Whole life carbon management in the rail industry

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With a background in Climate Science from University of Bristol, Nick has spent several years as a consultant in Atkins' sustainability team and has developed considerable expertise in relation to whole life carbon management.

Nick has led carbon management projects both in the UK and internationally across various sectors including, road, aviation, water and rail. He is passionate about working with clients to find new and innovative approaches to minimising carbon within their projects and supporting them to meet their net zero goals.

Before joining Atkins, Hector graduated from Oxford Brookes University, completing a dissertation focusing on sustainability within the workplace environment.

Post-university he worked in agriculture, carrying out sustainable regeneration and biodiversity enhancement in farming. From this Hector joined Atkins as an Assistant Carbon & Sustainability Consultant where he has been involved in multiple projects including carbon assessments of rail and road infrastructure.

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Having worked previously as a sustainability researcher, Mohammad has a strong interest in sustainability and climate change which is one of the greatest challenges faced by the world today.

INTRODUCTION

Climate change, accelerated by anthropogenic greenhouse gas (GHG) emissions, is one of the critical global issues within today's society. The effects of climate change are already visible, from rising sea levels to long term shifts in weather patterns and increased temperatures. Meeting net zero emissions targets is therefore paramount to avoiding further impacts and potentially reversing the changes that we are already seeing around the world.

The transport sector represents around 27% of the UK's GHG emissions[1]. Traditionally the focus of carbon reduction efforts in the transport industry has been on operational emissions from fuel combustion in vehicles, however as the net zero agenda grows in prominence and vehicles decarbonise through electrification, whole life carbon of transport infrastructure is becoming increasingly important.

Whole life carbon is the sum of total greenhouse gas emissions that occur throughout the lifecycle of a project, from the emissions released during the extraction of raw materials and manufacturing of products, the transport of products to the construction site and emissions released during the construction process, as well as operation and maintenance and finally end-of-life emissions, as demonstrated in figure 1.

This article explores whole life carbon management for the rail industry in the context of the wider net zero agenda. It aims to demystify carbon management and quantification to help people in the rail industry embed sustainability best practice. Guidance is provided for effective use of carbon calculators such as the RSSB Rail Carbon Tool[2] supported by a case study of an example of Atkins' experience in managing carbon on a rail infrastructure project and quantifying the benefits using the Rail Carbon Tool.

UK NET ZERO TARGETS

Responding to the threat of catastrophic climate change requires coordinated action to reduce greenhouse gas (GHG) emissions in order to meet targets set out in the Paris Agreement of 2015. These targets aim to keep global temperature rise this century below 2°C (above pre-industrial levels) and encourage efforts to limit the temperature increase even further to 1.5°C[3]. In response, the UK statutory target for reducing GHG emissions was strengthened in May 2019 to focus on achieving Net Zero by 2050[4].

The Committee on Climate Change (CCC) defines 'Net-Zero' emissions as the point when the "total of active removals of carbon from the atmosphere offsets any remaining emissions from the rest of the economy"[5]. In practice, this means that to achieve net zero, emissions must be reduced as far as possible, with any remaining emissions being offset by active removals (eg land use change to forests, grassland etc.). Understanding how to identify carbon emissions sources and then how to effectively manage those sources to create carbon reductions, is therefore paramount to achieving net zero.

GHG EMISSIONS IN THE RAIL INDUSTRY

Rail is one of the lowest carbon forms of transport, accounting for just 1.4% of the UK's domestic transport emissions in 2019, despite 9% of transport being carried out on the UK's railways[6].

Over 40% of the UK's railways are already electrified, enabling the transport of passengers and goods with minimal GHG emissions being released. As electrification of the rail network extends, and the National Grid continues to decarbonise, this mode of transport is becoming even less carbon intensive.

The Department for Transport's top priorities from the Rail Environment Policy Statement are:

- Achieve net zero GHG emissions from rail by 2050 (including whole life carbon emissions).
- Remove all diesel-only trains from the rail network by 2040.
- Sustainable, deliverable programme of electrification that delivers a higher performing, net zero railway.

In order to achieve these ambitions, and as operational emissions are actively being reduced across the rail network, reducing whole life emissions associated with rail infrastructure is becoming even more important. Emissions associated with the construction and maintenance of rail infrastructure will become the main source of emissions once trains are fully electrified.

The Department for Transport's plan 'Decarbonising transport: a greener, better Britain'[7] recognises this, stating that a joined-up approach across the supply chain to managing whole life emissions will be critical to achieving net zero across the non-traction elements of UK railways.

The rail industry's 2021 proposal for a cleaner and greener future[8] states that whole life carbon reductions will be achieved by including carbon reduction targets within rail management contracts and investing in zero carbon infrastructure along with providing Great British Railways with responsibility for carbon monitoring.

Furthermore, Network Rail's Environmental & Social Minimum Requirements[9] call for a capital carbon assessment to be carried out for all projects with a capital value of over £1million. These assessments must use the RSSB Rail Carbon Tool (RCT) to develop a baseline and identify opportunities for whole life carbon reduction[10].

Processes for quantifying and managing carbon in rail infrastructure therefore need to be defined, understood, and implemented to enable effective reductions of whole life carbon.

MANAGING WHOLE LIFE CARBON IN RAIL INFRASTRUCTURE

The key technical standard that provides guidance for management of whole life carbon in the infrastructure industry is PAS 2080[11]. PAS 2080 is a voluntary standard and aims to improve the management of carbon throughout the supply chain, allowing evidence-based decisions to be made and the identification of carbon reduction opportunities[12]. PAS 2080 provides a common framework for the whole supply chain, encouraging the right behaviours and approaches to deliver reduced carbon and cost.

The key requirements of an effective carbon management system, as defined by PAS 2080 are:

- **Show clear leadership:** Set an organisational strategy for carbon management and assign roles and responsibilities to individuals/teams so they understand the part they play in reducing carbon.
- **Embrace a culture of challenge and change:** Communicate the importance of carbon management to project teams and the supply chain and encourage challenging of the status quo.
- **Set bold targets:** Set challenging carbon reduction targets against a defined baseline and establish KPIs to monitor emissions during project delivery.
- **Develop a carbon management process integrated within standard project delivery:** Ensure carbon information feeds into decision making from the earliest project stages.
- **Engage the value chain early:** Collaborate with the whole value chain from the earliest project stages to share carbon objectives and identify innovative low carbon solutions, removing any constraints to collaboration.
- **Establish an accurate carbon accounting procedure:** Use relevant tools and processes to quantify and report carbon throughout project delivery to feed into decision making.
- **Promote continual improvement of the process:** Seek the input of the whole supply chain to improving the carbon management process.

Following the principles of PAS 2080 on rail infrastructure projects will allow for innovation, carbon, and cost reduction. It ensures consistency within infrastructure delivery, making carbon visible across the supply chain, and ultimately will lead to low carbon solutions. Developing a carbon management system for projects, aligned with PAS 2080, is therefore strongly recommended.

Tools, such as the Rail Carbon Tool, can be used to support carbon management throughout project delivery and chapter 7 of PAS 2080 provides a methodology for effective use of such tools.

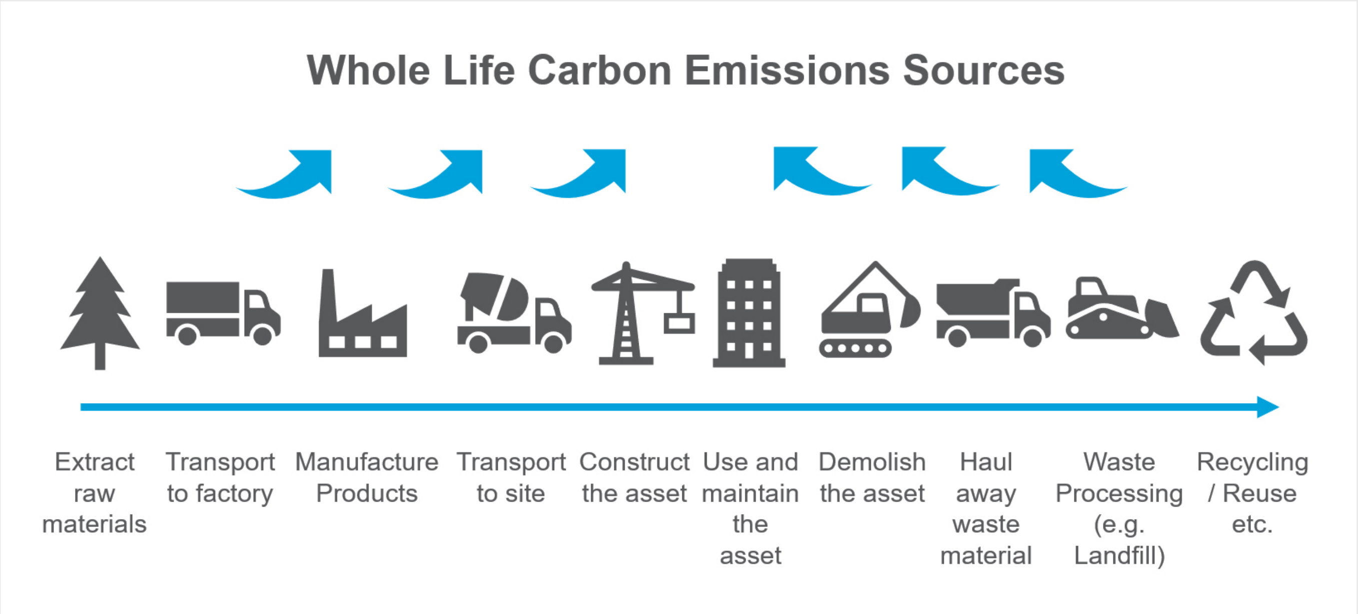

Figure 1: End-to-end emissions sources across the whole life of a construction project.

INTEGRATING CARBON MANAGEMENT INTO PROJECT DELIVERY

To ensure that carbon is considered at all project decision points alongside other key factors, such as cost and programme, carbon must be embedded within the delivery of a project from the earliest stages. The 2013 Infrastructure Carbon Review[13] illustrates this importance through the infrastructure carbon reduction hierarchy, as set out in figure 2.

Carbon can be reduced at any point during project delivery but the proportion of emissions that can be reduced decreases over time. The earlier that whole life carbon is considered in project decision making, the greater the potential to reduce emissions. The carbon reduction hierarchy forms the basis of effective management of whole life carbon within the delivery of assets or programmes of work.

In practice, the carbon reduction hierarchy provides a framework for decision making that will result in innovation and low carbon results:

- **Build Nothing:** Evaluate the basic need for an asset and/or programme of works and explore alternative solutions to achieve stated project aims.
- **Build Less:** Evaluate the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required.
- **Build Clever:** Consider the use of innovative approaches or low carbon solutions to minimise resource consumption during construction operation and use, and build infrastructure that has been designed for easy decommissioning and reuse/recycling.
- **Build efficiently:** Use technologies that reduce resource consumption during construction, operation and end of life[14].

Working closely with stakeholders including clients, project teams and the supply chain is essential to embedding the carbon reduction hierarchy into all areas of project planning and delivery. This can be achieved through in-depth discussions and holding workshops that allow for supply chain collaboration where all parties can gain an understanding and contribute ideas.

Using the carbon reduction hierarchy as the framework to these conversations, and as general principles to follow during design and construction, helps to instil a challenge culture throughout project delivery where carbon reduction is considered at every stage.
By embedding the principles of PAS 2080 and the carbon reduction hierarchy within project delivery, substantial carbon reduction opportunities are unlocked. These opportunities can be explored, options can be compared, and whole project reporting can be carried out by assessing carbon using carbon calculation tools, such as the Rail Carbon Tool.

WHOLE LIFE CARBON ASSESSMENT

FUNDAMENTALS

Calculating whole life carbon emissions is often perceived as being a complicated process, however the basic calculation is very simple. At its core, carbon calculation is simply multiplying project activity data (eg a quantity of material) by a relevant carbon factor. A carbon factor is a coefficient representing the average emissions associated with a single unit of a specific source (eg the average emissions associated with the production of 1 tonne of concrete). Carbon factors are provided by various carbon factor libraries and cover all processes across the project lifecycle including products/materials, vehicle transport, construction processes, fuel, energy and water use as well as end of life processes. Carbon factors are produced according to specific technical standards, such as BS EN 15804[15], to ensure consistency and accuracy.

In some instances, product manufacturers may provide a carbon factor that has been calculated for a specific product and is reported in an Environmental Product Declaration (EPD). EPDs are the most accurate form of carbon factor and therefore should be prioritised wherever possible.

Carbon emissions factors and calculated emissions from project activities are expressed in carbon dioxide equivalents (CO_2e) per unit (eg per tonne). CO_2e represents the global warming potential of all GHGs released by an activity, put in the context of carbon emissions to enable easy comparison.

CARBON MODELLING AND CARBON TOOLS

To carry out a robust carbon assessment of a project or a project option, there are a number of technical components that must be in place and understood, including:

- A thorough understanding of the life cycle of the project/asset, and where the measurable emissions sources exist.
- Data sources, including project-specific input data as well as appropriate carbon emissions factors.
- A robust assessment methodology that is aligned with relevant technical standards (eg PAS 2080).
- A defined system boundary, outlining the physical and geographical boundaries to be included in the assessment as well as all inclusions and exclusions within that boundary.

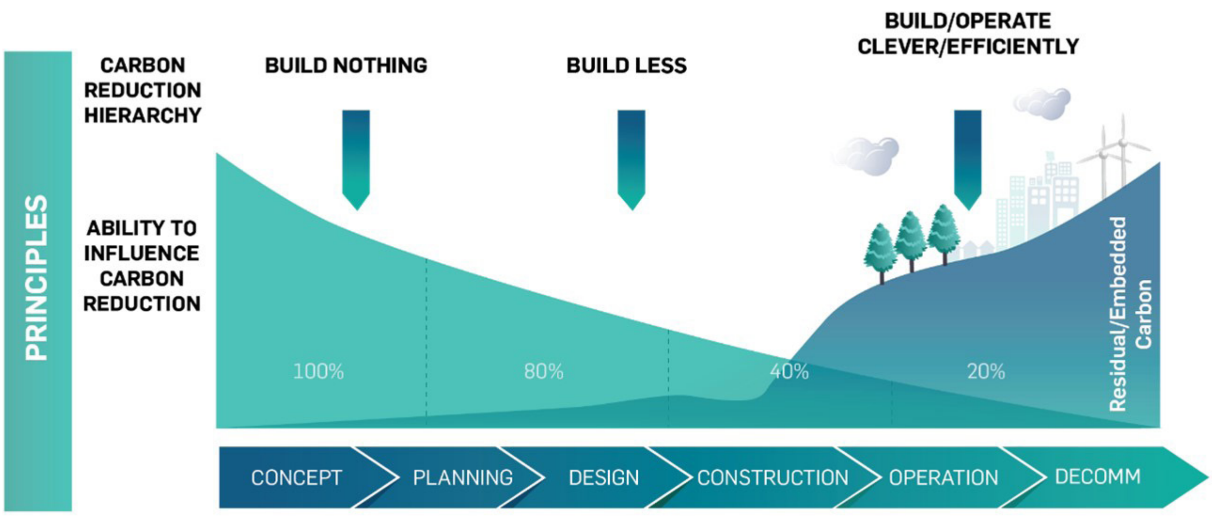

Figure 2: The carbon reduction hierarchy. Source: Infrastructure Carbon Review – 2013.

- A reference study period, which defines the time-period for the assessment, and consequently the range of operational activities for which emissions will be accounted for (eg energy required during operational lifetime, maintenance/replacement requirements).

BENEFITS OF QUANTIFYING EMISSIONS

A wealth of benefits arise from calculating whole life carbon emissions within projects. Carbon calculation is most effective when feeding into the optioneering process of project development. Understanding the whole life carbon impact of each project option enables teams to make sustainable decisions.

Calculating emissions also enables project teams to fully understand where the majority of carbon is occurring within a project or option, often referred to as the carbon hotspots. Efforts can then be focussed on reducing these large emissions sources where the potential for reduction is greatest.

Carbon quantification can also be particularly useful when making a business case for more sustainable solutions; if a sustainable product has greater upfront costs then understanding the potential emissions savings helps to make a case for the additional upfront capital expenditure. Similarly, calculating whole life carbon ensures that the lifetime of a product/asset is considered, and therefore may enable teams to select options that have greater upfront costs but will save money over the lifetime of the project as they last longer or require less maintenance.

LEVELS OF QUANTIFICATION

There are varying levels of carbon quantification that can be followed; depending on the size and budget of the project and the project stage, certain approaches are likely to be more relevant than others.

For larger projects (eg Network Rail projects with a capital value of over £1million) it is likely that a fully quantified carbon model is required and from early stages of the project lifecycle covering the whole life of the project, and comparing emissions reductions against an agreed project baseline.

In some instances, in particular when feeding into particular decisions within project delivery, it may be appropriate to carry out a more targeted assessment. This may be a quantified carbon model covering only certain stages of the assets' life cycles that are likely to have a material impact on the results of a comparison between options. For example, when comparing the carbon associated with two options with the same expected lifespan and maintenance requirements, it may only be necessary to quantify the impact of the materials, transport and construction to understand which will have the larger whole life carbon impact.

Projects at very early stages or smaller projects may not require a quantified carbon model in order to make low-carbon decisions. In these instances, qualitative data may be utilized. This may take the form of discussions regarding the project options and which ones will use the most materials, have the shortest lifespan or will take the longest to build. Discussions may also be focussed on a single option, framed around the carbon reduction hierarchy and identifying ways to make assets smaller, or use alternative materials.

Whenever a qualitative approach is taken, the whole life impact should still be considered, to ensure that all aspects that will make a material impact are accounted for. Such discussions are most effective when they are collaborative and involve supply chain stakeholders and are often aided by the presence of a carbon management expert, however this is not a necessity as long as the principles of the carbon reduction hierarchy are followed and the whole life impact is considered.

Regardless of whether a quantitative or qualitative approach is followed, it is important to track decisions that are made so the processes and resulting carbon savings can be documented. Furthermore, when data is limited at early project stages, if documented, these early decisions may be quantified at later stages when data is more available so the total emissions reduction can be reported.

GATHERING DATA

When carrying out a quantitative assessment, data should be gathered from all potential emissions sources as per figure 1. Ensuring that the various disciplines within project teams know they are required to provide data, in what format it should be provided and when it will be required streamlines the process and ensures consistency.

Whilst some data may be difficult to acquire and may require teams to make assumptions based on experience and technical judgement, often a lot of the data required is already captured as part of traditional project delivery. For example, bills of quantities, costing exercises and construction programmes all create usable datasets that feed into carbon calculation. Planning data sources and working with teams to understand what data will be available is therefore an important exercise.

Accurate whole life data is most effectively sourced through collaboration between supply chain stakeholders, each providing data relevant to their particular specialist area (eg contractors providing fuel/energy use data for the construction process). Again, it is important for stakeholders to understand that they will be required to provide data and in what format to make the process as streamlined as possible.

At very early project stages, it may not be possible to gather project-specific data across the whole life cycle of the project. In these cases, previous project examples may be utilised, in combination with assumptions made through expert technical judgement or standard data provided by technical standards or industry best-practice. Where this is the case, this data should be updated at the next iteration of assessment by project-specific data where possible, and the baseline adjusted where necessary.

THE RAIL CARBON TOOL

The RSSB Rail Carbon tool (RCT) is a freely available, web-based, carbon assessment tool for the rail industry, hosted and provided by RSSB and originally developed by Atkins. Premium carbon factor libraries for the infrastructure industry, including the Inventory of Carbon & Energy (ICE) database[16] are embedded within the RCT, enabling the assessment of whole life carbon for rail projects. The RCT is simple to use and enables all levels of carbon quantification to be carried out, from small scale targeted assessments to holistic whole life assessment for whole project reporting. When the correct methodology is followed, the Rail Carbon Tool can be used to carry out carbon calculations that adhere to the quantification requirements of PAS 2080.

For further information and training regarding use of the RCT, please refer to the RSSB website[17].

CASE STUDY: SOHAM STATION REDEVELOPMENT

A CARBON ASSESSMENT USING THE RAIL CARBON TOOL SITUATION

Soham Station in Ely, Cambridgeshire, previously operated on the Ipswich to Ely line serving the town of Soham, until its closure in the 1960s. Following a long campaign to rebuild it, the station was reopened in December 2021. The new station reconnects the local community to the rail network supporting further investment as part of Cambridgeshire & Peterborough Combined Authority's vision for the wider area[18].

Atkins were involved in project design optioneering and used the principles of PAS 2080 to make low-carbon decisions and then quantified carbon in the Rail Carbon Tool, feeding into the wider options appraisal.

CLIENT ISSUES

The client, Network Rail, needed to decide what type of platform should be built at the station as well as understand the carbon benefits of design decisions that were made. An appraisal of five platform options was required considering cost, constructability, and carbon, and a full project assessment was required to quantify the carbon benefit of design changes throughout options appraisal stage.

ATKINS SOLUTIONS AND ADDED VALUE

Atkins' carbon experts and engineering design team worked in collaboration to gather life cycle inventory data of the five platform options to feed into a targeted carbon assessment using the Rail Carbon Tool, comparing each option. The options included:

1. Red brick, crosswall and plank platform
2. Steel modular platform
3. Glass Reinforced Plastic (GRP) modular platform
4. Polystyrene modular platform
5. Concrete modular platform

The results of the assessment fed into a wider options appraisal considering various factors including cost, constructability, and sustainability.

Additional to the platform assessment, Atkins' sustainability team worked with the designers to identify sustainable, low-carbon solutions within all aspects of the overall design, by integrating the principles of the carbon reduction hierarchy and by carrying out carbon reduction workshops.

At later stages, once the preferred platform option had been chosen, a full carbon model was developed covering the whole station, including the station footbridge, access road and car park, shelters, signalling structures and the platform. The intention of the full model was to demonstrate how carbon had been reduced throughout the options appraisal stage.

Atkins' carbon specialists also used the assessment to identify carbon hotspots within the overall station design and worked with the design team to identify further opportunities to reduce carbon associated with those hotspots in later stages.

METHODOLOGY

The carbon assessments carried out throughout project delivery were conducted using the Rail Carbon Tool, in line with Network Rail's environment standard (NR/L2/ENV/015). The assessment methodology followed the principles set out in section 7 of PAS 2080: Carbon Management in Infrastructure on whole life carbon quantification.

FINDINGS

Atkins identified through the targeted platforms assessment, that the Polystyrene Modular solution had the lowest associated carbon emissions, as illustrated in figure 3.

Key benefits and success factors

- The carbon assessments provided the information necessary to enable design decisions that were significantly more informed and justifiable from a sustainability perspective. A key factor in this was the transparent assessment methodology, using direct project and supplier data.
- Atkins used the Rail Carbon Tool to quantify carbon between different platform components, demonstrating to the client that the most carbon efficient solution (polystyrene modular) delivered a carbon reduction of 49% against the baseline option (crosswall and plank).
- Based on the results of the platforms carbon assessment and the wider aspects of the options appraisal, the client chose the lowest carbon platform solution, polystyrene modular, which contributed a significant amount to the overall carbon reduction of the station design.
- Through embedding the principles of the carbon reduction hierarchy into the design decision making process, Atkins were able to achieve further carbon reductions across the whole station design.
- An overall carbon reduction of 18% was achieved throughout the options selection stage, when compared to the baseline design from the previous stage.

From the in-depth comparison between options and the identification of carbon hotspots within the design, Atkins' carbon experts were able to make the following recommendations to the project team:

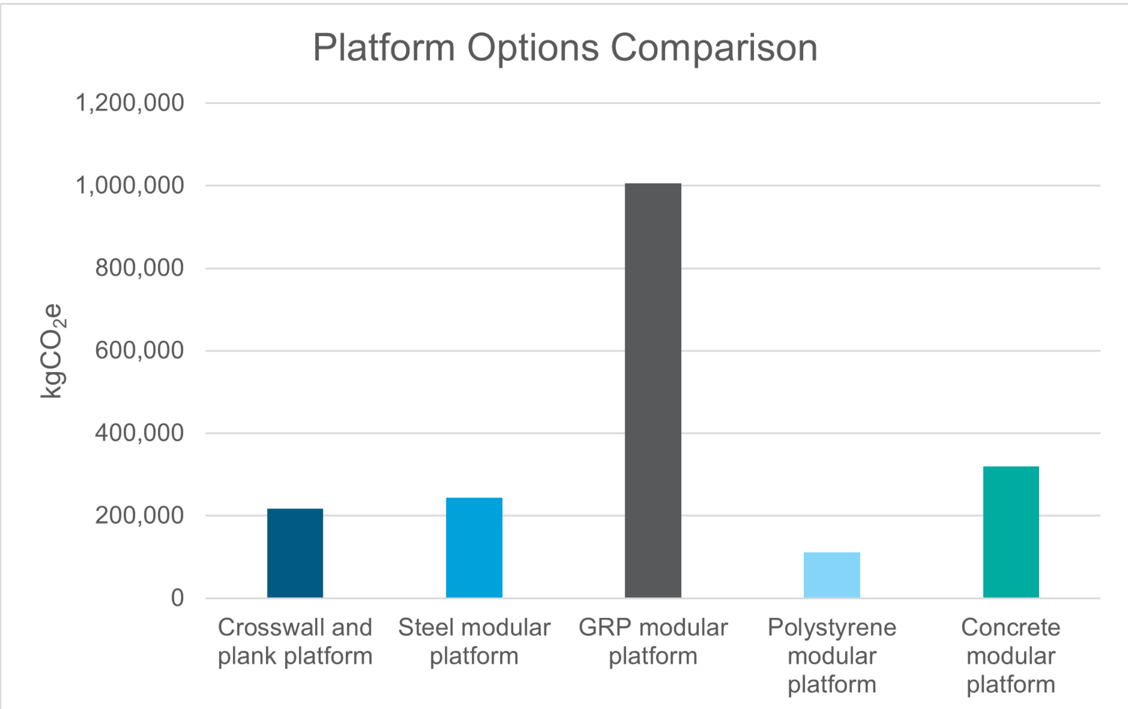

Figure 3: Platform options carbon assessment comparison.

- Consideration should be given to potential opportunities to reduce the volumes of materials in the design option taken forward, aligning with the 'Build Less' principle of the carbon reduction hierarchy.
- Consideration of opportunities to transport materials by rail, wherever possible, as rail transport has a lower carbon intensity than road.
- Seek to identify alternative materials with a lower carbon intensity, wherever possible, aligning with the 'Build Clever' principle of the carbon reduction hierarchy. Opportunities may exist to utilise recycled, or site won materials in the design which would reduce the overall carbon impact.
- Explore opportunities to optimise the construction process by reducing the plant machinery and vehicles required and/or their time on site, aligning with the 'Build Efficiently' principle of the carbon reduction hierarchy. Choosing electric plant machinery and vehicles and using renewable energy wherever possible on site should also be considered.
- A large opportunity exists to reduce carbon emissions if materials are recycled at their end-of-life. Implementing project components so they are as recyclable as possible will therefore increase the opportunity to minimise carbon through recycling at end-of-life.

ATKINS' APPROACH TO WHOLE LIFE CARBON MANAGEMENT

As part of the SNC Lavalin group, Atkins made a commitment in May 2021 to achieve net zero by 2030. Our approach to whole life carbon management forms part of our contribution to the SNC Lavalin purpose to "create sustainable solutions that connect people, data and technology to design, deliver and operate the most complex projects".

Our approach is a core part of our Engineering Net Zero[19] initiative, with a vision of "embedding sustainability in everything we do, progressing attitudes within the industry and aspiring to make all schemes in which we are involved net zero by 2030."

We are committed to offering our clients ambitious design options and advice that are fully compatible with Net Zero outcomes. We aim to design out carbon at every opportunity, with our methodology focused on driving engagement, collaboration, and innovation amongst all our project partners, including asset owners, designers, construction teams, operators and materials suppliers. At every project stage we strive to challenge carbon intensive materials and methods and push the boundaries of innovation to enable our clients to develop solutions that deliver long-term positive change. We channel our low-carbon engineering experience into pioneering solutions for faster decarbonisation of businesses, sectors and regions at scale, to deliver sustainable economic growth.

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