Transforming Infrastructure Sustainability

Unlocking data-driven decarbonization in design, construction, and operation

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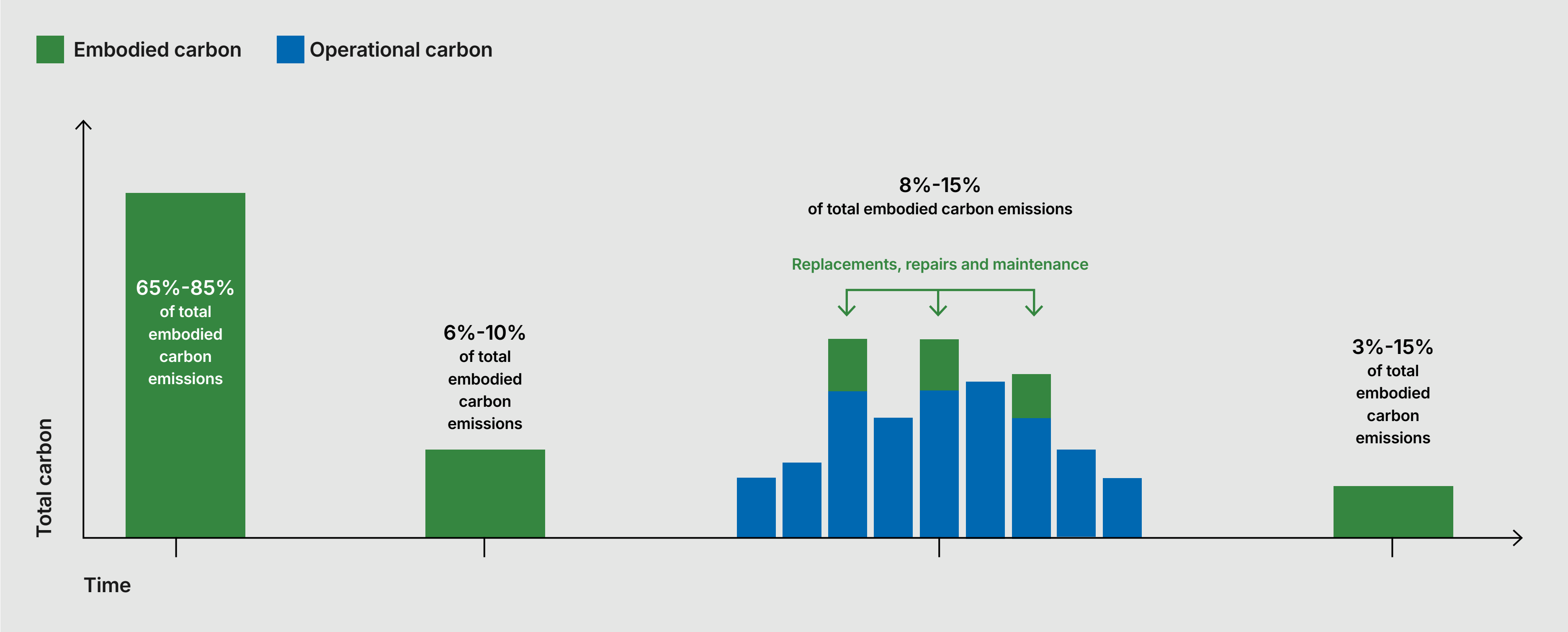
Introduction

The infrastructure sector is at a crossroads. With mounting pressure to meet global climate goals, engineers, architects, and asset owners must confront a critical but often overlooked contributor to greenhouse gas emissions: embodied carbon dioxide. While operational emissions have long been a focus for mitigation, embodied carbon—the emissions associated with materials and construction processes—can account for over 50% of total lifecycle emissions in many infrastructure projects. These emissions can be mitigated long before the asset becomes operational.

Yet, despite its importance, embodied carbon is still challenging to measure, analyze, and manage effectively. Traditional workflows are fragmented, manual, and not designed to provide early-stage carbon insights when they matter most.



The carbon challenge in infrastructure

The construction sector is one of the largest contributors to global carbon emissions. As its role in decarbonization grows, effective carbon assessment has become essential to reduce an asset's lifetime footprint.

Yet in most projects, embodied carbon data is fragmented. Early design decisions often lack carbon insight, while assessments occur later in siloed tools. As projects progress, carbon data is often lost or becomes outdated, making it difficult to use it to inform decisions or refine strategies.

Without integrated tools and real-time insights, managing resource efficiency, circularity, and sustainable design goals become increasingly challenging.

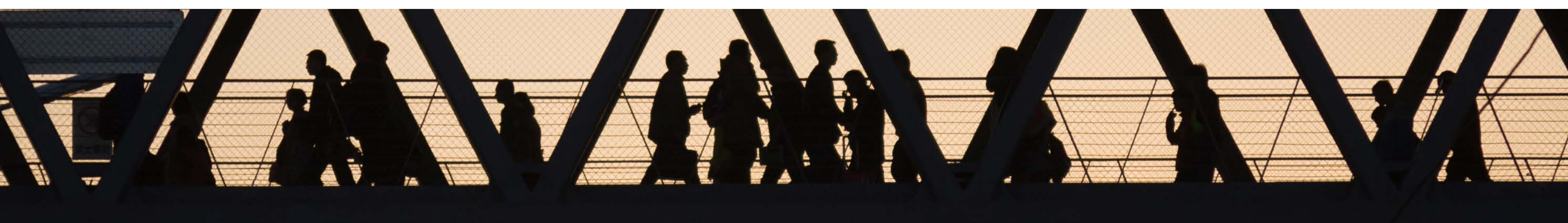
Poor data continuity
Carbon data does not flow smoothly across project phases as insights from early assessments are often lost, outdated, or disconnected from evolving designs and downstream decisions.

Lack of visibility
Carbon data is often inaccessible or available too late to influence design decisions.

Missed opportunities
Without timely insights, teams miss the chance to optimize for sustainability in early planning and design.

Manual effort
Calculating embodied carbon typically requires time-consuming manual data entry.

Disconnected systems and siloed teams
Carbon data is often trapped in separate calculators and teams, isolated from design files and engineering workflows, making it difficult to bring insights into project decisions.



What is embodied carbon reporting and accounting?

Embodied carbon reporting and accounting refers to the systematic measurement, documentation, and management of carbon emissions associated with the entire lifecycle of materials used in a construction or infrastructure project from extraction and manufacturing to transport, installation, maintenance, and end-of-life.

Effective decarbonization begins with the ability to measure, report, and manage embodied carbon. External drivers ranging from regulation to client expectations are making embodied carbon reporting and accounting not just important, but essential for project success.

The purpose of carbon reporting and accounting

Assessment
Evaluates the carbon footprint of materials and processes across all lifecycle stages.

Reduction planning
Identifies actionable opportunities to lower embodied carbon through design, material selection, and procurement strategies.

Compliance and transparency
Supports alignment with regulatory requirements, certification schemes, and stakeholder expectations.

Decision support
Provides data to inform sustainable trade-offs during planning, design, and procurement.

Key components of carbon reporting and accounting

- **Material inventory:** Detailed listing and classification of all materials used in the project.
- **Quantity takeoffs:** Measurement of material quantities using standard units for consistent carbon estimation.
- **Emission factors:** Application of verified carbon intensity values for each material or process.
- **Carbon calculation:** Aggregation of emissions by material, lifecycle phase, or project scope.
- **Data quality and validation:** Cross-checking data sources for completeness, accuracy, and consistency.

The business case for carbon intelligence

While the primary goal of carbon analysis is environmental impact reduction and climate change mitigation, its secondary benefits are compelling, especially when viewed through the lens of long-term asset performance:

- Lower material consumption and waste
- Improved cost control during construction and operational use
- Resilient, future-proof infrastructure ready for climate impacts
- Enhanced livability for communities and end users
- Increased eligibility for green funding and ESG investment

Because infrastructure assets often remain in service for decades, decisions made in design can influence emissions and operating costs for generations.

Introducing Bentley's Carbon Analysis

Bentley's Carbon Analysis enables designers and engineers to efficiently calculate, report, and visualize the embodied carbon footprint of their proposed designs. Leveraging Bentley's iTwin technology, design data—regardless of source location or type—can be accessed for streamlined carbon quantification and 3D visualization to inform design and review workflows. This integrated approach provides:

- Easily **repeatable,** for as much reporting as needed
- Highly **accurate,** one-click reporting
- **Time and cost** savings
- Optimize for **decarbonization** during the design process
- **Insights** into live carbon hotspots to affect immediate design improvements
- Ensure regulatory **compliance**
- Enhanced collaboration and **alignment** opportunities with an iTwin®

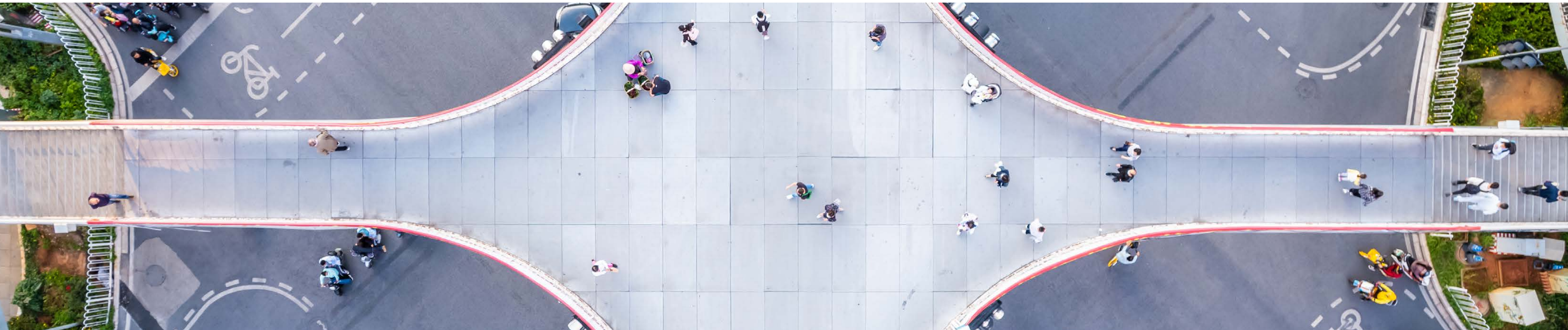
Bridging the decarbonization gap

Using Carbon Analysis within digital twins
Decarbonization goals are set at the organizational and policy levels, but project teams often lack the data, tools, and workflows needed to translate those goals into practical design decisions, creating a gap between ambition and action.

Carbon Analysis, embedded within digital twins, helps close this gap by enabling real-time, data-driven decisions throughout the project lifecycle.

- **Contextual insight:** Digital twins provide a live, connected representation of infrastructure assets. When Carbon Analysis is layered into this environment, it allows designers to visualize embodied carbon in context, by asset, location, phase, or material type.
- **Early and continuous feedback:** With digital twins, teams can assess carbon implications from early planning through construction, supporting iterative optimization and design choices that align with decarbonization goals.
- **Data-driven decision-making:** Carbon metrics are tied to actual quantities and verified emission factors, giving teams trusted data to support reduction strategies and stakeholder reporting.
- **Integrated workflows:** Rather than relying on siloed carbon assessments, Carbon Analysis within digital twins integrates seamlessly with existing design and review processes, improving adoption and reducing friction.
- **Transparency and accountability:** Visualizing carbon performance within the digital twin promotes collaboration, accountability, and stakeholder engagement, ensuring decarbonization is not just a goal, but a measurable, trackable outcome.

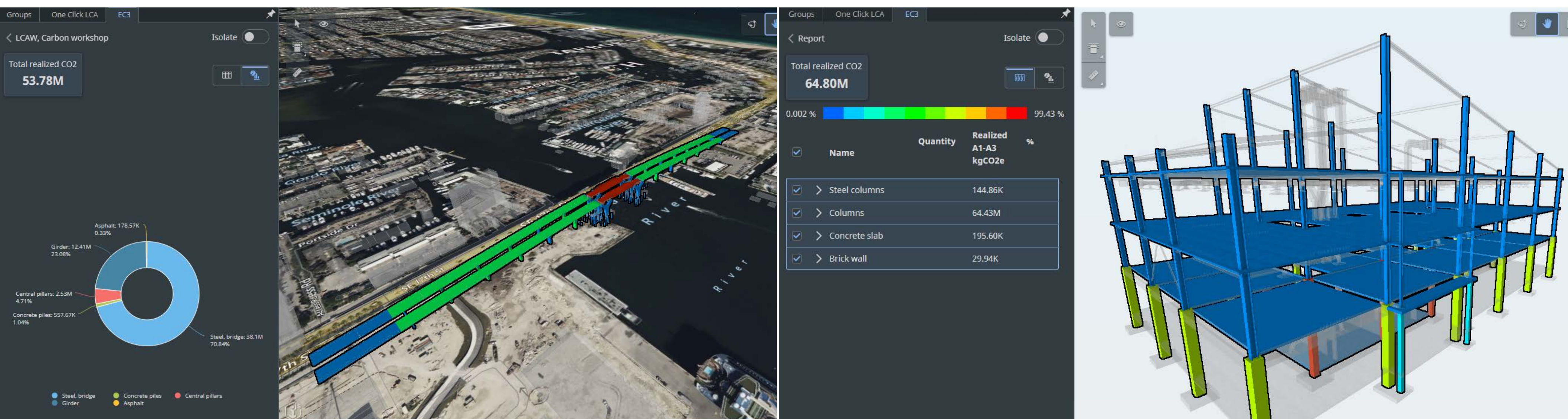
By embedding carbon intelligence into the 3D model, Bentley's approach transforms sustainability from a static report into an active, ongoing design parameter, empowering infrastructure professionals to drive real, measurable impact.



The core capabilities of Bentley's Carbon Analysis

Going beyond reporting, Carbon Analysis pulls the embodied carbon assessment data straight into the live design. Appearing as a simple heatmap within the 3D model, users can instantly see the impact that individual design elements have on their environmental footprint.

- **Automated quantity extraction:** Extracts material quantities from design models without manual input, saving time and reducing errors.
- **Faster, easier data preparation:** Using aggregated project data from inside or outside of Bentley, data prep is streamlined with auto calculation of material volume and quantity data and simple grouping functionalities.
- **One-click carbon reporting:** With integrations with EC3 and One Click LCA, highly accurate A1-A3 embodied carbon reporting is generated with one click. Run them early and often—all custom data is saved, so reporting is always fast and easy.
- **Cloud-based visualization:** See your embodied carbon as simple heat maps within individual design elements in your 3D model, providing more opportunity to identify and make changes that optimize for decarbonization before the design is finalized.
- **Web-based access and interoperability with open data ecosystems:** Provides broad stakeholder access without requiring specialized software and ensures project data is reusable across disciplines and tools, minimizing vendor lock-in and maximizing collaboration.



Use Case

Driving early-stage carbon reductions

WSP, a global engineering leader, turned to Bentley's Carbon Analysis platform to simplify and accelerate embodied carbon assessments throughout their portfolio. Traditional tools were too slow and complex to support early design decisions, where the biggest impact can be made.

By using interactive 3D visualizations and real-time feedback, WSP replaced static spreadsheets and reduced assessment timelines from weeks to hours. Seamlessly integrated into their design workflow, the platform enabled continuous evaluation as projects evolved.

The results: faster decision-making, stronger stakeholder engagement, and deeper carbon reductions. As WSP put it, "It's really a game changer."

View the video testimonial to learn more

Driving sustainable outcomes across industries

Carbon Analysis is reshaping how industries approach infrastructure design and delivery. From transportation to utilities and buildings, Bentley's solutions help quantify emissions, improve decision-making, and align with sustainability goals.

Transportation infrastructure
Use case: Road, rail, and airport projects

Benefit: Quantify embodied carbon during design and construction phases to support greener procurement and compliance with government mandates.

Buildings and campuses
Use case: Commercial buildings, healthcare facilities, campuses

Benefit: Assess and reduce embodied carbon in structural and MEP systems through design iteration.

Mining and industrial facilities
Use case: Material handling infrastructure, processing plants

Benefit: Analyze the carbon impact of heavy infrastructure and enable more sustainable site planning and asset operations.

Cities, municipalities, and land use planning
Use case: Capital planning, zoning, public works, parks, greenways, urban infill, and nature preserves

Benefit: Prioritize low-carbon, low-impact developments and support data-driven decisions for infrastructure growth, resilience, and preservation.

Getting started

Explore practical strategies for reducing embodied carbon in the third chapter of Environmental Analyst's Corporate Guide: Delivering Resilient Infrastructure.

Ready to take control of embodied carbon in your infrastructure projects? Check out Bentley's Carbon Analysis and let us help you turn your carbon goals into measurable results—starting today.

Learn more