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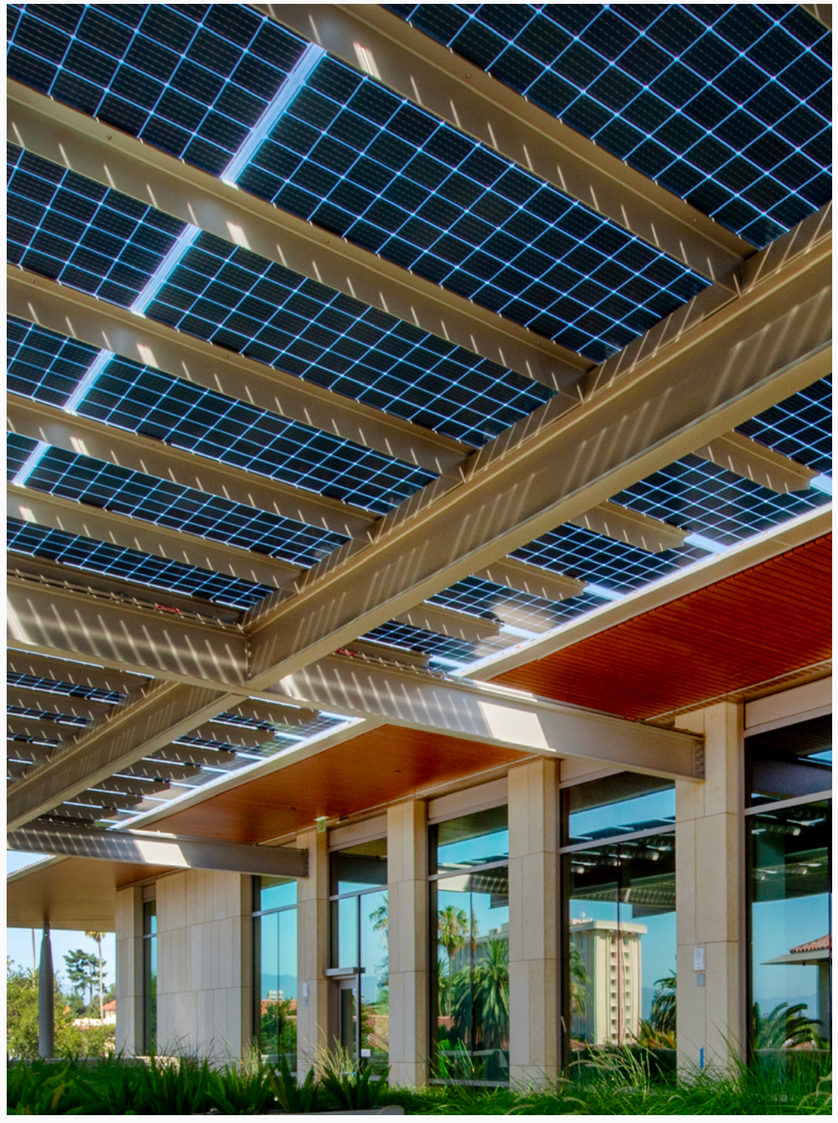


The Architect's Guide to Carbon Management

AUTODESK

The Architect's Guide to Carbon Management

Thank you for picking up this guidebook. We have produced this resource for *you*, the architects and designers who design and shape our built environment.

Our intention is to support you and your work and deliver key information in your quest to design sustainably using the technology tools available to your firm.

We will address how to analyze the carbon impact of buildings early in the design process, at a stage when it is easier to influence design decisions.

We will also explain how to manage both embodied and operational carbon holistically, from planning through to detailed design and documentation, within standard architectural workflows. And we will give you insights into understanding how carbon analysis can benefit your business.

Contents

Introduction

As architects, you are the designers of our built environment. Your knowledge and skills create new designs and innovative retrofitting of spaces to live, work, and play. This work brings opportunities to reduce the impacts of carbon emissions on climate change.

Increasing regulations and government net-zero policies are elevating sustainability as a design requirement, such as the EU Energy Performance of Buildings Directive regulatory framework. Alongside ever-tightening standards and mandates, commitments to report environmental data (AIA 2030 Commitment) and meet voluntary environmental certification programs are on the rise: LEED, BREEAM, DGNB, Passive House, Zero Energy Certification, Living Building Challenge, and more.

It's not surprising that we have "reached a tipping point", where market demand for low carbon building stock is at an all-time high. Designing to meet sustainability criteria is good for the environment, good for people, and good for your firm's business.

While carbon mitigation is an increasing priority in building design and green construction practices, historically it has been challenging to estimate or quantify the carbon footprint of a building—accurately calculating key metrics such as embodied carbon or predicted energy consumption.

BLDUS/Grass House (c)Ty Cole/OTTO

Fortunately, early-stage carbon assessment is now more accessible. Integrated analyses, robust platform-enabled APIs, and AI-powered tools are enabling real-time design feedback and connecting data with intuitive dashboards in design authoring technologies.

These tools empower you to analyze environmental site conditions, quantify building materials, and measure both the embodied and predicted operational carbon of a design directly integrated with BIM workflows. Additionally, leveraging AI in early-stage assessments can help accelerate this workflow, such as to aggregate dozens of data sources and data types and deliver you more robust data-driven information.

Enhanced workflows and connected data enable you to assess and balance trade-offs between design decisions, including key issues such as optimal space layouts, design and operational predictions like embodied carbon, energy efficiency, and renewable energy system offsets.

Because sustainability isn't just about carbon—it's about successfully balancing all these multidimensional design criteria to deliver on the project goals.

> "The biggest climate gains are made up front in the project development process, when data is scarce, but the solution set is vast."
>
> —Brad Jacobson, FAIA, a principal at EHDD

Chapter 1

The importance of setting a carbon baseline from the very start of the design process

Your design team can make the biggest impact by integrating carbon assessments into the earliest stages of design and conceptualization to set a baseline and a project target for carbon emission reductions.

Starting early enables you to 'put a stake in the ground'—have a carbon baseline—from which you can continually measure and manage your carbon impacts throughout the design process. The further you go before doing an initial assessment, the less context you have for understanding which design decisions have carbon impacts.

Once a baseline is established, managing carbon and measuring your carbon reduction efforts relative to your baseline can be implemented across the lifecycle of a building design or renovation project. Measuring the total carbon emissions of a building project requires nuanced analysis of supply chains, materials, operational performance, and more. Because of this complexity, you may have relied on specialist experts, with their own toolsets, to provide these analyses.

Many of these analyses are not integrated with regular BIM workflows, and they tend to occur later in the design process, including carbon assessments. At this point, the expert's role is to verify metrics and suggest changes where still possible. However, if the design is not already optimized for carbon emissions from the start, there are fewer, and less impactful, incremental options to consider and implement. And changes that are made in the later stages become costlier.

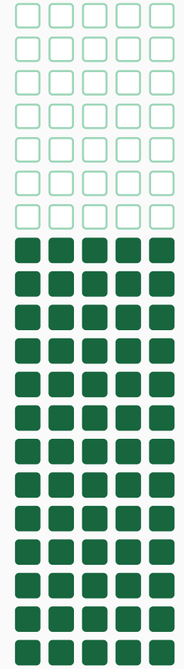
However, if you design for more sustainable outcomes from the very beginning of the design process and strive to set a baseline and carbon reduction target, you can open up a much greater and more impactful opportunity space for the reduction of carbon emissions (demonstrating quality, performance, and sustainability credentials).

Bearing in mind the goals and benchmarks of certifications, you can work towards meeting these requirements by testing and optimizing from the earliest point. And you can analyze the role and impact of all design choices—building form, structural systems, envelope and façade materials, interior outfitting. Clear data and insights from analysis tools embedded in the architectural workflow can facilitate smarter and more informed decisions in the conceptual design phase.

Whatever the desired outcome, aiming for a 'good' understanding of design choices and their impact at a point when they can still be optimized, is essential.

65%

of a project's total carbon emissions have already been determined by the end of conceptual design[1]



[1] Hakkinen, T., Kuittinen, M., Ruuska, A., & Jung, N. (2015, July 21). Reducing embodied carbon during the design process of buildings.

Embodied and operational carbon

What is 'embodied carbon'?

Embodied carbon refers to the greenhouse gas (GHGs) emissions created from the extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials.

These upfront emissions contribute around 13% of annual global greenhouse gas emissions and are called "embodied carbon" because the environmental impacts associated with building activities are locked in place once a structure is built–before it's even occupied or used.

What is 'operational carbon'?

Carbon emissions are generated by the burning of fossil fuels to create energy and are released during the operational phase of a building–during building use for normal operations until the building is no longer in use.

These emissions, called operational carbon, are the byproduct of the consumption of all operational energy sources used to keep our buildings warm, cool, ventilated, illuminated, and powered and contribute to around 28% of global greenhouse gas emissions.

Chapter 2

Five steps to incorporate carbon analysis tools into your workflow

We've seen how initiating carbon analysis, with a holistic view of embodied and operational carbon, at the conceptual stage, lets you first set a baseline from which to better assess and manage the tradeoffs around design and sustainability.

But how can you start integrating carbon analysis in your design and planning workflow? And how can you start understanding and estimating carbon impacts?

Here are 5 steps to get you started.

1

Start with analyzing the site to optimize for passive design strategies

Thinking about environmental factors such as climate, surrounding buildings, and site context from the start of the project is the foundation of sustainable design decisions. With easy-to-use cloud software such as Autodesk Forma, you can access a wide range of data, which help you optimize your site designs for microclimate, wind, or solar conditions in real time, while designing. This enables you to make and implement earlier and better decisions and reduces dependency on disconnected and incompatible toolsets.

2

Iterate with different design strategies

Cloud-based tools such as Autodesk Forma and Insight based on powerful APIs allow you to evaluate and analyze building form, spaces, materials, and construction systems at a conceptual level and continue through the design process. In addition to programmatic criteria, you can iterate with different materials, structure, floor area, window size, and other variables to see how they affect carbon impacts.

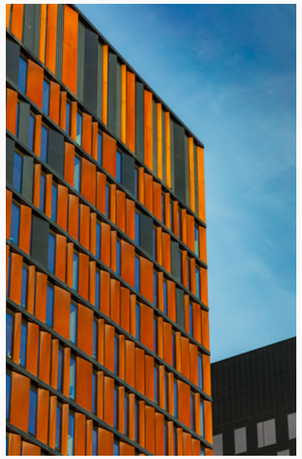
This evaluation lets you explore the impacts and tradeoffs of different design options as you seek to reduce the project's carbon footprint in harmony with all the other functional and practical goals.

3

Benchmark design options against project goals

If you're looking to hit specific targets and outcomes, use carbon analysis to test different design strategies against these goals.

Whether it is a general goal to reduce embodied carbon, or more specific goals about energy-use intensity or solar PV generation, benchmarking design strategies at an early stage helps you meet them with optimal efficiency and cost.



4

Track while designing

Certification programs like LEED, BREEAM, and DGNB award projects that incorporate early environmental design analysis to optimize design strategies for well-performing, efficient, and healthy buildings. That process starts with the three steps already outlined. Whether it is sustainably upgrading a brownfield site or understanding the impact of materials and systems in a greenfield project, the most sustainable outcomes begin in conceptual design. Starting sustainability analysis early, tracking progress throughout design, and tracking performance against targets maximizes the chances of success to meet project goals and certifications.

5

Take advantage of the third-party ecosystem in the detailed design phase

Autodesk's tools give you an unrivalled and unique start in tracking carbon use in a project towards more sustainable outcomes. But sometimes you'll need specialized tools to narrow and focus your carbon analysis.

There are a range of third-party solutions which help with augmenting carbon analysis. These might be focused on meeting specific standards and regulations or local requirements, or they might give access to specific local data sources. Tools like tallyCAT (materials embedded carbon analysis) and One Click LCA and tally LCA (lifecycle assessment calculation tools) are extensions to the Autodesk platform and can be used to enable detailed analysis and reporting requirements.

You can use Autodesk Platform Services (APS) to build custom tools, dashboards, and workflows that access design data to conduct carbon analysis. You can shift analysis to the cloud, where resources can scale and jobs run more quickly.

Firms are using APS to bring embodied carbon and performance data into Forma, BIM 360, and Revit. You can see initial and long-term sustainability calculations for building materials, glazing, and mechanical systems as you design.

In addition, there are thousands of ready-to-run applications in the Autodesk App Marketplace. APS Certified Partners—including Sustainability Tech Partners—can build custom solutions.

Chapter 3

Incorporating carbon analysis is good business for architecture practices

Carbon management helps you design for reduced environmental impact of projects, contributing to global climate goals.

But investing in carbon analysis is also good for your firm's business. Firstly, both commercial and publicly funded projects are increasingly requiring sustainable design. What's more, you can monetize your expertise and differentiation through added-value services, and attract the next generation of talent to your firm.

Here are four specific ways you can use carbon expertise to build your business.

1

Sell more services across the project lifecycle

Being able to conduct sustainability assessments such as carbon analysis throughout the building design and renovation lifecycle expands your influence, design impact, and ability to sell value-added sustainability services. Establishing baselines and recommending one or more sustainability targets may positively influence the project direction. That may include directional advice about intentional design iterations such as a general analysis of the tradeoffs between mechanical and architectural system strategies or the projection of the building's operational cost savings by comparing different types of envelope systems.

2

Differentiate your firm as a leader in best practices

Adapting existing workflows to include carbon analysis can have a significant impact on project outcomes. And this expertise can help differentiate your firm from others.

By developing leadership in the application of analysis workflows to drive sustainable outcomes in architecture and building design, you can enhance your reputation in the market through demonstrable success in sustainability.

3

Become an expert in performance analysis for certification requirements

Using carbon analysis tools to deliver outcomes that meet certification requirements expands your offering for clients who desire certifications to improve their building performance.

4

Carbon analysis brings you closer to owners, operators, and clients

Your understanding of and ability to optimize for the long-term operational carbon of a building project is valuable information for any owner, operator, or client who wishes to meet particular building performance criteria and to qualify for favorable financing options (which may be available, for example, for projects with high LEED or BREEAM scores). Your ability to lower operational costs can boost the competitiveness of any proposals you make and can help in building mutually beneficial long-term relationships.

311 Third Transformation, San Antonio, Texas, Lake|Flato, Image Courtesy Robert G. Gomez

Chapter 2

How one architecture firm transformed a 100-year-old former car dealership into a beacon of sustainable design.

Read the story >

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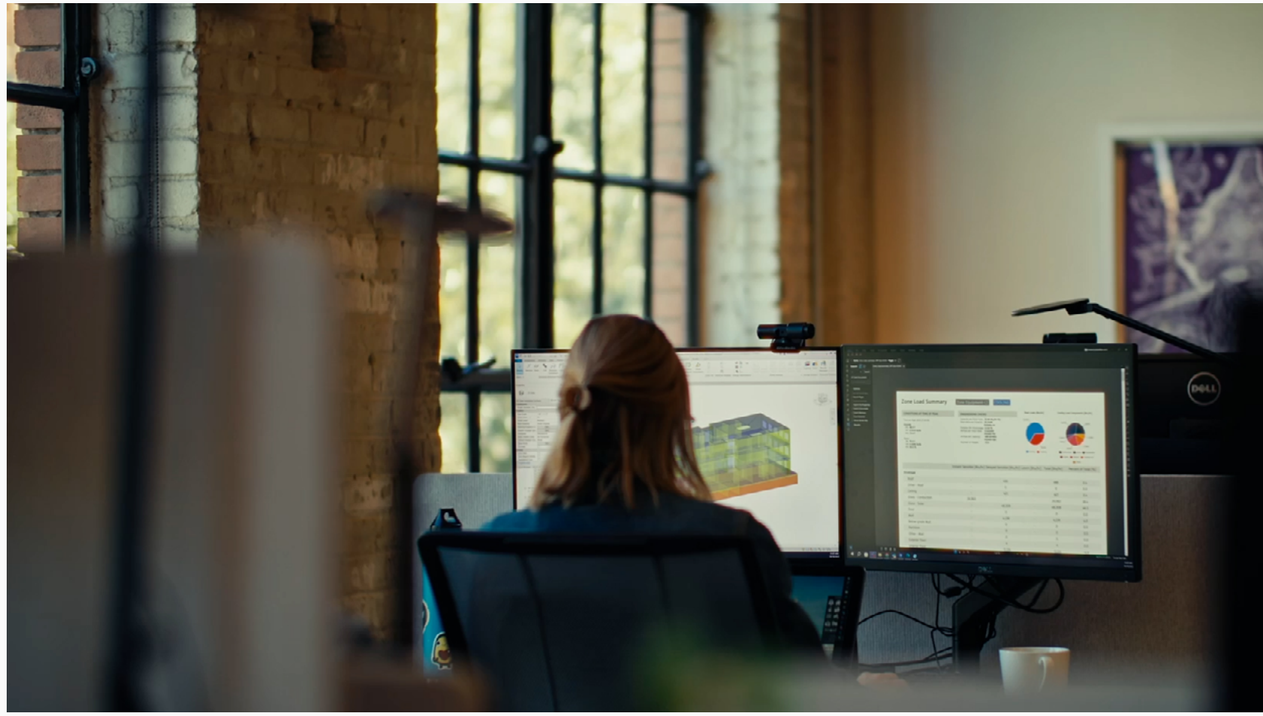
Chapter 4

The role of carbon analysis tools in the design process: how Autodesk helps



We've looked in detail in how carbon management tools empower you to quantify, analyze, and minimize the carbon footprint of building designs. But which tools? And when should you use them in the process?

The process of calculating embodied carbon requires a significant amount of material data and product transparency spanning mining, refining, manufacturing, logistics, and disposal. Calculating operational carbon means determining energy sources and then calculating energy use form heating, cooling, lighting, appliances, and equipment. That information can be totaled and converted to CO2 equivalent, projected over the building's lifetime.

The industry is standardizing this complex process through the implementation of Environmental Product Declarations (EPDs). EPDs provide rigorously tested, environmental data based on a lifecycle assessment that was independently verified.

Autodesk has invested in developing and supporting solutions and integrations that use EPD material data to equip you with the data and insights you need to make informed decisions that can reduce the embodied carbon of your building projects.

At every stage of the design process, Autodesk tools and plugins can extend carbon analysis capabilities into your conceptual design and standard BIM workflows. So, you can manage the sustainability process from design to documentation without a complex and disconnected toolset.

311 Third Transformation, San Antonio, Texas, Lake|Flato, Image Courtesy Robert G. Gomez

Embodied Carbon Analysis in Autodesk Forma

Autodesk Forma is a cloud software that offers powerful, yet easy-to-use AI-powered tools for conceptual design.

Autodesk Forma lets you rapidly set up a site with real-world contextual data and model complex 3D designs in minutes. Even without specific expertise, you can then iterate on designs to account for factors such as daylight, wind, noise, microclimate, or embodied carbon. You can explore myriad concepts and evaluate their performance, sustainability, and living qualities to optimize for the best outcomes, all while designing.

The Embodied Carbon Analysis in Forma, developed in cooperation with architecture firm EHDD, enables you to better understand the carbon impacts from primary material choices and building form during site feasibility and massing studies at the beginning of a project planning process. You can evaluate material suitability and rapidly see the influence of your design decisions on associated carbon emissions.

Early concept planning has the greatest opportunity for impact and at the same time, it is the point where design changes have the lowest cost risk.

With Autodesk Forma, you can start the conversation about your project's carbon emissions early, whether it is with your clients or internal stakeholders. And to continue your detailed design process, you can fluidly pass data between analysis applications in Forma and Revit. That way, you can begin early phase assessment of embodied carbon in Forma, followed by more integrated assessment of total carbon in Insight during the detailed design phase.

> The biggest opportunity for technology to manage our carbon footprint is by having tools like Forma, that will allow us to analyze our designs, in real time, as we're designing them. Being able to have that information, that feedback, as we're doing the design work is really what's going to enable us to achieve the goals that we need to reduce the carbon impact of the built environment
>
> —Mike DeOrsey, Principal,
> Digital Practice Manager, Stantec

See more >

Visualize embodied and operational carbon in Autodesk Insight

Ideal for new construction as well as retrofit, reuse, and renovation projects, the next generation of Autodesk Insight allows you to visualize key sustainability indicators and projected energy performance, with real-time cause and effect feedback to guide you towards better outcomes.

The next generation of Autodesk Insight is a cloud service that integrates with Revit to offer flexible dashboards, an intuitive interface, and a simple approach to analysis that makes it easy to explore, visualize, and compare carbon analysis results.

Insight uses Revit's Energy Analytical Model as the starting point for Operational (OC) and Embodied Carbon (EC) analysis. Open and extensible, Insight helps you measure, visualize, and compare the interrelated effects of integrated building systems, including building form and orientation, envelope design, internal loads, HVAC systems, material types and quantities, renewable energy offsets, energy costs, and more.

Insight helps you quantify and visualize operational and embodied carbon data stored in the Revit Energy Analytical model. It can aggregate and visualize data from Revit for building envelope performance, material specifications, and more to show the interplay between carbon impacts and energy offsets, among other factors.

See more >

Explore third-party integrations for sustainability

Embodied Carbon in Construction Calculator (EC3):
A free, open-source tool that analyzes available materials and suppliers to help you reduce embodied carbon. This tool enables in-category comparisons, and the database is exclusively Environmental Product Declarations (EPDs) for specific products and materials. Autodesk has been a lead sponsor of EC3, providing easy access for our customers through integration with our design and construction software, including Autodesk Construction Cloud's Takeoff.

tallyCAT: Tally Climate Action Tool enables real-time embodied carbon data connection between a Revit model and the EC3 tool, providing the full functionality of EC3 without leaving Revit.

This free tool can annotate Revit models and components to reuse; save libraries of materials and assemblies for future use.

tallyLCA : With tallyLCA you can conduct cross-category and system Life Cycle Assessments comparison (LCAs–analyses of the potential environmental impacts of products or services during their entire lifecycle) and design option comparisons directly in a Revit model. You can also create LCA without specified products and can compare system design options.

One Click LCA – One Click LCA enables you to export Revit model data and conduct LCAs for whole-life-carbon calculations easily. This tool (which requires a separately paid license) connects BIM data to embodied carbon data from databases globally.

One Click LCA now connects to Autodesk Platform Services. This allows you to get carbon and lifecycle assessments and EPDs automatically with Autodesk Cloud Models without the need to access Revit.

> The motivation for sustainability goes back to our purpose: bringing ideas to life, leaving a legacy, and improving the communities that we live in."
>
> – David Mackenzie, Managing Principal, Digital, Aurecon

> Architects are crucial in combating climate change.... Architects can significantly reduce carbon pollution by integrating innovative design, education, supportive policies, and research."
>
> – Dan Stine, Director of Technology, Lake Flato

Conclusion: The empowered architect in a sustainable future

The built environment accounts for almost 40% of carbon emissions. And it is you who envision and create that built environment. So, you inevitably play an irreplaceable role in the creation of a sustainable future by seeking to reduce emissions.

Autodesk strives to support and augment your unique skills and vision with tools that make your work easier, more productive, and more sustainable—and give you answers you can use and implement—from client presentations to your team's design insights.

The information you will discover by using carbon analysis tools will enable you to be more impactful in reducing emissions for a more sustainable built world.

Interested in learning more about tools for total carbon management?

Find solutions for architects >