Digital Tools Drive Decarbonization in Infrastructure Projects

Reducing lifecycle carbon emissions with project stakeholders

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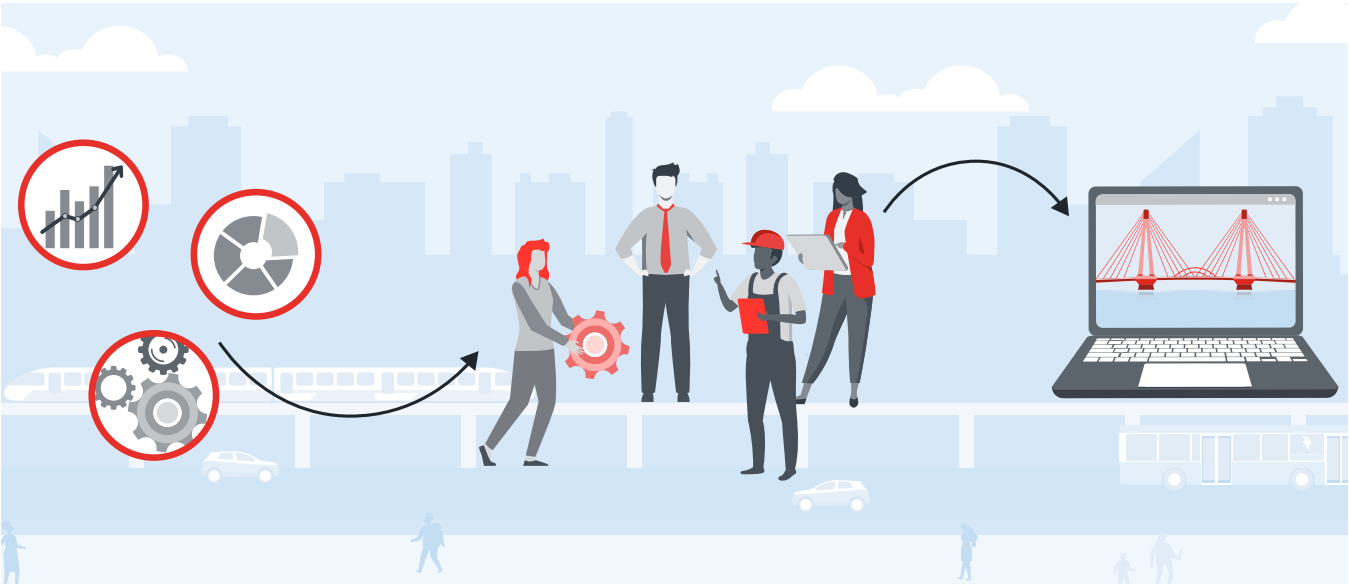

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Digital tools provide an essential means for infrastructure project stakeholders—from engineers and designers to contractors and clients—to assess and report lifecycle impacts toward reducing the overall environmental impact of an envisioned asset. LCPro and Carb0nise, two of the digital tools developed by WSP, enable the identification and selection of the most environmentally friendly design solutions, including materials, and the results can be made visible to all relevant project stakeholders. Projects can then apply the material and structural options with the lowest embodied carbon[1] for newly constructed, refurbished or repurposed structures.

The following article explores LCPro and Carb0nise—their use in infrastructure projects and evolving development.

1 Embodied carbon refers to all emissions of greenhouse gases associated with materials and construction processes throughout the lifecycle of infrastructure assets. The word "carbon" is used to indicate a broader range of emissions, including not just carbon dioxide but also other greenhouse gases.

Overview

Neil Ganju: Following the principles of PAS 2080, the international standard for managing embodied carbon in infrastructure projects, both tools can measure the embodied carbon at the very beginning of our projects to understand the baseline of each project. The biggest impact a team can make on embodied carbon is from the concept design stage—if we can accurately measure the baseline embodied carbon of our project using these digital tools, we can then set an achievable target to decarbonize the project.

Elisa Khouri Chalouhi: The comparison functionality in LCPro is especially useful in the preliminary stages of the project to quickly compare alternative design solutions, set a target for the end-of-project embodied carbon level and support ongoing decision-making.

LCPro helps designers see the effect of their choices—in terms of materials and dimensions, such as slab thickness or reinforcement amount—on the total cost and environmental impact. Thus, it familiarizes them with the options toward making more sustainable choices. Thanks to the automatic extraction of information from 3D models, production of reports including input data, assumptions, detailed calculations and results, LCPro supports the communication between coworkers in consecutive steps in the project.

Matt Taylor: Any project modelled in Autodesk Revit can have its carbon measured with Carb0nise. Carb0nise honors project phasing, such as existing or demolished, while also allowing for comparison of multiple design options, such as 32/34/36 storey options. Depending on whether the audience is a client, contractor or a carbon accountant, the output can be shown in simple one-pagers or complex break-down reports.

Snapshot of LCPro and Carb0nise

The digital tools can be applied in different types of infrastructure projects, such as bridges, roads, rail, aviation and maritime.

LCPro

- LCPro is a desktop application that can be used standalone or in connection with 3D models within Tekla Structures.
- A1-A4 lifecycle stages are supported, with plans to extend to other lifecycle stages.
- The analysis includes embodied carbon for climate change as well as other impact categories, such as energy consumption, human toxicity and ozone depletion.
- In addition to lifecycle assessment, the tool performs lifecycle cost analysis. It covers investment, operation and maintenance, inspection and demolition costs as well as user and society costs associated with traffic disturbances and increased accidents risk during activities, such as repairs and inspections.
- Two possible design solutions can be compared—in terms of environmental impact or costs—in the graphical user interface.
- Results of the LCA and LCC analyses are displayed in the graphical user interface and can be exported as Word and Excel reports to communicate to clients and other stakeholders in the project. The reports are customized in shape, content and language for every region using LCPro.
- The tool can be used across countries within WSP; it currently includes environmental data from Sweden and the United States.

Carb0nise

- Carb0nise is WSP's embodied carbon calculator for Autodesk Revit.
- A1-A5, C1-C4, D lifecycle stages are supported, with B1-B5 in testing.
- Carbon-reducing values and traditional material values can be actively measured to quantify reductions. Users can compare multiple design solutions and share the results with project stakeholders.
- Carbon data is added to elements as they are created to allow early decision-making.
- Carbon data is exported in formats consumable by reporting tools such as Power BI.
- Colour-coded 3D views are created in Revit to allow visual analysis.
- Includes features to estimate the amount of steel-reinforcement and steel connections in the design.
- The tool can be used across countries within WSP. Data exists for the United Kingdom, New Zealand and Australia, with data for the United States, Canada and Middle East in early planning stages.

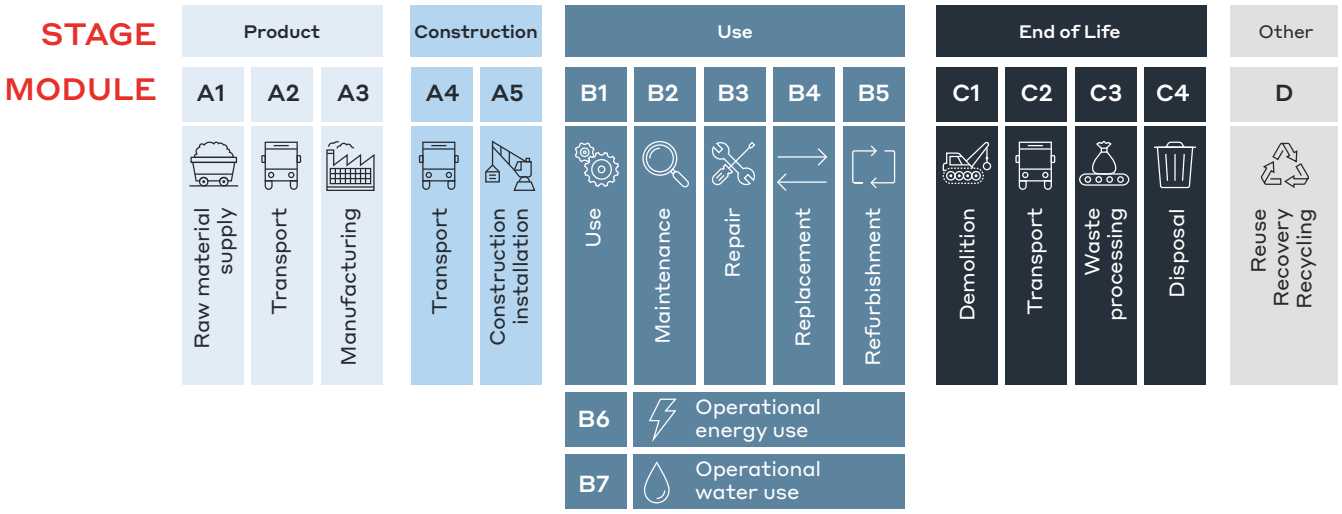

Figure 1 represents the stages and elements of lifecycle carbon emissions. Adapted from *Guidance Document for PAS 2080*, April 2023 – Permission to reproduce and adapt extracts from British Standards is granted by BSI.

Digital Tools in Detail

LCPro

Elisa Khouri Chalouhi: LCPro is a desktop application that automates the calculation of embodied carbon environmental impacts and costs associated with the infrastructure being developed, refurbished or repurposed.

The lifecycle assessment (LCA) methodology is used to calculate embodied carbon for climate change as well as other impact categories, such as energy consumption, human toxicity, ozone depletion during the production phase (A1-A3) and transportation to the building site (A4).

Within the tool, the user can select among a list of available materials with country-dependent emissions factors and introduce alternative materials as well as alternative EPDs (Environmental Product Declarations).[2] It is possible to select the distance between the producer of each material and the building site as well as the transportation mode. These choices, together with the design of the structure in terms of material

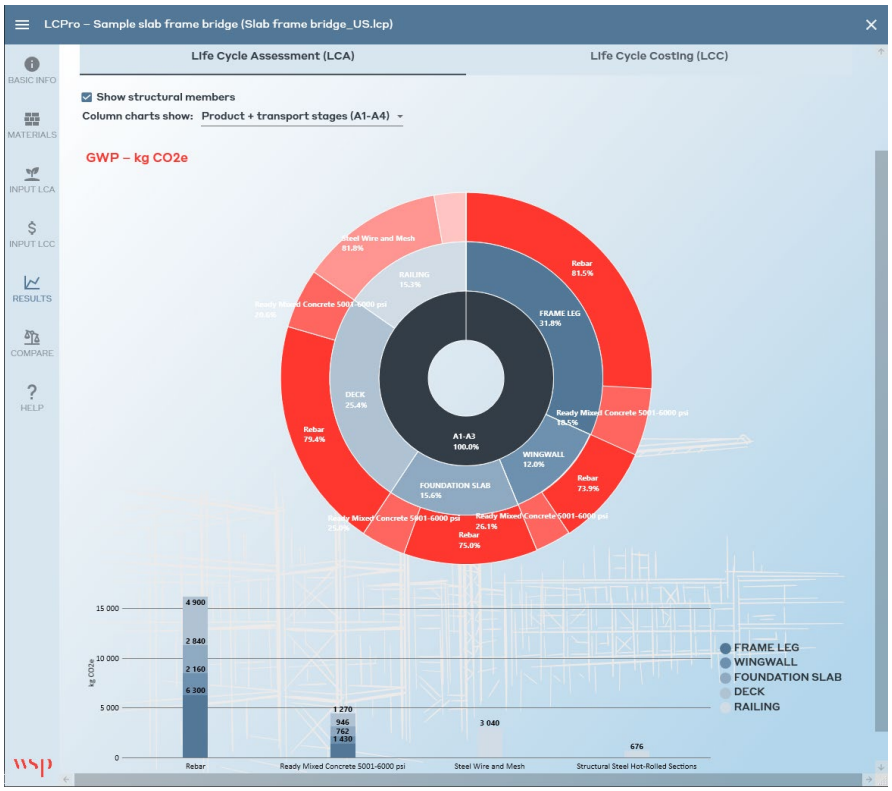

Figure 2 – Results of analysis using LCPro

2 An Environmental Product Declaration communicates the environmental impact of materials over their lifetime.

amounts, affect the total embodied carbon of the structure. The way the results of the lifecycle assessment are displayed in the LCPro graphical user interface highlights emissions contributions to the total emissions from several areas: each lifecycle stage, structural component and material. Discovering, for example, that a big percentage of the total embodied carbon is due to stages A1-A3, the engineer could decide to opt for a producer farther away from the building site but with cleaner production techniques. Another approach to reduce the emissions could be to optimize the structure by, for example, adjusting the amount of concrete and corresponding reinforcement content. In some cases, it would be necessary to evaluate a completely different solution such as a reinforced concrete bridge instead of a composite bridge. The list of possible climate actions is long, and LCPro supports the engineer in identifying the most effective option.

Once the engineer produces two possible design solutions, the solutions can be compared—in terms of environmental impact or costs—in the graphical user interface.

In addition to lifecycle assessment, LCPro can perform cost analyses. The lifecycle cost (LCC) methodology is used to calculate direct costs—including investment, operation and maintenance, inspection and demolition—as well as indirect costs, including user and society costs associated with traffic disturbances and increased accidents risk during activities, such as repairs and inspections.

Figure 3 – Comparing two design solutions using LCPro

Modifiable LCC and LCA reports, which can be delivered to clients, are generated together with Excel files for future use in the project. LCPro can be used standalone in the early design stage to quantify and compare embodied environmental impacts and costs of several alternative solutions; it can also be used in advanced design stages starting from a 3D model of the structure. The tool automatically imports material information (volumes and materials used), thus improving efficiency and reducing the risk of mistakes when transferring data.

The use of the application, when compared to the traditional manual approach, reduced by 90 percent the time needed to collect data, perform the analyses and produce reports; therefore, more time can be spent on identifying areas to optimize the design for reduced carbon impact.

Carb0nise

Matt Taylor: Carb0nise is an Autodesk Revit plugin that helps measure and analyze carbon savings/reductions in our projects.

Two options are shown for each material: a carbon-reducing option and a traditional material option. These values allow the designer to estimate reductions and make real-time choices. Allowances are added for components that are not modelled, such as reinforcement, insulation and connections.

Alternative design solutions are possible within the same model. Each can include different design options, phases and elements. Each of the solutions is visualized, totalled and exported separately, allowing easy comparison.

Carb0nise is useful for live projects, for benchmarking past projects and benchmarking construction methods for early concept guidance.

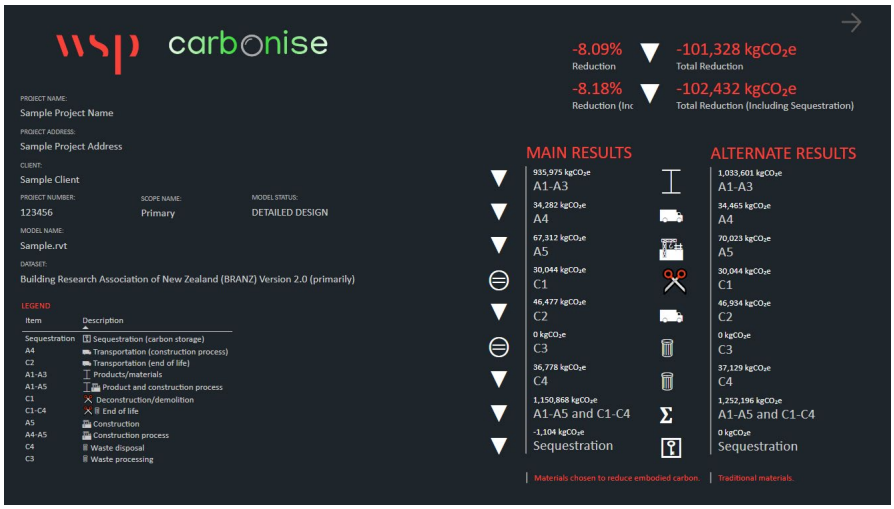

Figure 4 – Example project results-comparison report using Carb0nise

Neil Ganju: Our teams in Australia use Carb0nise because it is incredibly fast to generate an embodied carbon estimate from a Revit model and enables users to explore alternative materials. Importantly, it also allows users to estimate steel reinforcement for reinforced concrete structures—even if the steel reinforcement hasn't been modelled in Revit.

Digital Tools in Use

Benchmarking

Elisa Khouri Chalouhi: LCPro is currently used by WSP in Sweden to calculate the environmental impact of past projects and create a database. One of the aims is to have a baseline to compare new projects against and prove that a reduction in carbon emissions has been achieved.

The Swedish Transport Administration often requests to include in the project delivery environmental actions to reduce embodied carbon. The tool is used in internal seminars to train designers to find such solutions.

Neil Ganju: The Australian construction industry has been at the forefront of using building information modelling (BIM) to deliver complex, major transport infrastructure projects. WSP has developed advanced capabilities in BIM, and Revit is now used for the majority of our structural designs. Leveraging this expertise, WSP teams in Australia have implemented Carb0nise to retroactively measure the embodied carbon of past projects. This creates a valuable database that can serve as benchmarks for our design teams from the very beginning of new projects, enabling them to understand the embodied carbon implications of their designs. With Carb0nise now configured for Australian projects, WSP will seamlessly integrate it into project delivery, allowing for semi-automated measurement and tracking of embodied carbon in our designs.

Engaging a Range of Stakeholders

Matt Taylor: These digital tools also enable the project stakeholders to quantify carbon reductions as the project progresses by tracking changes such as material choices.

Dominique Quesnel: In the context of integrated project delivery, the information from decarbonization tools can be used by many stakeholders throughout the project, in addition to planners and designers, including contractors, owners and environmental agencies, utility companies and community groups, whose approval may be required for projects.

The tools can help quantify and demonstrate carbon quantities to various stakeholders on the project. This facilitates early stakeholder engagement and helps secure approval for material choices.

During the project planning phase, the owner, the owner's engineer and

other stakeholders can also evaluate the development of the project from a sustainability standpoint; this can contribute to establishing realistic and achievable sustainability targets.

During the tender or bid phase of a project, contractors working in a common data environment such as a controlled BIM model can use these tools to help evaluate and compare various design and construction solutions. Decisions made by contractors during the tender or bid phase are influenced by many factors, such as cost, schedule, quality—and increasingly sustainability targets. Having the ability to quantify embodied carbon can help a contractor achieve desired project outcomes and submit a more competitive bid.

In the delivery phase, the development of the controlled BIM model continues. These tools, when applied in the delivery phase, help contractors follow through on decarbonization targets established during the bid phase. A contractor may also use the tools during the delivery phase of the project as input to sustainability reporting on a monthly basis, for example.

Making Ongoing Progress

Matt Taylor: One way we can be prepared for the future is having a broad range of benchmarking at our fingertips. Benchmarking can be at a macro level (projects), or at a micro level (construction methods, materials, economizing).

Neil Ganju: As infrastructure projects grow increasingly bigger and more complex, and with the planet's temperature hurtling towards the 2-degree warming limit, effectively managing project embodied carbon becomes critical. While measuring embodied carbon can be a challenging process, especially within tight project timelines and demanding deliverables, digital tools can automate this process. By providing our project teams with insights into the embodied carbon impact of their decisions and offering a carbon-focused lens for project evaluation, these tools empower data-driven decision-making to reduce our projects' embodied carbon footprint. This allows us to treat embodied carbon as a cost, encouraging collaboration and data-based choices for minimizing it.

How the Tools are Evolving

LCPro

- More BIM tools will be integrated with the LCPro tool.
- LCPro will be connected to other WSP tools for the automated design of structures to perform structural optimization aimed at minimizing costs and environmental impact.
- More lifecycle stages will be added to the LCA.

Carb0nise

- Measuring lifecycle stages B1-B5 will be the latest substantial improvement to Carb0nise. Future improvements include reduction recommendations (such as reductions in slab thicknesses or beam sizes) and stepped timeline graphing.

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