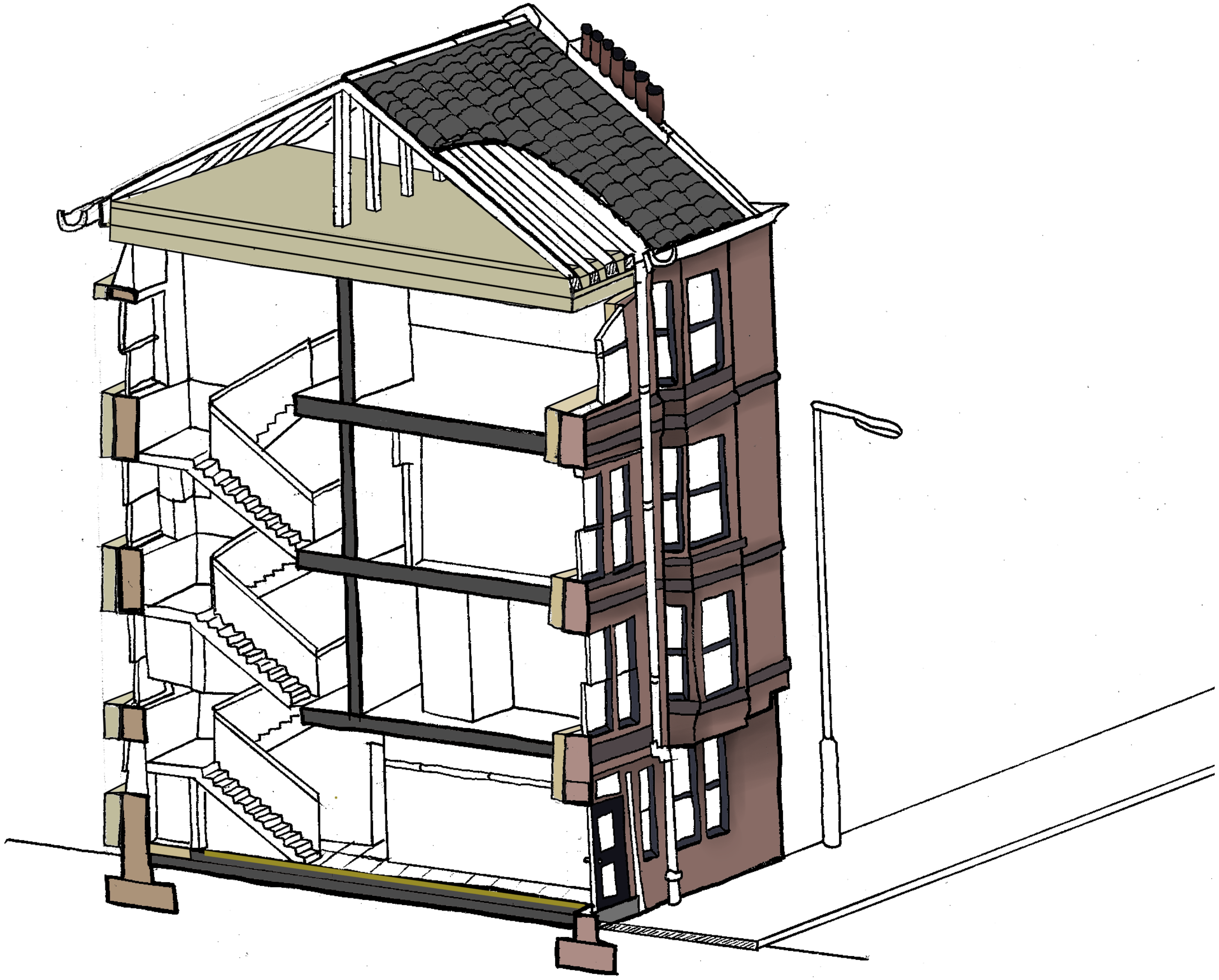


OLD SHETTLESTON ROAD RETROFIT
P-23-AG0090

SHETTLESTON HOUSING ASSOCIATION

FEASIBILITY STUDY REPORT

DECEMBER 2023

ECD Architects
ENERGY CONSCIOUS DESIGN

This report has been prepared by ECD Architects on behalf of the Shettleston Housing Association.

Client:

Shettleston Housing Association
65 Pettigrew St
Glasgow
G32 7XR

Submitted by:

ECD Architects
The Centrum Building
38 Queen Street
Glasgow G1 3DX
t:+44 (0) 141 204 7855
www.ecda.co.uk

With Assistance from:

RYBKA
With MEP consultancy

Doig+Smith
With Costing

Building Analysed:

40-70 Old Shettleston Road
Glasgow
G32 7EW

EnerPHit Report

Client: Shettleston Housing Association

Signed by:

Date:

Author	Reviewer	Date	Rev.	Notes
LW	LW	22/12/23	-	First Issue

CONTENTS

01

Executive Summary

EXISTING BUILDING

HEATING DEMAND 225 kWh/m².a

CARBON EMISSIONS 125 tonnes CO_2

HEAT LOAD 101 W/m²

ENERGY BILLS £1990/yr

WITHIN FLATS, RESIDENTS IN SITU

CONSTRUCTION COST £770,321

HEATING DEMAND 187 kWh/m².a

CARBON EMISSIONS 106 tonnes CO_2

HEAT LOAD 76 W/m²

ENERGY BILLS £1779/yr

OUTSIDE FLATS, RESIDENTS IN SITU

CONSTRUCTION COST £2,016,947

HEATING DEMAND 115 kWh/m².a

CARBON EMISSIONS 56 tonnes CO_2

HEAT LOAD 43 W/m²

ENERGY BILLS £964/yr

WITHIN FLATS, WHEN VOID

CONSTRUCTION COST £1,088,457

CARBON EMISSIONS 21 tonnes CO_2

HEATING DEMAND 60 kWh/m².a

HEAT LOAD 31 W/m²

ENERGY BILLS £787/yr

Heat demand, load & carbon figures based on average of modelling of 3no. individual flats

MEASURES FROM BEST TO WORST BY CARBON IMPACT

- ASHP / electric storage heaters
- New windows
- EWI to rear end
- IWI to front
- Additional loft insulation
- Window draught stopping
- Insulate ground floor
- Flat front door improved
- MVHR
- PV
- Draught stopping to floor boards

BIG HITTER - The measure with the biggest impact on carbon emissions. Note can only be carried out in conjunction with other measures

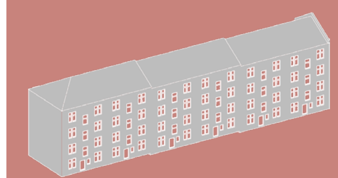
EASY WIN - The easiest + most effective upgrade to carry out.

TOTAL CONSTRUCTION COST
£3,875,725
(£99,378 / FLAT)

CARBON SAVING: 100 TONNES PER YEAR

ANNUAL HEATING COST SAVING: £926/ FLAT

TIMELINE OF WORKS



- Detailed Condition Survey
- Detailed PHPP Analysis
- M&E and Structural Consultancy

- New flat front doors
- Draught stopping between floor-boards (ground floor)
- Draught stopping windows
- Mechanical ventilation with heat recovery

- New communal doors
- Double glazing upgraded to Triple
- EWI Installation at rear and ends
- PV Panels serving each flat
- Communal corridor floor insulation
- Eaves Extension & Loft insulation

- IWI Installation at front
- Ground floor insulation
- Air tightness Improvements
- ASHP Installation

EXISTING:

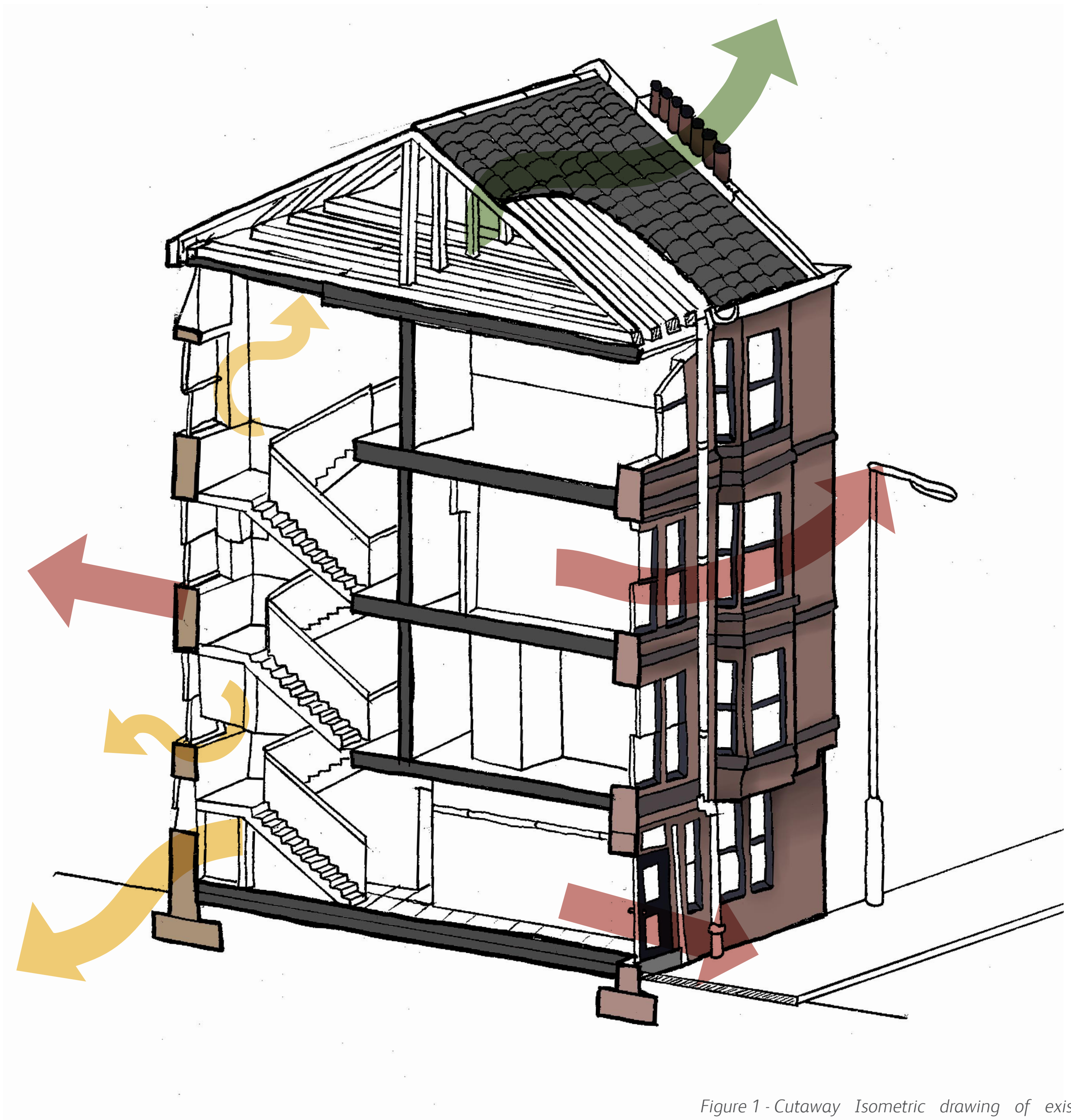


Figure 1 - Cutaway Isometric drawing of existing building showing staircore and inside of flats

PROPOSED:

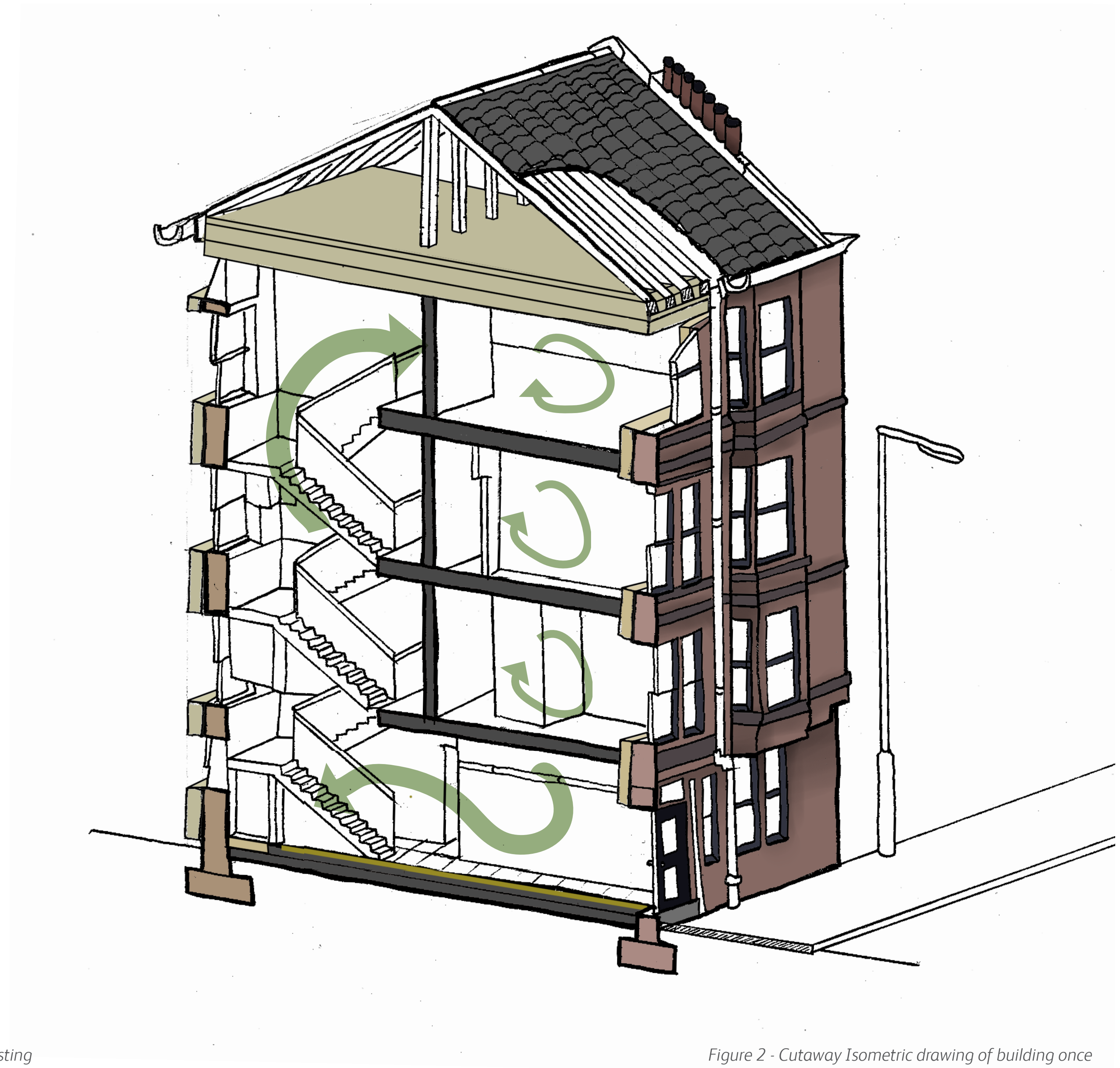


Figure 2 - Cutaway Isometric drawing of building once proposed measures have taken place

INTRODUCTION

This report has been prepared by ECD Architects Ltd on behalf of Shettleston Housing Association.

This study is intended to provide high-level advice on the required design parameters required to achieve the best possible retrofit for the housing association's building. The aim of the project is to progress the client's understanding of the costs, benefits, construction risks and delivery implications of refurbishment specifications. This report also contains detailed cost and M+E analysis from Doig + Smith and RYBKA.

ECD have provided commentary on the extents of retrofit works required as well as its impact on cost and intrusiveness.

BACKGROUND

ECD carried out a previous study for Shettleston Housing Association (SHA), evaluating 5 different archetypical buildings across SHA's stock. One of these was the tenement building at 40 Old Shettleston Road. This report builds on that work, focussing on establishing a level of retrofit that is feasible with residents in situ. It sets out measures that can be applied across the whole building and those that may be carried out in individual flats while residents are living there. It then sets out further measures that can be implemented when a flat becomes void. For each stage the potential heat demand, energy bill and carbon reduction are presented along with resultant SAP scores.

It is key for Shettleston Housing Association (SHA) to confirm what measures are needed to get all homes to EPC B, as they are required to do this by 2032 (?) (ref. legislation). By looking at the decarbonisation potential of void homes, and applying this to SHA's typical void rate, it is also possible to establish the potential carbon reduction SHA can achieve over the period to 2032.

Glasgow City Council (GCC) are particularly interested in the outcome of this study, as there are a large number of similar buildings across the City. Consequently they are carrying out related monitoring and user surveys to provide a better understanding of how homes are currently used and heated and how this relates to existing energy bills.

BRIEF

SHA have not requested a specific outcome from the retrofit proposals, in terms of heat demand. They would like to know how deep of a retrofit is realistic without decanting residents from the block and the cost of doing so. ECD will present the outcomes in relation to specific standards, but the key determinant of which measures are proposed will be the disruption to residents.

SHA would like to understand

- what retrofit measures are appropriate for the building
- the potential carbon reduction of these works
- the potential energy bill reduction for residents
- the cost of doing the works.

Without decanting residents from either each stairwell in turn, or the whole block, there are limitations to the extent of retrofit that is possible, particularly around services. This has been agreed with SHA, and is set out in more detail in Appendix 1.

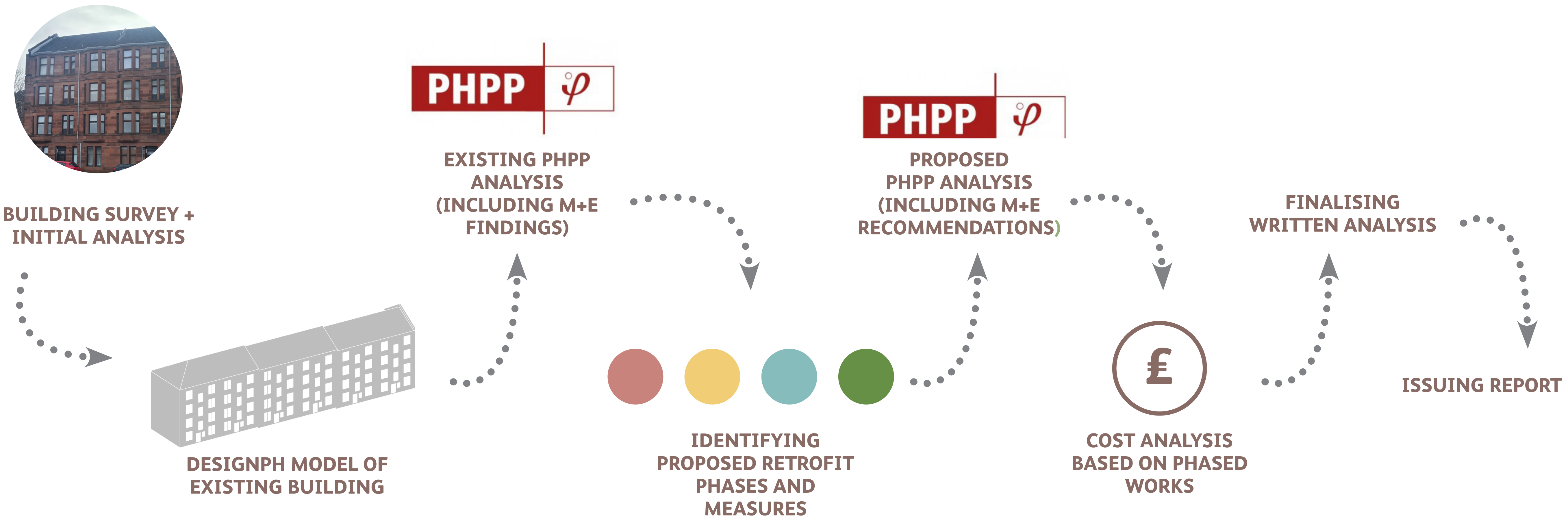
METHODOLOGY

ECD have visited the building several times, undertaking a high-level measured survey of a few flats to which they had access. Further surveys and testing have been carried out in the form of airtightness testing of 3no. flats, opening up works in one flat and hygrothermal testing of stone samples from 3 façades of the building.

All of this, combined with desktop research on typical tenement construction, allow ECD to build up a good understanding of the existing building and how it works. Information derived from these surveys has been put into a Passivhaus Planning Package (PHPP) energy model, to determine current energy performance of the building as a whole. This has been compared against existing SAP ratings and resident surveys about their experience of the building. Further, 3no. flats have been modelled individually in PHPP to give an understanding of the impact of different locations within the block.

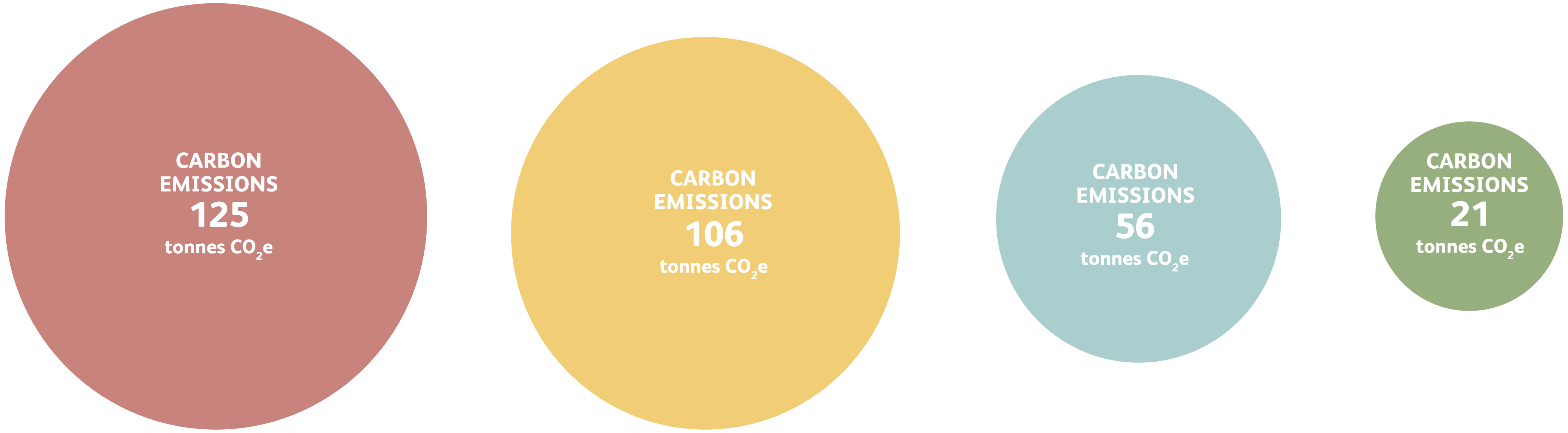
ECD have then proposed a long-list of potential energy efficiency measures that could be applied to the building, and selected those that are most appropriate for the construction type and the presence of residents. These have been inputted into the PHPP models.

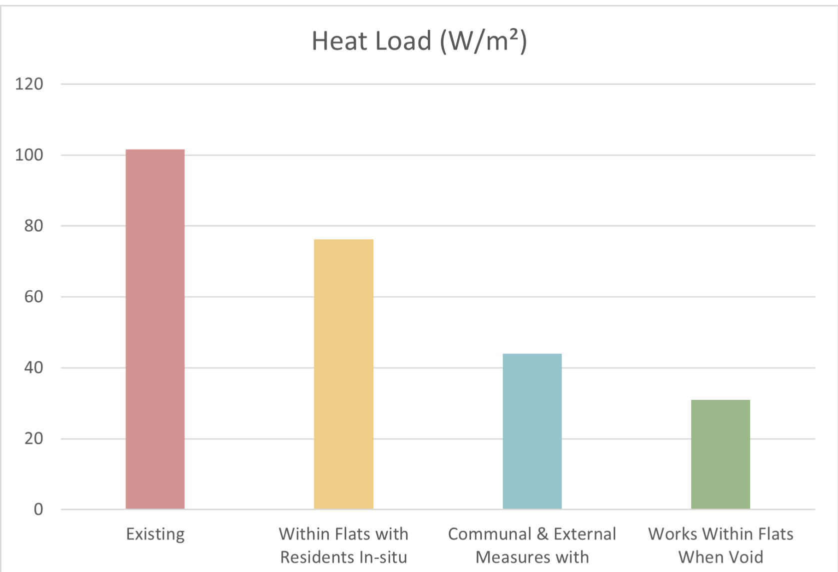
The total operational energy savings possible from each step of the retrofit is presented, along with the carbon and energy bill savings. Sketch details are shown for some key junctions. WUFI modelling has been carried out where internal wall insulation is proposed to ensure this does not create risks. An outline specification is provided to cover the main works proposed and this is what has been costed. This is all supported by a risk register gathering items discussed in project meetings, suggestions for ongoing monitoring and a set of next steps for SHA to consider.

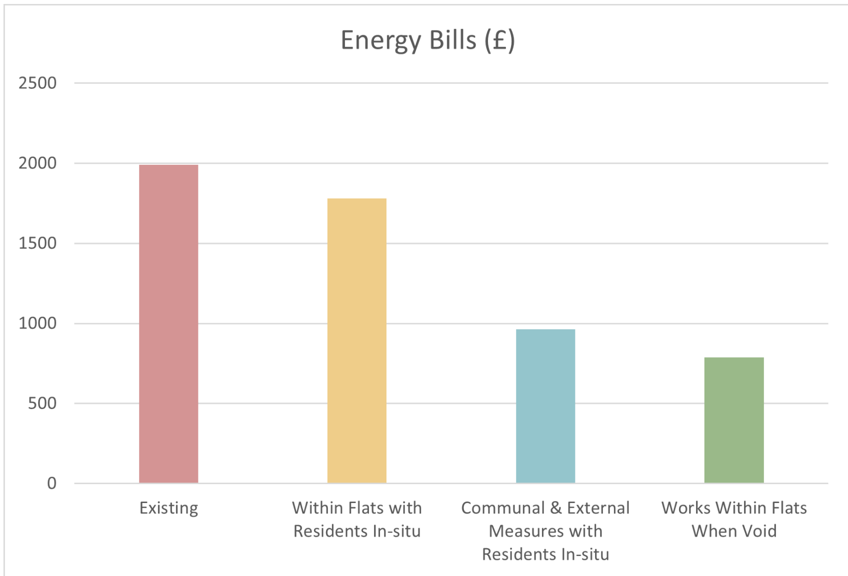


PROPOSED RETROFIT PHASES EXPLAINED

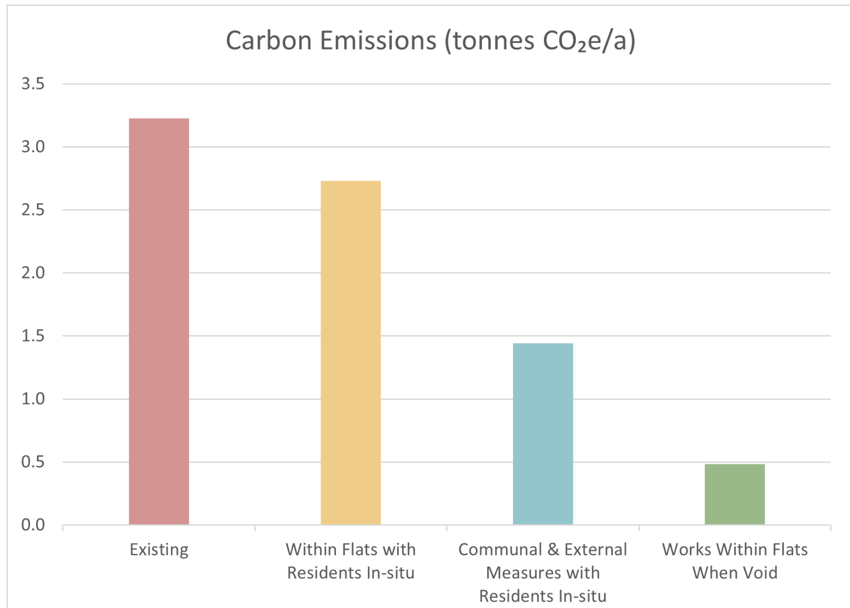
	WITHIN FLATS, RESIDENTS IN-SITU	OUTSIDE FLATS, RESIDENTS IN-SITU	WITHIN FLATS, WHEN VOID
	The works within flats with residents in situ contains retrofit measures which require no decant and "lightly touch" the building, e.g. draught stopping existing windows. Other items support the works that can be carried out in Phase 2, such as improving ventilation.	The works outside the flats contains retrofit measures to the external and communal areas, such as external wall insulation and photovoltaic panels. This enables a significant reduction in heat demand and improvement in comfort. However further works within each flat are still needed to replace gas boilers with non-fossil fuel powered heating	The works within the flats as each one becomes void contains retrofit measures which can only take place when the flats are void and intrusive works can be completed. Gas is removed from each home, so that the building's carbon emissions reduce still further.
PROS -	Less intrusive, requires no decant, generally cheaper than intrusive works, a "stepping stone" to deep retrofit.	Allows the building to reduce heat demand while residents are still living in the flats.	Building is decarbonised as far as possible while reducing residents' energy bills.
CONS -	Does not reduce heat demand enough to meet low energy targets, and the building will need more intrusive works in the future if the works stop at this stage as it will not be affordable to move residents off fossil fuels.	This is a stepping stone to the full retrofit. It will not move residents off fossil fuels, so will not fully decarbonise the building	Can only be carried out when each flat becomes void, so carried out over a long period, with numerous visits, adding cost.





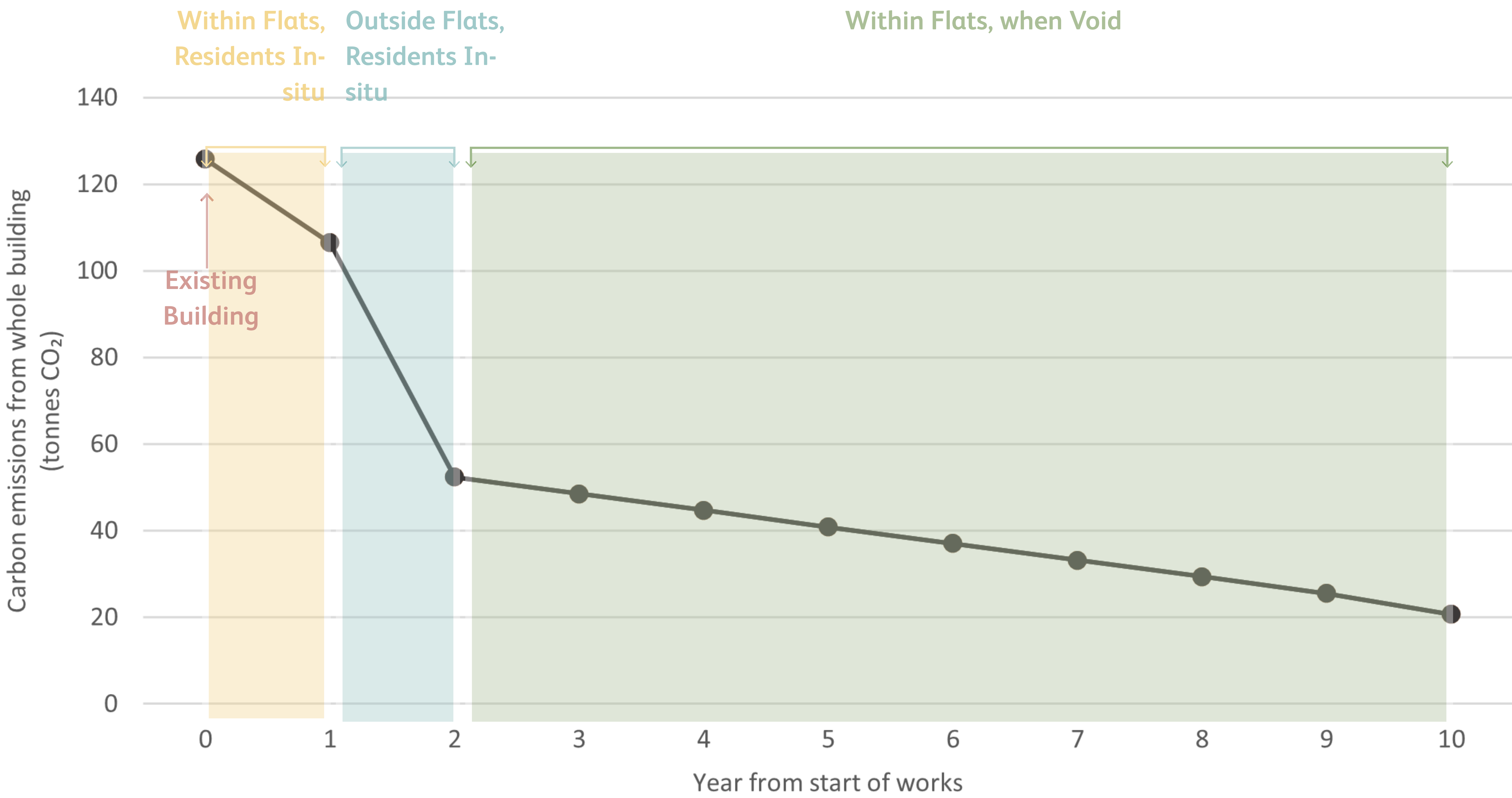


Assumes gas at £0.0751/kWh with standing charge of £106/year. Electricity at £0.3011/kWh and standing charge of £193/year. As per July 2023 price cap

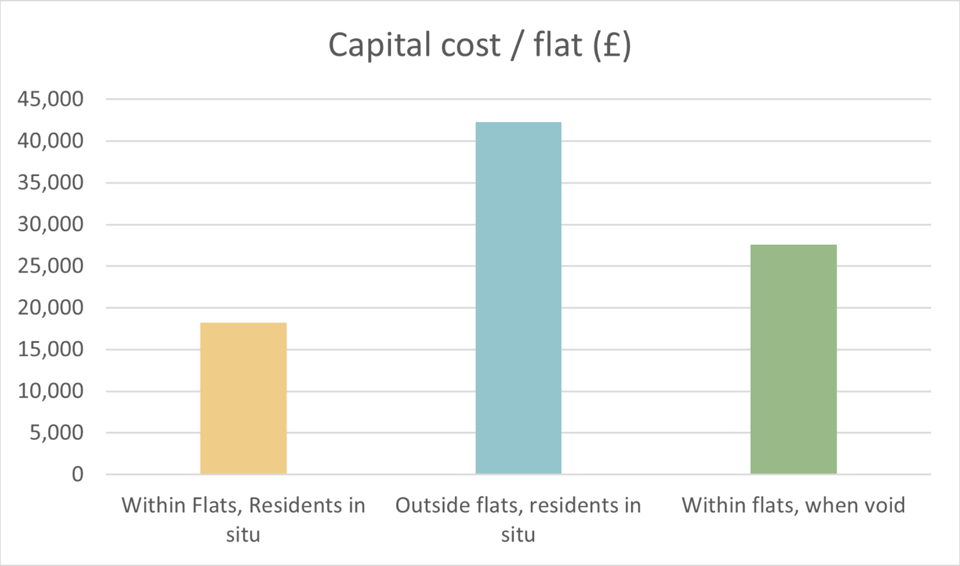


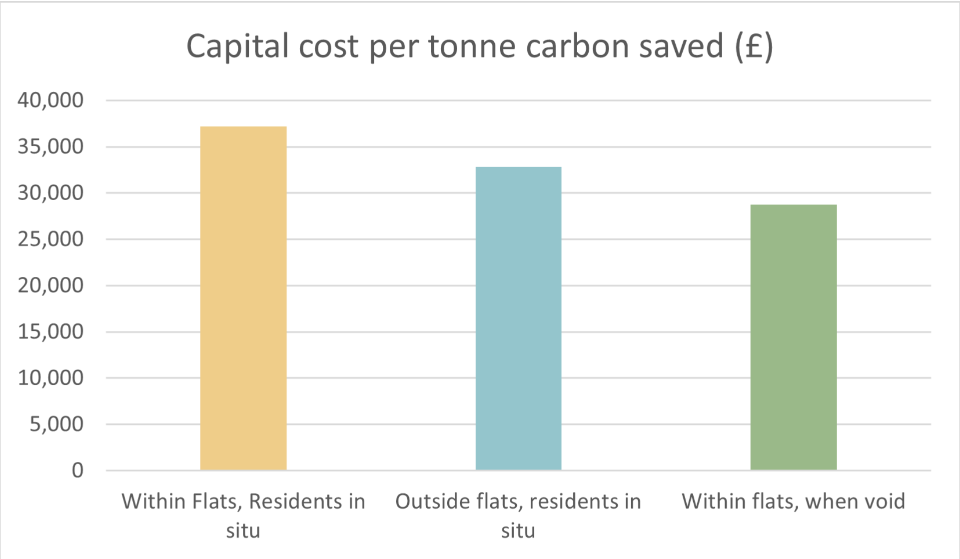
Assumes carbon factor of gas 0.1829289 tonnes CO_2/kWh and carbon factor of electricity 0.2070742 tonnes CO_2/kWh as per BEIS 2022 figures https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

At each stage of work the carbon emissions from the building reduce, with the most significant reduction achieved through the works to the communal areas and the outside of the building. However some of those measures are dependent on preparatory works in the preceding package of works. The graph shows how the various phases of work add up to provide a long term strategy for reducing the building's carbon emissions by around 77 %, assuming that flats become void at a rate of around 4 per year.



CARBON EMISSIONS OVER TIME AS RETROFIT WORKS CARRIED OUT





RECOMMENDATIONS AND NEXT STEPS

Each set of measures offers a fairly similar effectiveness in terms of cost in vested vs carbon saved, though the deepest retrofit is the most effective. This is largely because this step includes the switch away from the carbon-intensive burning of gas. However, this position can only be reached by implementing the measures in the earlier phases.

The 'green' measures are intended to be carried out as flats naturally become void. The rate of carrying out these works could be increased if SHA were prepared to move residents between flats within the block.

The sooner the works can be carried out the less the building's whole life carbon emissions will be, so the sooner works can be implemented the better.

However it is also noted that some specific pieces of work must be carried out prior to this:

- Further surveying
- Fire safety survey
- Resident engagement
- Confirm electrical capacity
- Gain statutory approvals

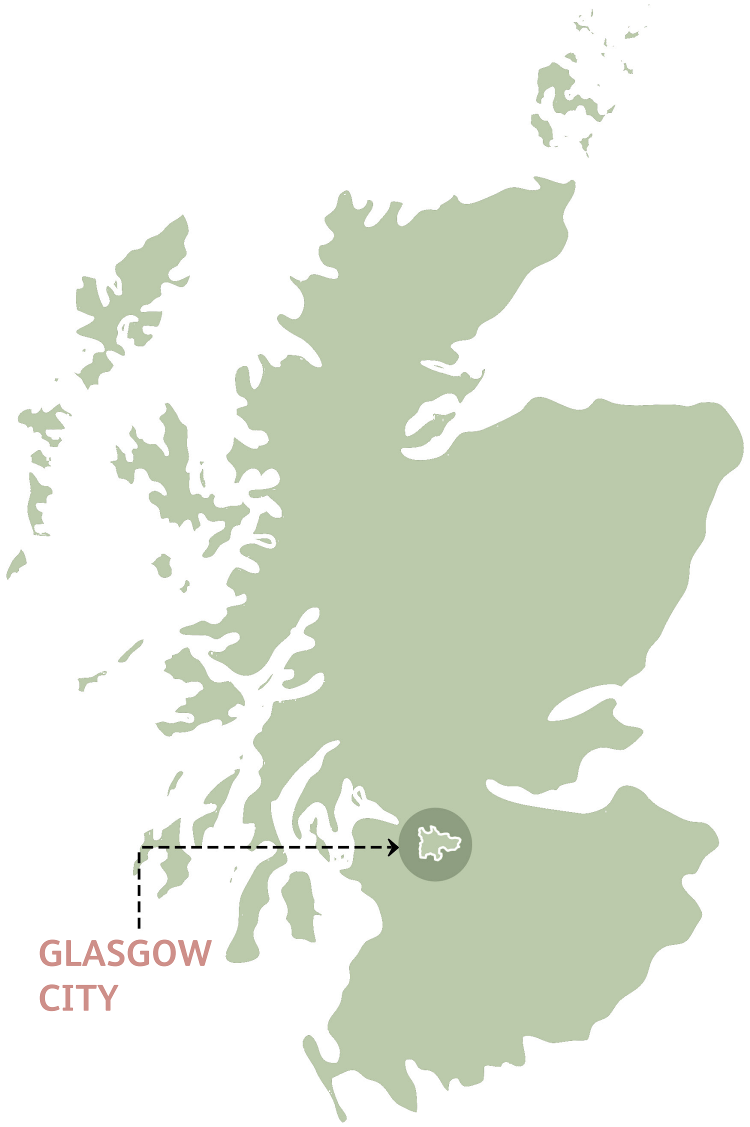
WITHIN FLAT, RESIDENTS IN SITU				OUTSIDE FLATS, RESIDENTS IN SITU				WITHIN FLATS, WHEN VOID			
Capital Cost	Annual Energy Bill Saving (per flat)	CO_2 Reduction	Capital Cost per Tonne Annual CO_2 Reduction	Capital Cost	Annual Energy Bill Saving (per flat in addition to previous)	CO_2 Reduction	Capital Cost per Tonne Annual CO_2 Reduction	Capital Cost	Annual Energy Bill Saving (per flat in addition to previous)	CO_2 Reduction	Capital Cost per Tonne Annual CO_2 Reduction
£ at todays rate	*£ at todays rate*	*Tonnes*	*£/tonne*	*£ at todays rate*	*£ at todays rate*	*Tonnes*	*£/tonne*	*£ at todays rate*	*£ at todays rate*	*Tonnes*	*£/tonne*
£18k	£211	0.49	37k	£42k	£815	1.78	33k	£27k	£177	2.74	28k

Each set of figures in this table assumes that the previous set of measures has been implemented. e.g. the numbers in the blue section are only for the implementation of the blue measures, but assume that the yellow measures have already been implemented

02

Existing Building

SITE INTRODUCTION



CONTEXT

The building 40-70 Old Shettleston Road analysed within this report is located within the City of Glasgow, 3.03 miles East from the centre of Glasgow. The building sits on Old Shettleston Road.

INITIAL EXISTING BUILDING ANALYSIS
ORIENTATION ANALYSIS

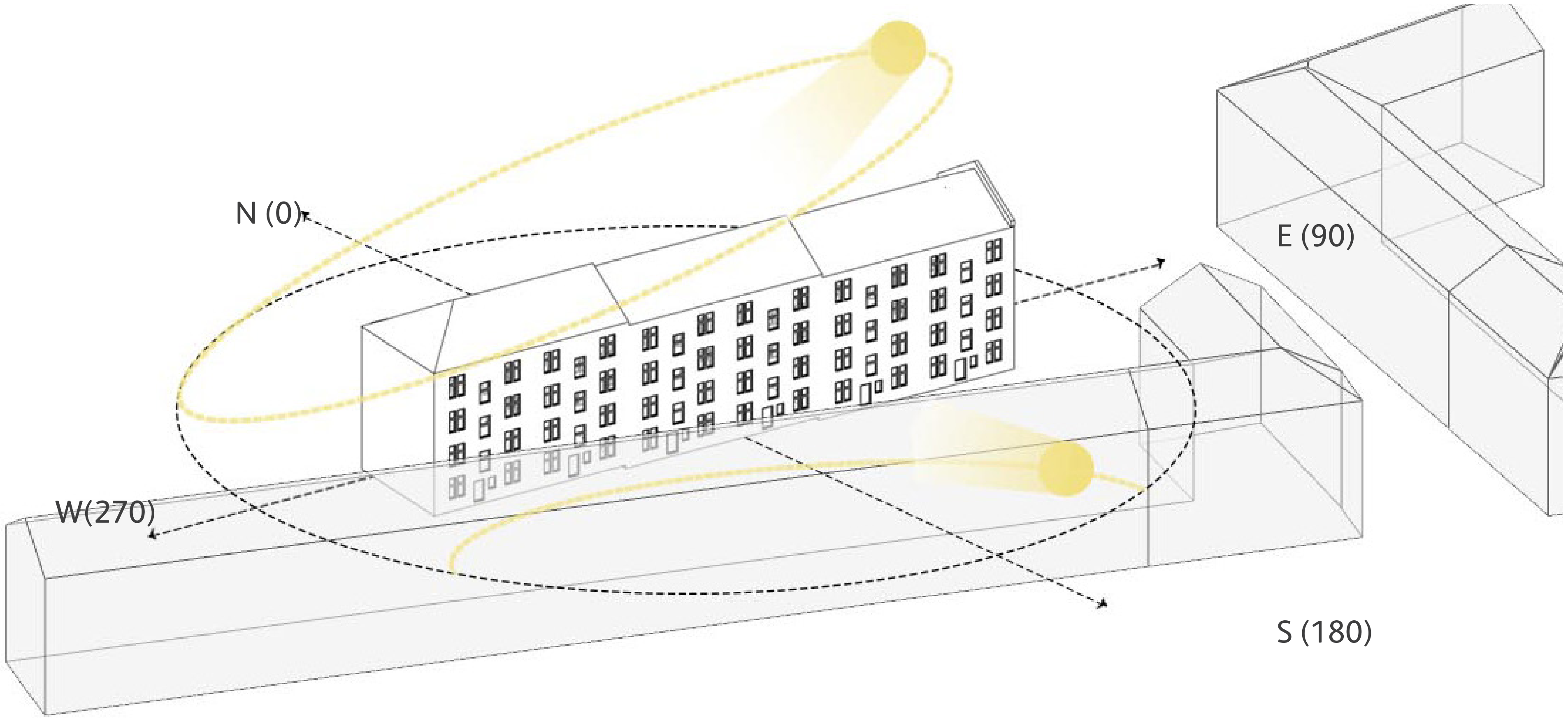


Figure 3 - Diagram showing the summer and winter sunpaths on 40-70 Old Shettleston Road

The orientation of a building refers to the direction in which its main façades (The front and rear façades in this case) face in relation to the points of the compass. The orientation can influence the availability of natural light and solar heat, affecting both lighting and heating requirements.

The rear façade including the outdoor spaces of 40-70 Old Shettleston Road faces South-East, therefore receives the most sunlight over the course of the day. It's southern facade sits on an axis of approximately 11.9 degrees, which is in-keeping with the Passivhaus recommendation of +/- 30 degrees of south as illustrated below. The most direct impact neighbouring buildings have on solar gain is through shading. The building placed south of 40-70 Old Shettleston road is approximately the same height of this building and therefore casts shadows on the building's exterior and outdoor spaces, reducing the amount of sunlight that reaches at ground level.

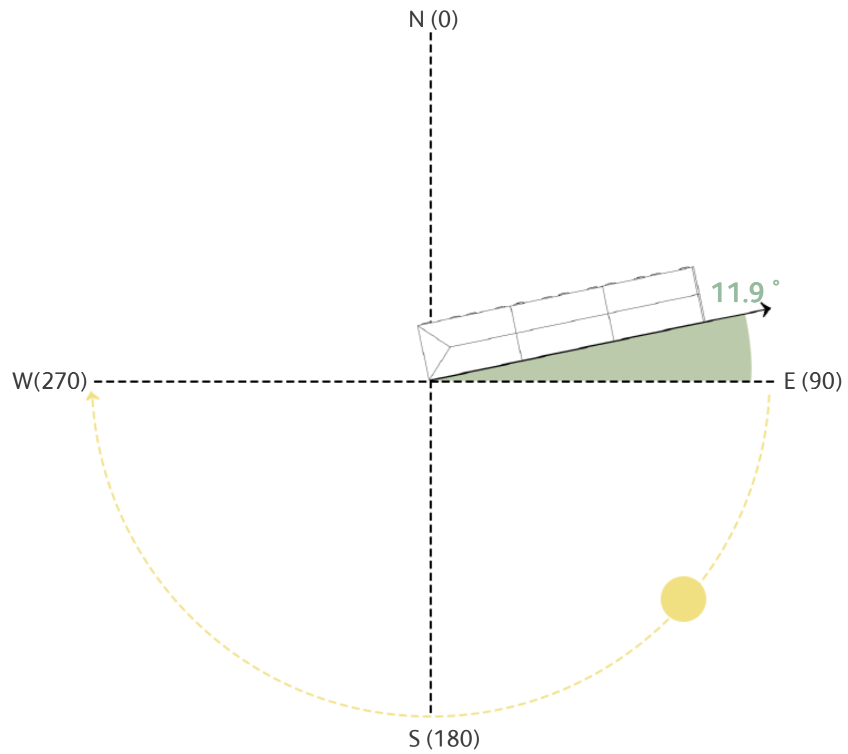
The Northern façade receives diffused light and there are no neighbouring buildings facing to the North of the building, therefore offers a more consistent, glare- free illumination.

TREATED FLOOR AREA

Total Room floor area: 444.7m^2

Communal Area : 95.8m^2

Total Treated Floor Area: 540.5m^2



INITIAL EXISTING BUILDING ANALYSIS

FORM CONSIDERATIONS

The Form Factor is the ratio of external envelope to treated floor area.

We analysed the massing model on the right in DesignPH to ascertain the Heat Loss Form Factor of 40-70 Old Shettleston Road. The massing diagram on the right illustrates that the building is a simple cuboid form.

The initial massing has an HLFF of 1.64

These results indicate that the building's Form Factor is within the recommended Passivhaus range

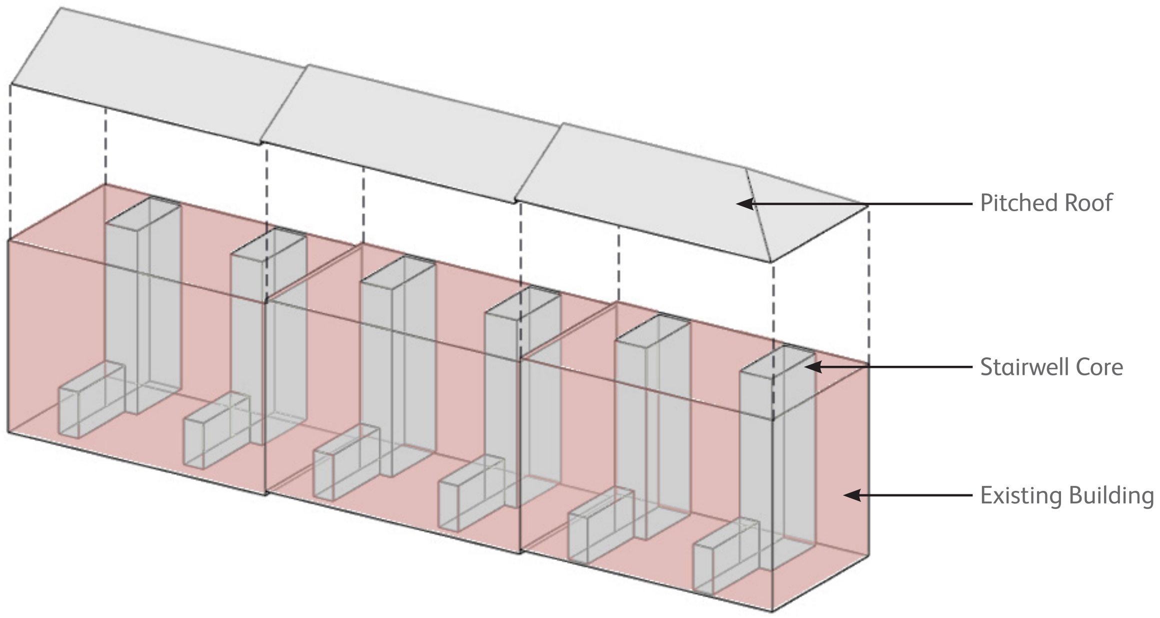


Figure 5 - Diagram illustrating the overall form of the building showing the stairwell cores of each block of the building

The grey spaces in the diagram illustrating the form of the building represent the unheated spaces. These unheated spaces include the pitched roof and communal stairwell core. Whereas the red spaces represent the heated spaces which are the existing flats of the building. This diagram has been illustrated this way because the flats lose a significant amount of heat through to the stairwell core and pitched roof.

Figure 4 - Rear of existing building with existing outdoor spaces

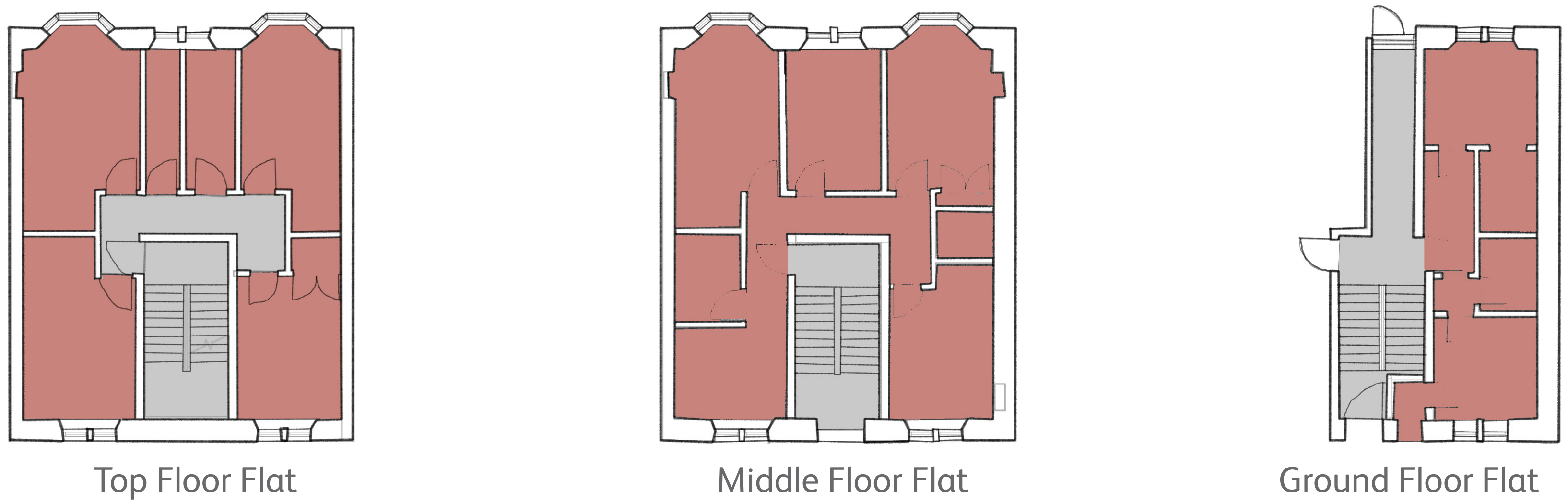


Figure 6 - Floor plans of a typical flat on the top, middle and ground floor

Summary of Existing Building:

- **Neighbouring buildings to the south of 40-70 Old Shettleston Road have a significant impact on the solar gain the building receives.**
- **The building overall has an excellent form factor, but this includes unheated staircore areas to which heat is lost**

EXISTING BUILDING INTRODUCTION

The existing building is a typical 4 storey pre-1919 stone-built tenement consisting of 6 separate stairwells, each with flats at each floor. The arrangement and size of flats varies between the different stairwells.

The 4 storey tenement consists of 39 flats in total. There are 12 flats on the ground floor, 9 flats on the 1st floor, 9 flats on the second floor and 9 flats on the third floor. The flats are a mixture of 1 bedroom and 3 bedroom homes.

WALLS

The external walls are all uninsulated stone. The front wall is red sandstone ashlar, with bay windows at first floor and above, but relatively simple banding and no other detailing.

The rear wall and west gable are of blonde sandstone with red sandstone banding at floor levels on the gable wall. This has a less smooth, regular coursed squared rubble finish.

The block appears to have originally been longer, such that the east gable wall is rendered over what was presumably previously a party wall. Some stone work that used to form the continuation of the front wall still projects beyond the gable wall.

Both front and rear walls have had internal plasterboard lining on timber studs added, giving an overall wall thickness of around 700mm, of which 650mm is assumed to be the stone wall. These walls themselves appear to be stone faced on the inside as well, though it is assumed there is a layer of rubble & mortar in the centre of the walls. Below the windows the walls are thinner, at around 410mm deep. Opening up of the plasterboard layer suggests that the stone itself creates an angled internal reveal to the windows, but that the plasterboard lining is squared off in some cases.

Neither depth nor width of existing foundations are known.

FLOORS

The ground floors to the stairwell areas are tiled in quarry tiles, presumably over a solid concrete floor, though this may have been laid over the original stone slab floor. The stairs themselves and the landings are concrete with exposed steelwork support.

The ground floors to the flats are suspended timber on 152mm deep joists which run front to back. In the single instance that has been opened up so far (flat 0/1, 70 Old Shettleston Road) the void below this varied from 240mm – 540mm deep from underside of joists to earth below. The void contains significant amounts of rubble and rubbish. Brick dwarf walls are visible supporting the joists. The void below these floors ought to be ventilated to ensure the timber remains dry and rot-free. Investigations of the ventilation slots to one area of suspended floor suggest that these have been closed up over time and ventilation may currently be inadequate.

The upper floors are also assumed to be timber joists with floorboards above and plasterboard ceilings below. (given the lack of original cornicing etc and the presence of plasterboard lining elsewhere it is assumed that original lath and plaster ceilings are no longer in place). It is not known what, if any, sound insulation is in place within the floors.

It is assumed that the timber joists are built into the external walls at front and back, though how deeply they are embedded is not known at present.

ROOF

The pitched roofs are covered in interlocking concrete tiles. The west gable is hipped, while at the east the gable wall runs up to form an upstand above the pitch line. As the site rises slightly, the building and hence roofline steps up twice, with dry verges between. Lead is also used to the flat roof areas at the top of the projecting bay window areas.

There appear to be small rooflights above each stairwell. These are assumed to provide a small amount of light to the loft area. It is understood that loft insulation has been added between and over rafters, though it has not been possible to access the loft to confirm the quality of this installation or type of insulation used.

CHIMNEYS

Stone chimney stacks project to the west gable wall, but other chimney stacks have been removed, with flues projecting through the roof where these would have been. It is understood that internally fireplaces have been closed up but remain ventilated.

WINDOWS & DOORS

Windows have been replaced throughout with double glazed timber framed tilt & turn windows. These are recessed about 240mm from the wall face and all have trickle vents. There are no projecting stone sills, though there a projecting band of stone immediately below windows to the upper floors at the front.

Front doors to the closes are secure PPC metal doors with vision panels with glazed fanlights over. A secure access system is fitted. Rear close doors vary with some being just a timber gate.

Flat front doors were noted in some cases to be particularly poorly fitted and residents have in some cases taken steps to stop drafts getting in between the wall and the door frame.

GUTTERS & RWPS

Rainwater is collected in gutters at both front and rear and the west gable. These are ogee gutters to front and gable end and half round to the rear. Rainwater downpipes run down all three of these façades.

SERVICES

At present all flats are heated by gas condensing boilers that serve radiators as well as providing domestic hot water to kitchen and bathroom sinks. Radiators typically have thermostatic valves on. Gas is delivered via pipes in risers. Showers are electric. Common areas are unheated.

Windows have trickle vents and there are extract fans in kitchens and bathrooms. Light fittings are a mixture of compact fluorescent fittings.

A full report by Rybka can be found in the appendix of this report.

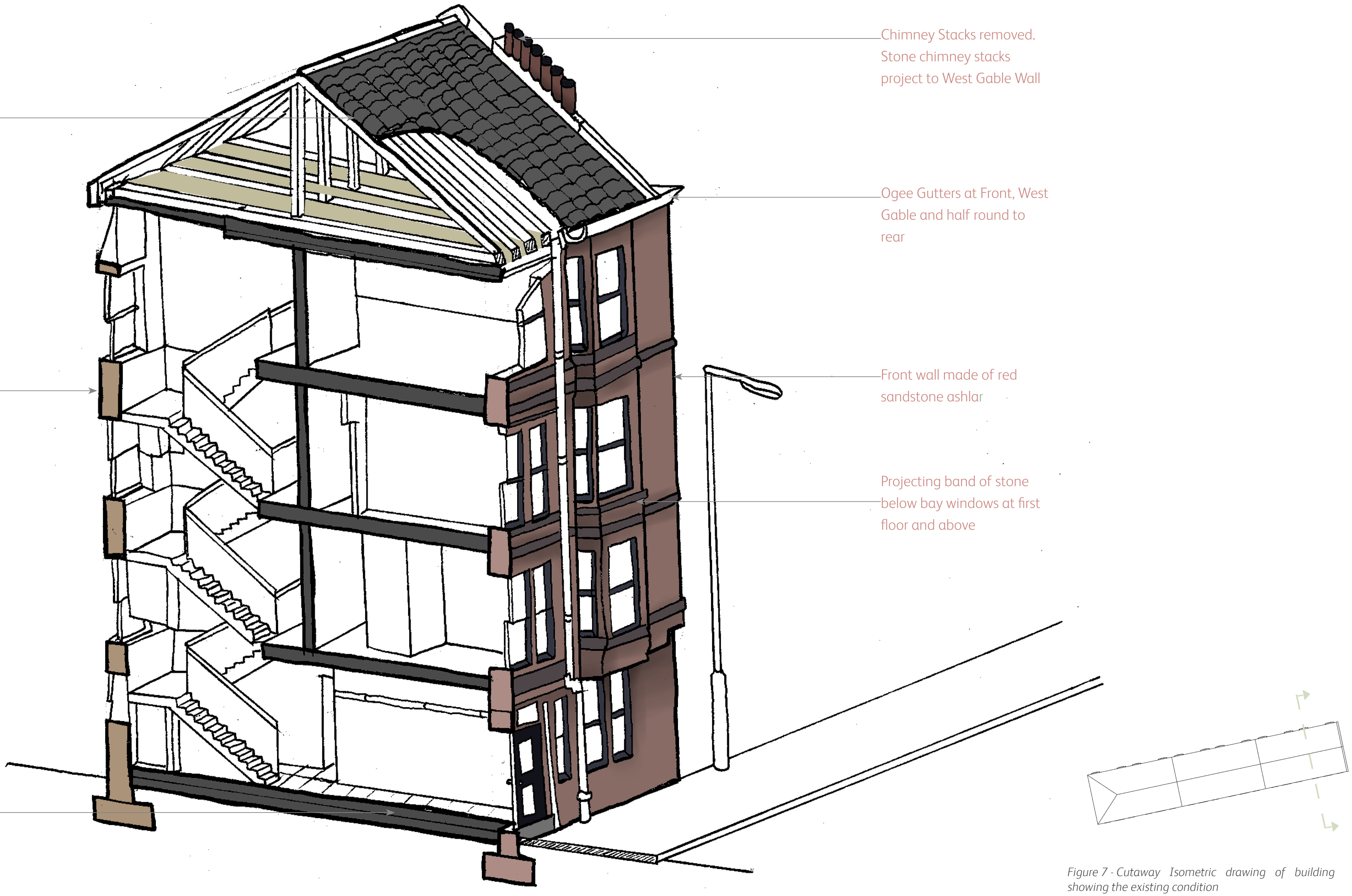


Figure 7 - Cutaway Isometric drawing of building showing the existing condition

EXTERIOR PHOTOGRAPHS

North facing front façade of building. Ashlar red sandstone external walls.

West Facing Façade. Blonde Bullnose Ashlar sandstone.

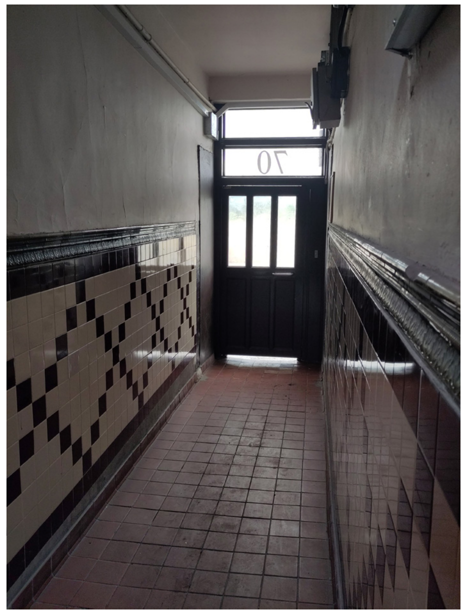
Ground floor communal corridor. concrete flooring with Terracotta tile floor covering. Rear external gate opening up to outdoor garden space.

South-facing façade. Erosion found on blonde bullnose ashlar sandstone stonework. Cracked terracotta tile floor coverings on communal corridor.

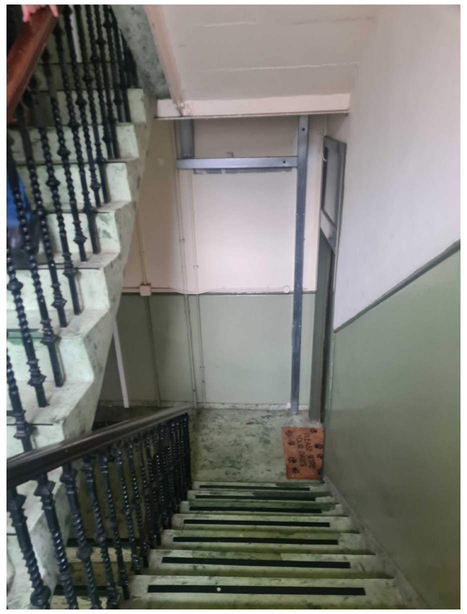
Stepped roof tiles. Vegetation built-up to ogee gutters.

Vegetation growth along base of front façade facing Old Shettleston Road.

South-facing façade. Blonde Bullnose ashlar sandstone.



Communal corridor to front external secure access door. There is a large gap between door and unlevelled threshold.



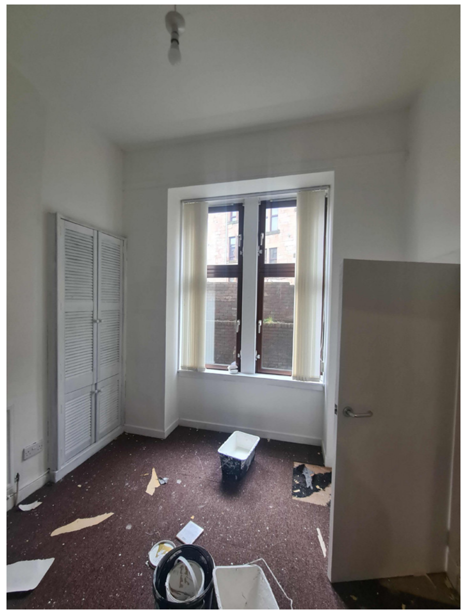
Typical communal stairwell. Cracked terrazzo floor coverings.

Existing window with ventilation louvre above to communal stairwell on top floor.

INTERIOR PHOTOGRAPHS

Main door to flat of building.

Upper floor flat bay double glazed timber framed windows located on front façade of building.



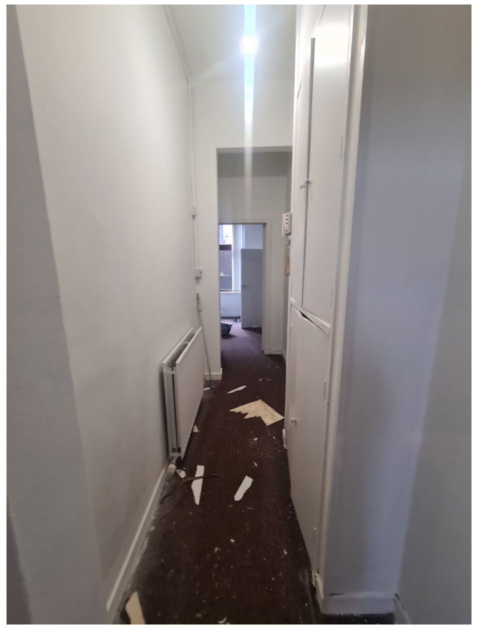
Upper floor flat double glazed timber framed windows located on rear end of building.

Existing radiators in flat of building.

Kitchen unit of flat of building.

Living Room Space of upper floor flat.

Opening up rear wall showing existing service void behind plasterboard finish.



Hallway of flat in building.

Existing gas-fired combi-boiler providing hot water.

Opening up of suspended timber floor boards to ventilated void revealing timber floor joists and pipework of ground floor flat.

BUILDING INSPECTION REPORT

An inspection of the outside and common areas of the building was carried out on 18th May 2023 by Reid Mitchell. The full report is in the appendix to this study. Key points are as follows:

- Building generally in fair condition
- A number of issues with roof and gutters that together lead to a suggestion to replace roof coverings in the coming1-3 years.
- Immediate need to replace window restrictors in the communal stairwell (note that SHA have instructed the replacement of these)
- Some redecoration of communal windows & doors is included for in the short them.
- Potential presence of asbestos noted (though only based on age of building, not in relation to specific elements)

Many of the items noted will be upgraded or altered should the retrofit works in this report be taken forwards, so it is suggested that other than the urgent item already instructed, other decisions are postponed until decisions have been made about retrofit.

AIRTIGHTNESS TESTING

Blower door airtightness testing was carried out to three of the flats in the block on 21st June 2023. The results of these are shown here:

Flat number	Flat location	Air permeability ($m^3/m^2.h$)	Airtightness (air changes per hour)
0/1, 58	Ground, mid-terrace	13.77	7.39
1/1, 70	Mid-floor, end terrace	14.20	7.63
3/1, 70	Top, end terrace	15.73	8.45
Average		14.56	7.82

These measurements tell us about how airtight each flat is, with its party floor / ceiling and walls forming part of the envelope being considered along with its external walls. The blower fan will have been placed in each flat's front door, so any lack of airtightness here will not be accounted for. The overall building is likely slightly less airtight than these averages suggest, given that some of the closes have gates as rear doors.

Both air permeability and airtightness tell us how leaky a building is. If it is very leaky, the air that the resident has paid to heat escapes quickly through gaps and cracks. This warmed air is replaced by cold outside air, which the resident then needs to heat up, costing more money. The more airtight the building is, the less quickly this happens, so less air needs to be heated, costing less.

Air permeability is the metric used by the UK Building regulations. It tells us what volume of air moves through the outside surface of the building every hour.

Airtightness is the metric used for Passivhaus buildings, and tells us how fast all the air in the building leaks out. So an airtightness of 7.82 means that the air in the building changes 7.82 times each hour.

Both measurements are given at a pressure of 50 Pascals, so in normal conditions the actual rate of air leakage is lower.

[Blank page]

EXISTING PHPP ANALYSIS

WHOLE BUILDING

ECD have modelled the whole block of flats using designPH and the Passivhaus Planning Package (PHPP). The predicted heat demand, energy use intensity and bills have been calculated from this and are presented here.

A number of assumptions have been made to create this model:

- Existing U values based on typical tenements have been used (from Historic Scotland, Technical Paper 3: *Energy modelling analysis of a traditionally built Scottish tenement flat, 2008*) except to the loft, where 250mm insulation is understood to have been installed. This has been assumed to be mineral wool. Key elemental U values are listed below:

Element	U value (W/m2K)
Wall (thicker)	1.086
Wall (thinner)	1.449
Stairwell wall	1.961
Ground floor (timber)	2.090
Top floor ceiling	0.158

- Airtightness of 7.83 air changes per hour (as per average of flats air tested) In fact the overall building's airtightness may be less good than this, as some closes have gates to rear entrances, but this will not significantly affect the airtightness of the individual flats measured.
- Target internal temperature adjusted on basis of periodic heating, leading to an average internal temperature of 16.9°C
- Surrounding buildings have not been modelled (at present) which will affect solar gains
- While key thermal bridges have been roughly estimated, no thermal bridge modelling has been undertaken.
- While some close rear entrances have gates rather than doors, making the communal corridor and stair cold, the thermal line has been assumed to include these cold stairwell areas. This may make the building appear to use less energy than it really does.

This whole building model suggests the existing heat demand is 120 kWh/m2.a, This is the average across the whole block, and in reality flats with more external envelope will have higher heat demands (top and ground floor flats, and end of terrace) and those in the middle will have lower heat demands.

The heat losses and gains graph shows that the main losses are through external walls, windows and ventilation. Losses through the roof are minimal, due to the presence of a significant depth of insulation. While the floor is uninsulated, as heat is lost less quickly into the earth than into surrounding air, heat losses here are not so significant.

Flats in the middle of the building have smaller areas of external wall compared to their internal area, so will have a lower heat loss rate per square metre of floor area. Similarly those on the top floor are relatively well insulated by the loft insulation, while those on the ground floor will experience heat losses through the floor.

This translates into significant energy bills of around £1,299 a year (averaging £108 per month or £15,80 a week). Again, this is average of all the flats, not all of which are the same size. It also assumes that people do in fact heat their homes to around 20/21 °C when they are in them, which not all residents may be able to afford to do.

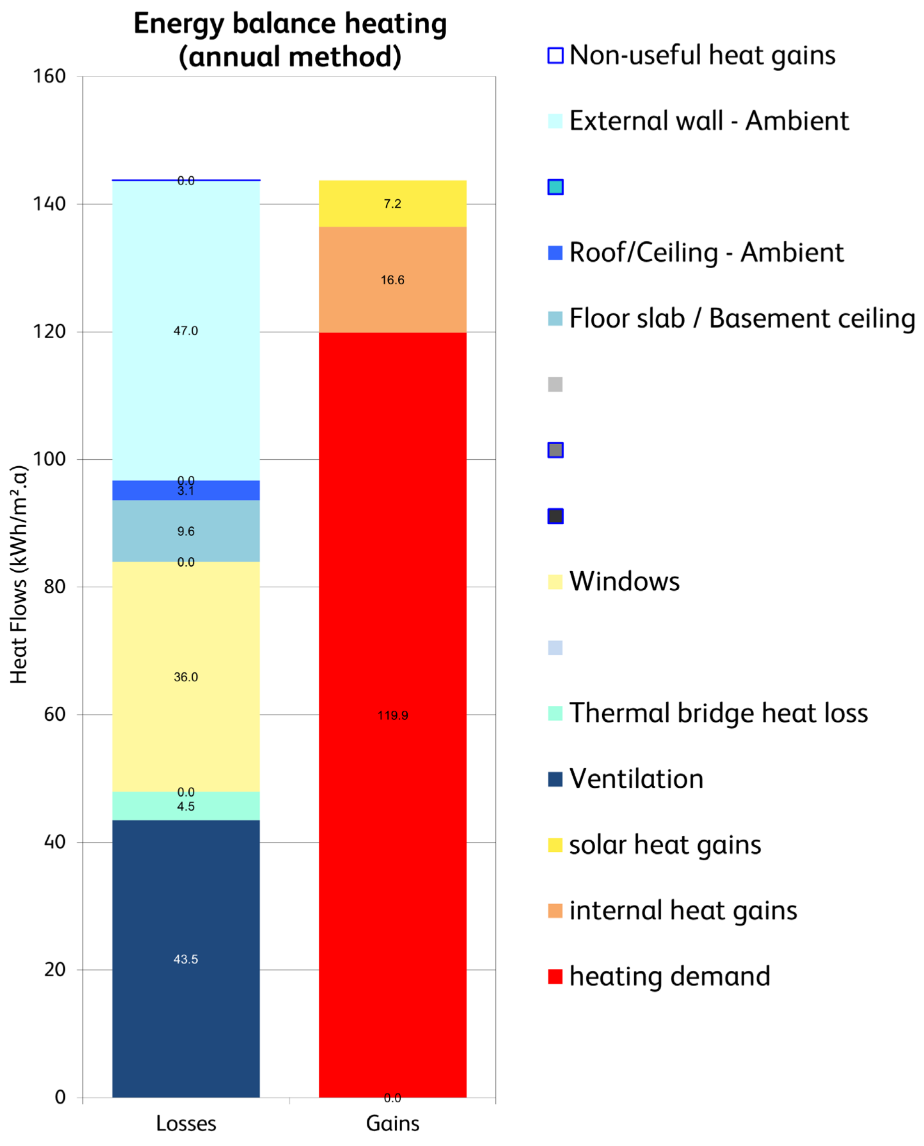
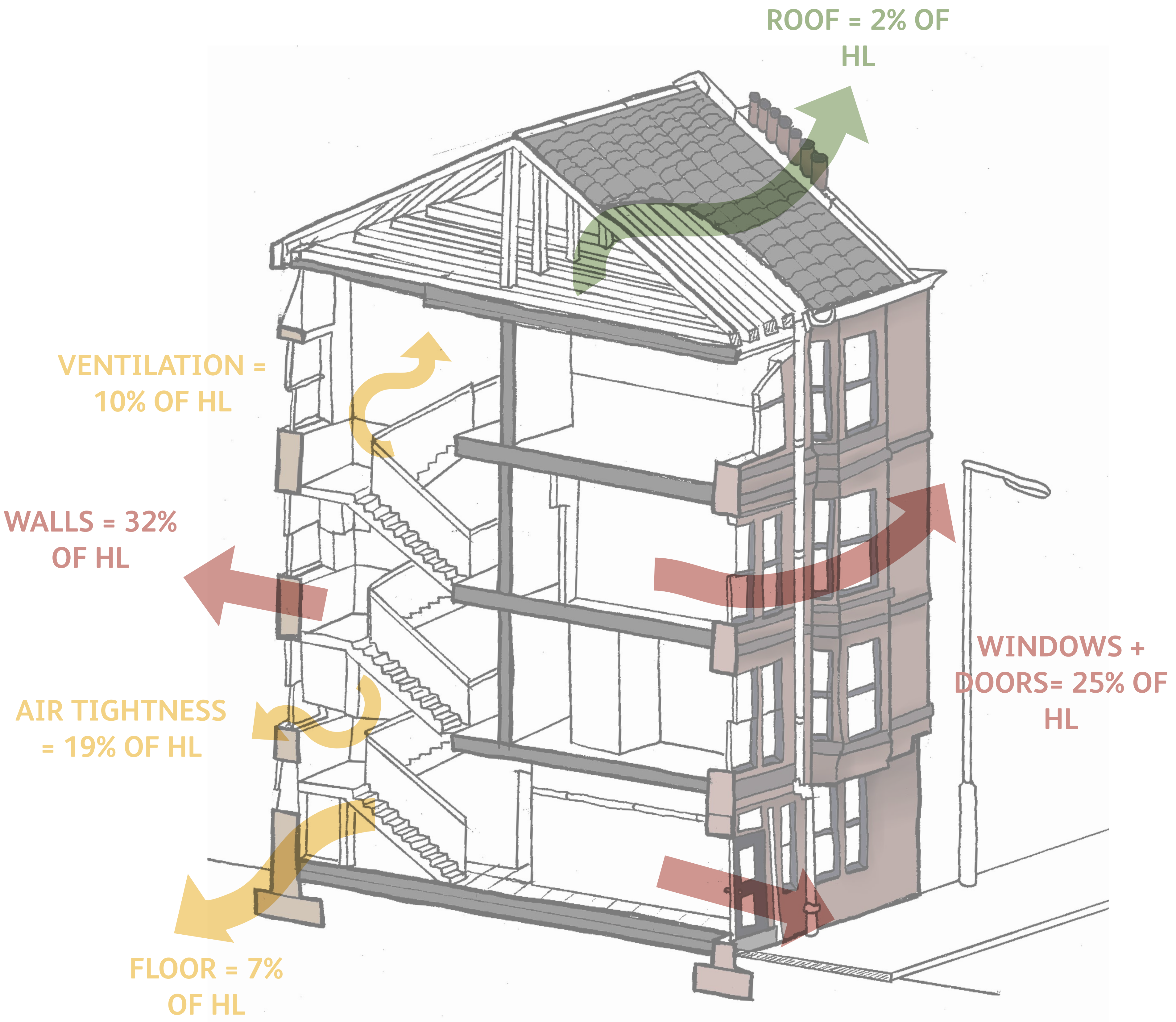


Figure 8 - Whole building, Annual heat losses & gains.

HEAT LOSSES TRAFFIC LIGHTS SYSTEM



RED - Building elements with poor energy performance. Very likely to need upgrade/improvement to decarbonise building.

YELLOW - Building elements with average energy performance. Likely to need upgrade to decarbonise building.

GREEN - Building elements with good energy performance. Least likely to need upgrade to decarbonise building.

INDIVIDUAL FLATS - AS EXISTING

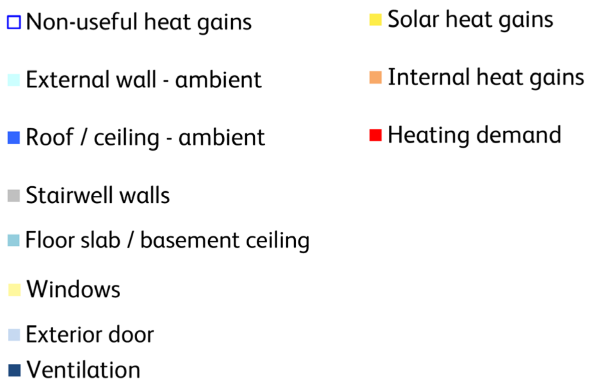
If the building is used roughly as predicted, as a whole around 67 tonnes of carbon dioxide equivalent are emitted each year by the occupation of the building.

In order to gain a more detailed picture of how individual flats perform, and how energy bills and carbon emissions might be impacted by proposed works, ECD have made separate PHPP models of three individual flats. These are a

- top-floor end terrace 3 bedroom flat,
- ground-floor end terrace 1 bedroom flat
- mid-floor, mid-terrace 3 bedroom flat.

Unsurprisingly the mid-floor, mid-terrace flat has the lowest heat demand, as it has the best form factor. Meanwhile the ground floor flat has the highest heat loss per metre squared, as it is losing heat through its uninsulated floor. Both top and ground floor flats are also end of terrace, and so have long areas of external wall. This is more pronounced for the one bedroom ground floor flat, as its floor area is smaller, so the proportion of external wall to floor area is greater.

All of these individual flats show significant heat loss through the stairwell wall to the communal corridor and stair. As this is unheated and not entirely closed off from outside, it has been assumed that the average temperature in the existing condition will be 12°C. This means heat is quickly lost through these uninsulated walls.



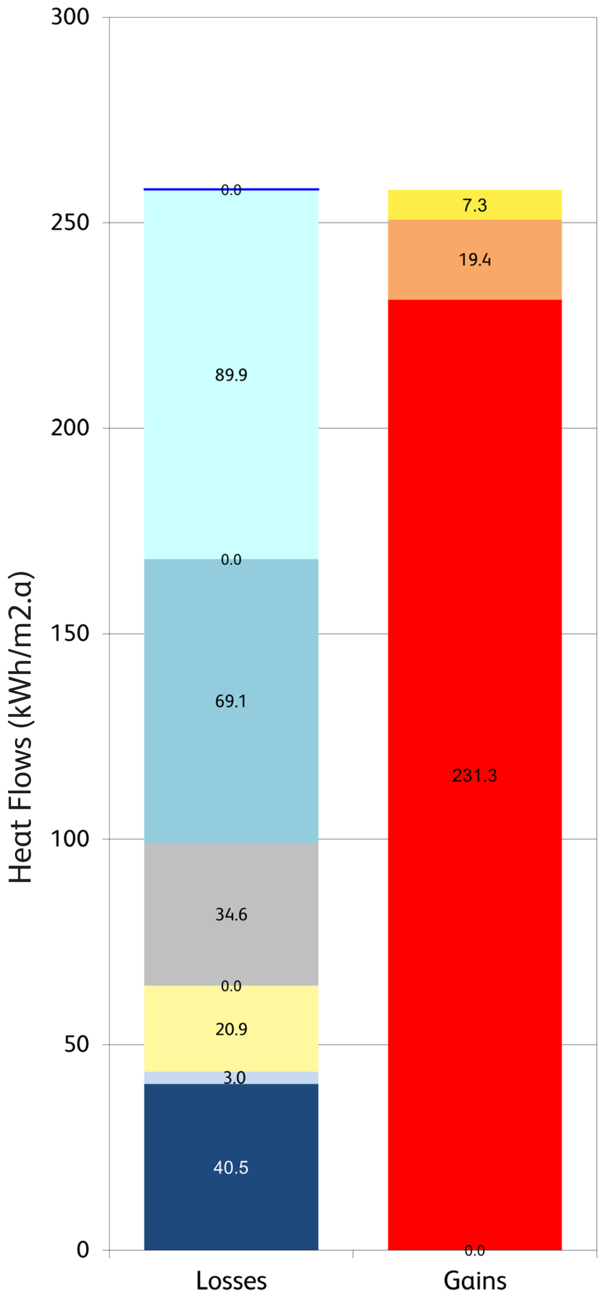


Figure 9 - Existing 1 bedroom ground floor end of terrace flat. Annual heat losses & gains.

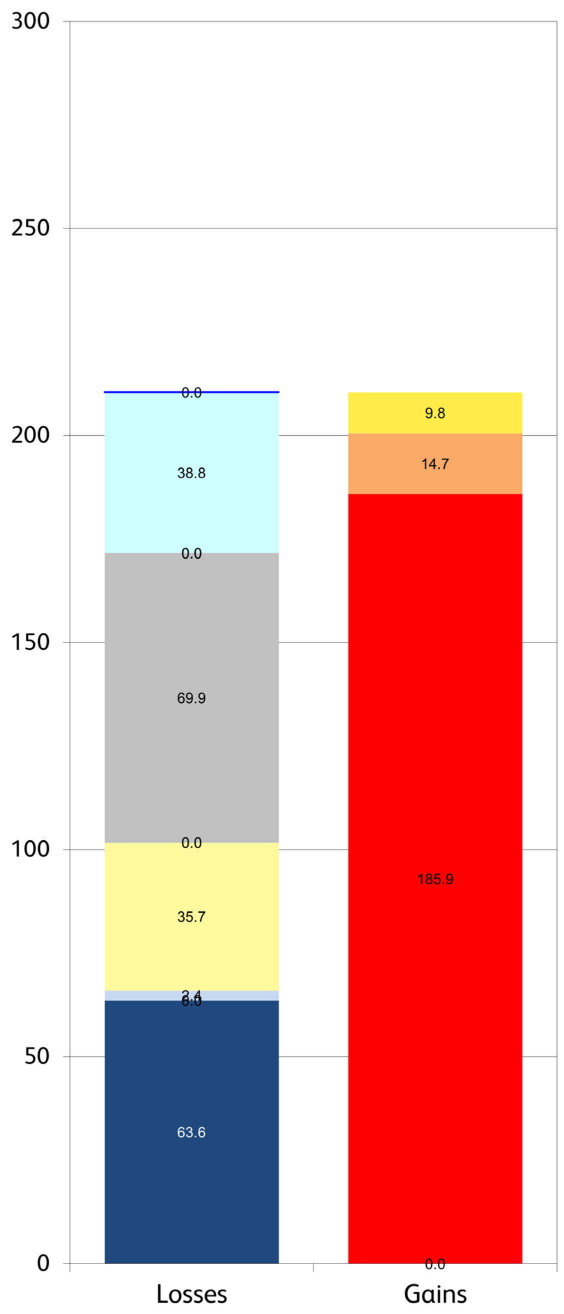


Figure 10 - Existing 3 bedroom mid floor, mid terrace flat. Annual heat losses & gains.

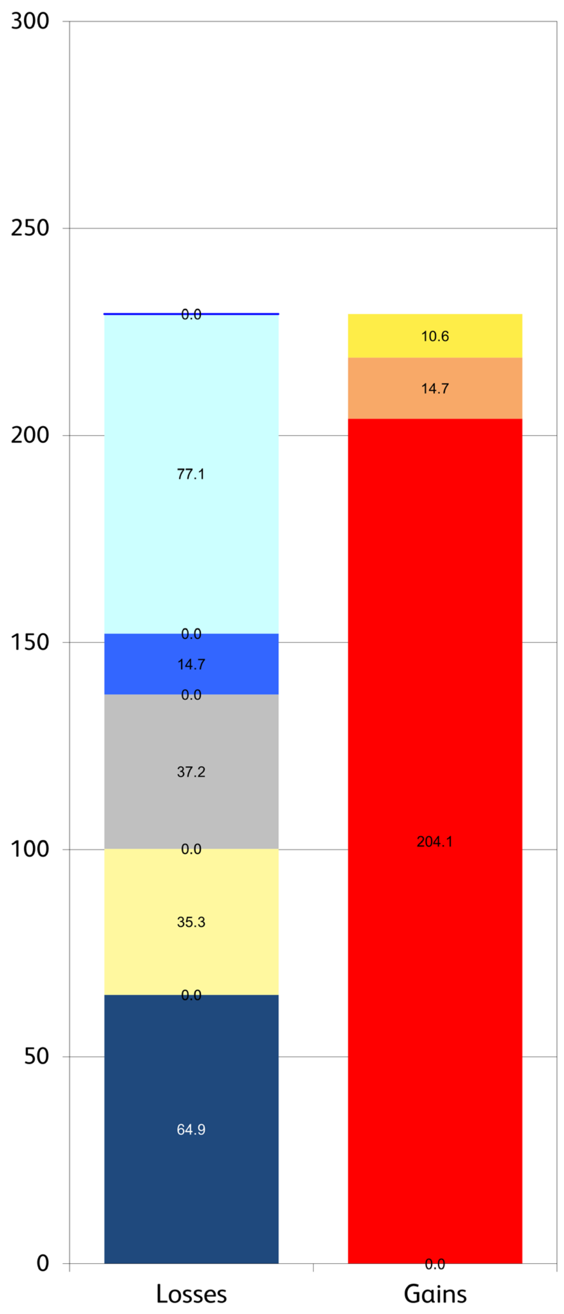


Figure 11 - Existing 3 bedroom top floor, end of terrace flat. Annual heat losses & gains.

Where flats neighbour one another, it is assumed that the neighbouring flat is at the same temperature, so there will be no heat loss. This is of course not exactly what will happen in real life, but is correct on average.

The figures below are averages of the three flats modelled. They are not area-weighted, so are probably marginally worse on average than most flats, as thee flats were deliberately chosen to represent two of the worst performing flats.

ENERGY BILLS
£1990

HEATING DEMAND
225
kWh/(m².a)

HEATING LOAD
101
W/m²

CARBON EMISSIONS
125
tonnes CO_2e

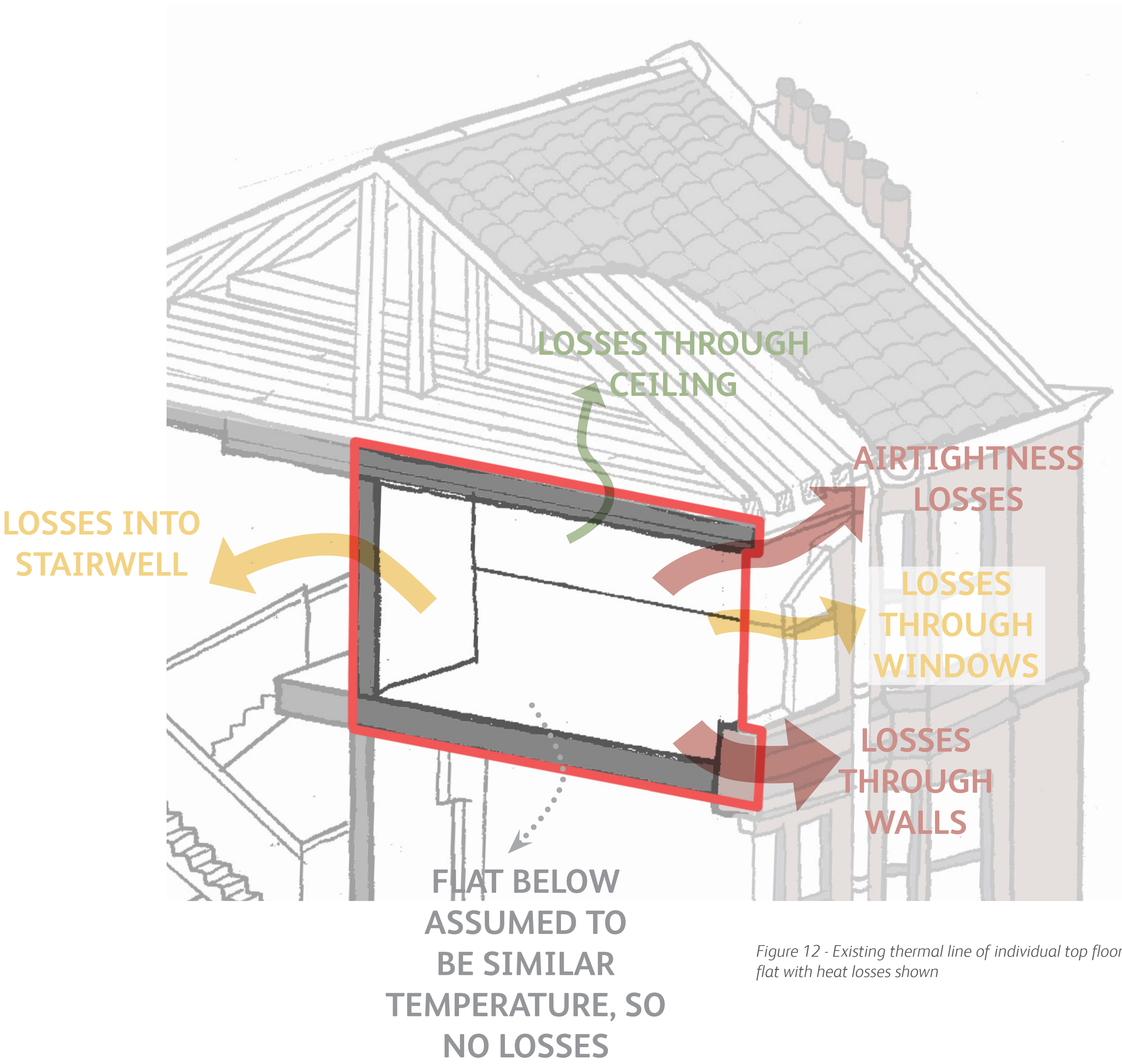


Figure 12 - Existing thermal line of individual top floor flat with heat losses shown

RED - Building elements with poor energy performance. Very likely to need upgrade/improvement to decarbonise building.

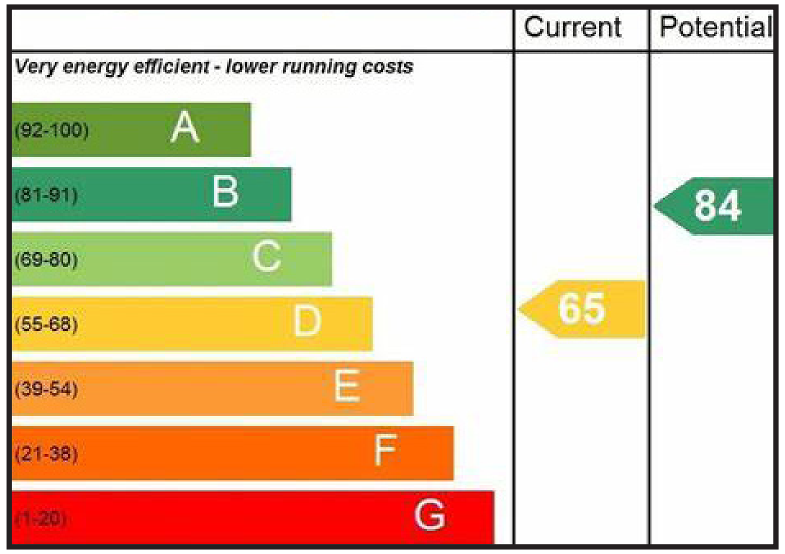
YELLOW - Building elements with average energy performance. Likely to need upgrade to decarbonise building.

GREEN - Building elements with good energy performance. Least likely to need upgrade to decarbonise building.

SAP & EPCS

Existing EPC certificates have been sourced, and the data is presented here. Different homes within the block will perform differently, due to their location within the block and consequent variation in area of external wall, floor and roof. The existing SAP data is based on EPC surveys carried out over the last 10 years, so some of the information is out of date. For example SHA have confirmed that they have upgraded loft insulation during this period. However the SAP ratings are evenly spread between Cs and Ds with no discernible difference between those on different floors or exposed gable end walls. The average predicted heat demand is 109 kWh/m2/yr.

This is fairly typical of Scottish housing stock overall, with 45% of homes having an EPC band C or better. (2019 data, https://www.gov.scot/publications/scottish-house-condition-survey-2019-key-findings/pages/5/)



Existing EPCs include an overall energy rating for the property, from A to G. A home energy assessor looks at current heating systems and how efficient insulation is for walls, windows, doors, floors and the loft. An overall rating is then assigned. In theory, homes that are 'A' rated is the most efficient which means cheaper energy bills. The chart above is an example of an Energy Efficient Rating. It is shown that the energy efficient rating of this existing home is currently rated Band 'D'. Additionally, after effect of undertaking the recommendations for insulating this existing home, the potential rating is raised to Band 'B', which means an overall reduction in energy bills.

SAP Table : 40 OLD SHETTLESTON ROAD

Flat	Total Floor Area (m²)	EER	EIR	Space Heating Demand (kWh/m²/year)	Calculated Emissions (kg CO2/m²/yr)
0-1	45	C	C	131	45
0-2	49	D	D	170	57
1-1	68	D	D	n/a	43
2-1	79	D	C	88	n/a
3-1	83	D	D	144	n/a

SAP Table : 46 OLD SHETTLESTON ROAD

Flat	Total Floor Area (m²)	EER	EIR	Space Heating Demand (kWh/m²/year)	Calculated Emissions (kg CO2/m²/yr)
0-1	31	C	C	122	46
0-2	41	D	D	156	61
1-1	41	C	C	86	43
1-2	40	C	C	n/a	46
2-1	43	C	C	n/a	45
2-2	45	C	C	n/a	42
3-2	39	D	D	119	n/a

SAP Table : 52 OLD SHETTLESTON ROAD

Flat	Total Floor Area (m²)	EER	EIR	Space Heating Demand (kWh/m²/year)	Calculated Emissions (kg CO2/m²/yr)
0-1	36	C	C	149	49
0-2	42	D	D	160	64
1-1	41	C	C	87	35
1-2	39	C	C	98	44
2-1	44	C	C	98	44
2-2	39	C	C	87	44
3-1	42	D	D	114	n/a
3-2	42	C	C	121	n/a

SAP Table : 58 OLD SHETTLESTON ROAD

Flat	Total Floor Area (m²)	EER	EIR	Space Heating Demand (kWh/m²/year)	Calculated Emissions (kg CO2/m²/yr)
0-2	41	D	D	155	n/a
1-1	41	C	C	86	33
1-2	41	C	C	87	35
2-1	41	C	C	88	41
2-2	44	C	C	79	33
3-1	41	C	D	125	52
3-2	65	C	C	62	28

SAP Table : 64 OLD SHETTLESTON ROAD

Flat	Total Floor Area (m²)	EER	EIR	Space Heating Demand (kWh/m²/year)	Calculated Emissions (kg CO2/m²/yr)
0-1	32	D	D	166	65
0-2	42	D	D	161	64
3-1	85	D	D	114	47

SAP Table : 70 OLD SHETTLESTON ROAD

Flat	Total Floor Area (m²)	EER	EIR	Space Heating Demand (kWh/m²/year)	Calculated Emissions (kg CO2/m²/yr)
0-1	32	D	E	241	85
0-2	42	D	D	161	55
1-1	68	C	C	89	38
3-1	90	D	D	n/a	46

Figure 13 - Existing SAP Tables of 40-70 Old Shettleston Road.

AVERAGE PREDICTED HEATING DEMAND (SAP)

109

kWh/(m².a)

SHA have spoken to a number of residents of the building about their current energy use, bills, perception of the flats and awareness of renewable technologies.

Of the 39 flats, contact was made with 13 residents either by phone or in person. Key points from analysis of the data include:

- Far more residents are at home during the day than the SAP assessment or the PHPP assumes, therefore energy bills may be higher
- Monthly bills are very varied, with an average of £142 per month or £1,707 per year
- Almost all residents find the flats draughty
- All residents currently find their heating unaffordable
- However only 8 out of 13 say they would heat their homes for longer or to a higher temperature if this was affordable
- All residents sometimes open their windows for fresh air
- All residents find current heating system effective and easy to use
- The majority of residents (10 out of 13) use pre-payment meters to pay for energy, so typically pay a higher rate per kWh. This also means the monthly energy cost amounts shown are recollections and approximations rather than actual bill data
- Only 4 out of 13 (c. 30%) residents have gas hobs

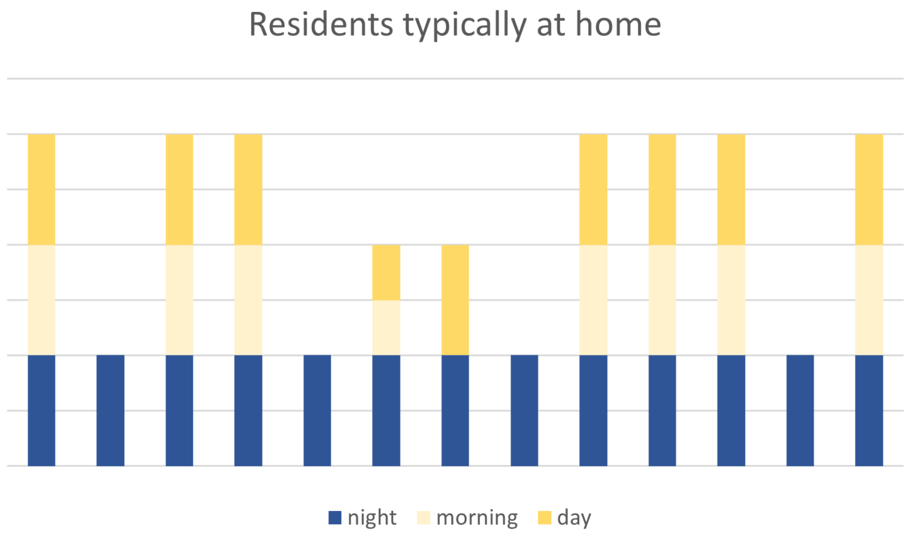


Figure 14 - Times during a typical weekday that residents are at home. Note that around half are in their homes during the day

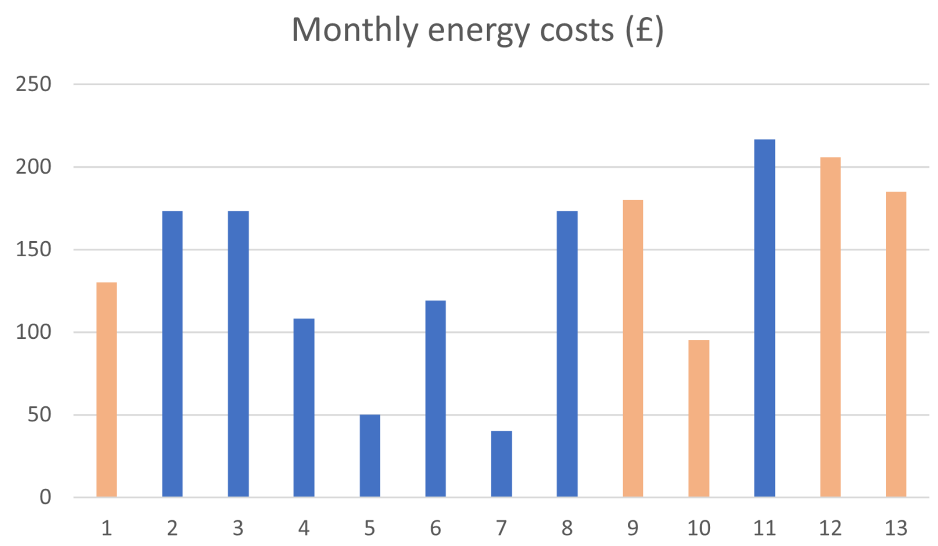


Figure 15 - Monthly energy bills. Those in orange are 3 bedroom flats. Those in blue are 1 bedroom flats

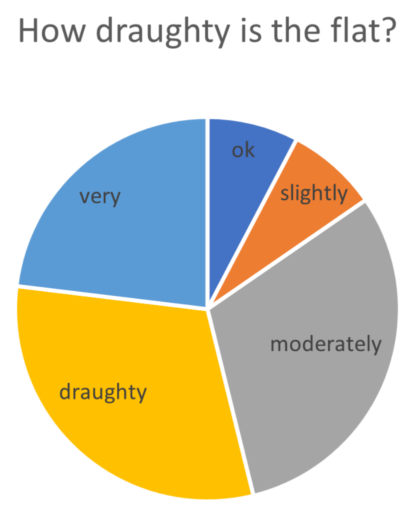


Figure 16 - All but one resident found their flat draughty. The windows were particularly noted to be a problem, with one resident sealing hers up herself

Key takeaways for the proposed works

- New windows will likely be welcomed by residents but must be well-sealed
- New heating controls must be as simple as those currently in place
- Existing bills are very varied so any indication of reduced energy costs needs to be very carefully considered
- A reduction in energy costs will likely be welcomed.
- Any future services arrangements must work with pre-payment meters as well as credit payment

03

Considered Measures

CONSIDERED MEASURES

ECD and Rybka have set out all the types of measures that might be applied when retrofitting a building, in order to demonstrate why certain measures have been taken forwards and others have not. Where measures appear viable for the Old Shettleston Road tenement, they have been categorised by whether they can be implemented with residents in-situ, and whether they need to be implemented inside a flat or not. These are then investigated in more detail in the following pages.

BUILDING REGULATIONS

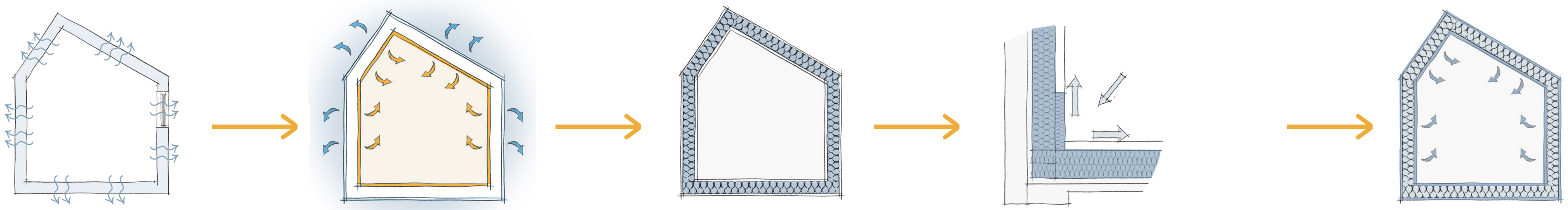
Building Regulations set out maximum U values for building elements of both new and existing buildings. However these are also caveated for traditional buildings, where it is acknowledged that such standards may not be achievable or may increase the risk of moisture within walls.

Domestic Technical Handbook June 2023, table 6.2 sets out these maximum U values:

Type of element	Area-weighted average U-value (W/m^2K) for all elements of the same type
Wall [1]	0.17
Floor [1]	0.15
Roof	0.12
Windows and doors [2]	1.4
Rooflights [3 4 5]	2.1
Cavity separating wall	0.0

Section 6.2.1 goes on to state that any individual elements of the building should have U values of no worse than 0.7 W/m^2K for walls and floors and 0.35 W/m^2K for roofs. Glazing should have a U value of no worse than 3.3 W/m^2K. Section 6.2.7, which pertains to traditional buildings says that the figures in table 6.2 should be the aim, but than the higher numbers above should be a fall back where the lower numbers are not possible for technical reasons. Higher U values than those in table 6.2 are likely to be accepted by building control, but may need to be justified.

Steps to Achieve an Efficient Building Envelope



Air Leaking Through an Inefficient Building Envelope

Add a Continuous Airtight Barrier

Allow for Continuous Insulation

Detail Carefully at Envelope Junctions

An Airtight and Energy Efficient Builidng Envelope

MATRIX OF MEASURES CONSIDERED

Those in grey have not been taken forwards for further investigation

	Strategy	Material	Reason not to take forwards	To confirm if considering	Within flats, residents in-situ	Outside flats, residents in-situ	Within flats, when void	Additional / related works
Floors								
	draught stopping between floor boards				x			
	Insulate between joists	woodfibre		depth of below floor void			x	"Ensure vents open / unblocked Ensure pointing around joist ends to improve airtightness"
		mineral wool					x	
	Insulate over existing	aerogel				x	x	Insulate over existing communal ground floor area
	Replace suspended floor with insulated slab	concrete & XPS	Too invasive					
	Qbot	spray foam	Depth of void, rubble in void	Risk around moisture?				
	Demand controlled vent to void	AirEx			x			vents to be opened up regardless of strategy chosen
Walls								
	EWI (to rear & end)	PIR	Combustible, high EC, thermal bypass behind					Eaves extension, replace external fixtures. Need to flatten off face of stonework with parge coat prior to installation
		mineral wool				x		
		woodfibre				x		
	below ground (w/ EWI)	Foamglas				x		Review how beneficial this could be given sub-floor ventilation remains.
		XPS				x		
	IWI (to front)	woodfibre					x	"lime plaster internally as airtightness layer Return walls may require some work to minimise thermal bridging. Rain repellent 'cream' required to external face of stonework if this solution adopted"
		mineral wool					x	
		diathonite	too long to dry				x	
		Calsitherm					x	Return walls may require some work to minimise thermal bridging.

MATRIX OF MEASURES CONSIDERED

Those in grey have not been taken forwards for further investigation

	Strategy	Material	Reason not to take forwards	To confirm if considering	Within flats, residents in-situ	Outside flats, residents in-situ	Within flats, when void	Additional / related works
		other? (hemp, aerogel, Calsithern…)						
	IWI (to exg service cavity)			existence & depth of void to all areas.	x			Sheathing of electrical conduit required
	Draught stopping at wall / floor junctions				x			Replace skirting boards. Possibly touch up painting
Windows								
	Exg windows & draught stopping				x			
	Exg windows & moveable solutions	curtains			x			
		shutters			x			
		secondary glazing			x			
	Replace	Double glazed, insulated frames				x		Ensure well installed, in line with insulation where possible
		Triple glazed, insulated frames				x		
Doors								
	Well-fitting doors to close	Insulated metal secure door				x		Threshold levelling & draught stopping
	Well-fitting doors to flats	Insulated secure doors			x			
Roof								
	Insulation at loft level	mineral wool				x		wind proof layer, airtightness below, maintain eaves ventilation to roof
		cellulose				x		
		sheeps wool				x		
	Insulation at roof line		Unnecessarily complex & requires more air to be heated, therefore less efficient					

MATRIX OF MEASURES CONSIDERED

Those in grey have not been taken forwards for further investigation

	Strategy	Material	Reason not to take forwards	To confirm if considering	Within flats, residents in-situ	Outside flats, residents in-situ	Within flats, when void	Additional / related works
Ventilation								
	MVHR		potentially too invasive when flats are occupied, refer to Rybka proposed drawing for further details on proposed system for typical flat (this includes system dimensions, ventilation rates, component locations)	overall system considered viable and can be installed on a flat by flat arrangement. Considered needed if air permeability of less than 3m3/h.m2 @50Pa is being achieved	x			builder's work associated with wall openings for ducts and louvres , decorative works to conceal ducts etc
	centralised mechanical extract		limited space in attic for centralised AHU per block, creating risers and duct routes will be invasive to occupants	not considered viable	x	x		builder's works associated with new primary distribution risers, decorative works to conceal ducts. Potential structural strengthening to support central attic AHUs
	extract @bathroom & kitchen		can be installed when flats are occupied however will not provide sufficient ventilation if works provide a air permeability of less than 3m3/h.m2 @50Pa	considered viable however performance limitations	x			minimal works associated with this item
	humidity controlled trickle vents		can be installed when flats are occupied however will adversely impact air permeability targets associated with AECB and EnerPHit targets	considered viable however performance limitations	x			window design needs to incorporate these units
Heating								
	renewables	ASHP	Centralised ASHP needs a whole building install to work, Local ASHPs viable however requires fabric to be improved to level that reduces current heat demand by 45% to make system operationally cost beneficial when compared to current set up. EAHP unlikely to be suitable for the flats due to their large sizes and relatively high heat demands.	localised ASHPs per flat viable	x	x		builders work to form primary distribution routes for pipework. Electrical works to power ASHPs. Radiators in flats would need replaced to suit new hydraulic regime. External ASHP compound needed to house ASHPs (refer to Rybka sketch)
		GSHP (whole block, plus HIUs per flat)	Limited space external to the building to locate bore holes associated with the system	not viable	x	x		geographical assessment of ground conditions would need to be undertaken before design can progress. External compound needed for HPs etc
	Gas boiler		current system uses gas combi boilers, small efficiency improvement to be gained if these boilers are replaced with more modern boilers however overall improvements to energy loads and carbon emissions are small. It is still permissible to replace gas boilers with new gas boilers for existing properties as phase out of gas heating only applies to new builds.	not viable based on carbon reduction aspirations	x			minimal further works would be needed with this proposal

MATRIX OF MEASURES CONSIDERED

Those in grey have not been taken forwards for further investigation

	Strategy	Material	Reason not to take forwards	To confirm if considering	Within flats, residents in-situ	Outside flats, residents in-situ	Within flats, when void	Additional / related works
	Electrical boiler		current system uses gas combi boilers, these boilers can be replaced with electric combi boilers with minimal disruptions to current heating system set up providing improvements to flats carbon improvements due to carbon factor of grid electricity being much lower then gas. Operational cost when compared to current gas boiler arrangement is a issue as heat demand would need to reduce by 66% to make electrical boilers comparable to gas in peak winter conditions.	considered viable based on carbon reduction aspirations however operational costs likely to be higher even with maximum fabric improvements proposed (model 6 of PHPP). System only likely to be operationally cost effective when used in conjunction with PVs.	x			PVs likely to be needed to make system viable
	Electric Panel Heaters		current system uses gas combi boilers, these boilers can be replaced with electric panel heaters providing improvements to flats carbon improvements due to carbon factor of grid electricity being much lower then gas. Operational cost when compared to current gas boiler arrangement is a issue as heat demand would need to reduce by 66% to make electrical heaters comparable to gas in peak winter conditions. Electrical immersion cylinder also needed for domestic hot water generation.	considered viable based on carbon reduction aspirations however operational costs likely to be higher even with maximum fabric improvements proposed (model 6 of PHPP). System only likely to be operationally cost effective when used in conjunction with PVs.	x			existing wet heating system would need stripped out. Space needed for hot water cylinder. PVs likely to be needed to make system viable

MATRIX OF MEASURES CONSIDERED

Those in grey have not been taken forwards for further investigation

	Strategy	Material	Reason not to take forwards	To confirm if considering	Within flats, residents in-situ	Outside flats, residents in-situ	Within flats, when void	Additional / related works
	Electric Infrared Heaters		infrared panels transfer heat to objects, not the air making them different to conventional electrical panel heaters. this makes them more efficient than traditional heating systems, however it also means that they won't work properly if anything is obstructing their heat path. If a object (like a item of furniture) is put in front of a panel, that object will absorb the heat and not the intended recipient/ area. the more compact flats will struggle to make space for infrared panels. IR panel heaters will provide improvements to flats carbon emissions due to carbon factor of grid electricity being much lower then gas. Operational cost when compared to current gas boiler arrangement is a issue as heat demand would need to reduce by 66% to make infra red heaters comparable to gas in peak winter conditions. Electrical immersion cylinder also needed for domestic hot water generation. Infra red heaters are also more expensive when compared to boiler and electrical panel heating.	considered viable based on carbon reduction aspirations however operational and capital costs likely to be higher even with maximum fabric improvements proposed (model 6 of PHPP). System only likely to be operationally cost effective when used in conjunction with PVs.	x			existing wet heating system would need stripped out. Space needed for hot water cylinder. PVs likely to be needed to make system viable
	phase change and storage heaters		Using storage heaters would provide modern thermal storage radiators that uses lower-cost, off peak energy to charge the unit. The system heats a super insulated core to a high temperature which then enables the user to distribute the heat when they want it throughout the day, offering much more control than traditional brick storage heating. If replacing the wet gas fired heating with this type of thermal storage heater will reduce the flats carbon emissions whilst providing suitable space heating which is controlled to meet the user demands by using an electronic thermostat and intelligent programmer alongside smart features including special boost, frost-watch and defined user profiles. storage heaters would be installed in the flats hall and living room with standard panel heaters fitted in all other rooms which have a heating demand. it is critical a off peak electricity tariff is available for this system to work. If using electric heating panel type systems the domestic hot water would need to be generated using electric immersion storage vessels sized to suit the flats size.	considered viable based on carbon reduction aspirations however operational and capital costs are closely linked to proposed level of fabric improvements to allow for comparison with current set up. system relies on off peak electricity tariff being available to all end users	x			existing wet heating system would need stripped out. Space needed for hot water cylinder.

MATRIX OF MEASURES CONSIDERED

Those in grey have not been taken forwards for further investigation

	Strategy	Material	Reason not to take forwards	To confirm if considering	Within flats, residents in-situ	Outside flats, residents in-situ	Within flats, when void	Additional / related works
Hot water								
	Waste water heat recovery		waste water heat reclaim loads associated with flats unlikely to be sufficient to have real impact on overall heat loads and associated carbon reductions	not viable due to scale of loads	x			plumbing would need local reconfiguration, floor boards may need locally lifted to access pipes etc
	hot water storage tank		new hot water vessels will be needed at each flat to serve domestic hot water loads if shifting from using combi boilers. Vessels to be charged from new ASHPs or directly from electrical immersion heater	viable and space is available for vessels within each flat	x			cupboard within flat would need formed (where flats currently use combi boilers)
Renewables								
	photovoltaic panels		Roof area might not be sufficient to accommodate panels needed for each flat. Roof structural loads to be checked to ensure it is capable to accommodate panels. Inverter panel space needed at each flats consumer unit. Rear elevation roof only suitable for PVs as front elevation faces north.	considered viable however further studies needed to determine overall yields of PV array. Dedicated PVs serving each flat would be needed as opposed to a communal array to properly address individual flat needs. Battery storage provisions would not be needed.	x	x		Structural suitability of roof to add PVs would need to be assessed. Adequate space will be require formed adjacent to existing consumer units to house PV equipment such as inverter panel. Communal close would require additional electrical containment (likely metal trunking) to house cabling from PV on roof to each flat.
	Solar thermal panels		not suited to buildings load profile and climate	not viable for development	x	x		
	Wind Power generation (using urban wind turbines)		not suited due to limited external areas to site turbines, noise generated by turbines and planning permission challenges	not viable for development	x	x		

GROUPS OF PROPOSED RETROFIT MEASURES

Each set of proposed measures is presented in the tabular format below, and then expanded on over the following pages. An example measure from the table is shown below with an explanation of what each box means.

Reduction in space heating demand by carrying out this measure, as compared to the building prior to this set of measures. This is measured in amount of energy needed to keep the flat warm (kWh), per metre squared of the building (m2), per year.

i.e. the yellow measures are referenced against the existing building; the blue measures are referenced against the building once the yellow measures have already been implemented; the green measures are referenced against the building once the blue measures have been implemented.

All figures are averaged, so some flats will have higher or lower savings. In some cases the savings only relate to top or bottom floor flats. An asterix marks these.

Note that the sum of all measures will typically be more than the saving actually realised by implementing all measures together.

Brief explanation of the intended energy efficiency measure

More detailed explanation of the works required, including limited description of builders work in connection with the measure

Explanation of the benefits of carrying out proposed measure, to overall energy use, carbon emissions or resident comfort.

Measure	Image	Proposal	Disruption	Pros	Cons / Risks	Savings & Costs
New doors Replace front doors to each individual flat.		New insulated doors, fanlight over & frame. Well sealed to existing wall opening. New threshold strip. Letterbox flap or brush and cover over keyhole.	No implications for existing use-able space. Short-lived & very localised disruption.	Reduce heat loss through doors. No draughts near doors.	Only do when doors require replacement anyway? Limited impact as surrounding wall uninsulated. Limited impact as not on external envelope - if external doors are improved this may make less difference.	Heat demand reduction (kWh/ m2.year): 16 Annual cost saving (£): 88 Capital cost (£): 3,524

Image, either of the proposed measure being implemented or the relevant part of the existing building

Explanation of disruption to residents during works (assuming they are in homes during the works / justifying why works are best carried out why flats are void during the works) Also explains disruption or spatial change after works

Any further considerations to be borne in mind when deciding on which measures to implement or planning the works

The cost to implement the measure per flat (prime cost + 60% mark up)

Annual energy bill saving to residents, measured in the same way as the heat demand (i.e. relative to the existing / preceding set of measures). Measured in pounds, but related to energy prices in July 2023, and assuming residents are not using pre-payment meters.

[Blank page]

04

Proposed Measures

Within flats, with residents in situ

GROUPS OF PROPOSED RETROFIT MEASURES

SHA want to know what measures are realistic without decanting their residents. This has been broken down into minor measures that could be carried out inside each flat while residents are living in them, measures that could be applied to the outside of the building and to communal areas while residents are living in their flats, and measures that could be carried out when flats become void. If and when all steps are able to be carried out across all flats, this will lead to a huge reduction in carbon emissions from the building, as well as a reduction in residents' bills.

There groups of measures and their impacts are set out across the following pages, with an explanation of the proposals made and an evaluation of which are best to take forwards.

WITHIN FLATS, WITH RESIDENTS IN SITU

As these are all small changes, the impacts will be limited. It is not possible to provide exact modelling of these impacts, as this will depend significantly on the starting point of each individual flat. While some of these measures are only worth implementing if deeper measures will not be carried out for some time, others are preparatory steps for more impactful later change.

Measure	Image	Proposal	Disruption	Pros	Cons / Risks	Savings & Costs
New doors Replace front doors to each individual flat.		New insulated doors, fanlight over & frame. Well sealed to existing wall opening. New threshold strip. Letterbox flap or brush and cover over keyhole.	No implications for existing use-able space. Short-lived & very localised disruption.	Reduce heat loss through doors. No draughts near doors.	Only do when doors require replacement anyway? Limited impact as surrounding wall uninsulated. Limited impact as not on external envelope - if external doors are improved this may make less difference.	Heat demand reduction (kWh/m2.year): 16 Annual cost saving (£): 88 Capital cost (£): 3,524
Improvements to windows Draught stopping & curtains / shutters.		Draught proofing strips with brushes or wipers around opening panes. Also investigate window seal with existing wall & seal up where possible.	Minimal.	Addresses specific resident complaint of how windows are draughty. Cheap & quick to install.	Some draughts will remain so building will not be very airtight Efficacy of draught proofing strips will deteriorate over time, so further maintenance needed. Curtains / shutters only impactful if residents use them appropriately New windows likely as part of next steps.	Heat demand reduction (kWh/m2.year): 26 Annual cost saving (£): 106 Capital cost (£): 563
Floors Draught Stopping between floor boards (ground floor only).		Block up unwanted gaps that let cold air in and warm air out.	Ground floor flats only. Level of disruption will depend on existing floor coverings.	Cheap for relatively significant improvement in comfort. Gaps between floorboards to allow draughts from solum below to enter ground floor flats.	Make sure to not block up any intentional ventilation including underfloor airbricks as this keeps flooring dry. Use filler that can tolerate movement as floorboards often contract or move slightly with everyday use.	Heat demand reduction (kWh/m2.year): 9* Annual cost saving (£): 24* Capital cost (£): 1,877
MVHR Mechanical ventilation with heat recovery system installed to each flat		MVHR unit installed in hallway, with intake & exhaust ducts to outside and supply ducts to each habitable rooms and extract ducts from kitchen & bathroom	Significant disruption to each flat, involving creating holes in some internal walls, through external walls. Installing ducts & boxing out.	Ventilation upgrade required to all flats as airtightness & insulation improved. This will be the most efficient solution in the long run as heat is not wasted.	Excellent internal air quality. Heat in outgoing air is recovered rather than wasted. Full benefits not realised until other measures implemented & airtightness further improved. Need to replace filters c. every 6 months. Need to educate residents on use & benefits.	Heat demand reduction (kWh/m2.year): 35 Annual cost saving (£): 114** Capital cost (£): 12,400 ** cost saving will increase as building made more airtight in future phases

IMPROVEMENTS TO WINDOWS

Depending on the state of individual windows, draughts stopping could be added around opening panes, as well as the window installation being investigated and any gaps here sealed. Existing trickle vents should be checked for functionality and SHA should confirm that residents understand the function of these and make use of them. This only represents good value for money if window replacements throughout are not imminent.

It would also be possible to add shutters or curtains to windows. These have been shown to reduce effective U values to single glazed windows from c. 5.5 Wm^2K down to around 3.2 Wm^2K for curtains and 2.2 Wm^2K for shutters[1]. However will only reduce heat loss if they are used by residents on winter nights, and the impact will be less dramatic at Shettleston Road where windows are already double glazed. There improvements are not therefore recommended, particularly as it is assumed that windows will be replaced and improved in the coming years as part of wider works.

NEW FRONT DOORS TO EACH FLAT

The impact of these prior to other works will be significant, as the communal corridor and stairwell is currently cold and draughty. However, once the rear gates and doors to the communal areas have been replaced, this impact will lessen, as the communal areas will be less cold, so heat will be lost to them less quickly. Individual doors will currently perform differently, so it is not possible to accurately confirm energy savings. However this is something residents have specifically noted as a problem, so should be addressed. The specification of the doors may depend on how soon communal works are likely to be carried. It is important than new doors and fanlights over are insulating, as the communal areas will remain colder than flats, so heat will be lost to these areas. Similarly they must be well-fitted to avoid draughts.

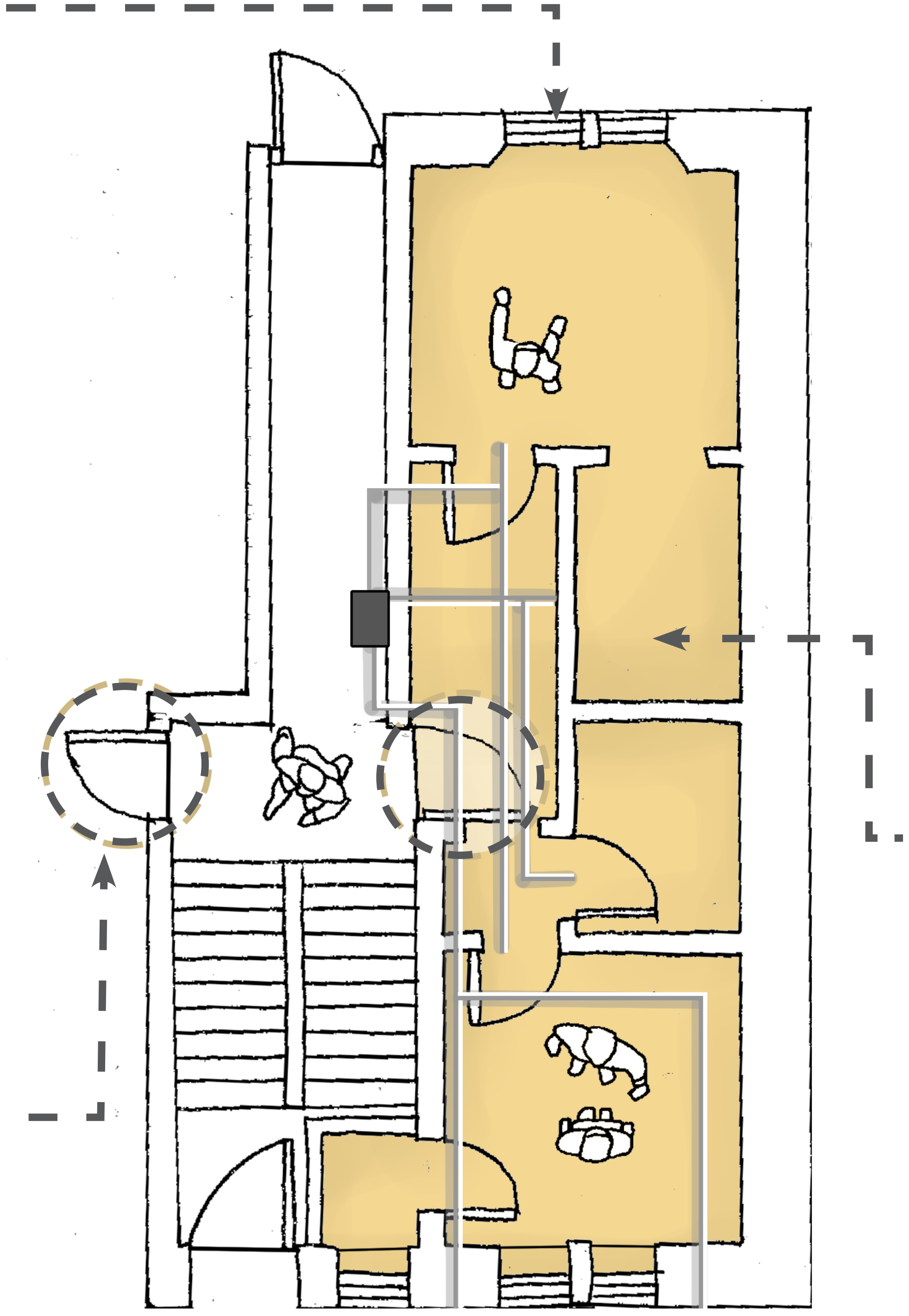


Figure 17 - Floor Plan of typical ground floor flat showing works done within flats with residents in situ.

WIRING TO ALLOW FOR FUTURE PHOTOVOLTAIC PANELS

If it is SHA's intent to add PVs to the roof in a later phase, and to split the output from this between the flats, wiring and inverters will need to be installed adjacent to consumer units in each flat. Metal trunking will also be needed in the communal stair to run wiring between the roof and the flats.

DRAUGHT PROOFING FLOORS TO GROUND FLOOR FLATS

Although the flats are currently relatively airtight, a cold draught can be felt between floorboards in some areas, suggesting that heat is lost through the ventilated ground floors. The air vents that provide air to the below floor void do not appear to all still be functioning. These should be unblocked or replaced if necessary, to avoid risk of under-ventilation leading to rotting of floor joists. There is a risk that effectively increasing this ventilation to the level it ought to be at, will make ground floor flats more draughty. Anecdotally, draught stopping floors can be an effective way to reduce heat loss from ground floor flats, so this measure is recommended, depending on existing floor finishes and whether below floor insulation is likely to be fitted relatively soon or not.

VENTILATION

Assuming that insulation and airtightness works are to go ahead, it is crucial that the flats are well-ventilated, to ensure fresh air and avoid the risk of mould growth. Ventilation must therefore be upgraded at the same time as or before significant insulation work. The best choice for ventilation depends on the intended level of airtightness when all homes have been retrofitted. Conversely the level of airtightness to be achieved may depend on how much disruption SHA believe residents can put up with.

Details of each option are set out below, together with implications for heat demand, energy bill savings and carbon emissions and an outline idea of layouts for MVHR.

Continuous Decentralised Mechanical Extract

New extract fans would be installed in the kitchen and bathroom. These would run continuously at a very low rate, very quietly, using little energy. Should a room become too humid, the fans will run faster for a short period. Trickle vents to windows will allow air into the flat, and this will be pulled through to the rooms where the extract fans are running, ensuring continuous ventilation. As there is not heat recovery included, the heat energy in the air will be lost to outside.

Mechanical Ventilation with Heat Recovery (MVHR)

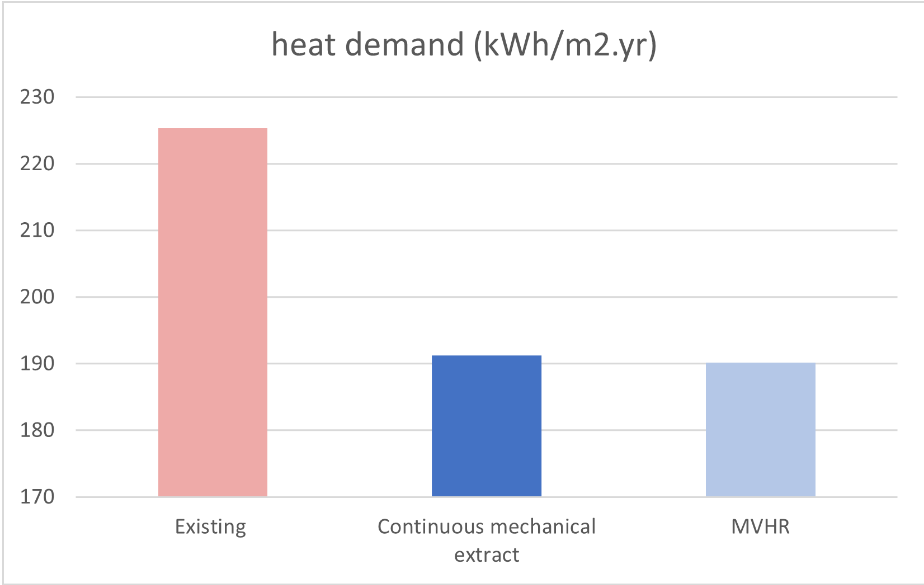
If over the course of all works the airtightness is likely to be improved to around 3 air changes per hour or better, this will be the most energy efficient ventilation solution. While it does require ductwork to be run throughout each flat, this can largely be limited to the corridor areas, with supply and extract grilles to each room installed over doors, as shown on the indicative drawing shown here.

The MVHR unit itself takes up space, and this may be a particular challenge in the one bedroom flats, though ceiling mounted units are available. Filters need to be change in an MVHR unit around twice a year. This would leave SHA with an ongoing maintenance requirement, greater than the current requirement to carry out gas check annually. A solution to mitigate this problem is to install the MVHR units themselves in the stairwell. The implications in terms of fire, electricity supply, ownership and safe access to units at high level would need to be carefully thought through.

Specification	Continuous mechanical extract	MVHR
Heat demand saving through specific measure (kWh/m2.year)	34	35
Energy bill saving through specific measure (£/year)	40	114
Carbon saving through specific measure (kgCO2e/year)	-40	50

Each solution reduces the building's heat demand by a similar amount. However the MVHR offers greater energy bill savings due to the lower overall amount of energy taken to run the system, as it can run at a lower average air change rate, using less electricity to power fans. However it should be noted that both systems are sensitive to the exact commissioning and use, as small changes in the air change rate or how long the units are run at their higher rate will impact the energy use as well as the ventilation rate experienced in the flats.

Neither system has a dramatic impact on carbon savings, but as the continuous extract system without heat recovery uses more electricity, it actual adds to carbon emissions overall. It should be remembered that while the ventilation system can have a positive impact on carbon emissions, it's primary function is to ensure a clean and healthy indoor environment for residents and the building itself.



Rybka have proposed MVHR duct layouts for example one and three bed flats, and these are shown here.

The units are in the stairwell, and would be mounted at high level, so that operatives would need to stand on a ladder to change filters. The exhaust and intake ducts would run to the rear of the building and through new openings in the wall to external grilles. These ducts need to be well insulated, so end up quite large - around 200mm total diameter. This would then be boxed in and in each instance run around 3 sides of the bedroom ceiling.

The supply and extract ducts do not require insulation and are smaller. These would run above a dropped ceiling in the hallway of each flat, to serve each room above its doorway.

Note these plans also show the heating and hot water changes that are proposed in the final stage of the retrofit. These are not part of the measures proposed within the flats while residents are in situ.

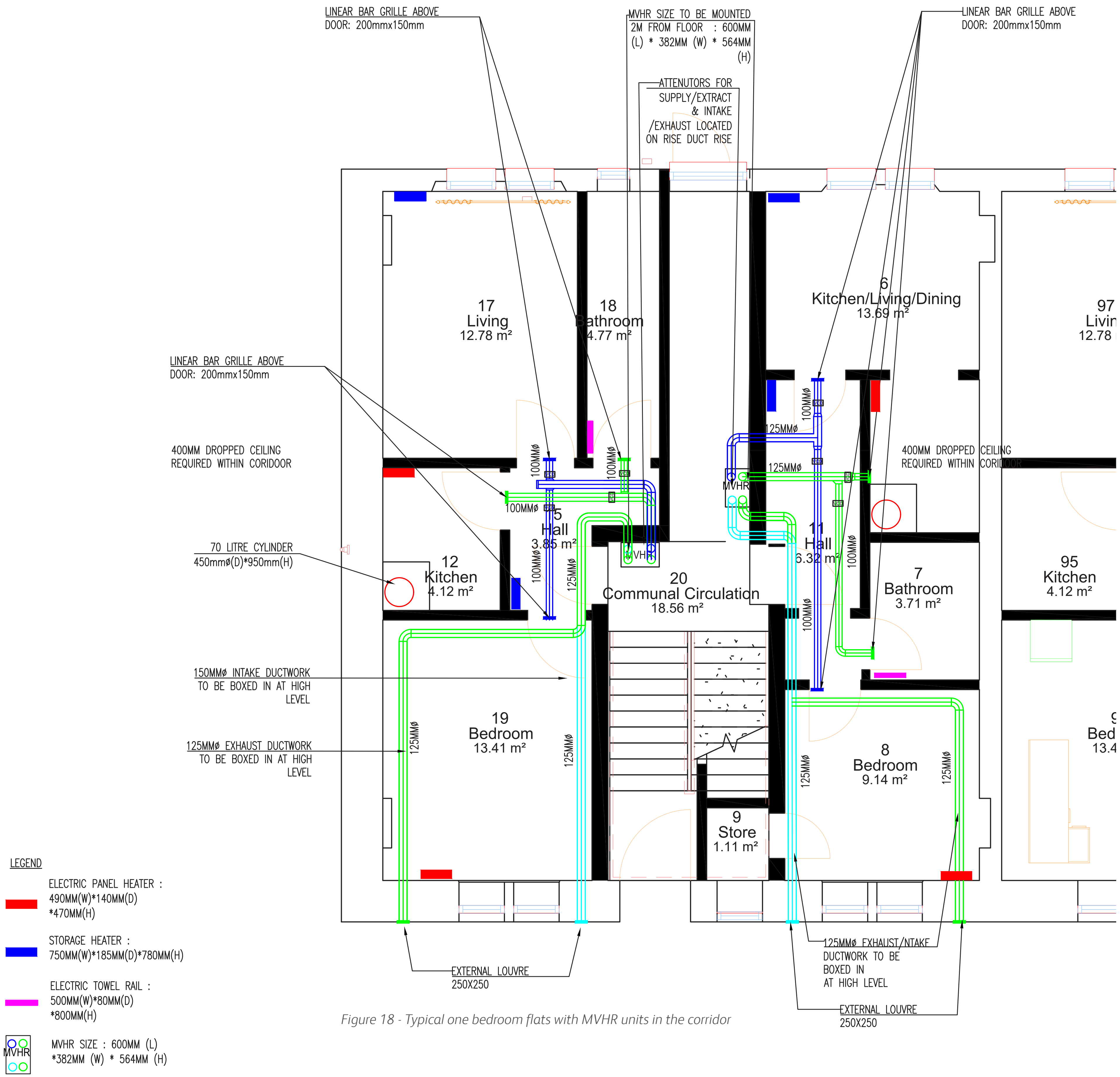


Figure 18 - Typical one bedroom flats with MVHR units in the corridor

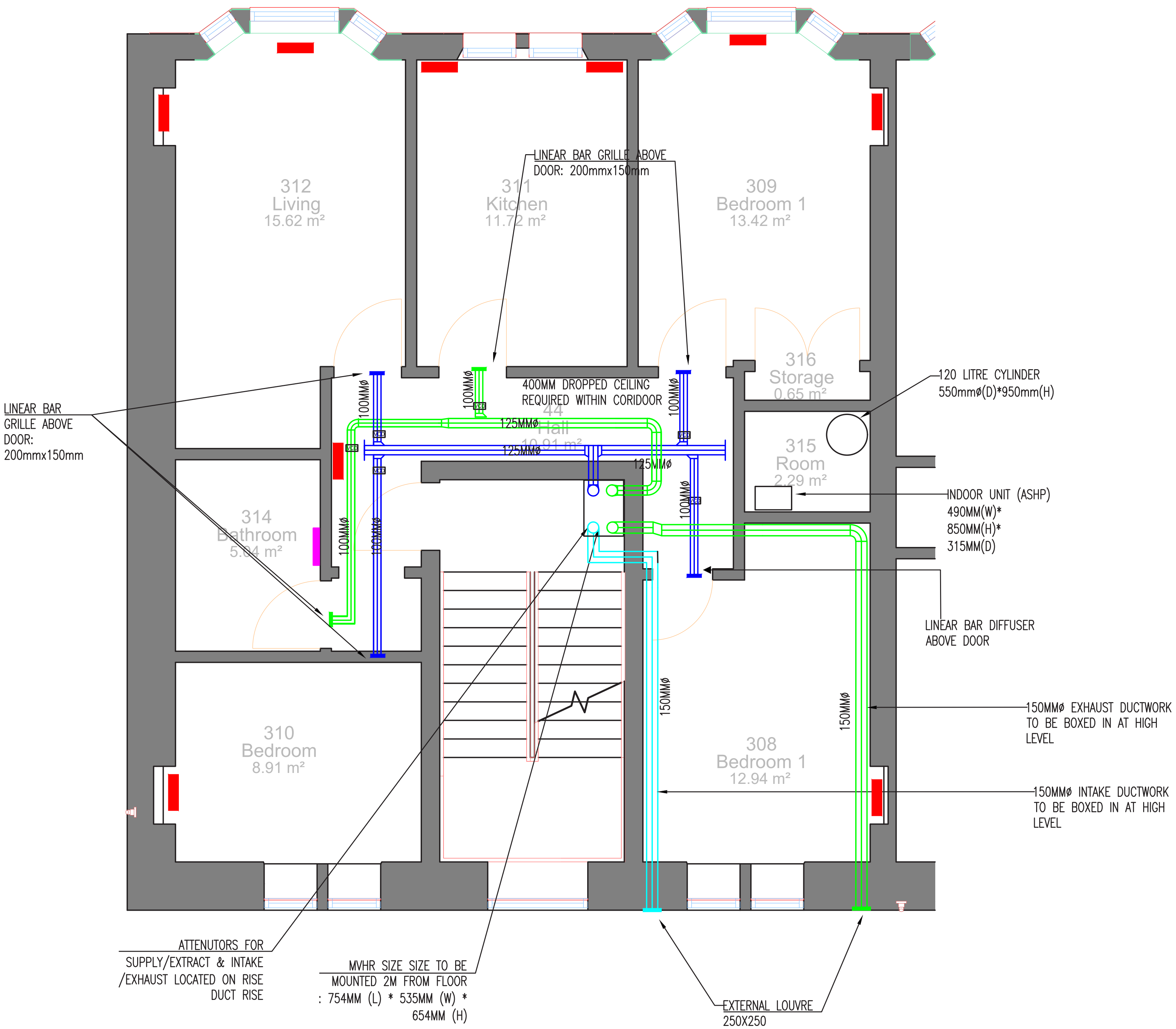


Figure 19 - Typical three bedroom flat with MVHR unit in the corridor

OUTCOMES

The graphs opposite show the energy bill and carbon dioxide emissions savings potentially available by making these limited changes inside residents' flats. While the potential bill savings of all combined measures, in the best case scenario is significant, at almost £300, it must be noted that the minimum saving is around £60. These graphs do not include the potential savings of the installation of improved ventilation, as this only becomes a necessity when the works outside individual flats are also undertaken.

Even when all of these measures are combined, the heat load remains as high as 84 W/m^2 which would not economically support the use of a heat pump. Consequently these measures alone do not offer the opportunity to decarbonise the homes.

However as some of the measures included at this stage are in preparation for future, deeper retrofit measures, it may be that carrying out some of these small steps, particularly where they respond to residents' concerns, is a good way to demonstrate positive impacts for residents in the short term, while also preparing for longer term changes

ENERGY BILLS
£1779

HEATING LOAD
76
W/m^2

HEATING DEMAND
187
$kWh/(m^2.a)$

CARBON EMISSIONS
106
tonnes CO_2e

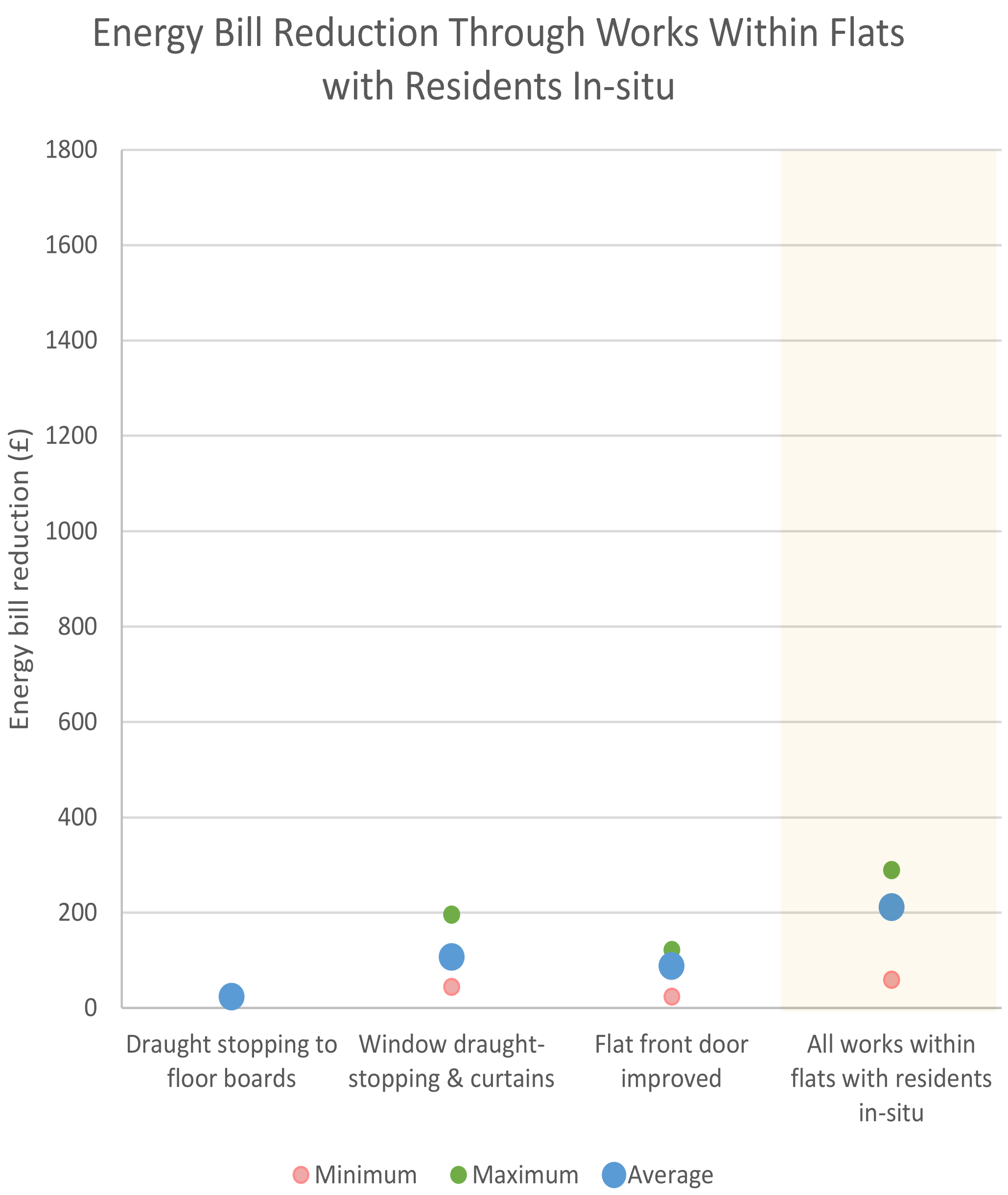


Figure 20 - Potential energy bill reduction, based on use of flats as per SAP assumptions, and on energy prices at July 2023

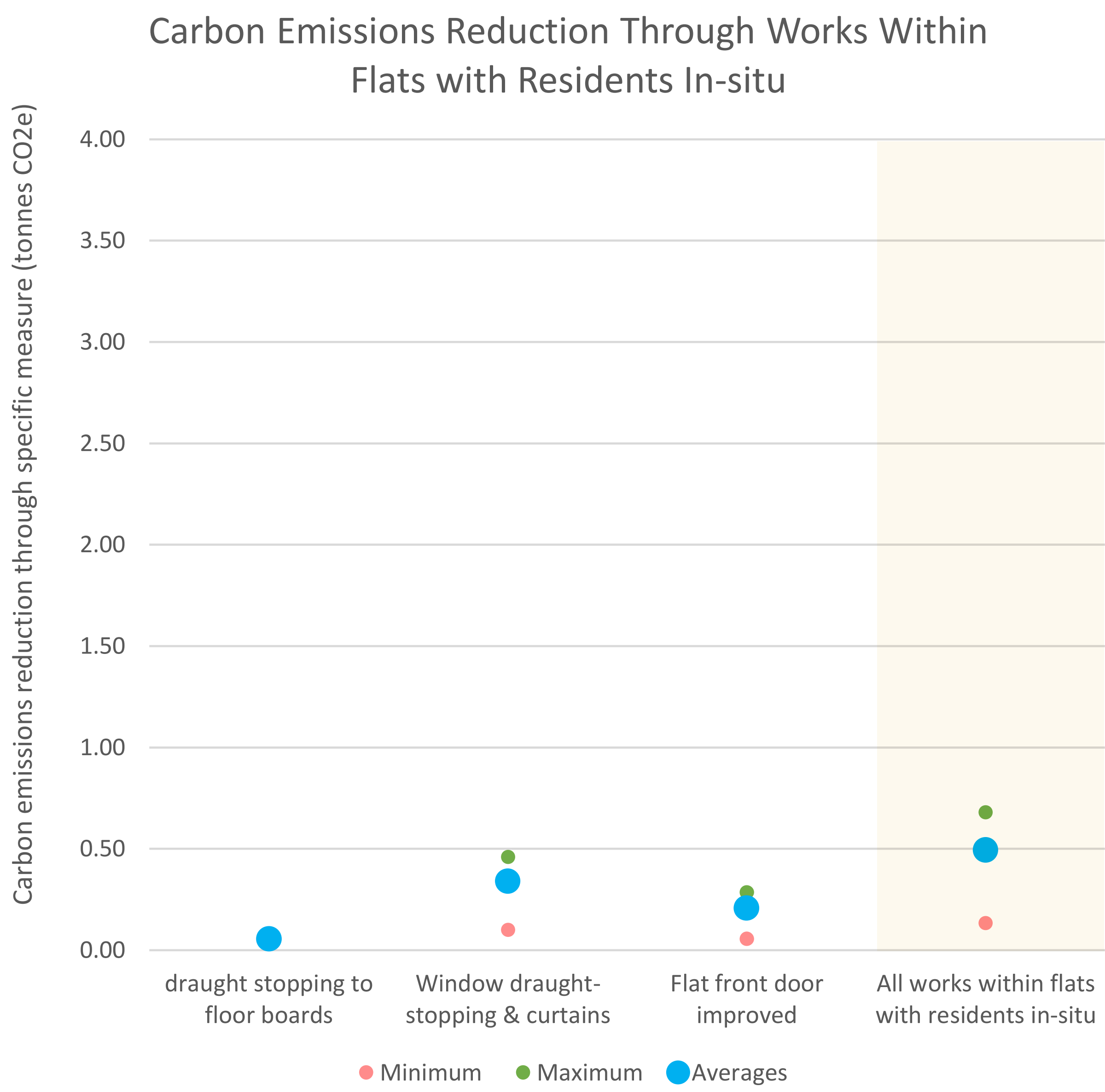


Figure 21 - Potential carbon dioxide emissions reduction, based on use of flats as per SAP assumptions, and on UK government carbon factors at July 2023

05

Proposed Measures

Communal & External Works, with residents in situ

Measure	Image	Proposal	Disruption / space	Pros	Cons / Risks	Savings
Close Doors Replace front & rear communal doors.		New insulated doors, fanlight over & frame. Well sealed to existing wall opening. New threshold strip.	No implications for existing useable space.	Reduce heat loss through doors. No draughts near doors.	Need to re-do plastering around doors. Limited impact as surrounding wall uninsulated. Limited impact as not on external envelope - if external doors are improved this may make less difference.	Not individually calculated
New Windows Replace existing windows.		Replace double glazed, timber framed windows with triple glazed windows in insulated frame. Windows to be air permeability class 4, sealed to airtightness layer of wall.	There will be scaffolding when replacing existing windows from outside the building.	Avoid window condensation. No cold draughts by windows.	Ensure well installed, in line with insulation where possible. Triple glazing windows are heavier so ease of opening to be considered.	Heat demand reduction (kWh/m2.year): 53 Annual cost saving: 185 Capital cost (£): 19,231
External Wall Insulation New EWI to rear & side walls.		Remove and replace external fixings. Add diathonite insulating plaster, mineral wool insulation, new ventilated void with new render board.	Insulating External walls will cause a temporary disruption as it creates a dusty environment.	Mineral wool insulation is a highly-effective noise barrier and is a non combustible material.	Render board will be less durable than existing stone wall and will require maintenance e.g. cleaning and resealing.	Heat demand reduction (kWh/m2.year): 36 Annual cost saving: 306 Capital cost (£): 15,852
Floors Insulate solid floors to close corridors.		Add 15mm aerogel insulation to communal corridor floors.	Temporary disruption.	Aerogel is extremely water repellent.	There is potential respiratory effects from inhaling and handling the insulation.	Not individually calculated
Roof Top up loft insulation Extend eaves to rear.		Eaves extension to rear with replacement gutters. Add mineral wool insulation with wind-proof membrane over.	None.	Increased thermal comfort in top floor flats and a reduction in energy bills as heat isn't lost through the roof.	Detail necessary to be developed that ensures continuity of the thermal line between loft insulation and walls. Roof ventilation will need to be maintained.	Heat demand reduction (kWh/m2.year): 36* Annual cost saving: 259* Capital cost (£): 1,154
Photovoltaic panels New PV panels on existing roof		4no. PV panels per flat installed on the south facing side of the pitched roof. Inverters installed, with wiring implemented in earlier works to allow electricity to be split between flats	Limited disruption during installation if installed alongside other measures which require scaffolding. Some limited disruption within flats in earlier phase	Reduced electricity demand & hence cost for residents. Especially important to support ASHPs / direct electric heating implemented in following phase	Roof strength to be confirmed. Occasional maintenance requirements	Heat demand reduction (kWh/m2.year): 0 Annual cost saving: 305 Capital cost (£): 3,848

EXTERNAL WALL INSULATION

External wall insulation is the most effective insulation for existing walls. As it covers any potential thermal bridges these do not present a risk, and consequently a thick layer of insulation can be used. It is far less disruptive to install than internal wall insulation and has no spatial implications internally. As the existing stone will be kept warm throughout by the new insulation, condensation risk is considered to be very low.

A layer of insulating plaster (diathonite) is proposed to flatten off the existing bullnosed stonework, so that flat insulation boards can be applied without a risk of thermal bypass behind these. This will also create an airtight layer to which windows and doors can be sealed. It is however still breathable, so moisture can move through this layer.

Mineral wool insulation is proposed as it is non-combustible. Any material could be used as an external finish, but render is suggested to keep costs down. If this is applied directly to the insulation, micro-cracks are likely to appear over time, allowing water into the construction and causing degradation. Therefore a carrier board system is suggested. The precise details of this system, colour, durability and other potential finishes can be explored at a later stage. It is noted that the existing brick walls are extremely durable, and whatever material External insulation is the most effective insulation for existing walls. As it covers any potential thermal bridges these do not present a risk, and consequently a thick layer of insulation can be used. It is far less disruptive to install than internal wall insulation and has no spatial implications internally. As the existing stone will be kept warm throughout by the new insulation, condensation risk is considered to be very low.

Prior to insulation being installed, all fixtures will need to be removed, including rainwater downpipes, waste pipes, satellite dishes and cables, to be replaced at the end of the work. Existing boiler flues and extract grilles will need to be extended.

The eaves will need to be extended over the new insulation to keep it dry. A detail will need to be developed that ensures continuity of the thermal line between the loft insulation and the walls, as well as maintaining roof ventilation. Gutters will then need to be reinstalled to suit this new line. This will apply to the rear and the hipped west end roof. At the east end the insulation should be taken up the gable to the pitch line and the waterproofing over the gable end wall should be replaced to cover both existing wall and new insulation layer.

It would be possible to take insulation down below ground level, thus reducing thermal bridging where the EWI stops. This may also reduce heat loss into the ground to some extent. However as the floors to the flats are ventilated there will continue to be cold air moving through the void below, so this will be of limited impact. Thermal bridge calculations can be carried out at the next stage to determine the impact of this and whether the thermal bridge presents a moisture risk.

As noted in the explanation of ventilation options, prior to the installation of this insulation, which will change how the building functions as an holistic system, it is important that ventilation is upgraded.

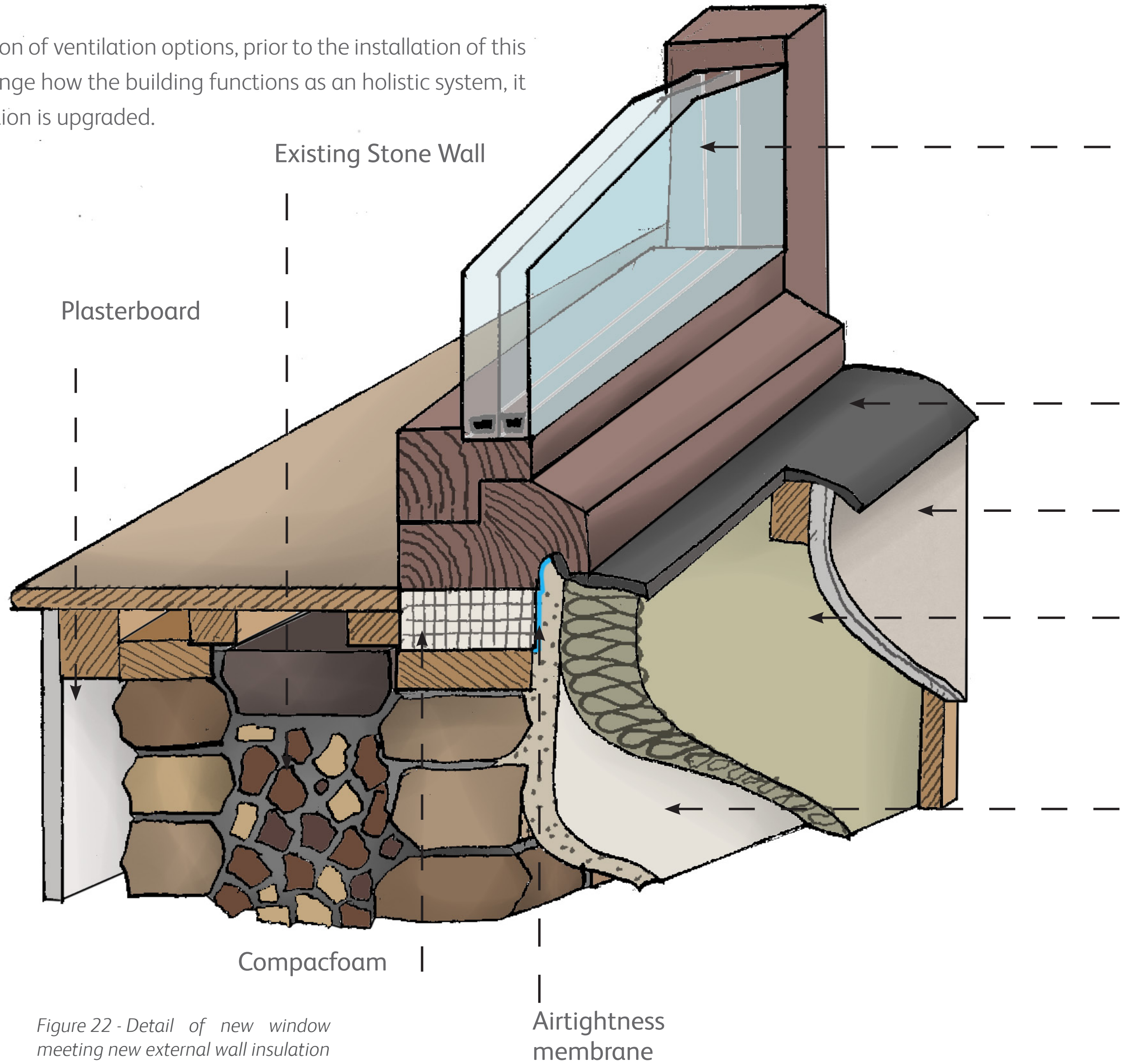
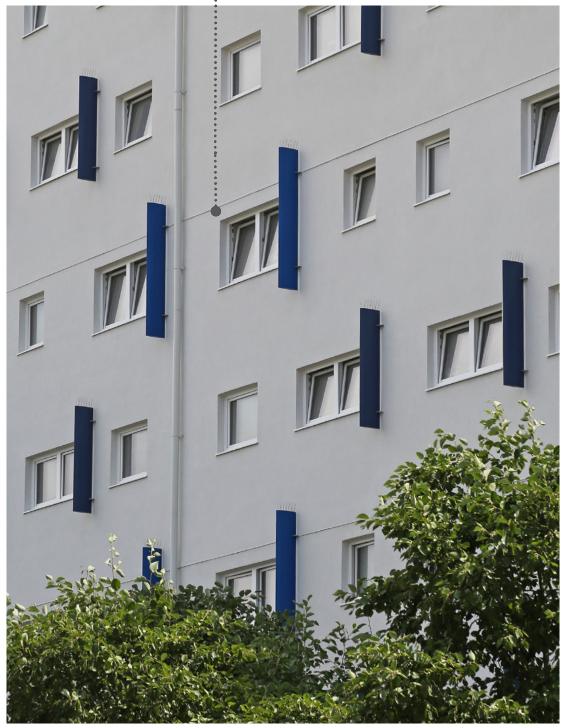


Figure 22 - Detail of new window meeting new external wall insulation

EWI APPEARANCE AND OPPORTUNITIES

Render colour options



Brick Slips and Projecting brick composition

Varying the colour of render to make an interesting facade appearance

Render composition with mural feature

WATERPROOF FINISH

The new insulation layer will need to be finished with a durable, waterproof covering. While all proposed materials must be non-combustible to maximise fire safety , a range of options exists.

BRICK SLIP FINISH

Blonde/ Red brick slips could allow the retrofitted building to retain a relatively similar appearance to its context, but use of varied colours and brick laying patterns could also be used to introduce focal points to the building's façades. However, this may be an expensive option especially if only being applied to the sides and rear elevations.

RENDER FINISH

Render could also be used over the insulation, this may be a more economic option and is what we have initial proposed and costed for.

LOCAL ARTIST OPPORTUNITY

If a standardised neutral colour is selected there is the opportunity to get a local artist involved to paint a mural on one of the gables. This could bring an aspect of local culture and vibrancy to the street.

COLOURED RENDER FINISH

However, render does not have to be white/cream and coloured renders could be considered to allow the use of a range of colours without the need for frequent repainting.

EWI APPEARANCE AND OPPORTUNITIES

A DURABLE GROUND FLOOR FINISH

Tenements have always been known for their long-lasting and sturdy use of materials. They can weather any kind of harsh weather, constant use, wear and tear and still maintain their appearance, requiring less maintenance over time.

However, when it comes to applying EWI and render to the external walls, there is a downside. These materials are not nearly as durable as sandstone and will degrade over time, reducing the effectiveness and appearance of the building.

We believe that there is an opportunity to take into account the history of these materials and create a modern and complementary solution. That's why we propose a render finish at high level, but a more durable finish at ground level.

We suggest taking the interior finish and wrapping it around the exterior walls on the rear and side elevations to create a plinth finish. This could be achieved using tiles, brick slips, or a concrete finish in a range of colours and patterns. The images to the right and below demonstrate this concept.

Contrasting use of colour

Durable Plinth

EWI APPEARANCE AND OPPORTUNITIES

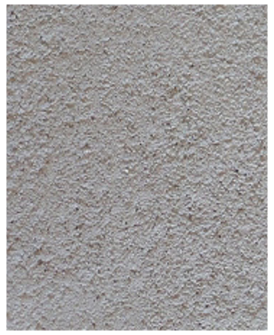
PLACE MAKING AND SENSE OF IDENTITY

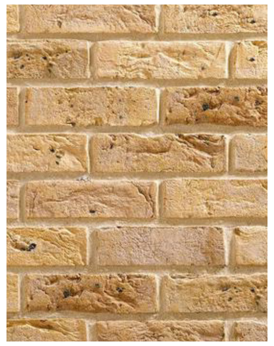
The examples to the right show how tiles, colours and textures can be used to create a sense of identity and vibrancy.

If a general strategy of tiles at ground floor and render above was agreed in principal across the whole of the clients estate then consideration could be given to selecting a different colour for each block or area. This would help give each block a sense of identity and could be tied back to the history of the site or the choice made by residents at the time of the refurbishment.

By having a sense of ownership residents may be more inclined to take pride over their surroundings and less maintenance may be required in the long run.

Contrasting use of colour to bring vibrancy and a sense of place





Tiles used at ground floor

COMMUNAL CORRIDOR FLOORS

A further reduction to heat loss in the communal areas could be achieved by adding insulation over the existing concrete floor. The thickness needs to be limited to avoid significant difference in floor levels at doors and stairs. However a thin layer of high performance insulation, such as Aerogel, could reduce heat losses without causing these problems. At the next stage, a full survey will establish floor levels throughout, so that a detailed assessment can be carried out.

PREPARATION FOR AIR SOURCE HEAT PUMP INSTALLATION

Assuming that heat pumps are at least part of the solution to providing heating and hot water without using fossil fuels, some preparatory works are needed in the communal areas in advance the first flats actually being powered by these. Pipework will need to be run from each flat through the stairwell and corridor to the location of future external heat pump units. An acoustic and visual screening will need to be erected in the garden areas to enclose the future external heat pump units. These need to be large enough to ensure sufficient air circulation is available to each unit.

DOORS TO EACH CLOSE

Replacing existing doors and gates at the front and back of each close with airtight, insulated doors, will mean that the air in the communal corridors and stairs will be kept warmer. This means less heat will be lost from each flat into this space.

New doors need to be well-sealed into the existing openings, and will need to be sufficiently robust that they remain relatively airtight even after years of use. At present doors into the rear gardens are often left open, so educating residents about the impact of doing so in the winter may help to ensure that the money spent on new doors is an effective investment.

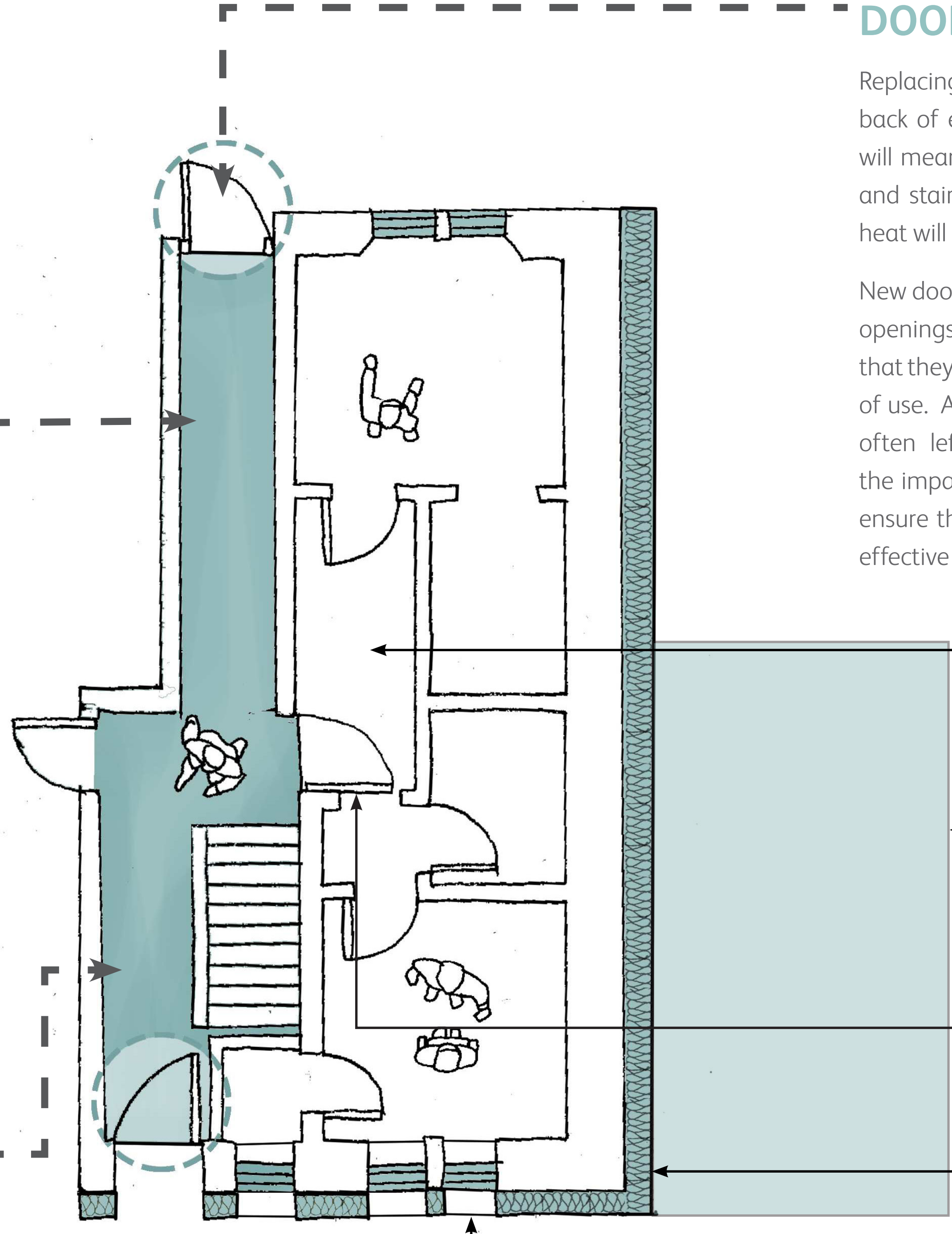


Figure 23 - Floor Plan of typical ground floor flat showing communal and external works done with residents in situ

NEW WINDOWS

Residents have specifically noted that windows are draughty, suggesting poor installation. Replacing existing double glazed windows with triple glazed windows, that are airtight and well-installed, will reduce heat loss through both glass and frames, as well as through gaps around the edges. This will also make it more comfortable near windows even if the actual internal temperature is no warmer.

While there will be some disruption as windows are replaced, this is a task housing associations typically carry out with residents in-situ. Although speed will be of the essence, the contractor will need to ensure original timber framing has been fully removed. The installation design will need to take into account phasing of the works, so that ultimately an airtight seal can be made to the airtightness layer within the wall.

If MVHR is the chosen ventilation solution, the windows must not have trickle vents. If demand controlled mechanical extract is chosen the windows should include trickle vents, ideally controlled by humidity.

PHOTOVOLTAIC PANELS

The strength of the existing roof structure needs to be confirmed by a structural engineer to confirm that it can support the additional weight of PV panels. Additional structure could potentially be added if required. It is noted that the building conditions survey suggests a complete re-roof in the coming 1-3 years. This could be combined with the installation of PV panels. Additional weight could be kept to a minimum by using integrated panels that replace tiles rather than sit over them.

As the flats face roughly north/south, only the south facing area of the roof will be suitable for PV panels. It is possible to direct electricity from specific panels to individual flats. Each flat could be linked to a certain number of panels, either based on floor area or predicted energy demand. This will maximise usage of the electricity created, which is more cost-effective for residents than selling excess energy to the grid. Electricity production from PVs is typically not well-aligned with need for electricity in the flats - electricity is not needed as much when the sun is shining, while it is needed more when it is cold and at night. However new hot water cylinders installed as flats are retrofitted when they become void will act a bit like a battery, using electricity produced during the day to heat up the water for use later when heating and hot water requirements are higher. It should also be noted that a significant number of residents are at home during the day, so may derive more benefit from the PVs than those who are out all day.

At present 4no. PV panels per flat are allowed for. The exact size, number and layout needs to be designed in detail. It is also essential that the local authority building control is consulted to ensure they will accept the use of PVs on the roof of a block of flats, as fire-related concerns have been raised in some instances.

OUTCOMES

The significant measures here will reduce the building's heat demand, and consequently reduce how much energy residents use, and so reduce their energy bills. The flats will continue to have gas-powered heating and hot water after this stage of work, and gas use will go down. Electricity use is likely to remain relatively constant after this stage of work. So overall energy bills reduce dramatically, by an average of £750 per year, from and average of £1,779 down to around £1,243

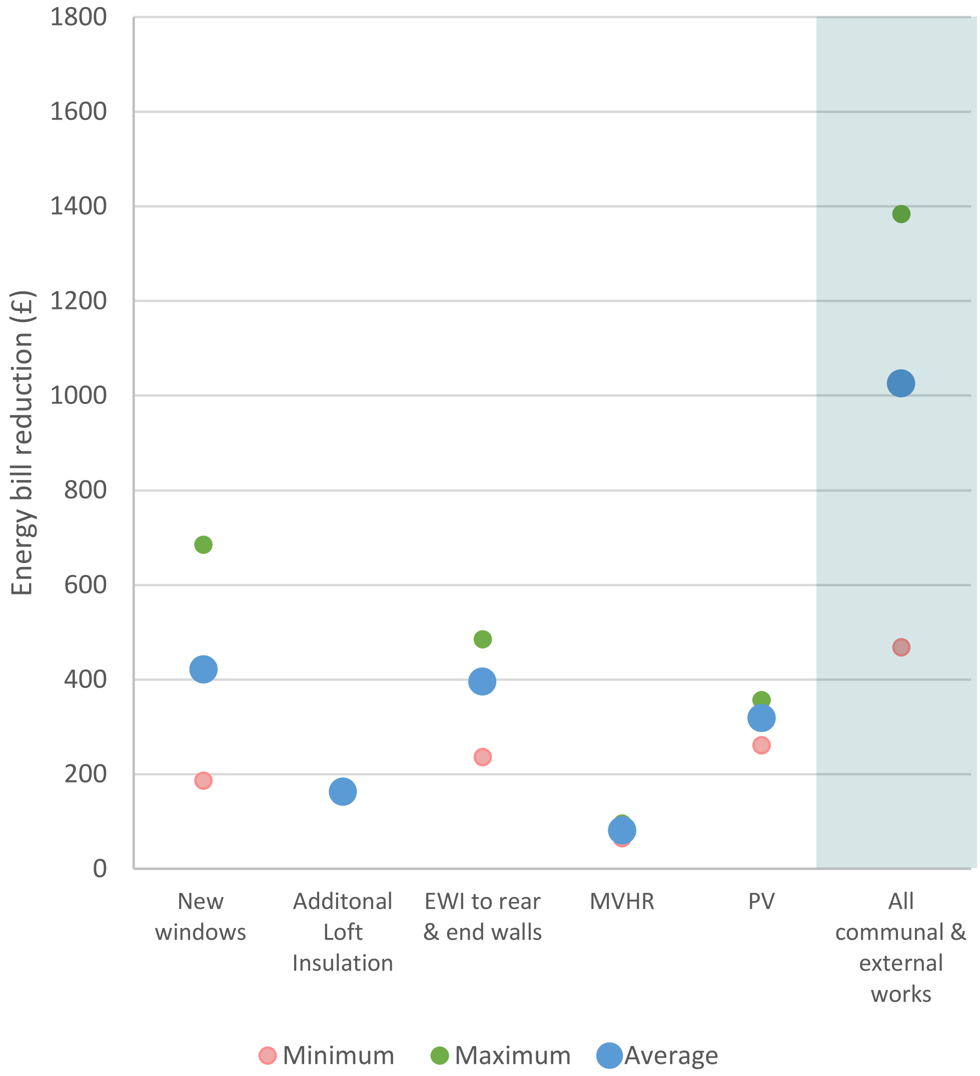
ENERGY BILLS
£1779

HEATING LOAD
76
W/m²

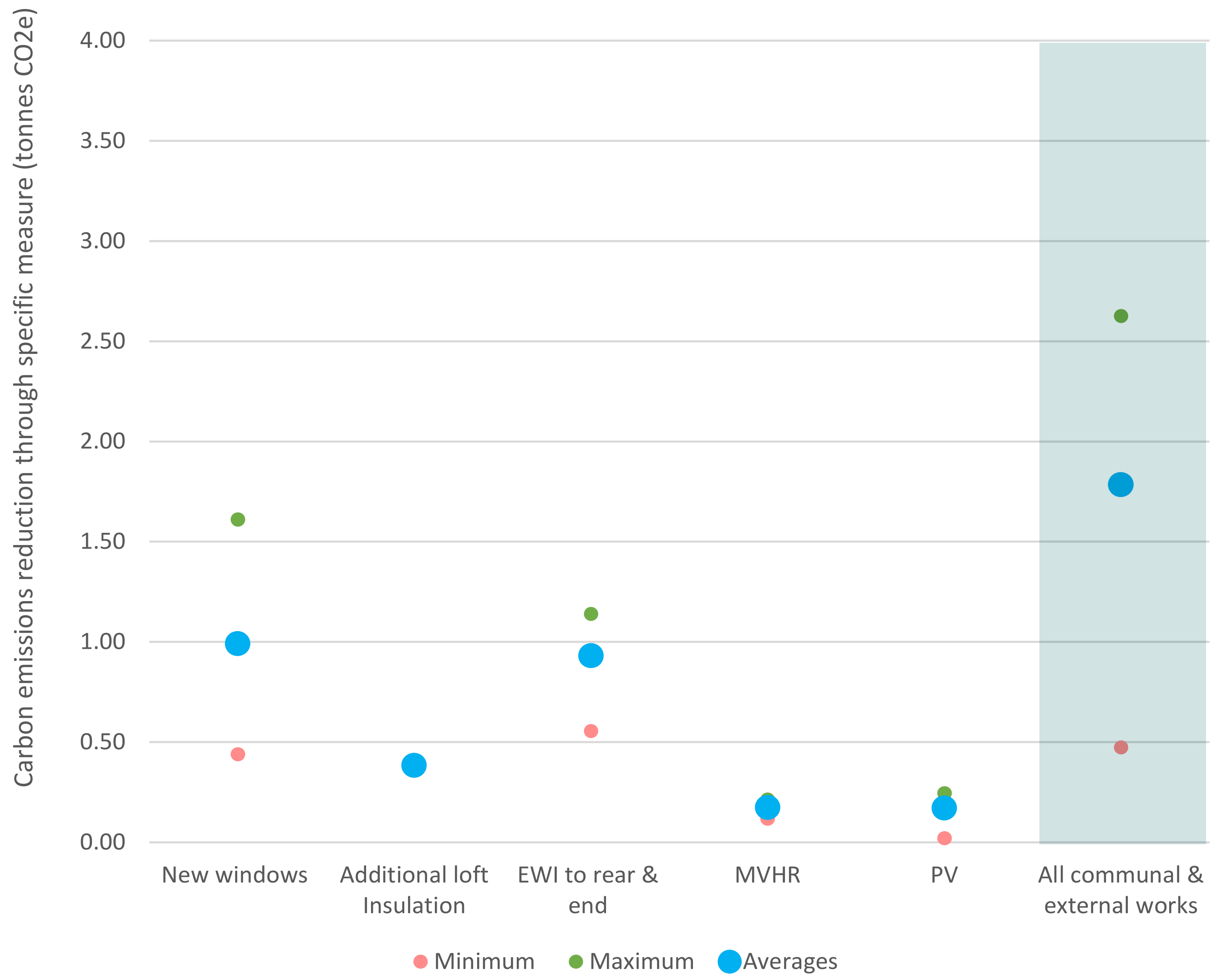
HEATING DEMAND
187
kWh/(m².a)

CARBON EMISSIONS
106
tonnes CO_2e

Energy Bill Reduction Through Communal & External Works with Residents In-situ



Carbon Emissions Reduction Through Communal & External Works with Residents In-situ



[Blank page]

06

Proposed Measures

Within Flats, When Void

PROPOSED MEASURES

Measure	Image	Proposal	Disruption / space	Pros	Cons / Risks	Savings
Internal Walls Internal Wall insulation.		Remove internal fixtures such as skirtings & existing service void. Level existing stonework with layer of insulating plaster. Add new woodfibre board insulation with lime plaster airtightness layer. Reinstate service void & skirtings.	Minor loss of space to front facing rooms. Disruptive during installation (hence to be done in void flats). Kitchens / bathrooms on these walls to be replaced in conjunction with these works.	Creates relatively complete and continuous layer of insulation to all external walls, reducing heat loss, improving airtightness & comfort.	Full hygrothermal modelling of joist ends in wall must be carried out for all situations that will occur (eg. flat above insulated but not flat below, both flats insulated etc) to ensure no moisture risk created in existing stone wall. Also carry out thermal bridge analysis to ensure no overly cold spots created in neighbouring flats not yet insulated.	Heat demand reduction (kWh/m2.year): 21 Annual cost saving: 87 Capital cost (£): 4,452
Heat Pumps Air Source Heat Pumps.		Install Air Source Heat Pump and hot water tank . Upgrade radiators (depending on heat load of each flat).	Space will be lost in each individual flat for the hot water tank to be installed. Depending on the heat load, radiators will need to be replaced with larger radiators.	Flats no longer have to rely on fossil fuel and therefore reduce emitting carbon dioxide significantly.	Installation cannot be taken place until all fabric improvements have been carried out, otherwise energy bills could go up. Not suitable for small, 1 bedroom flats, as hot water cylinder also required with ASHP and space not available in small units.	Heat demand reduction (kWh/m2.year): 0 Annual cost saving: 2 Capital cost (£): 15,397
Insulate ground floors Insulation between joists to ground floors of flats.		Windtight membrane installed over joists. Airtightness layer installed over joists and insulation.	Invasive as access is required to the full floor of each ground floor flat.	Maintain thermal comfort to ground floor flats.	Ventilation grilles should be restored to full functionality prior to this proposed work taken place. Windtight and airtight membrane should be taped to the inside of existing wall.	Heat demand reduction (kWh/m2.year): 98* Annual cost saving: 342* Capital cost (£): 1,500
Roof Ceiling replacement.		Remove and replace existing ceiling. Install new airtightness membrane to underside ceiling joists.	Invasive as access is required to all rooms within top floor flats.	Maintain comfort to top floor flats.	Ensure proper safety measures are taken for workers prior to measures taken place.	Not individually calculated

INTERNAL WALL INSULATION

In order to preserve the original front facade of the building external wall insulation is not proposed here. Internal wall insulation is more invasive to install, so it is assumed that it will be installed as each flat becomes void over time, along with other renovation works that are typically carried out between tenancies.

The total thickness of insulation that can be used is limited by the need to avoid creating moisture risks within the wall. At present the stone wall is cold on the outside and warm on the inside, and the joists that are embedded in it are basically warm. Installing insulation on the inside of the stone means that it will in future be cold all the way through. The temperature around the joist ends will also be lower. At lower temperatures moisture in the air is more likely to condense. Therefore there is a risk that moisture could condense around joist ends and ultimately lead to rot. A thinner layer of insulation can still reduce heat loss and make the home more comfortable but not create the risk of moisture forming. A hygrothermal assessment has been carried out, evaluating the existing stone and looking at what thickness and types of insulation may be suitable. The report is included in the appendix.

It is suggested that the existing service void is removed and a layer of insulating plaster is applied to the inner face of the stone work to level it out prior to new insulation being fitted. Insulation would then be installed and a new service void can then be created to the inside of this, allowing future flexibility of services arrangements. The skirting would then be replaced, and this would impinge about 65mm into the existing rooms along the front wall.

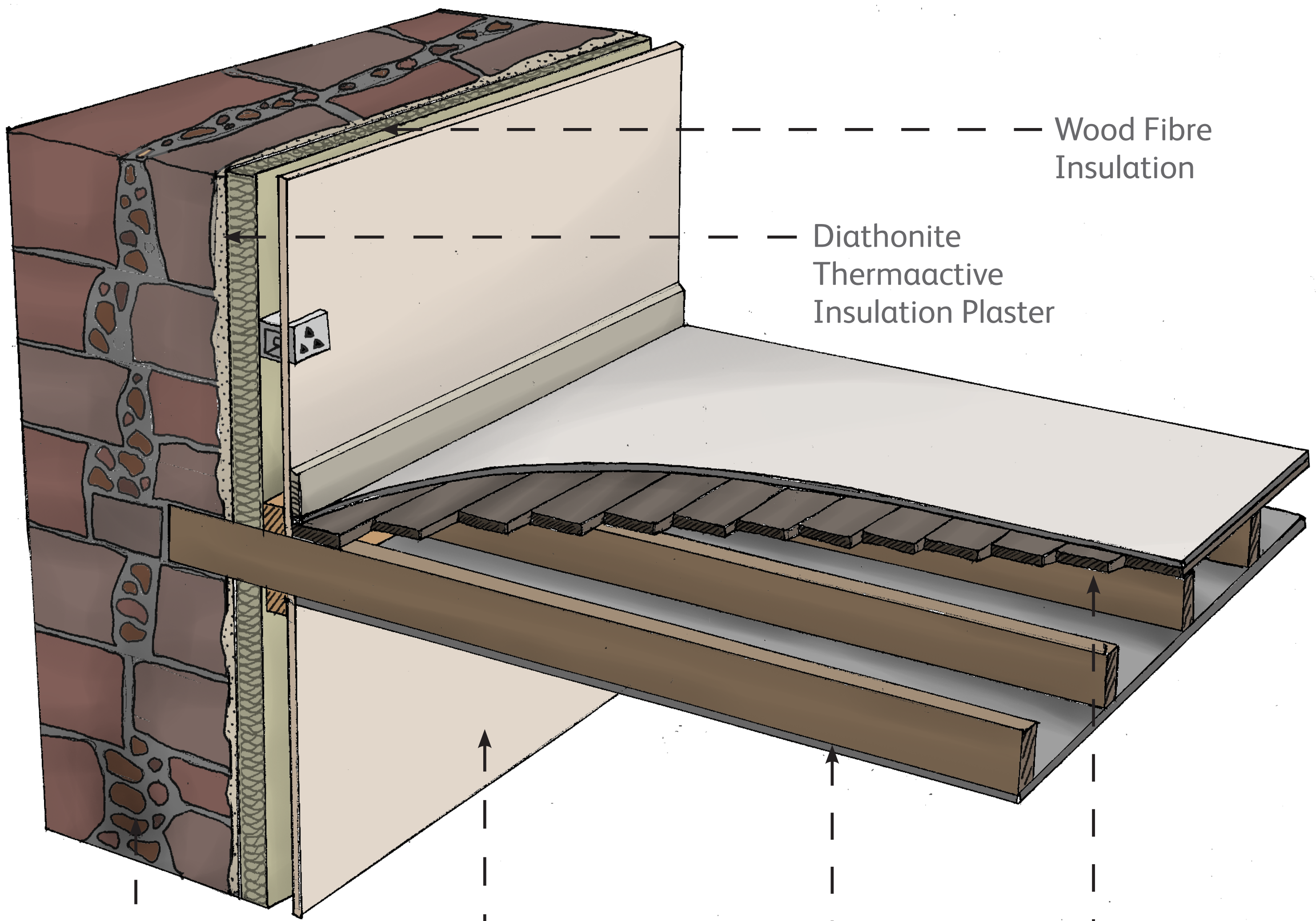


Figure 24 - Detail of existing floor joists embedded in stone wall with new internal wall insulation to wall above and below floor

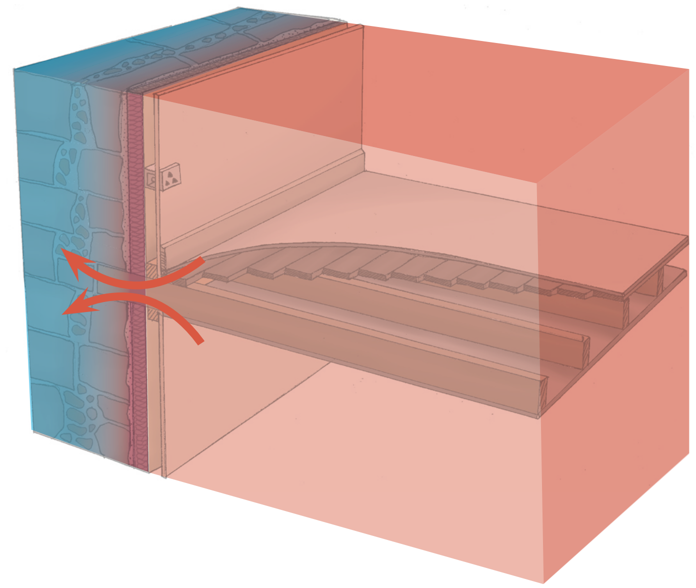


Figure 25 - Detail coloured to show heat movement through thermal bridge at joist ends

Internal Wall Insulation Material Choice

The new insulation material should be breathable (i.e. allow moisture to move through it, rather than trapping it). Two possible materials were investigated - woodfibre board and calcium silicate board. Woodfibre board is cheaper and is a more efficient insulant, but manages moisture less well. While it had been suggested that Woodfibre board could only be with water-repellent 'cream' applied to the outside of the stone, it has subsequently been confirmed that with a hygrothermal assessment that demonstrates that moisture content within the wall build up will be sufficiently low this is not necessary. Therefore it is proposed that 60mm woodfibre board is used, on top of the diathonite insulating plaster. It is noted that the completed U value (0.32/0.34 W/m^2K) will be higher than the maximum target set by 6.2.1 of the Building Regulations. However the traditional nature of the building and the hygrothermal analysis demonstrate the risk of over insulating this wall, in line with 6.2.7 of the Building Regulations, so this is considered likely to be acceptable, particularly as it is significantly better than the current performance and better than the absolute maximum U value of 0.7 W/m^2K.

Build up	60mm wood fibre, 25mm diathonite	50mm Calcium silicate board, 10mm diathonite
U value (W/m^2K)	0.32 / 0.34	0.49 / 0.55*
Heat demand saving through specific measure (kWh/m^2.year)	65	60
Energy bill saving through specific measure (£/year)	87	83
Carbon saving through specific measure (kgCO2e/year)	240	200

*two numbers denote thinner and thicker areas of existing external wall

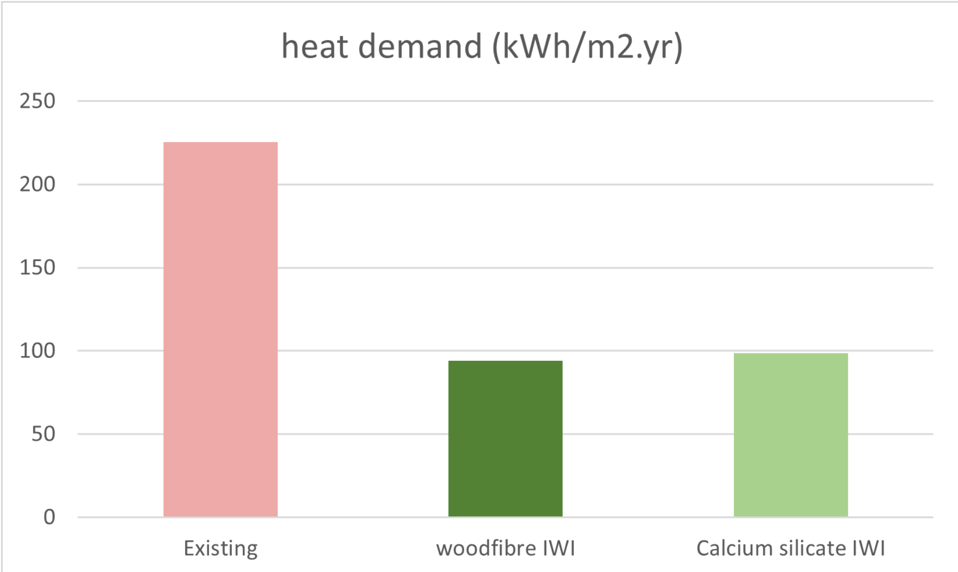


Figure 27 - Graph showing heat demand for different internal insulation materials. Although the conductivity of the build ups and the consequent U values are somewhat different, the area covered as a proportion of the whole building is relatively small, so it is not very impactful on the heat demand

Insulating Existing Service Void

An investigation was carried out as to whether insulation could be blown into the existing service void, as this might offer a lower-disruption solution. This could then potentially have been applied to all external walls. This proposal has not been taken up because:

- Services would need to be put in conduit prior to insulation being blown in, so this would in fact be quite disruptive
- Hygrothermal assessment showed that on the south wall, which receives more wind-driven rain, a high moisture risk would be created if IWI was installed here
- The service void was not built to take insulation, so the quantity and quality of stud work etc is unknown, meaning the quality and continuity of insulation would be uncertain.

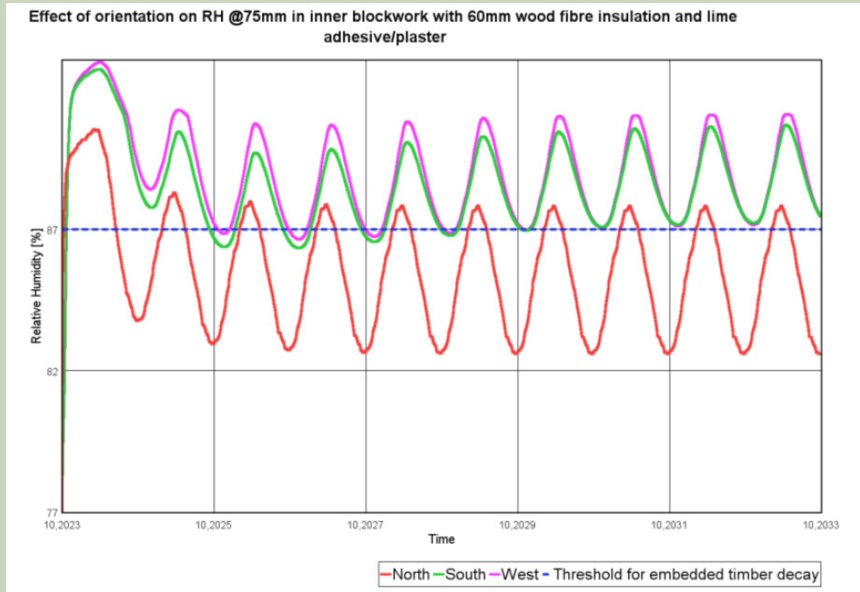


Figure 26 - Graph showing relative humidity in the wall if IWI (60mm woodfibre & lime) is applied to north, south and west orientations. While all orientations peak above the cut-off line with this particular build up, the lowest risk is to the north facing wall.

Insulation into window reveals

It is assumed that new windows will have been installed before any IWI is installed. The window installation will need to be designed to ensure that when IWI is added space is left for this to return into the window reveals to reduce thermal bridging here. In order to reduce the depth of this insulation aerogel could be considered. The windows will also need to be taped to the new airtightness layer, which will be lime plaster over the insulation.

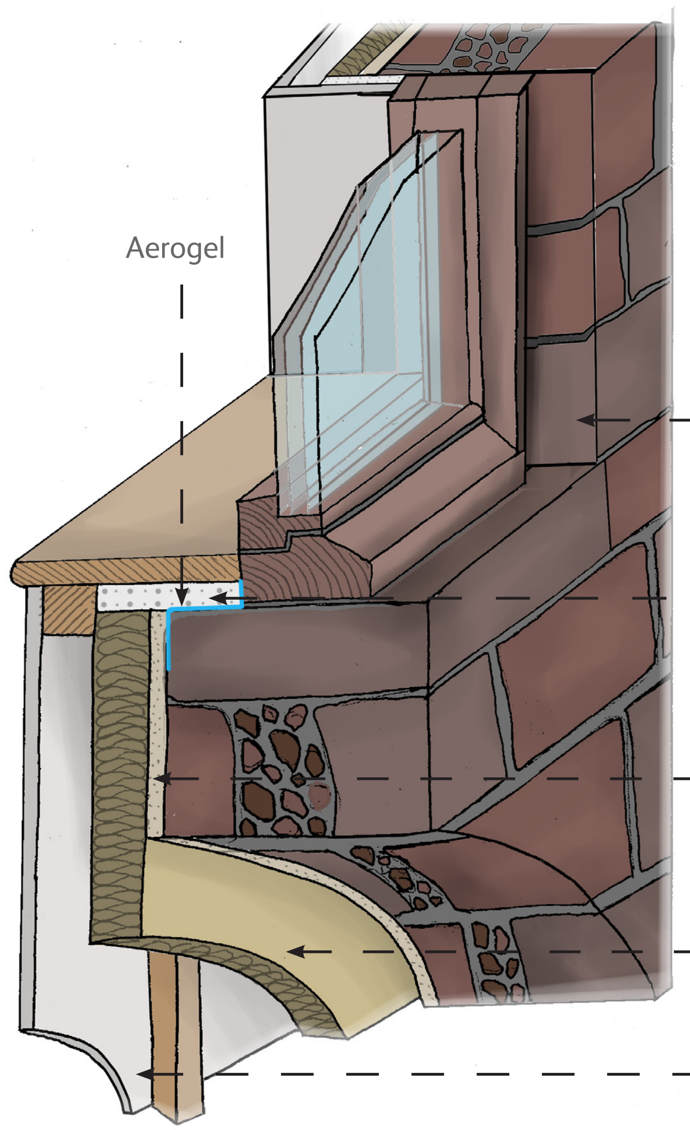


Figure 28 - Detail of new window meeting new internal wall insulation

Limitations of working flat by flat

Inevitably there are limitations to only ever having access to one flat at a time. It will not be possible to have a completely continuous line of airtightness or insulation around the whole building, so the overall airtightness will never be excellent.

Not getting to access joist ends during the works is part of the reason that the thickness of IWI needs to be limited, as set out on P58.

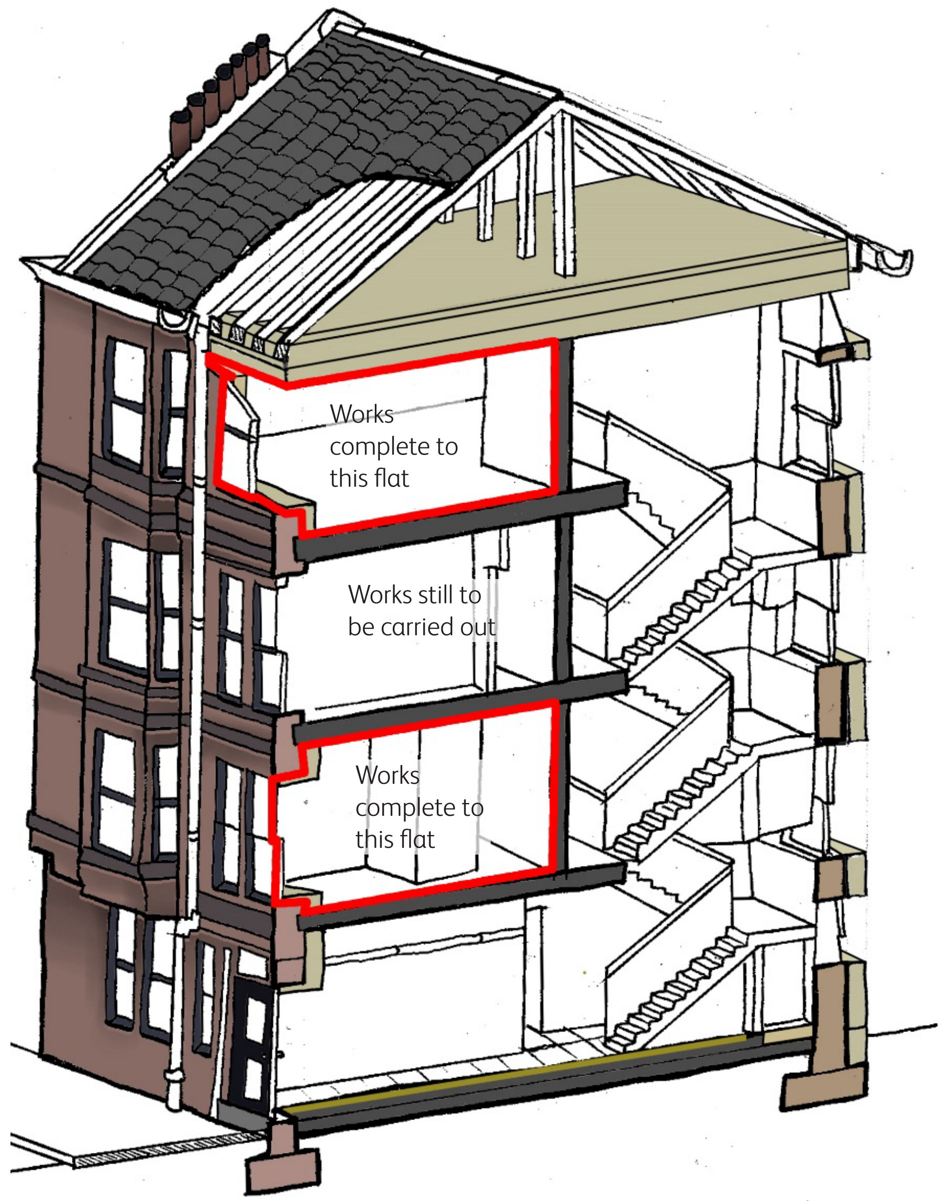


Figure 29 - View of block highlighting some flats being accessed before others, limiting the efficacy of work overall

INTERNAL GROUND FLOOR

This work would also be invasive as it will require access to the full floor area of each ground floor flat, including in kitchens and bathrooms. A windtight membrane should be installed over the existing joists, stopping windwashing of the insulation and supporting the insulation. An airtightness layer can then be installed over joists and insulation. Both membranes should be taped to the inside of the existing masonry walls / the airtightness layer of these walls.

The opportunity should be taken to remove rubbish from the below floor void, and it is imperative that the ventilation grilles are restored to full functionality before this insulation is installed.

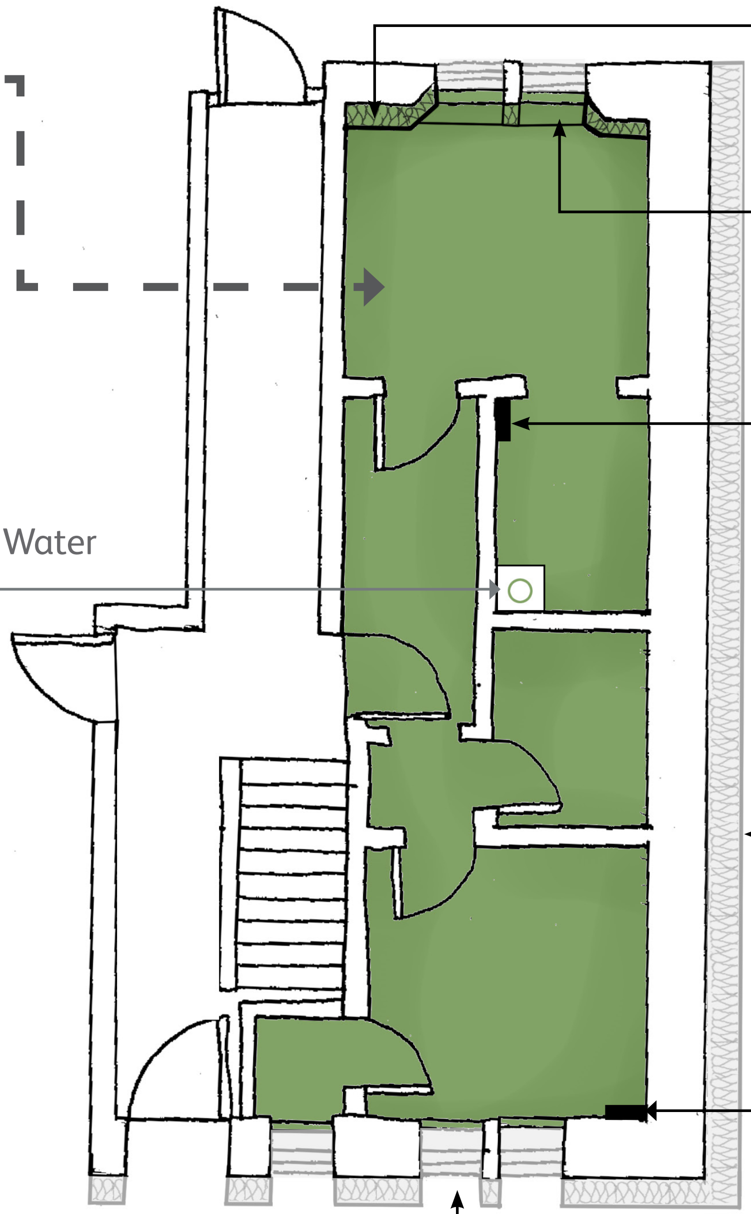


Figure 30 - Floor Plan of typical ground floor flat showing works done within flats when void.

LOFT INSULATION

It is understood that 250mm insulation has already been installed in the loft, in two layers, one between joists, and one running the other way over the joists. The quality of this should be checked in above each stairwell, as it is understood that there may be areas of lesser quality installation. The type of insulation used should also be confirmed, along with checking that eaves ventilation is maintained and that insect mesh is in place at the eaves.

This level of insulation is adequate, and broadly in line with the other measures proposed. However adjustments to the eaves may lead to a requirement for alterations to the existing situation. If SHA are minded to go as far as possible with the project, the following additional measures could further reduce heat losses through the roof:

- Install insulation at least 1 metre up the party walls within the roof void to minimise thermal bridging here.
- Add a further 50mm - 100mm insulation to what is there
- Install a wind proof membrane over the insulation to stop 'wind washing' of the insulation, which reduces its effective performance
- During individual flat works to top floor flats, remove ceilings, install an airtightness membrane across the underside of the joists, and replace ceilings.

AIRTIGHTNESS LAYER TO TOP FLOOR FLAT CEILINGS

As set out in the works to outside the flats, the flats would be more airtight if existing ceilings to top floor flats were removed, an airtightness layer installed below the joists and a new ceiling put up. It will likely not be worth carrying out this step if the decentralised mechanical extract ventilation solution is chosen, as in this case windows will have trickle vents, so the building will never become extremely airtight.

AIR SOURCE HEAT PUMP INSTALLATION

This is the key step to move the flats away from relying on fossil fuels and hence emitting carbon dioxide, but cannot be implemented until fabric improvements have been carried out. This is explained in detail in the boxed text to the right.

Each of the larger flats would have its own dedicated external heat pump unit, in the rear gardens. These would be linked to an internal Hydrobox unit, which is a similar size to the boiler that will be being removed.

Depending on the heat load of each flat after the fabric works, it is likely that new radiators will be needed. This is because the heat pump will work best at lower temperature. With cooler water in the radiators, larger radiators are needed to emit a similar amount of heat.

A hot water tank will also be needed alongside the heat pump, as unlike the current gas boilers, the heat pump cannot produce lots of hot water immediately. It is understood that there is likely to be space for this in the 3 bedroom flats.

In the one bedroom flats there is not likely to be space to install both the hydrobox and a new hot water cylinder. As heat load and the domestic hot water requirements here are low, it is suggested that these homes will be heated by a combination of electric panel heaters and storage heaters, with domestic hot water supplied by an electric boiler. As the flats will now have a much lower heat load the energy bills will still go down, even compared to the previously gas-powered boilers. (see page 42 for details). Exact bills will of course vary with changing energy prices, but also depending on the tariffs that residents are on.

This also reduces the number of external ASHP units that are required in back gardens, so that these take up less space.

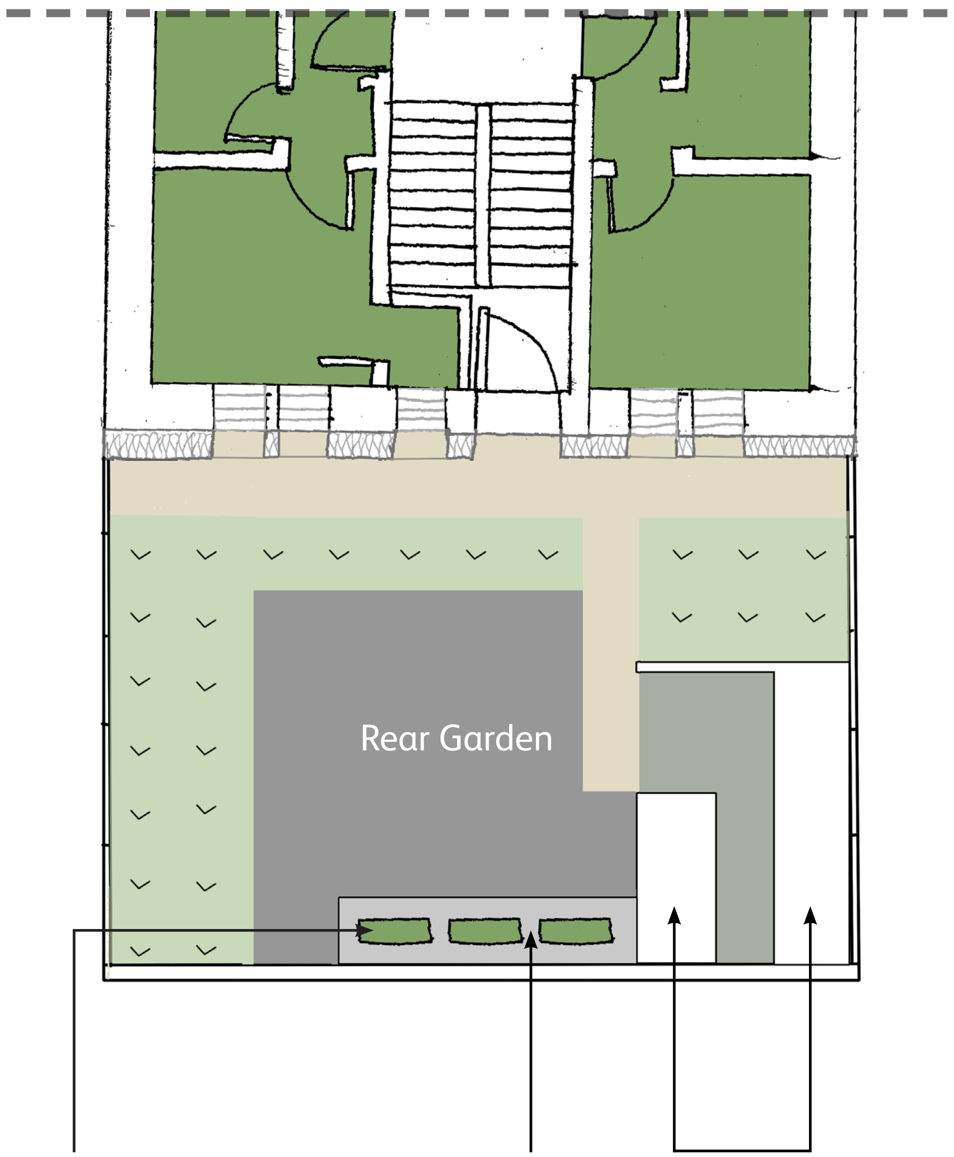


Figure 31 - Ground floor plan showing typical external compound placed at garden at rear.

HEATING DEMAND & HEAT LOAD

Heating demand and heating load are different numbers describing different factors however both figures have an impact on the detailed design and overall performance of any retrofit project.

Heating demand is the amount of heat required to keep the flat within an acceptable, comfortable temperature range which typically for a domestic property is 21deg.C. Heating demand is expressed as the amount of kilowatt hours per square metre per year (kWh/m²/a).

The heating demand is calculated as part of the energy modelling that happens at design stage. It's a holistic review of how that individual building's components will perform, taking all specifics into account (heat loss from fabric, air permeability levels, thermal bridging etc)

Heating load is the power used by a heater generator of sufficient size to keep the temperature within the flat comfortable on the coldest days of the year. For example, if the if the calculated heating demand of the flat is 6kW (for space heating and hot domestic water generation) and the proposal was to use air source heat pumps to generate this demand and the heat pumps operated at a seasonal coefficient of performance (SCOP) of 3.0 the heating load to meet this 6kW demand would be 2kW.

From an operational cost perspective at Old Shettleston Road the base heat load is starting around 101 W/m2 and opportunities have been identified to reduce the heat load to around 31 W/m2 when various improvement measures are applied. Gas is generally 3 times cheaper than electricity per kWh, a local ASHP SCOP is around 3.0 however the COP during more extreme winter conditions (which is when the heating is most needed) drops to just above 2.0 hence ideally, we should try and get the demands down to at least 41W/m2 to keep the heating bills cost neutral for the before and after works if adopting ASHPs. Should less efficient electrical forms of heating be proposed the requirement to further reduce heat load from the base point becomes more stringent.

Note that the numbers for either heating demand or load do not directly relate to achieving carbon net zero. Even a certified EnerPHit build will need some heating to remain at 21deg.C through the winter and will have domestic hot water demands. The relationship to net zero relates to the carbon factor of the heating systems fuel source and if any carbon offsetting is to take place. Using electrified heating systems (like heat pumps) will greatly assist in achieving net zero carbon as opposed to fossil fuel sources (like gas boilers).

OUTCOMES

While all flats' energy bills reduce in this phase, the variation in bill reduction is greatest for this step. This is due to two factors: Insulating the ground floor obviously only really affects these homes; the three bedroom flats benefit from the excellent coefficient of performance of the air source heat pumps. This means that for every kWh that they pay for, they get 2-3 kWh of heat. Meanwhile the smaller homes, with direct electric heating only get 1kWh of heat for each kWh they pay for.

The carbon emissions reduction from the transition to heat pumps is the most dramatic of all measures in any phase.

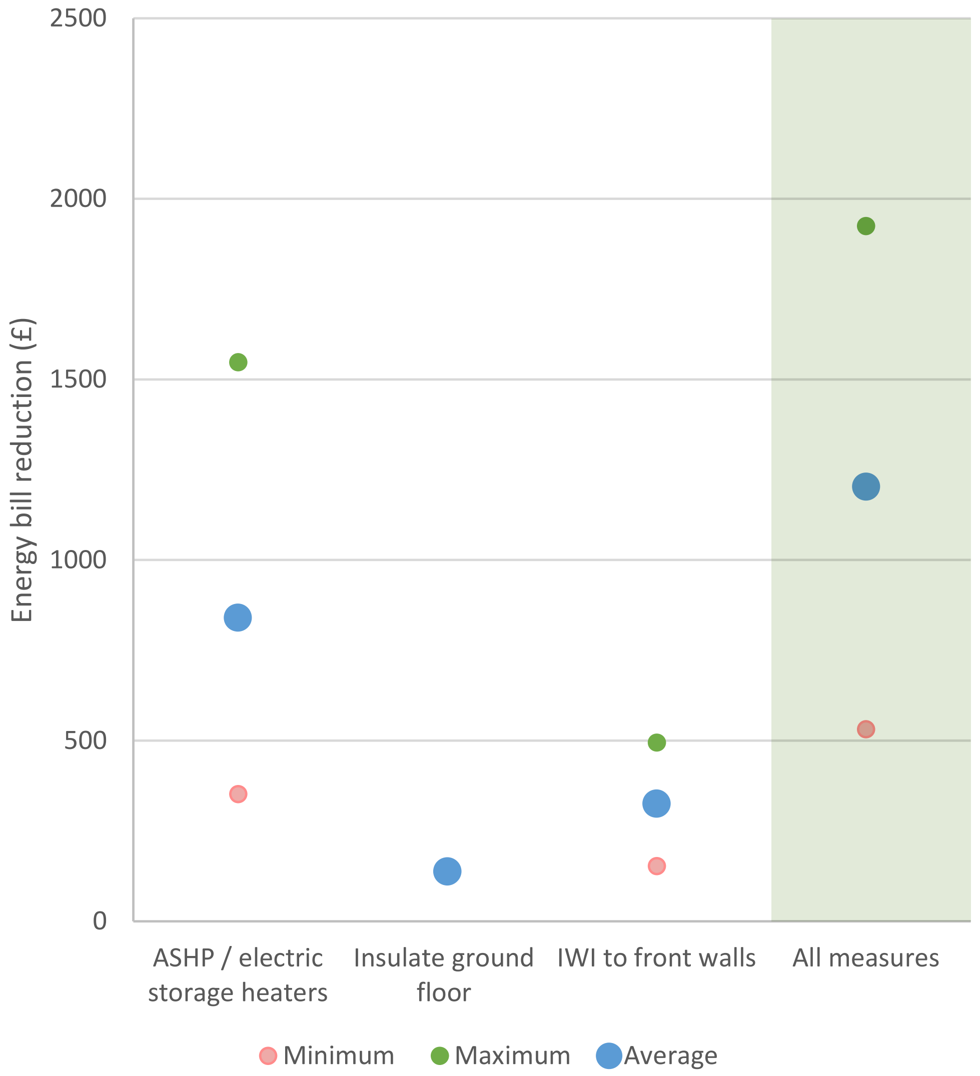
ENERGY BILLS
£1159

HEATING DEMAND
59
kWh/(m²·a)

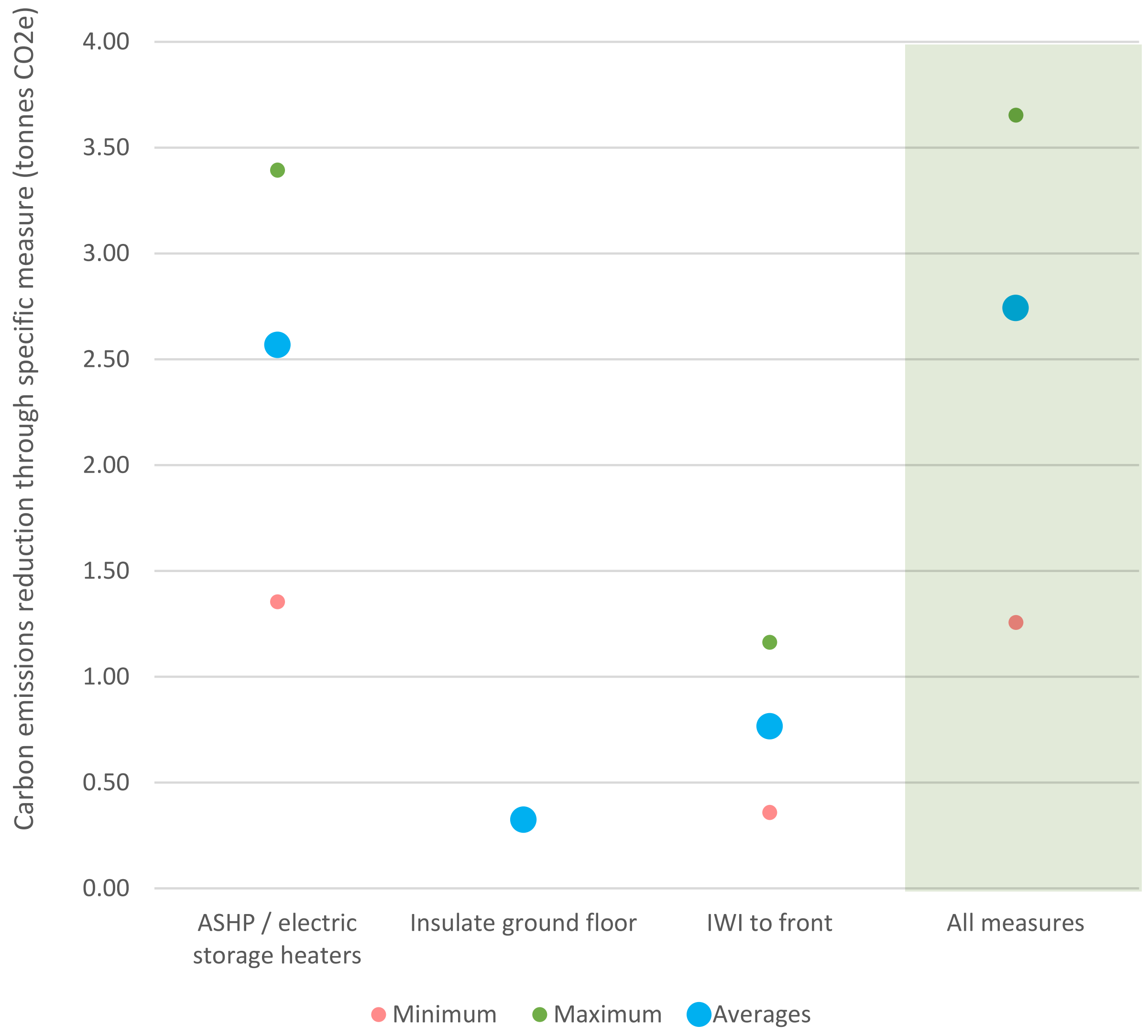
HEATING LOAD
31
W/m²

CARBON EMISSIONS
25
tonnes CO_2e

Energy Bill Reduction Through Works Within Flats When Void



Carbon Emissions Reduction Through Works Within Flats When Void



[Blank page]

07

Further Considerations

Shettleston HA intend to implement some of the measures outlined in this report, potentially over a period of years as flats become void. Understanding the positive impact of the investment SHA are making is key to ensuring good decisions are made across the block as a whole, across SHA's wider stock and indeed across tenements around Scotland.

Monitoring the building before, during and after works, with a clear strategy, will demonstrate the impact of the works, as well as highlighting any unintended consequences. This should include ongoing discussion with and surveying of residents, as while improving the building is important, improving residents lives is the top priority.

DESIRED OUTCOMES OF EVALUATION

- Highlight specific areas that are not working as intended and remedy these
- Learn lessons during project for better implementation across flats and for other future retrofits by SHA or of other tenements.

PRIOR TO WORKS

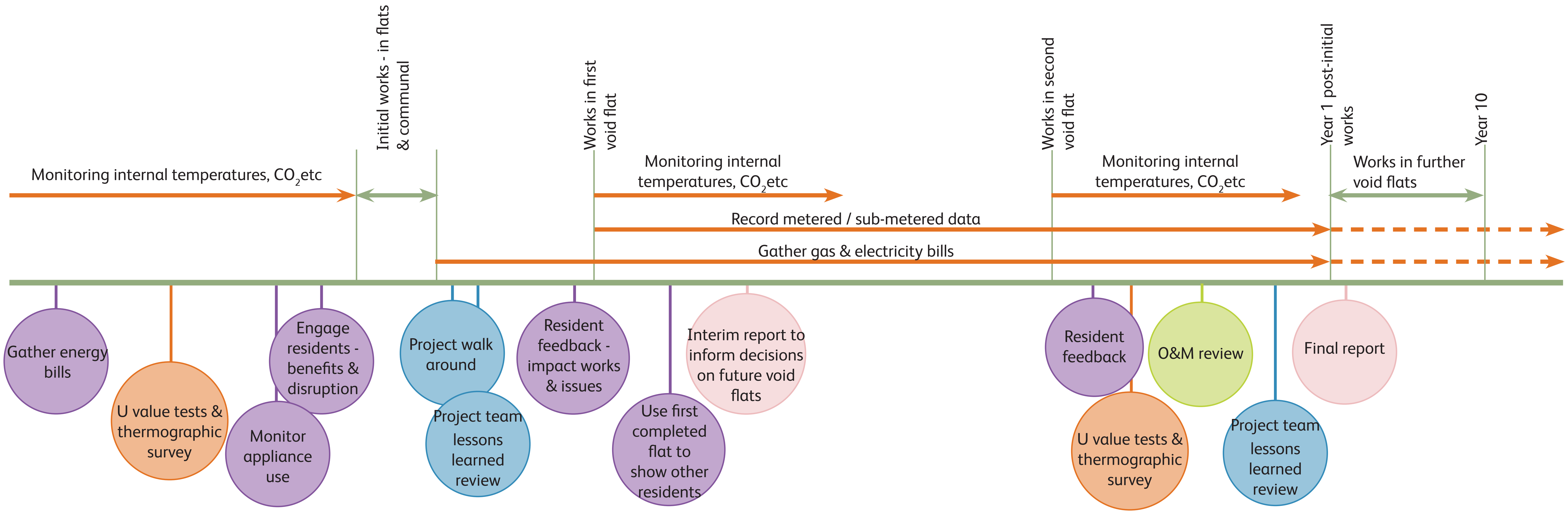
- Gather residents' existing energy bills
- Face-to-face survey of residents' opinions
- Thermographic & U value surveys to confirm assumptions re. existing building
- Incorporate sub-metering strategy (at c. RIBA stage 3) to allow recording of gas and electricity use to groups of flats (such that data is anonymised) OR incorporate smart meters and agree method of capturing this data.

MONITORING REPORT

ECD would provide an interim report during the ongoing works, to gather learnings at that point. Depending on overall programme, we suggest this after communal works and after at least one flat has been retrofitted while void. We will also provide a final report recording and evaluating the monitoring carried out. This will set out next steps both in terms of any suggested remediation or changes to the way the building is used, as well as lessons for future projects.

POST WORKS

- Review O&M manuals with users to confirm usefulness
- More detailed building user interviews with selected individuals
- Install monitors in both summer & winter periods to record:
  - * Internal temperatures (check for overheating, relate internal temp to energy used for heating)
  - * Internal CO_2 and RH levels, allowing understanding of building user health & comfort
- Thermographic survey to highlight any areas not built or performing as expected
- Embodied carbon analysis of building (ideally start early in design process to enable good decision making)
- Water meter data gathering



IMPACT ON RESIDENTS

Clearly such a long programme of works will be disruptive to residents, though the majority of the disruption will be in the initial c. 2 year period as works are carried out around residents. It is also important that expectations are managed, as works will not be completed until all the current residents have moved out, so they will all experience disruption but without ultimately benefiting from the full works.

CARRYING OUT WORKS

While the major communal and external works will require scaffolding and together form a significant construction project. The works within void flats may however be more efficiently carried out by Shettleston's own operatives who usually carry out void works. Specific training would be needed to ensure that the works were carried out correctly, with some products that are likely unfamiliar. However this would be of long-term benefit to both Shettleston and its operatives, upskilling them.

SAP OUTCOMES

Rybka have assessed the proposed measures using the Standard Assessment Procedure to provide an indicative Energy Performance Certificate (EPC) for a 'worst case scenario' flat, i.e. an end of terrace, ground floor 1 bedroom flat. This correlates to Flat 0-1 at no. 70 Old Shettleston Road. This currently has an EPC score of 56, which is a low band D. Meanwhile, the theoretical existing ground floor flat calculated by Rybka has an EPC score of 68 D. This difference is probably due to different actual services in the an actual specific flat and what Rybka have worked on as an 'average' existing flat. Also changes may have been made to the actual flat since the EPC was carried out.

After the Phase 2 works, this would rise to EPC C, with a score of 75.

The Phase 3 works to this one bedroom flat involve changing from the existing gas boiler to electric boiler and heaters. While the bills will reduce overall, as EPC scores relate directly to the cost of running the home, and electricity is more expensive than gas, the bills will not go down greatly in this step. The actual out-turn EPC score is also impacted by the electricity tariff that the resident is on. This can cause the EPC score to vary from a D (56) up to a C (78).

If it were possible to move this small flat onto a heat pump this would enable it to reach an EPC band B, with a score of up to 88 (again dependent on the electricity tariff).

It should also be noted that the Phase 2 proposals include replacing the doors and windows to the close, which will keep the stairwell warmer. The SAP recommendation for further improvement is to insulate the party wall. While this would still marginally improve the flat's performance after the proposed works, the heat loss into the stairwell would in fact be minimal, and this is not reflected in the SAP assessment, which is limited to the flat itself.

RISK REGISTER

A number of risk items have been raised during project meetings. These have been recorded to ensure they are picked up as the project progresses to the next stage.

Item	Risk	Description	Probability	Impact	Rating	Mitigation
1.1	Lack of existing fire stopping	Likely existing service risers are neither fire stopped at each floor, nor at openings to each flat	5	5	High	Full survey to be carried out by specialist prior to any works taking place
1.2	Perceived PV fire risk	Some building warrant officers raised concerns over PVs and fire risk.	3	3	Medium	Early engagement with warrant officers to establish local requirements
1.3	Prepayment meters functioning with PV	Risk that residents don't get full financial benefit of electricity being produced, as prepayment meters don't allow for this	3	3	Medium	Early engagement with various potential energy suppliers to establish how system could work
1.4	Potential fire risk of some flats having gas supply and others not	Full gas removal can only happen at end of programme of works, while flats will increasingly be moved off gas	5	1	Low	Design in gradual removal and review any perceived fire risk with building warrant officer early
1.5	Perceived fire risk of running refrigerant up stairwells	Heat pumps require refrigerant to run from external units to each flat, via stairwells. Perceived fire risk	4	2	Medium	Early engagement with warrant officers to establish level of concern. Establish actual risk posed by specific refrigerant. Ensure service void is ventilated
1.6	EWI to rear & side walls	Planners may not approve new external finish	2	4	Medium	Pre-application planning meeting to set out benefits. Demonstrate energy and carbon savings acheivable with and without this.
1.7	Heat pump enclosure too large	ASHPs require significant space around them and make noise. Residents may object to noise and loss of garden space	4	4	High	Review potential to avoid heat pumps to 1 bed flats, reducing overall number of heat pumps needed. Resident consultation to explain benefits. Propose more positive use of remaining garden space
1.8	Not meeting b.regs U value requirements	Due to hygrothermal constraints depth of new insulation is limited, and will not meet building regulations minimums in some cases	5	2	Medium	Hygrothermal report demonstrates reasoning for limiting thickness of new insulation and not meeting building regs requirement
1.9	Leaseholders	Leaseholders may object or hold up process	3	3	Medium	Early engagement, and help leaseholders find funding to pay for works to their homes, so that whole block can have gas removed
1.10	Increased electricity demand	Possible risk that sufficient electrical capacity is not available	3	5	High	Confirm with statutory authorities
1.11	Incremental installation of measures results in less good outcome	Repeat visits by different installers, and installation of measures over time leads to lesser quality work with poor junctions, leading to lesser energy use reduction & moisture risks	3	4	Medium	Careful planning with detailing work carried out with an understanding of programme. Hygrothermal & thermal bridge modelling carried out for all potential states that will exist during whole life of the project

08

Conclusions

COMPLETE DESIGN RECOMMENDATIONS

This investigation involved the use of non-destructive methods and therefore assumptions of the existing construction types have been made using information provided by the client and a non-intrusive site survey. This has provided the basis for the analysis and informed costing. Every effort has been made to ensure that the results are accurate and reliable. However, as with other indirect methods there is a possibility of localised inconsistencies and inaccuracies within the results. If retrofit works are to go ahead we would suggest further investigation and an in-depth site survey where a selection of walls are broken into to ensure the correct wall build ups are being analysed, a thermographic survey may also provide useful to address the continuity of insulation, if any, and locate defects.

Building Information For Costing					
	External Wall (front)	External Wall (rear & ends)	Loft Area	Roof Area	Roof area (bay windows)
Total Aea (m2)	538.1	917.2	698.2	803	12.7

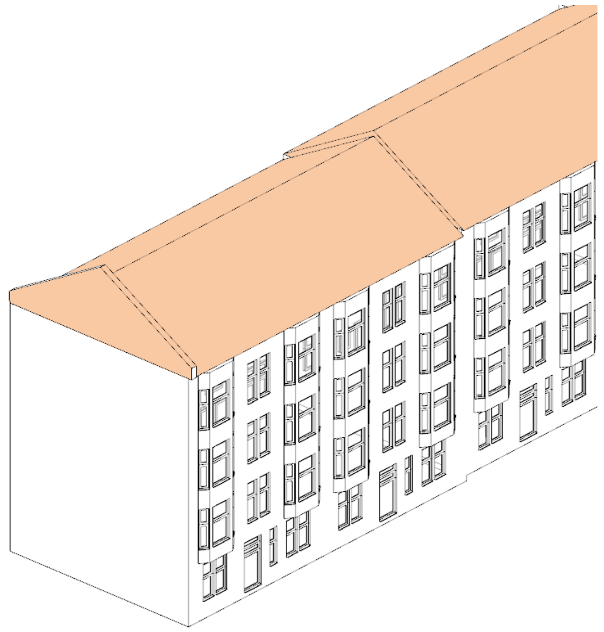


Figure 32 - Total Roof Area calculated

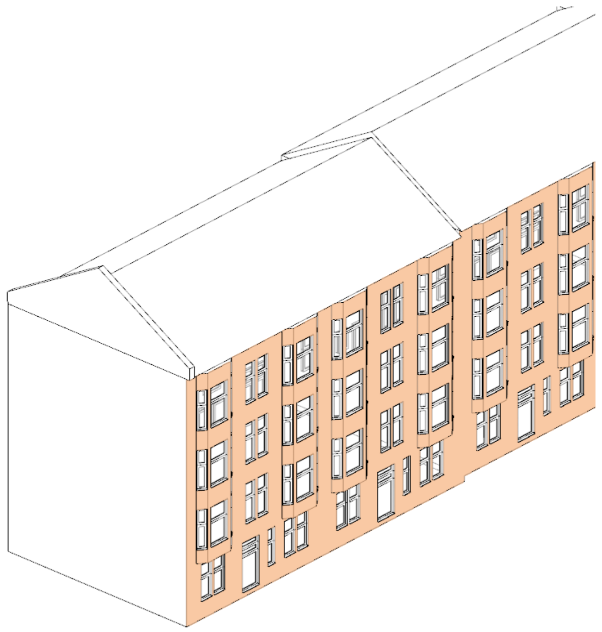


Figure 33 - Total External Front Wall Area calculated

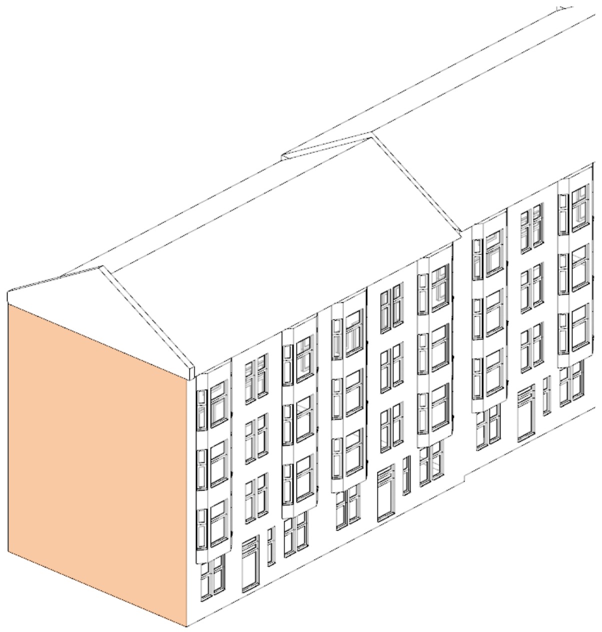


Figure 34 - Total Rear and End Walls Area calculated

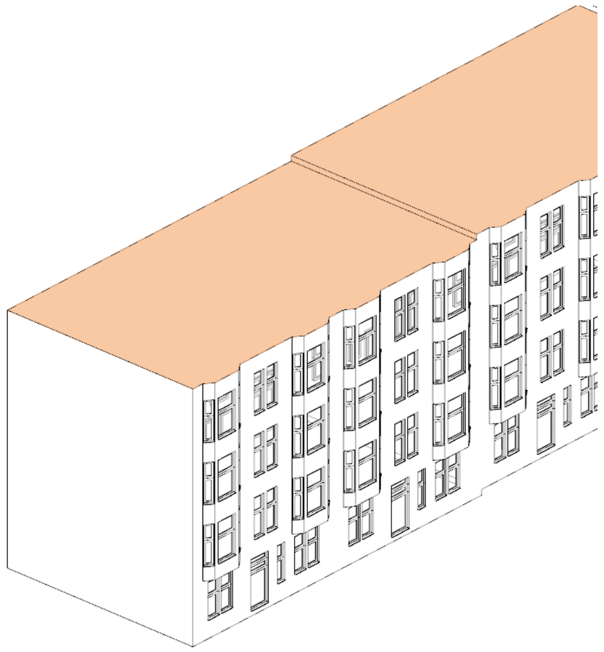


Figure 35 - Total Loft Area calculated

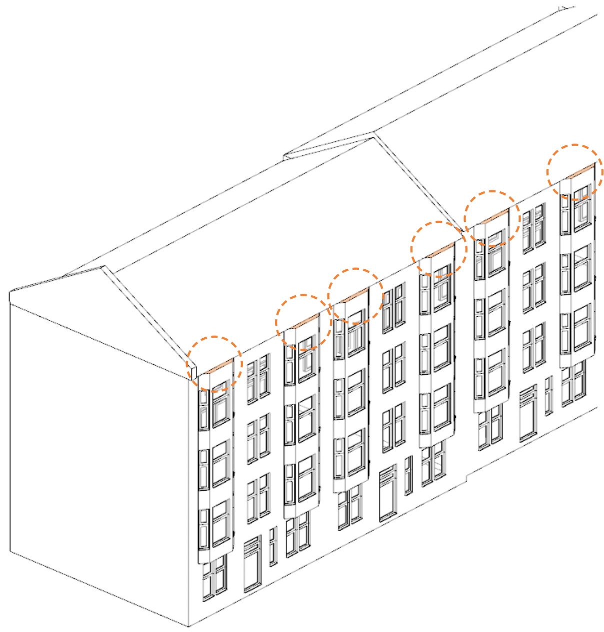


Figure 36 - Roof of Bay Windows Area calculated

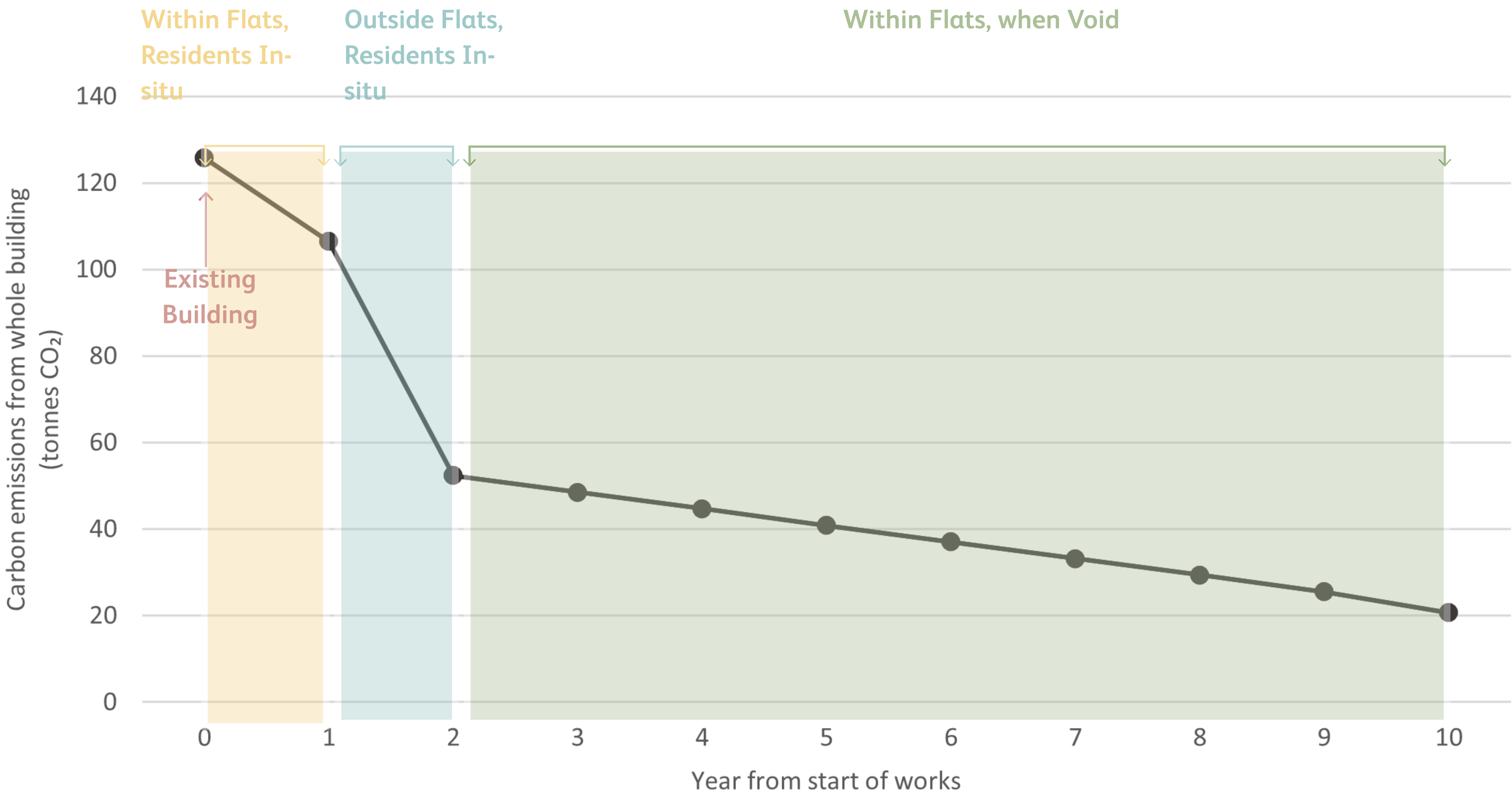
	EXISTING	WITHIN FLATS, WITH RESIDENTS IN SITU	COMMUNAL & EXTERNAL WORKS, WITH RESIDENTS IN SITU	WITHIN FLATS, WHEN VOID	BUILDING REGS U VALUE (W/m^2K) (figures in brackets are fall back values)
Heating Demand kWh/m_2a	208 - 241	162 - 219	48 - 100	31 - 79	
Heating Load W/m_2	93 - 105	66 - 84	29 - 42	24 - 37	
Wall (rear & ends)	Blonde sandstone, c. 400 - 650mm thick. Internal service void of plasterboard on timber studs. U value c. 1 - 1.5 W/m^2K	No Change	Remove all exg external fixings. c. 15mm diathonite thermactive insulating plaster to create flat surface. 200mm mineral wool slab insulation over. Studs / ventilated void over with new render on board over. Replace external fixings. U value c. 0.158 W/m^2K	No change	0.17 (0.7)
Wall (Front)	Red sandstone, c. 400 - 650mm thick. Internal service void of plasterboard on timber studs. U value c. 1 - 1.5 W/m^2K	No Change	No Change	Remove existing service void. 10mm diathonite thermactive to create flat surface. 60mm woodfibre board adhered to wall, lime plaster over. Seal around head & base of wall. Create new service void. Replace skirting boards. U value c. 0.36 - 0.4 W/m^2K	0.17 (0.7)
Floor	Timber floor boards on c. 152mm deep timber joists. Ventilated void below. U value c. 1.07 W/m^2K	Draught-stopping between floorboards (to ground floor flats only) No specific U value improvement but airtightness assumed improved Open up existing vents to below floor void	15mm aerogel insulation (Spacetherm multi or similar) to communal corridor floors. U value c. 0.75 W/m^2K	Lift floorboards as necessary to drape wind-tight breathable membrane over joists & seal to walls, to support 150mm woodfibre insulation between joists. Install airtightness membrane over & seal to walls. U value c. 0.27 W/m^2K	0.15 (0.7)
Roof	Concrete tiles on timber rafters. c. 250mm insulation between and over ceiling joists. Assumed plasterboard ceiling below U value c. 0.15 W/m^2K	No Change	Eaves extension to rear with replacement gutters (consider oversizing) Re-do capping to gable walls where EWI creates thicker walls. 50mm mineral wool top up loft insulation, including wind-proof membrane over. Confirm eaves ventilation maintained & insect mesh incorporated. Take insulation 1m up inside face of internal gable walls. U value c. 0.132 W/m^2K	Remove existing ceiling & install new airtightness membrane to underside ceiling joists. Replace ceiling No specific U value improvement. Improvement to airtightness	0.12 (0.35)
Windows	Double glazed timber framed windows. U value c. 2.61	Draught-stopping around opening panes & at junction with walls. Curtains used at night U value c. 1.85	Triple glazed windows with insulated frames throughout. Airtightness tape to seal to existing walls / diathonite layer of EWI. If MVHR, no trickle vents, air permeability class 4. If DCME, humidity controlled trickle vents. U value c. 1.04 W/m^2K	Aerogel insulation into window reveals & seal to windows. Board & re-plaster over. Replace internal sill boards U value improvement accounted for with IWI	1.4 (3.3)
Doors	Metal/ glazed security front communal doors, gates / doors to rear Timber doors with fanlights over to individual flats U value c. 1.7	New front doors to each flat, well-sealed to existing wall. U value c. 1.13 W/m^2K	New front & rear communal doors. Insulated doors, air permeability class 4, well-sealed to existing walls / new airtightness layer U value c. 1.2 W/m^2K	No change	1.4
Heat Source	Gas boilers to each flat	No Change	Communal works for air source heat pumps, including acoustic screening	Air Source Heat Pump installation & upgrade radiators	
Hot Water	Gas boilers to each flat	No Change	No Change	Hot water tank	
Ventilation	Trickle vents to windows, extract fans to kitchens & bathrooms Average within flat 8.5 air changes	MVHR **or** Demand control mechanical extract (note impact on future windows' trickle vents) Assumed airtightness 5 air changes	Airtightness assumed 3 air changes	Airtightness assumed 2 air changes	
Electricity + Lighting	Mixed LED lighting & incandescent	Low energy lighting throughout Inverter installed & linked up for future PVs	Photovoltaic (PV) panels, to supply each flat (assumed 4no. 1.67m^2 panels per flat)	Any gas cookers / supply removed. Ensure electrical supply in place for electric / induction ovens & hobs	
Sanitary Installations + Foul Drainage	Individual WCs, sinks etc to each flat. Primary ventilated stacks, some external, others internal	Close up any redundant services holes. Seal around services penetrations.	Seal up any services penetrations only accessible at this stage of work, eg. passing through loft.	Low Flow appliances installed	

CARBON EMISSIONS REDUCTION STRATEGY

One of Shettleston Housing Association's drivers for carrying out this study is to establish a route to decarbonising its stock, in line with or in advance of the Scottish Government's target for Scotland to have net zero greenhouse gas emissions by 2045.

The graph below shows how the proposed measures can be implemented over time, as flats become void, such that the building's overall carbon emissions reduce from 125 tonnes per year down to around 25 tonnes within about 10 years. This assumes that 4-5 flats within the block become void each year and can be more deeply retrofitted at that point. It may be that Shettleston chose to actively move residents between similar flats to speed up the process. It has been assumed that the communal and external measures are applied to the leasehold flats, but no the void works.

These calculations do not account for the decarbonisation of the electricity grid over time, and it can be seen that even after the deepest retrofit the building is still not 'net zero' for carbon emissions. However the UK electricity grid is expected to become less carbon intensive over time, so that any building powered solely by electricity will effectively become net zero. While this grid decarbonisation is largely outside the scope of this project, it will only be possible if most buildings become more energy efficient, reducing overall demand, and with an increase in the use of local energy generation, such as the photovoltaic panels proposed here.



CARBON EMISSIONS OVER TIME AS RETROFIT WORKS CARRIED OUT

NEXT STEPS

SURVEYS

Carry out **thermographic survey** of whole building once external temperatures hare dropped and residents are likely to have heating on.

Carry out **in-situ U value** testing

Consider full **dimensional survey** of internal & external building to ensure accurate model of building as design is developed.

Structural survey of roof, particularly if PV panels are proposed. Testing to confirm pull out capacity of rear and end walls.

MAINTENANCE WORKS

Ensure vents to below ground floor voids are functional

OWNERSHIP & LEGAL ISSUES

FIRE SAFETY

Investigate condition of **fire stopping** to existing risers, chimneys

Confirm SHA **employer's requirements** around use of combustible materials for retrofit

RESIDENT LIAISON

Gather further **energy bills**

Carry out in-situ **temperature monitoring** in selection of flats during winter

Meaningful **consultation with residents** prior to carrying out any works

STATUTORY MATTERS

Discuss potential for external wall insulation to rear and ends of building with local authority planning team

Discuss perceived fire risk of PVs and of refrigerant pipework in stairwells with local building control

SERVICES

Confirm electrical capacity available can support electrification of flats

COSTS

Investigate funding options & review programme in light of these.

[Blank page]

DoigSmith
plan. project. protect.

Feasibility Cost Plan (R4)

Shettleston Housing Association
Old Shettleston Road Retrofit
Energy Reduction & Decarbonisation Retrofit Study

17th November 2023

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)
17th November 2023

DoigSmith plan. project. protect.

Executive Summary

	Within Flats (Occupied)	Outside Flats	Within Flats (Void)	Total
Estimated Prime Cost (excl Prelims)	**£ 508,398**	**£1,331,150**	**£ 675,689**	**£2,515,237**
Preliminaries	£ 72,976	£ 191,074	£ 96,989	£ 361,039
Estimated construction Cost (incl Prelims)	**£ 581,374**	**£1,522,224**	**£ 772,677**	**£2,876,276**
Other Development Costs @ 20%	£ 116,275	£ 304,445	£ 154,535	£ 575,255
Design & Construction Risk @ 12.5%	£ 72,672	£ 190,278	£ 96,585	£ 359,534
Phasing Allowance @ 10% of Within Flats (Void)			£ 64,659	£ 64,659
Inflation Risk	Excluded	Excluded	Excluded	Excluded
Totals	**£ 770,321**	**£2,016,947**	**£1,088,457**	**£3,875,725**
The cost per flat is (39 in total):	**£ 19,752**	**£ 51,717**	**£ 27,909**	**£ 99,378**
The resulting cost per m2 GIFA is:	**£ 314**	**£ 823**	**£ 444**	**£ 1,582**

Options: Cost Per Flat				
Retrofit - Within Flats (Void) - Ceiling Works	**£ -**	**£ -**	**£ 1,969**	**£ 1,969**
Retrofit - Within Flats (Void) - Sanitary Installations	**£ -**	**£ -**	**£ 1,250**	**£ 1,250**
Retrofit - Within Flats (Occupied) - Draughtproofing	**£ -**	**£ -**	**£ 2,460**	**£ 2,460**

** It is noted that not all flats are the same size / configuration.*

The Gross Internal Floor Area, (GIFA), is measured as: **2,450 m2**

Phasing

Retrofitting within occupied flats could be carried out without significant phasing, however there is a risk of disruption due to occupiers' not allowing or being able to give access when required.

Retrofitting outside flats should be able to be carried out without phasing.

Retrofitting within flats when they are void needs to be carried out on an ad hoc basis, which will result in mobilisation and demobilisation for each flat.

Basis of Cost Estimate

The estimate is based on the following design information:
* 10th August 2023 Meeting Presentation
* L. Westmacott email dated 11th August 2023
* A. Sharma email dated 15th August 2023 (possible measures matrix attached)
* ECD Architects existing floor plans (Level 0 - Level 3) dated 21st August 2023 (based on measuremets of a limited number of flats - not a professional survey)

Exclusions

Findings from Building Inspection Report carried out on 18th May 2023, including:
- Replacement of roof coverings
- Window restrictors in communal areas (separate instruction by SHA - works completed?)
- Redecoration of communal windows and doors
- Asbestos removal or containment

Replacing kitchens and/or bathrooms in part or in full
Electrical re-wiring
Making good to fire related items
Fire risk remediation works
Upgrades to/replacment of finishes other than where directly related to the described works
Common areas excluded other than door replacement and floor insulation to corridor
Any works in relation to the removal of contaminated land
Any structural works

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)
17th November 2023

Executive Summary

Assumptions and clarifications

Refer to estimate detail for further assumptions and clarifications.
Assumed construction programme as below.
Main contractor OHP 4.5% (3% overhead, 1.5% profit)

Programme

Key programme dates for the Project are:

Retrofit - Within Flats	6 months	Assumes 2 closes being retrofitted concurrently
Retrofit - Outside Flats	8 months	
Retrofit - Within Flats (Void)	As available -Approx 2 - 3 weeks per flat	

Anticipated Project Risks

The following main risks have been identified to date for the Project:

Unknown conditions discovered during works
Phasing logistics of work being carried out during flat occupation
Inflation (excluded)

Inflation

Inflation is excluded from the cost plan and we forecast the next few years as follows:
2023: 4.5%
2024: 3.0%
2025: 3.0%
2026: 2.5%
2027: 2.5%

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)
17th November 2023

Elem	ELEMENTAL SUMMARY	£/M2	PER FLAT	X 39 FLATS	Notes
	MEASURED WORKS	**982**	**61,716**	**2,406,925**	
	Retrofit - Within Flats	**199**	**12,475**	**486,506**	
	Fabric	35	2,203	85,898	
	Mechanical & Electrical	164	10,272	400,608	
	Retrofit - Outside Flats	**520**	**32,662**	**1,273,828**	Includes scaffolding
	Fabric	438	27,509	1,072,866	
	Mechanical & Electrical	82	5,153	200,962	
	Retrofit - Within Flats (Void)	**264**	**16,579**	**646,592**	
	Fabric	78	4,900	191,087	
	Mechanical & Electrical	186	11,680	455,505	
SUB TOTAL: BUILDING WORKS		**982**		**2,406,925**	
9	**MAIN CONTRACTOR'S PRELIMS**	**147**		**361,039**	
9.1	Employer's Requirements	0	0		excluded
9.2	Main Contractor's Cost Items	147	361,039		Allow 15%
10	**MAIN CONTRACTOR'S OH&P**	**44**		**108,312**	
10.1	Main Contractor's Overheads	29	72,208		Allow 3%
10.2	Main Contractor's Profit	15	36,104		Allow 1.5%
SUB TOTAL: BUILDING, PRELIMS & OVERHEADS		**1,174**		**2,876,276**	
11	**PROJECT/DESIGN TEAM FEES**	**exc.**		**0**	
11.1	Consultant's Fees				Included in Other Development Costs
11.2	Main Cont. Pre-construction Fees	N/A	N/A		N/A
11.3	Main Contractor's Design Fees	N/A	N/A		N/A
12	**OTHER DEV'P/PROJECT COSTS**	**235**		**575,255**	
12.1	Other Development Costs	235	575,255		Allow 20%
13	**RISKS**	**173**		**424,194**	
13.1	Design Development Risks	88	215,721		Allow 7.5%
13.2	Construction Risks	59	143,814		Allow 5%
13.3	Employer Change Risks	0	excl.		
13.4	Phasing	26	64,659		Allow 10%. Applies to Within Flat (Void)
14	**INFLATION**	excl.			excluded
14.1	Tender Inflation	0	excl.		excluded
14.2	Construction Inflation	excl.	excl.		excluded
COST PLAN EXCLUDING INFLATION		**1,582**		**3,875,725**	

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)

17th November 2023

DoigSmith plan. project. protect.

Elem	RETROFIT: WITHIN FLATS, WITH RESIDENTS IN SITU	Q	U	R	£	Notes
2	**Fabric**				2,203	
2	**Wall**					
	Rear & Ends					
	No change					
	Front					
	No change					
2	**Floor**					
	Lift floor coverings prior to application of draughtstopping	0	m2	3.50	0	Included in Options
	Draught stopping between floorboards	0	m	3.30	0	Included in Options
	Replace floor coverings following application of draughtproofing	0	m2	35	0	Included in Options
	Open up existing vents to below floor void	0	m2	8	0	Included in Options
2	**Roof**					
	No change					
2	**Windows & Doors**					
	Draught stopping around opening panes and at junction with walls	0	m	11	0	Included in Options
	New front doors to each flat, insulated doors, fanlight over and frame	1	nr	1,050	1,050	
	Sealing new front doors to each wall	7	m	20	132	
	New threshold strip	1	nr	80	80	
	Re-plastering around new doors	10	m2	80	792	
	Re-painting around new doors	10	m2	15	149	
5	**Mechanical & Electrical**				10,272	
5.1	**Sanitary Installations**					
	No change					
5.2	**Services Equipment**					
	N/A					
5.3	**Foul Drainage (above ground)**					
	Close up any service holes. Seal around services penetrations.	4	nr	75	300	Allow 4nr per flat
5.4	**Hot Water Distribution**					
	No change					
5.4	**Local Hot Water Distribution**					
	No change					
5.5	**Heat Source**					
	No change					
5.7	**Ventilation Systems**					
	MVHR system	50	m2	155	7,750	As per Rybka one and three bed layouts.
5.8	**Local Electricity Generation System**					
	Install inverter ready to link up to future PVs	1	nr	650	650	
5.8	**Lighting Installations**					
	Remove all existing incandescent light fittings	12	nr	16	192	Assumed 1/2nr per room
	Replace all incandescent light fittings with LED light fittings	12	nr	115	1,380	Lighting replaced recently, assumed 1/2nr per room. Re-wiring excluded.
	1-9. MEASURED WORKS TOTAL				12,475	

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)

17th November 2023

DoigSmith plan. project. protect.

Elem	RETROFIT: OUTSIDE FLATS, WITH RESIDENTS IN SITU	Q	U	R	£	Notes
2	**Fabric**				27,509	
2	**Wall**					
	Rear & Ends					
	Remove all external fixings	19	m2	10	190	
	External wall insulation	19	m2	405	7,685	15mm diathonite thermoactive insulating plaster to create flat surface. 200mm mineral wool slab insulation over. Studs / ventilated void over with new render on board over.
	External wall insulation, below ground	1	m2	520	705	Foamglass / XPS insulation, appox 600mm deep
	Replace all external fixings	19	m2	10	190	
	Front					
	No change					
2	**Floor**					
	15mm aerogel insulation to communal corridor floors	4	m2	135	478	Spacetherm Multi or simnilar
2	**Roof**					
	Close up any service holes. Seal around services penetrations.	3	nr	490	1,470	Allow 3nr per flat, including chimney stack/pot, vents, pipework, redundant service holes
	Seal skylights and other similar roof penetrations	1	nr	1,100	1,100	Skylights and vents
	Eaves extension to rear with replacement gutters (consider oversizing).	4	m	210	781	
	Re-do capping to gable walls where EWI creates thicker walls	1	m	300	231	
	50mm top up loft insulation, including windproof membrane over. Take insulation 1m up inside face of gable walls	18	m2	25	442	
	Confirm eaves ventilation maintained and insect mesh incorporated.	4	m	75	279	
2	**Windows & Doors**					
	Remove existing windows	12	m2	32	398	
	New triple glazed windows	12	m2	875	10,881	
	Extend cills to accommodate EWI	6	m	200	1,138	
	Airtightness tape to seal existing walls / diathonite layer of EWI	24	m	10	240	
	Humidity controlled trickle vents	4	nr	125	500	
	New front & rear commual doors	0.3	nr	1,500	462	Ins doors, air perm class 4, well sealed to existing walls / new airtightness layer. Pro-rated for one flat.
	Sealing new communal doors to each wall	1	m	20	25	
	New threshold strip	1	nr	90	90	
	Re-plastering around new doors	2	m2	100	185	
	Re-painting around new doors	3	m2	15	42	
5	**Mechanical & Electrical**				5,153	
5.1	**Sanitary Installations**					
	No change					
5.2	**Services Equipment**					
	N/A					
5.3	**Foul Drainage (above ground)**					
	Seal in-use and close up redundant stanitary and foul drainage service holes where required	1	nr	1,000	1,000	Allow 1nr per flat
	Seal in-use and close up redundant stanitary and foul drainage service holes where required	1	item	500	500	Allowance for sealing service penetrations that are only accessable at this stage, e.g. passing through the loft
5.4	**Hot Water Distribution**					
	No change					
5.4	**Local Hot Water Distribution**					
	No change					
5.5	**Heat Source**					
	Communal works for air source heat pumps (only to 3-bed flats):					
	Provide base for future provision of equipment, allow	1	item	346	346	Assume communal bases per close
	Acoustic screening, allow	1	item	577	577	
	Extend existing gas boiler flues to accommodate EWI	1	nr	325	325	Assuming that this does not contravene regulations
5.7	**Ventilation Systems**					
	No change					
5.8	**Local Electricity Generation System**					
	PV panels mounting	7	m2	160	1,069	Assumes roof is structurally capable of taking panels
	Install PV panels on roof	7	m2	200	1,336	Assumes roof is structurally capable of taking panels. Assumes 4 x 1.67m2 panels per flat.
	Batteries for PV panels	0	nr	3,200	0	Excluded
5.8	**Lighting Installations**					
	No change					

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)

17th November 2023

Elem	RETROFIT: WITHIN FLATS, VOID	Q	U	R	£	Notes
2	**Fabric**				4,900	
2	**Wall**					
	Rear & Ends					
	No change					
	Front					
	Remove existing service void and create new service void:					Assumed size 10m2
	Remove existing service void	1	nr	70	70	
	Create new service void, frame	10	m2	25	249	Allowance
	15mm diathonite thermactive to create flat surface	10	m2	85	846	
	50mm wood fibre board adhered to wall	10	m2	60	597	
	Lime plaster over	10	m2	64	637	
	Breathable paint / wall finishes	10	m2	10	99	
	Seal around head & base of wall	12	m	15	180	
	Replace skirting boards, make good & paint	3	m	35	105	
2	**Floor**					
	Lift floor coverings	18	m2	3.50	62	Ground Floor flats only
	Lift floor boards as necessary	18	m2	2	35	Ground Floor flats only
	Drape wind-tight breathable membrane over joists and seal to walls	18	m2	5	88	Ground Floor flats only
	150mm woddfibre insulation between joists	18	m2	14	248	Ground Floor flats only
	Install airtightness membrane over and seal walls	18	m2	4.50	80	Ground Floor flats only
	Replace floor coverings	18	m2	24	425	Ground Floor flats only
2	**Roof**					
	Remove existing ceiling	0	m2	4.50	0	Included in Options
	Install airtightness membrane to underside of ceiling joists	0	m2	4.50	0	Included in Options
	Install new ceiling	0	m2	60	0	Included in Options
2	**Windows & Doors**					
	Aerogel insulation into window reveals & seal to windows.	26	m	15	385	
	Board & re-plaster & re-paint over	26	m	15	385	Allowance
	Replace internal cill boards	10	m	40	410	Allowance
5	**Mechanical & Electrical**				11,680	
5.1	**Sanitary Installations**					
	Remove existing appliances, WC	0	nr	25	0	Included in Options
	Install low flow appliances, WC	0	nr	500	0	Included in Options
	Replace taps, add aerators, as necessary, allowance	0	item	250	0	Included in Options
5.4	**Local Hot Water Distribution**					
	New hot water cylinder	1	nr	645	645	70 litre for 1-bed, 120 litre for 3-bed (ave rate)
5.5	**Heat Source**					
	Air Source Heat Pump System					
	Remove existing gas boiler & flue	1	item	240	240	Remove flue in phase 2 due to scaffolding requirement?
	Air source heat pump system	18	m2	200	3,692	Individual for each 3-bed flat
	Allow for all pipework, builderswork between heat pump and flats	18	m2	50	923	Only to 3-bed flats
	Allow for controls & wiring	1	item	231	231	Only to 3-bed flats
	Remove existing radiators	90	nr	14	1,260	
	New radiators	10	nr	200	2,000	Assumed that pipework does not need to be replaced
	Electric Storage Heaters & Panel Heaters					
	Electric panel heater, 490 x 140 x 470mm	3	nr	385	1,185	Only to 1-bed flats
	Electric storage heater, 750 x 185 x 780mm	3	nr	415	1,277	Only to 1-bed flats
	Electric towel rail, 500 x 80 x 800mm	1	nr	295	227	Only to 1-bed flats
5.7	**Ventilation Systems**					
	No change					
5.8	**Local Electricity Generation System**					
	No change					
5.8	**Lighting Installations**					
	No change					
	1-9. MEASURED WORKS TOTAL				16,579	

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)

17th November 2023

Elem	OPTIONS	Q	U	R	£	Notes
	Retrofit - Within Flats (Void)					
2	**Roof**					
	Remove existing ceiling	18	m2	4.50	80	Top Floor flats only
	Install airtightness membrane to underside of ceiling joists	18	m2	4.50	80	Top Floor flats only
	Install new ceiling	18	m2	60	1,062	Top Floor flats only - assume plasterboard & paint
	Sub Total				1,221	
	Prelims & MC OH&P	19.5%			238	
	Prime Cost				1,459	
	Development Costs & Risk	35.0%			511	
	Total Option				**1,969**	
5.1	**Sanitary Installations**					
	Remove existing appliances, WC	1	nr	25	25	
	Install low flow appliances, WC	1	nr	500	500	
	Replace taps, add aerators, as necessary	1	item	250	250	
	Sub Total				775	
	Prelims & MC OH&P	19.5%			151	
	Prime Cost				926	
	Development Costs & Risk	35.0%			324	
	Total Option				**1,250**	
	Retrofit - Within Flats (Occupied)					
2	**Floor**					
	Lift floor coverings prior to application of (	18	m2	3.50	62	Ground Floor flats only
	Draught stopping between floorboards	106	m	3.30	350	Ground Floor flats only
	Replace floor coverings following application of draughtproofing	18	m2	35	619	Ground Floor flats only
	Open up existing vents to below floor void	18	m2	8	142	Ground Floor flats only
2	**Windows & Doors**					
	Draught stopping around opening panes	32	m	11	352	
	Sub Total				1,525	
	Prelims & MC OH&P	19.5%			297	
	Prime Cost				1,822	
	Development Costs & Risk	35.0%			638	
	Total Option				**2,460**	

Old Shettleston Road Retrofit
Feasibility Cost Plan (R4)

17th November 2023

Ph	Elem	MVHR RATE BUILD UP	Q	U	R	£	Notes
		One Bed Flat (40m2)					
		MVHR, 600mm x 382mm x 584mm	1	nr	1,470	1,470	
		Ductwork, 150mm	7	m	120	840	
		Ductwork, 125mm	14	m	110	1,540	
		Ductwork, 100mm	11	m	100	1,100	
		Linear bar grille, 200 x 150mm	4	nr	115	460	
		External louvre, 250 x 250mm	2	nr	120	240	Scaffolding needed?
		BWIC, allow	1	item	250	250	
		Electrical works, allow	1	item	500	500	
		Controls, allow	1	item	250	250	
		Dropped ceilings & boxing in, allow	1	item	750	750	
		Total				**7,400**	
		Rate / m2				**185**	
		Total One Bed Flats	**30**	**nr**		**222,000**	
		Three Bed Flat (85m2)					
		MVHR, 754mm x 535mm x 654mm	1	nr	1,470	1,470	
		Ductwork, 150mm	25	m	110	2,750	
		Ductwork, 125mm	18	m	15	270	
		Ductwork, 100mm	11	m	95	1,045	
		Linear bar grille, 200 x 150mm	5	nr	115	575	
		Linear bar diffuser	1	nr	115	115	
		External louvre, 250 x 250mm	2	nr	120	240	Scaffolding needed?
		BWIC, allow	1	item	500	500	
		Electrical works, allow	1	item	750	750	
		Controls, allow	1	item	450	450	
		Dropped ceilings & boxing in, allow	1	item	1,000	1,000	
		Total				**9,165**	
		Rate / m2				**108**	
		Total Three Bed Flats	**9**	**nr**		**82,485**	
		Total MVHR				304,485	
		Average Rate Per m2	**1,965**	**m2**		**155**	

[Blank page]

Shettleston Retrofit

linear design & construct

Phase 1 - Within Flat, with residents in-situ

- Draught stopping between floorboards (to ground floor flats only) (Floor)
- Open up existing vents to below floor void (Floor)
- Draft-stopping around opening panes & at junction with walls (Windows)
- New front doors to each flat, well-sealed to existing wall (Doors)
- Low energy lighting throughout (Electricity & Lighting)
- MVHR

Shettleston Retrofit

Communal & External Works, with resistant's in-situ

- Remove all existing external fixings and apply 15mm diathonite thermactive insulating render plaster to create flat surface. 200mm mineral slab insulation over studs/ventilated void over with new render on board over then replace external fixings (walls Rear & Ends)
- 15mm aerogel insulation (Spacetherm multi or similar) to communal corridor floors (Floor)
- Eaves extension to rear with replacement gutters. Re-do capping to gable walls where EWI creates thicker walls (Roof)
- 50mm mineral wool top up loft insulation, including wind-proof membrane over. Take insulation 1m up inside face of internal gable walls (Roof)
- New triple glazed windows with insulated frames throughout. EPDM seal to existing walls/diathonite layer of EWI (windows)
- New front & rear communal doors, well sealed to external walls (Doors)
- Photovoltaic panels to supply each flat (Electricity & Lighting)
- Invertor installed & linked up for PVs (Electricity & Lighting) – Moved to this section whilst in changing windows over

Shettleston Retrofit

Within flats, when void

- Remove existing service void, apply 10mm diathonite thermactive to create flat survey. 60mm woodfibre board adhered to wall, lime plaster over. Seal around head & base of wall, create new service void. Replace skirting boards. (Wall front)
- Lift floorboards as necessary to drape wind-tight breathable membrane over joists & seal to walls, support 150mm woodfibre insulate between joists. Install air-tightness membrane over & seal walls (Floor)
- Remove existing ceilings & install new air-tightness membrane to u/s ceiling joists and replace ceilings (Roof)
- Aerogel insulation into window reveals& seal to windows. Board & re-plaster over. Replace internal cills. (Windows)
- Air Source Heat Pump installation and upgrade radiators (Heat Source)
- Hot water tanks (Hot Water)
- Replace gas cooker and supplies for electric/induction oven & hobs (Electricity & Lighting)

Surveys

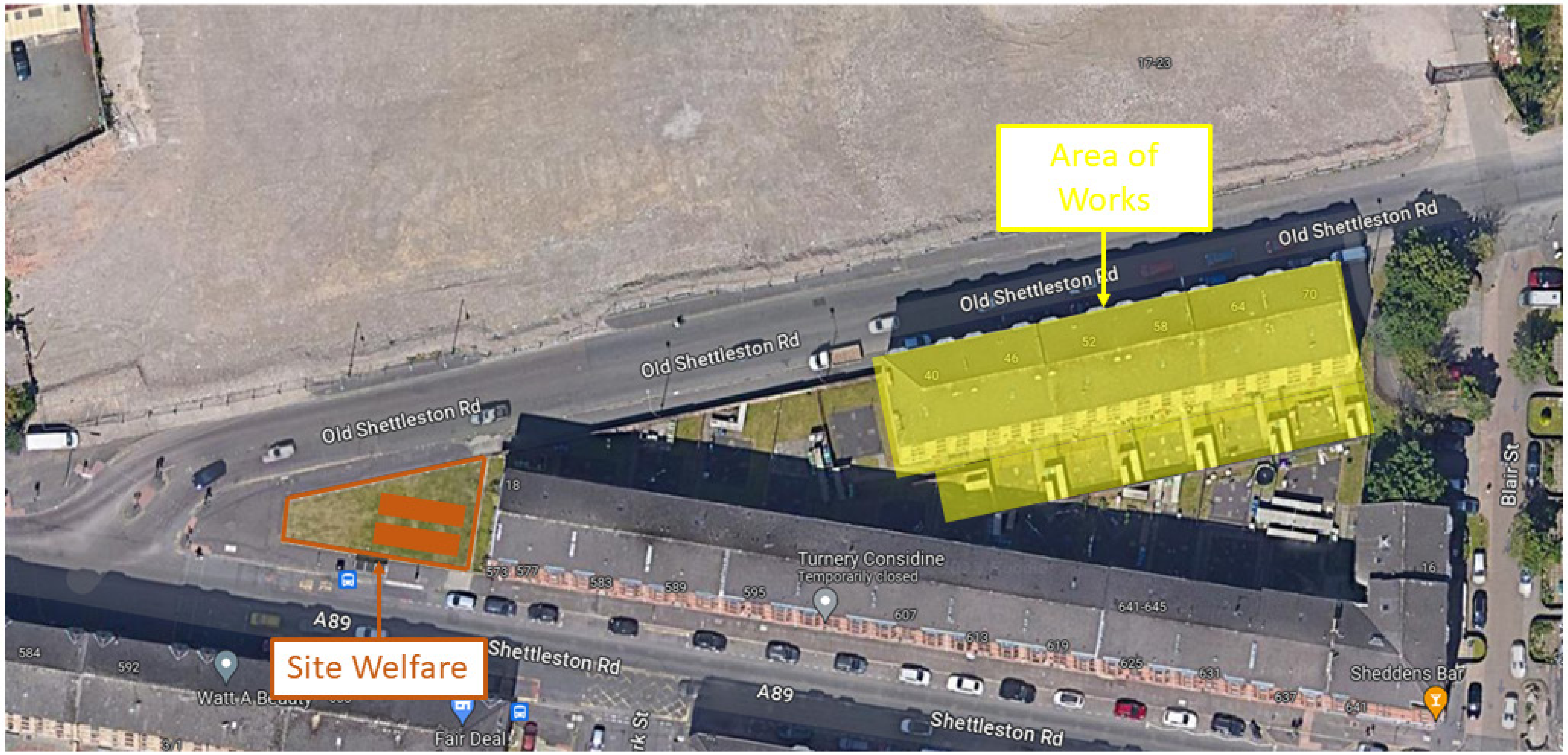
Shettleston Retrofit - Early Survey Programme

Rev: A

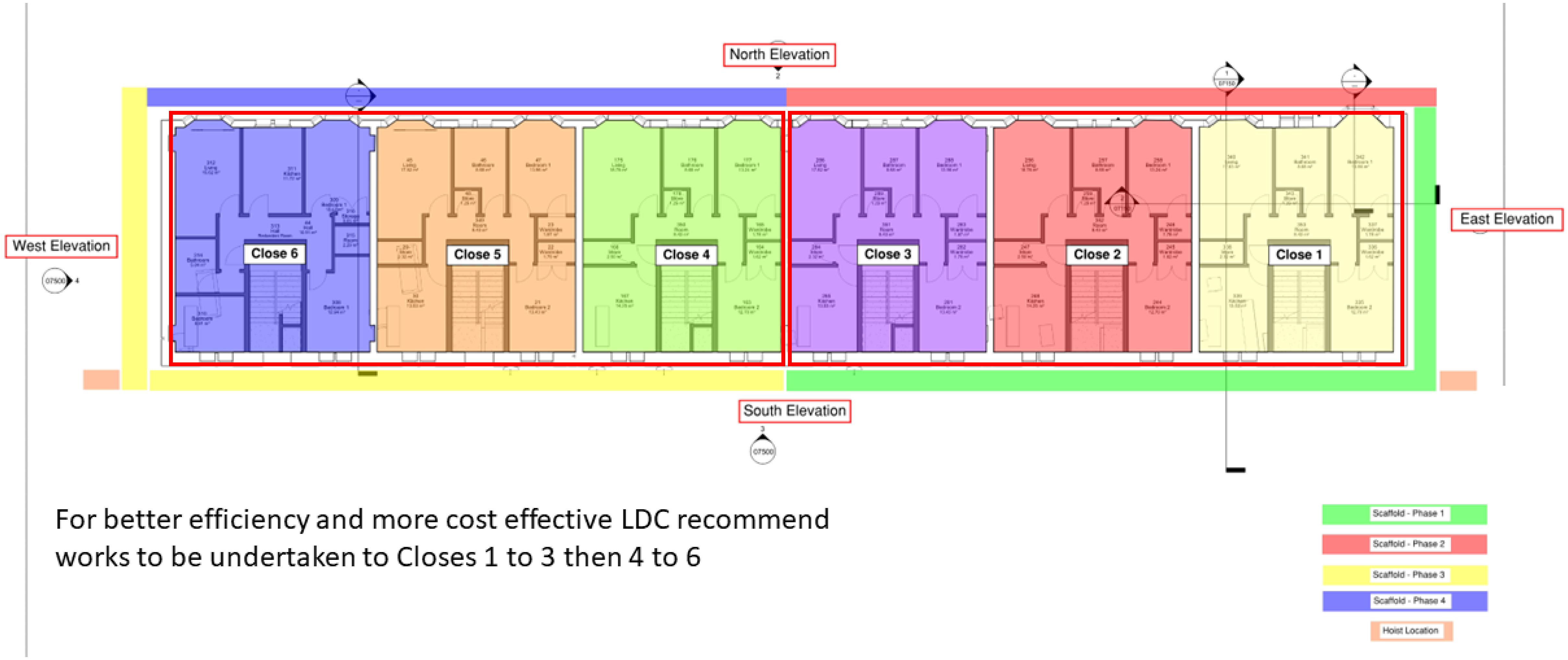
Yellow	Site Works
Orange	Further Survey Required
Green	Complete with report

Surveys	1 w/c	2 w/c	3 w/c	4 w/c	5 w/c	6 w/c	Comments
Externals							
Engineer							
Rot survey to rafters							
Structural survey of rafters/roof to support PV Panels							
Drainage CCTV Survey - downpipe pop-ups							
GPRS							
Ground conditions for HSP slabs							
Architect							
External Building Survey (boss testing/mortar testing)							
Thermographic Survey							
Roof Slate inspection							
M&E							
Existing services fixed to external façade - BT Lines							
Existing services fixed to external façade - Sky							
Existing services fixed to external façade - Virgin							
Existing services fixed to external façade - Lights							
Gas							
Existing services fixed to external façade - Boiler flu extracts							
Existing services fixed to external façade - Vent extracts							
Internals							
Engineer							
Opening up works/service penetrations through load-bearing walls							
Architect							
Replacement Window Site Sizing							
Replacement Internal and External Doors site sizing							
Internal wall lining cavity survey							
Measurement survey							
Open up existing floor void Incl. existing vents							
M&E							
MVHR routes and size locations							
Other							
Asbestos Survey							
Ecology Survey							

Logistics Plans



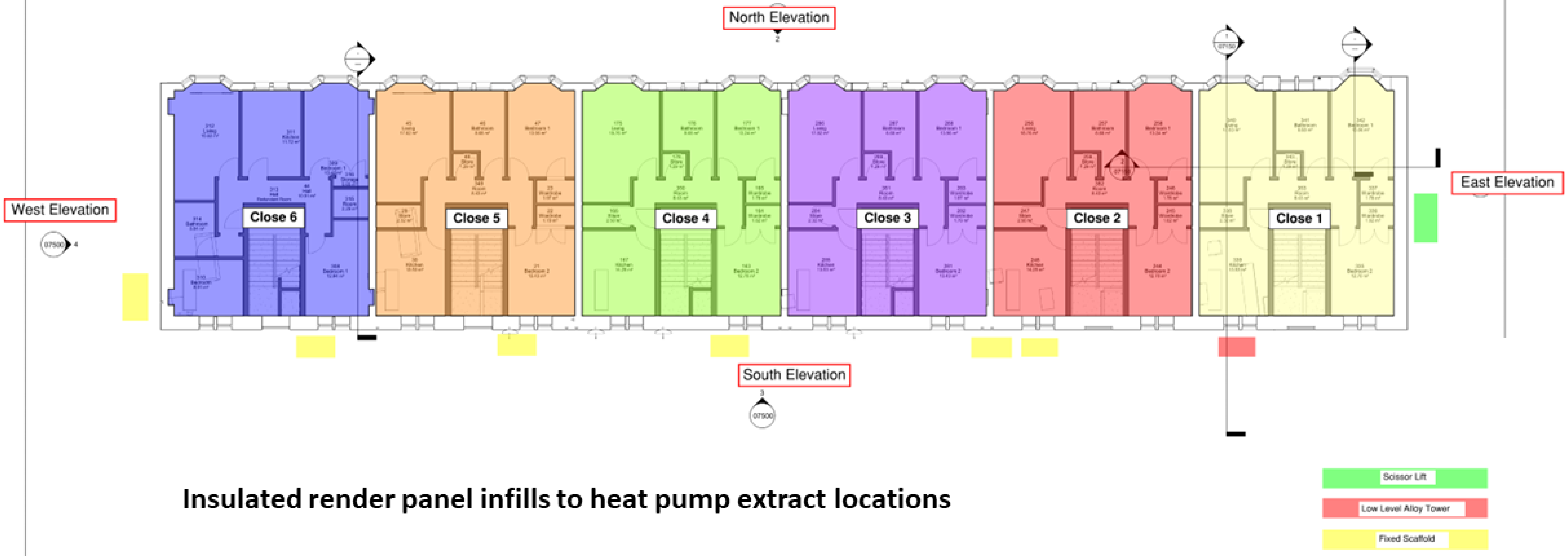
Phase 2 - Communal & External Works, with resistant's in-situ



For better efficiency and more cost effective LDC recommend works to be undertaken to Closes 1 to 3 then 4 to 6

Phase 3 - Within flats, when void

- External works being carried out following gas boiler being changed over to heat source pump



Insulated render panel infills to heat pump extract locations

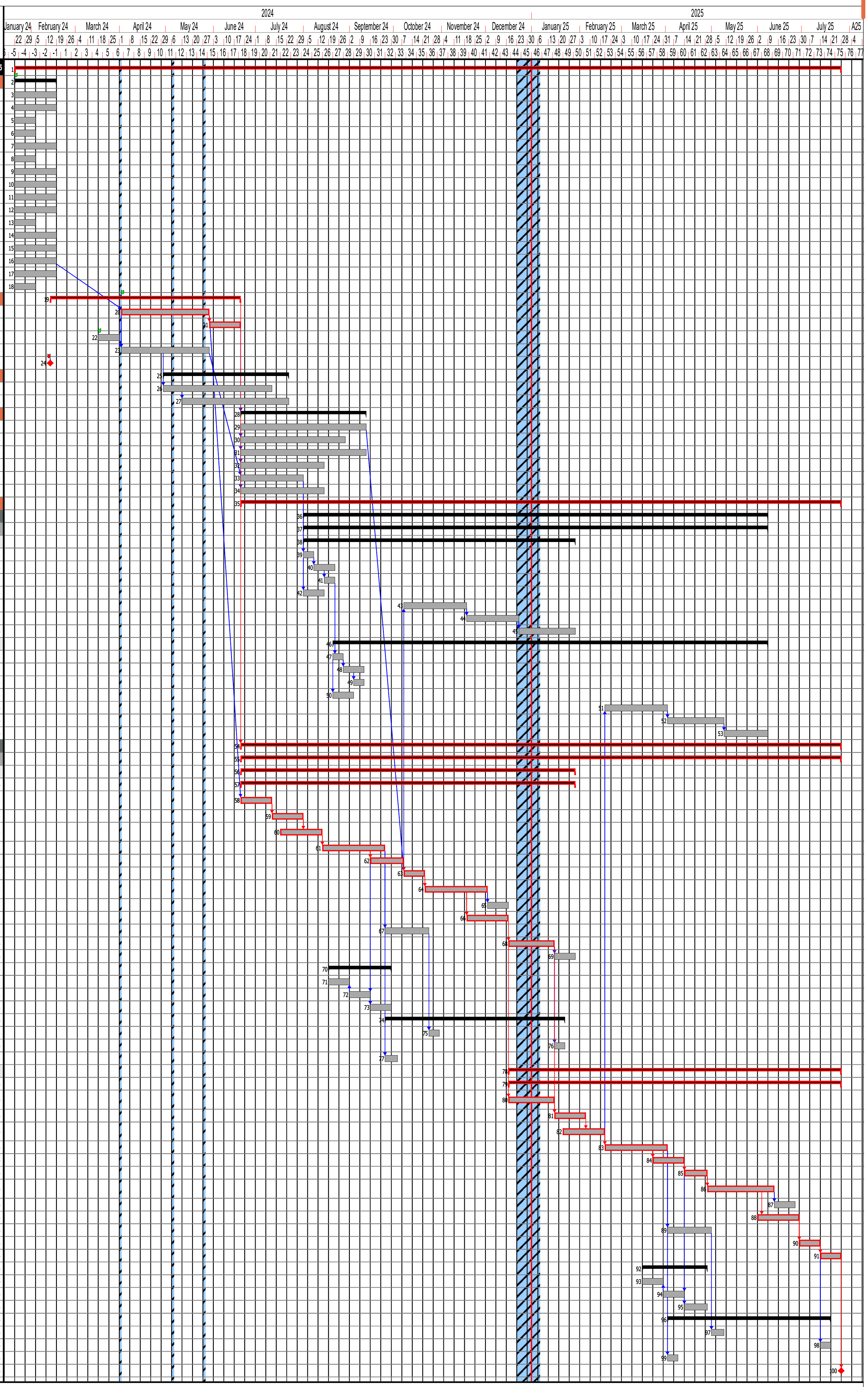
Shettleston Retrofit

Shettleston Housing Association

30/10/2023

Rev: 0

Line	Name	Start	Duration	Finish
	Shettleston Retrofit	**22/01/2024**	**76w 1d**	**28/07/2025**
2	**Early Surveys Inc. Reports**	**22/01/2024**	**4w**	**16/02/2024**
3	Rot survey to rafters	22/01/2024	4w	16/02/2024
4	Structural survey of rafters/roof to support PV Panels	22/01/2024	4w	16/02/2024
5	Drainage CCTV Survey - downpipe pop-ups	22/01/2024	2w	02/02/2024
6	Ground conditions for Heat Source Pumps (slabs)	22/01/2024	2w	02/02/2024
7	External Building Survey (boss testing/mortar testing/inspections)	22/01/2024	4w	16/02/2024
8	Roof Slate inspection	22/01/2024	2w	02/02/2024
9	Survey external services	22/01/2024	4w	16/02/2024
10	Opening up works/service penetrations through load-bearing walls	22/01/2024	4w	16/02/2024
11	Replacement Window Site Sizing	22/01/2024	4w	16/02/2024
12	Replacement Internal and External Doors site sizing	22/01/2024	4w	16/02/2024
13	Internal wall lining cavity survey	22/01/2024	2w	02/02/2024
14	Measurement survey	22/01/2024	4w	16/02/2024
15	MVHR routes and size locations	22/01/2024	4w	16/02/2024
16	Asbestos Survey	22/01/2024	4w	16/02/2024
17	Thermographic Survey	22/01/2024	4w	16/02/2024
18	GPRS	22/01/2024	2w	02/02/2024
19	**Design**	**14/02/2024**	**17w 3d**	**19/06/2024**
20	Updated design based on surveys	02/04/2024	8w	29/05/2024
21	Costs to be updated following design	30/05/2024	3w	19/06/2024
22	Cost submission service alterations	18/03/2024	2w	29/03/2024
23	Applications for service alterations (BT/Sky/Virgin etc.	02/04/2024	8w	29/05/2024
24	Submission for Grant	14/02/2024		14/02/2024
25	**Statutory Consents**	**30/04/2024**	**11w 3d**	**22/07/2024**
26	Planning Application	30/04/2024	10w	10/07/2024
27	Building Warrant Application	13/05/2024	10w	22/07/2024
28	**Manufacture**	**20/06/2024**	**12w**	**11/09/2024**
29	Windows	20/06/2024	12w	11/09/2024
30	Doors	20/06/2024	10w	28/08/2024
31	Heat Source Pumps	20/06/2024	12w	11/09/2024
32	PV Panels	20/06/2024	8w	14/08/2024
33	MVHR	20/06/2024	6w	31/07/2024
34	Insulating Render Board	20/06/2024	8w	14/08/2024
35	**Construction Phases**	**20/06/2024**	**55w 1d**	**28/07/2025**
36	**Phase 1 - Within flats, Residents In-situ**	**01/08/2024**	**42w 1d**	**06/06/2025**
37	**Internal**	**01/08/2024**	**42w 1d**	**06/06/2025**
38	**Closes 1 to 3**	**01/08/2024**	**24w 2d**	**29/01/2025**
39	Draft stopping between floorboards (GF Flats only)	01/08/2024	1w	07/08/2024
40	Draft-stopping around opening panes & at junction with walls	08/08/2024	2w	21/08/2024
41	New front doors to each flat, well-sealed to existing wall	15/08/2024	1w	21/08/2024
42	Low energy lighting throughout	01/08/2024	2w	14/08/2024
43	Install MVHR	08/10/2024	6w	18/11/2024
44	Box in all ductwork and MVHR	19/11/2024	5w	23/12/2024
45	Decoration to flats	24/12/2024	4w	29/01/2025
46	**Closes 4 to 6**	**21/08/2024**	**39w 2d**	**06/06/2025**
47	Draft stopping between floorboards (GF Flats only)	21/08/2024	1w	27/08/2024
48	Draft-stopping around opening panes & at junction with walls	28/08/2024	2w	10/09/2024
49	New front doors to each flat, well-sealed to existing wall	04/09/2024	1w	10/09/2024
50	Low energy lighting throughout	21/08/2024	2w	03/09/2024
51	Install MVHR	19/02/2025	6w	01/04/2025
52	Box in all ductwork and MVHR	02/04/2025	5w	08/05/2025
53	Decoration to flats	09/05/2025	4w	06/06/2025
54	**Phase 2 - Communal & External Works, With Residents In-situ**	**20/06/2024**	**55w 1d**	**25/07/2025**
55	**External Works**	**20/06/2024**	**55w 1d**	**25/07/2025**
56	**Closes 1 to 3**	**20/06/2024**	**30w 2d**	**29/01/2025**
57	East and South East Elevations	20/06/2024	30w 2d	29/01/2025
58	Excavate down tight to building to allow insulation board to provide thermal break	20/06/2024	3w	10/07/2024
59	Erect scaffold Inc. Hoist	11/07/2024	3w	31/07/2024
60	Temporary remove and support existing services to rear and gable walls	17/07/2024	4w	13/08/2024
61	Extend roof eaves	14/08/2024	6w	24/09/2024
62	Apply Diathonite Thermactive to achieve smooth surface	16/09/2024	3w	07/10/2024
63	Window replacement for triple glazing (40No.)	08/10/2024	2w	21/10/2024
64	Install 200mm insulating render board (leave strip full height to boiler extracts)	22/10/2024	6w	02/12/2024
65	Fit window cill extensions	03/12/2024	2w	16/12/2024
66	Re-instate services	19/11/2024	4w	16/12/2024
67	Install PV Panels	25/09/2024	4w	23/10/2024
68	Strip Scaffold	17/12/2024	3w	15/01/2025
69	Make good to ground	16/01/2025	2w	29/01/2025
70	North East Elevation	19/08/2024	6w	27/09/2024
71	Erect scaffold	19/08/2024	2w	30/08/2024
72	Window replacement Inc. making good to window surrounds (58No.)	02/09/2024	2w	13/09/2024
73	Strip scaffold	16/09/2024	2w	27/09/2024
74	Other items	25/09/2024	15w 3d	22/01/2025
75	Infrastructure for Heat Source Pumps	24/10/2024	1w	30/10/2024
76	Install front and rear communal doors	16/01/2025	1w	22/01/2025
77	Loft Insulation	25/09/2024	1w	02/10/2024
78	**Closes 4 to 6**	**17/12/2024**	**29w 4d**	**25/07/2025**
79	East and South East Elevations	17/12/2024	29w 4d	25/07/2025
80	Excavate down tight to building to allow insulation board to provide thermal break	17/12/2024	3w	15/01/2025
81	Erect scaffold Inc. Hoist	16/01/2025	3w	05/02/2025
82	Temporary remove and support existing services to rear and gable walls	22/01/2025	4w	18/02/2025
83	Extend roof eaves	19/02/2025	6w	01/04/2025
84	Apply Diathonite Thermactive to achieve smooth surface	24/03/2025	3w	11/04/2025
85	Window replacement for triple glazing (40No.)	14/04/2025	2w	28/04/2025
86	Install 200mm insulating render board (leave strip full height to boiler extracts)	29/04/2025	6w	11/06/2025
87	Fit window cill extensions	12/06/2025	2w	25/06/2025
88	Re-instate services	02/06/2025	4w	27/06/2025
89	Install PV Panels	02/04/2025	4w	30/04/2025
90	Strip scaffold	30/06/2025	2w	11/07/2025
91	Make good to ground	14/07/2025	2w	25/07/2025
92	North West Elevation	17/03/2025	6w	28/04/2025
93	Erect scaffold	17/03/2025	2w	28/03/2025
94	Window replacement	31/03/2025	2w	11/04/2025
95	Strip scaffold	14/04/2025	2w	28/04/2025
96	Other items	02/04/2025	15w	18/07/2025
97	Infrastructure for Heat Source Pumps	01/05/2025	1w	08/05/2025
98	Install front and rear communal doors	14/07/2025	1w	18/07/2025
99	Loft Insulation	02/04/2025	1w	08/04/2025
100	Project Completion	28/07/2025		28/07/2025



Symbols: Critical | Start After | Start On | Finish On

Start: 22/01/2024

Finish: 28/07/2025

1

GBEC1037 – Shettleston Housing Association

Material Testing and Hygrothermal Risk Assessment

Date: 02/08/2023
Author: JC
Revision: B
Check: OdSC

1

Project Background

Shettleston Housing Association manage several buildings in the Shettleston district of Glasgow, Scotland in which they are seeking to improve the energy efficiency. As part of the works, they have appointed ECD architects to aid them in identifying a suitable retrofit strategy

The Figure 1. below shows the existing condition of the walls with the front (north facing) in red sandstone and the Gable end (west facing) in blonde sandstone.

Figure 1. Photograph showing the existing stonework of 40 Old Shettleston Rd

Due to the nature of the existing building, any proposals to improve the thermal performance will require careful consideration to mitigate any moisture risks and prevent unwanted or unintended damage to the existing fabric.

As part of this project, Greengauge were approached to assess the moisture risk associated with internally insulating the existing walls at Old Shettleston Road and the Shettleston Housing Association office which was assumed to be the same block type. To allow the risk assessment to be as representative as possible, material testing of the existing stone was undertaken to determine the key material properties for the existing materials and to inform the inputs for the hygrothermal risk assessment.

Hygrothermal Risk Assessment

British and International Standards
Hygrothermal risk in buildings is a complex topic that requires careful assessment by an experienced assessor. Guidance for this is given in several documents and standards, with the most notable being:

- BS EN ISO 15026:2007 Hygrothermal performance of building components and building elements – Assessment of Moisture Transfer by Numerical Simulation
- BS EN ISO 13788:2012 Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods
- BS 5250:2021 Management of Moisture in Buildings;

Wufi Pro
The software used for the hygrothermal risk assessments here is called Wufi Pro, which is a one-dimensional hygrothermal simulation tool based on principles outlined in BS 15026:2007. These 1-D simulations are a simplification of the real-life processes occurring in the build-up and as such cannot represent more complex 2-D effects that can occur at junctions, but when used correctly, can give useful guidance.

DELPHIN
This is a simulation program for the coupled matter, heat and moisture transport in porous building materials. It allows thermal and hygrothermal assessment of 1D, 2D and 3D details.

Flixo Pro
This is a finite element analysis tool for assessing 2D thermal bridges. It has been validated against several internationally recognised standards including BS EN ISO 10077-2:2017.

Key Risk Factors
When a building element is designed or retrofitted the moisture risk factors should be assessed. The key risk factors that will be focussed on for this assessment include:

Mould Growth
This includes both mould growth on the surface and within the build-up and which can lead to negative health impacts for occupants. As a rule of thumb, mould growth can occur when the relative humidity at a location remains above 80% for an extended period of time. This is heavily dependent upon the temperature and is investigated further using the VTT Mould Growth Model where necessary.

Moisture Accumulation
This can often be known as surface or interstitial condensation and refers to the risk of moisture accumulating at a specific location on or within the build-up which could lead to condensation occurring. To assess the risk of moisture accumulation, the overall moisture and humidity trends for each material within the build-up are assessed. Moisture accumulation in and of itself is not necessarily a problem, but it can catalyse problems such as mould, rot and corrosion.

Timber Decay
Elements within a build-up that consist of either pure timber or are timber based (i.e., plywood, wood fibre, OSB etc.) can be at risk of decay when their water contents exceed a certain risk threshold.: 20M-% (percent by mass) for pure timber materials and 18M-% for timber-based materials [DIN 68800:2012].

When looking at service voids that may have timber elements within them or old masonry walls which can have embedded timber joists ends, the 1-D aspect of Wufi Pro means that the water content in these layers cannot be assessed directly as they are not themselves explicitly modelled. Therefore, the relative humidity of the materials in which they lie are assessed (i.e., the air within the service void or the masonry within the wall). Using a generic moisture storage function for a spruce material, a 20M-% water content in timber is equivalent to a relative humidity in the surrounding material of c.87% and so this value is used as the risk threshold in these situations. The risk of decay is also heavily dependent upon the temperature, where necessary this is further explored within the report.

Spalling Risk
Spalling is a phenomenon where the outer face of a masonry wall can be seen to be 'blown off'. This a result of this masonry reaching c.30% saturation and being subjected to freezing temperatures, causing the moisture within the pores to freeze, expand and break off part of the masonry. This is a complex risk factor to assess and so a simplified method is adopted looking at water content and temperature.

Corrosion Risk
Metallic elements within a construction may corrode when exposed to high humidity. One example of this is reinforcing steel in concrete; the reinforcement steel is protected by the alkalinity of the concrete however when the carbonation process occurs (which can be catalysed by high humidity) to a certain extent, the steel can be at risk of corrosion. Corrosion is a complex chemical process outside of the field of our expertise. However, we understand that these processes can occur at elevated moisture levels; for other moisture risks, 80% relative humidity (RH) is a significant threshold because beyond this level the availability of free water rises rapidly. The Fraunhofer Institute for Building Physics gives informal guidance that below 80% RH, the corrosion of steel in carbonated concrete is negligible. If the client has any concerns regarding corrosion, we recommend seeking advice from a suitably qualified material scientist.

Limitations
This report is for the exclusive use of the client and should not be used in whole or in part by any other third parties without the express permission of Greengauge in writing. This report should not be solely relied on by the client to inform decisions but should be used in conjunction with other documents such as architectural plans. The hygrothermal simulation assessments and thermal assessments undertaken are done based on large areas of uncertainty such as material properties, internal and external climates, construction quality, workmanship and usage. Taking these uncertainties into account, our best efforts have been made to give accurate and informative results and analysis, and a reasonable assessment of the risks identified.

Caveats and Context

All assessments were undertaken based on information received from the client. Some calculations in this report have been completed using Wufi Pro 6.7, (which is a one-dimensional hygrothermal simulation tool based on principles outlined in BS EN 15026:2007). It is important to understand that these 1-D simulations are a simplification of the real-life processes occurring in the build-up and as such cannot represent more complex 2-D effects that can occur at junctions, but when used correctly, can give useful guidance.

Although many materials within the Wufi Pro and DELPHIN database have been tested and analysed by certified bodies, only a small percentage of these are UK building materials and as such most are not directly equivalent to materials used within the UK. The most closely matching materials within these databases have been selected to represent the actual proposed materials and generate meaningful results.

The climate file used has been generated externally and reflects weather data for the Shettleston region. Although it is accurate for present-day simulations, due to the nature of the fluctuating climate along with climate change, it cannot be used to accurately predict the future climate of this region.

Assumptions about the occupancy and occupant behaviour based on the provided information have been used to inform the simulation and so these may differ from these assumptions when in-use.

Information Received

Prior to works, Greengauge received several documents to aid in the assessment, including;

- 230090-ECD-XX-XX-M3-A - 07150 - Existing Sections.pdf
- 230090-ECD-XX-XX-M3-A- 07500 - Existing Elevations.pdf
- 230090-ECD-XX-XX-M3-A- 07100 - Existing Plans No-40.pdf

Material Testing

Material testing and characterisation was undertaken on the seven stone samples which were collected during a site visit. These samples were chosen as they were such that they provided good representation for stone types across the building. The specific stone properties can influence what type, and how much internal insulation can be used on each.

Methodology

The samples are cut into a prismatic shape to approximate 1-dimensional flux, e.g., Figure 2 (below). The sample is suspended from an analytical balance as shown in Figure 2 (below). Additional water is slowly added to the water bath until the water level reaches the bottom face of the sample. The surface area of the bath is large in relation to the sample, such that the volume of water absorbed has a negligeable effect on the water depth. The sample mass is recorded at regular intervals e.g. 1 second. Analysis specified in BS EN ISO 15148 is then undertaken to calculate the absorption coefficient.

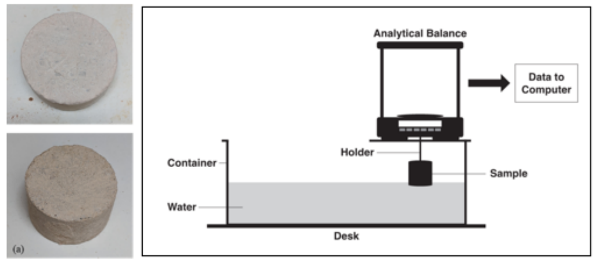


Figure 2. Image showing the desired shape of the samples and a diagram indicating the apparatus set-up.

Results

The results from the testing are as follows:

Table 1. Material Testing Results for the Samples collected from Shettleston Housing Association.

Sample	Density (kg/m³)	Absorption Coefficient (kg/m²s$^{1/2}$)	Capillary Saturation (kg/m³)
Stone 1 (red)	*2100*	0.053	110
Stone 2 (red)	1900	0.454	170
Stone 3 (red)	1900	0.596	180
Red Stone Average	*2000*	*0.368*	*150*
Stone 4 (blonde)	2000	0.039	120
Stone 5 (blonde)	2000	0.037	130
Stone 6 (blonde)	2100	0.039	110
Stone 7 (blonde)	2100	0.026	120
Blonde Stone Average	*2050*	*0.035*	*120*

The absorption coefficient is a quantity which indicates how absorptive a material is; the larger the value, the greater the absorptivity and so the quicker it will take up water.

The capillary saturation quantifies the total amount of moisture the material can hold; the larger the value, the more moisture the material can hold.

The figure below shows photographs for each of the samples tested, with the testing face shown. From these photographs, stone 1 appears to be a slightly lighter shade of red compared to stones 2 and 3. Stone 5 appears to have a more granular texture than the other blonde stones tested.

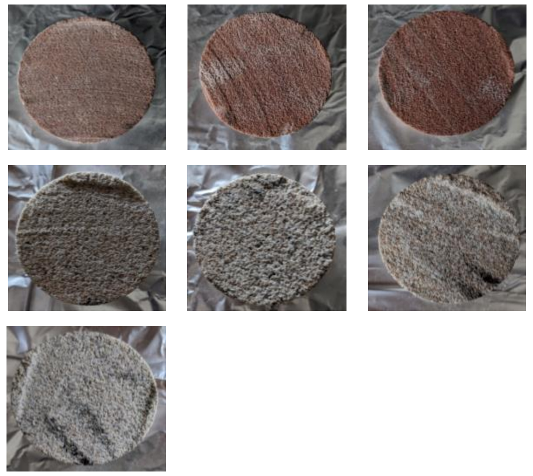


Figure 3. Photographs of the samples tested.

Figure 4. and 5. below show the absorptivity of the three red stones and four blonde stones graphically – the steeper the gradient of the line, the more absorptive the stone.

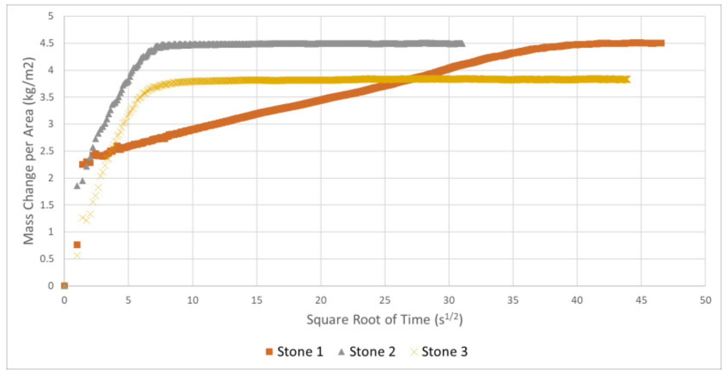


Figure 4. Graph showing the absorption testing results for red sandstone.

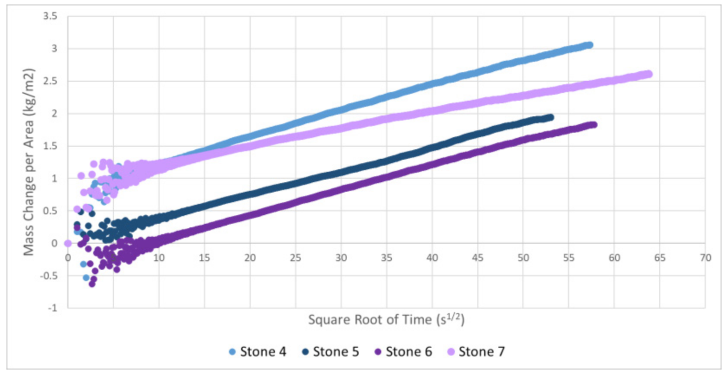


Figure 5. Graph showing the absorption testing results for blonde sandstone.

These results highlight:

- There is variation in the properties between each stone sample tested
- Stone 1 displays quite different properties to the other two red sandstone samples (2 and 3) and is much less absorptive
- In general, the red sandstone is more absorptive than the blond sandstone but has a higher capillary saturation and so can hold more moisture

These material testing results were then used to select the most appropriate representative materials from the material database within the Wufi Pro software. The table below outlines the materials from the Wufi pro database which were selected to represent the existing stone.

Table 2. The representative materials selected for the existing stone from the Wufi Pro database.

Database Material	Density (kg/m³)	Absorption Coefficient (kg/m²s$^{1/2}$)	Capillary Saturation (kg/m³)
Red Sandstone			
Stone B (Sandstone Ruthen)	1919	0.33	160
Blonde Sandstone			
Stone A *(Sander Sandstone)*	2120	0.021	130

Model Set-Up

Greengauge have run several simulations to test the moisture behaviour in the proposed build-ups using Wufi Pro, a dynamic hygrothermal simulation software as per BS EN 15026.

This section of the report will address only the hygrothermal performance of the proposed external wall build-ups. It will not address any other aspects of design and so should be used in conjunction with other technical reports for decision making purposes.

Climate

The external climate file was generated for the Shettleston, Glasgow location. Although it is accurate for present-day simulations, due to the nature of the fluctuating climate along with climate change, it cannot be used to accurately predict the future climate of this region. The internal climate was assigned a 'medium moisture load+5%' which represents an internal relative humidity that fluctuates between 35% and 65% relative humidity.

Orientation

The models were simulated with a north, south and west orientation based on plan drawings for Old Shettleston Road indicating the orientations of the stone type and the highest risk orientations due to the low levels of solar radiation (north) and the high levels of wind driven rain (west and south). Figure 6. below shows the solar radiation and driven rain for different orientations of the climate file used for this assessment.

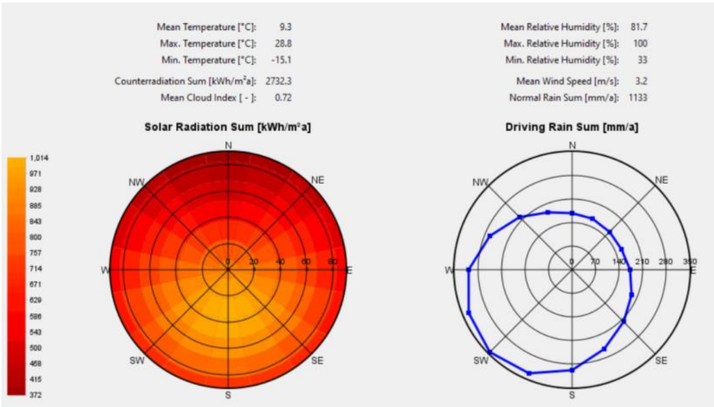


Figure 6. Diagram showing the climate data used within this assessment.

Existing Conditions

A preconditioning assessment was undertaken initially in which the existing walls were modelled for 10 years (or until a dynamic equilibrium had been reached). The final moisture contents for each layer of the build-ups were used as the starting moisture content for the main assessment iterations. Due to the age of the building and visual inspection on site, it has been assumed that a lime-based mortar would have been used within the walls.

Build-ups

Figure 7. below shows the build-up modelled in the Wufi Pro database for the proposed wall. A sandwich structure of stone, mortar and stone was used here as per guidance in Historic Environment Scotland Technical Paper 15. This has been shown to be a suitable way to represent the 2D mortar matrix in 1D. The build-up has been assumed to be a solid stone wall, as opposed to a rubble filled cavity wall acting as a capillary break, this presents a more conservative approach, assuming moisture from the outside is able to reach the inside through capillary action. Given internal samples were not possible to be taken, it has been assumed that the interior stone is the same as the exterior stone.

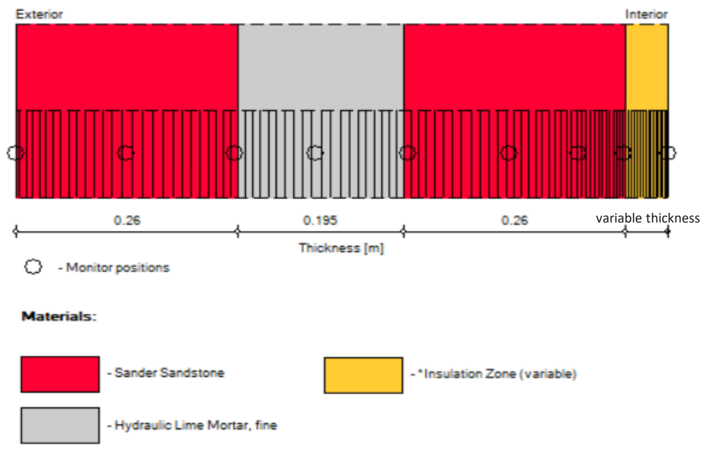


Figure 7. The proposed build-up modelled in the Wufi Pro interface.

Variables

As part of the assessment the impact of several variables were assessed for each wall build-up separately:

- Orientation - The Blonde Stone was assessed in both a westerly and southerly orientation to assess the impact of orientation with the worst case being taking forward
- Stone type – the exact stone material was not present in the database and so the most closely matching materials were selected. To understand the impact of the slight difference in properties between the different representative stone materials selected, a preliminary assessment to investigate this was undertaken.
- Mortar sensitivity – 4 different lime mortars materials were compared in the initial assessment and the worst case taken forward
- Insulation type and thickness –
    - 10mm lime, wood fibre (variable thickness), 10mm lime
    - 25mm Diathonite, 4mm lime, wood fibre, 10mm lime
    - 50mm Diathonite Thermactive
    - 50mm Calcium silicate board & lime adhesive
    - 80mm Calcium silicate board & lime adhesive
    - 50mm Calcium silicate board & 10mm Diathonite Thermactive adhesive
    - 80mm Calcium silicate board & 10mm Diathonite Thermactive adhesive
- Additional moisture sources – the impact of wind driven rain ingress, air leakage and an elevated internal humidity were assessed.
- Embedded timbers – The assumption is the floor joists run from front (North) to back (South) however, the risk of embedded timber decay has also been considered for the west wall.

Key Risk Factors

We understand that the key risk factors are:

- Decay of any embedded timber elements (e.g., timber joist ends)
- Mould growth or decay of the insulation product
- Mould growth on the internal surface
- Moisture accumulation within the build-up

Material Properties

Table 3. below outlines the key properties for the materials included in this assessment.

Sample	Capillary Saturation (kg/m³)	Density (kg/m³)	Absorption Coefficient (kg/m²s^1/2)	µ- value (-)	Thermal Conductivity (w/mK)
Sandstone Ruthen	*160*	*1919*	*0.3300*	*13.00*	*1.882*
Sander Sandstone	130	2120	0.0210	33.00	1.600
Lime Mortar	250	1700	0.0870	14.76	0.800
Lime Plaster	250	1600	0.0500	7.00	0.700
Wood Fibre Board	546	198	0.0028	2.70	0.041
Diathonite Thermactive	541	252	0.0480	3.00	0.037
Calcium Silicate Board	815	222	0.93	5.4	0.057

Table 3. Key Properties of the materials included in the assessment.

Main Assessment

Impact of Orientation

The impact of orientation was assessed. Figure 8. shows the relative humidity at a 75mm depth in the wall (this is the predicted location of any embedded timbers in the wall) for a north, south and west orientations. This graph is for a case with 60mm wood fibre adhered and finished with a lime plaster.

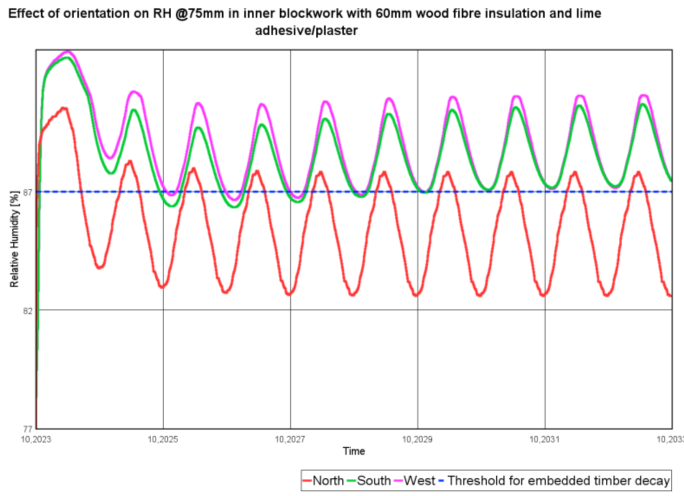


Figure 8. Graph showing RH in the wall for a North, South and West orientations.

Figure 8. indicates that west and south orientations result in a higher humidity at this location within the wall and hence a higher risk to any embedded timbers in the wall. This is likely a result of the higher levels of wind driven rain when compared to the north facing wall. Both the west and south orientations exceed the 87% risk threshold for timber decay and so installing this level of wood fibre insulation (60mm) could result in a high risk of damage to any existing embedded timbers in the wall. The impact of orientation on the conditions within the wood fibre insulation itself were also assessed – this is presented in Figure 9.

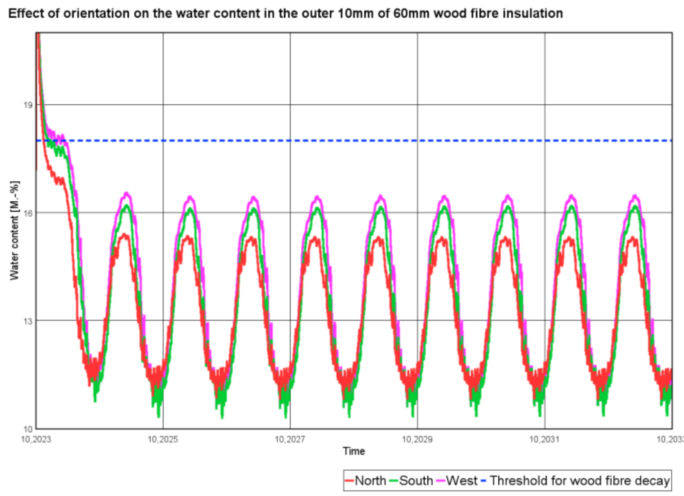


Figure 9. Graph showing the WC in outer region of wood fibre for different orientations.

Figure 9. indicates that there is a minimal impact of the orientation on the conditions within the outer 10mm of wood fibre insulation and that the water content is well below the risk threshold for wood fibre decay.

To remain conservative, the remainder of cases for the blonde sandstone presented in this report will be for a west, whereas any north orientations use the red sandstone blockwork, unless otherwise stated, the results for the blonde stone can be considered as suitable for either the south or west orientations however the report later explored options for the west wall in which there are no embedded timbers, this requires confirmation prior to any retrofit works.

Impact of insulation thickness

Insulation thickness can play a large part in the moisture retention and hygrothermal conditions of an element. To understand the impact of this the North wall was modelled with an 80mm layer of wood fibre and compared to that with a 60mm layer, the results of which are shown in figure 10.

Figure 10. shows the water content at the outer 10mm of the wood fibre. As can be seen, the thicker 80mm wood fibre results in a greater water content, highlighting the sensitivity to insulation thickness. However, each option is below the risk threshold for decay, despite this given the previous results for the South and West orientations exceeding the risk threshold for embedded timber decay, it is advisable to explore alternative options for insulation.

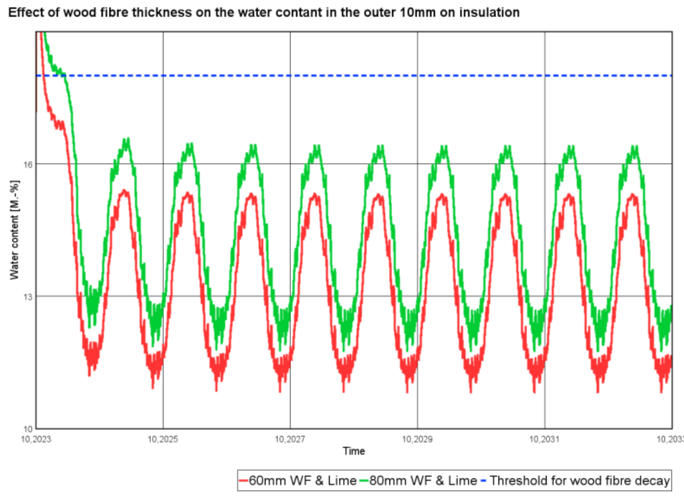


Figure 10. Graph showing the impact of insulation thickness on the WC in the North wall.

Impact of Insulation Type

Given the previous iterations exceeding the risk thresholds for relative humidity in the inner block work, other options for insulation have been explored. First of which is a Diathonite levelling layer of 25mm, with a lime adhesive layer, 60mm of wood fibre and a lime finishing plaster of 10mm.

Diathonite is a lime-cork insulating plaster and as such does not have any timber components that would be at risk of decay and thus the threshold for water content (<18M-%) does not apply, in addition, due to the alkaline nature of the lime plaster, it aids in inhibiting mould growth. Therefore, the risk within the Diathonite was not directly assessed here. The addition of Diathonite to the mix can help with some of the issues previously observed alongside improving the U-Value of the build-up. The second option is to use a 50mm layer of Diathonite exclusively. The results of the two options compared against the original 60mm wood fibre with regards to the RH in the inner blockwork are shown in figure 11. and figure 12 for the North and West orientations, respectively.

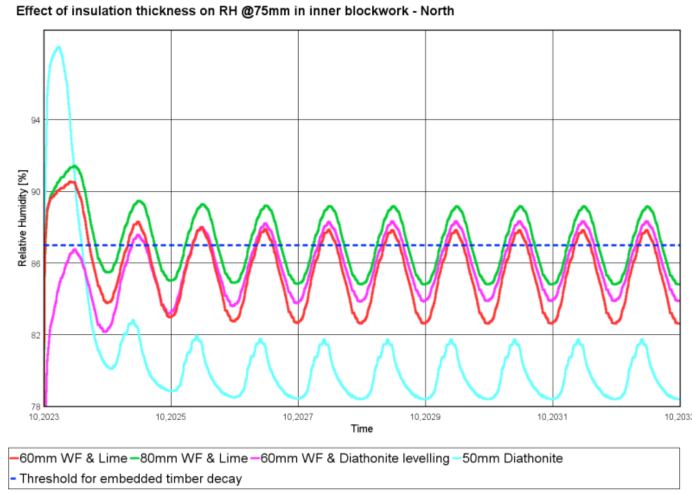


Figure 11. Graph showing the impact of different insulation types on the RH in the North wall

The initial spike of high humidity can be attributed to the Diathonite drying, for the purposes of modelling the Diathonite has been modelled as one 50mm layer however in application this would be applied in two 25mm layers with a drying period between which would reduce this initial peak.

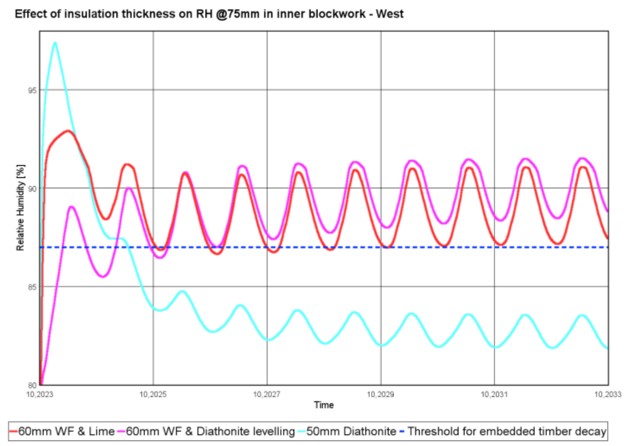


Figure 12. Graph showing the impact of different insulation types on the RH in the West wall

Main Assessment

Comparison of Figures 11 and 12 indicates that there is a lower risk of embedded timber decay for most insulation options (except the 80mm of wood fibre) in the north wall than the west wall. However, figure 12. indicates that all insulation options except the 50mm Diathonite in the west wall present a high risk to any embedded timbers. Therefore, further stress testing was modelled with this 50mm Diathonite option.

Impact of Additional Moisture Sources
The following section compares the impact of different stress tests on the hygrothermal risk simulated when using 50mm of Diathonite Thermactive. This insulation strategy is the only one to present a low risk of embedded timber decay within the west wall in typical situations but to ensure that it is robust it is important to ensure that unpredictable events do not post extra risk. Several additional moisture stresses were applied to each of the buildups to understand their behaviour under As Built, In Service conditions.

The following additional moisture sources were assessed to understand the behaviour of the wall under as built in service (ABIS) conditions:

- A degree of air infiltration (Q50=5 m3/m2 @50Pa)
- 1% Wind Driven Rain (WDR) ingress – i.e. 1% of rain incident on the surface of the wall is deposited at a selected location within the build-up - representative of cracks or faults in the masonry
- An elevated internal moisture load

These stresses were modelled individually to assess the impact on the Diathonite and to highlight any causes for concern in implementing the IWI system. Figure 13. shows the stress tests for the North wall at 75mm into the inner blockwork all fall below the risk threshold for embedded timber decay of 87% RH. In the instance of air ingress, the impact was minimal due to the fully bonded nature of the insulation strategy and thus this can be considered as the baseline for comparison for the following graphs regarding the stress tests.

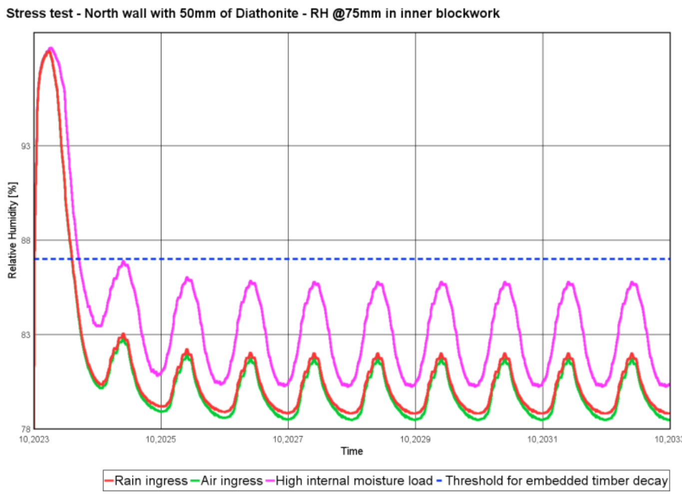


Figure 13. Graph showing RH in the North wall for different stressors.

Figure 14. indicates that once equilibrium has been reached, the risk of timber decay in the West wall, which has shown itself to be the higher risk orientation is still low, with the high moisture load peaking above the threshold for a short period, which will require management of the internal moisture after installation. Provided there are no embedded timbers in the wall as suggested, there should be no cause for concern.

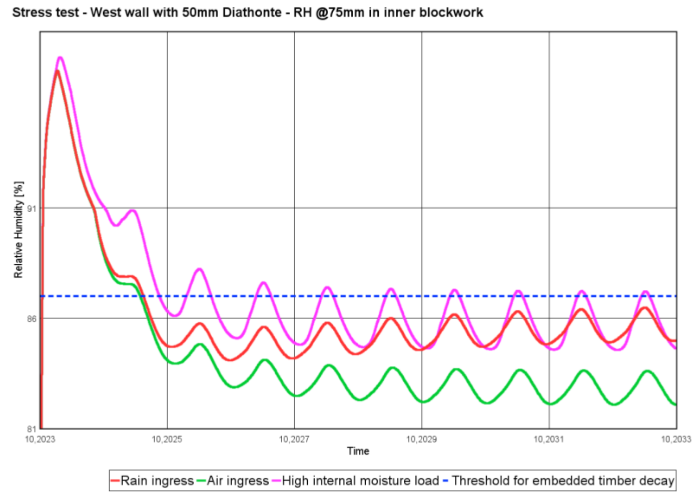


Figure 14. Graph showing RH in the West wall for different stressors.

Figure 15. shows the RH in the inner blockwork for the south wall under the three stressors, despite posing lower risk than the west wall, given the expectation that it contains embedded timbers, it is prudent to ensure that there is low risk due to the IWI intervention.

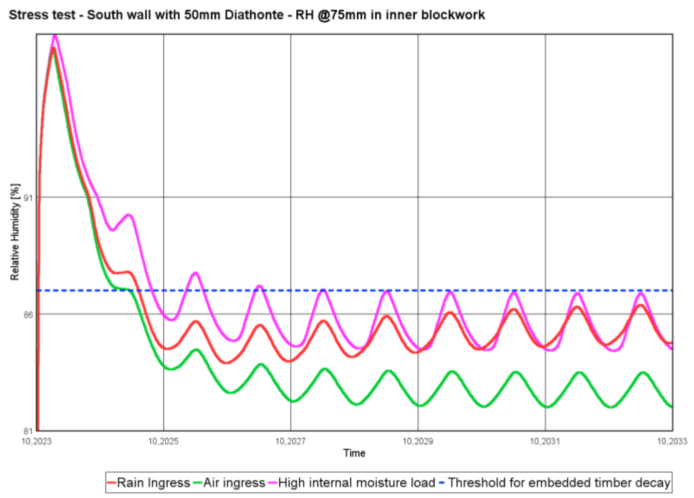


Figure 15. Graph showing RH in the South wall for different stressors.

The impact of these additional moisture sources on the water content in the outer 10mm of wood fibre insulation was also assessed for the case with 40mm wood fibre. The trends seen follow those above, with the internal moisture load having the largest impact on the risk of wood fibre decay but in this instance, all cases remain below the 18M-% risk threshold.

Diathonite is a lime-cork insulating plaster and as such does not have any timber components that would be at risk of decay and thus the threshold for water content (<18M-%) does not apply, in addition, due to the alkaline nature of the lime plaster, it aids in inhibiting mould growth. Therefore, the risk within the Diathonite was not directly assessed here.

Overall, provided that the internal conditions are well controlled, 50mm Diathonite Thermactive could be installed with a low hygrothermal risk and provide a suitable level of thermal improvement and air tightness.

No embedded timbers – west wall
Provided confirmation that the west wall does not contain embedded timbers, it could be possible to use a higher performing insulation strategy in these areas (presumed the west and east wall) in order to reduce the heat loss of the gable end apartments.

The options explored were 60-80mm of wood fibre with a Diathonite adhesive of 25mm to achieve a U-value of 0.36-0.31W/m^{2}K respectively. In these areas the RH of the inner blockwork becomes less of a concern and the main risk thresholds considered are the RH (<95%) and water content (<18M-%) in the outer 10mm of the wood fibre.

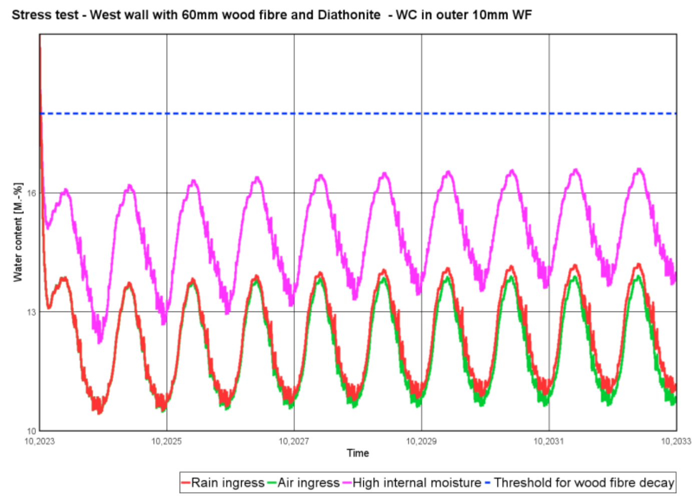


Figure 16. Graph showing WC in the West wall for different stressors with 60mm wood fibre and 25mm Diathonite.

Main Assessment

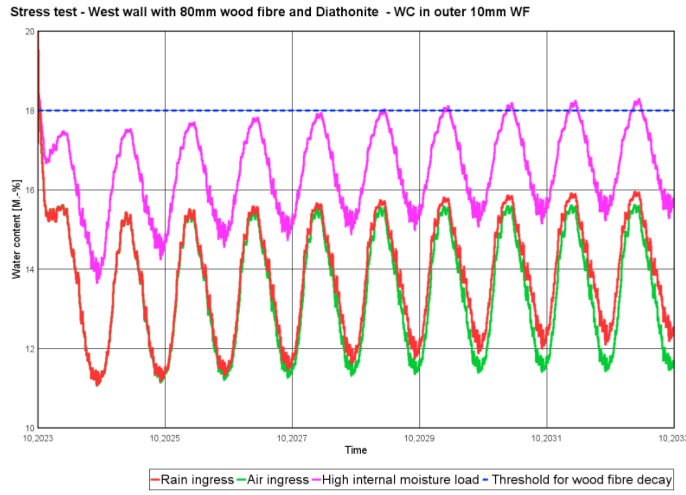


Figure 17. Graph showing WC in the West wall for different stressors with 80mm wood fibre and 25mm Diathonite

Figure 16 and 17 shows that the 60mm and 80mm of wood fibre and Diathonite respectively, are safely below the risk threshold. Figure 17. shows that there is a short period where the water content may exceed the threshold for a high moisture load but given the period is short (below 3 months annually) and dries out sufficiently between, this is not cause for concern.

Calcium Silicate board IWI on the North Wall

Further discussion with the architect raised the subject of using calcium silicate board in the North Facing wall. The board is often used as a last resort given the expense and thermal performance, but it can result in better hygrothermal performance. Calcium silicate boards are readily available in 30mm and 50mm thicknesses and layered to achieve greater thermal performance.

Current proposals are to use the Calcium Silicate board on the North wall as an IWI as and when apartments become vacant. This will leave some apartment blocks uninsulated adjacent to insulated apartments, as a result consideration will be required for the way and location in which the IWI terminates to avoid hygrothermal issues and thermal bridging, which can lead to a risk of surface moisture in uninsulated properties where warm moist air reaches dew point.

Initial investigations were to establish an appropriate thickness and adhesive/levelling layer for which to adhere the Calcium Silicate board to the existing wall.

Figure 18 shows the results for the Relative Humidity in the inner 75mm of the inner blockwork (where it is expected any embedded timbers would terminate). The 4 options investigated were;

- *50mm Calcium Silicate and 10mm lime adhesive*
- *80mm Calcium Silicate and 10mm lime adhesive*
- *50mm Calcium Silicate and 10mm Diathonite adhesive*
- *80mm Calcium Silicate and 10mm Diathonite adhesive*

As can be seen in figure 18 all options presented a low risk of timber decay, however the thicker layer of calcium silicate presents a greater risk, peaking just below the risk threshold of 87% whereas for the 50mm calcium silicate board the margin is greater. Alongside this, the addition of Diathonite to the build-up as an adhesive layer results in an increased RH, which may be a result of the increased thermal resistance and thus lower temperatures and higher RH within the wall.

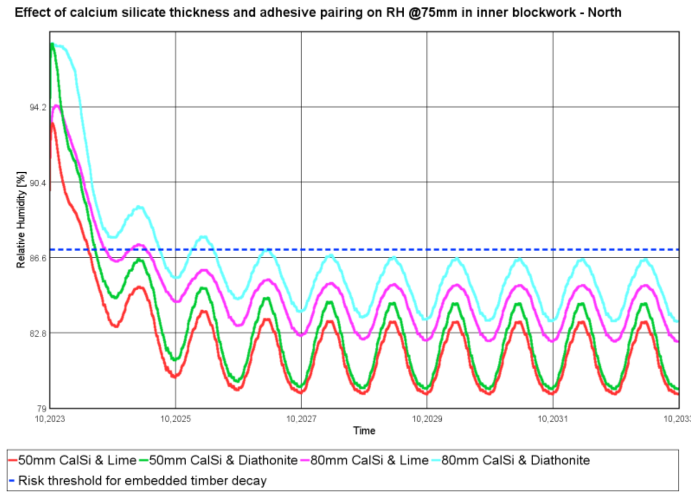


Figure 18. Effect of calcium silicate thickness and adhesive pairing on RH @75mm in inner blockwork - North

The junction between the IWI and blockwork was further investigated for the 4 options above. The 95% risk threshold (as per directly bonded insulation) was referenced here. Figure 19 presents the results, showing the resulting RHs at this location remain below the 95% risk threshold and a low risk of moisture related issues.

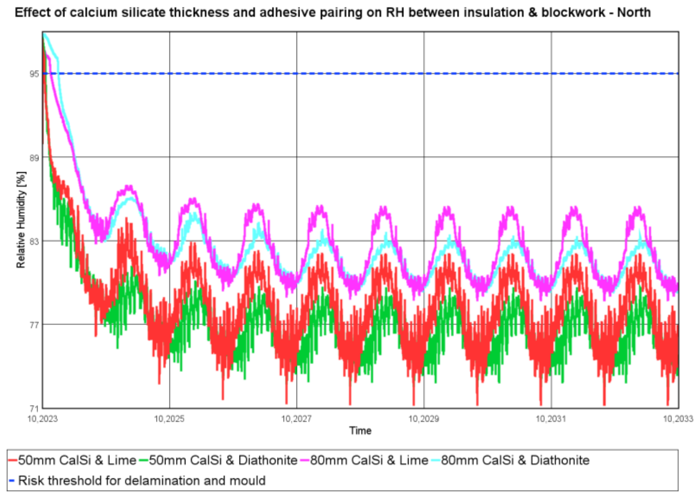


Figure 19. Effect of calcium silicate thickness and adhesive pairing on RH between insulation & blockwork - North

Finally figure 20 shows the results of critical stress tests for the thicker and thus riskier board (80mm with Diathonite) It shows that a high internal moisture load would result in the RH at a 75mm depth in the stone exceeding the risk threshold for timber decay, as such a good ventilation strategy would be required for this thickness of calcium silicate board and Diathonite and without internal moisture management a more conservative approach may be more appropriate such as 50mm calcium silicate and lime.

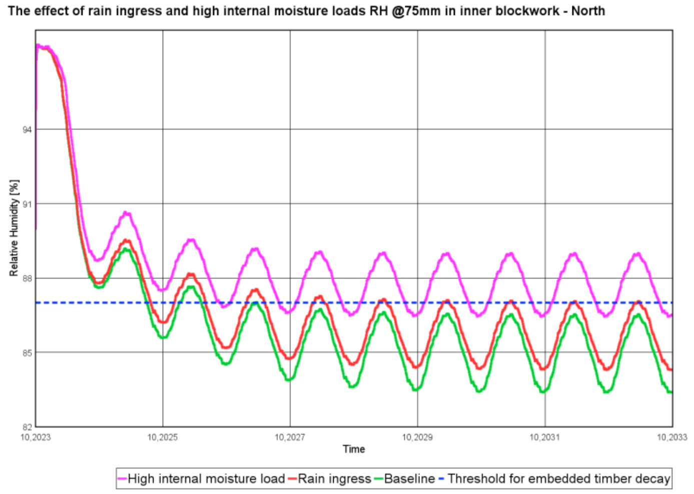


Figure 20. The effect of rain ingress and high internal moisture loads RH @75mm in inner blockwork - North

Conclusions

The moisture risk associated with installing internal wall insulation onto existing stone walls at Old Shettleston Road was investigated.

Material testing was undertaken on a selection of stone samples collected on site and the results for these were used to inform the material input for the hygrothermal risk assessment.

Without Embedded Timbers
In the instance in which there are no embedded timbers within the wall, or the existing embedded timbers are removed, up to 80mm wood fibre insulation can be installed with a low risk internally with a 25mm Diathonite Thermactive levelling, a 4mm lime adhesive and 10mm lime plaster finishing layer.

With Embedded Timbers
For the North wall, in the instance in which there are embedded timbers, up to 60mm wood fibre and lime or 80mm wood fibre and 25mm Diathonite levelling can be applied with a low risk. A 60mm wood fibre and Diathonite solution would provide the greatest benefit thermally with a U-Value of 0.36W/m2K. If a calcium silicate board is preferred, then the thickness should be limited to 50mm and Diathonite (achieving a 0.56W/m2K) without a suitable internal moisture management or up to 80mm board thickness and Diathonite (achieving 0.39W/m2K) with internal moisture management.

On the West wall with embedded timbers the lowest risk IWI solution presented would be 2no. 25mm layers of Diathonite Thermactive (totalling 50mm) with a period of drying between, application during the summer months. In additional, active dehumidification can aid the drying times and reduce the initial risk due to the high humidity spike.

The internal moisture load (i.e., internal relative humidity) had the largest impact on the risk for all build-ups and highlights the importance of ensuring a suitable and robust ventilation system is in place. In many cases, there may be an elevated moisture risk without this.

Wind driven rain had an impact on the risk for the build-ups, particularly those with embedded timbers, and so it is important to ensure the existing masonry is in good condition (i.e., repointed and repaired where required) to prevent excess rain ingress and ensure the longevity of the construction.

A degree of air infiltration had a minimal impact on the overall build-up moisture risk. This is likely a result of the capillary active, and vapour open nature of the insulation options investigated as part of the assessment.

Additional Comments

Following the initial issuing of the report it was raised that the current strategy is to use an EWI system on the South and Gable Walls, to allow retrofit without decamping tenants as well as ensuring a lower hygrothermal risk strategy and better thermal performance.

For the North wall, the strategy remains an IWI system and as such the initial guidance still stands, however, there was a client preference to use calcium silicate boards, as such this has been investigated additionally with details being included in the report at a later stage. The mixing of the two approaches (IWI and EWI) does present some complications and is not without risk due to the junctions between the two systems. This will require consideration with regards to the thermal bridging.

Regarding the calcium silicate boards, the layering has been assumed to be made using an adhesive layer of Diathonite and/or lime, which reflects in the modelling. Further advice has been sought from Ecological Building Systems on the approved method but at the time of writing this report no further advice has been provided.

Alongside the above, the approach being taken is a staged retrofit and as such there will be prolonged periods in which one apartment is insulated with an adjacent one being uninsulated. This may lead to hygrothermal issues in the long run and as such may require consideration and management. Strategies such as dehumidification and ventilation may help mitigate the risk. At floor junctions, the intermediate floor to external wall junction will also remain uninsulated. This will also present a risk with regards to hygrothermal issues and thermal bridging related heat loss, if it is not possible to insulate these areas, a strategy that has been previously employed is to use a tapered calcium silicate board up to this region, this ensures a less drastic temperature gradient at the junction and can help mitigate localised risk areas.

As part of the works, it is recommended that any faults in the existing masonry or existing damp issues are addressed prior to the insulation being installed. We also recommend that the structure is well maintained to prevent unwanted moisture issues occurring in future.

We would recommend that the internal paint selected is vapour open to allow the insulated build-up to distribute moisture as intended.

Below Ground Walls
All options discussed up to this point have been in relation to above ground walls only. No explicit assessment has been undertaken for areas below ground. Any areas in contact with the ground or falling out of the scope of the options explored previously may require alternative insulation options. These insulation specifications will likely vary depending upon the intended depth below ground, the moisture content of the soil and the proposed reinforcement options/materials

We would recommend that below ground build-ups are discussed with manufactures to determine the most suitable and lowest risk option.

Shettleston Housing Association Office
It is understood the Shettleston Housing Association office is of a similar build type and period and that works may be carried out to retrofit them also using guidance provided in this report. It is important to highlight that the material testing and modelling performed were not carried out for the office and there are many factors that can affect the hygrothermal risk of a wall that may lead to different outcomes. As such it would be advisable to proceed with caution and ensure that internal conditions are favourable to drying and low humidity.

References

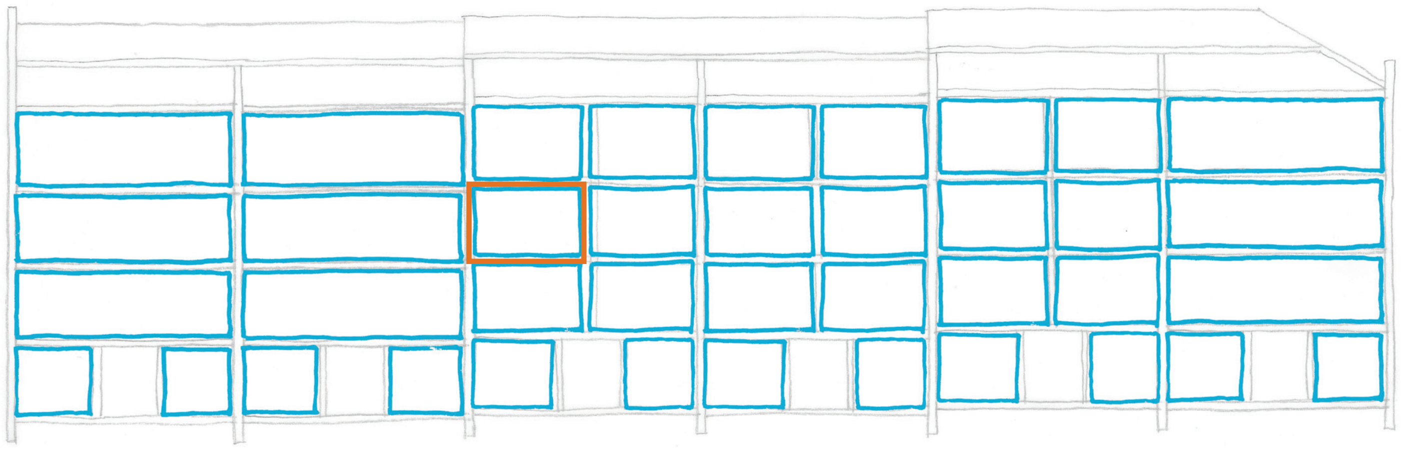
- BS EN ISO 13788:2012 Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods, BSI 2012.
- BS EN ISO 15026:2007 Hygrothermal performance of building components and building elements – assessment of moisture transfer by numerical simulation, BSI 2007.
- AHSRAE Standard 160-2016 Criteria for Moisture Control Design Analysis in Buildings, ASHRAE 2016
- DIN 68800:2012-2 Wood Preservation - Part 2: Preventative Constructional Measure in Buildings, German Institute for Standardisation, 2012
- WTA 6-2 Simulation of Heat and Moisture Transfer, 2002
- DIN 4108-2 Thermal protection and energy economy in buildings, German Institute for Standardisation, 2013
- WTA leaflet 6-8-15: Humidity evaluation of wooden components - Simplified verification and simulation.
- WTA leaflet E 6-5-12: Interior insulation according to WTA II - verification of interior insulation systems using numerical calculation methods. 2012
- BS EN ISO 10456:2007 Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values

1. Work to all flats with residents in situ

Decant strategy
None

Fabric possibilities & limitations
EWI to rear & gables
Increased loft insulation
PV panels
New windows (best in conjunction with insulation to relevant wall, also consider ventilation / airtightness & inclusion of trickle vents or not)
Shutters / curtains
Front & rear close doors
Ventilation improvements
General repairs & maintenance

Services possibilities & limitations
Adjustments to water flow temperatures
Low energy lighting throughout
All radiators fitted with TRVs



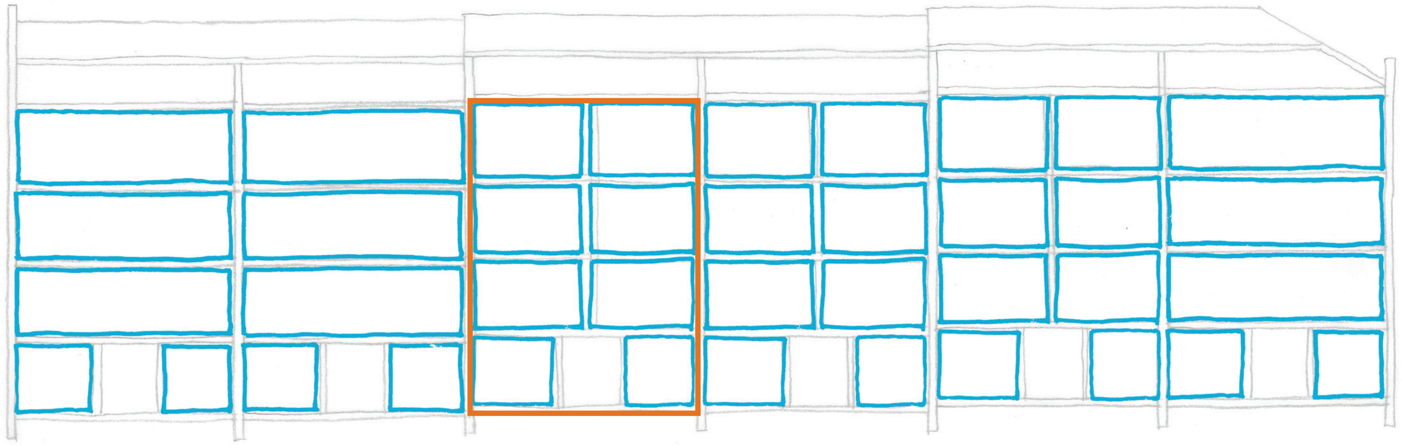
2. Work as individual flats become void

Decant strategy
Supplement work to each flat with more intrusive works as and when homes are temporarily void.
What proportion of homes might be improved over 10 years?

Fabric possibilities & limitations
IWI to front wall & party walls as required (IWI thickness limited by moisture issues, ref. stone type & joist embedment, potential need for new kitchen to some flats to suit reduced floor area)
Airtightness to walls, ceiling & floor of individual flat
Ground floor insulation as those flats are void

Services possibilities & limitations
Individual ASHP & new HW cylinder - ideally as compact unit, but likely only possible for smaller flats.
Upgrade / replace heating pipework & radiators to suit new heat load & insulation requirements.

New ventilation system to flat (MVHR or dMEV)



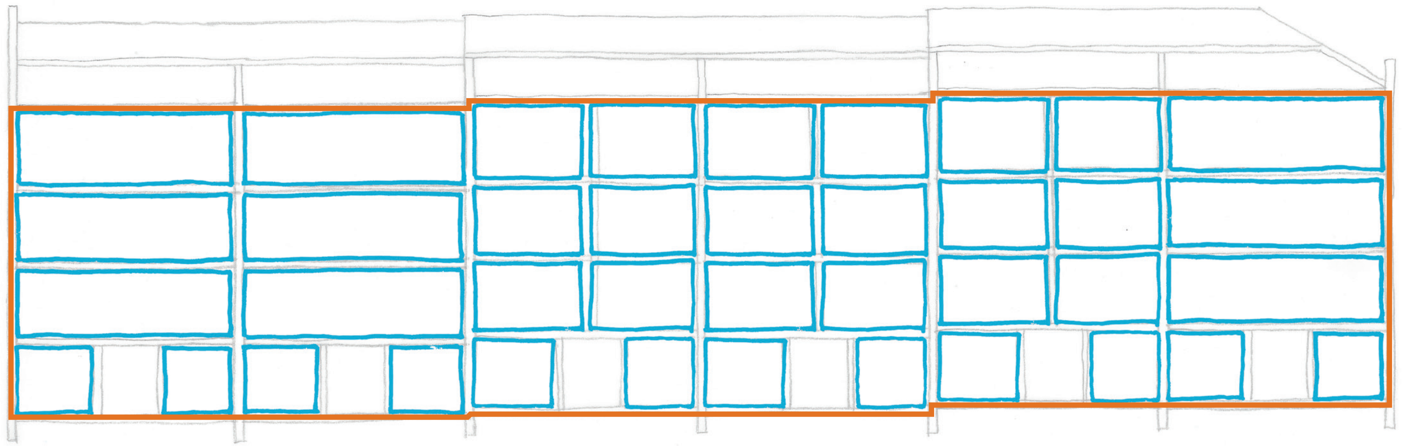
3. Whole staircase

Decant strategy
Decant one staircase at a time.

Less disruption to neighbours as none in situ during works

Fabric possibilities & limitations
IWI & Airtightness can be implemented to whole staircase including between joists
Opportunity for deeper maintenance

Services possibilities & limitations
Individual ASHP & new HW cylinder - simpler to implement individual ASHPs with external units & communal pipework
Simpler to remove gas from whole staircase in one go
Simpler to upgrade / replace heating pipework running in floor zone



4. Whole block

Decant strategy
Decant entire tenement

No disruption to neighbours as none in situ during works

Fabric possibilities & limitations
IWI & Airtightness can be implemented to whole block

Services possibilities & limitations
Communal ASHP possible - suits available external space better

Old Shettlestone Road Retrofit - All possible measures

	strategy	material	Reason not to take forwards	To confirm if considering	individual flats with residents in-situ	Communal works	when void	Additional works
Floors								
	draught stopping between floor boards				x			
	Insulate between joists	woodfibre		depth of below floor void			x	Ensure vents open / unblocked Ensure pointing around joist ends to improve airtightness
		mineral wool					x	
	Insulate over existing	aerogel				x	x	Insulate over existing communal ground floor area
	Replace suspended floor with insulated slab	concrete & XPS	Too invasive					
	Qbot	spray foam	Depth of void, rubble in void	Risk around moisture?				
	Demand controlled vent to void	AirEx			x			vents to be opened up regardless of strategy chosen
Walls								
	EWI (to rear & end)	PIR	Combustible, high EC, thermal bypass behind					Eaves extension, replace external fixtures. Need to flatten off face of stonework with parge coat prior to installation
		mineral wool				x		
		woodfibre				x		
	below ground (w/ EWI)	Foamglas				x		Review how beneficial this could be given sub-floor ventilation remains.
		XPS				x		
	IWI (to front)	woodfibre					x	lime plaster internally as airtightness layer Return walls may require some work to minimise thermal bridging. Rain repellent 'cream' required to external face of stonework if this solution adopted
		mineral wool					x	
		diathonite	too long to dry				x	
		Calsitherm					x	Return walls may require some work to minimise thermal bridging.
		other??? (hemp, aerogel, Calsithern…)						
	IWI (to exg service cavity)			existence & depth of void to all areas.	x			Sheathing of electrical conduit required
	Draught stopping at wall / floor junctions				x			Replace skirting boards. Possibly touch up painting
Windows								
	Exg windows & draught stopping				x			
	Exg windows & moveable solutions	curtains			x			
		shutters			x			
		secondary glazing			x			
	Replace	Double glazed, insulated frames				x		Ensure well installed, in line with insulation where possible
		Triple glazed, insulated frames				x		
Doors								
	Well-fitting doors to close	Insulated metal secure door				x		Threshold levelling & draught stopping
	Well-fitting doors to flats	Insulated secure doors			x			
Roof								
	Insulation at loft level	mineral wool				x		wind proof layer, airtightness below, maintain eaves ventilation to roof
		cellulose				x		
		sheeps wool				x		
	Insulation at roof line		Unnecessarily complex & requires more air to be heated, therefore less efficient					
Ventilation								
	MVHR		potentially too invasive when flats are occupied, refer to Rybka proposed drawing for further details on proposed system for typical flat (this includes system dimensions, ventilation rates, component locations)	overall system considered viable and can be installed on a flat by flat arrangement. Considered needed if air permeability of less than 3m3/h.m2 @50Pa is being achieved	x			builders work associated with wall openings for ducts and louvres , decorative works to conceal ducts etc
	centralised mechanical extract		limited space in attic for centralised AHU per block, creating risers and duct routes will be invasive to occupants	not considered viable	x	x		builder works associated with new primary distribution risers, decorative works to conceal ducts. Potential structural strengthening to support central attic AHUs
	extract @bathroom & kitchen		can be installed when flats are occupied however will not provide sufficient ventilation if works provide a air permeability of less than 3m3/h.m2 @50Pa	considered viable however performance limitations	x			minimal works associated with this item
	humidity controlled trickle vents		can be installed when flats are occupied however will adversely impact air permeability targets associated with AECB and EnerPHit targets	considered viable however performance limitations	x			window design needs to incorporate these units
Heating								
	renewables	ASHP (EAHP?)	Centralised ASHP needs a whole building install to work, Local ASHPs viable however requires fabric to be improved to level that reduces current heat demand by 45% to make system operationally cost beneficial when compared to current set up . EAHP unlikely to be suitable for the flats due to their large sizes and relatively high heat demands.	localised ASHPs per flat viable	x	x		builders work to form primary distribution routes for pipework. Electrical works to power ASHPs. Radiators in flats would need replaced to suit new hydraulic regime. External ASHP compound needed to house ASHPs (refer to Rybka sketch)
		GSHP (whole block, plus HIUs per flat)	Limited space external to the building to locate bore holes associated with the system	not viable	x	x		geographical assessment of ground conditions would need to be undertaken before design can progress. External compound needed for HPs etc
	Gas boiler		current system uses gas combi boilers, small efficiency improvement to be gained if these boilers are replaced with more modern boilers however overall improvements to energy loads and carbon emissions are small. It is still permissible to replace gas boilers with new gas boilers for existing properties as phase out of gas heating only applies to new builds.	not viable based on carbon reduction aspirations	x			minimal further works would be needed with this proposal
	Electrical boiler		current system uses gas combi boilers, these boilers can be replaced with electric combi boilers with minimal disruptions to current heating system set up providing improvements to flats carbon improvements due to carbon factor of grid electricity being much lower then gas. Operational cost when compared to current gas boiler arrangement is a issue as heat demand would need to reduce by 66% to make electrical boilers comparable to gas in peak winter conditions.	considered viable based on carbon reduction aspirations however operational costs likely to be higher even with maximum fabric improvements proposed (model 6 of PHPP). System only likely to be operationally cost effective when used in conjunction with PVs.	x			PVs likely to be needed to make system viable
	Electric Panel Heaters		current system uses gas combi boilers, these boilers can be replaced with electric panel heaters providing improvements to flats carbon improvements due to carbon factor of grid electricity being much lower then gas. Operational cost when compared to current gas boiler arrangement is a issue as heat demand would need to reduce by 66% to make electrical heaters comparable to gas in peak winter conditions. Electrical immersion cylinder also needed for domestic hot water generation.	considered viable based on carbon reduction aspirations however operational costs likely to be higher even with maximum fabric improvements proposed (model 6 of PHPP). System only likely to be operationally cost effective when used in conjunction with PVs.	x			existing wet heating system would need stripped out. Space needed for hot water cylinder. PVs likely to be needed to make system viable
	Electric Infrared Heaters		infrared panels transfer heat to objects, not the air making them different to conventional electrical panel heaters. this makes them more efficient than traditional heating systems, however it also means that they won't work properly if anything is obstructing their heat path. If a object (like a item of furniture) is put in front of a panel, that object will absorb the heat and not the intended recipient/ area. the more compact flats will struggle to make space for infrared panels. IR panel heaters will provide improvements to flats carbon emissions due to carbon factor of grid electricity being much lower then gas. Operational cost when compared to current gas boiler arrangement is a issue as heat demand would need to reduce by 66% to make infra red heaters comparable to gas in peak winter conditions. Electrical immersion cylinder also needed for domestic hot water generation. Infra red heaters are also more expensive when compared to boiler and electrical panel heating.	considered viable based on carbon reduction aspirations however operational and capital costs likely to be higher even with maximum fabric improvements proposed (model 6 of PHPP). System only likely to be operationally cost effective when used in conjunction with PVs.	x			existing wet heating system would need stripped out. Space needed for hot water cylinder. PVs likely to be needed to make system viable
	phase change and storage heaters		Using storage heaters would provide modern thermal storage radiators that uses lower-cost, off peak energy to charge the unit. The system heats a super insulated core to a high temperature which then enables the user to distribute the heat when they want it throughout the day, offering much more control than traditional brick storage heating. If replacing the wet gas fired heating with this type of thermal storage heater will reduce the flats carbon emissions whilst providing suitable space heating which is controlled to meet the user demands by using an electronic thermostat and intelligent programmer alongside smart features including special boost, frost-watch and defined user profiles. storage heaters would be installed in the flats hall and living room with standard panel heaters fitted in all other rooms which have a heating demand. it is critical a off peak electricity tariff is available for this system to work. If using electric heating panel type systems the domestic hot water would need to be generated using electric immersion storage vessels sized to suit the flats size.	considered viable based on carbon reduction aspirations however operational and capital costs are closely linked to proposed level of fabric improvements to allow for comparison with current set up. system relies on off peak electricality tariff being available to all end users	x			existing wet heating system would need stripped out. Space needed for hot water cylinder.
Hot water								
	Waste water heat recovery		waste water heat reclaim loads associated with flats unlikely to be sufficient to have real impact on overall heat loads and associated carbon reductions	not viable due to scale of loads	x			plumbing would need local reconfiguration, floor boards may need locally lifted to access pipes etc
		hot water storage tank	new hot water vessels will be needed at each flat to serve domestic hot water loads if shifting from using combi boilers. Vessels to be charged from new ASHPs or directly from electrical immersion heater	viable and space is available for vessels within each flat	x			cupboard within flat would need formed (where flats currently use combi boilers)
Renewables								
	photovoltaic panels		Roof area might not be sufficient to accommodate panels needed for each flat. Roof structural loads to be checked to ensure it is capable to accommodate panels. Invertor panel space needed at each flats consumer unit. Rear elevation roof only suitable for PVs as front elevation faces north.	considered viable however further studies needed to determine overall yields of PV array. Dedicated PVs serving each flat would be needed as opposed to a communal array to properly address individual flat needs. Battery storage provisions would not be needed.	x	x		Structural suitability of roof to add PV's would need to be assessed. Adequate space will be require formed adjacent to existing consumer units to house PV equipment such as inverter panel. Communal close would require additional electrical containment (likely metal trunking) to house cabling from PV on roof to each flat.
	Solar thermal panels		not suited to buildings load profile and climate	not viable for development	x	x		
	Wind Power generation (using urban wind turbines)		not suited due to limited external areas to site turbines, noise generated by turbines and planning permission challenges	not viable for development	x	x		