Dorset Council Residential Lifecycle Embodied Carbon and Operational Carbon Analysis

Rev 6

For Dorset Council

REF / 10164
March 2023

ARCHITYPE

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Existing building, North Quay, Weymouth

Contents

Figure 1 / Existing office building North Quay, Weymouth

Figure 2 / Proposed residential development on North Quay, Weymouth (Image by Ben Pentreath & Associates, provided by Dorset Council)

1. Introduction

1.1 Approach

Dorset Council have commissioned Architype to undertake a review of the lifecycle embodied carbon and operational carbon of two residential schemes submitted for planning on the North Quay site, Weymouth. The two schemes being reviewed are the permitted development application for change of use in the existing building, approved in the summer of 2016, and the new build residential scheme approved in 2015. This report follows similar investigations for the retrofit of the existing office building and a larger residential new build scheme on the same site.

The primary aim of the study was to provide a high level comparison of the environmental impact of a new residential development on the North Quay site, looking at different embodied and operational carbon scenarios. These scenarios were compared against a baseline of the current office building continuing in its current operation - ie. Business as Usual (BAU). The scope of this revision of the report was to evaluate the impact of foundations on both the refurbishment and the new-built proposals as these were previously excluded from the calculations. The embodied carbon of foundations have been added to provide a more accurate carbon analysis of the two options.

It should be noted that this study represents a high level analysis and outputs are strictly for comparison purposes only. Landscaping and external works have not been included in the analysis. The comparison focuses on the following key strategies:

Business as Usual - as an office building. Undertaking no major work to the building and continuing to operate as now. No embodied carbon impact from refurbishment and existing operational carbon impact. This strategy provides a baseline scenario for comparing environmental impacts of the refurbishment and new build options.

Residential EnerPHit Refurbishment - Undertaking a deep refurbishment/retrofit of the building to the Passivhaus 'EnerPHit' standard. No embodied impact from superstructure as retained. Embodied impacts from the fabric and services upgrade along with end of life impacts have been considered, including foundations. Significantly improved operational carbon performance against baseline.

New Residential Passivhaus Development - Timber Frame - Demolishing the existing building and subsequently redeveloping the North Quay site into residential accommodation, using a timber frame structure which leads to significantly lower embodied carbon emissions. This option assumes certification to the Passivhaus Standard which will radically reduce operational energy consumption. Four different scenarios explore the potential reuse of the existing foundations in the new scheme ranging from no reuse to 20%, 40% and 60% reuse of existing foundations respectively.

Methodology
The embodied carbon calculations for the above strategies were carried out using ECCOlab. ECCOlab is a web based tool that enables life cycle assessment of new build and refurbishment projects from the early stages of design to completed buildings.

The layouts for the proposed residential refurbishment and the new build development were provided by Dorset Council. Structural information on the foundations of the existing scheme was taken from the 'Existing Building Study and Structural Report' undertaken by GAP Engineers on behalf of Dorset Council. The layouts for the proposed new build development were developed by Ben Pentreath & Associates on behalf of Weymouth & Portland Borough Council (WPBC) in support of an outline planning application for the demolition of the existing Municipal Council Office Buildings on the site.

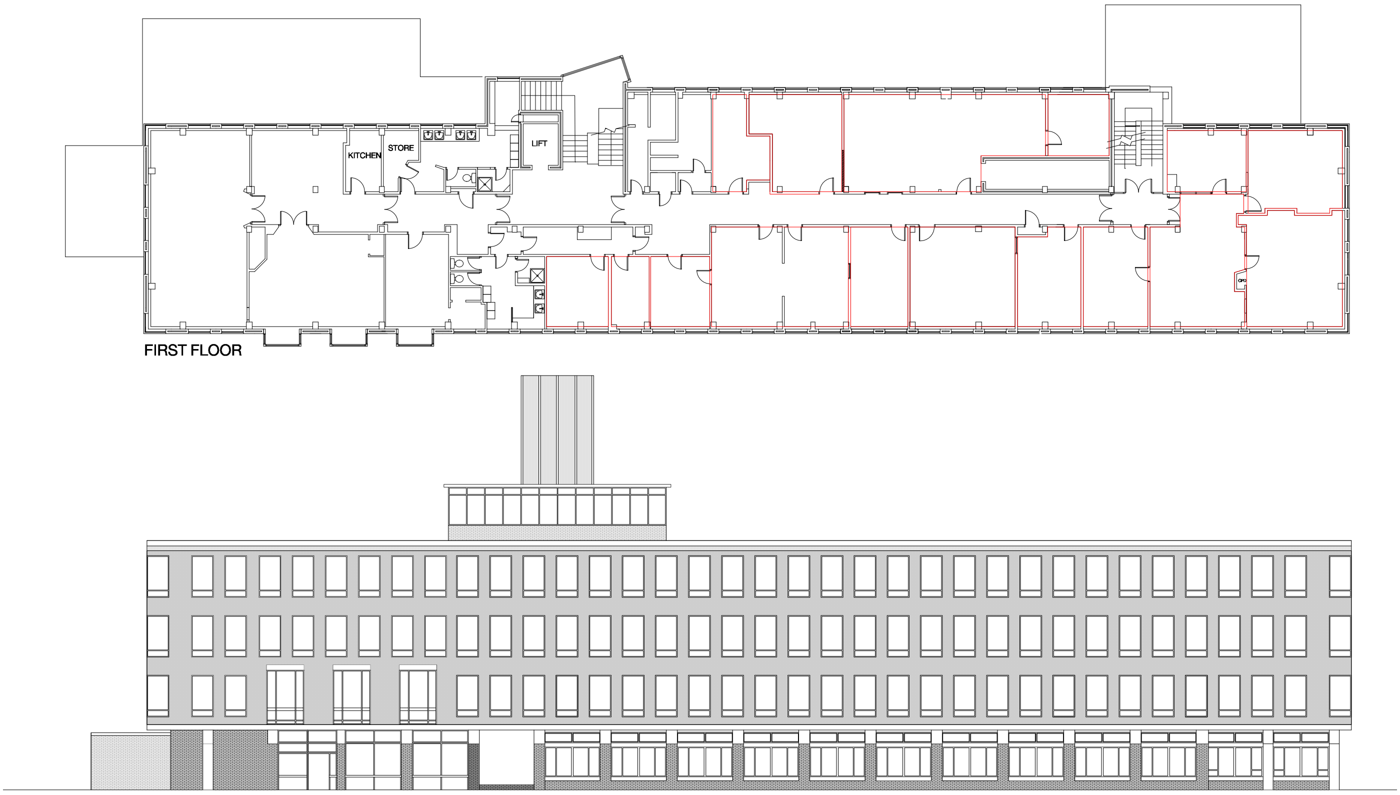


Figure 3 / CAD plans and elevations of the existing building (provided by Dorset Council)

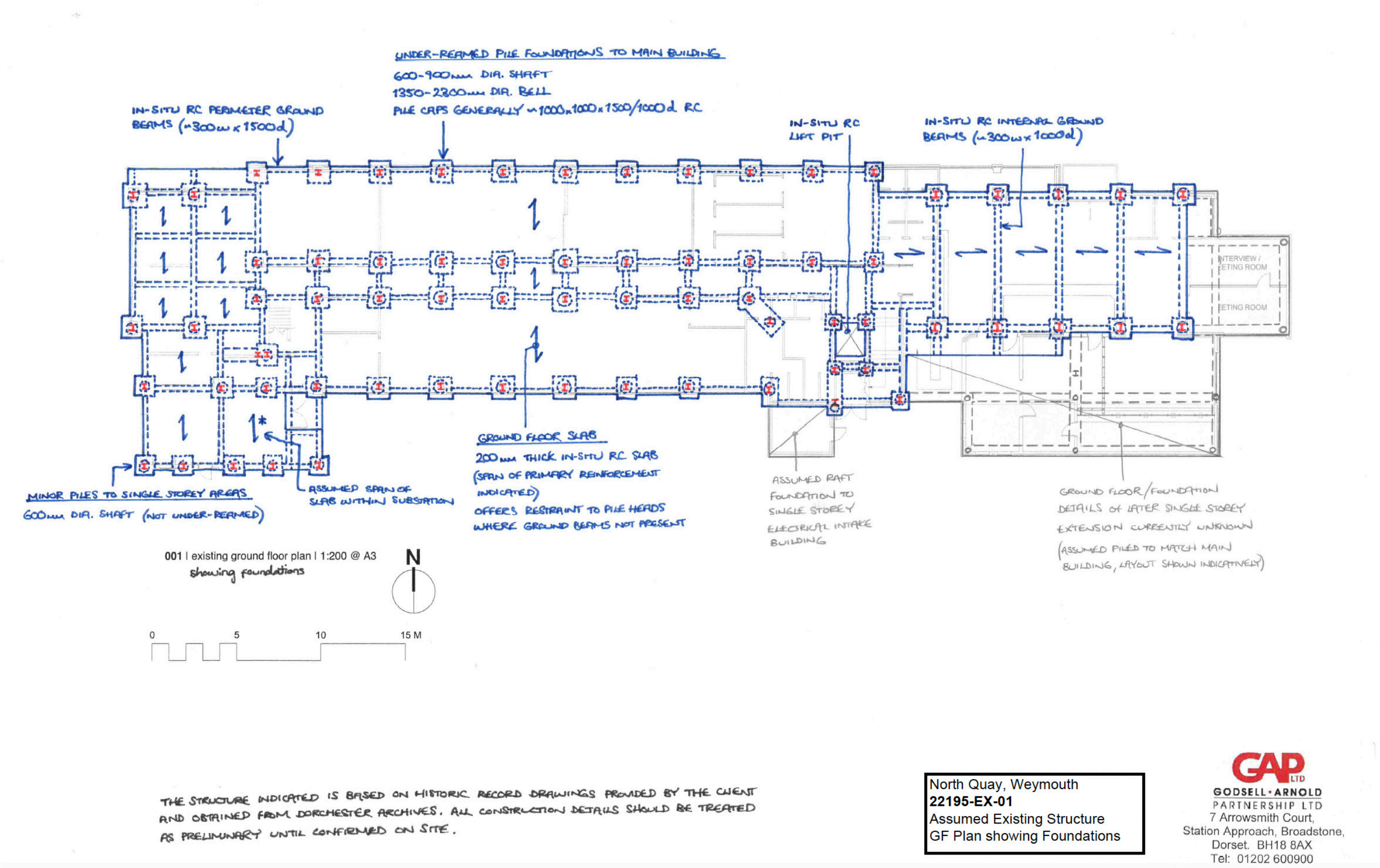


Figure 4 / Assumed existing foundations (Report by GAP Engineers, provided by Dorset Council)

1. Introduction

1.2 Existing building

The information provided to Architype in November 2019 as part of the previous study was used to create the Business as Usual benchmark for this analysis. The existing office building is located on North Quay, Weymouth, directly overlooking the Marina to the north.

According to the latest information included in the structural report issued in July 2022, the 4 storey building was constructed in two phases, with the main building constructed in 1963 and a subsequent extension of the 3rd floor completed in 1973. The building was purpose-built as council offices from inception and the building use has not changed over its lifetime. It is understood that no major refurbishment of the building has taken place since this time.

Structure and fabric

According to the structural report, the superstructure comprises a fabricated steel frame, heavily encased in reinforced concrete at the perimeter and generally internally as well. The upper floors and roof are generally formed from in-situ reinforced concrete, and external walls are of masonry brick and block construction with stone cladding in most areas. These findings match the assumptions previously used in our Lifecycle calculations.

Information provided by GAP Engineers on the assumed existing foundations has been used to estimate the volume of the existing piles, pile caps and ground beams. It should be highlighted that the depth of the piles could not be estimated but GAP Engineers expect them to be 15-20m deep. For the purposes of this report's calculations we assumed that piles have an average diameter of 0.7m and are 20m deep. Ground beams were assumed to be 0.3x1.5m on average, and pile caps were assumed to be 1.5m^3 each on average. These volumes were used as inputs in ECCOlab to estimate the Lifecycle carbon of the existing foundations. As these are retained elements their impact is only visible at the End of Life stage (C1-C4).

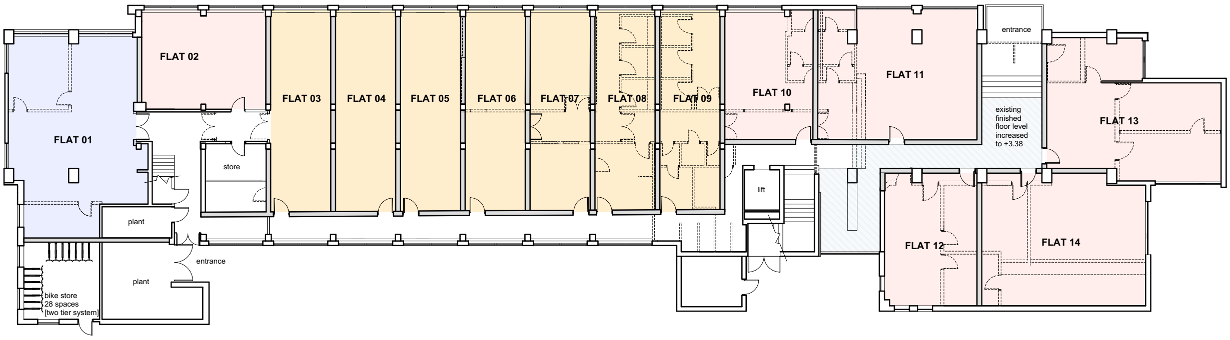
The building appears to be naturally ventilated by the means of opening windows to all façades.

Some CAD drawings and partial historic drawings had previously been received from the Client.

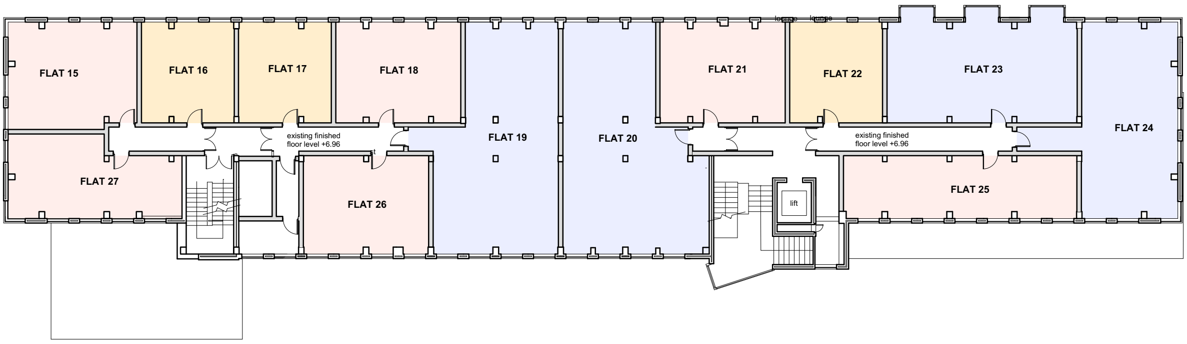
Limit of information

The Lifecycle carbon analysis of the Business as Usual option was based on information previously received by the Client as part of the original carbon analysis undertaken in 2020.

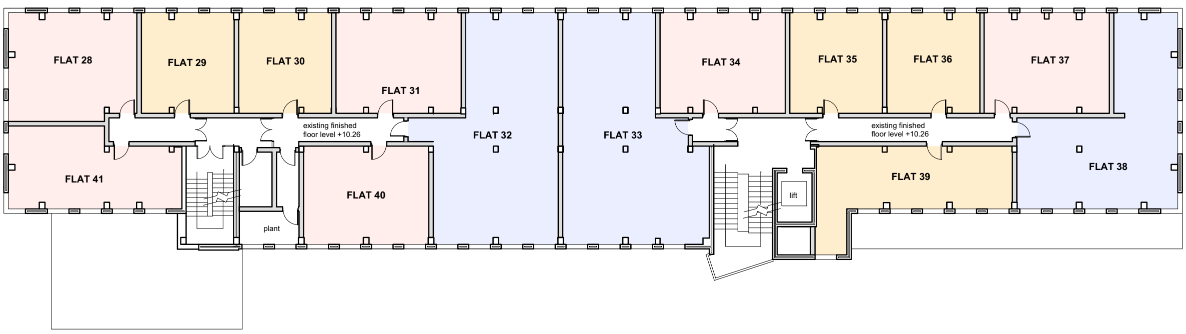
For this study, information captured in the Structural Report issued in July 2022 was used to evaluate the impact of foundations on the Lifecycle Carbon of these options.



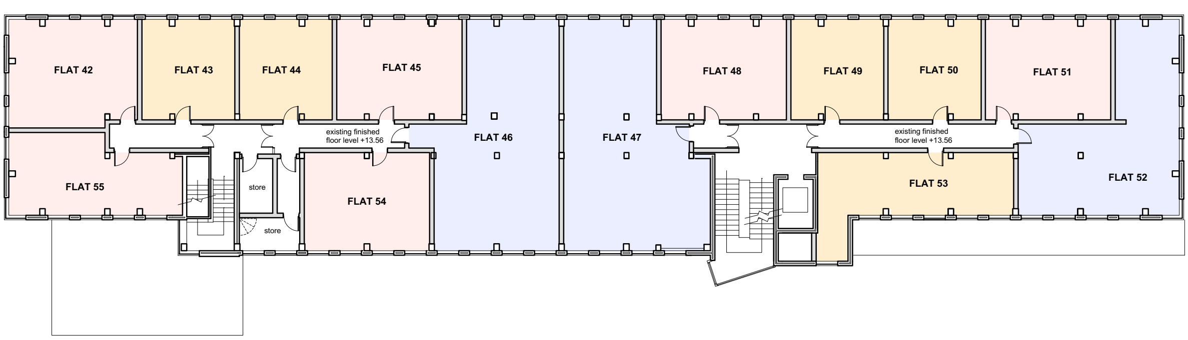
001 I proposed ground floor plan



001 I proposed first floor plan



001 I proposed second floor plan



001 I proposed third floor plan

Figure 5 / Floor plans for the residential refurbishment (drawings provided by Dorset Council)

1. Introduction

1.3 Residential EnerPHit Refurbishment

This option involves refurbishing the existing building into residential accommodation to the Passivhaus EnerPHit Standard.

The proposed layout was provided by Dorset Council and includes a mix of 1-bed and 2-bed flats. The proposal results in a total of 56 flats.

The structure is retained as is the external cladding. The internal layouts are completely reconfigured while the building's envelope is upgraded to meet the EnerPHit standard.

A model of the proposal was created in gModeller, the SketchUp plug-in for ECCOlab and the carbon analysis was subsequently done in ECCOlab.

Regarding operational energy, the Passivhaus EnerPHit standard was assumed to be achieved. Passivhaus is considered the most robust standard for significantly reducing a building's energy in use in a cost effective manner. Material assemblies were based on typical assemblies Architype have used before in similar schemes.

Limit of information

The Lifecycle carbon analysis of the Eco-refurbishment option was based on information previously received by the Client as part of the original carbon analysis undertaken in 2020.

For this study, information captured in the Structural Report issued in July 2022 was used to evaluate the impact of foundations on the Lifecycle Carbon of these options.

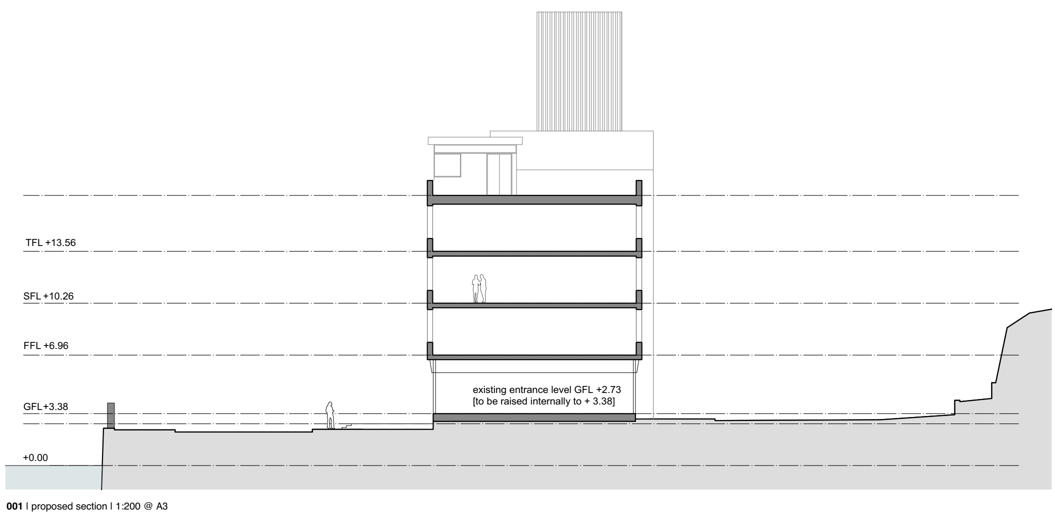


Figure 6 / Figure 1.4 Section for the residential refurbishment (drawings provided by Dorset Council)

Figure 7 / Schematic drawings for the redevelopment of the site into a residential scheme (Image by Ben Pentreath & Associates, provided by Dorset Council)

1.4 New Passivhaus Residential Development

This option involves redeveloping the North Quay site into residential accommodation. It was based on the information provided by Dorset Council that included an Outline Planning Application document from December 2014 produced by Ben Pentreath and Associates, a outline masterplan and elevations showing the redevelopment of the wider site (Figure 1.4). A number of assumptions were made as part of the study including internal layout of flats and construction assemblies. It should be noted that this is a high level analysis and outputs are strictly for comparison purposes only.

The development comprises 72 dwellings and 216m2 of commercial space. The proposal provides a mix of different typologies ranging from flats to townhouses and includes both private and affordable dwellings. The proposal includes a mix of 2, 3 and 4 storey buildings with some pilotis parking and some parking courts. Figure 1.5 shows a breakdown of the proposed accommodation.

A model of the proposal was created in gModeller, the SketchUp plug-in for ECCOlab and the carbon analysis was subsequently done in ECCOlab. As no engineering proposals are currently provided for the scheme, ECCOlab templates were used for the assessment of the timber frame structure and Passivhaus built-ups. For the assessment of the foundations' carbon impact we have reverted to best practice guidance from the LETI Embodied Carbon Primer (London Energy Transformation Initiative, January 2020), according to which Substructure accounts for 21% of embodied carbon (A1-A3) in medium residential schemes. Landscaping is excluded from these calculations.

Regarding operational energy, the Passivhaus Classic standard was assumed to be achieved. Material assemblies were based on typical assemblies Architype have used before in similar schemes.

Limit of information

Information supplied for this comparative exercise on the proposed new-built scheme is limited mainly to geometry and does not capture actual build-ups and structure.

A more detailed Lifecycle Carbon analysis is recommended should the project progress beyond a feasibility level assessment.

NORTH QUAY PROPOSED DEVELOPMENT

Building	no. of dwellings	no. of bedrooms per dwelling	total no. of bedrooms	total no. of bedrooms	total no. of bedrooms	Commercial Area (m2)	
			MARKET	SOCIAL RENTED	INTERMEDIATE		
Town House	7	3	21				
Bldg 1	7	2	14			170	
Bldg 2	1	1	1				
Bldg 2	1	3	3				
Bldg 3	3	2			6		
Bldg 3	3	3	9				
Bldg 3	9	1	9				
Bldg 4	3	1	3				
Bldg 5	3	1	3				
Bldg 5	3	1		3			
Bldg 6	4	2	8				
Bldg 7	6	3		18			
Bldg 7	1	1		1			
Bldg 8	3	3	9				
Bldg 8	4	2	8				
Bldg 9	7	1		7			
Bldg 9	4	2		8			
FOG	2	1	2				
FOG	1	2	2				
TOTAL	72	35	92	37	6		
			68.1	27.4	4.4	%age of total	
				86.2	13.8	%age of total affordable housing	
		TOTAL no. of bedrooms	135				

Table 1 / Proposed accommodation division (Table by Ben Pentreath & Associates, provided by Dorset Council)

2. Glossary

Abbreviations:

BCIS	-	Building Cost Information Service
CIBSE	-	Chartered Institute of Building Services Engineers
DEC	-	Display Energy Certificate
EPD	-	Environmental Product Declaration
FF&E	-	Furniture, fixtures and equipment
GA drawings	-	General Arrangement drawings
GWP	-	Global Warming Potential
LCC	-	Life Cycle Carbon/ Cost
EoL	-	End of Life
WRAP	-	Waste and Resources Action Programme
GGBS	-	Ground Granulated Blast Furnace Slag
FOG	-	Flats over garage
LETI	-	London Energy Transformation Initiative
RICS	-	Royal Institute of Chartered Surveyors

Terms and definitions:

Embodied carbon:
The resultant emissions from all the activities involved in the creation, maintenance, repair and demolition of a building

Feed-in-Tariff (FIT):
An energy supply policy that promotes deployment of renewable energy resources. It offers a guarantee of payments to renewable energy developers for the electricity they produce.

Operational energy:
Operational energy from the building includes energy consumed for heating, lighting, ventilation, air conditioning and small power. e.g. regulated and unregulated energy.

Operational carbon:
The carbon emissions resulting from the operational energy demand.

Cradle to gate (A1-A3):
A system boundary of an environmental life cycle assessment. A portion of a product life cycle from inception to the point it leaves the manufacturer.

Cradle to site (A1-A4):
A system boundary of an environmental life cycle assessment. A portion of a product life cycle from inception to the point it arrives to the building site.

Cradle to grave (A-C):
A system boundary of an environmental life cycle assessment relating to the full life cycle of a product or building including extraction, processing and delivery to site, maintenance, refurbishment, demolition and waste treatment.

Figure 8 / ECCOlab has been utilised for option appraisal in the low carbon Passivhaus EnerPHit retro-fit of existing office space for the University of Cambridge

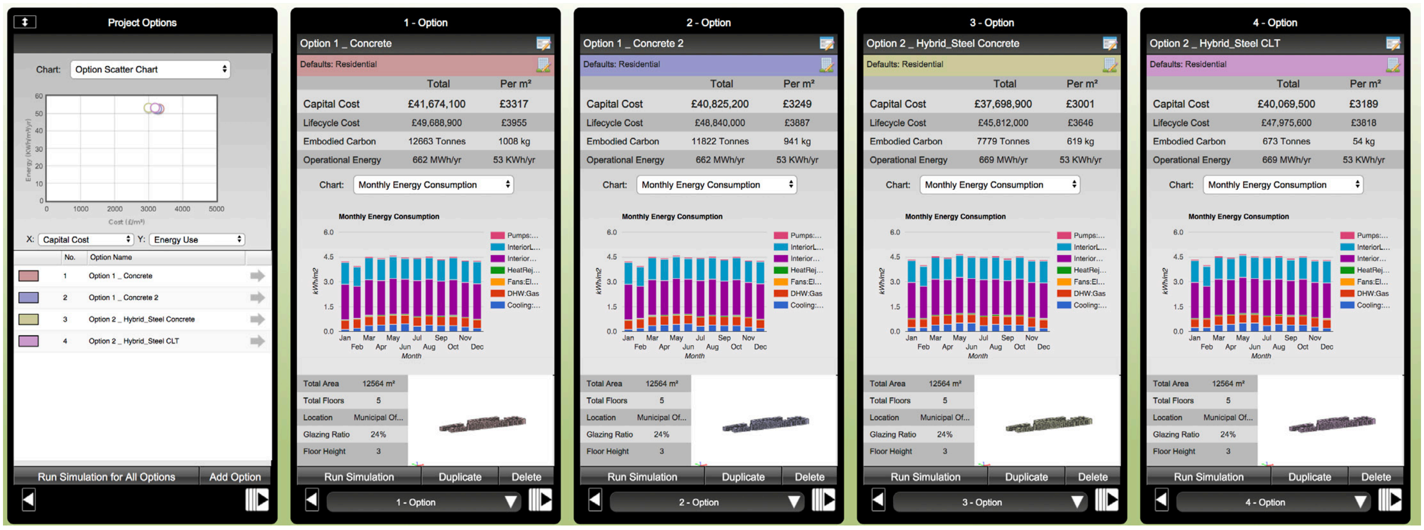


Figure 9 / Screengrabs of work in progress ECCOlab analysis

3. Methodology

3.1 ECCOlab

The embodied carbon calculations for the case studies were carried out using ECCOlab. ECCOlab is a web based tool that enables life cycle assessment of projects from the early stages of design to completed buildings enabling informed design decision making from the outset of the project throughout the project's development to assessment of the completed building. It was developed by GreenSpaceLive, ChapmanBDSP, Architype and Currie & Brown.

The modelling, analysis and reporting is based on the following recognised industry standards: BS EN 15978:2011 - Sustainability of construction works, BS ISO 15686-5 - Standardised Method of Life Cycle Costing, PAS 2050:2011 and BCIS NRM.

Embodied carbon for Stage A1-3 and C1-4 is assigned directly for each product based on EPD information, manufacturer information and the ICE database. Embodied carbon for Use stage (B1-7) is calculated in ECCOlab according to the predicted service life and maintenance profiles which are defined for each component and component assembly. Service life periods for each product were defined based on EPDs, product data sheets, warranties and general references as Fannie Mae Estimated Useful Life Report. Where EPDs did not include information on End of Life carbon (stage C), it was estimated as 3% of the Product stage (A1-A3) carbon. Materials' density, specific heat capacity and conductivity were based on EPD, material data sheets and CIBSE Guide A.

The carbon emissions for transport to site (Stage A4), are calculated using ECCOlab's dynamic transportation calculation for point-to-point geo-positional transportation. All locations are defined by country, latitude and longitude. Point-to-point distance calculations are used for inland transportation between sites or to shipping ports, modified with appropriate country specific wiggle factors and transport splits. For each landmass origin and destination, the engine establishes the shipping route to be used. Calculated distances are then converted into carbon CO2eq emission factors for road freight, rail and shipping, using the latest recognised figures produced by DECC in the UK. This represents a conservative estimate of total transport impacts, as it assumes the most efficient route possible from manufacture location to site.

Data input & modelling assumptions

The data for the modelling of the existing building was based on the following information supplied by Dorset Council:

- AutoCAD drawings of the existing building - plan and elevation
- Annual energy bills of the existing building
- Internal photos of the existing building
- Very limited construction information (3 details) of the existing building
- The Outline Planning Application (PDHAS) document for Weymouth North Quay, December 2014, prepared by Ben Pentreath & Associates.
- 1 AutoDAD Masterplan and 2 AutoCAD North Elevation drawings of the proposed North Quay Residential Development, prepared by Ben Pentreath & Associates.
- The 'Existing Building Study and Structural Report', July 2022, prepared by GAP Engineers.

Where no project information was provided typical material assemblies were used from ECCOlab's database. The reference study period was defined as 60 years.

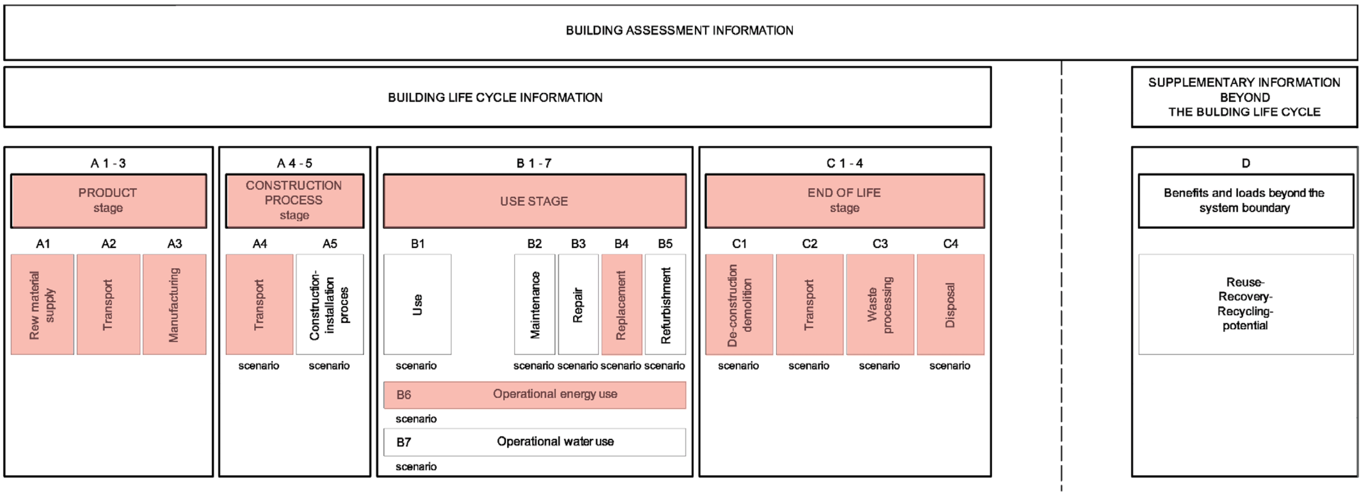


Figure 10 / Display of modular information for the different stages of the building assessment (Source: BSI 2011). Highlighted stages are included in the scope of this report.

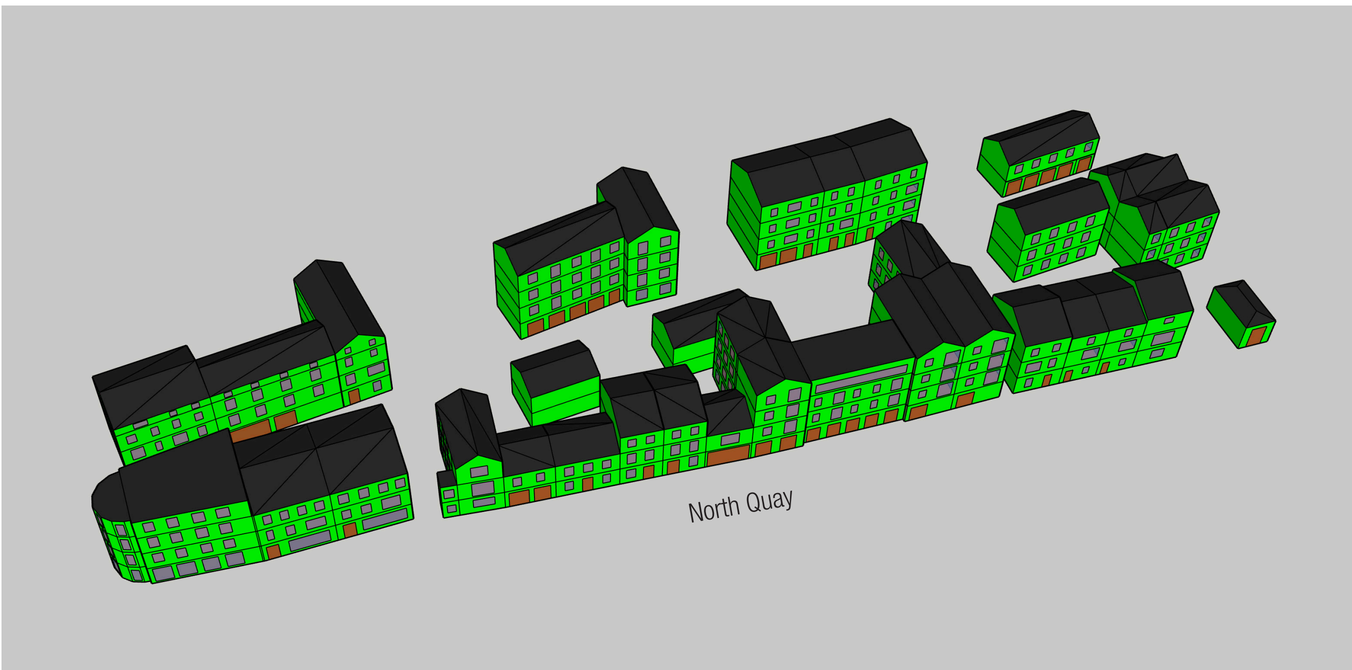


Figure 11 / ECCOlab model of the proposed residential scheme

3. Methodology

3.2 Life cycle carbon analysis

The study analyses the carbon emitted throughout the life of the building (Figure 3.1). The building life cycle includes construction, use and deconstruction commonly termed 'cradle to grave'. It aligns with the relevant standard BS EN 15978 which splits down the energy associated with construction projects into the following stages:

› Product stage (A1-A3)
› Construction process stage (A4-A5)
› Use stage (B4)
› End of life stage (C1-C4)

Supplementary information beyond the building life cycle (D) is beyond the scope of this analysis. Following EN 15804 approach, any benefits of recycled materials that are currently taking place are included in product stage A1-A3. Landscape design has been excluded from this report.

The carbon impact of foundations has been added in this revision of the report in line with the RICS guidance (RICS,2017) according to which new build projects assessed are considered to commence their development on a cleared, flat site for consistency purposes. Demolition works are therefore decoupled from new construction projects, hence the responsibility for any emissions arising from demolition is not necessarily solely attributable to the new build project. Similarly, for retrofit projects, the equivalent state to that of 'a cleared flat site' as described for new build, is represented by any retained elements. Any removal and/or stripping out of building elements to get the structure to the 'cleared flat site' equivalent state should be treated as demolition works and reported separately. For this reason, demolition carbon related to building structures within the boundary line of each project is captured only under the 'End of Life'(C1-C4) element of that option.

3.3 Operational carbon analysis

The operational carbon estimation (Use Stage B6) has been derived for each option on the following basis:

- **Business as Usual**_Office Use – Annual energy bills for the office's electricity and gas usage have been provided for the last 6 years by the client. Operational carbon has been derived based on an average of previous performance using typical regional utility costs per unit and current grid carbon factors.
- **Residential EnerPHit Refurbishment** – based on previous analysis by Architype of similar Passivhaus EnerPHit projects.
- **New Passivhaus Residential Development _Timber Frame –** based on previous analysis by Architype of similar Passivhaus projects

Regulated and un-regulated energy, including the energy consumed for heating, lighting, ventilation and small plug-in power, has been included in the operational carbon figures throughout. Operational water impact has not been considered in the analysis. In general the carbon impact of mains water supply is low and would not have a bearing on the outcomes of the study.

3.4 Renewable energy and LZC

The comparisons presented in this report focus on embodied carbon, fabric performance and operational energy. Options for renewables and LZC technologies have not been considered. On-site renewable generation, for example building integrated photovoltaics panels, could be added to any of the options with a similar beneficial impact on energy consumption and operational carbon.

4. Carbon Analysis

4.1 Business as Usual - Office use

The following analysis investigates the option of leaving the building as it stands and continuing to operate as office space through a further 60 year lifespan. This option creates a theoretical baseline for comparison of further options. The following strategic decisions have been made in the analysis:

Structure	Above and below ground	Retained - steel columns encased in concrete, 200mm concrete floor slabs, 300mm ground floor slab
Building Fabric	External walls and roofing	Retained - cavity construction, masonry and portland stone, limited insulation. Existing roof system left in place
	Windows and doors	Retained - single glazed opening units.
	Internal walls and partitions	Retained - masonry partitions
	Internal finishes	Retained - Suspended ceilings, carpets
Operational Energy	Figures taken from energy bills provided by the Client	
Assumed building lifespan	60 years	

Table 2 / Summary of BAU model assumptions

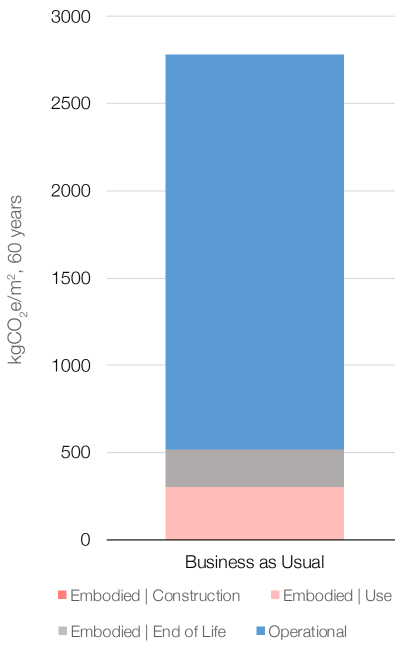


Figure 12 / Lifecycle carbon of BAU option, 60 years

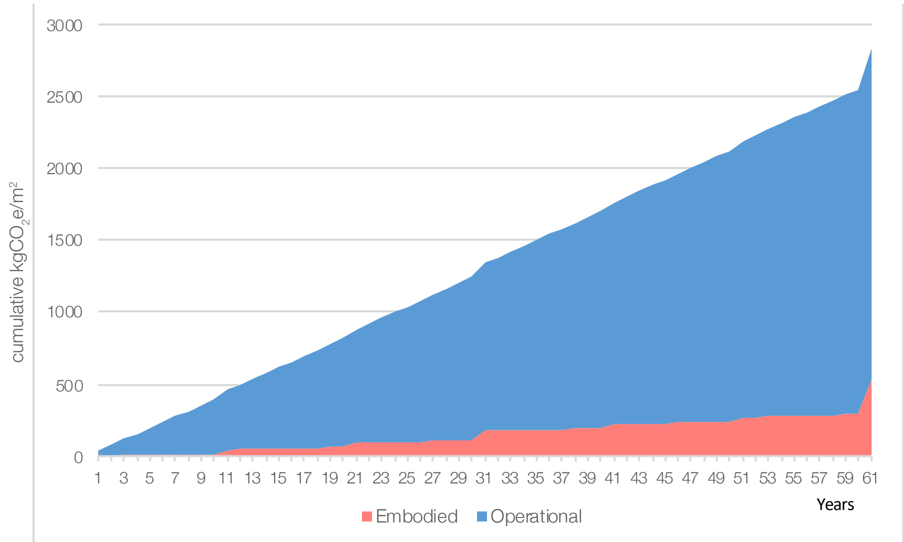


Figure 13 / Cumulative Lifecycle carbon of BAU option

Lifecycle Carbon Impacts **kg per m2**	60 years	**Business as Usual**
Embodied Carbon Impact *kgCO2e/m2*	Demolition of existing structure	0
	Total A - Construction	0
	Total B - Use 60 years	305
	Total C - End of Life	215
	Total Embodied, 60 years	**520**
Operational Carbon Impact kgCO2e/m2	Operational per year	38
	Total Operational, 60 years	**2260**
Total Lifecycle Carbon Impact *kgCO2e/m2/60yrs*		**2779**

Table 3 / Breakdown of BAU Lifecycle carbon estimates

4. Carbon Analysis

4.2 Residential EnerPHit Refurbishment

The following analysis investigates the option of undertaking a deep refurbishment to the Passivhaus EnerPHit Standard and converting the existing building into residential accommodation. This option establishes minimum operational carbon impacts and also analyses the impact of using low embodied carbon materials and systems in the refurbishment. The proposed layout was provided by Dorset Council and includes a mix of 1-bed and 2-bed flats. The proposal results in a total of 56 flats. The following strategic decisions have been made in the analysis:

Structure	Above and below ground	Retained - steel columns encased in concrete, 200mm concrete floor slabs, 300mm ground floor slab
Building Fabric	External walls and roofing	Existing external wall system retained. Internal insulation system on metal frame with plasterboard lining introduced. Existing roof system removed and replaced with insulated warm roof system. U-values to Passivhaus EnerPHit standard
	Windows and doors	Existing units removed and replaced with high performance triple glazed opening units to Passivhaus EnerPHit standard
	Internal walls and partitions	Existing internal walls removed and replaced with metal stud, acoustic insulation and plasterboard system
	Internal finishes	Existing finishes removed and replaced with new plasterboard ceiling, linoleum floors and paints
Operational Energy	Figures taken from Passivhaus EnerPHit standard	
Assumed building lifespan	60 years	

Table 4 / Summary of Residential EnerPHit Refurbishment model assumptions

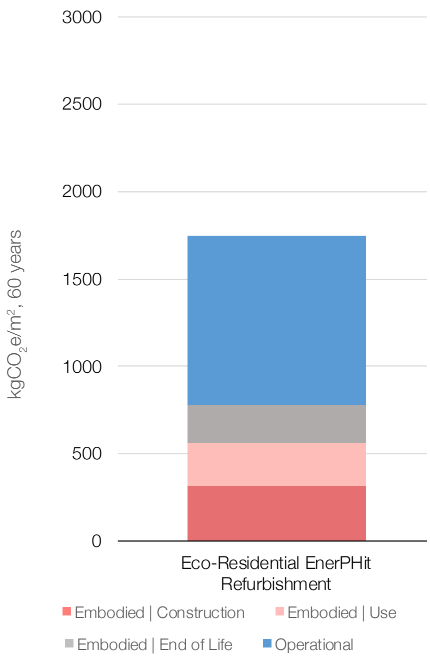


Figure 14 / Lifecycle carbon of Residential EnerPHit Refurbishment option, 60 years

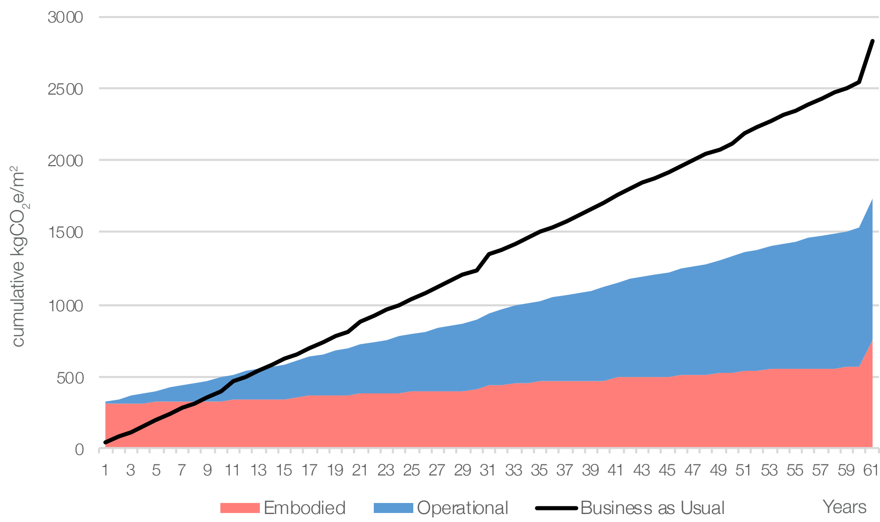
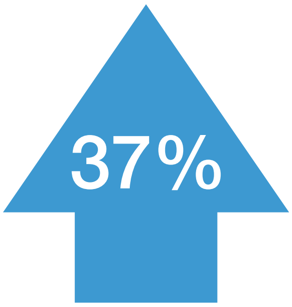


Figure 15 / Cumulative Lifecycle carbon of Residential EnerPHit Refurbishment option, compared against BAU



Percentage Improvement compared to 'Business as Usual'

Lifecycle Carbon Impacts kg per m2	60 years	Eco-Residential EnerPHit Refurbishment
Embodied Carbon Impact *kgCO2e/m2/yr*	Demolition of existing structure	0
	Total A - Construction	318
	Total B - Use 60 years	244
	Total C - End of Life	219
	Total Embodied, 60 years	**781**
Operational Carbon Impact *kgCO2e/m2/yr*	Operational per year	16
	Total Operational, 60 years	**966**
Total Lifecycle Carbon Impact *kgCO2e/m2/60yrs*		**1747**

Table 5 / Breakdown of Residential EnerPHit Refurbishment Lifecycle carbon estimates

4.3 New Passivhaus Residential Development - Timber Frame

The following analysis investigates the option of redeveloping the North Quay site into residential accommodation, using a timber frame structure. This option assumes certification to the Passivhaus Standard which will radically reduce operational energy consumption. The following strategic decisions have been made in the analysis:

Structure	Above and below ground	Timber frame with timber floor slabs. Concrete ground floor slab.
Building Fabric	External walls and roofing	New external walls - brick and/or stone cladding and timber frame system with plasterboard internal linings. Tiled roof on timber structure with mineral wool insulation. U-values to Passivhaus standard
	Windows and doors	New high performance triple glazed opening units to Passivhaus standard
	Internal walls and partitions	New metal stud, acoustic insulation and plasterboard system
	Internal finishes	New plasterboard ceiling, carpet floors and paints
Operational Energy	Figures taken from Passivhaus standard	
Assumed building lifespan	60 years	

Table 6 / Summary of New PH Residential Development model assumptions

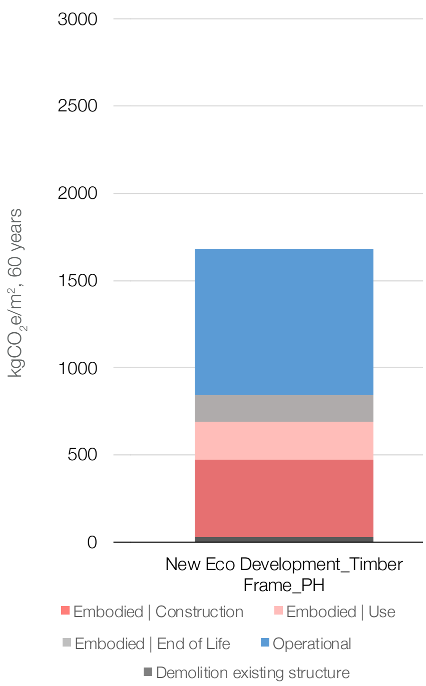
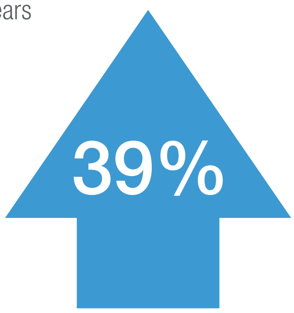


Figure 16 / Lifecycle carbon of New PH Residential Development option, 60 years



Percentage Improvement compared to 'Business as Usual'

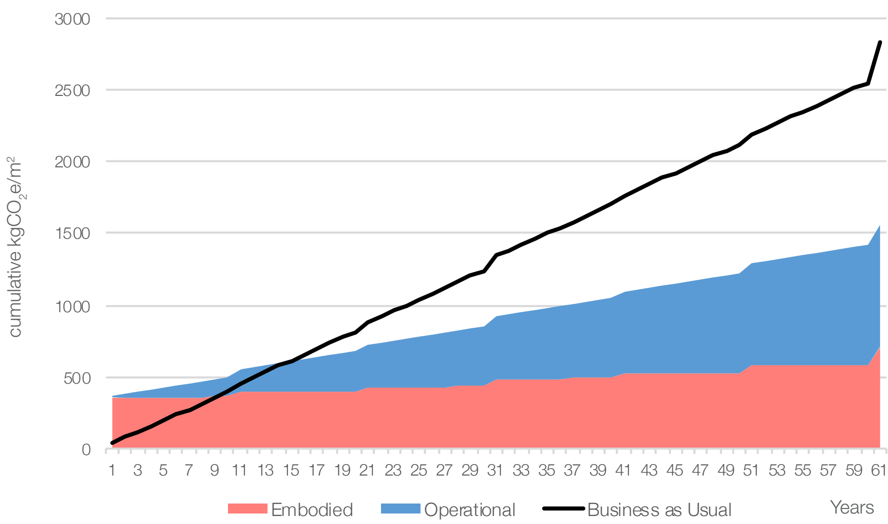


Figure 17 / Cumulative Lifecycle carbon of New PH Residential Development option, compared against BAU

Lifecycle Carbon Impacts kg per m2	60 years	New Eco Development_Timber Frame_PH
Embodied Carbon Impact *kgCO2e/m2/yr*	Demolition of existing structure	33
	Total A - Construction	439
	Total B - Use 60 years	217
	Total C - End of Life	154
	Total Embodied, 60 years	**844**
Operational Carbon Impact kgCO2e/m2/yr	Operational per year	14
	Total Operational, 60 years	**840**
Total Lifecycle Carbon Impact *kgCO2e/m2/60yrs*		**1684**

Table 7 / Breakdown of New PH Residential Development Lifecycle carbon estimates

5. Comparison and Conclusions

5.1 Comparison of different scenarios

The section compares the relative lifecycle carbon impact of the different scenarios analysed in the report through a series of charts and tables.
Taking the results of each scenario in turn:

Business as Usual – This option has no initial carbon impact (A1-A5) as the building is left as is. It does however have a very significant carbon impact over the 60 year lifecycle due its relatively poor operational energy performance. The End of Life (C1-C4) carbon up tick is also significant (Figure 18).

Residential EnerPHit Refurbishment – This option incurs a small initial embodied carbon impact from the refurbishment works which results in a significant improvement in operational energy performance. The carbon penalty of the initial works is paid back in approximately 14 years. This option represents a 33% improvement in lifecycle carbon, compared to the 'Business as Usual' model as it benefits from the retention of the existing building structure and also delivers very low carbon in use.

New PH Residential Development - Timber Frame_- This option incurs an initial embodied carbon impact from replacing the existing building structure. However, the proposed timber frame for the new buildings has a relatively low carbon impact compared to other frame options and represents the best structural option for the development from an embodied carbon perspective. The Passivhaus standard building envelope results in a significant improvement in operational energy performance over business as usual (Figure 20). Passivhaus is also considered an industry leading standard for low energy design and is also recognised for delivering expected energy savings due to a rigorous QA process during construction. The carbon penalty of the initial works is paid back in approximately 14 years (Figure 18). Embodied carbon for the new development is higher than that of the refurbishment case, as expected (Figure 19). However, operational carbon is lower due to the higher fabric performance.

5.2 Cumulative lifecycle carbon*, kgC0_2e/m2

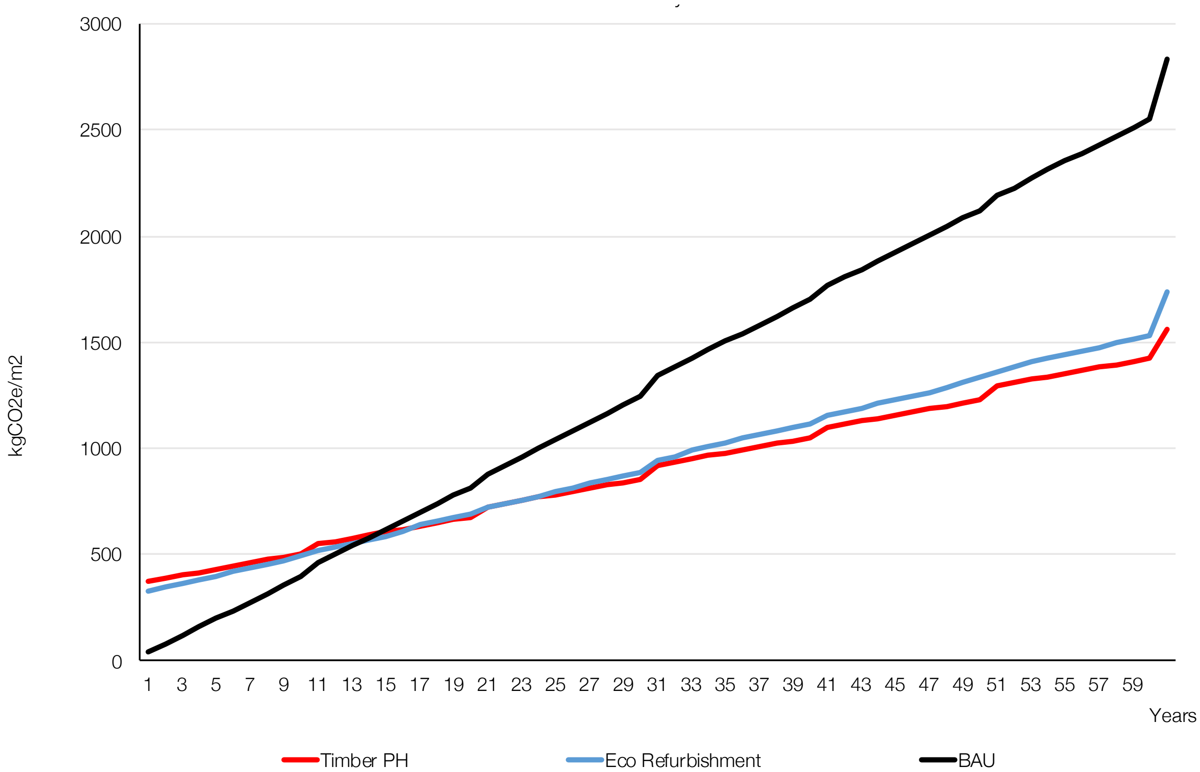


Figure 18 / Cumulative Lifecycle carbon of BAU, Residential EnerPHit Refurbishment, New PH Residential Development
* The impact of demolition of existing office building is not captured in this graph

5. Comparison and Conclusions

5.3 Embodied carbon comparison, $kgC0_2e/m^2$ 60 years by lifecycle stage

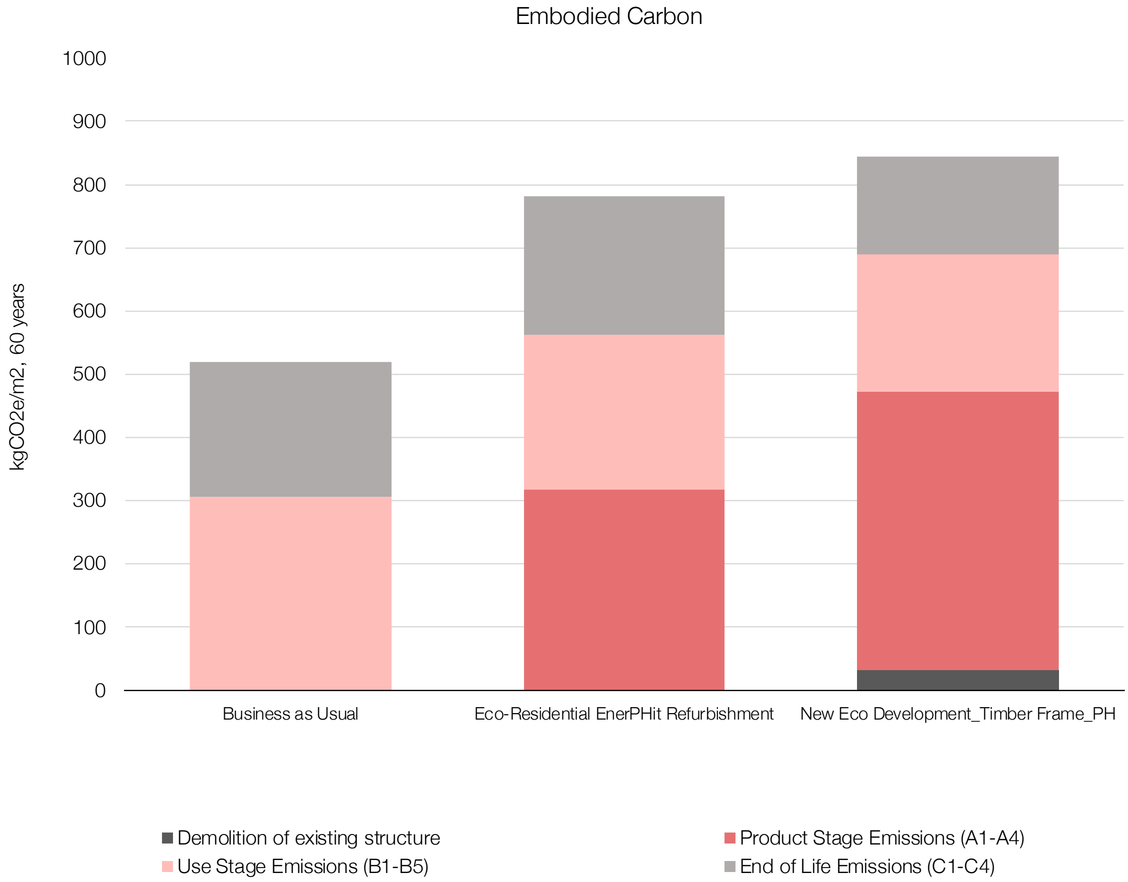


Figure 19 / Comparison of embodied carbon excluding sequestration, 60 years

5.4 Lifecycle carbon comparison, $kgC0_2e/m^2$ 60 years by lifecycle stage

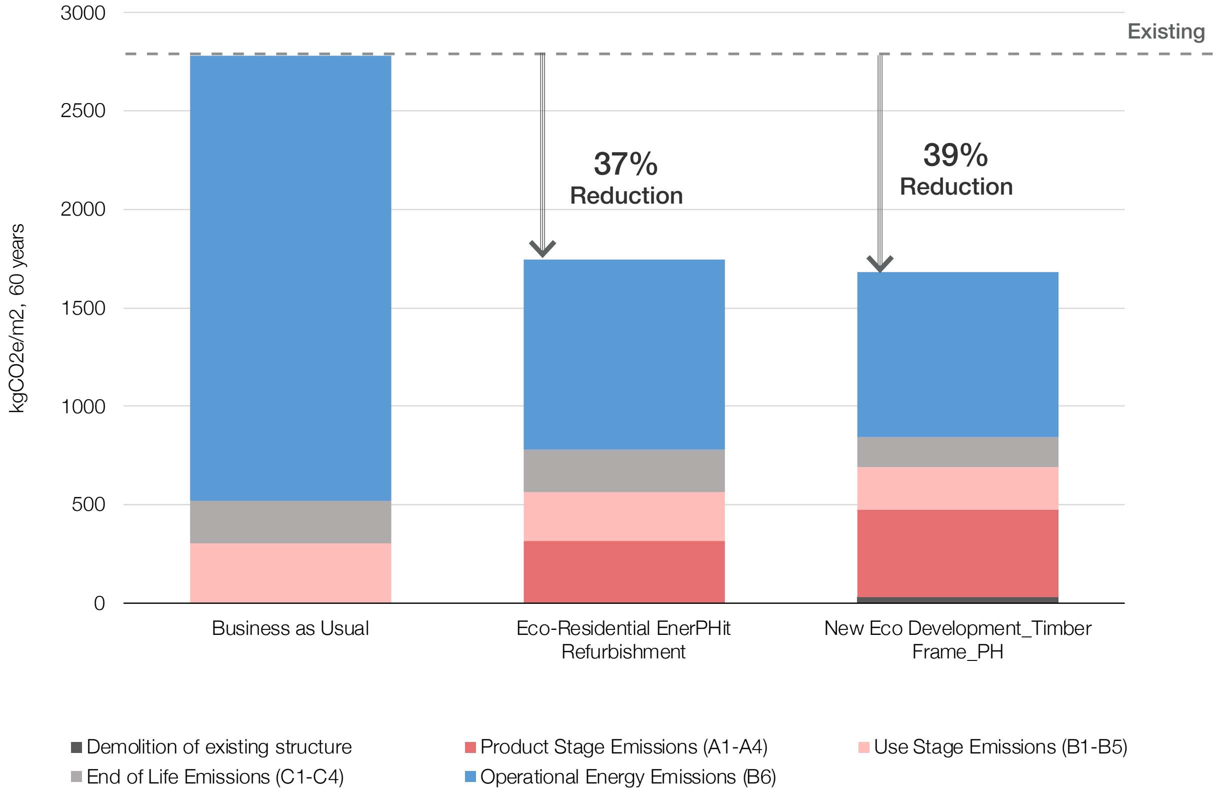


Figure 20 / Comparison of Lifecycle carbon excluding sequestration, 60 years

5.5 Potential reuse of existing structure and foundations

The potential for reusing part of the existing structure and foundations in the proposed residential development was explored in order to estimate potential carbon savings, in line with the LETI guidance. Similarly, according to RICS (2017) guidance, due to potential opportunities for recovery, reuse and recycling, and for improving the deconstruction and demolition process, pre-demolition assessments should be carried out where possible.

The recently issued report by GAP engineers suggests that there is scope to explore the potential for reusing the existing foundation structure which appears to be relatively robust. The structural report states that existing foundations could potentially be reused if in reasonable condition and able to be coordinated with below ground service runs. A detailed structural analysis is needed to evaluate whether the existing foundations could be reused and at what extent. For the purposes of this study three scenarios were analysed including 20%, 40% and 60% of the existing foundations being reused and integrated in the new development.

As shown in Figure 21, potential savings in embodied carbon appear to be quite low, ranging from 1% to 3% as the new residential development has a much higher footprint compared to the existing building.

Regarding the structural frame of the existing building, the structural report states that the structure appears relatively robust and should be capable for supporting residential/ commercial loading at all levels, including an additional floor at 4F level over the existing roof, but more careful consideration would be needed at a next stage. The existing concrete slabs and the facades are flexible and would be able to accommodate new service risers and new cladding respectively. On the other hand, taking the existing building apart and reusing some of the structural elements and materials, beyond the foundations, does not appear feasible or practical due to the nature of the structure. GAP Engineers have commented that the removal of the concrete-encased steelwork would involve significant breaking-out, vibrations and cleaning that would be carbon and cost intensive and could also lead to damage to the structural integrity of the elements. As such, it would be difficult to justify the reuse of the steelwork in the proposed new building. Reuse of material is therefore limited to crushed concrete being used for groundworks. The extent of this potential reuse would have to be evaluated at a more detailed design stage.

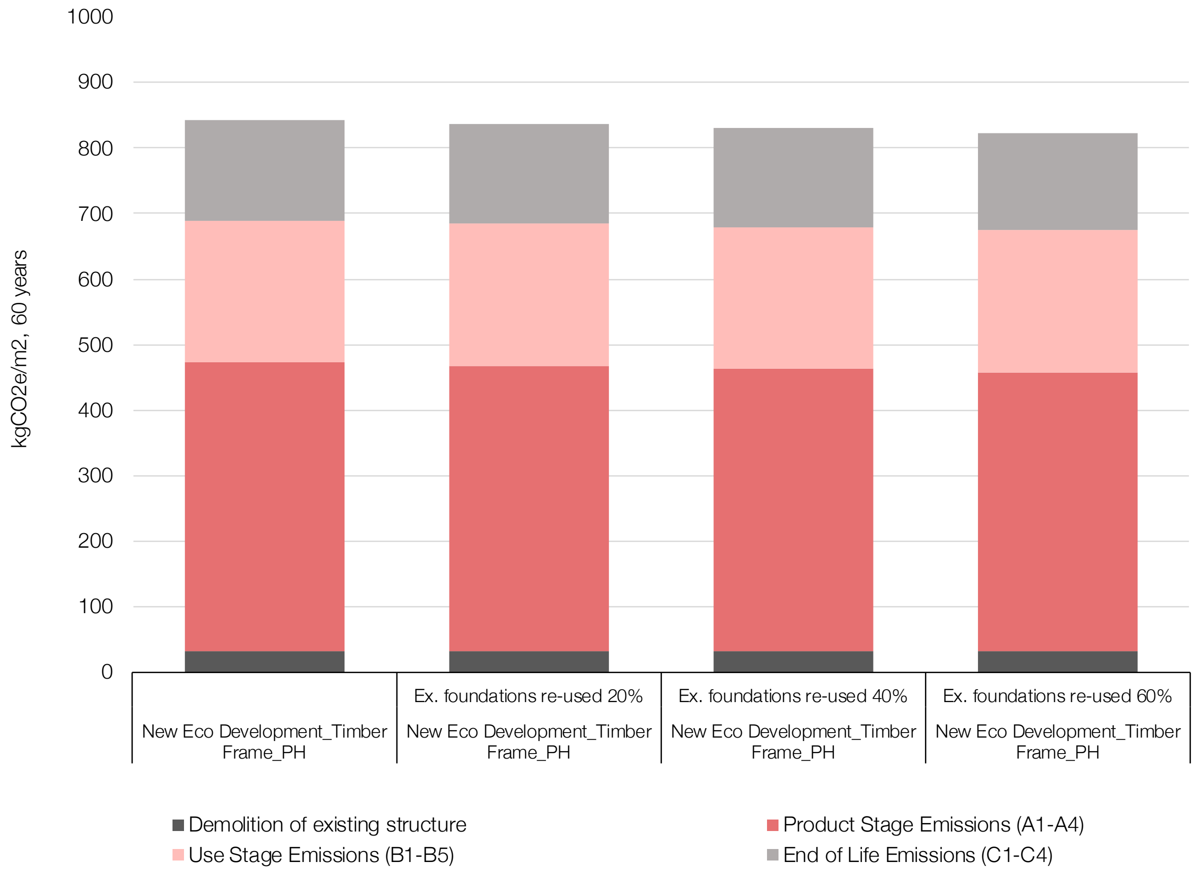


Figure 21 / Embodied carbon impact of reusing existing foundations in the New PH Residential Development, 60 years

5. Comparison and Conclusions

5.6 Lifecycle carbon summary, kg per m^2

Lifecycle Carbon Impacts kg per m2	60 years	Business as Usual	Eco-Residential EnerPHit Refurbishment	New Eco Development_Timber Frame_PH	New Eco Development_Timber Frame_PH Ex. foundations re-used 20%	New Eco Development_Timber Frame_PH Ex. foundations re-used 40%	New Eco Development_Timber Frame_PH Ex. foundations re-used 60%
Embodied Carbon Impact *kgCO2e/m2*	Demolition of existing structure	0	0	33	33	33	33
	Total A - Construction	0	318	439	434	430	424
	Total B - Use 60 years	305	244	217	217	217	217
	Total C - End of Life	215	219	154	152	150	148
	Total Embodied, 60 years	**520**	**781**	**844**	**836**	**830**	**823**
Operational Carbon Impact kgCO2e/m2	Operational per year	38	16	14	14	14	14
	Total Operational, 60 years	**2260**	**966**	**840**	**840**	**840**	**840**
Total Lifecycle Carbon Impact *kgCO2e/m2/60yrs*		**2779**	**1747**	**1684**	**1676**	**1670**	**1663**

Table 8 / Breakdown of Lifecycle carbon estimates for all options, $kgCO_2e/m^2$

5.7 Lifecycle carbon summary, tonnes whole building

Lifecycle Carbon Impacts Total tonnes whole building	60 years	Business as Usual	Eco-Residential EnerPHit Refurbishment	New Eco Development_Timber Frame_PH	New Eco Development_Timber Frame_PH Ex. foundations re-used 20%	New Eco Development_Timber Frame_PH Ex. foundations re-used 40%	New Eco Development_Timber Frame_PH Ex. foundations re-used 60%
Embodied Carbon Impact *tnCO2e*	Demolition of existing structure	0	0	122	122	122	122
	Total A - Construction	0	1176	4093	4044	4002	3953
	Total B - Use 60 years	1131	900	2024	2024	2024	2024
	Total C - End of Life	792	809	1433	1415	1399	1381
	Total Embodied, 60 years	**1919**	**2885**	**7857**	**7790**	**7732**	**7665**
Operational Carbon Impact *tCO2e*	Operational per year	140	59	130	130	130	130
	Total Operational, 60 years	**8370**	**3566**	**7824**	**7824**	**7824**	**7824**
Total Lifecycle Carbon Impact *tCO2e/60yrs*		**10289**	**6451**	**15681**	**15614**	**15556**	**15489**

Table 9 / Breakdown of Lifecycle carbon estimates for all options, $tonnesCO_2e$

5.8 Conclusions

Both the ‘Residential EnerPHit Refurbishment’ and the ‘New PH Residential Development - timber frame’ options are significant improvements over the existing building’s operation and begin to show a lifecycle carbon payback after approximately 14 years. However, when comparing cumulative lifecycle carbon, (kgC02e/m2), there is only a minor difference in figures between the two development options on a per m^2 basis. It should be noted that direct comparison is not possible given the lack of information on the structure and foundations of the new proposed residential development.

Therefore, for the purposes of comparison and given the relatively basic level of information that was provided about the schemes’ construction, this report cannot provide clear evidence that either the ‘Residential EnerPHit Refurbishment’ or the ‘New PH Residential Development - timber frame’ is better from a lifecyle carbon perspective on a per m2 basis.

If however, you need to build more and larger units than refurbishment of the existing building can provide, this report and its previous iterations, is good evidence that taking a Passivhaus + low embodied carbon approach has significantly improved lifecycle carbon outcomes than the other construction and operational energy standards reviewed.