GOLDEN LANE ESTATE – CRESCENT HOUSE PROPOSED WINDOW REPLACEMENT

ENERGY, CARBON AND THERMAL COMFORT STRATEGY

Jul 2021 I Rev E

Etude

Introduction and context

Crescent House is a 1950's / 1960's built residential block of apartments located on Goswell Road that forms part of the Golden Lane Estate in the City of London. Due to the building's age and lack of insulation within its fabric, occupants have been experiencing difficulties during cold winter conditions including high fuel bills, difficulty maintaining comfortable internal temperatures and condensation/mould growth issues. In order to go someway to addressing these issues it is being proposed to carry out a full refurbishment of the building's windows and façade elements. The proposals will involve balancing the need to create healthier, more affordable and more comfortable homes whilst preserving the important heritage of the building, which is Grade II* listed.

This report looks at the energy and sustainability improvement strategy for the areas of refurbishment. This has involved modelling samples of dwellings against different refurbishment options using SAP and PHPP, in addition to detailed thermal bridge modelling for key junctions.

Crescent House – North view from Goswell Road

Crescent House – East view from Goswell Road

The façade improvement in the context of the City of London's Climate Action Strategy

City of London targeting Net Zero by 2027 in operations, Net Zero by 2040 across the Corporation's full value chain

The City of London Corporation (CoL) has a target of achieving net zero carbon for all its Scope 1 and Scope 2 emissions by 2027, achieving net zero carbon for all its Scope 3 emissions by 2040.

Scope 1 emissions are all emissions associated with fossil fuels purchased and combusted by the corporation. Scope 2 emissions are all emissions associated with electricity purchased by the corporation.

In the context of CoL's housing portfolio, this includes:

- Communal heating and hot water provided to the estates
- Heating of community centres, estate offices, or other ancillary functions of the housing estates.
- Emissions associated with shared spaces such as lighting and lifts.

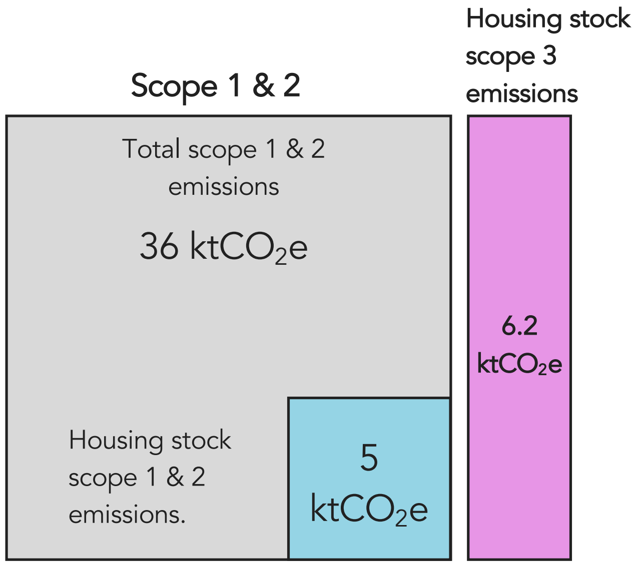
Scope 3 emissions are all emissions associated with any activity that takes place within the jurisdiction of the Square Mile or the Corporations assets. In the context of CoL's housing portfolio, this includes:

- Resident purchased energy for heating, hot water, lighting, appliances or any other energy used in the home.

The façade replacement work at Crescent House will be critical to achieving a reduction in the heating energy for the current decentralised gas heating, and provides energy efficiency improvement to enable change to a low carbon heating system in future.

The City of London Corporation also commits to achieving climate resilience in buildings. In particular the façade design needs to consider limiting overheating risk in flats.

City of London Climate Action Strategy 2020-2027



Housing stock Scope 1 & 2 emissions compared to total City of London Scope 1 & 2 emissions. The housing stock is a significant proportion, and around 60% of this is likely to be heating energy. This includes emissions from only landlord controlled and communal areas. Housing Scope 3 emissions (from energy that residents buy) is estimated to be an additional 6.2$ktCO_2e$

City of London – Key actions to support the achievement of net zero

"Transform the energy efficiency of our operational buildings through the adoption of best available technologies"

"Accelerate the move to net zero carbon and energy efficient tenanted buildings, working closely with tenants to achieve shared goals"

"Increase engagement and communications about sustainability with residents, businesses, visitors and other stakeholders"

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Crescent House building heritage

Crescent House is Grade II* listed

Crescent House is Grade II* listed and therefore any refurbishment measures will need to carried out in a way that is sensitive to the heritage and context. Grade II* buildings are considered particularly important buildings of more than special interest. For Crescent House items that are particularly mentioned in the asset register and impact the approach to fabric efficiency are:

- the exposed and bush hammered reinforced concrete structure and arches;
- mosaic tiling to the storey bands and pilotis (piers);
- Hardwood timber frames stained dark;
- Centre pivot windows;
- Access corridor exposed to the open air.

Energy efficiency works to listed buildings that could affect their appearance or construction will need to be carried out in a way that minimises any impact to its aesthetics or elements of special interest. This will likely mean a reduced efficiency improvement can be achieved compared to what would be technically possible if the listed building constraints didn't exist.

Despite the listed status of Crescent House, it is very important that energy efficiency improvements are carried as part of the refurbishment works. The building regulations give some leeway for historic buildings, but do ask for improvements. Guidance from Historic England has been taken into account, however much of this focusses around much older property types. Crescent House is a 1958-1962 solid reinforced concrete construction where many of the concerns over breathability of construction do not apply. The windows are casement windows, not sash windows provided for in guidance. Improving ventilation and thermal performance is in fact important to the long term survival of the building fabric.

"3.9 When undertaking work on or in connection with a building that falls within one of the classes listed above [listed buildings], **the aim should be to improve energy efficiency as far as is reasonably practicable**. The work should not prejudice the character of the host building or increase the risk of long-term deterioration of the building fabric or fittings".

Extract from Building regulations approved document Part L1b. The onus is on the design team to improve energy efficiency as far as practical within the listing and historic character of the building.

Traditional window guidance for energy efficiency improvement is less relevant to Crescent house and does not acknowledge the huge potential for health, comfort and energy improvement from window upgrade in this more heavily glazed type of building.

Issues caused by the existing façade thermal performance

Too cold inside for tenants in winter

Data from the energy bills of existing tenants compared to a building energy model of sample flats shows that the tenants are likely to be under heating their flats, or more likely only heating the flat for very short periods of the day. The average winter internal temperature is estimated to be 15-16°C based on calibrating the energy model against actual fuel bills. World Health Organisation recommended minimum internal temperature for homes is 18°C (WHO 2018), this is probably achieved for only parts of the day when occupied.

Likely barriers to higher temperatures are the cost of heating energy, and physical limit of poor thermal performance of the building fabric.

Monitoring the temperature of individual homes would give a clearer idea of the range of temperatures within the flats. It is likely they will drop below 15°C when the heating is not on.

Excessive condensation and mould growth on the inside of the façade and adjacent concrete structure

It is very difficult for the tenants to manage condensation and associated mould and internal air quality risk inside their homes whilst maintaining reasonable comfort levels. The ventilation rates and temperatures needed to compensate for the very poor thermal performance of the existing façade and structure are unachievable. Studio Partington surveyed residents and 20/24 responses (83%) noted suffering from condensation and mould.

Tenants are unable to dry washing, cook significant meals, or bathe as they wish without significant impact on the internal air quality.

Excessive cost of energy and high carbon emissions

The current average fuel bill for tenants is £680/year, equating to around 1,630kgCO_2/yr. With a move away from gas towards low carbon heating technologies the cost is likely to greatly increase. Energy efficiency improvements enable low carbon heating to be introduced without increase in fuel costs.

Looking from outside at the internal wall reveal, very significant black mould growth on the internal plaster surface despite good ventilation and heating.

View from inside of evidence of excessive condensation internally, mould growth and timber rot externally.

Existing heat losses are dominated by the front façade and rear glazing

Replacing the windows at Crescent house is a one in a generation opportunity to reduce heating energy and carbon emissions

Reducing heating energy demand through energy efficiency is one of the major opportunities to reduce building carbon emissions whilst improving homes. Around 60% of the energy consumption from these flats is from heating.

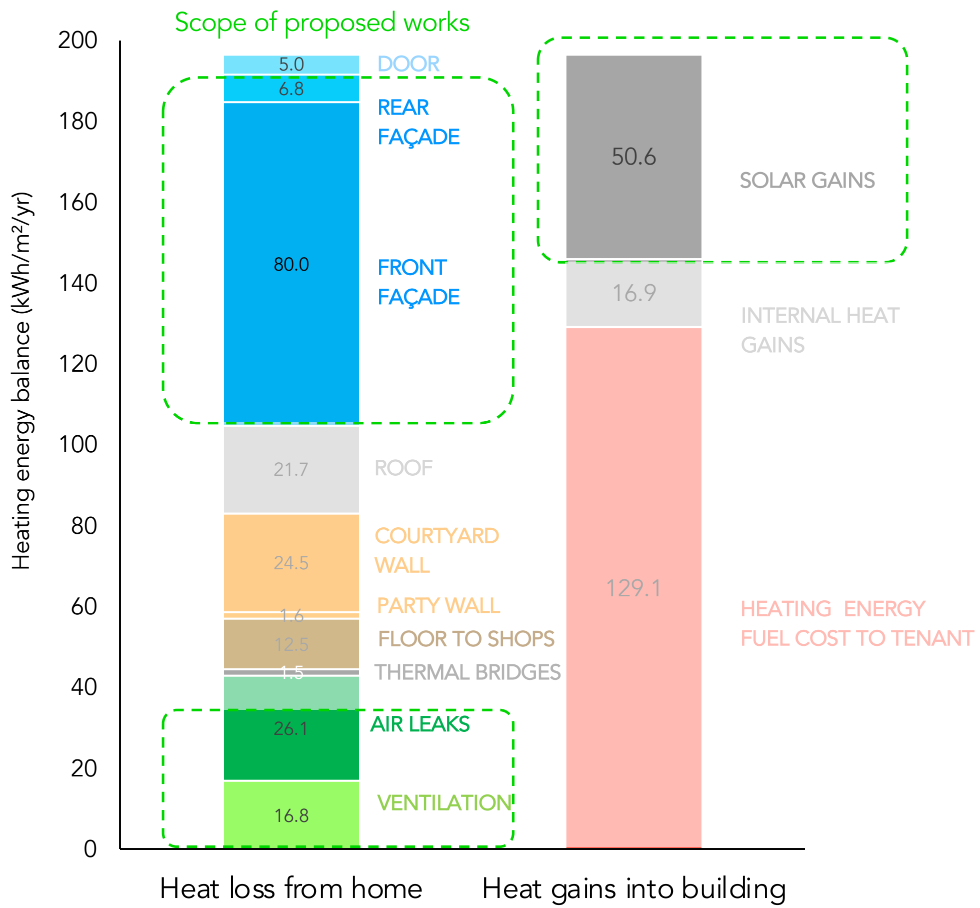
The total heating energy demand is around 130kWh/m²/yr, a new flat constructed to the London Plan would achieve a heating energy of less than 60kWh/m²/yr, as well as improved higher internal winter temperature and summery comfort.

Across all flats 55% of the winter heat loss from Crescent house flats is due to just the front façade and rear glazing. For the mid floor flats this is significantly higher, at around 68%.

Replacing the glazing gives a once in a generation opportunity to reduce the heating energy and improve the comfort of these flats.

Upgrading the glass performance will reduce summer solar gain

New high performance glass will provide a clear view out, but allow a reduction in summer solar gain compared to single glazing. This could reduce summer overheating risk to the flats if coupled with a good ventilation strategy. Solar gain is useful in winter and clear glass is preferable for heritage reasons, so solar control coatings will not be used.



Heating energy balance from a predicted in-use energy model of a vertical stack of 3 sample flats (units 145, 245 & 345). The calculation shows that most of the heating energy needed for the homes is lost through the façade and within the scope of the proposed works. The air leakage will be improved through reducing leakage in the façade.

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Façade refurbishment options under consideration

Building element	Case 1: Existing building	Potential options for improvement: Case 2: Thermal improvement (minimum refurbishment)	Case 3: Optimised thermal improvement using timber framed facades	Case 4: Best possible energy efficiency Discounted due to visual impact
Window glazing	Single pane	Double glazing	Triple glazing	Triple glazing
Window frame	Existing 95mm hardwood frame	New 95mm hardwood frame to match existing	New 95mm thermally broken hardwood frame with additional bead around pivot	New 125mm thermally broken softwood frame with additional bead around pivot
Window air sealing	None	Brush seals	Double rubber lip seal	Double rubber lip seal
Trickle ventilation	Permanently open slot vent	Closable slot vent	Closable slot vent (or ventilation provided by active supply)	No trickle vent. Ventilation provided by active supply
Spandrel panels	Back painted single glazing, 12mm solid wood, uninsulated	Coated double glazing, 12mm solid wood lining	External coated glass, insulated with 50mm mineral wool or equivalent depth of aerogel	External coated glass, insulated with 120mm mineral wool
Bookshelf	Uninsulated solid timber	Sandwich panel 15mm mineral wool timber	Sandwich panel 15mm aerogel and timber, 50mm reduction in bookshelf depth.	Bookshelf provided internally. Fully filled with insulation
1st floor concrete upstand wall	Uninsulated	Internally insulated (50mm mineral wool)	Internal insulated concrete upstand wall ~20mm aerogel internal wall insulation.	Externally insulated concrete upstand wall, 150mm Rockwool layers)
Oriel window floor	Uninsulated solid timber	Sandwich panel 15mm mineral wool timber	Internally insulated with aerogel, thickness TBC	Externally insulated (150mm PIR insulation)
Oriel window roof	Uninsulated solid timber	Sandwich panel 15mm mineral wool timber	Externally insulated (100mm mineral wool insulation)	Externally insulated (150mm mineral wool insulation)
Intermediate floor slab to external wall detail	Exposed tiles	Exposed tiles (possible internal ceiling partial lining)	Externally insulated slab edge (50mm mineral wool or equivalent depth of aerogel)	Externally insulated slab edge (100mm mineral wool)
Party wall to external wall detail	Unbroken structure to outside	Internal aerogel insulation partial lining	Internal aerogel insulation partial lining	Internal aerogel insulation 40mm thick partial lining.
Roof slab to external wall detail	Unbroken structure to outside	Internal insulation partial lining under review	Internal insulation partial lining under review	Internal insulation partial lining under review. Investigating external soffit lining
Estimated / predicted air permeability	15 $m^3/m^2.hr$ @ 50Pa	8 $m^3/m^2.hr$ @ 50Pa	5 $m^3/m^2.hr$ @ 50Pa	5 $m^3/m^2.hr$ @ 50Pa

Recommended option

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Proposed reduction in heating energy

More accurate and detailed building energy modelling

A predicted in-use energy calculation has been used to show the heating energy reductions. This was carried out in PHPP software which is shown to be better at predicting real energy consumption.

A solid timber heritage sensitive double glazed façade is unlikely to give significant energy or carbon savings

Due to the rebound effect of people being able to heat their homes to a higher temperature to improve comfort, it is unlikely that a simple double glazed replacement will give energy savings. Carbon emissions and fuel bills may be similar or even higher with this solution.

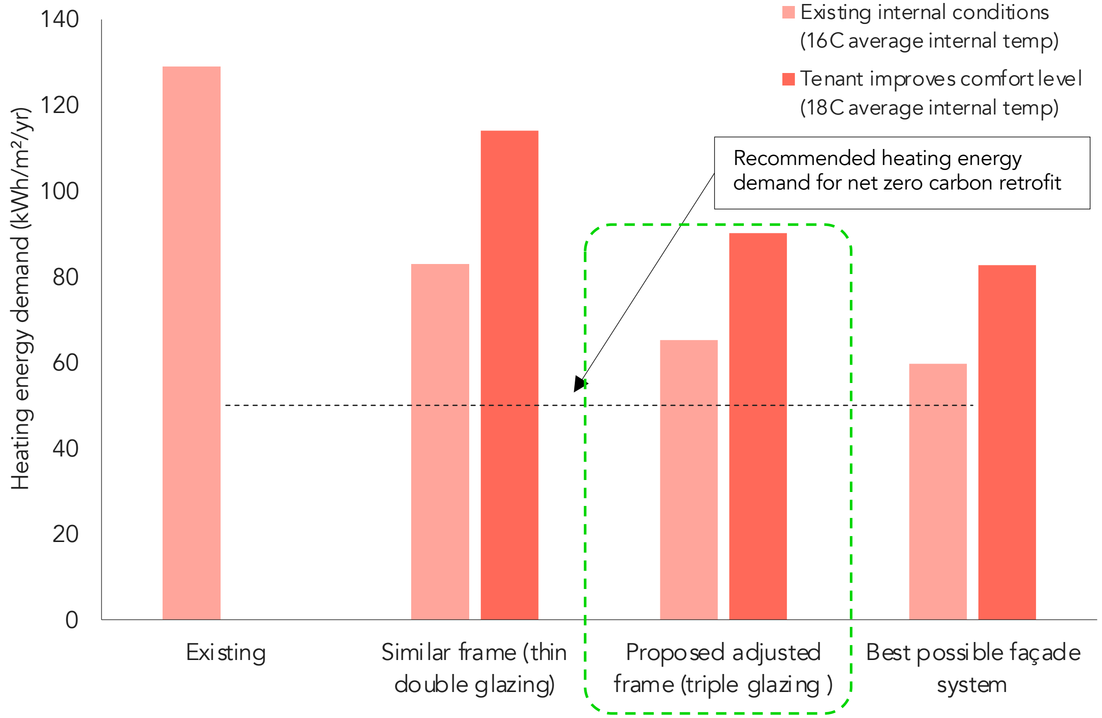
A triple glazing façade system with insulation to the face of floor slabs would reduce heating energy, even with tenants choosing to improve comfort.

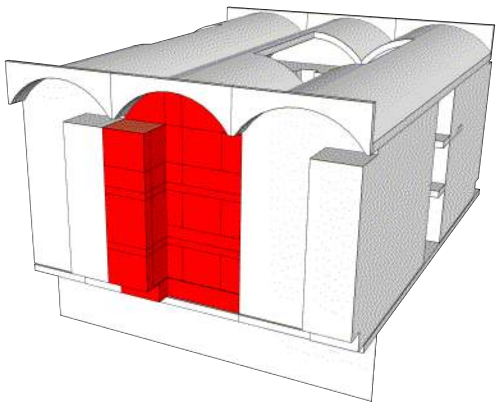
Even with higher internal temperatures energy reductions are predicted to be between 35 and 50%.

A better performance glazing system is possible

Introducing curtain walling elements and increasing the insulation depth of bay window cheeks would mean the building was capable of meeting the AECB Retrofit target in the future, considered a robust net zero carbon approach. This strategy has been rejected due to the unacceptable visual impact to the listed building.

Better performance could be achieved with the proposed approach coupled with future further fabric improvements such as upgrading the roof insulation.





Predicted heating energy demand for different façade replacement options. The existing heating demand is also shown and was used to calibrate the building energy model. Left: a screenshot of the building geometry and extent of the sample flats used to calculate heating energy.

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Impact on heating cost

Reducing energy consumption can reduce resident fuel bills

Comparing the calculations based on the same average internal air temperature shows a reduction in space heating energy bills for residents.

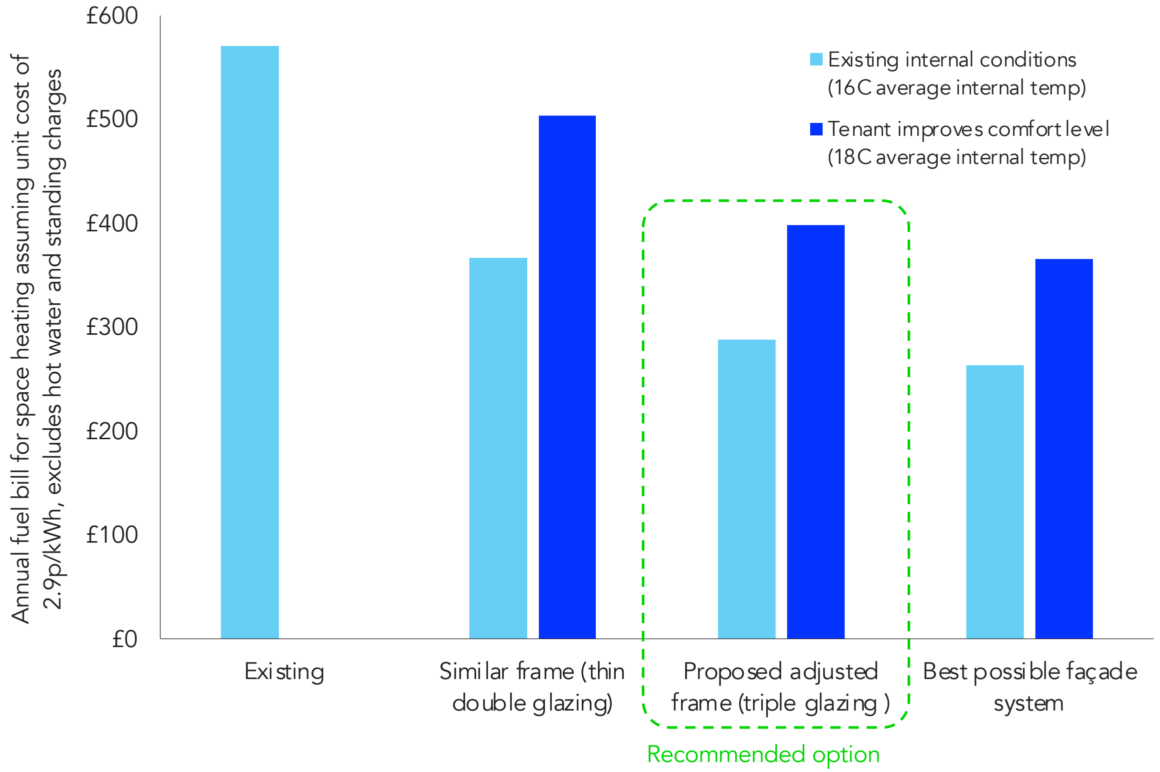
Residents may choose comfort

The window replacement will make it possible to heat the flats to a higher temperature for less or similar cost. The actual average internal temperature that the residents adopt after the retrofit could potentially be higher than needed, reducing the energy savings seen. This is known as the 'rebound' effect and is why a larger improvement in energy efficiency is required to achieve energy, carbon and cost savings in practice.

Preparing for future higher low carbon heating cost

Future energy costs are unknown but are likely to increase and be subject to higher volatility. Reducing energy consumption makes residents less vulnerable to these changes.

Reduction of heating costs from replacing the windows could offset the increase in heating cost from the planned future change in heating system. The unit cost of fuel is likely to increase significantly from the ~3p/kWh that residents are currently paying.



Predicted space heating energy cost for different façade replacement options. Only heating is shown, hot water and electricity bills would be additional. The existing heating demand is shown and was used to calibrate the building energy model. The average total gas bill from those analysed was £681/year. The costs assume a low price of energy (2.9p/kWh) and this is considered likely to increase in the future.

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Reduction in regulated carbon emissions compared to existing

Improvement in EPC score

SAP calculations have been carried out for a sample lower, mid and top floor studio flat for the existing and proposed options. The existing calculations have been checked against Energy Performance Certificate (EPC) ratings lodged for a sample of eight flats at Crescent House.

The SAP calculation has been used to demonstrate the % reduction and improvement in EPC score possible for each of the potential options.

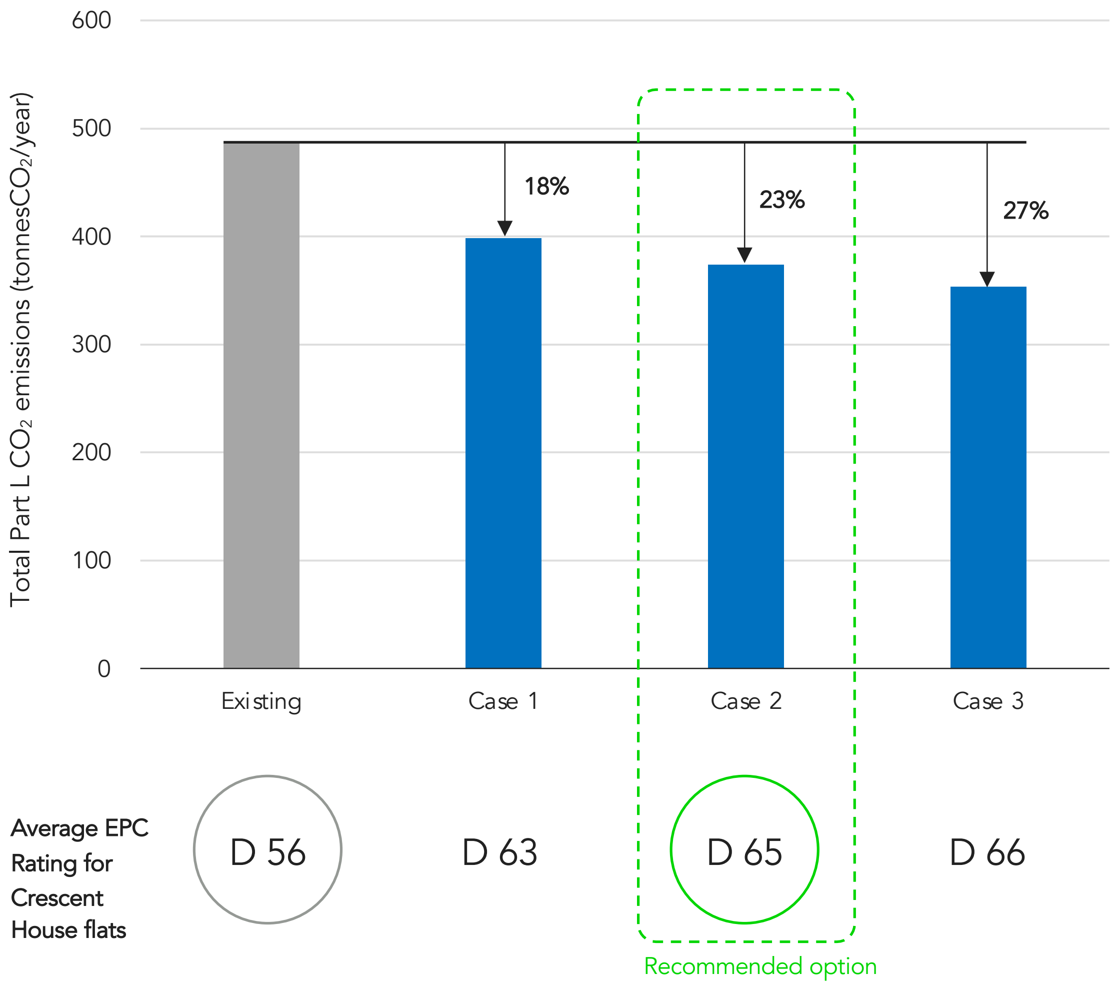
	Lower-floor flat	Mid-floor flat	Top-floor flat	Average
Existing - Calculated EPC scores	E 53	D 64	E 52	56
Case 2 Improved EPC after works	D 61	C 72	D 60	65
Lodged existing EPC scores for comparison	Flat 124 - **59**	Flat 207 – **69**	Flat 341 - **45**	
	Flat 132 - **63**	Flat 216 - **59**	Flat 349 - **47**	
	Flat 145 – **63***	Flat 234 - **69**		
Average	62*	66	46**	

The calculations show a 23% reduction in carbon emissions from the existing building just through improvements to the façade. These improvements enable future changes to a low carbon heating system, and coupled with additional fabric improvements would mean a substantial carbon emissions reduction. likely making an EPC 'C' possible for the flats in future.

It should be noted that SAP calculations have been shown to be a poor estimate of actual energy consumption. PHPP design calculations have been used to inform the design decisions.

*Lodged EPCs for the lower floor flats do not include the exposed floor above the shops and are thought to be overly optimistic.

**Lodged EPCs for the top floor flats do not include any insulation in the roof build up and are worse than the actual condition.



Part L carbon emission for Crescent House comparing the existing building to different façade replacement options. Indicative average EPC ratings are also shown. Individual flats will have very different SAP scores, particularly top and bottom floors which will be worse than the average.

All the properties would likely achieve an EPC D (55-68), some improved from an EPC E (39-54).

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Further related reductions in heating energy

Enabling future improvements

Making improvements to the façade give the potential for a very good energy efficiency and carbon reduction to be achieved in the future. This page shows how those improvements would impact heating energy.

Roof insulation for the top floor flat

There is currently thought to be 50mm of insulation in the curved roof structure. Increasing the flat roof insulation to a total of more than 250mm thickness would have a significant impact to the heating energy of the top floor in particular, with almost no visual impact.

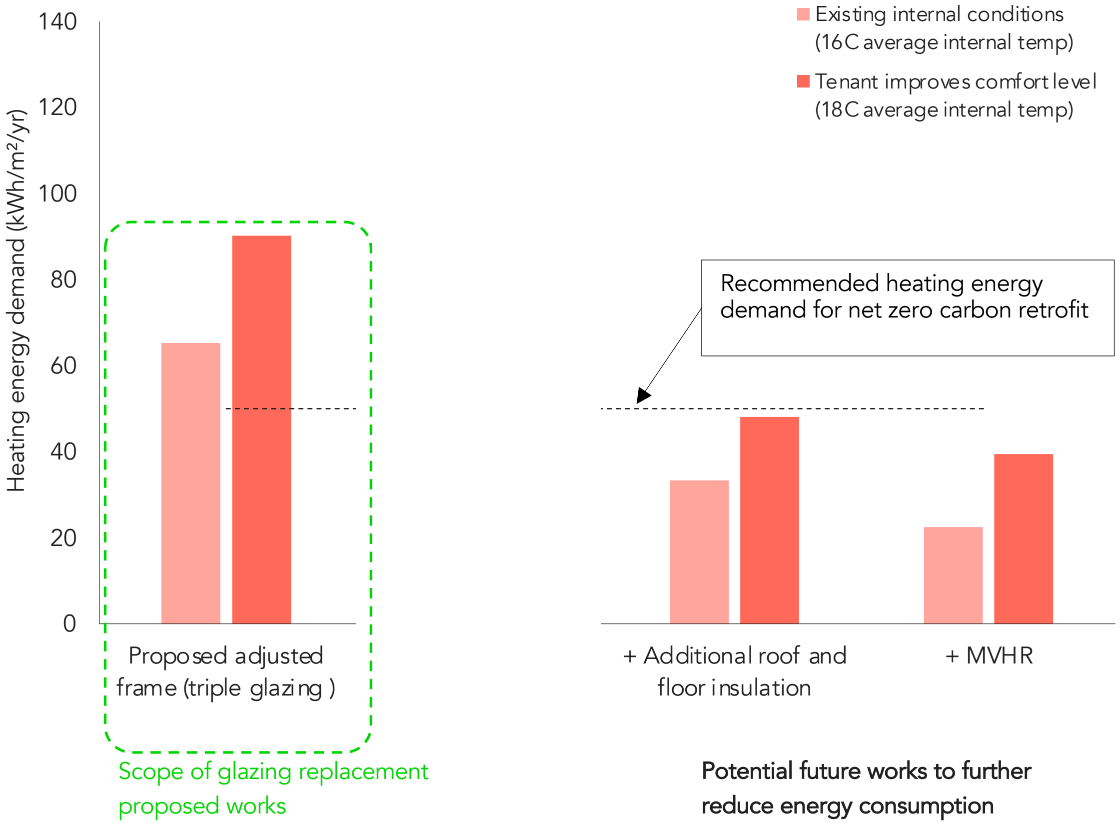
Floor insulation for the first floor above flats

There is currently no insulation between the lower floor flats and the exposed walkway, or the lower floor flats and the shops. Both these areas will have significant impact on the heating of the lower floor flats. The shops are not heated at night, and so there is high heat loss from the flat floor into both areas.

There is a screed beneath the floor finish. It should be possible to introduce 20mm rigid insulation board beneath the screed for the first floor flats in the future.

Balanced supply and extract ventilation with heat recovery

A balanced supply and extract mixed mode mechanical ventilation system would allow heat recovery, saving an estimated additional 450kWh/year heating, or a further 20% of heating energy. This is up to 15x more than the electricity needed to power the fan and is a very effective way of reducing operational energy and carbon emissions. MVHR has been considered in the flats, however it is not thought to be feasible to integrate within the heritage constraints.



Predicted heating energy demand for further improvements to the building fabric. The façade improvements enable a very good level of energy efficiency to be reached in the future with further fabric improvements. The impact of heat recovery ventilation (MVHR) is shown for information only. MVHR is not proposed due to heritage constraints on the internal layout, and the tight ceiling heights.

Importance of effective ventilation when improving airtightness

Active ventilation can hugely improve indoor air quality

Homes without good ventilation quickly become damp, stagnant and unpleasant spaces with poor indoor air quality. Passive vents relying on wind and stack pressure differences are very ineffective at removing moisture and odour from homes, particularly for Crescent house single storey small flats with one sheltered side. Some individual rooms or areas are left unventilated due to random unknown air paths, or in windy conditions the ventilation rate is very high and negates any comfort improvement to the home.

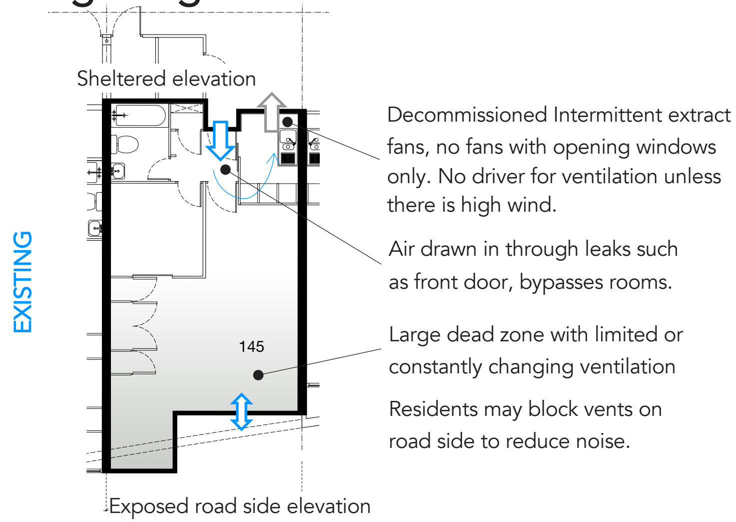
Fan energy is more than compensated by saving in heating energy

A mechanical fan uses a very small amount of electricity (~20kWh/year) that is completely compensated by the reduction in heating energy achieved by controlling the ventilation rate. This is widely accepted with new homes and low energy retrofits using central mechanical ventilation with heat recovery to reduce moisture risk, reduce energy cost and carbon emissions, and to improve comfort. Passive ventilation requires much larger openings that cause unwanted very high ventilation and wasted heat on windy winter days. Active ventilation allows much smaller fixed openings with a steady background ventilation rate, whilst still enabling flexible passive ventilation from opening windows when required.

Continuous extract fan ventilation (MEV) is proposed for Crescent house.

Quiet operation is the key to effective use

The design of the fan will be such that it does not present a noise irritation for residents. Good systems should be nearly inaudible in operation.



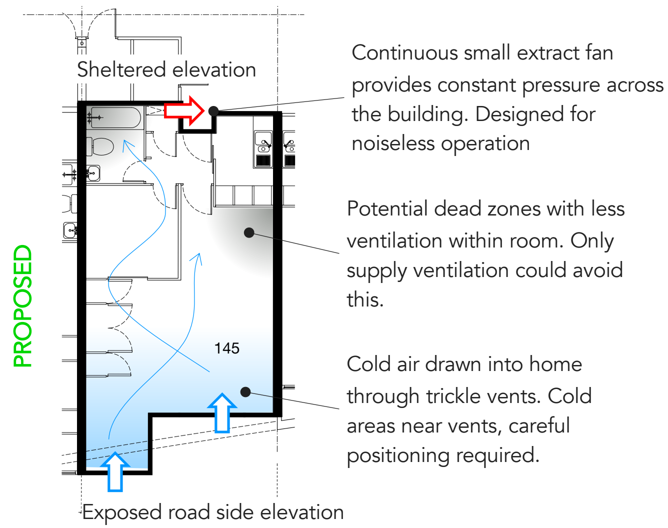
Example flat floor plan showing existing ventilation strategy. Sheltered elevation means limited pressure to drive air movement. Vents are often blocked up in winter to improve comfort, with a negative impact on air quality.

80
kWh/year

Estimated electrical energy used by constant mechanical extract fan

700
kWh/year

Estimated heating energy saved by reduction in cold air movement



Example flat floor plan showing proposed ventilation strategy with continuous mechanical extract ventilation. The ventilation will be more reliable and greatly improved compared to the current situation.

Proposed mixed mode system:

- Background ventilation from continuous mechanical extract system to reliably remove moisture and smells.
- Summer ventilation and comfort ventilation for residents from opening windows.

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Benefits of a triple glazing approach

Increase surface temperature to improve comfort

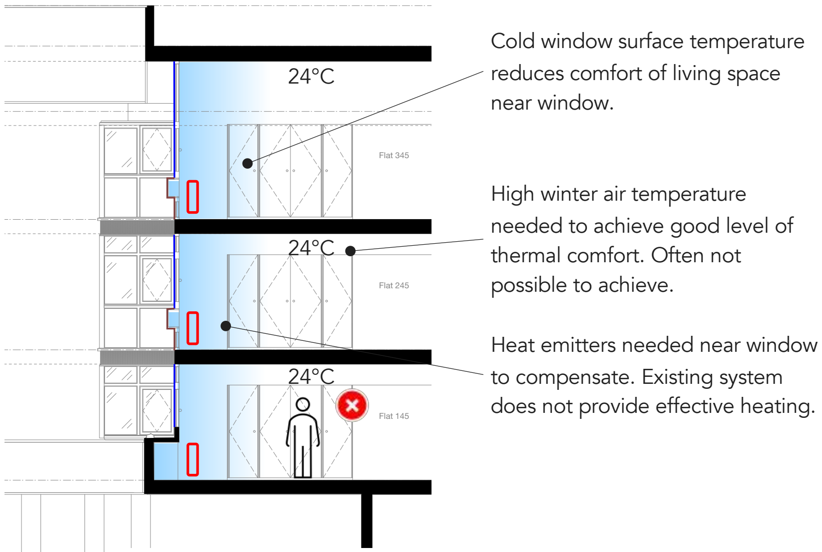
Triple glazing has a higher internal surface temperature than double or single glazing. Critically the surface temperature is within 4°C of the other external room surfaces, this means that residents do not feel the lower temperature of the glass. The higher window surface temperature means:

- Similar or better levels of comfort can be achieved with a lower air temperature and lower energy consumption
- Radiators or trench heaters are not needed beneath the window to compensate for a low surface temperature. The current heat emitters are not sufficient to compensate for the glazing.
- Water vapour in the air does not condense out on the inside of the glass or window frames.

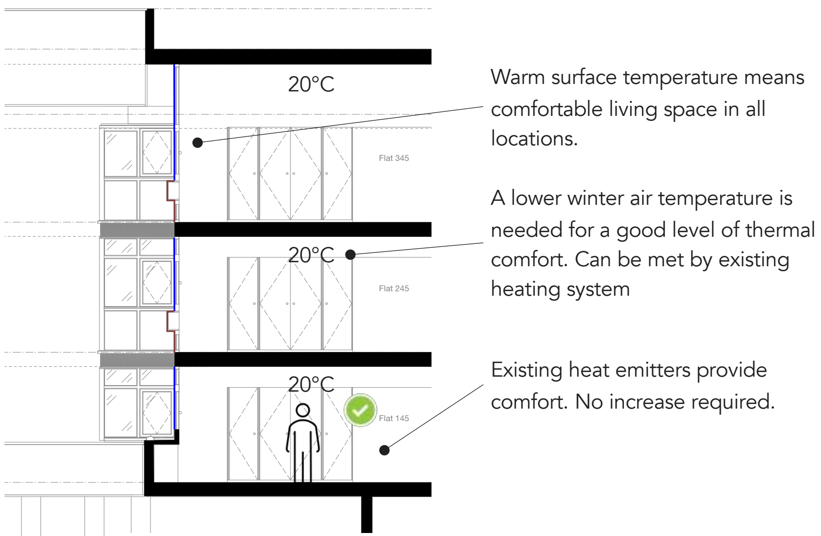
Secondary benefit of reduced noise

Triple glazing will have considerably better acoustic performance than the existing single glazing or alternate double glazing options being considered here. Although there will be opening windows for summer ventilation, when the windows are closed it will reduce traffic and external noise, particularly for the flats facing Goswell road.

Considering openings and weight



Section through Goswell Road elevation showing comfort impact of single glazing on internal environment



Section through Goswell Road elevation showing improved comfort from triple glazing approach

Thermal bridging and mitigating condensation risk

A key aim of the proposed façade refurbishment of Crescent House is to reduce and de-risk the potential for cold bridging through the external envelope. Retrofitting existing buildings with insulation and thermally efficient windows can result in a greater proportion of heat loss occurring through thermal bypasses such as where the structure penetrates the insulation layer. This can result in localised cold spots occurring, which have two main risks:

- The formation of condensation spots and mould growth, putting the occupants' health at risk.
- Significant fabric heat losses resulting in higher energy costs and carbon emissions.

There is evidence that both are occurring at Crescent House due to extensive cold bridging through exposed parts of the structure, which are currently largely uninsulated. Large patches of black mould have been found around the ceilings and walls near the facade.

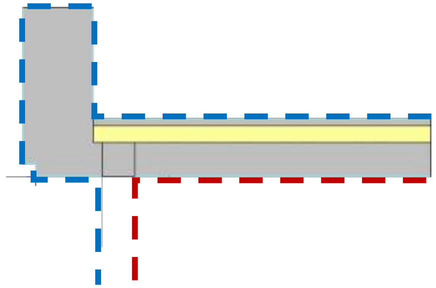
Mitigating the risk of condensation

In order to mitigate the risk of condensation there are two key parts of the refurbishment that must be addressed:

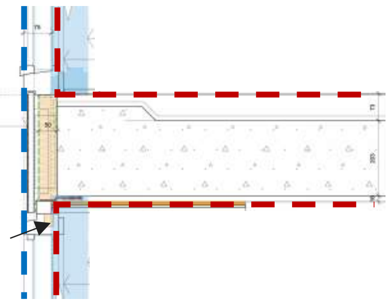
- Actively ventilate the apartments to lower relative humidity levels and avoid air stagnation around potentially cold surfaces.
- Insulating around high risk junctions (externally or internally) to raise the minimum surface temperature above the dew point (the temperature at which condensation is expected to occur).

To address the 2nd point, three key junctions have been modelled to calculate the minimum surface temperatures likely to occur and determine the design strategies required to mitigate the risk of condensation forming. This is done by raising the minimum surface temperatures to be above the dew point. The three junctions currently modelled are shown adjacently.

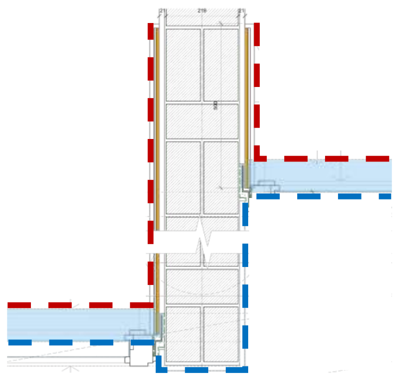
Junction 1: External wall to parapet roof



Junction 2: External wall to internal floor slab



Junction 3: External wall to staggered party wall



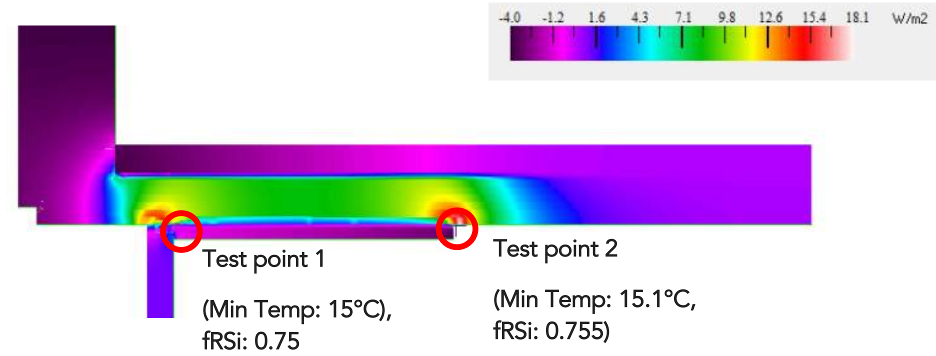
Thermal Bridging and Mitigating Condensation Risk

Estimated dew point temperature: **14.4°C**

Junction 1: External wall to parapet roof

Lining the internal surface of the roof slab next to the perimeter with aerogel insulation (Spacetherm A2) will help to maintain the high risk areas (Test Points 1 and 2) above the dew point temperature and achieve an fRSi of at least 0.75. From the modelling results, it was found that the insulation lining must be at **least 30mm thick and extend 600mm** into the room.

Psi Internal (SAP) = 0.01 W/m.K
Psi External (PHPP) = -0.19 W/m.K

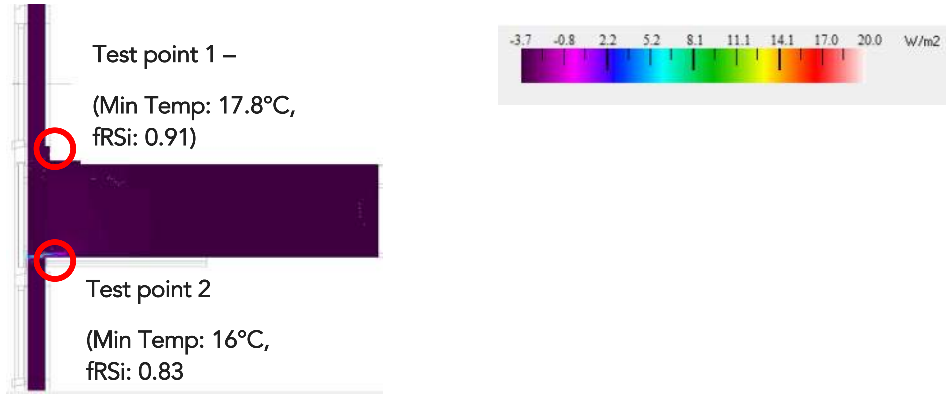


Junction 2: External wall to internal floor slab

As part of the strategy to replace the windows, it is proposed to externally insulate the exposed slab edge to reduce thermal bridging. It is currently assumed that this will be **50mm of mineral wool** or an equivalent amount of aerogel insulation. Externally insulating this area achieves the targeted criteria without relying on internal insulation lining.

Psi Internal (SAP) = 0.39 W/m.K*
Psi External (PHPP) = 0.16 W/m.K

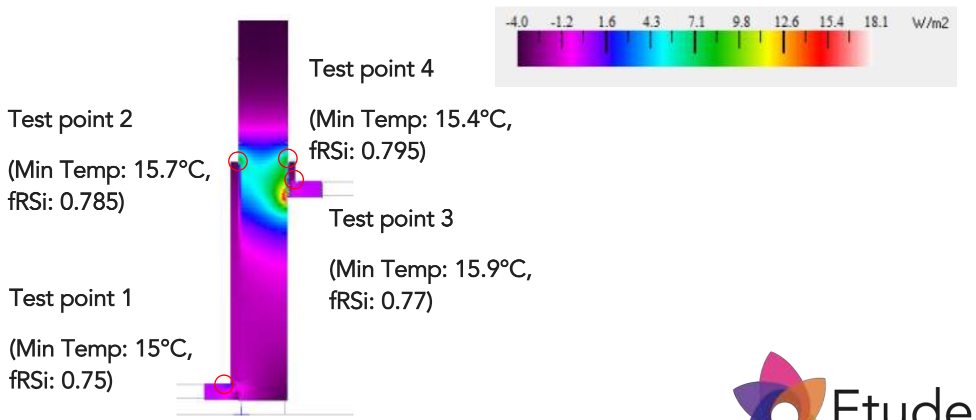
** This is the overall psi-value and would be divided between both apartment*



Junction 3: External wall to staggered party wall

It is proposed to line the internal surfaces of the party wall next to the façade with aerogel insulation. This will help to raise the minimum surface temperature through the staggered part wall junction. From the modelling results, it was found that the insulation lining must be at **least 40mm thick and extend a minimum of 100mm** into the inner most apartment.

Junction near Test Point 1	Junction near Test Points 2, 3 & 4
Psi Internal (SAP) = 0.01 W/m.K	Psi Internal (SAP) = 0.01 W/m.K
Psi External (PHPP) = -0.19 W/m.K	Psi External (PHPP) = -0.19 W/m.K

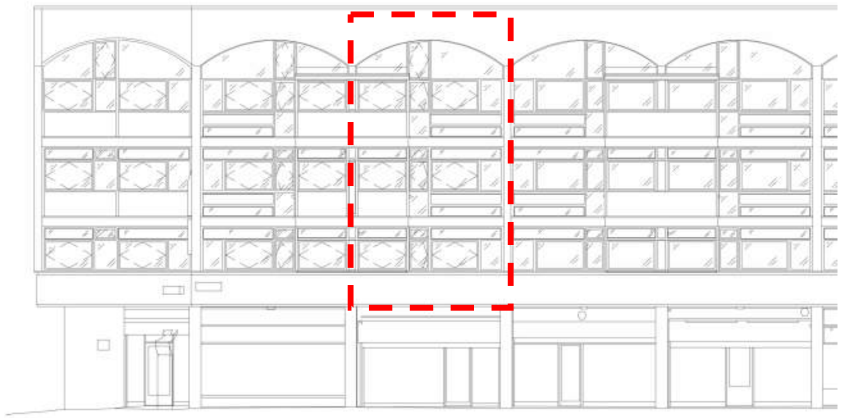


Goswell Road elevation façade heat loss assessment

Design note:	3-01	RIBA Stage: -
Date: 20/05/21	Rev: A	Author: LT

The average heat loss transmittance / façade U-value has been assessed for typical column of three stacked flats along the Goswell Road facing elevation. After calculating the heat losses through the existing façade, further heat loss calculations were carried out for three fabric upgrade scenarios. In summary, the following cases were assessed.

- Case 1: Existing building
- Case 2: Minor thermal improvement (minimum refurbishment)
- Case 3: Significant thermal improvement
- Case 4: Best possible energy efficiency (discounted due to visual impact)

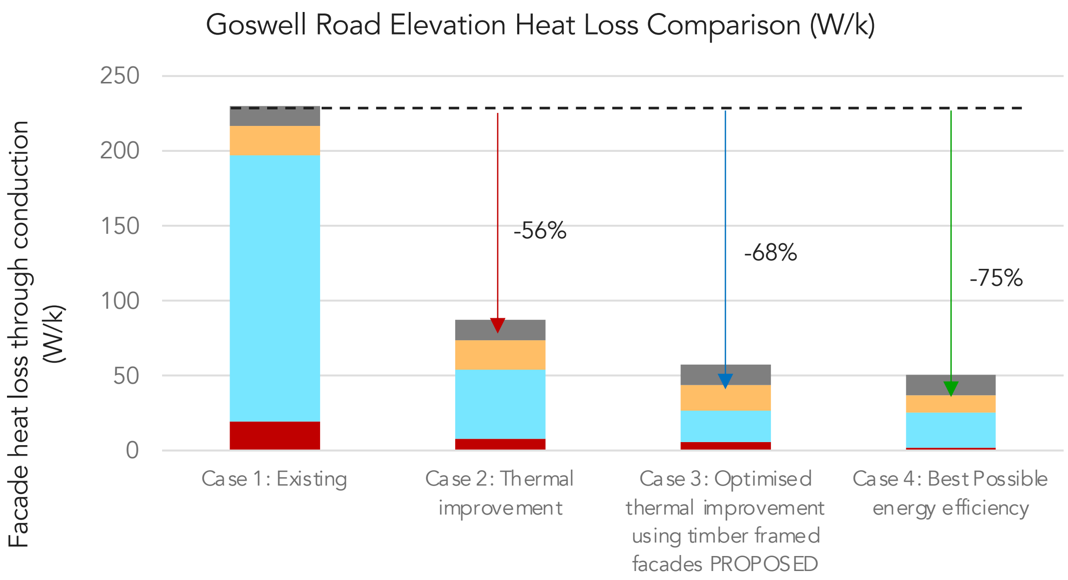


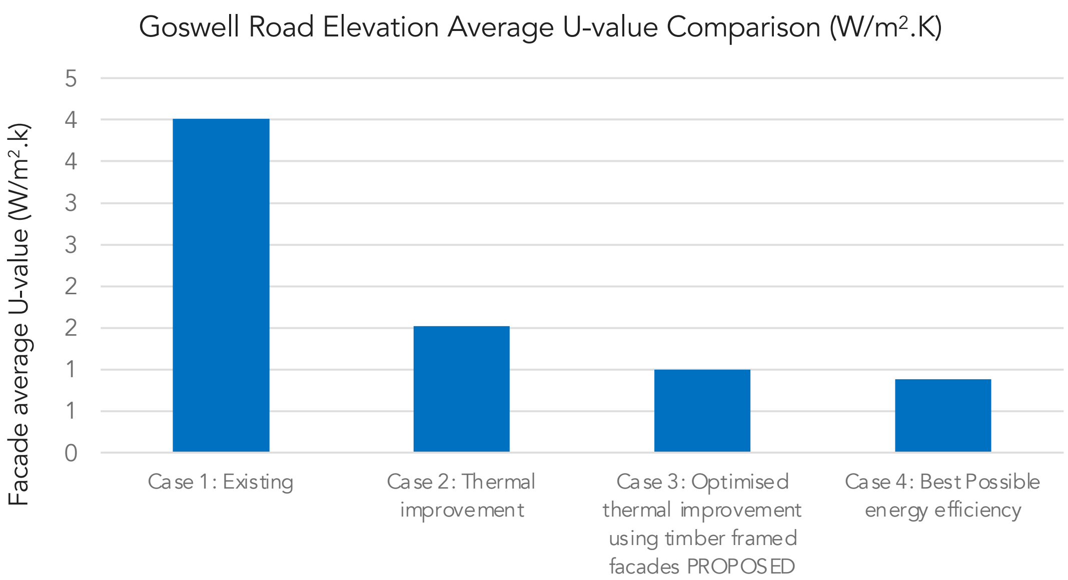
Crescent House – Typical vertical window bay

Façade heat loss summary

The adjacent graphs show a comparison between the heat loss parameter and average U-value of the Goswell Road elevations. It should be noted that this assessment does not include heat losses through the bay roof and floor or through air infiltration, both of which will also provide significant improvements by reducing heat loss.

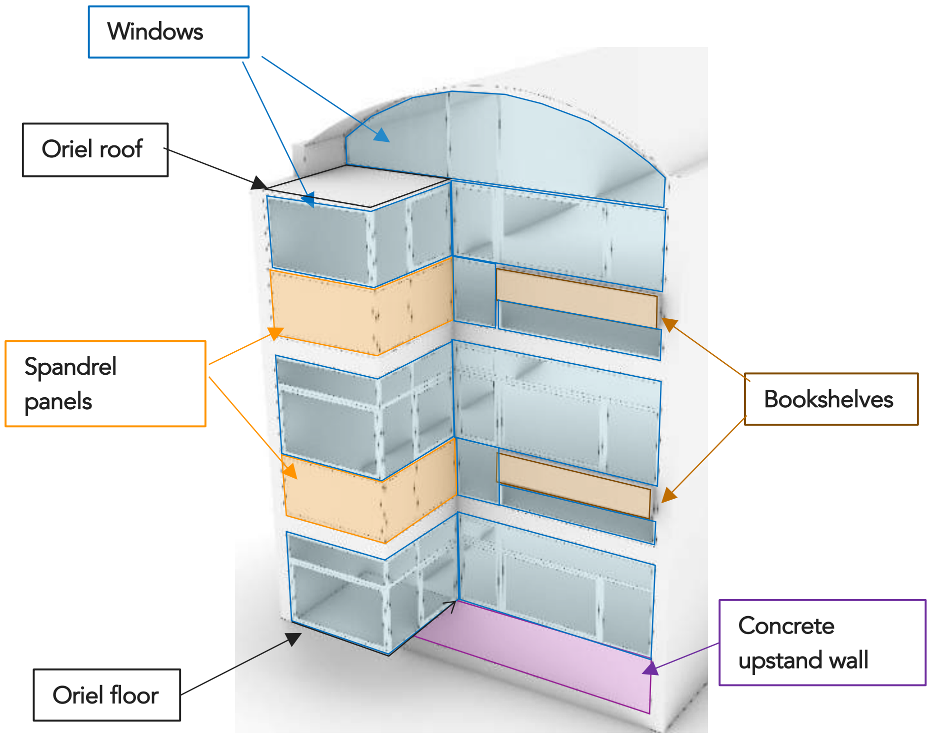
The graphs show that the three refurbishment cases reduce heat transfer by approximately 56 - 75%



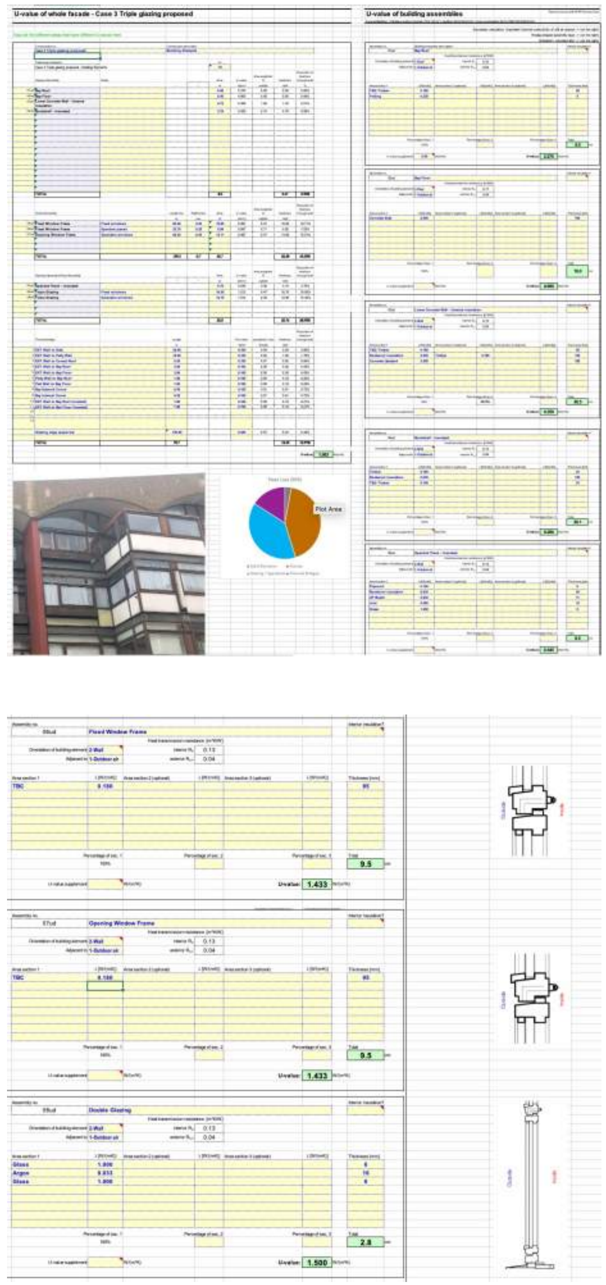


Heat loss calculation methodology

For calculating the the heat loss parameter and average U-value through the façade, a proprietary calculation tool was produced. This consisted of a 3D Rhino model combined with a spreadsheet based heat loss calculator.



Crescent House front elevation. Mark-up showing the individual elements that make up the Crescent House façade along the Goswell Road elevation. Each of the existing façade elements have been assessed and proposals made to improve their thermal efficiency.



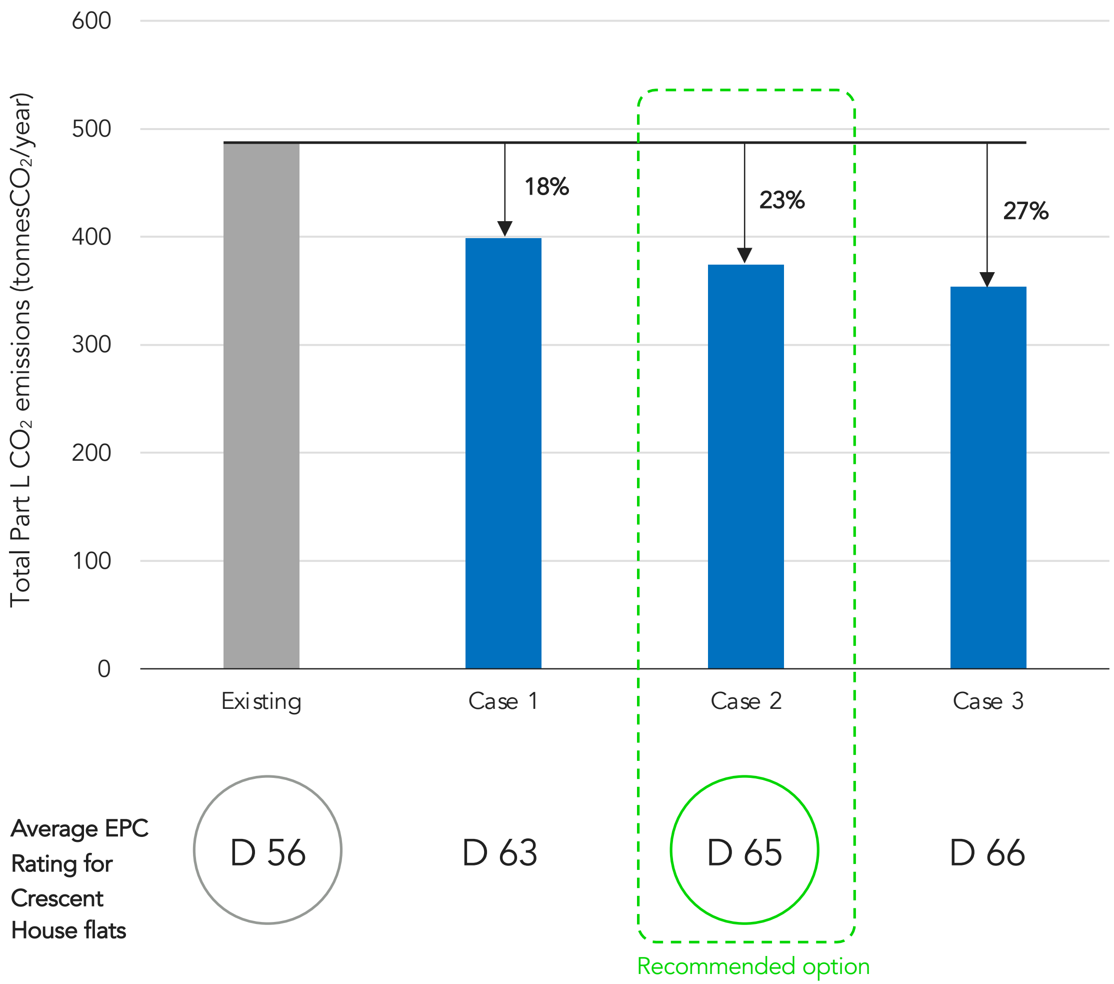
Screenshots of the Rhino model and spreadsheet calculation tool

Conclusion

The façade refurbishment proposals for Crescent House aim to achieve a more energy efficient fabric, lower energy bills and improve occupant comfort and wellbeing whilst minimising the impact to the building's heritage. These include a range of improvement measures such as replacing the single pane windows with triple glazing modules in a hardwood timber frame, replicating the current aesthetics, insulating the spandrel panels and internally lining parts of the walls and ceilings with high performance aerogel insulation.

From the initial calculations it is estimated that the proposed refurbishment measures will reduce heat loss through the façade by approximately 68%, which represents an average 23% reduction in CO_2 emissions. It is strongly recommended that these proposals should be not carried out in isolation but combined with an improved ventilation strategy and provision of low carbon heating. As a combined overall package, a significant reduction in energy consumption and carbon emissions should be achievable.

The proposals have also been designed to reduce the risk of condensation and mould growth forming on internal surfaces caused by cold bridging. Thermal bridge modelling of key junctions has helped to inform the provision of internal lining of aerogel insulation to ensure minimum surface temperatures are kept above the dew point temperature. This strategy is dependant however on the dwellings also having improved ventilation systems to prevent build-up of excessive humidity (such as continuous mechanical extract).



Part L carbon emission for Crescent House comparing the existing building to different façade replacement options. Indicative average EPC ratings are also shown. Individual flats will have very different SAP scores, particularly top and bottom floors which will be worse than the average.

All the properties would likely achieve an EPC D (55-68), some improved from an EPC E (39-54).