# Embodied Carbon Action Plan – 2022

Submitted to the SE 2050 Committee on June 28, 2022

**Introduction**

We are pleased to submit our second Embodied Carbon Action Plan, parts of which will look very familiar to readers of the first. Equilibrium has been involved in sustainable design for many years, particularly with our work in timber. We have been expanding our internal knowledge base on embodied carbon in recent months and years. The SE 2050 program is coming at a great time to help keep us moving in the right direction, and we enthusiastically embrace the goals of the program.

Our first year as part of the commitment had some great outcomes such as the addition of new members to our internal Sustainability Committee, submitting our first projects to the SE 2050 database, and actively integrating carbon goals into many of our projects. At times we struggled with the commitment of time and effort required as embodied carbon reduction efforts are frequently done outside of our official scope of services on projects. Overall, it was a great first year, and we head into the second year with renewed enthusiasm.

This ECAP is broken down into four parts per the guidance from the Program Requirements document: Education, Reporting, Embodied Carbon Reduction Strategies, and Advocacy. Items marked with [R] are required per the SE 2050 Commitment whereas items marked with [E] are electives.

**Part 1 – Education**

The term "embodied carbon" is still unknown to many practicing engineers, architects, and owners. At Equilibrium we are increasing our carbon literacy, but still have much to learn. We plan to take the following steps in order to educate ourselves.

- [R] Distribute firmwide announcement sharing our previous year's ECAP.
    - Our 2021 ECAP was distributed internally last year. We will circulate this year's version when it is submitted.
- [R] "Provide a brief narrative describing how your firm is promoting a firm-wide education program for embodied carbon reduction and the firm's commitment to SE 2050."
    - Equilibrium is currently about twenty people most of whom are structural engineers. We have an internal sustainability committee with a current roster of eight engineers. This group meets regularly to discuss sustainability-related topics and through discussion, collaboration, and sharing of information, we advocate to raise awareness of sustainability matters.
    - Over the past year, this group has become more structured. Initiation requirements include acknowledgement of the time commitment required and reading of three key papers (one of which is the SEI Sustainability Committee's white paper on achieving net zero – shout out to Mark).
    - As part of our normal technical review process on projects we now perform sustainability reviews as well. These are summarized and discussed during Sustainability Committee meetings.
    - We are leveraging relationships within the Vancouver community to organize guest lectures at our office on the topic of embodied carbon.



    - This group periodically holds sessions with the rest of the firm to keep everyone in the loop as to our progress and to educate the whole team on embodied carbon, SE 2050, and related initiatives. We also produce internal-facing documents summarizing our learnings to share with the group and post them to our intranet for reference and consumption by all.
- [R] Establish an Embodied Carbon Reduction Champion.
    - Our Embodied Carbon Reduction Champion for the SE 2050 Commitment is the same this year as in the past and is also the author of this plan:
      Matt Kantner, PE, SE. Matt is an associate engineer with the firm and is based out of Atlanta, GA. Matt has been working as a structural engineer in Atlanta since 2012 and has worked on a wide variety of projects in all structural materials. Working on the Kendeda Building at Georgia Tech inspired an interest in mass timber and structural sustainability which led him to Katerra and then Equilibrium where he now focuses primarily on large mass timber projects. Matt is a member of SEI's Sustainability Committee and the SE 2050 Committee.
- [E] "Have one representative of your firm (any employee) attend quarterly external education programs (e.g. webinar, workshop) provided by SE 2050, Carbon Leadership Forum (CLF), or other embodied carbon resources."
    - Most members of the sustainability committee already regularly attend webinars on the topic of sustainability and will continue to do so.
- [E] "Provide narrative outlining plans for minimum (2) firm-wide presentations per year on the topic of embodied carbon.
    - Tom Place is our new internal Sustainability Committee leader and has been active in the structural embodied carbon movement for years during his time at Arup in London. Tom will be leading discussions on embodied carbon with our full technical stuff in the form of lunch-and learns. We anticipate that we will do at least two per year. We envision the next one as being a bit of a refresher (and perhaps in introduction to some new staff) on the basics of global warming, embodied carbon, and the structural engineer's role in it all. The second one will be focused on mass timber – a method of construction that we use frequently – and in particular a study that Tom took part in to determine the GWP of cross-laminated timber from major European suppliers.
- [E] "Initiate an embodied carbon interest group within your firm and provide a narrative of their goals."
    - Our sustainability committee serves this function. The committee's mission statement reads "To design more sustainable buildings by decreasing the environmental impact of buildings' structural systems. In doing so, we will become subject matter experts and sustainability resources for our clients. Ultimately, we will elevate the profile of Equilibrium and establish ourselves as leaders in structural sustainability. More importantly we'll be doing our part to mitigate the climate crisis."

**Part 2 – Reporting**

- [R] "Provide a narrative on how your firm plans to measure, track, and report embodied carbon data."
    - We are attempting to decrease the carbon footprint on all of our projects, and there are small things that we can do on virtually every project to achieve reductions; however, it is not currently feasible for us to perform full Life Cycle Assessments on all projects, particularly small ones with small budgets. For projects where we are planning to perform LCAs and track embodied carbon more closely, we have developed a process to do so. At key milestones throughout each project



we perform LCAs on the building's structure, then use the results to identify hot spots for potential carbon reduction and optimization. We have developed a standardized report to convey results to the rest of the project team and ownership at these key stages. The key quantitative result in the report is the embodied carbon per building area. For timber projects this is reported both with and without consideration of biogenic carbon. The report also lists embodied carbon hot spots and opportunities for reduction. An example (with some information redacted for privacy of the client) of one of our reports can be seen in the Appendix.

    - In most cases we will rely on the Life Cycle Inventory within Tally to get embodied carbon data for structural materials. We do have access to other EPDs via EC3 and through other sources in cases where we'd prefer to use something other than what is built into Tally.
    - We are using Tally (and the EPDs embedded within its LCI) to perform our LCAs.
    - While Cradle-to-Grave (A-C) GWP is the number we highlight in reports, we also calculate an intermediate stage, A1-A5, for our analysis as the near-term releases of $CO_2$ into the atmosphere are the most critical.
    - Material quantities are extracted from our Revit model when available. At early stages, material quantities are estimated and we use a spreadsheet tool developed in house and based on Tally's LCI data to do approximate LCAs. During our sustainability reviews, we ensure that all significant contributors to embodied carbon are included in the analysis (e.g. steel connectors in mass timber frame buildings are not modeled but will be "faked out" for inclusion in the LCA).
- [R] "Describe the internal training for embodied carbon measurement you provided or will provide."
    - All members of our sustainability committee have learned a great deal about embodied carbon in the past couple years. In its simplest form the only two things we need to get right in order to have a quality LCA are the material quantities and material assignments in Tally. All of us, including Tom Barlow, an engineer and our in-house LCAer, have been educating ourselves on LCAs and Tally by reading papers such as IStructE's "How to calculate embodied carbon", Carbon Leadership Forum's "Live Cycle Assessment of Buildings: A Practice Guide", and more. Being tied into the SEI Sustainability Committee and SE 2050 Committee also provides us with great resources.
- [R] Submitting project data for the SE 2050 database.
    - We submitted three (3) projects in 2021 and will submit at least two (2) this year.
- [E] "For a project submitted to the database, ask the Architect or Owner if the project has a carbon budget or if there are established project sustainability goals at the project kickoff meeting."
    - We do this on most of our projects now. Some projects come in the door with lofty sustainability goals and specialist companies already signed up to do LCAs. Others have no interest in embodied carbon. We do our best to help guide the conversation in either case.

**Part 3 – Embodied Carbon Reduction Strategies**

- [R] "Set an EC reduction goal for the coming year and an implementation narrative."
    - The embodied carbon of each of our projects is influenced by the form, function, design intent and environmental conditions associated with the structure in question. By systematically measuring, reviewing and reporting embodied carbon against industry-wide targets, we aim to contribute to EC reduction within our sphere of influence. In addition, we have set the following specific goals for the coming year:



        - Achieve 33% reduction on GWP of concrete in our projects compared to NRMCA benchmarks. This will go hand-in-hand with our uniform roll-out of concrete specifications that require reductions in embodied carbon compared to baseline values (or reduction in cement quantity when GWP is not known).
        - Quantify embodied carbon (including transportation emissions) of mass timber products from specific suppliers when recommending manufacturers to architects and building owners on projects. Several suppliers have EPD data available. We will use this as well as commonly accepted emissions for transportation to quantify this.
    - In addition to these quantitative objectives, we'll continue our internal education and advocacy. We'll continue implementing carbon reduction strategies on our projects and will implement new ones as our knowledge increases moving forward.
- [R] Lessons learned in our first year:
    - We learned that measuring and decreasing embodied carbon is easy: SMQ*CF = GWP. Using fewer materials in total, and specifically using less cement across all our projects is a realistic and achievable goal.
    - We learned that accurately measuring and decreasing embodied carbon is hard: There is a large amount of variability in GWP of materials so using industry averages is not always very accurate. Updated EPDs can throw off comparisons with old data, tweaks to designs lead to frequent re-running of LCAs and updating reports, other project stakeholders are not always interested in our embodied carbon reduction initiatives, concrete suppliers are often quite conservative and don't want to risk a low break for the sake of embodied carbon reduction.
    - We learned that on most of our projects (which are mass timber) there is a huge difference in perceived results if we consider or do not consider biogenic carbon.
    - We learned that the biggest challenge on getting to net zero for most of our projects is going to be concrete. There's no escaping concrete (at present) and there's no magic bullet for getting low- or zero-carbon concrete (at present). We know that our efforts are important, but we recognize that we can only go so far – the industry itself has to change. Part of our efforts, of course, is advocating for this change.
    - We learned that our mass timber projects in high-seismic regions often require a concrete diaphragm whereas we can often use the CLT itself as a diaphragm in low-seismic USA. Pushing for a VLFRS layout that does not require the diaphragms to work too hard at an early stage can push a project from having, for example, a 3 ½" NWC topping that functions as a diaphragm to a 2" NWC topping that is for acoustics only – a significant savings in embodied carbon (not to mention seismic mass).
- [E] "Complete an embodied carbon comparison study during the project concept phase."
    - We approach all our projects with an eye for embodied carbon now. We did not have the opportunity in the past year to do a full-blown comparison study of different structural systems for embodied carbon, but we are constantly making design decisions. This year, we hope the opportunity will present itself in a project.
    - One cool little paper that we've been working on is a mass timber framing guidance document. In it we compare various framing schemes such as post-and-beam, composite CLT, composite glulam girder, CLT flat plate, etc. for cost, speed of construction, etc. One of the metrics we are quantifying is embodied carbon. This will help us have a baseline understanding of the schemes we often use,



and which ones tend to perform better from a carbon standpoint. We plan to send this document out to industry contacts later this year.

- [E] "Update your specifications and incorporate embodied carbon performance. Include embodied carbon in your submittal review requirements."
    - This has been implemented on some projects in the past year but has not been rolled out uniformly. We will aim to incorporate this on all projects by the end of this year.
- [E] "Collaborate with your concrete supplier to reduce embodied carbon in a mix design."
    - We have had varied success on this. On one project in California, for example, we were able to get the concrete supplier to take out cement and add more SCMs when we pointed out that we did not need full strength at 28 days. On the same project, however, we were too slow to review the slab-on-ground mix and ended up not being able to make similar improvements. We will continue collaborating with concrete suppliers this year.
- [E] "Incorporate biogenic materials on at least one project annually."
    - This is quite an easy one for us as most of our projects are timber. We will continue advocating for mass timber on our projects (they don't all end up going that way) and within the larger building community.

**Part 4 – Advocacy**

- [R] "Provide a narrative about how you plan to share knowledge and data to accelerate adoption of embodied carbon reduction."
    - At this time, we believe that the best thing we can share is knowledge. The AEC community at large still knows very little about embodied carbon. Individuals within the firm have begun making posts on LinkedIn to educate our networks about embodied carbon and SE 2050. These posts are typically promoted by the Equilibrium LinkedIn account in order to spread them to a wider audience. As we start to compile meaningful data from our research and LCAs we will share this as well. A longer-term goal would be the development of an external-facing lunch-and-learn on embodied carbon and how we are measuring and reducing it on our projects.
    - Tangentially, it is clear to us that carbon sequestration in buildings, especially in long lifecycle materials such as the structure itself, is one of the best strategies for lowering embodied carbon (and eventually getting to zero). So by advocating for mass timber in buildings and by designing buildings with mass timber frames, we believe we have been promoting low carbon solutions for many years already and will continue to do so.
    - Matt Kantner, along with Kelly Roberts, is planning to present an introduction to embodied carbon to the Structural Engineering Association of Georgia's Young Members Group later this summer.
    - I was also pleased this past year to see that my former employer, Uzun + Case, has signed on to the Commitment and has reached out to me about my involvement in the group. Uzun + Case is the largest structural engineering outfit in Atlanta, and I suspect that it won't be long until other ATL-based firms start signing on.
- [R] "Describe the value of SE 2050 to clients. How can we collaborate to drive adoption? At your option, attach any associated marketing materials."
    - For our US projects, especially those with forward-thinking clients, we will certainly extol the virtues of the SE 2050 program. When appropriate, we will attach SE 2050 marketing materials.
- [R] "Declare your firm as a member of the SE 2050 commitment on boilerplate proposal language."



    - For US projects this is included in our boilerplate proposal language.
- [E] “Share your commitment to SE 2050 on your company website.”
    - We have done this – check out eqcanada.com.
- [E] “Start an embodied carbon community of practice or mentorship program in your office.”
    - We essentially already have this with our Sustainability Committee. Our main area of focus is embodied carbon; and a major goal of the committee is to educate the wider team and industry peers.

We are pleased that most of these goals for 2022 are in alignment with internal goals that we had already set for ourselves. We are happy to have the SE 2050 Commitment as a means of tracking our progress and to have the resources and network that we are developing through the Commitment / Committee to help us along the way. And most of all, we are happy to be part of something that we truly hope will help to transform the industry.

-Matt Kantner, PE, SE

**Appendix – Project Embodied Carbon Report Example**

Please find an example of a recent EC Report that we assembled for a project in the Schematic Design phase and delivered to the owner as part of our structural narrative on the following two pages.

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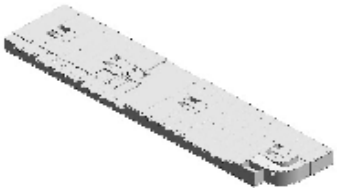
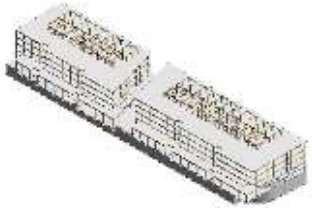
# Embodied Carbon Report

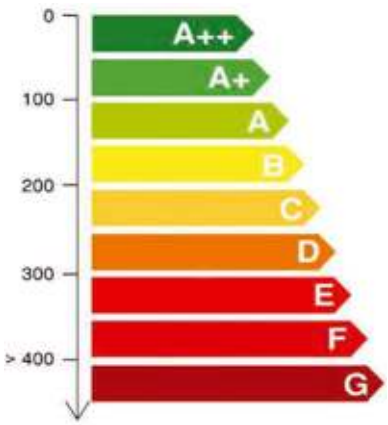
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project: | REDACTED | Boundaries: | Cradle to Grave | Gross Area: | 50062 m2 | Basement: | Yes |
| Project No.: | 21039 | LCA Stage: | Preliminary LCA | Building Life.: | 60 Years | Foundations.: | Pad Footings |
| Location: | REDACTED | LCA Notes: | Full Building Analysis ex. Biogenic Carbon of Streetworks, Westfield | Building Type: | Parking/Commercial | Ground Floor | Suspended Slab |
| Architect: | MGA | | | No. of Storeys: | 5 + Basement | Floors | CLT & Glulam |
| LCA Author: | Tom Barlow | | | | | Roof | CLT & Glulam |
| Date: | 5/13/2022 | | | | | Vertical System | Glulam<br>Glulam/Steel Braced Frames |





| Material Division | Foundations (Everything from Level 1 slab down) | Superstructure (Everything above Level 1) | Full Building |
|---|---|---|---|
| **GWP (kgCO2eq)** | 5,980,000 | 4,390,000 | 10,370,000 |
| 03 - Concrete | 5,970,000 | 2,580,000 | 8,550,000 |
| 05 - Metals | 0 | 61,700 | 61,700 |
| 06 - Wood/Plastics/Composites | 0 | 1,760,000 | 1,760,000 |

**SCORS Rating**
Based on cradle-to-grave embodied carbon of the building structure




C
243 kgCO2eq/m2

**Contextualizing Embodied Carbon**

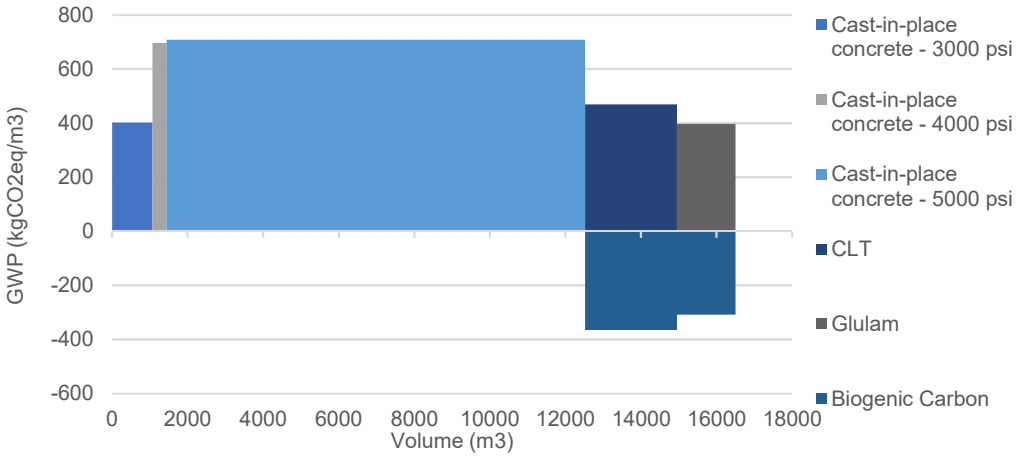
REDACTED is approximately 50 miles roundtrip. Based on an average of 0.486kgCO2 per mile, each trip would produce 24.3 kgCO2. The equivalent rail journey emits 9.7 kgCO2, based on a 0.95 kgCO2/mile/passenger average.

Therefore, if the car park enables 100 people per working day to take this journey via rail, the carbon savings per year would equate to 378,014 kgCO2 per year.

Based on this LCA, the payback period for the structure of this building would be 30 years.

**Opportunities for embodied carbon reduction**

- Reduce the number of column transfers at Level 1.
- Consider using post-tensioned concrete where appropriate.
- Consider decreasing the size of the parking structure.
- Consider pursuing timber braces in lieu of steel.
- Ensure timber comes from sustainably managed forests.
- Allow for extra days in construction scheduling for suspended concrete slabs to gain strength, thereby allowing lower-cement concrete mixes.



# Embodied Carbon Report

**How to Read Your Embodied Carbon Report**

Thank you for taking the time to read this embodied carbon report. While many people are familiar with the impact that operational energy usage has on a building's carbon footprint, embodied carbon may be less familiar. Embodied carbon is defined by SE 2050 as "the sum of greenhouse gas emissions released during the following life-cycle stages: raw material extraction, transportation, manufacturing, construction, maintenance, renovation, and end-of-life for a product or system." In other words, embodied carbon is the total carbon footprint of the physical building... all of its pieces and all of the processes that took place to get them from raw materials to finished products installed in the building. The structural systems of a building typically comprise more than 50% of the total embodied carbon.

Embodied carbon has historically been less important than operational carbon because buildings have not historically been very energy efficient. As energy codes tighten up and as the electricity grid gets greener, operational carbon is decreasing rapidly. Due to this, embodied carbon is becoming a relatively larger concern for earth-conscious builders and owners. Unlike operational carbon which is "paid" over the lifetime of the building, a building's embodied carbon bill is paid almost entirely by the time the building is occupied. The time to act on embodied carbon is now.

**Key terms**:

**Embodied Carbon** - The total carbon footprint of the physical building... all of its pieces and all of the processes that took place to get them from raw materials to finished products installed in the building.

**Lifecycle Assessment (LCA)** - An LCA is study performed on a building to determine its embodied carbon. At it's core, an LCA performs a simple calculation: the quantity of each of the different materials (e.g. CLT) included in the scope of the LCA is determined. Then each of these quantities is multiplied by the carbon intensity factor for the material. Summing up all the materials then gives the embodied carbon for the building. This report is based on an LCA that Equilibrium performed using the commercially available software Tally.

**Global Warming Potential (GWP)** - GWP is a measure of the potency of a greenhouse gas. The GWP of carbon dioxide is defined as 1.0. Other greenhouse gases are often more potent - methane's GWP is about 25 and nitrous oxide's is about 298 - but far fewer of these gases are emitted so carbon dioxide is still the primary concerned and is used as the baseline for greenhouse gas measurement.

**Biogenic Carbon** - Carbon associated with the natural biogenic carbon cycle. The natural biogenic carbon cycle is relatively short-term in nature: trees absorb and sequester carbon from CO2 molecules in the air. Eventually the wood in the tree either decomposes or burns and the carbon in the wood returns to the atmosphere as CO2. This is a natural cycle that occurs constantly and is starkly different from human's burning of fossil fuels which is an unnatural process that releases CO2 into the atmosphere that had been locked away for millions of years. Consideration of biogenic carbon is generally a boon to the overall carbon footprint of a timber building because considering biogenic carbon allows the calculation to consider all of the carbon that was sequestered from atmospheric $CO_2$ during the trees' life (carbon which is now locked inside the timber in the building).

**SCORS Grade** - IStructE, the main association for structural engineers in the UK, developed the SCORS system to assign grades for building structural systems based on their embodied carbon intensity. Refer to the paper "Setting Carbon Targets: an introduction to the proposed SCORS rating scheme" for more information.

**Key metrics:**

**kgCO2e** - Kilograms of carbon dioxide equivalent. Quantities of greenhouse gas emissions are "converted" to equivalent quantities of carbon dioxide emissions based on their GWP and then all are summed up in a single number.

**kgCO2e/m2** - The total amount of carbon dioxide equivalent divided by the floor area of a building. This is a good way to measure the carbon intensity of a building and compare to other buildings or alternative schemes.