John Lewis Building Carbon Assessment

Sheffield City Council

Scenario Summary Report

ARUP

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November 2021 Rev A

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Executive Summary

On behalf of Sheffield City Council, Arup has undertaken a whole life carbon assessment for the John Lewis site, accounting for a series of development options that range from refurbishment to demolition and new build.

The study estimates the total carbon emissions of the site, over a forward-looking 25-year time span.

The five scenarios assessed, which are explained in further detail later in the report, are summarised here:

1. Baseline: Retention of the current store building and replacement of existing boiler system with like for like.

2. Reuse: Major refurbishment of the existing building, replacing the façade and building services systems. Other significant structural alternations to the store building.

3. Replace: (For comparison only) a complete new building with the same floorplate as the current store – built to modern construction and carbon targets.

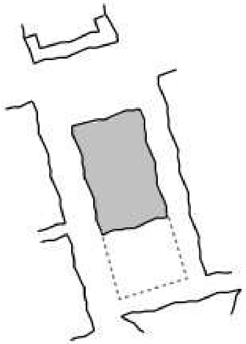
4. Replace: A new development with a proposed significantly reduced footprint at the rear of the site with an urban park adjacent to Barker's Pool.

5. Remove: Demolish the building and replace the whole site with a new central park.

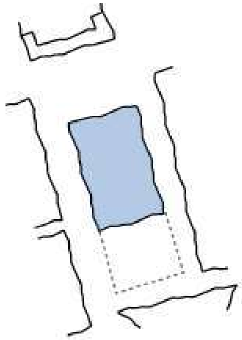
In this assessment, we have considered that for all scenarios the car park is to be demolished and replaced with landscaping. This is due to the existing poor condition of the car park and the fact that future uses are unlikely to require this capacity of car parking in this location.

In addition to the above, we have assessed the embodied carbon of the existing buildings and the relative performance of district heating and heat pumps.

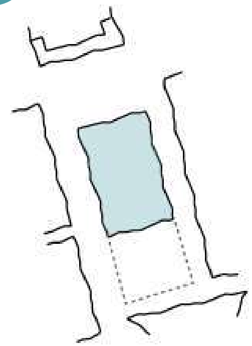
1 **Baseline**



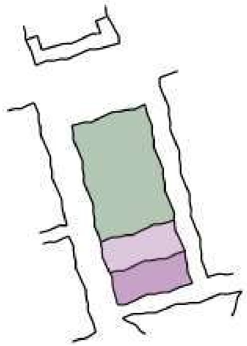
2 **Reuse**: Major Retrofit



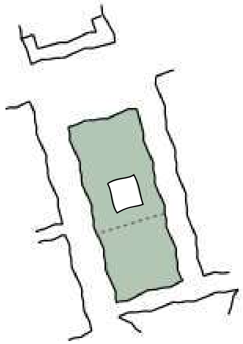
3 **Replace:** Same Floorplate



4 **Replace:** Green Terrace



5 **Remove**: Park



Executive Summary

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The carbon assessment provides total estimated Operational Energy and Embodied Carbon for each option over a projected 25-year period.

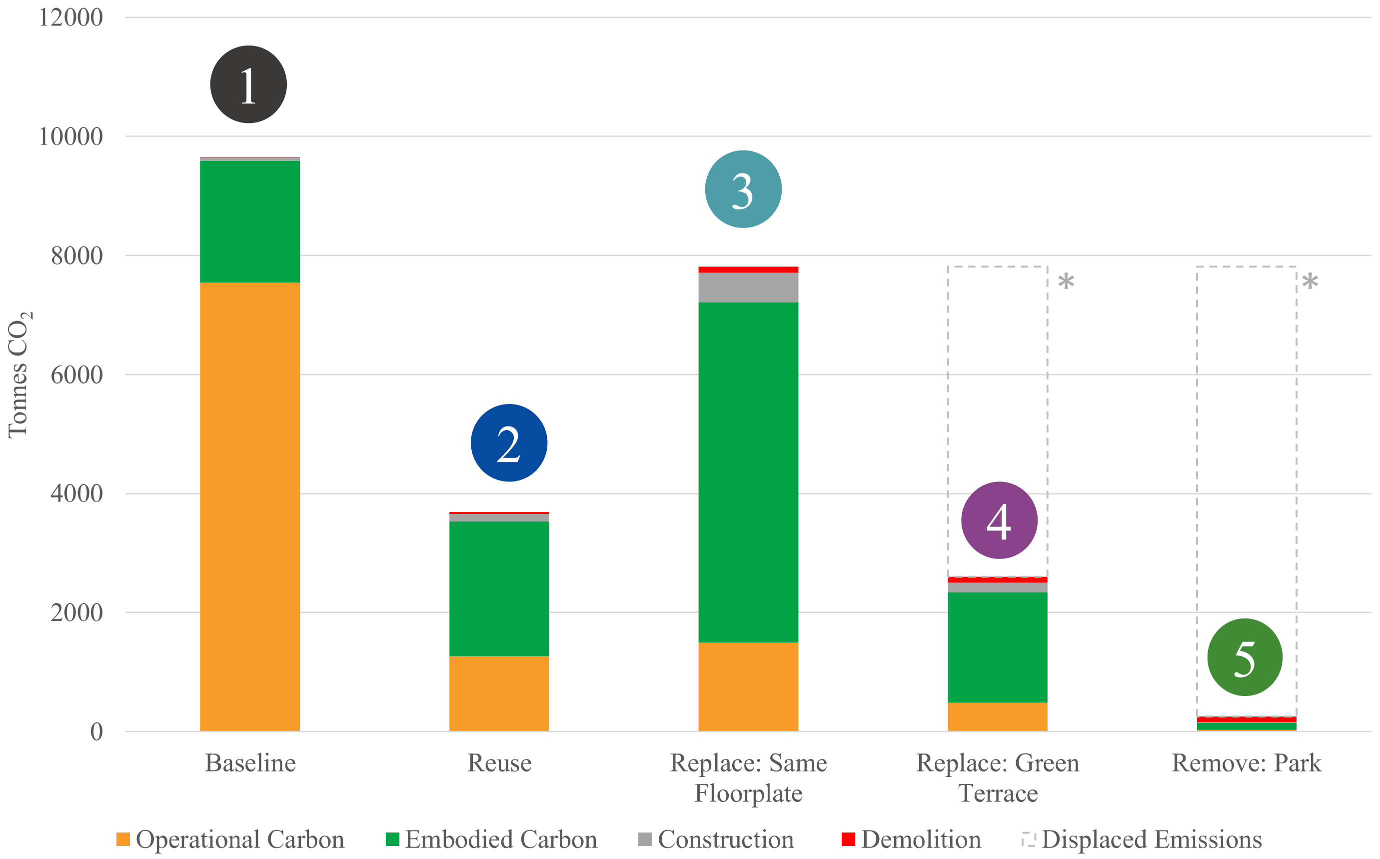
When looking at the Existing Building, a major refurbishment provides significant carbon savings (a 60% reduction from the baseline scenario over the assessment period).

Whilst a new build of a similar scale to the existing building provides a substantial 20% saving over the baseline scenario, it is still over twice the carbon intensity of the refurbishment option. The assessment would therefore suggest that a like-for-like new build option should not be considered.

There are two options that demolish the building, which then provide either a reduced scale new build on the site (with associated new public realm), or convert the whole site to a new park.

At a site level appraisal these two options provide the lowest carbon solutions for the development – mainly due to the reduced area being built and operated. The reduced scale new build option (3) uses a similar amount of embodied carbon to deliver when compared to the refurbishment option – and due to the reduced floorplate has a significant reduction in operational carbon. As such its total carbon cost is lower. However, on a per meter squared basis the reuse option remains more carbon efficient.

The assessment above is based on a site level appraisal, but it is worth considering the wider city context. The dashed line on the chart for the two reduced floor area options (*) shows the potential carbon cost associated with any requirement to build the remaining balance of the original floor area on a different site in the city. Whether this is relevant can only be determined by a needs-appraisal for this remaining area of floorplate in relation to the site, and consideration of the impact of this within the wider socio-environmental-economic context of the city.



Baseline
9600
$TonnesCO_{2e}$

Reuse
3700
$TonnesCO_{2e}$

Replace: Same Floorplate
7800
$TonnesCO_{2e}$

Replace: Green Terrace
2600
$TonnesCO_{2e}$

Remove: Park
250
$TonnesCO_{2e}$

Context

In 2021, John Lewis closed down its Barker's Pool department store, which had been a cornerstone of Sheffield City centre for many decades.

Sheffield City Council is considering the potential redevelopment of the site going forwards. There have been proposals to retain the existing building, refurbish it and even to demolish it and replace it with a new public park.

It is imperative this project considers and aligns with both national and local legislation, policy and targets around carbon emissions.

As such a prominent and strategic scheme, it would be prudent that it becomes a visionary and exemplar sustainable building within the city centre.

National Targets

The UK has committed to achieving Net Zero carbon by 2050 and has set out a long-term strategy to achieve that aim. Buildings are directly or indirectly responsible for 40% of UK GHG emissions. Decarbonising the buildings sector is essential to achieving our zero carbon targets.

Sheffield Targets

Sheffield has declared a climate emergency and set an ambitious target for the city to be zero carbon by 2030. That date is less than 9 years or 100 months away.

The Sheffield Zero Carbon Commission report set out a pathway to achieving zero carbon for the city.

1963 **Cole Brothers Opens in Barker's Pool**

1980 **Last Major Store Refurbishment**

2002 **Rebrand as John Lewis**

2021 **John Lewis Closes Store**

? **What's Next?**

The existing building is energy inefficient due to the poor thermal performance of the historic façade. However, any upgrades to the façade will have an associated embodied carbon investment which the improved operational performance will take time to "pay off".

By considering a whole life carbon approach, an assessment can be made weighing up embodied carbon against operational carbon over a building lifecycle for a range of scenarios.

We have undertaken a high-level benchmarked assessment for each scenario. These assessments cannot, at this stage, be detailed whole life carbon assessments compliant with ISO 14040: 2006; such a level of detailed assessment would not be possible without additional design information. Consequentially, there are margins of error which need to be considered but these uncertainties do not diminish the validity of the broad-brush comparisons made between the broad scheme options.

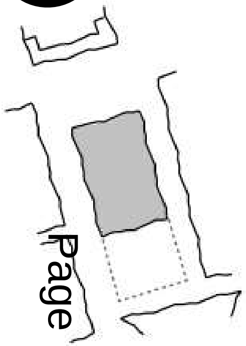
We have not completed any design work as part of this analysis, for example – assessing whether the building could be naturally ventilated to reduce operational emissions or optimising the structural design to reduce embodied carbon. Design details like those are secondary optimisations to the primary retain/refurbish/replace/remove decision addressed by this analysis.

The aim of this investigation is to understand the scale and amounts of carbon the future development of the John Lewis site could impact.

Future Scenarios

The following scenarios have been reviewed in this study to show the spectrum of likely outcomes, rather than to appraise specific design solutions or proposals. The study has estimated the total carbon emissions over a 25-year time span. The scenarios are as followed:

1 Baseline

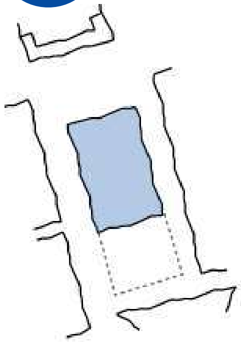


The baseline scenario takes into consideration the mandatory work the existing building needs to be operational.

This will require repairs to some structural elements. To comply with fire regulations, alterations will be required to create new escape routes.

The replacement of the gas boiler, full replacement of the building services and sprinkler system are needed as they are currently at end of life.

2 Reuse: Major Retrofit



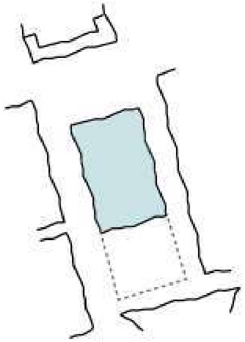
The major refurb will seek to maintain the primary structure to utilise the existing space.

With some major structural alterations, a central atrium and rooflights will allow more daylight and central circulation around the building.

The installation of net zero carbon ready building services will ensure operational carbon emissions are minimised.

Major improvement on the building fabric energy performance will also minimise operational carbon.

3 Replace: Same Floorplate

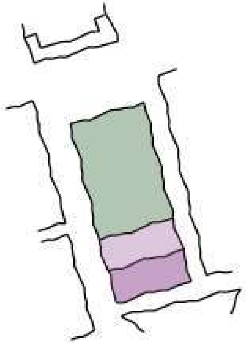


For comparison in this assessment, a new building with the same floor area as the current John Lewis has been considered.

This is based on an efficient low embodied carbon superstructure and maximising building material reuse from the demolished building. The operational carbon will be minimised with efficient all-electric services and optimised building fabric performance.

Please note that other studies have suggested that a new building of this scale is not appropriate for this location and so this option is not shown in the related commercial studies for this site. However, it is an important comparator for the carbon study.

4 Replace: Green Terrace

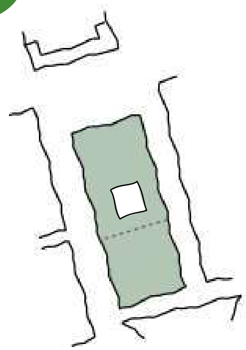


Under this option the building is demolished and a new mixed-use development is created at the rear of the site. This requires both new embodied carbon and operational carbon to create and use over the next 25 years. However, this is a much smaller footprint on the site and is driven by the city centre needs and strategic development goals for the area.

At the front of the site a new soft and hard landscaping scheme creates a link to Barker's Pool.

The use can be flexible but for the purposes of the study it assumes a mix of cultural, commercial office and residential within the building.

5 Remove: Park



The total demolition of the building will account a small amount of carbon but will allow a new urban park to be created across the full site.

At its centre, a small civic (e.g. gallery) space will be built. This will be the only new operational carbon to be considered.

The park would focus on soft landscaping, maximising tree planting, creating space for outdoor activities and bringing 'the outdoor city' feel to the city centre.

Future of the Car Park

In this report, we have considered the scenarios based on the demolition and replacement with landscaping of the car park at the rear of the store.

The future of the car park has been determined by a number of factors that a play a crucial role in the development of this site.

Structure of car park

The car park structure is a significant multi-storey ramped reinforced concrete structure that is independent to the store. There is a movement joint along the store car park boundary which would allow demolishment without affecting the store structure.

Each of the floors is sloped to maximise the number of car parking bays and reduce the floor area for ramps between the levels.

This structural layout would make it impractical for this scheme to utilise this structure for anything other than a car park in the future.

Condition of car park

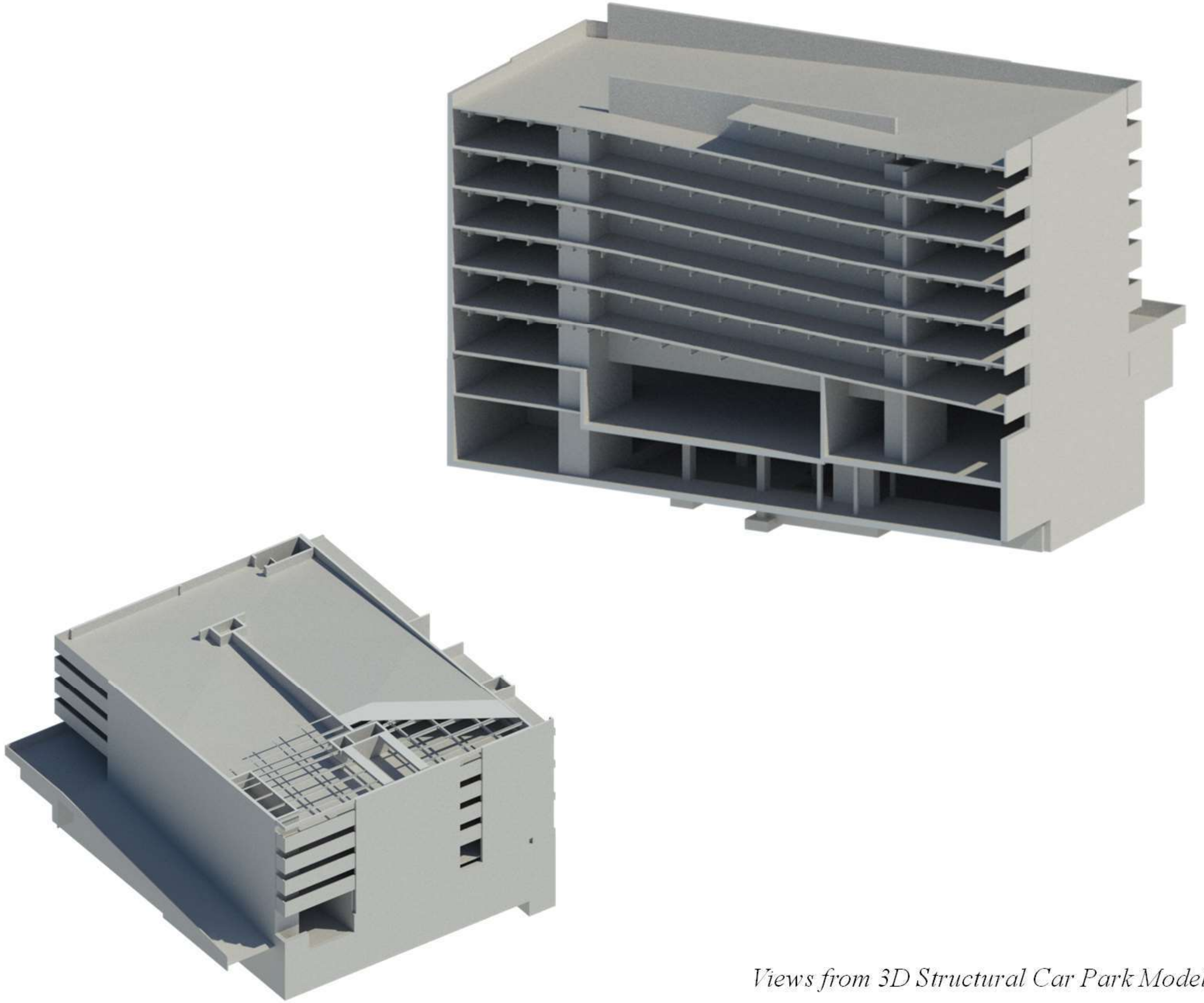
Due to the age, construction and typology of this building, there are a number of structural defects.

The de-icing salts used over the years have corroded the concrete structure. The chloride ingress has resulted in significant areas of deterioration. Significant repair works and maintenance would be required over the next 25 years.

Necessity for car park

It is important to consider the feasibility of a city centre car park, looking ahead. As society is anticipated to reduce private car ownership and city centres are focused on active and public travel, the need and viability of a car park will reduce over the next 25 years.

Any future use of the site is also likely to require less car parking provision than the previous John Lewis. The retention of the car park would likely be underutilised, with better located provision elsewhere in the city centre.



Views from 3D Structural Car Park Model

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Whole Life Carbon Analysis

There are carbon emissions associated with all elements of a building's lifecycle: construction, operation and demolition.

A whole life carbon assessment considers the emissions associated with all elements of a building's lifecycle.

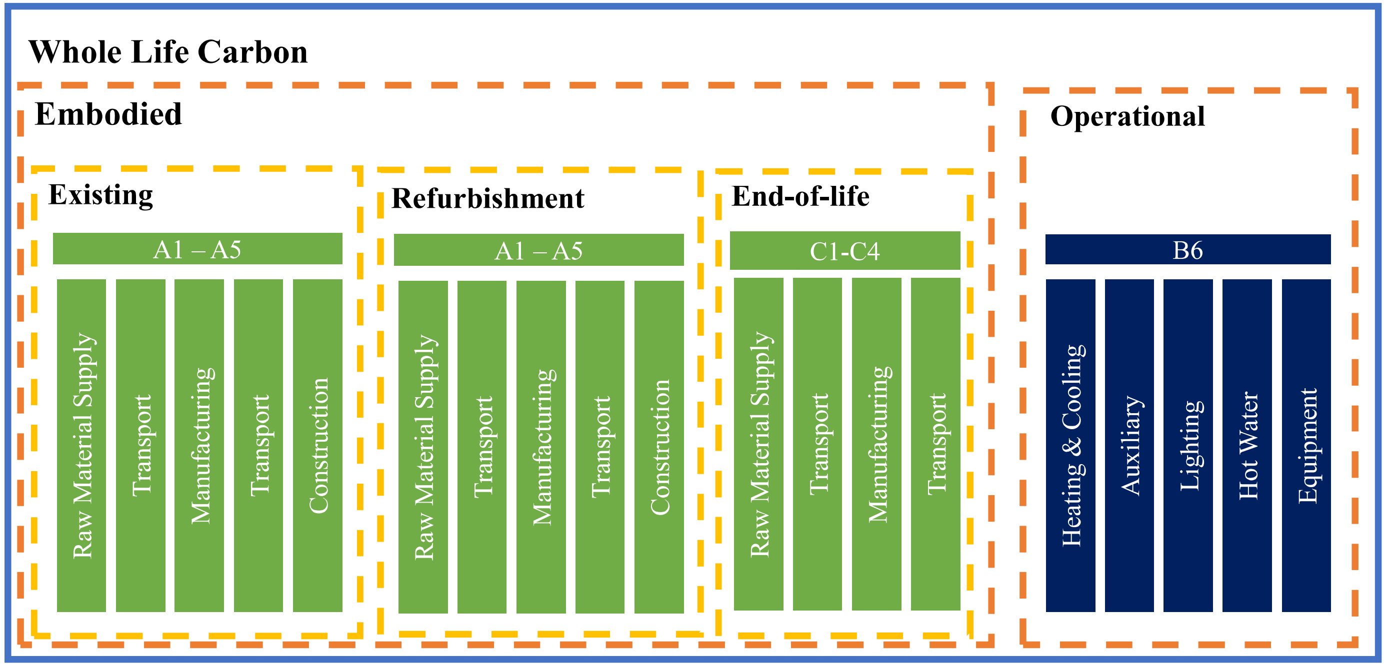
A full whole life carbon assessment in accordance with *EN15978* and *ISO 14040: 2006* requires significant design detail which is not available at this early stage of assessment for any of the scenarios proposed. This report sets out high-level benchmarked assessments for each scenario. While the accuracy of each scenario could be refined with further design work, the results at this stage should be broadly comparable.

A lifecycle assessment length of 25 years (2022-2046) has been assumed based on the client brief and project scope. This has limited consideration of the end of life stages except where significant demolition is required at the start of the project (i.e. new build).

The aim of this investigation is to understand the scale and amounts of carbon the future development of the John Lewis site could impact.

A number of standards have been used to establish benchmarks as appropriate for the project:

1. WBCSD Standards
2. OneClick LCA Benchmarks
3. LETI Embodied Carbon Benchmarks
4. RIBA 2030 Targets
5. Arup Carbon Insights Platform



Adapted Project Whole Life Carbon Cycle (EN15978)

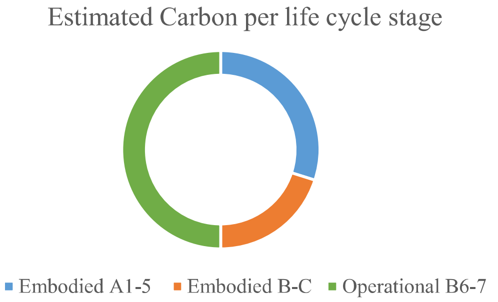
Historic Carbon

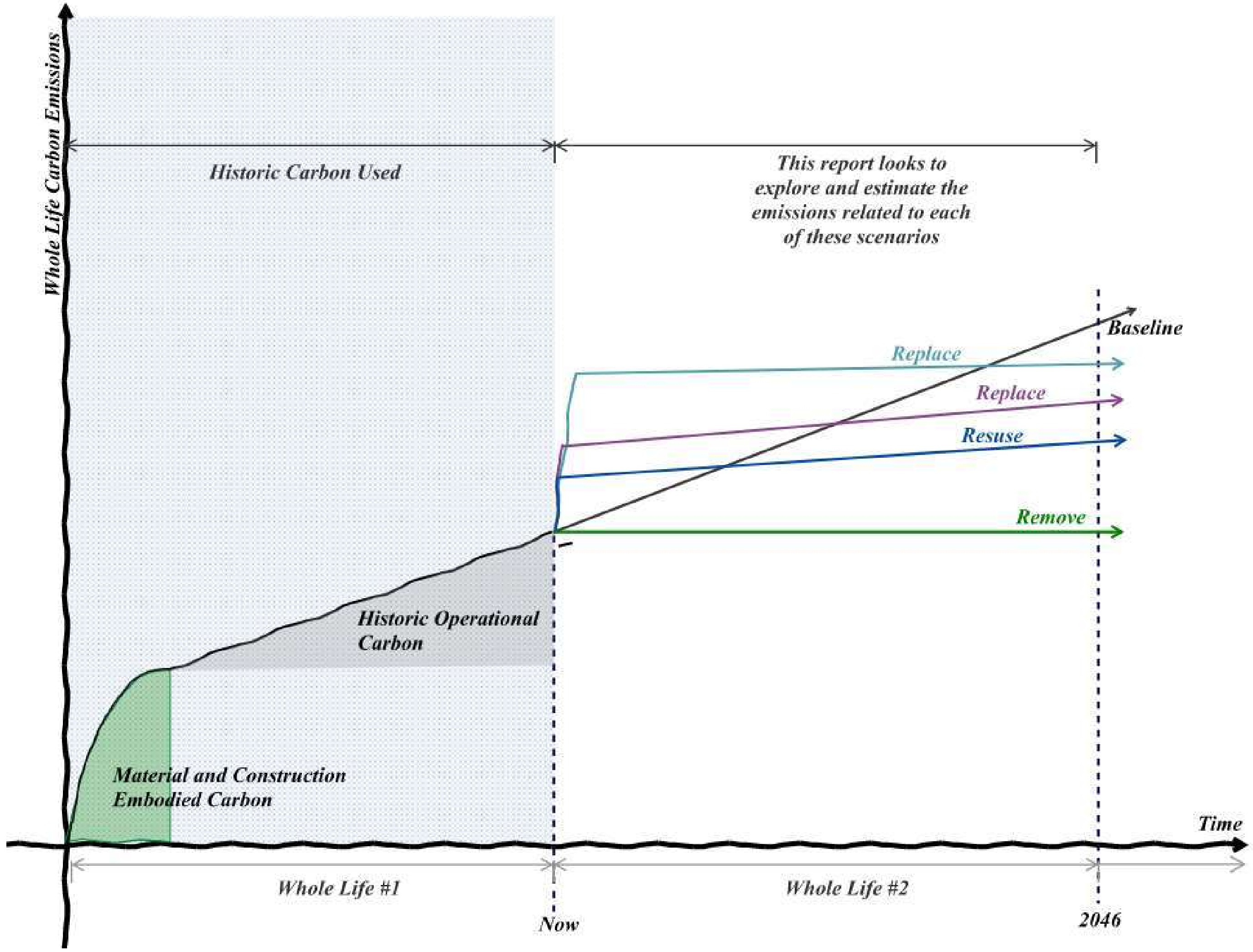
This report focusses on the future life of the John Lewis site, but it is informative to consider the carbon that is already stored in the existing structure for comparison.

The emissions associated with the construction and use of the building are already in the atmosphere.
Reusing elements of the existing building will not remove any carbon from the air, but it will reduce additional emissions by avoiding the need for new construction. For context, we estimate the embodied emissions of the existing store structure is 4600 tCO_2e.

However, putting too much onus on historically accrued carbon costs is misleading as it leads to a 'sunk cost fallacy'. As such, historically accrued emissions should not be directly considered in forward-looking decision making on how to minimise future carbon emissions.

The structure and building that exists do however provide an opportunity to reduce future carbon use through reuse and more importantly, by reducing future embodied carbon required to build new floor area. This is discussed further in the results/conclusion section.





Schematic graph exploring the possible Whole Life Carbon Emission of future scenarios for the John Lewis Building

Methodology

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Embodied Carbon Methodology

Embodied carbon is a critical value when looking to assess the whole life carbon emissions of a project.

The structural elements of a building account on average for 65% of a commercial building’s embodied carbon. Most of the building structure is associated with embodied carbon rather than operational carbon, as structural maintenance is often minimal over a building’s lifecycle.

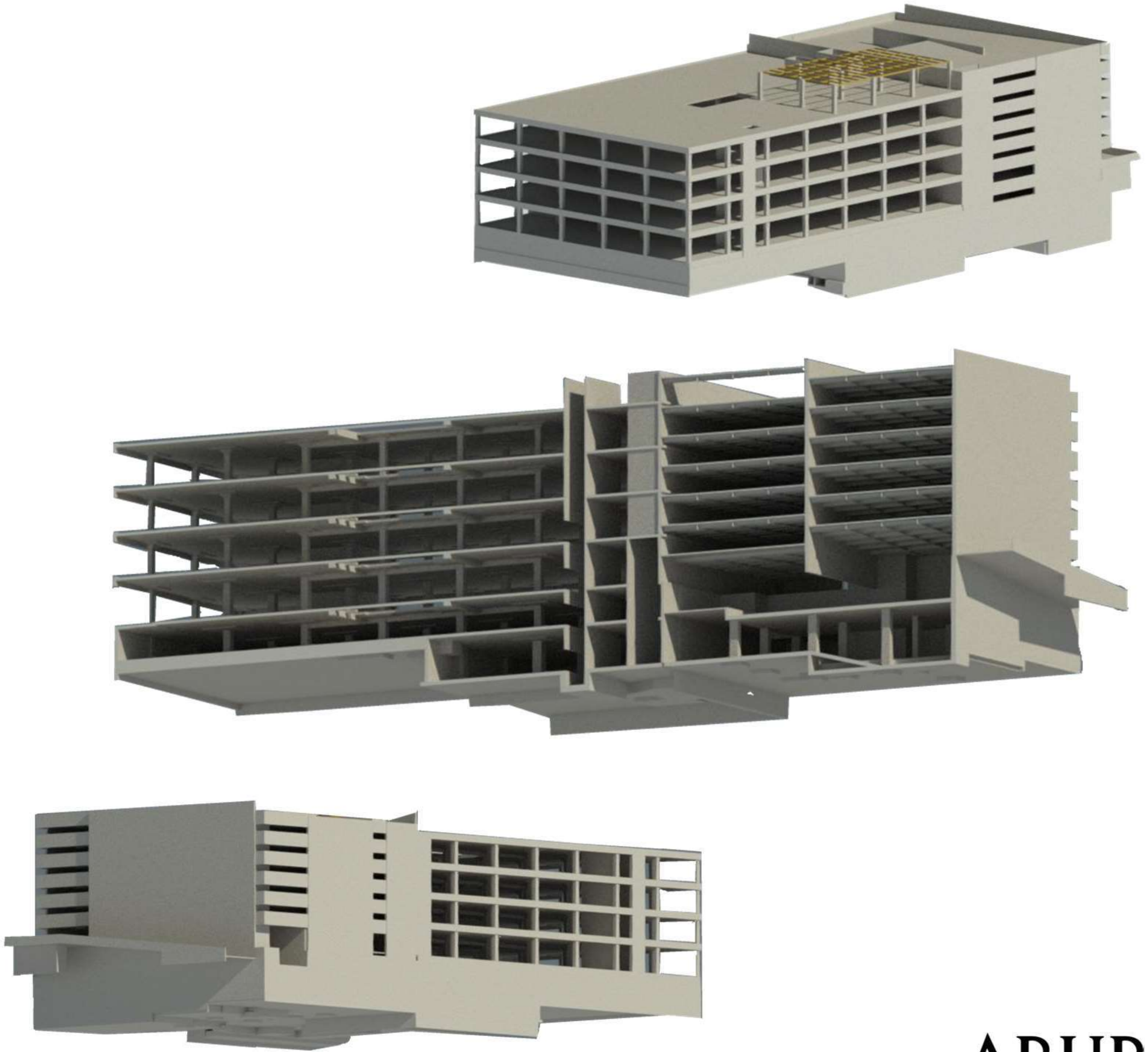
Whole life cycle assessments for embodied carbon identify and account for the emissions created by extraction and manufacturing of structural materials, transport to site and the construction process required.

Different structural typologies and systems have accompanying embodied carbon values. These can be used to make estimates associated with typical bay spans and build-ups. Arup’s internal embodied carbon database, based on material properties and LETI targets have been used to make assumptions for the refurbishment and new build scenarios.

Where building materials and volumes are known, more accurate calculations can be undertaken. This method has been used to calculate the embodied carbon in the existing structure, using the structural model created from a limited selection of the original drawings. From this study we estimate the embodied emissions of the existing store structure to be 4600 tCO_2e.

Whilst the structure is the primary source of embodied carbon, elements such as cladding, finishes, building services and fit outs make up the remainder. The sum of these are significant, so benchmarks outlined in industry guidance have been adopted and used in the calculation of the scenarios.

Views from the 3D Structural Model created from original drawings



Operational Carbon Methodology

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Future carbon use from the operation of the building has been considered, utilising modelling of the existing building, refurbishment and new build options – along with benchmarked comparisons.

A dynamic thermal analysis of the building in each scenario was undertaken to establish the total energy consumption each year by fuel type. This analysis was undertaken in IES VE 2021.3.0.0 and based on record drawings and observations taken during a site visit. A pro-rata assessment has been used for the smaller floorplate of the proposed new build options.

A building typology of office space was chosen as a standard for all models for energy benchmarking and due to a lack of outline design information at this early stage.

Existing fabric build-up assumptions are approximate and based on build-ups typical for this age of buildings. Major retrofit and new build fabric performance assumptions are based on best practice assumptions about what would be possible for the building. A seasonal heat pump, coefficient of performance of 3, has been assumed for heating and hot water systems.

The embodied carbon of building services has been calculated based on a 120 $kgCO_{2e}/m^2$ factor for services. *Source: CIBSE (2013).*

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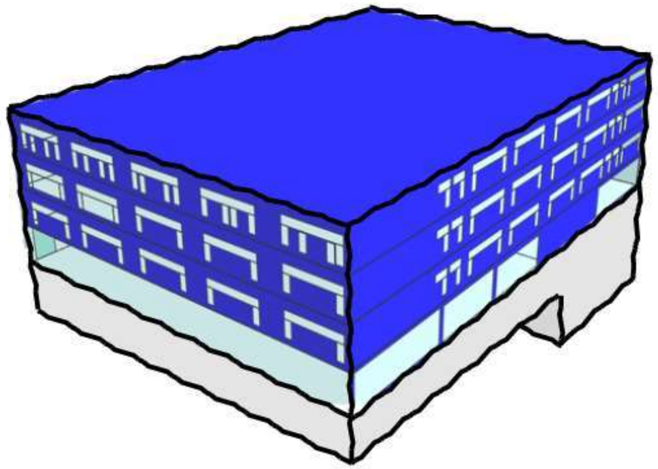
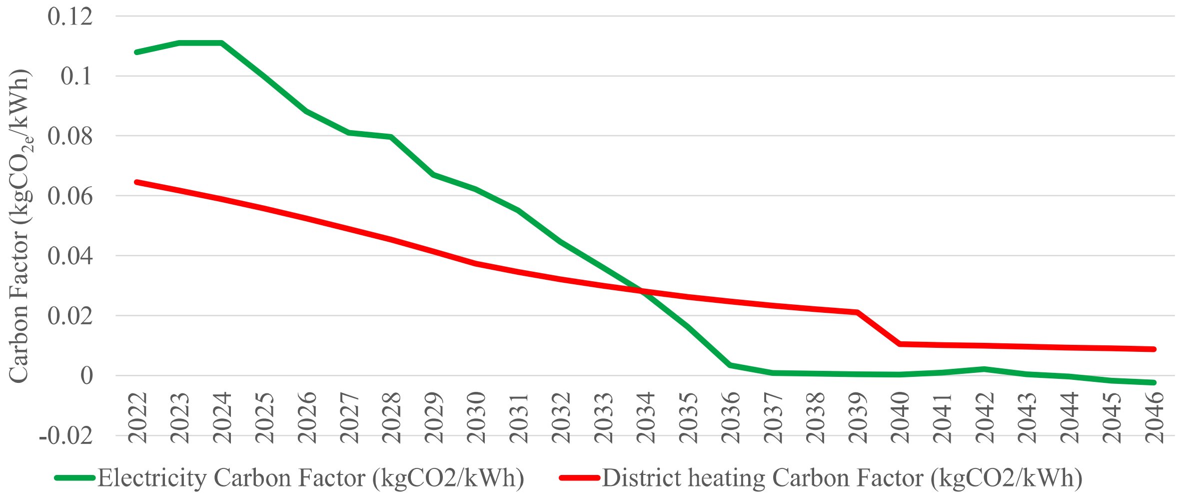
Grid decarbonisation over the next 25 years has been allowed for within our calculations, based on an average of BEIS and National Grid - Future Energy Scenario projections.

As part of a more detailed study included in the technical report, reviews of the Veolia Heat Network and Electric Heat pumps have been compared. Whilst each has its benefits the options do not significantly change the overall picture of a 25-year projection, and so electric heat pumps have been assumed for the analysis.

Scope 3 Operational emissions (such as the carbon used by occupants to travel to the building during use) have not been considered in this assessment.



Schematic Image of project base IES Model



District Heating and Grid Electricity Projected Carbon Factors

Onsite Renewables and Planting

The potential to introduce on-site renewable energy sources such as solar PV, and net carbon reduction measures such as tree planting has been considered in the appraisal. These are reviewed below. The conclusion of these assessments are that they will positively contribute to the carbon agenda, but that the magnitude of this impact is not significant enough to change the overall picture between the different scenarios.

Solar PV Assessment

This study looks to quantify the potential effect of on-site renewable energy on the whole life carbon assessment. Any design should seek to maximise renewable generation.

An outline assessment of the carbon impacts of a solar PV array at roof level have been assessed. A total available area of 4360m^2 has been assumed (entire usable roof) for the purposes of the assessment.

The peak output of the array has been calculated as 510 kW from 1280 panels. Over a typical year, this would be expected to output 550 MWh. We have assumed an embodied carbon rate of 615 kgCO_2/kWp based on 2020 data.

The total grid emissions offset by the array over 25 years are estimated to be 520 Tonnes. This includes an allowance for grid decarbonisation, which significantly lowers overall emissions savings. The total embodied carbon of the array is 315 Tonnes.

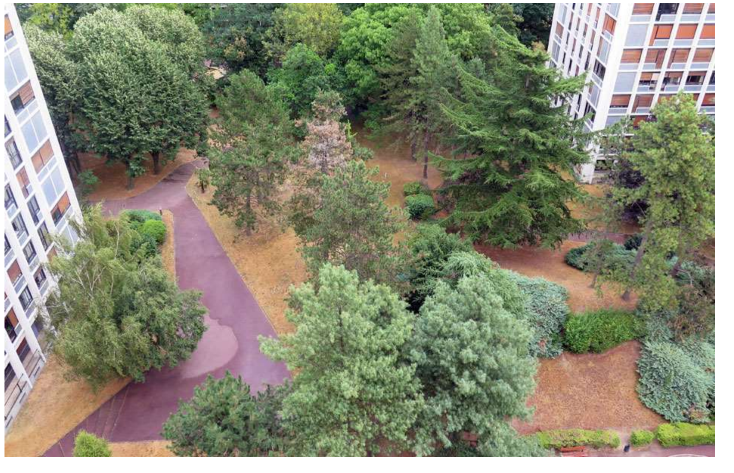
Therefore, the whole life carbon emissions of the array over its 25-year life (not accounting for recycling) are **negative 200 Tonnes.** While this would be a positive step to take, it cannot alone offset the emissions of any of the scenarios assessed.

Installing new renewable generation will impact the demand of grid energy and minimise the carbon whilst the grid is decarbonising.

Benefit of Tree Planting

We have undertaken a simple assessment of the potential impact of planting new trees as part of the proposed park. It is estimated 5 Tonnes CO2e can be saved per 100 square metre of replanted broadleaf forest in the UK. If the full area were replanted at this density it would provide a 230 Tonne CO2e saving over the assessment period.

Example of PV roof array



Example of dense urban tree planting

Estimated PV Array Carbon Savings

200 Tonnes CO_{2e}

Estimated Tree Planting Savings for the "Park" Scenario

230 Tonnes CO_{2e}

Results

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Results and Conclusions

This carbon assessment estimates the whole life carbon emissions for the five proposals for the John Lewis site over a projected 25-year period.

When looking at the existing building, a major refurbishment (2) provides a significant total carbon saving of a 60% reduction from the baseline scenario (1) over the assessment period.

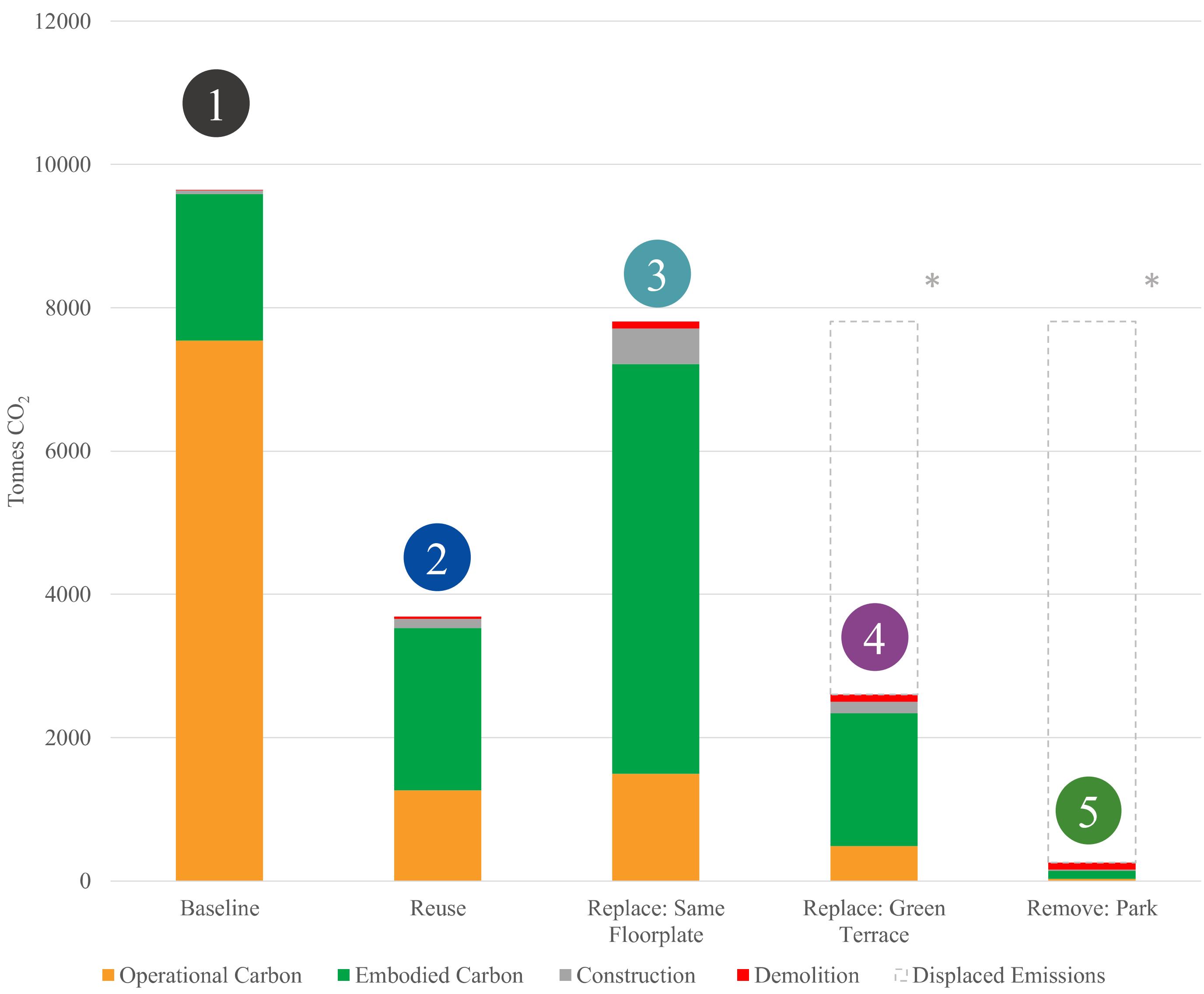
Whilst a new build of a similar scale to the existing building (3) provides a substantial 20% saving over the baseline scenario (1), it is still over twice the carbon intensity of the refurbishment option (2). The assessment would therefore suggest that a like-for-like new build option should not be considered.

The scenarios then look at two options that demolish the building and provide either a reduced scale new build on the site (with associated new public realm) (4) – or convert the whole site to a new public park (5). On a site level appraisal, these two options provide the lowest carbon solutions for the development – mainly due to the reduced area being built and operated.

The reduced scale new build option (4) requires a similar amount of embodied carbon to deliver when compared to the refurbishment option – and due to the reduced floorplate has a significant reduction in operational carbon. As such, the total carbon cost is lower. However, on a per meter squared basis the reuse option remains significantly more carbon efficient.

The assessment above is based on a site level appraisal, but it is worth considering the wider city context. The dashed line on the chart for the reduced floor area options (*) shows the potential opportunity cost associated with having to build the remaining balance of the original floor area as new build on a different site in the city. Whether this is relevant can only be determined by a needs-appraisal for this remaining area of floorplate in relation to the site, and consideration of the impact of this within the wider socio-environmental-economic context of the city.

Whole Life Carbon Results



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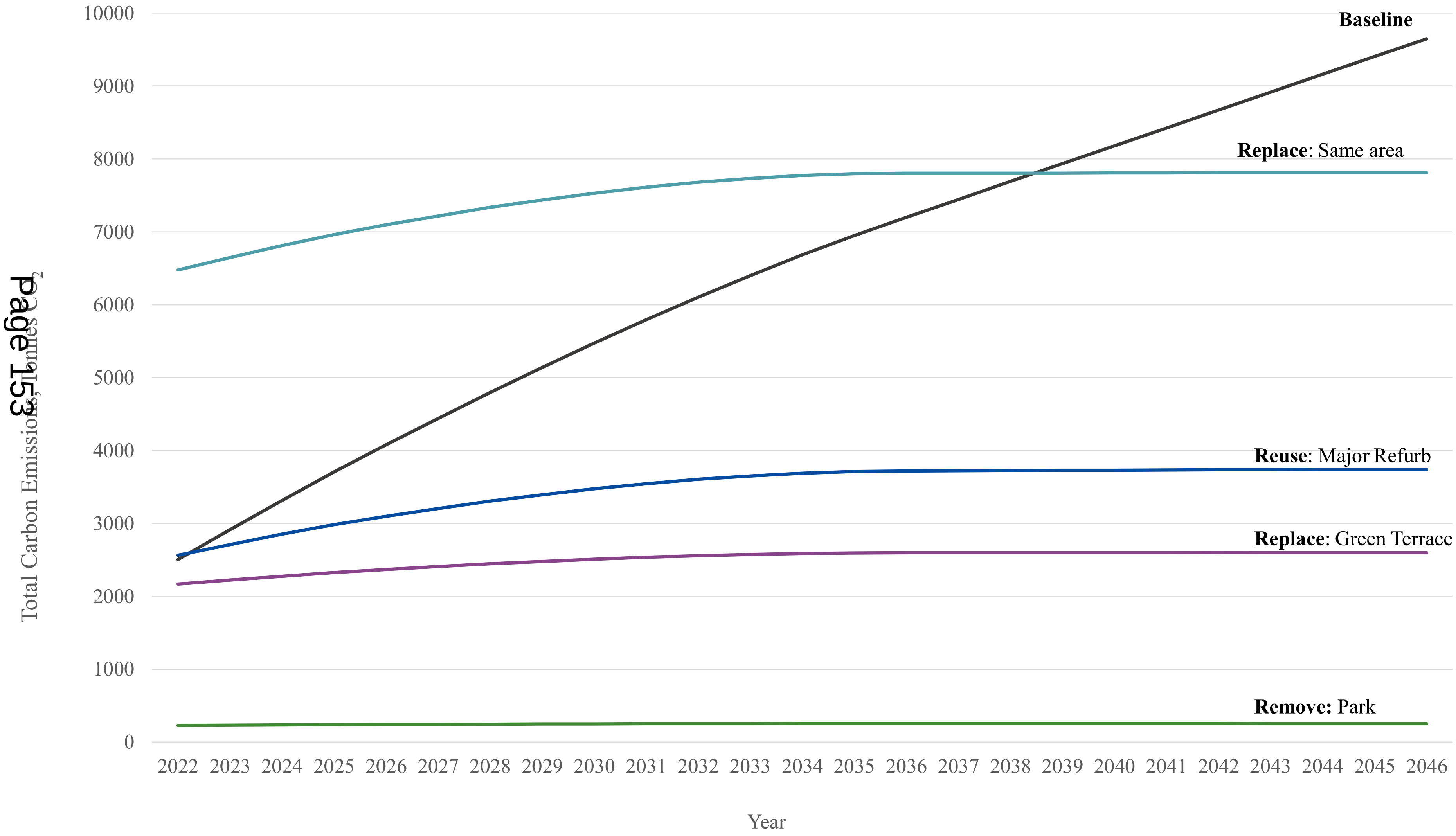
The graph below shows accrual of carbon emissions with time for each of the scenarios.



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