Life Cycle Assessment Options Appraisal Report

219-227 Sutton High Street

On behalf of Reid Capital

Revision A

Date: 16th December 2020

Revision History

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CONTENTS

1. Executive Summary

This Life Cycle Assessment (LCA) has been completed by Energist UK on behalf of Reid Capital.

It will set out the environmental impact of the proposed development site: 219-227 Sutton High Street ('the development') demonstrating compliance with:

i) BREEAM 2018 New Construction Mat01.

- Comparison with the BRE LCA benchmark during Concept Design (Office, Industrial, Retail only)
- Superstructure Options Appraisal during Concept Design
- Substructure and hard landscaping Options Appraisal During Concept Design
- Third Party Certification

This LCA concludes that the following BREEAM credits can be achieved at the Concept Design Stage, summarised here in Table 1.

Table 1: BREEAM credits achievable at Concept Design

Superstructure Benchmark Comparison	0 credits
Superstructure Options Appraisal	4 credits
Substructure and Hard Landscaping Options Appraisal	1 credit
Third Party Verification	1 credit (Technical Stage LCA required also)

The whole building is classified as mixed use, due to the mix of residential and retail functions therefore no comparison with the BRE benchmark can be made and all credits are based on the superstructure options appraisal within this report.

The LCA was modelled on the architectural information provided by LOM Architects and structural information provided by Hydrock. Energist have completed an options appraisal of 4 significantly different design options to determine any environmental impact improvements that can be made to the model and the Concept Design. The design options that have been recommended are summarised in Table 2 below.

	Lifetime CO_2 Emission Reduction (kg CO_2 eq)
Superstructure Option 1: Replace steel frame and clad external walls with traditional brick and block cavity	160,000
Superstructure Option 2: Replace upper floor steel frames with CLT (cross laminated timber)	590,000
Superstructure Option 3: Replace ground and first floor poured concrete slabs with hollowcore slabs	83,000
Superstructure Option 4: Replace aluminium window frames with timber or timber hybrid	100,000
Total savings	**933,000 kg CO_2 eq**

Table 2: Recommended Superstructure Options

Reid Capital in consultation with the Design Team have chosen not to implement the design improvement at the Concept Design Stage. However, Superstructure Options 3 and 4 are viewed as possible scenarios and will be reviewed further as the design develops and commercial viability is determined.

Superstructure Option 1 has been deemed unviable due to speed of construction, adaptability and reduced deadload of the proposed design. Superstructure Option 2 has been deemed unviable due to the increased fire risk this would cause in a high rise residential building.

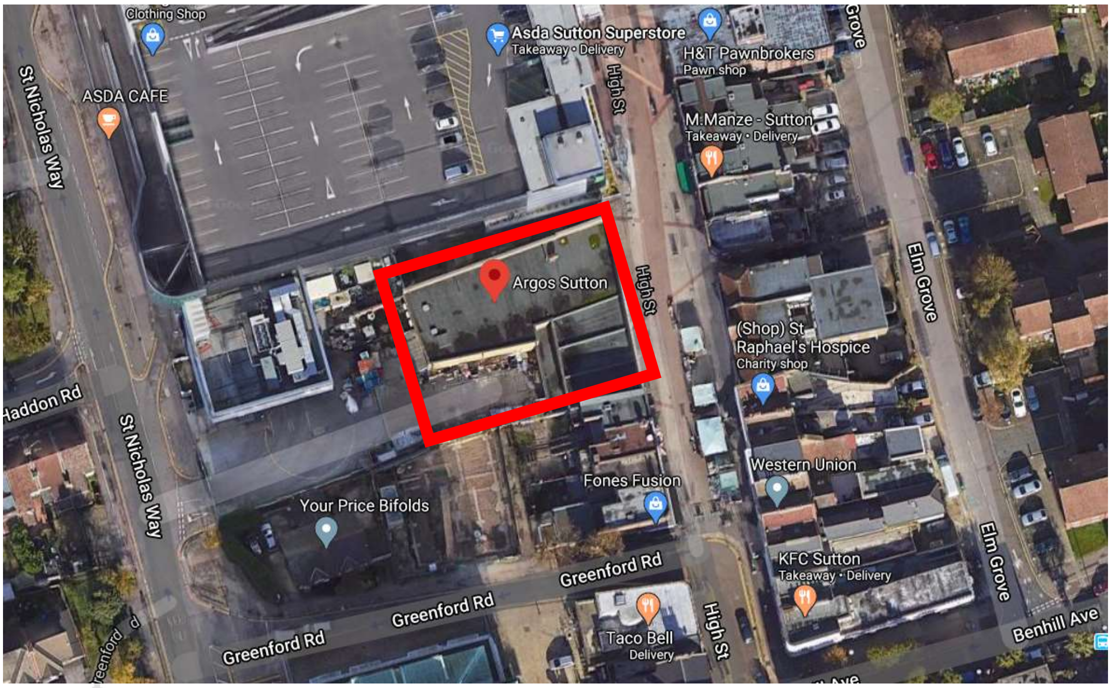
2. Introduction

2.1 Site Description

This LCA has been prepared for the Shell and Core Retail development by Reid Capital at 219-227 Sutton High Street, Sutton.

The Development consists of 3 ground floor retail units with multi-storey residential areas above, including associated hard landscaping and infrastructure.

The site lies within the London Borough of Sutton along Sutton High Street and is currently occupied by an Argos Store.



Map 1: Site location for 219-227 Sutton High Street
Source: Google Maps

2.2 BREEAM

BREEAM New Construction 2018 requires a Life Cycle Assessment (LCA) to be completed if credits are to be targeted and achieved in Materials Section Mat01. This section is one of the highest weighted in BREEAM with 22% of the assessment score available for Shell Only projects, 17.5% available for Shell and Core and 15% for Fully Fitted.

In order to achieve maximum credits a LCA with options appraisal must be completed at Concept Design stage and then updated at Technical Design stage. Credits are still available if started the LCA is started later than Concept Design although the credits available for this are reduced.

If the LCA has been carried out at Concept Design stage, 6 credits are available for the Superstructure model for comparison with the BREEAM LCA benchmark and for completing an options appraisal of 2-4 significantly different design options. One additional credit is available if Substructure and Hard Landscaping is included with the model and options appraisal and at least 6 different design options are appraised for this.

Exemplary credits are available if the design options appraised in the LCA are also included within the Man02 Life Cycle Assessment, core building service options are modelled and appraised and also if the LCA is verified by a suitably qualified third party.

2.3 Methods

Energist UK has used BREEAM compliant eTool LCD software to model the building against the BRE's IMPACT Database EN15804 Version 5. eTool is a dedicated Life Cycle Assessment (LCA) tool, which allows the environmental impacts for all the specified materials to be modelled using the BRE's IMPACT database which is integrated into the software.

There are 13 environmental impact and resources categories assessed within the IMPACT methodology as shown below. For the purposes of this report impacts will be reported against 1. Climate Change, plus the separate BRE EcoPoints.

1. Climate change (kg CO_2 eq. 100 yr.)
2. Water extraction (m_3)
3. Mineral resource extraction (tonnes)
4. Stratospheric ozone depletion (kg CFC-11 eq.)
5. Human toxicity (kg 1,4 dichlorobenzene (1,4-DB) eq.)
6. Eco-toxicity to freshwater (kg 1,4 dichlorobenzene (1,4-DB) eq.)
7. High level nuclear waste (mm^3)
8. Eco-toxicity to land (kg 1,4 dichlorobenzene (1,4-DB) eq.)
9. Waste disposal (tonnes)
10. Fossil fuel depletion (MJ)
11. Eutrophication (kg phosphate (PO_4) eq.)
12. Photochemical ozone creation (kg ethene ($C_2 H_4$) eq.)
13. Acidification (kg sulphur dioxide (SO_2) eq.)

The material types and quantities have been taken from information provided in dedicated IMPACT RFI schedules, supplemented where necessary with emails from the Project Team and drawings.

The LCA analysis has been undertaken in accordance with the BRE's IMPACT compliant scope and therefore includes the following applicable elements:

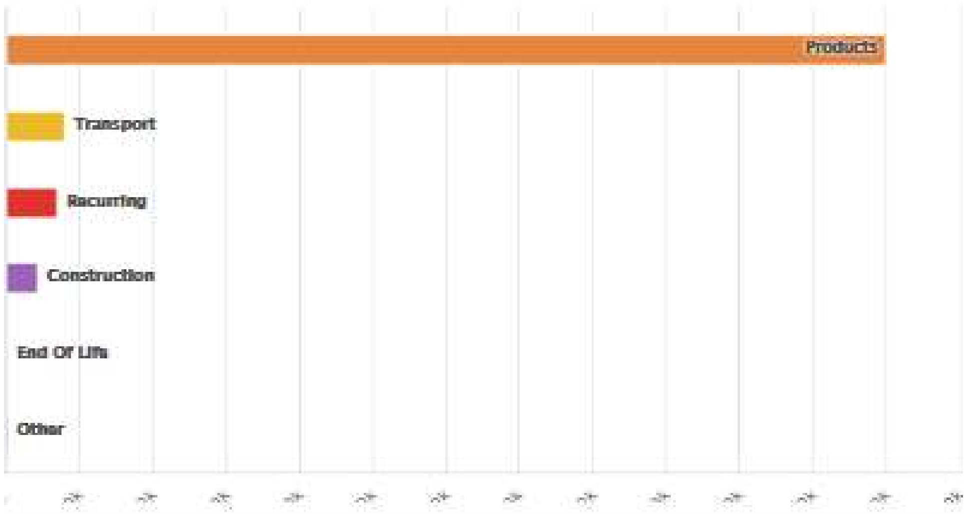
- Substructure: foundations, ground floor and basement (where targeted)
- Superstructure:
- Frame
- External walls
- Internal walls and partitions
- Windows
- External hard landscaping (where targeted)

Smaller fixtures and fittings (e.g. handrails, cubicles etc.), all furniture and equipment, are excluded from the LCA in accordance with the IMPACT scope.

The initial LCA model can be seen in the below screenshot taken from the eTool software (please note, all figures are given to 3 significant figures in the model):

Impact Summary

Global Warming Potential, GWP



Global Warming Potential, GWP (kg CO2 eq)*

Products	1,200,000.0
Transport	79,000.0
Construction	43,000.0
Recurring	69,000.0
Energy	1,200.0
Water	6.1
End of Life	2,500.0
Energy Export	0.0
Product Reuse	0.0
Total	**1,400,000.0**

Figure 1: Screenshot from eTool software summarising the CO_2 eq emissions by lifecycle stage

3. Results and Analysis

3.1 Production of the model

In order to create a life cycle model, the detailed architectural information for the building is required. This was provided in the form of the Energist LCA information schedule completed by LOM Architects Architects and structural information by Hydrock. Energist have used the detailed information to create the life cycle model. The results for the initial model can be seen in the screenshot below.

	GWP (kg CO2 eq) *
People and Equipment	
People	690.0
Equipment	49,000.0
Materials	
Facilitating works	0.0
Substructure	330,000.0
Superstructure	970,000.0
Internal finishes	0.0
Fittings, furnishings and equipment	0.0
Services equipment	0.0
Prefabricated buildings and building units	0.0
Work to existing building	0.0
External works	8,000.0
Project/design team	0.0
Undefined	0.0
Energy and Water	
Operational Energy	1,200.0
Water Use	6.1
Total	1,400,000.0

Figure 2: Screenshot from eTool software summarising the CO_2 eq emissions by each development category

3.2 Comparison with the BRE Benchmark

The Mat01 BRE benchmark is based on the BRE EN EcoPoints per $1m^2$ net lettable floor area of a notional building of the same function. The notional building EcoPoints per $1m^2$ is taken from a BRE sample of similar building type.

The comparison with the BRE benchmark is only applicable to office, retail and industrial building therefore this is not applicable to this mixed use building. Instead all credits are now available for the Superstructure Options Appraisal.

4. Superstructure Options Appraisal

Energist UK have completed an options appraisal of 4 significantly different design options for the superstructure.

4.1 Proposed Design

The proposed design (base model) has been created using the architectural schedule provided by LOM Architects Architects and structural information provided by Hydrock. The superstructure contains steel frame construction with a mixture of poured concrete and hollowcore concrete slab floors, screed and single ply roof and brick slip on steel support external walls. The windows are aluminium framed. Reid Capital have chosen this design as the preferred option at this stage until a cost analysis can be completed.

4.2 Option 1- Replace steel frame and clad external walls with traditional brick and block cavity

The external wall type proposed contains a significant amount of steel in the brick slip supports and the steel frame system. This steel can be eradicated entirely through the use of a more traditional brick and block cavity wall. Figure 3 below shows the GWP reduction for Option 1.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Replace metsec and steel support walls with traditional brick cavity	-180,000	-170,000	-160,000
Total	**-180,000**	**-170,000**	**-160,000**

Figure 3: Screenshot from eTool software showing the GWP reduction for Option 1.

Reid Capital have chosen not to implement this option because the development is on a constrained site and the slip system allows fast construction. It also allows the façade to be repaired and/or changed at a later date giving it better functional adaptability. It is also worth noting that this approach halves the amount of bricks used. This, in turn, would allow a more efficient steel structure as dead load is reduced.

4.3 Option 2- Replace upper floor steel frames with CLT (cross laminated timber)

The base model includes steel frames for the upper floors. Steel has an inherently high carbon intensity and additional environmental impacts from its production process. Option 2 looks to reduce this by using CLT frames.

The carbon sequestered in timber over its lifetime means that it has a negative embodied carbon due to the CO_2 it has absorbed from the atmosphere. CLT contains adhesives but this is the only product impact and therefore it is highly sustainable. The reduction in GWP for Option 2 is shown in Figure 4 below.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Building Material: Timber or Cross Laminated Timber	-610,000	-610,000	-590,000
Total	-610,000	-610,000	-590,000

Figure 4: Screenshot from eTool software showing the GWP reduction against the base model for Option 2.

Reid Capital have chosen not to implement this option due to the lack of market wide development in fire risk measures when using CLT in high rise buildings.

4.4 Option 3- Replace ground and first floor poured concrete slabs with hollowcore slabs

The proposed design contains ground and first floor slabs composing of reinforced poured concrete. Both concrete and the steel reinforcement have high embodied carbon, plus other associated impacts. Hollowcore slabs are proposed for the upper floors, which by their nature have less concrete and steel in them.

This option recommends the use of hollowcore slabs where possible at the ground and first floor levels. The benefits of replacing poured concrete slabs with hollowcore slabs is shown in Figure 5 below.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Replacement: Pourec concrete slabs for hollowcore	-82,000	-82,000	-83,000
Total	**-82,000**	**-82,000**	**-83,000**

Figure 5: Screenshot from eTool software showing the GWP reduction against the base model for Option 3.

Reid Capital have chosen not to implement this option at this time due to the structural implications. Hydrock have confirmed that the option is feasible in principle however this needs to be fully reviewed and it may be a hybrid solution of PC and insitu is most suited as there is a requirement to restrain the basement retaining walls.

4.5 Option 4- Replace aluminium window frames with timber or timber hybrid

The base model includes aluminium window frames. Aluminium has a high embodied carbon and is easily replaced with timber or timber hybrid options. The benefits of replacing all residential windows with timber alternatives are shown in Figure 6 below.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Replacement: Aluminium Window Frames for Timber	-52,000	-52,000	-100,000
Total	**-52,000**	**-52,000**	**-100,000**

Figure 6: Screenshot from eTool software showing the GWP reduction against the base model for Option 4.

Reid Capital have suggested that this option is viable and will be subject to a full cost analysis at developed design stages.

5. Substructure and Hard Landscaping

Energist have undertaken options appraisal modelling of 6 different substructure and hard landscaping options (2 hard landscaping and 4 substructure).

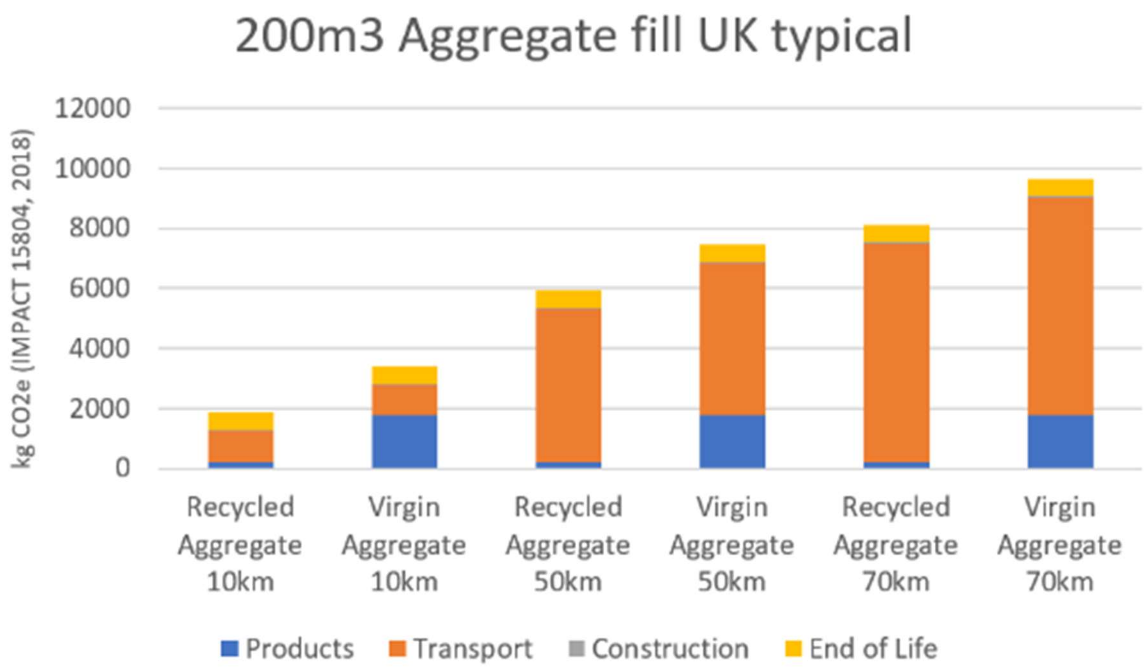
5.1 Option 1- Proposed Design

The base model for hard landscaping and substructure has been created using information supplied by LOM Architects and Structural Engineers Hydrock. The hard landscaping design currently includes concrete block paving over prepared sub-base. The substructure includes 10m long reinforced concrete piles, pile caps, ground beams, basement retaining walls and reinforced basement concrete slab.

5.2 Hard Landscaping Option 1

The base model includes concrete paving over prepared sub-base. The environmental impact from this can be easily reduced by using a recycled or secondary aggregate replacement. If recycled aggregate cannot be site won from demolition or excavation, then it is essential that this is sourced locally.

The graph below shows how the CO2 emissions for recycled aggregate can actually be higher than virgin material extraction and use if the transport distance is high.



Graph 1: Aggregate transportation comparison (Source- IMPACT)

The GWP savings from using a locally sourced recycled aggregate can be seen in the screen shot below:

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
100% Recycled aggregate in landscaping	-18	-18	-44
Total	**-18**	**-18**	**-44**

Figure 7: Screenshots from eTool software showing the GWP change for recycled or secondary aggregate.

Reid Capital have suggested that this option will be possible to implement.

5.3 Hard Landscaping Option 2

The base model includes concrete pavers for hard landscaping. Concrete has an inherently high environmental impact compared to other forms of hard landscaping. This option looks at replacing concrete pavers for reclaimed clay pavers. Although there is a significant amount of labour involved in sourcing and cleaning clay pavers, they can be cost competitive with new paving slabs. The aesthetic look of recycled clay is also very popular in architecturally designed buildings.

Reclaimed clay pavers have a significantly lower GWP than concrete pavers. The GWP savings can be seen in the screen shot below:

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Replacement: Concrete pavers for reclaimed clay	-150	-120	-110
Total	**-150**	**-120**	**-110**

Figure 8: Screenshots from eTool software showing the GWP change for reclaimed clay pavers.

Reid Capital have suggested that this is hard landscaping option is possible and will be reviewed further.

5.4 Substructure Option 1

The proposed substructure design contains a significant amount of steel reinforcement which has a high embodied impact. Option 1 looks to reduce this by using steel with a more sustainable production method such as arc furnace production, see figure 4 below.

Figure 9: Electric Arc Furnace (Source – Celsa Steel)

Steel produced by electric arc furnace rather than blast furnace methods has only 1/3 the embodied carbon. Steel produced by this method is still far less common than traditional blast furnace production and is therefore typically more expensive to source and transport but is becoming more frequently available in the UK.

Replacing the steel reinforcement with arc furnace produced steel will reduce GWP in the design as shown bin Figure 10 below.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Replacement: Standard steel for arc furnace steel production.	-72,000	-72,000	-72,000
Total	**-72,000**	**-72,000**	**-72,000**

Figure 10: Screenshots from eTool software showing the GWP change for arc furnace steel.

Reid Capital have suggested that this is substructure option is possible however it will need reviewing for cost viability at the procurement stage.

5.5 Substructure Option 2 and 3

The substructure for the base model contains a high quantity of reinforced concrete. In order to reduce the high environmental impact of concrete Energist have recommended changing the concrete specification to include either a 30% fly ash blend mix or a 40% GGBS (Ground Granulated Blast Slag).

Fly-ash is a by-product of power generation in coal fired power stations and can be used to directly replace Portland cement in varying proportions up to 50%. Fly-ash is also cost competitive with standard cement depending on the application.

Fly ash blend concretes can actually produce a stronger product but typically have longer curing times which can greatly impact multi-story developments. Curing agents are available to alleviate this but may have an impact on the cost.

Ground Granulated Blast Furnace Slag, GGBS is a by-product from the blast furnaces used to make iron. The by-product is collected in the form of finely granulated powder and is used in the production of cement, concrete, and soil stabilizer.

The inclusion of GGBS in substructure concrete ranges in content typically from 30 to 50% and has been found that the higher the content leads to higher concrete strength and durability, this is due to the granulated profile is found to be less permeable and chemically more stable than normal concrete.

The slag by-product is aiding in the problem of sourcing alternative construction materials as the conventional materials continue to deplete. Fly ash and GGBS is considered a greener construction method given the cement requires less than a fifth of the energy used in typical cement production, and less than a fifteenth of the carbon emissions.

The inclusion of GGBS in ready-mixed concrete has been found to have the following benefits:

- Better workability, aiding in placement and compaction,

- Lower early age temperature rise which reduces the risk of thermal cracking,
- Elimination of the risk of internal reactions, such as Alkali-silica reaction,
- High resistance to chloride ingress, reducing the risk of reinforcement corrosion,
- High resistance to sulphate and chemical reactions

Replacing the Portland cement within concrete with either fly ash of GGBS can has a huge impact on the environmental impact of the building. The resulting change in GWP for each of these options is shown in Figure 11 below.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Concrete Replacement 30% fly-ash blend substructure	-39,000	-39,000	-39,000
Total	**-39,000**	**-39,000**	**-39,000**

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Concrete Replacement 40% GGBS blend Substructure	-41,000	-42,000	-41,000
Total	**-41,000**	**-42,000**	**-41,000**

Figure 11: Screenshot from the eTool software showing the reduction in GWP for the different substructure options.

Reid Capital have suggested that this is substructure option is possible however it will need reviewing for cost viability at the procurement stage.

5.6 Substructure Option 4

The proposed substructure design has a high impact due to the quantity of steel and concrete. This can be reduced simply by reducing the superstructure load through fabric efficiencies and optimised design. Substructure option 4 assumes a reduced dead load from the superstructure which in turn will reduce the size of foundations required.

The current design uses 450mm diameter piles. It has been confirmed by the Hydrock Structural Engineer that in a hypothetical scenario the load could be reduced and 300mm diameter piles could be used therefore reducing the quantity of concrete and steel.

This option assumes that the design can be changed to 300mm piles. Note additional benefits such as reduced pile caps may result however this have not been included in the reduction.

Recommendation	GWP (kg CO2 eq)		
	Initial	10 Year	Life time
Reduction: Reduce the building load to reduce pile diameter	-52,000	-53,000	-52,000
Total	**-52,000**	**-53,000**	**-52,000**

Hydrock have confirmed that this may be possible and the most efficient substructure design is yet to be determined. An embodied carbon calculator will be used to determine the most sustainable design once this is underway.

6. Conclusions and Recommendations

Energist UK have completed a Life Cycle Assessment on behalf of Reid Capital.

The environmental life cycle impact of the proposed development site: 219-227 Sutton High Street has been determined and 4 superstructure options and 6 substructure and hard landscaping options have been appraised to reduce the impact of the building. The options appraised and the Planning Team comments are summarised in the table below:

Options	Comments
Superstructure Option 1: Replace steel frame and clad external walls with traditional brick and block cavity	Rejected due to structural and load implications
Superstructure Option 2: Replace upper floor steel frames with CLT (cross laminated timber)	Rejected due to fire safety
Superstructure Option 3: Replace ground and first floor poured concrete slabs with hollowcore slabs	Potential to achieve but needs full structural review
Superstructure Option 4: Replace aluminium window frames with timber or timber hybrid	Potential to achieve but needs full cost review
Hard Landscaping Option 1: Recycled sub-base	Accepted in principle
Hard Landscaping Option 2: Reclaimed clay pavers	Accepted in principle
Substructure Option 1: Arc furnace steel production	Potential to achieve but needs full cost review

Substructure Option 2: Fly ash cement replacement	Potential to achieve but needs full cost review
Substructure Option 3: GGBS cement replacement	Potential to achieve but needs full cost review
Substructure Option 4: Optimised design to reduce load and pile diameter	Potential to achieve but needs full structural review

The following BREEAM credits are achievable for this project:

- Comparison with the BRE LCA benchmark during Concept Design (Office, Industrial, Retail only) – 0 credits
- Superstructure Options Appraisal during Concept Design and Technical Design – 4 credits
- Substructure and hard landscaping Options Appraisal During Concept Design – 1 credit
- Third Party Certification – 1 credit

This LCA is required to be updated with additional detailed information at Technical Design Stage for achievement of full credits.