mabeyhire

A PERI COMPANY

Calculating Embodied Carbon in Temporary Works

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Executive Summary

This document outlines our approach to calculating the embodied carbon in our temporary works solutions. Our methodology follows a framework aligned with BS EN 15978's[1] life cycle stages, The Temporary Works Forum's Guidance on how to reduce carbon in excavations[2], guidelines the Institution of Structural Engineers (IStructE) have published in their document How to Calculate Embodied Carbon[3], and PAS 2080:2023: Carbon management in buildings and infrastructure[4]. This comprehensive approach provides customers with detailed insights into the environmental impacts of our temporary works solutions and allows comparison between different solution options.

By promoting sustainable practices, we enable our clients to benefit from embodied carbon data, empowering them to make informed decisions that align with industry standards and sustainability goals. This not only supports our customers in their efforts to reduce their carbon footprints but also contributes to the broader industry goal of fostering sustainable construction practices.

1 Introduction

As the construction industry increasingly prioritizes sustainability, the measurement and reduction of environmental impacts have become paramount. Among these impacts, embodied carbon (defined as the total carbon dioxide emissions resulting from the creation, transportation, and installation of building materials) is a critical metric for evaluating the environmental performance of construction practices. This metric covers every stage of a material's lifecycle, from raw material extraction through to manufacturing, transportation, and on-site installation.

Mabey Hire is a leader in the design and provision of temporary works solutions, which are essential for ensuring stability and support during various phases of construction projects. Our expertise spans a wide range of innovative and reusable systems, designed to meet the diverse needs of the construction industry. Mabey Hire is committed to sustainable practices, by calculating the embodied carbon applicable to each of our projects we enable those we work with to make informed decisions. This paper aims to provide transparency on our approach to calculating embodied carbon and to help promote sustainable decision making.

Our temporary works solutions offer significant advantages over traditional single-use structural steel, primarily through their design for multiple reuses across various projects. This reusability not only enhances efficiency but also significantly reduces the total embodied carbon per project, positioning our solutions as a more sustainable option.

1.1 Lifecycle Stages of Embodied Carbon Calculation

In our approach to calculating embodied carbon, we have considered the Life Cycle stages established in BS EN 15978[1] and have applied the framework established by the Institution of Structural Engineers (IStructE) in their publication How to Calculate Embodied Carbon[3]. Figure 1 is an extract from this publication, showing the life cycle stages defined in BS EN 15978[1] for buildings and PAS 2080[4] for infrastructure. For our operations, the focus is on Product and Construction stages (as highlighted by the blue dashed box), These stages encompass the most significant aspects of our products' lifecycle that is relevant to our services. This approach aligns us with the guidelines established in the Temporary Works Forum’s Guidance on how to reduce carbon in excavation[2] which states *“Most temporary works will normally occur in the construction stage and will therefore be bounded within the upfront carbon modules”*. The whole lifecycle shown relates to construction projects in general, not all stages are directly applicable to Temporary Works.

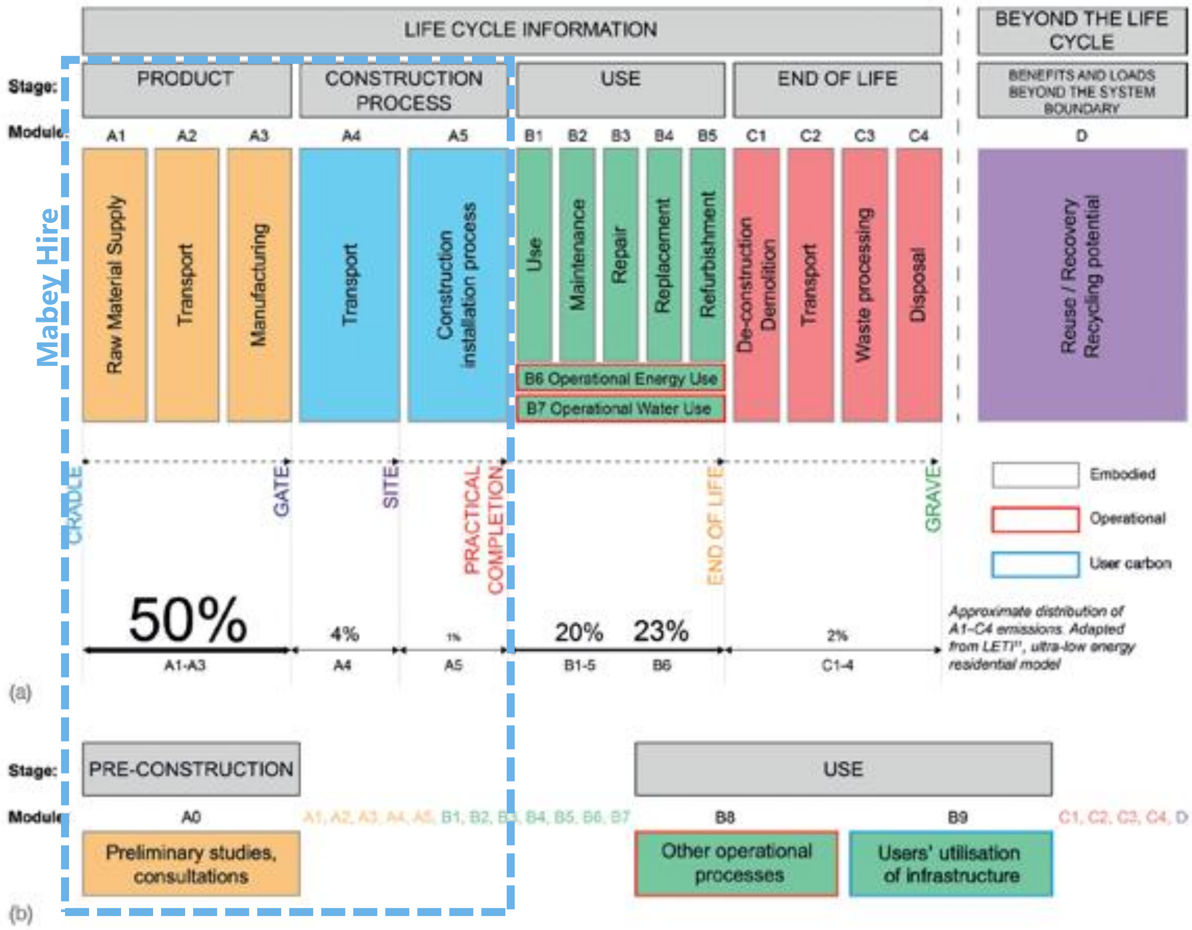

Figure 1- Life Cycle Stages as defined in BS EN 15978 for buildings and PAS 2080 for infrastructure projects (Image from IStructE's How to Calculate Embodied Carbon 2nd Edition)

1.1.1 A1-A3 (Product Stage)

These stages encompass the extraction of raw materials (A1), transportation of these materials to manufacturing sites (A2), and the manufacturing process itself (A3). For our products, this means calculating the embodied carbon based on the material composition and the weight of each item. This calculation will be bifurcated into two distinct outputs: the embodied carbon of creating the item (to be used when selling the product) and the embodied carbon per week on hire (to be used when hiring out the product).

1.1.2 A4 (Transportation)

Stage A4 addresses the transportation of our equipment to and from the construction site. This stage is project-specific and involves calculating the emissions associated with transporting the equipment over the required distances. Factors such as the type of transportation used, fuel consumption, and distance travelled will be taken into account to ensure an accurate calculation.

1.1.3 A5 (Construction and Installation Process)

Stage A5 covers the installation of the equipment on-site. This includes emissions from on-site activities such as assembly, installation, and any machinery used during the process.

1.2 Carbon Estimate Process

Our carbon estimate process aligns with that established by the TWf guidance[2]. Figure 2 is an extract from the publication showing the Temporary Works Carbon Estimate Process. This ensures the use of a standardised format, allowing for comparisons across various projects.

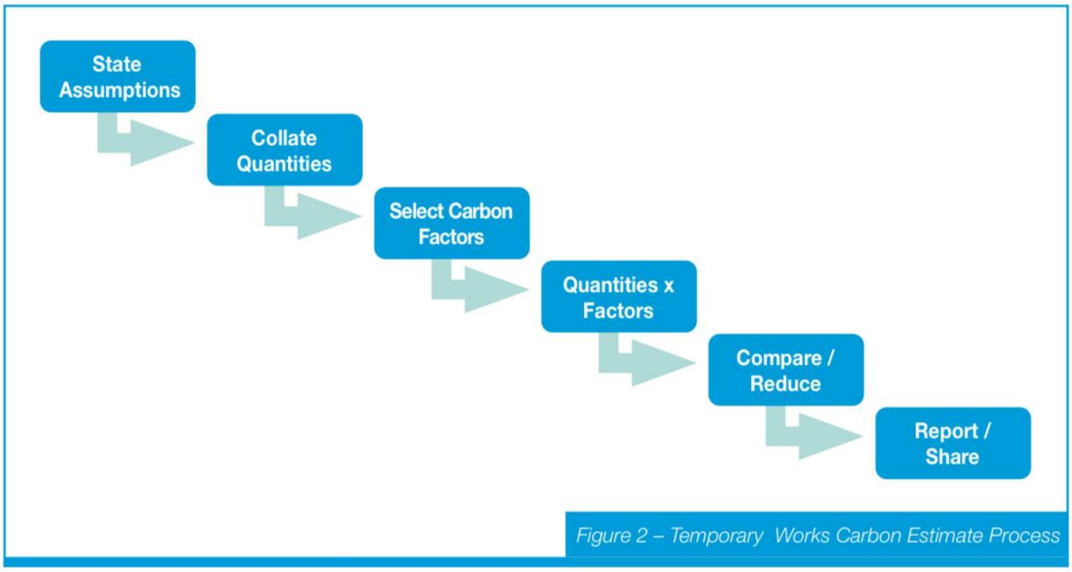

Figure 2 – Temporary Works Carbon Estimate Process

Figure 2 – Temporary Works Carbon Estimate Process (Temporary Works Forum)

1.3 $kgCO_2e$

$kgCO_2e$ refers to carbon dioxide equivalent emissions, often referred to as ‘carbon’ for short. This measure considers other greenhouse gas emissions (GHGs) in addition to carbon dioxide (CO_2), expressing them in terms of CO_2 normalised by their global warming potential (GWP).

2 Product Stage (A1-A3) Calculations

The recommended approach by IStructE[3] and TWf[2] for calculating the embodied carbon of materials involves multiplying the quantity of each material by a specific carbon factor corresponding to the life cycle module being considered.

$$Embodied\ Carbon\ ECF\ (kgC0_2e) = Material\ quantity\ (kg)\ x\ Carbon\ factor\ (kgC0_2e/kg)$$

This implies that the total embodied carbon for lifecycle modules A1-A3 is derived from the cumulative embodied carbon of each individual module (Module A1, A2, and A3).

$$ECF_{A1-A3}\ (kgC0_2e) = ECF_{A1}\ (kgC0_2e) + ECF_{A2}\ (kgC0_2e) + ECF_{A3}\ (kgC0_2e)$$

$Where;$

$ECF_{A1-A3}\ (kgC0_2e) =$ The total embodied carbon for life cycle modules A1-A3

$ECF_{A1}\ (kgC0_2e) =$ The total embodied carbon for life cycle module A1 (Raw material supply)

$ECF_{A2}\ (kgC0_2e) =$ The total embodied carbon for life cycle module A2 (Transport)

$ECF_{A3}\ (kgC0_2e) =$ The total embodied carbon for life cycle module A3 (Manufacturing)

2.1 Material Type

A product's material type determines the amount of embodied carbon accrued during its production. The material types of products within our stock include steel, aluminium, HDPE, anti-skid, timber, rubber, polyester and plastic. We have adopted the embodied carbon values recommended by the TWf[2] guide for steel and aluminium equipments (as shown in Table 1 below) for calculating the embodied carbon in these materials. The embodied carbon values for other material types have been pulled from other referenced sources.

Subgroup	Material	($ECF_{A1\text{-}A3}$) $(kgC0_2e/kg)$	Reference
1	Steel Equipment	1.55	Ref 2
2	Aluminium Equipment	2.12	Ref 2
3	HDPE	3.09	Ref 6
4	Anti-Skid	3.85	Ref 7
5	Timber	0.49	Ref 8
6	Rubber	2.55	Ref 8
7	Polyester	5.36	Ref 9
8	Plastic	3.16	Ref 6

Table 1 - Embodied carbon factors (ECF_{A1-A3}) for material in our fleet

2.2 Item Analysis Groups and Subgroups

To efficiently manage our diverse range of products, our inventory is divided into distinct item analysis groups. Each analysis group contains a number of different individual products which are used together. For example, all products associated with our Mass 50 equipment are categorized under one group, while those related to our Mass 25 equipment are grouped under a different group. Each of these analysis groups contain a variety of material types, therefore each analysis group is divided into material type subgroups as shown in Table 1. For example, within our Walers analysis group we have products that are Aluminium (subgroup 2); Steel (subgroup 1); Timber (subgroup 5); and Rubber (subgroup 6).

2.3 Embodied Carbon per item $\boldsymbol{ECF_{(A1-A3)I}}$:

This is the embodied carbon of a material, multiplied by the weight of the item.

$$\boldsymbol{ECF_{(A1-A3)I} = ECF_{(A1-A3)f}\ x\ Item\ Mass\ (Im)} \qquad \text{(Units: } kgC0_2e\text{)}$$

This represents the embodied carbon value for products being **sold** to our clients. This calculation has been performed for each individual item in our fleet.

2.4 Target Utilisation $\boldsymbol{U_T}$:

This refers to the percentage of time an item is expected to be on hire within its Lifespan. The target utilisation is set for each product group.

2.5 Assigned Lifespan $\boldsymbol{l_A}$:

This refers to the expected number of years that all items within an analysis group made from the same material (subgroup) are anticipated to last before being in deemed no longer usable and subsequently scrapped. It is a simplified method that assigns all products within an item analysis group made of the same material (subgroup) a single lifespan. This assigned lifespan has been determined based on comprehensive analysis of historical records and design data for each individual item. For example, the ~~s~~*teel equipment* subgroup of the *Mass 50* analysis group has been given an Assigned Lifespan of 15 years, whereas the *Aluminium Equipment* subgroup of the *Walers* analysis group has been given an Assigned Lifespan of 6 years.

2.6 Utilized Lifespan $\boldsymbol{UL}$:

The Utilized Lifespan is the actual amount of time a product is in use during it's lifespan. The utilized lifespan is the product of the item's target utilization and its assigned lifespan.

$$\text{Utilized Lifespan } (UL) = Target\ Utilization\ (U_T)\ x\ Assigned\ Lifespan\ (l_A)$$

(Units: Weeks)

(e.g. if a product has an Assigned Lifespan of 10 years, and a 40% Target Utilization, then it's Utilized Lifespan is 4 years).

This has been calculated for each individual product in our fleet.

2.7 Embodied Carbon per week on hire:

This is calculated by taking the embodied carbon per item $\boldsymbol{ECF_{(A1-A3)I}}$ and dividing it by the utilized lifespan UL for that item.

$$ECF_{(A1-A3)w} = \frac{ECF_{(A1-A3)I}}{UL}$$

(Units: $kgC0_2e/week$)

This is the value applied as the embodied carbon value per week the item is on hire. This has been calculated for each individual item in our fleet.

3 Transport Stage (A4) Calculations

In line with the recommendations of the IstructE[3] and TWf[2], the embodied carbon contribution from transportation has been categorised into two distinct types.

3.1 Operational Emissions (Direct Emissions):

This involves the emissions resulting from the combustion process converting fuel (gasoline, diesel, etc) into Energy hence leading to the release of greenhouse gases GHGs into the environment.

3.2 Greenhouse Gass Conversion Factor:

This is the amount of greenhouse gas released from burning one litre of fuel. The TWf[2] recommends a greenhouse gas conversion factor of *3.24* $kgC0_2e/Litre$ For diesel fuel.

3.3 Miles Per Litre:

This is the distance in miles a vehicle can travel on one litre of fuel.

$$\boldsymbol{Miles\ per\ Litre} = \frac{Distance\ travelled\ (Miles)}{Fuel\ Consumed\ (Litres)}$$

$Unit: Miles/Litre$

3.4 Transport Emission Factor TEF:

This is a metric quantifying the amount CO_2e emissions produced per mile of transportation activities. The transport emission factor is obtained by dividing the greenhouse gas conversion factor by Miles Per Litre.

$$\boldsymbol{Transport\ Emission\ Factor\ TEF} = \frac{Greenhouse\ Gas\ Conversion\ Factor}{Miles\ per\ Litre}$$

$Unit: kgC0_2e/Mile$

IstructE[3] and TWf[2] recommends estimating the operational carbon by taking the product of the distance travelled and the Transport Emission Factor.

$$\textbf{Operational Carbon}\ \boldsymbol{ECF_{A4,i1}} = \boldsymbol{Distance\ Travelled\ x\ Transport\ Emission\ Factor\ (TEF)}$$

(Units: $kgC0_2e$)

3.5 Embedded Emissions (Indirect Emissions):

This is an indirect carbon emission associated with the manufacturing of the vehicles. In accounting for this a ten-year vehicle life cycle has been utilised in line with our historical records.

3.6 Vehicle Weight

This refers to the unloaded (empty) weight of the vehicle.

3.7 Capital Carbon Factor

Capital Carbon Factor refers to $kgC0_2e$ equivalent emissions associated with the manufacture of the vehicle. The TWf[2] recommends a capital carbon factor of 3.77 $kgC0_2e$.

3.8 Journey Per Day

The Journey per day is the average number of trips made by an individual vehicle within our fleet in a single day. An average journey per day value of 1.7 have been adopted in line with our historical records.

3.9 Vehicle Working Days

This refers to the average number of days each vehicle within our fleet is utilised in a year. This takes into consideration a five-day working week and fifty-one weeks working year.

3.10 Asset Contribution $\boldsymbol{kgC0_2e}$ per Journey $\boldsymbol{ECF_{A4,i2}}$

This refers to the amount of carbon equivalent $kgC0_2e$ emissions we attribute to a single journey made by a vehicle in our fleet.

$$Asset\ Contribution\ per\ Journey\ \boldsymbol{ECF_{A4,i2}} = \frac{Vehicle\ Weight\ x\ Capital\ Carbon\ Factor}{(Total\ working\ days\ per\ year)\ x\ (Journey\ per\ day)}$$

The total $kgC0_2e$ 'carbon' resulting from the transportation of our temporary works equipment to site is the sum of the Operational Carbon and the Asset Contribution per Journey.

$$Total\ kgC0_2e\ per\ transporation\ activity = \boldsymbol{ECF_{A4,i1}} + \boldsymbol{ECF_{A4,i2}}$$

4 Construction Stage (A5) Calculations

The IStructE guide categorises the Module A5 emissions into two distinct groups. The first group, known as A5w emissions, pertains to the emissions resulting from the waste volume of each material on site. The second group, referred to as A5a emissions, includes emissions from general construction activities, such as energy consumption by machinery and temporary site offices.

4.1 A5w Emissions - Material wastage on site

A5w emissions are calculated as the sum of the embodied carbon factors from production (A1-A3), transportation away from the site for waste processing (C2), and waste processing or disposal (C3-C4), multiplied by the waste factor for the material.

$$ECF_{A5w,i} = WF_i \; x \; (ECF_{A13,i} + ECF_{A4,i} + ECF_{C2,i} + ECF_{C34,i})$$

$$WF_i = (\frac{1}{1 - WR_i} - 1)$$

$WF_i = Waste\ Factor$

$ECF_{A5w,i}$ = Construction waste embodied carbon factor for i^{th} material.

$ECF_{A13,i}$ = Embodied carbon factor for A1-A3 for i^{th} material.

$ECF_{A4,i}$ = Embodied carbon factor for transport to site for i^{th} material.

$ECF_{C2,i}$ = Embodied carbon factor for transport away from site for i^{th} material.

$ECF_{C34,i}$ = Waste processing and disposal embodied carbon factor.

For our multiple-use products in temporary works solutions, where prefabricated components are assembled on-site, the carbon factors for transportation away from the site for waste processing (C2) and for waste processing or disposal (C3-C4) are essentially zero. Additionally, since no waste is produced because all components are prefabricated (and any waste during manufacturing is captured in the calculations in 2 above), the waste factor (WF_i) for this stage is also zero. Consequently, the carbon factor accounting for material wastage on-site for our multiple-use products is essentially zero.

4.2 A_{5a} $Emissions$ - Site Activities

The IStructE guide[3] recommends following the RICS guidance[5] for calculating the embodied carbon value of site activities as shown below.

$$ECF_{A5a} = CAEF \; x \; \frac{PC}{100{,}000}$$

Were,

$EC_{A5a} = Embodied\ carbon\ from\ construction\ site\ activities\ (A5a)$

$CAEF = Construction\ activities\ emission\ factor\ (500kgCO_2e/£100{,}000)$

$PC\ = Project\ Cost$

For projects that predominantly utilize off-site manufacturing and fabrication, such as in our temporary works business, the guidance recommends using a construction activities emission factor of ($500kgCO_2e$/£100,000). This factor will be applied to calculate the embodied carbon resulting from our construction team's site activities (where applicable).

5 Implementation

PAS 2080[2] highlights that as projects progress through the work stages the available level of detail of embodied carbon increases, whilst the ability to reduce whole life carbon decreases (see **Error! Reference source not found.**). In order for our embodied carbon calculations to have the greatest impact and be of most use to our customers we will be showing the embodied carbon on all of our quotes. This will provide customers with the greatest level of detail possible at the earliest opportunity, at the Optioneering / Design interface. All our quotes will show:

- Embodied carbon per week of equipment quoted for hire
- Embodied carbon of equipment quoted for sale (including any project-specific specially fabricated components)
- Anticipated embodied carbon of our installation service (if quoted)
- Anticipated embodied carbon of transport

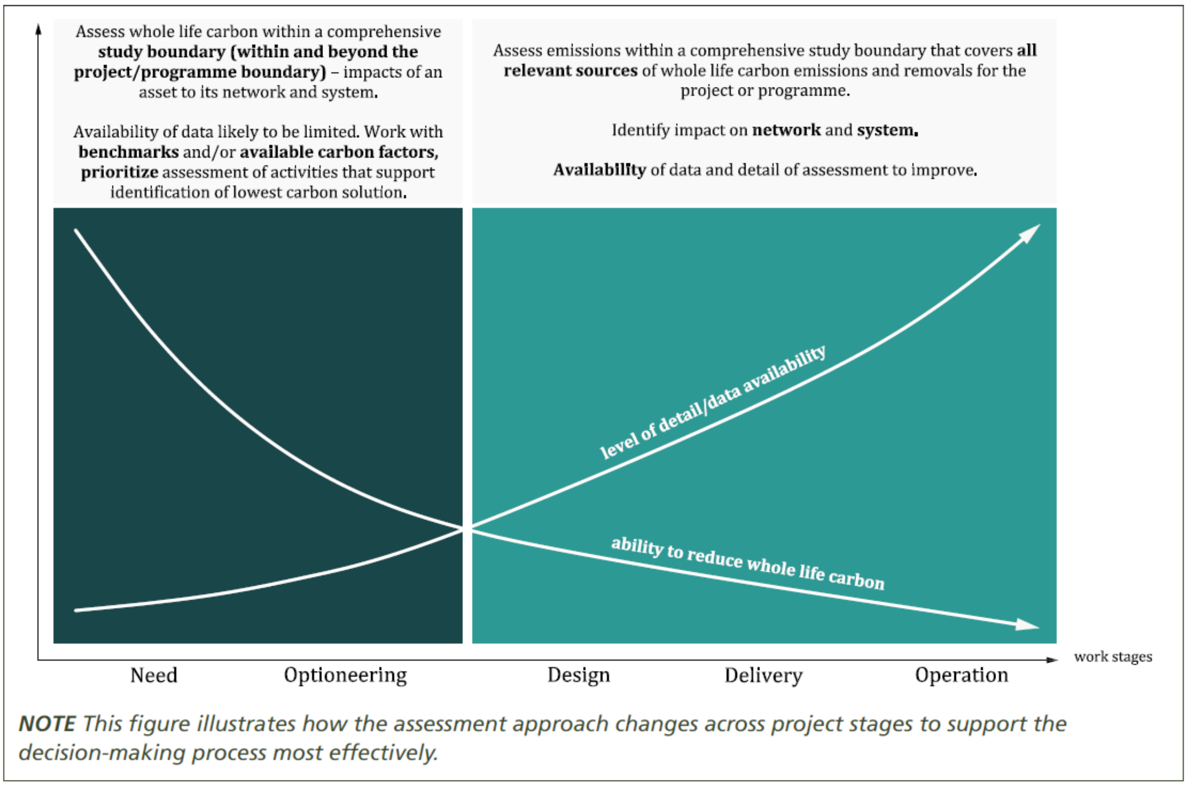

Figure 3- Level of detail/data available vs ability to reduce whole life carbon (PAS 2080)

6 Conclusion

Our approach to calculating embodied carbon in temporary works solutions provides a transparent and structured methodology that aligns with industry standards, including BS EN 15978, PAS 2080, and guidance from the Institution of Structural Engineers (IStructE) and the Temporary Works Forum (TWf). By integrating lifecycle assessment principles into our calculations, we enable informed decision-making that supports sustainability objectives across the construction sector.

By incorporating embodied carbon data into our quotations, we empower our customers to evaluate and compare solutions based on their environmental impact from the earliest stages of project planning. This proactive approach not only supports carbon reduction initiatives but also aligns with the industry's broader push towards sustainable construction practices.

As the construction industry continues to evolve towards lower-carbon solutions, we remain committed to refining our methodologies, leveraging innovation, and collaborating with industry stakeholders to drive meaningful reductions in embodied carbon. Through our expertise in temporary works and our commitment to sustainability, we are helping to shape a more environmentally responsible future for the built environment.

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