MAGNUSSON KLEMENCIC ASSOCIATES FOUNDATION

Building Transparency

Carbon Results Framework Project

Project LCA Results Output Assessment, Recommendations, and Graphical Mockups

June 2024

Context

Funded by the MKA Foundation, the Carbon Results Framework Project (CRFP) aims to create a framework for visualizing embodied carbon and whole building life cycle assessment (WBLCA) results that any WBLCA or embodied carbon estimation tool can utilize. One of the key goals of the project is to more accurately express results as a range of values, with uncertainty and variability considered and represented clearly in graphical representations.

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Contributors

The authors would like to thank the following individuals for their contributions to this project.

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Table of Contents

Background

Beginning in January 2023, the MKA Foundation and Building Transparency evaluated outputs from various major WBLCA and embodied carbon tools including tallyLCA1, EC32, OneClick LCA3, and Athena's Impact Estimator4. An advisory panel of industry experts was assembled to guide and inform the development of the results framework including LCA practitioners, developers, architects, structural engineers, mechanical engineers, and sustainability consultants. This paper summarizes key findings from the evaluation period, outlines successes and failures of existing outputs based on feedback from the advisory panel, and provides a recommended carbon results framework. The framework includes elements to include in pdf and excel reports and recommendations for visual communication of results via a series of graphical mockups. The framework also includes an excel tool to generate graphical mockups.

Existing Output Assessment

Four major carbon accounting and whole building life cycle assessment tools were evaluated to determine the components included in the outputs of each of these tools. The pdf reports, excel reports, and graphical representation of results were studied to determine common components, valuable uncommon components, alignment with major whole building life cycle assessment standards (ISO 21931[5] and EN 15978[6]), and visual communication and organization of each output. A summary of the successes and failures of existing outputs, as determined by the advisory panel, is provided below.

Successes and Failures of Existing Outputs

Both pdf and excel reports from the four tools included in this study were evaluated. Several graphics created by advisory panel members were also evaluated. Key themes emerged from this evaluation as outlined below.

Top 5 Successes of Evaluated Reports

1. **Concise and Comprehensive Graphics**
    a. Visuals are clear, succinct, and sufficiently detailed. They effectively convey information without overwhelming the audience and can be quickly comprehended.
2. **Benchmark Comparisons**
    a. Reports showcase comparisons to benchmarks, aiding in contextualizing data. This includes references to benchmarks for WBLCA or embodied carbon results, enabling comparisons at both the building and material levels.
3. **Thorough Data Breakdown**
    a. Excel reports offer comprehensive breakdowns, dividing results by assembly, division, and various life cycle stages. This presentation of data in multiple formats enhances depth of understanding of results.
4. **Inclusion of Key Data Points**
    a. Reports incorporate valuable data points like the mass or weight of materials and results for various environmental impact indicators.
5. **Information on Methodology**
    a. Reports that include background information about the methodologies in the tools were favored over reports that did not include sufficient detail about methodology.

Top 5 Failures of Evaluated Reports

1. **Use of Single Deterministic Numbers**
    a. Presenting WBLCA or embodied carbon results as a single deterministic number may falsely imply accuracy and/or precision.
2. **Lack of uncertainty representation**
    a. Most reports fail to incorporate uncertainty in graphics and results tables, resulting in a crucial aspect missing that impacts trust of the data.
3. **Inconsistent Treatment of Biogenic Carbon Emissions**
    a. The reports evaluated either did not break out or account for biogenic carbon. Further, there is a lack of uniformity in handling biogenic emissions across different tools and reports.
4. **Unclear or Hard-to-Read Visuals**
    a. Some reports include graphics that are challenging to interpret, particularly when overloaded with too much text making them difficult to comprehend.
5. **Complex Notation**

a. Unnecessary use of scientific notation complicates interpretation of results, creating unnecessary barriers to understanding data in reports.

Table 1. Advisory Panel ranking of existing tools

Scale: 1 (poor) - 5 (great)	**Athena IE**	**OneClick LCA**	**tallyLCA**	**EC3**
Usability	2.2	3.6	3.8	2.4
Ease of Communication	1.6	2.7	3.4	3.4
Visual Experience	1.4	3.5	3.6	3
Quality of Content in Output	2.3	2.7	3.9	2.8
Average	**1.9**	**3.1**	**3.6**	**2.9**

Note: This is a direct reporting of the results from the advisory panel members based on their experience at the time of the survey. This report is not intended to recommend one tool over another.

Defining Success in a Carbon Results Framework

After identifying successes and failures of existing outputs, advisory panel members were asked to define what success would look like in a results framework and aligned around the following:

1. Clients are able to make informed design and/or procurement decisions based on embodied carbon and other impacts. Clients are able to effectively communicate the embodied carbon story.
2. Users have the ability to generate an internal detailed report and external client facing summary that is independent of the program or tool that was used to create it
3. The framework encourages reporting alignment and standardization.
    a. Aligned nomenclature
    b. Alignment on which elements contribute to which systems (structure, enclosure, etc.)
    c. Standardized material and assembly categorization systems.

Note: Achieving alignment and standardization in the practice of conducting WBLCA and embodied carbon accounting and in the reporting of results stands as a crucial concern currently under active exploration by multiple groups globally. One such initiative, the ECHO project, is a complementary effort to this Carbon Results Framework Project.

Snippet 1. The ECHO Project[7]

Launched in 2023, the ECHO Project is a coalition convened jointly by five leading non-profit organizations: Architecture2030, Building Transparency, the Carbon Leadership Forum, the International Living Future Institute, and the US Green Building Council. It is comprised of representatives from the The American Institute of Architects, the Contractors Commitment, the Climate Positive Design Challenge, American Society of Landscape Architects, the MEP 2040 Commitment, the American Society of Civil Engineers (ASCE) (Infrastructure 2050 and SEI SE 2050 Commitment), Institute for Sustainable Infrastructure (ISI), and the Urban Land Institute (ULI).

In 2024, the ECHO project published "Project Life Cycle Assessment Requirements - ECHO Recommendations for Alignment" and a harmonized data reporting schema, "V1.0 ECHO Schema Fields and Descriptions (Excel) to ensure that all organizations (standards-setting organizations, professional commitment organizations and others) use the same data schema for databases and digital tools to gather and share WBLCA and project embodied carbon data in the same format, supporting interoperability of results between tools and databases.

Reporting of embodied carbon emissions from built environment construction has increased rapidly across North America, but variations in Whole Building Life Cycle Assessment (WBLCA) boundary definitions have resulted in inconsistent reporting that does not easily allow for comparison, benchmarking, or setting reduction targets. Standardized reporting is critical to advancing the industry's understanding of embodied carbon emissions and its ability to measure meaningful reductions, as well as providing a mechanism to reliably compare emissions reporting between projects.

4. All tools should differentiate between generic/industry average data vs. product-specific data.
5. The framework Includes modeling guardrails to ensure good data inputs by non-expert users.
6. The framework includes a method to represent modeling and impact data uncertainty.

7. There is some "typical" impact reference by system to compare to, so that we can tell how correct or realistic the reported values are. Benchmarks at system level and benchmarks that allow for red flagging.

   **Note: The Carbon Leadership Forum (CLF) is currently working on a WBLCA Benchmarking study for various building types that, once complete, could be built into existing tools to serve as a point of reference. For more information on this effort, visit CLF's website.*

8. The output reports of each tool should align with relevant standards (ISO, EN, and other emerging WBLCA/WLC standards such as ASHRAE 240P and RICS Whole Life Carbon Standard). Include e.g., data quality, uncertainty, impact by scope, etc. Each tool should be evaluated on level of compliance with standards.

Recommended Carbon Results Framework

Pdf reports

Pdf reports from tallyLCA, Athena's Impact Estimator (IE), and OneClick LCA were evaluated to determine common components and valuable uncommon components. EC3 does not currently generate a pdf report and was therefore excluded from this evaluation. The pdf reports were also evaluated to determine if their contents are compliant with the requirements outlined in ISO 21931 and EN 15978. Based on this evaluation and feedback from the advisory panel, it is recommended that the following components be included in a pdf report.

1. Project Information
   a. Project Name
   b. Project Location (address)
   c. Project Area included in assessment (Gross sf or m2)
   d. Building Height (ft or m)
   e. Project Client
   f. Table of Contents
2. Assessment Information
   a. Report Title
   b. Report Date
   c. Name, Company, and qualifications of person who conducted the assessment
   d. Units (Metric/Imperial)
   e. Building Type

f. Reference Service Life
g. Summary of Boundaries
h. Goal and Scope of Assessment
i. Summary of assemblies included
j. Project phase when assessment was completed (e.g. Design Documents, 100% CD's, as-built)
k. Information about the tool used to conduct the assessment including version number
l. Date the assessment was completed (*note, this could be different than the report date*)
m. Period for which assessment is valid (*note - currently none of the major tools report this information, but it is required by EN 15978 and ISO 21931)*
n. Statement regarding verification of the assessment, such as if it was reviewed or verified by a third party to comply with a specific standard or regulatory requirement (*note - currently none of the major tools report this information, but it is required by EN 15978 and ISO 21931)*
    i. Name and qualification of the verifier, if verification is applied

3. Definition of Functional Equivalent
    a. Building Type (e.g. office, factory)
    b. Pattern of Use (e.g. occupancy)
    c. Relevant technical and function requirements (e.g. regulatory or client specific requirements)
    d. Required Service Life
4. Statement of Boundaries and Scenarios Used in Assessment
    a. Life cycle stages included in assessment
    b. Statement of relevant assumptions and scenarios
    c. Whether biogenic carbon is included or excluded from assessment
5. Data Sources including type and quality of data used shall be reported.
    a. List type of EPDs or data inputs used (industry-wide, product-specific, plant specific, facility specific, generic estimates, etc.)
    b. Describe how quantity take offs were performed
6. Results
    a. Indication whether results are in imperial or metric units
    b. External Report
        i. List of environmental indicators included in assessment and results for each indicator

ii. For each module of the life cycle, values should be reported for all indicators that have been included in the assessment.
iii. Results broken out by assembly, life cycle stage, and/or masterformat depending on external audience needs.

c. Internal Report
i. List of environmental indicators included in assessment and results for each indicator
ii. For each module of the life cycle, values should be reported for all indicators that have been included in the assessment.
iii. Results broken out by assembly
iv. Results broken out by CSI division
v. Summary of quantity takeoffs to support QA of results
vi. Notes on modeling approach that could be useful to other modelers
vii. Reporting needs for AEC commitment programs

d. (Optional) Module D. Results for impacts resulting from reuse, recycling, energy recovery and other recovery operations beyond the building life cycle.

e. Graphs - With input from the advisory panel and MKA, a set of recommended graph mockups were developed. Reference the Appendix A for more detail.
i. Internal Reports
ii. External Reports

Excel reports

Excel reports from tallyLCA, Athena's Impact Estimator (IE), OneClick LCA, and EC3 were evaluated to determine common components and valuable uncommon components. Based on this evaluation and feedback from the advisory panel, it is recommended that the following components be included in an excel report.

1. Project Information
   a. Project Name
   b. Project Location (address)
   c. Project Area included in assessment (Gross sf or m2)
   d. Building Height (ft or m)
   e. Project Client
2. Assessment Information
   a. Report Title
   b. Report Date

c. Name, Company, and qualifications of person who conducted the assessment
d. Units (Metric/Imperial)
e. Building Type
f. Reference Service Life
g. Summary of Boundaries
h. Goal and Scope of Assessment
i. Summary of assemblies included
j. Project phase when assessment was completed (e.g. Design Documents, 100% CD's, as-built)
k. Information about the tool used to conduct the assessment including version number
l. Date the assessment was completed (*note, this could be different than the report date*)
m. Period for which assessment is valid (*note - currently none of the major tools report this information, but it is required by EN 15978 and ISO 21931)*
n. Statement regarding verification of the assessment, such as if it was reviewed or verified by a third party to comply with a specific standard or regulatory requirement (*note - currently none of the major tools report this information, but it is required by EN 15978 and ISO 21931)*
    i. Name and qualification of the verifier, if verification is applied

3. Bill of Materials
    a. using a standardized material quantity nomenclature/schema for building LCA quantities. While this does not yet exist, there are some efforts to develop such a nomenclature. To learn more, reach out to Athena Sustainable Materials Institute or SE2050.
4. Results in Excel form should include the following
    a. Tabulated material quantities, GWP values for each material per quantity unit, total GWP for each material, and GWP intensity per square meter.
    b. Dashboard with Key Graphs
    c. A tab with results broken out by CSI Division
    d. A tab with results broken out by Life Cycle Stage and CSI Division
    e. A tab with results broken out by building assembly (Uniformat)
    f. A tab with results broken out by environmental impact indicators (if the assessment includes more than GWP such as a WBLCA)
    g. A table with uncertainty values for each material and calculation of material impact and material quantity uncertainty (reference Mockup #1).
    h. Visualizations in tables to quickly see largest contributions

   i. Biogenic carbon should be reported separately from GWP Fossil using the following format:
      i. GWP_life.cycle.stage_fossil
      ii. GWP_life.cycle.stage_biogenic_emissions
      iii. GWP_life.cycle.stage_biogenic_sequestered
5. Data Sources
   a. Detailed list of all data sources used. If EPDs are used as data inputs, include a link to EPD.
   b. Include percentage of data inputs that are product specific.

Recommended Components and Guidelines for Graphs

1. Visual Representation of material impact and material quantity uncertainty. Reference
2. Use of colorblind safe color palettes.
   a. Refer to the National Center for Ecological Analysis and Synthesis report on Colorblind Safe Color Schemes[8] for more information.
3. Reference to a benchmark or baseline, where feasible
4. Results broken out by system, sub-system, and product type.
5. Consistent nomenclature and units including the following:
   a. Embodied carbon intensity is expressed as kg CO2e/m2, even in countries that use the imperial system.
   b. The term "Total Embodied Carbon" is used consistently rather than "GHG Equivalent", "GHG Emissions" or "GWP".
   c. The term "Embodied Carbon Intensity" is used consistently rather than "GHG Intensity", "Carbon Intensity" or "GWP Intensity".
6. Biogenic Carbon
   a. The term "emissions" shall apply to values greater than zero, the term "uptake" shall apply to values less than zero.
   b. Represent biogenic carbon, or "uptake" values below zero, with a colored bar with diagonal hash marks.
   c. A disclaimer should be included on the graph that indicates stored carbon values should only be accounted for if the product is sourced from a sustainably managed forest.
7. For external audiences/clients, it is recommended to communicate embodied carbon savings in tangible equivalent terms. It is suggested to use EPA's Greenhouse Gas Equivalencies Calculator[9] to convert emissions data.

Conclusion

The findings and recommendations outlined in this study provide a roadmap for advancing the consistency, usability, and effectiveness of embodied carbon and project LCA reporting. By evaluating existing LCA tools and identifying their successes and shortcomings, this project has highlighted the need for standardized reporting frameworks that facilitate meaningful comparisons, improve data reliability, and enhance decision-making.

The proposed Carbon Results Framework serves as a comprehensive guide for creating pdf and excel reports and graphical outputs of project LCA results that are aligned with international standards, accessible to diverse audiences, and capable of communicating complex data effectively. Central to this framework are principles of transparency, alignment with established standards, and the incorporation of modeling guardrails to ensure accuracy. The integration of uncertainty representation, consistent nomenclature, and benchmarks are essential, and strengthens the credibility of reported data.

Appendices

Appendix A: CRFP Mockups

Terms, Definitions, and Notes

Note that everything on this page is primarily to describe the naming convention in the mockup data tables and charts in this particular document. This project's goal is to define best practice guidance on visual exploration of building GWP and environmental impact data.

Nomenclature

GWP - Global Warming Potential
BOM - Bill of Materials, used to describe quantities of materials.

GWP Value types

GWP.a123.high - High estimate of project's GWP due to uncertainty in GWP intensity, variability in BOM, or both.
GWP.a123.low - Low estimate of project's GWP due to uncertainty in GWP intensity, variability in BOM, or both.
GWP.a123.mean - Estimate of mean GWP based on average GWP factors, average BOM, and using non-specific data.
GWP.a123.actual - Estimate of actual GWP based on specific data.

Note: There can be many different approaches to accounting for "actual" GWP. This project uses an approach of using "high" estimates of GWP factors unless there is a specific selection of a product EPD, in which case the "high" estimate for that EPD is used. This is a direct carryover of data that gets exported from EC3. Tools can use different methodology for estimating "actual" GWP - this project only demonstrates how the "actual" values can be shown in relation to other value types.

References to statistical terms

Mean (Average): This is a measure of central tendency, calculated by adding up all the values and dividing by the number of values.
Estimated: This term is used when a value is not directly measured but is inferred or predicted based on a model or other data.
Expected: This is similar to 'estimated' but often implies a prediction based on probability or a statistical model. For instance, the expected carbon footprint of a building could be based on typical energy usage patterns for similar buildings.
Actual: These are the real, measured values. There can be different approaches to describing "actual" results in carbon accounting.

Audience

Internal - Charts that help design teams analyze decisions in depth. These can be more complex and convey more information at once.
External - Charts that help broader stakeholder groups understand final results and decision options. These charts should be simpler than Internal charts and convey one or two distinct takeaways but not more.

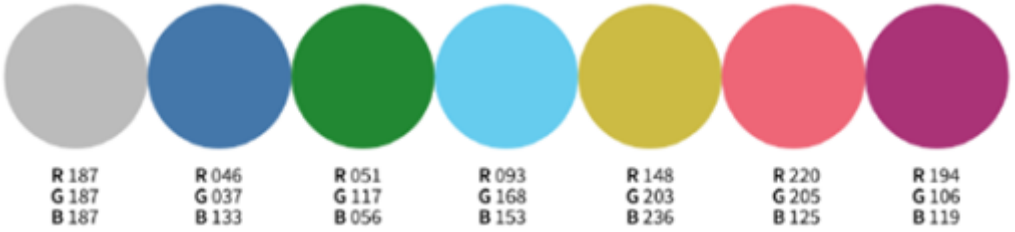
Note: External charts can be useful for Internal use as well. Internal charts can be used for External communication, but may be too confusing to an external audience without enough training and exposure to the topic.

Formats

Paper format - Very small contributions to any chart may be difficult to read in a paper format, where users cannot interact with the diagram and see tooltips that would reveal the actual values. In charts intended for paper-based reports, we include recommendations for lumping items with minimal contributions to an 'Other' category.
Digital format - Charts that can be viewed in a software tool or webpage can use tooltips and other interactive elements to show even the smallest contributors to results. In these cases it may be beneficial to list all contributing items without lumping them together in an 'Other' category, like in the paper-based reports. We will include recommendations on which items in the charts benefit from interactiveness.

Colors

Colors used in these mockups are colorblind friendly as determined by the National Center for Ecological Analysis and Synthesis.



Technical Standardization

The proposed framework defines specific project phases, building systems, product types, and their grouping, and color assignments. However, this project is only demonstrating the level and example of standardization that may be needed in similar assessments. The project's goal is not proposing an authoritative naming and grouping convention.

Design Options

Baseline - The main design option to which other design strategies are compared to. Alternatively, this could be called the "Main" option. (we used the term 'Main' in some of the mockups)
Options - Options that include design strategies or alternates aiming to reduce the project's impact.

The results of each design option often need to be in a specific order. We give the user the option to assign an integer value to each design to set that order, with the exception of value 0, which is reserved for the "Baseline" results.

Project Phases & Milestones

For describing project-level results throughout time, we use the following set of standard project phases:

code	name	order
CO	Concept	1
SD	Schematic Design	2

DD	Design Development	3
CD	Construction Documentation	4
AB	As-Built	5

Additionally, each phase can have a milestone expressed as a percent completion of a particular phase, e.g., 50% DD, 100% DD, etc.

Systems

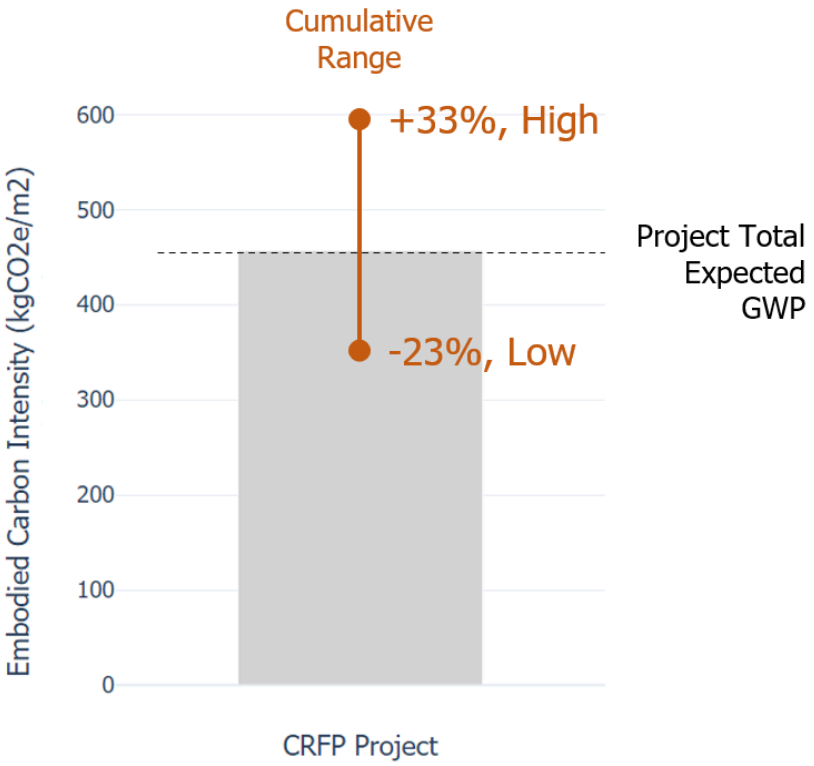
The system groups have been scoped based on EC3's building project scope checkboxes (i.e., Foundation, Structure, Envelope, Interiors) and other systems that AEC and owners often track (i.e., Services/MEP, Site/Hardscapes). We do also have a catch-all 'Other' category but there is no icon.

The full set of systems is as follows:

name	**order**	**color**	**description**
Foundations	1	#aa3473	Piles, retaining walls, and substructure.
Structure	2	#e96474	Beams, columns, walls, and floor structure.
Envelope	3	#ccbb44	Exterior walls and cladding, roofs, etc.
Interiors	4	#66ccee	Interior walls, finishes, furnishings, etc.
Services	5	#4477aa	Mechanical, electrical, plumbing, fire protection, and other systems.
Site	6	#228833	Roads, walkways, site elements.
Other	7	#bbbbbb	All other systems.

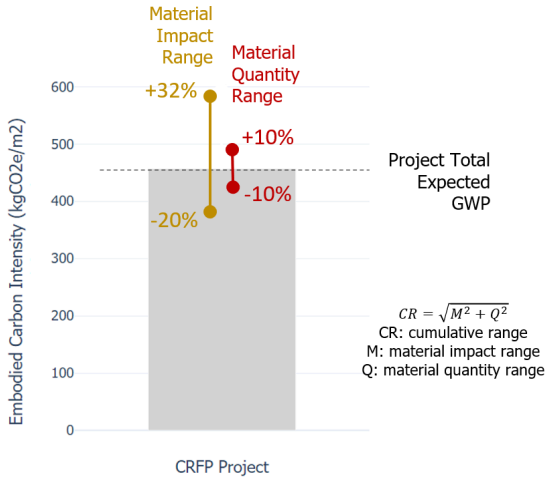
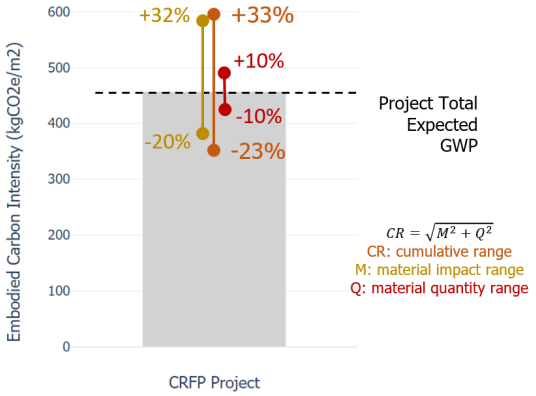
Mockups

1. Project Estimate & Uncertainty



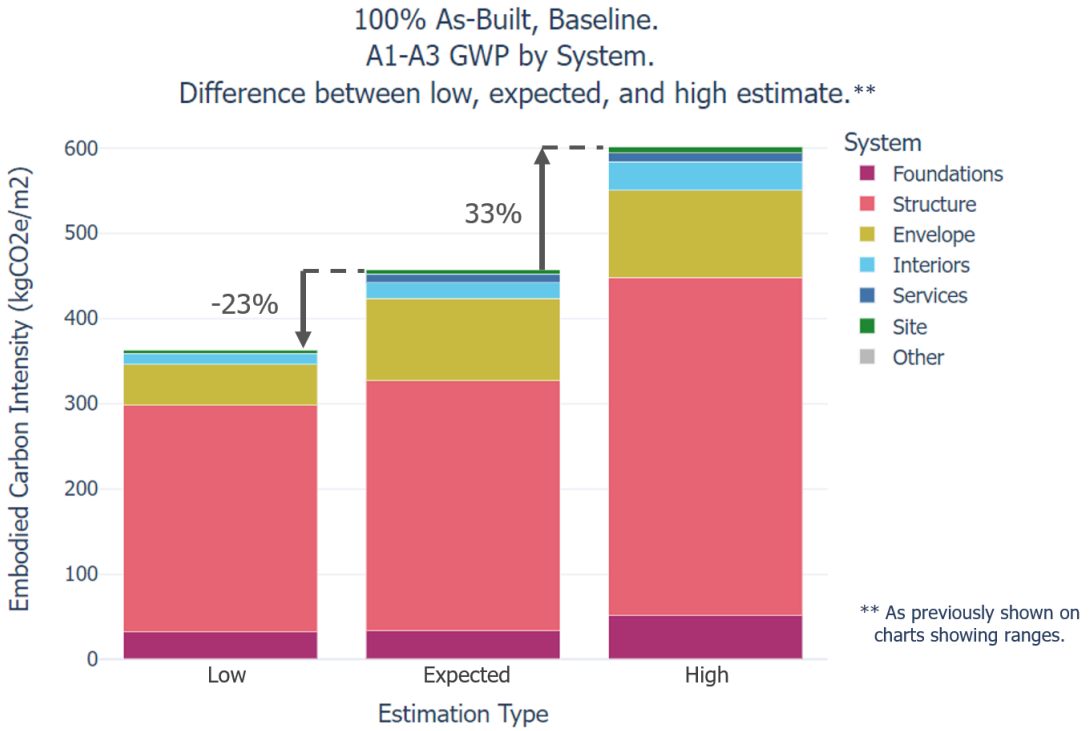
Audience	External
Description	Scale of uncertainty around project's GWP estimate.
Objectives	Show the cumulative range of impacts relative to the project's expected value.
Graph Format	digital/interactive, static

2. Project Estimate & Uncertainty by Materials & Quantities

Mockup 1	**Mockup 2**
	

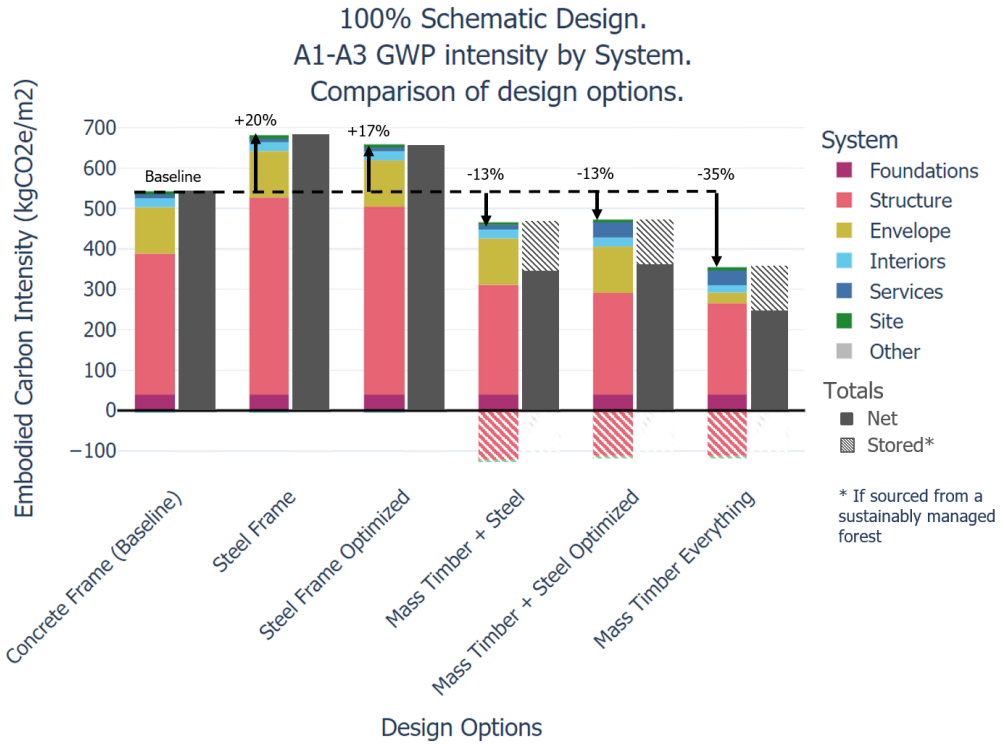
Audience	Internal
Description	Scale of uncertainty around project's GWP estimate and the differences in uncertainty by source.
Objectives	Show 1) material impact range, and 2) quantity takeoff range, relative to the project's expected result. Show the combined (cumulative) range.
Data inputs	Project total GWP intensity (kgCO2e/m2) for high, low, and expected values by accounting for high low and expected variation in individual elements' impact and quantity estimates (determining uncertainty in quantity estimates is a separate topic from these mockups).
Data manipulations	Material range and Quantity range is summed using root sum squared (RSS) approach to arrive at Cumulative range.

3. Subsystem Contributions with Stepped Uncertainty



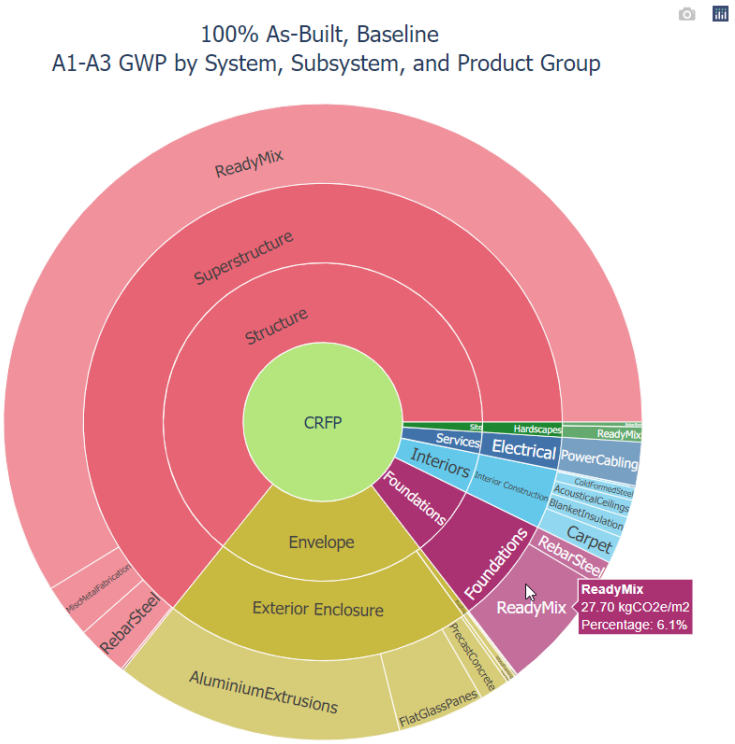
Audience	Internal
Description	Conservative, Realized, and Achievable Intensity Comparison by System - Single Project
Objectives	Primary: Show cumulative high, expected, and low GWP intensity results for a single project, showcasing the potential uncertainty in the expected values. Secondary**:** Show contribution by subsystem.
Data inputs	A123.gwp.high, A123.gwp.expected, A123.gwp.low for each element of the project
Data manipulations	Group elements by subsystem and summarize a123 GWP values for each estimation type.

4. Material Contribution in Design Optimization Strategies Bar Chart



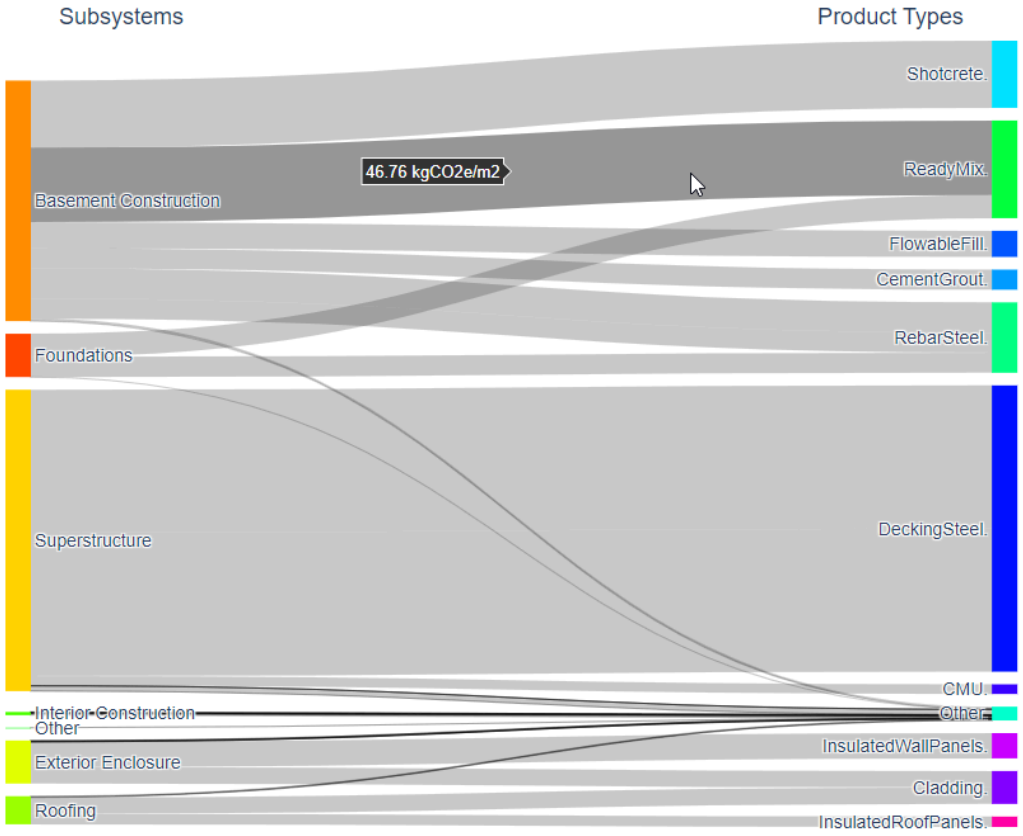
Audience	Internal & External
Description	Horizontal bar chart comparing embodied carbon intensity of four design options illustrating percentage emissions reduction potential from baseline design. Horizontal bar chart allows for legend to be located closer to bars and color shades are distinct making it easier to decipher contribution of materials in bars. Order of materials listed in legend corresponds with order shown in bars.
Objectives	Primary: Show differences between structural **options and reduction potential.** Secondary: Show contribution by **System** and **Materials**. Tertiary: Show **Stored Carbon**.
Data inputs	Materials list and embodied carbon intensity per square meter of each material type for each design option. Determine which materials contribute less than 10 kg CO2e/m2 individually and group them together in "Other" category to avoid portraying too much information in a single bar.

5. System, Sub-System, and Product Type Contributions Donut



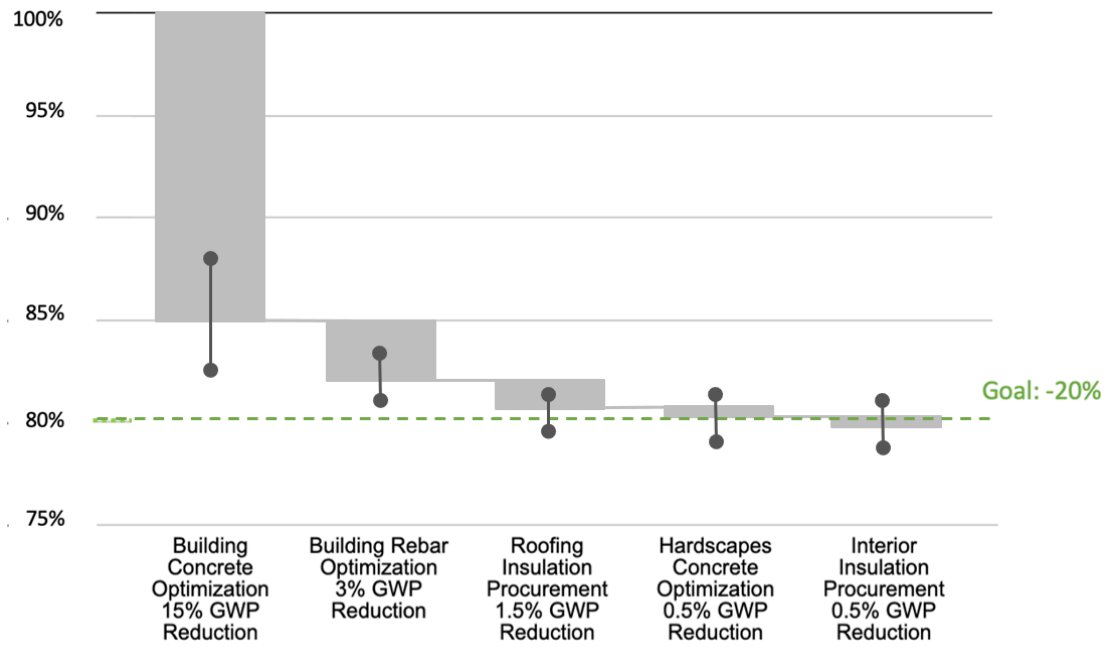
Audience	Internal and External
Description	Sunburst chart showing percentage contribution by system and subsystem in separate but adjacent rings.
Objectives	Primary: Show contribution by **System, Subsystem, and Product Group**.
Data inputs	Percentage contribution by system and subsystem.
Additional Notes	**This chart is best viewed digitally, there are interactive features where the user can click on a system or subsystem and it shows that specific selection only.**

6. Material and System Contributions Sankey



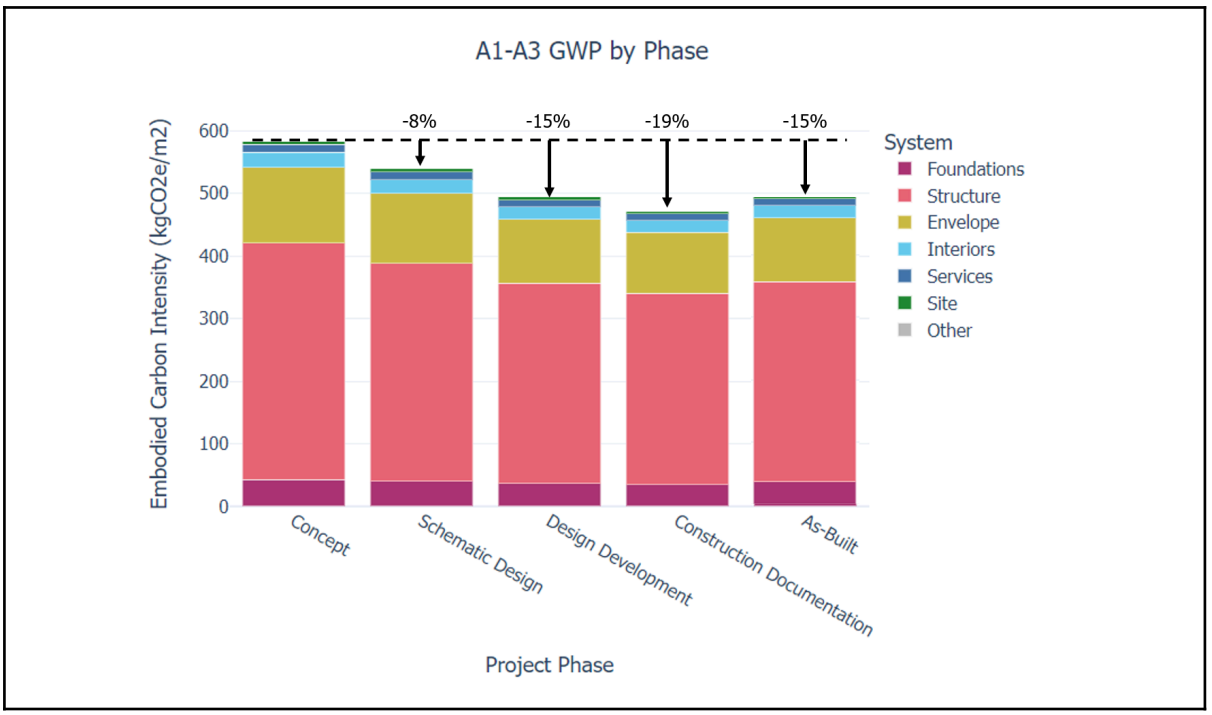
Audience	Internal
Description	Shows material and system contribution. **Avoids showing product types multiple times and therefore makes the labels and bars less cluttered** when compared to the sunburst chart #5.
Objectives	Primary: Show contribution by **Subsystem** and **Product Group**.
Data inputs	A123.gwp.expected for each element.
Data manipulations	Group by Subsystem and Product Type and summarize the GWP across elements. Group any Subsystems and Product types contributing less than 5% to an 'Other' category.

7. Goal Setting + Individual and Cumulative Emissions Reduction Strategies



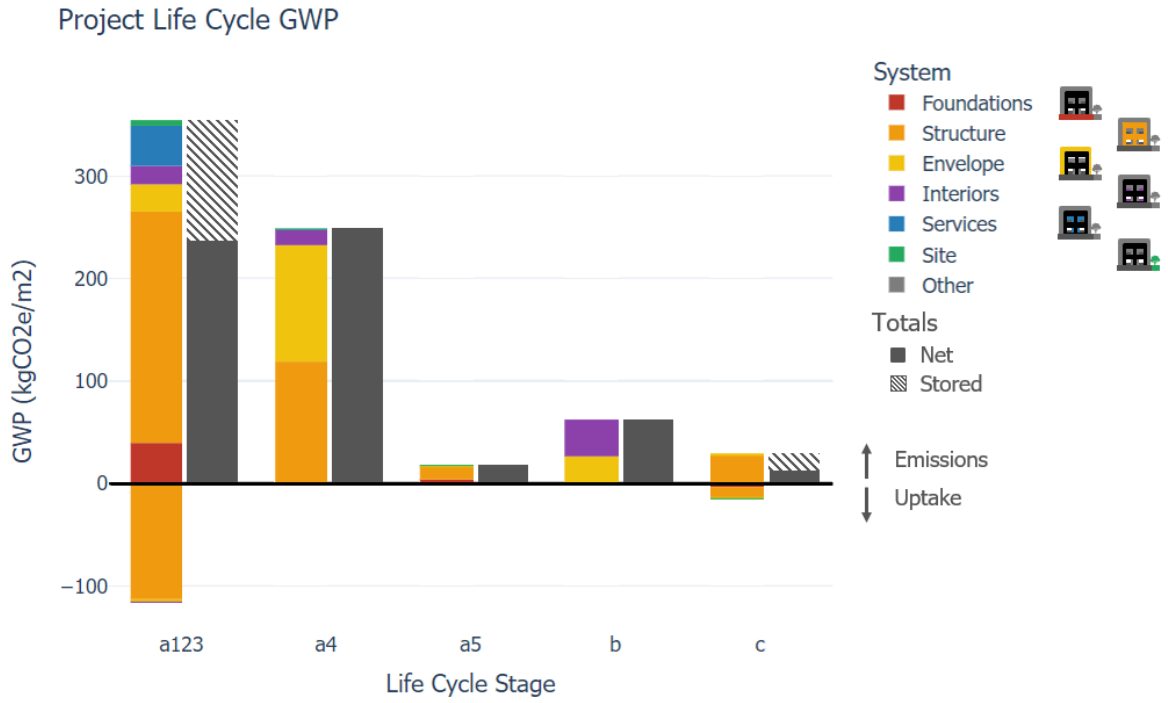
Audience	Internal and External
Description	Demonstrates the individual and cumulative GWP percentage reduction potential of reduction strategies. Also demonstrates the project's target GWP percentage reduction.
Objectives	Visualize the reduction potential of individual reduction strategies. Allows the audience to clearly see which reduction strategies will have the most impact on the total GWP of the project while also visualizing the uncertainty of each reduction strategy.
Data inputs	Baseline global warming potential, percentage reduction of individual reduction strategies, cumulative percentage reduction of reduction strategies, and project's target percentage reduction.

8. Design and As-Built Emissions Stacked Bar Chart



Audience	Internal & External
Description	Bar chart illustrating changes in emissions across design stages and as-built. Lists materials that increased in scope in as-built model.
Objectives	Primary: Show contribution by material category and emissions percentage changes across design phases. Show source of increase in emissions between final design model and as-built model.
Data inputs	Emissions value of top contributing materials (suggest a limit of 5 materials plus an "other" category that combines any materials that contribute less than 5% of total project emissions). Emissions intensity of each material in each design model.

9. Project Life Cycle by System



Audience	Internal
Description	Single project option life cycle GWP while also showing carbon uptake and net results.
Objectives	Primary: Show contribution by **Life Cycle Stage**. Secondary: Show contribution by **System**. Tertiary: Show **Stored Carbon** vs emissions.
Data inputs	GWP.expected (emissions) for each life cycle stage for each element. GWP.uptake for each life cycle stage for each element.
Data manipulations	Group Elements by System and summarize GWP emitted due to each LC Stage and GWP sequestered in each stage. Calculate the net emitted and sequestered GWP.

Appendix B: CRFP Graph Generator (Excel)

Click here to access the excel file with a demonstration of the visualizations per plot resulting from this project.

References

[1] https://www.buildingtransparency.org/tally/tally-lca/

[2] https://www.buildingtransparency.org/ec3-resources/ec3-faq/

[3] https://www.oneclicklca.com/

[4] https://www.athenasmi.org/our-software-data/impact-estimator/

[5] ISO 21931-1:2022(E): *Sustainability in buildings and civil engineering works - Framework for methods of assessment of the environmental, social, and economic performance of construction works as a basis for sustainability assessment - Part 1: Buildings*

[6] EN 15978:2012-01: *Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method*

[7] https://www.echo-project.info/

[8]https://www.nceas.ucsb.edu/sites/default/files/2022-06/Colorblind%20Safe%20Color%20Schemes.pdf

[9]https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator