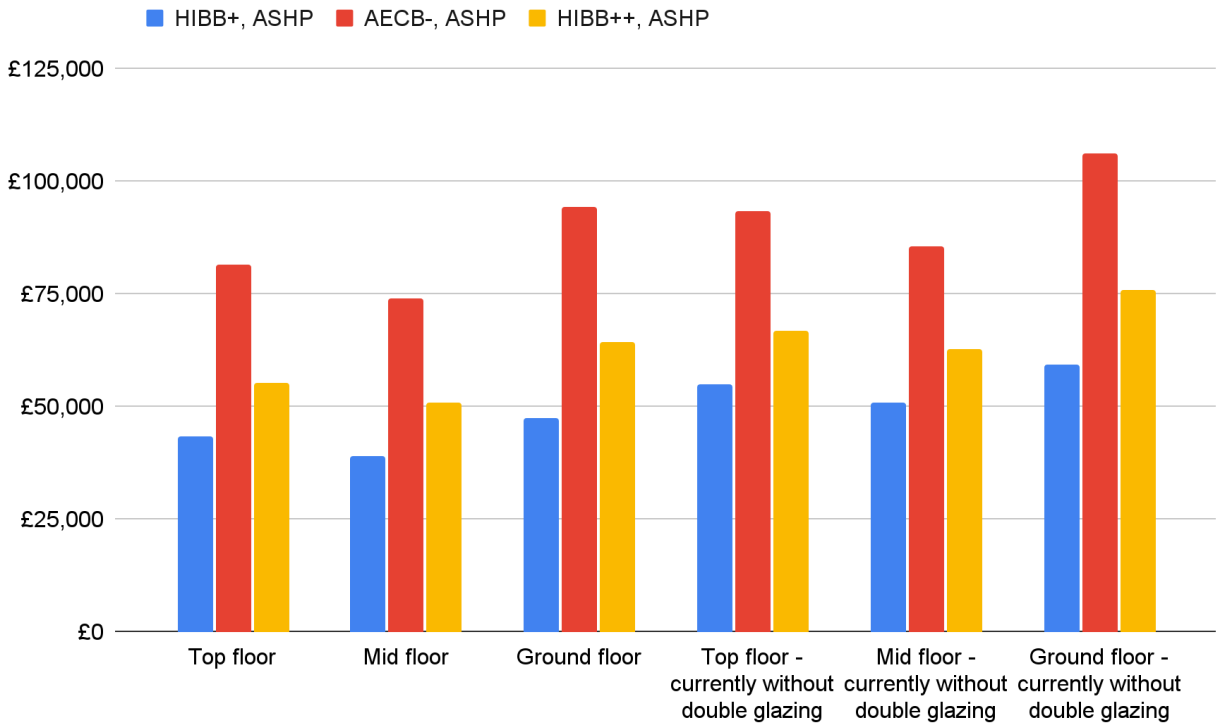


Figure 7.2: Indicative cost per flat. Includes project fees, roof repairs, rainwater goods upgrade and rear wall repointing. Excludes front wall stonework repair.

Figure 7.2 shows that AECB- adds around £40k to each flat compared with HIBB+. Figure 7.1 above shows that AECB- gives an annual bill saving of around £600 at most, meaning that on purely financial terms the cost uplift to AECB- requires at least 67 years to pay back with today's energy prices. This needs to be considered alongside the greatly superior comfort and air quality benefits provided by the AECB- scenario.

Table 7.1 shows how the costs of the HIBB+ scenario break down for a notional owner-occupier of a top floor flat which currently has single glazing. It shows that of a total cost of £55k, at least £38k needs to be funded from owner's savings or loans. Retaining the single glazing, which is HIBB-compliant, would save £12k.

The following funding is included for 'able to pay' households:

- Home Energy Scotland currently provides a grant of up to 75% or £7500 for ASHP.
    - (Grant funding is not available for double glazing or loft insulation top up.)
- Glasgow City Council 50% assistance for comprehensive repairs and maintenance. The budget for this fund is limited and is targeted at the most deprived areas. There is no assurance that this building would be eligible.

Further assistance may be available to owners falling within eligibility criteria for fuel poverty programmes including Energy Company Obligation ('ECO'/'ECO4'), Great British Insulation Scheme or Warmer Homes Scotland.

*Table 7.1: 'HIBB+ with ASHP' scenario costs with breakdown by category and potential funding source for an owner-occupier of a top floor flat with single glazing. *Note that Local Authority funding is extremely limited and is targeted at the most deprived areas.*

	Cost	Category		Source of funds		
		Repair & Maintenance	Energy	Home Energy Scotland	Local authority	Owner
Common	£14,375	£14,375			£7,188	£7,188
Flat measures	£20,500		£20,500	£7,500		£13,000
Floor-specific flat measures	£4,200		£4,200			£4,200
Upgrade to double glazing	£11,700		£11,700			£11,700
Revenue	£4,250	£4,250			£2,125	£2,125
TOTAL	**£55,025**	**£18,625**	**£36,400**	**£7,500**	**£9,313**	**£38,213**

7.3 DISCUSSION

The property owners face challenges ahead of them. Perhaps most pressing of all is the need to ensure that sufficient insurance is in place. Furthermore, repairs are overdue - especially for the front facade stonework. Also it can be expected that periodic maintenance is required in the next few years including replacement of the roof tiles and repairs to the chimney stacks.

In addition to the high costs of repairs and maintenance, proposed regulation for energy efficiency represents substantial cost and upheaval for the ground floor flats which would require floor insulation. Landlords will need to act earlier to be able to take on new tenants from 2028, if the proposed Heat in Buildings Bill passes into law.

Clean heating presents perhaps the greatest uncertainty. It is not clear whether or when a heat network will be deployed to the area or whether owners should instead install individual air source heat pumps.

Furthermore, while there is a clear technical basis that heat pumps are effective in this building, issues of practicality present barriers. With appropriate attention to system design including radiator sizing, running costs would be reduced with ASHP or GSHP compared with a gas boiler. However, owners had concerns about the location of hot water storage. They would not want to lose the use of the storage cupboard. Mitigating options exist such as a smaller and hotter cylinder which would require more frequent re-heating, or heat batteries. Both would likely result in some increase in running costs compared with a standard hot water cylinder.

Owners should remain aware of several technical risks and employ independent experts as needed. First, as described in section 2, internally insulating the external walls - such as by injecting spray foam behind the lath & plaster lining - can pose substantial risks for the building.

External wall insulation (cladding) also has risks. It is important to maintain the waterproof integrity of external wall insulation on the rear wall. This ideally requires that all penetrations, such as for ventilation and heat pump connections are completed prior to installation.

Third, if significant improvements to draught proofing are introduced then continuous mechanical ventilation should be introduced. Scottish Building Standards require continuous ventilation, such as extraction from kitchen and bathrooms, if permeability is reduced below 5 $m^3/m^2.h$ which would represent a significant draught-proofing intervention compared with the existing condition of around 15 $m^3/m^2.h$.

8. Conclusions

The combination of high costs with technical and cooperation issues as well as poor support from factors and regulation creates a huge challenge for tenement owners.

In the view of Loco Home, since there is no technical requirement for insulation or draught proofing to be introduced for the efficient operation of a heat pump, the most achievable decarbonisation plan may be one that involves relatively few changes to the common parts of the building. Such a plan should enable additional measures to be adopted on a flat-by-flat basis depending on the preferences of the individual owners. That would mean avoiding external wall insulation, ground source heat pumps and solar PV and instead focusing on draught proofing and controlled ventilation. Those owners wishing to decarbonise without waiting for clarity on a local authority-led heat network can opt now to install air source heat pumps.

However, if best practice governance were to be put in place, a deeper retrofit would be enabled including wall insulation and solar PV. This would require the creation of an owners association and building reserve fund with monthly owner contributions suited to a long term plan of repairs, maintenance and retrofit.

8.1 RECOMMENDED ACTION PLAN

The owners should form a plan based on the following steps:

1. Urgent - Insurance
    a. Instruct the property manager to put in place a common building insurance policy or take legal action to ensure all owners have sufficient insurance in place.
2. Urgent - front facade stonework repairs
    a. Independent survey and specification of necessary repairs
    b. Procure via tender.
    c. Decide whether these repairs are to be integrated with other maintenance requirements
3. Form a maintenance plan
    a. Using this report and the supporting documents, make a plan to execute the following: roof replacement, chimney repairs. Consider installing integrated solar PV .
        i. For Solar PV, speak to Scottish Power Energy Networks about installing cut out fuses and 3 phase supply.
    b. Adapt to changing rainfall patterns by upgrading rainwater goods.
    c. Best practice requires that the rear wall is repointed with lime mortar. Decide whether to add external insulation to the rear facade.
    d. If carried out as a comprehensive package, local authority assistance may be available. Alternatively this work may form a forward maintenance plan over the next ten years or so.
4. Implement governance best practice
    a. Instruct a solicitor to create an owners association and establish a sinking fund requiring monthly contributions towards a long term fund for repairs, maintenance and improvements.
    b. Establish the level of monthly payments to support the ten year maintenance plan.
5. Landlords to implement insulation upgrades to the standard proposed to be legislated

a. The standard has not been finalised. The proposed implementation deadline for landlords is 2028.
b. Draught proofing of windows; ground floor insulation.

6. Owner occupiers to implement insulation upgrades
    a. Draught proofing of windows; ground floor insulation.
    b. Options to go further: wall insulation, draught proofing and mechanical ventilation,
    c. Caution: take independent expert advice prior to commissioning wall insulation.
7. Implement clean heating
    a. Connect to a heat network, if one is forthcoming with attractive prices.
    b. Alternatively install individual ASHP on a time of personal preference or in consideration of resale price and proposed legislation.

8.2 LESSONS

Several lessons can be drawn from this experience about how to approach such projects. The first is that tenement owners' circumstances and challenges with cooperation and maintenance must be considered at the outset. This project attempted to start the discussion on the subject of energy bills, warmth and climate change. However the owners were stuck on issues of maintenance, repairs and frustrations with the factor.

The second lesson is that the budget should have been allowed for a solicitor or legal expert to support understanding of the deeds, the Tenement Act and Factors. Without this support we were unable to make definitive recommendations.

The third is that the combination of technical, regulatory and cooperation issues combine to create a hugely complicated challenge for decarbonising each building. We hope that this report will be useful to owners of other buildings.

8.3 POLICY RECOMMENDATIONS

Policy for decarbonising tenements should start with creating a supportive environment for repair and maintenance, which is the first step in retrofitting any building. This should start with implementing the recommendations of the Scottish Parliamentary Working Group on Tenement Maintenance[16]. Those recommendations were for mandatory owners associations, building reserve funds and five-yearly building surveys. Provided that funding can be arranged, this governance would also provide the conditions for deeper retrofit, such as wall insulation and solar PV.

Independent specialist holistic advice - which takes fabric maintenance, insulation, heating, ventilation, and legal issues in the round - will be required by tenement owners. This goes well beyond that which is currently available from factors, contractors, Home Energy Scotland and local authorities.

The financial burden of addressing overdue maintenance should not be placed solely on existing owners. Housing is national infrastructure and traditional tenements are part of the historic endowment to future generations that are critical to the look and feel of Scotland's towns and cities.

[16] 'Working Group on Maintenance of Tenement Scheme Property Interim Recommendations Report', RICS, 2019

Retention of these buildings has an intergenerational benefit, as well as being a far more sustainable use of resources than decay, demolition and rebuilding. Therefore, new forms of finance are required to fund repairs, maintenance and green retrofit. For example, publicly-supported property linked finance[17] products should be considered. These loans or charges stay with the property rather than the owners and may be administered by a local authority similarly to Council Tax.

[17] 'Property Linked Finance, Green Heat Finance Taskforce Report, Report Part 1', Scottish Government, 2023.,

Appendix A: Consultants Reports

Consultants reports are provided as separate attachments:

1. Retrofit_barriers_in_tenement_buildings:_owner_co-operation_and_governance_complexities (Under One Roof)
2. Fabric survey report (John Gilbert Architects)
3. Services survey report (Luths Services)
4. Fabric energy modelling and specifications (John Gilbert Architects)
5. Services options report (Luths Services) (Luths Services)
6. Heat pump visualisations (Luths Services)
7. Indicative Costings (NBM Construction Cost Consultants)

Appendix B: Details of Existing Building

The table below characterises the flats in their existing condition, characterised by tenure type; existing EPCs, where available (sourced from public register); and the peak heat demand (calculated by Luths Services).

Flats, oriented as viewed from street	
3/2 - Owner-occupier. EPC EER 54 (E) Aug 2017, based on: • Non condensing combi boiler • SSHD 191 kWh/m2.a • No loft insulation - assumed (incorrectly) due to no safe access* • Double glazing • No mechanical ventilation. Peak heat demand: 5.56kW * 270mm loft insulation is in fact installed, but was not observed by EPC surveyor.	**3/1 (surveyed) -** Owner occupier EPC EER 60 (D) Sep 2019, based on: • Condensing combi boiler • SSHD 192 kWh/m2.a • No loft insulation - assumed (incorrectly) due to no safe access* • Double glazing • No mechanical ventilation. Peak heat demand: 5.56kW * 270mm loft insulation is in fact installed, but was not observed by EPC surveyor.
2/2 - Private landlord EPC EER C(73), Oct 2018, based on: • Condensing combi boiler • SSHD 81 kWh/m2.a • Double glazing • No mechanical ventilation. Peak heat demand: 5.46 kW	**2/1 (surveyed) -** Private landlord EPC EER 74 (C), Oct 2023 based on: • Condensing combi boiler • SSHD 85 kWh/m2.a • Double glazing • No mechanical ventilation. Peak heat demand: 5.46 kW
1/2 (surveyed) - Owner occupier EPC EER 73 (C), July 2020, based on • Condensing combi boiler • SSHD 96 kWh/m2.a • Single glazing • No mechanical ventilation. Peak heat demand: not calculated	**1/1 -** Owner occupier. EPC EER 66 (D) March 2018, based on: • Condensing boiler • SSHD 114 kWh/m2.a • Double glazing • No mechanical ventilation. Peak heat demand: 5.46 kW
0/1 - Private landlord EPC 60 (D), 2015, based on: • Condensing combi boiler • SSHD 11906 kWh/78m2 = 152 • Double glazing • No floor insulation • No mechanical ventilation. Peak heat demand: 7.79 kW	**0/2 (surveyed) -** Owner occupier No EPC Gas combi boiler Single glazing No floor insulation No mechanical ventilation. Peak heat demand: not calculated

Appendix C: Notes on Capital Costs

Not included:

- Front facade stonework repairs. There is a known need but the cost is not yet known.
- Grid connections: Installing cut out fuses in each flat. Installing a 3 phase supply which would be necessary for solar PV.
- Capital cost of ground source borehole network. This is assumed to be provided on a utility basis with owners paying a standing charge to connect to the network.

Included:

- ASHP: outdoor unit, internal heat exchanger, hot water storage, radiator and pipework upgrades.
- GSHP: indoor heat pump, hot water storage, radiator and pipework upgrades. Borehole drilling is not included - this cost is assumed to be covered by the network provider and recovered over a long period through a connection charge comparable with a gas standing charge.
- Cost of putting up scaffolding once.
- New consumer units (fuse boxes).
- All other repairs and maintenance including replacement of roof covering, chimney stack repairs, rear wall repointing and upgrading rainwater goods.
- Some allowance for internal redecoration.
- Revenue (non capital costs) including solicitor to establish owners association and sinking fund, architect, planning application fees, etc.

Assumptions:

- Measures within flats are procured individually by homeowners without any economy of scale.

Notes on allocation of costs.

- The costs of all common measures are split equally between flats, in accordance with the Title Deeds for this building.
    - This includes roof, walls, rainwater goods, rear wall external insulation.
- Costs allocated to individual flats
    - Individual heat pumps, hot water storage, mechanical ventilation,
    - Double glazing, internal insulation of the external walls,
    - Redecoration
- Roof insulation (at ceiling level) is assumed to be paid only by the top floor flats.
    - The law says this is a cost to be shared by all flats but this could seem unreasonable since benefits accrue mainly to the top floor flat.
- Ground floor insulation is assumed to be paid only by the ground floor flats.
    - The ground upon which the tenement is built is common property. The solum space and floorboards belong to the ground floor flat unless Title Deeds say otherwise[18].

[18] 'Below Ground Level', Under One Roof.