2023

SE 2050 Embodied Carbon ACTION PLAN

kpff

01

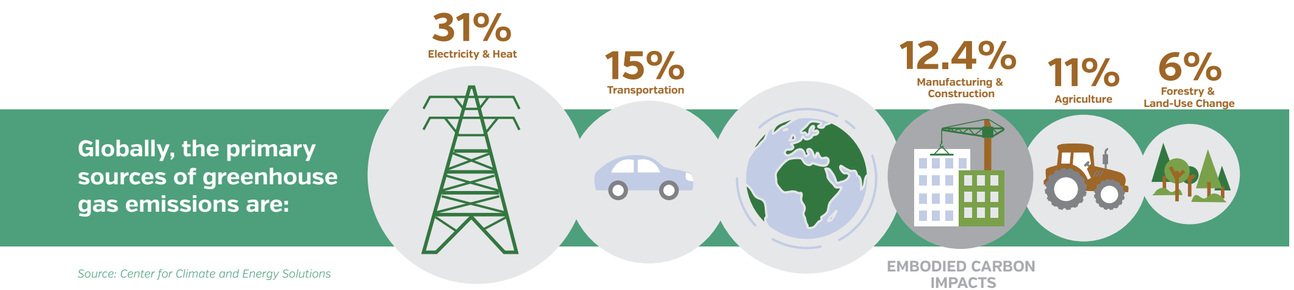
Introduction

KPFF recognizes and supports the SE 2050 Challenge vision statement that “all structural engineers shall understand, reduce, and ultimately eliminate embodied carbon in their projects by 2050.” As the SEI Board of Governors stated in their endorsement of the SE 2050 Challenge, we also “recognize the need for coordinated action across our profession to achieve the globally stated goal of net zero carbon by 2050.”

We joined the SE 2050 Commitment in 2021 and we update our Embodied Carbon Action Plan (ECAP) yearly on Earth Day to show what we have been doing during the past year and what our plans are for this next year.

PAE LIVING BUILDING

PORTLAND, OR



Source: Center for Climate and Energy Solutions

The vision of SE 2050 directly aligns with the core values that have guided our organization successfully over the last 60 years. These values are relationships, trust, passion, excellence, and stability. The vision of the future contained within the SE 2050 program is one of **relationships**, to our community locally and globally. It is a vision of providing **stability** and maintaining **trust** with future generations, recognizing that we play an essential role in reducing the embodied carbon (EC) that will impact future generations for the next 27 years and beyond. It exemplifies the **passion** we have as engineers to meet the challenges of today with new ideas and solutions. It requires the leadership and **excellence** to find and implement new carbon strategies that are truly effective and impactful.

Project Highlight >>

Catalyst

Spokane, WA

KPFF provided structural engineering services for a new 5-story, 160,000 sf mass timber office/classroom building with a partial daylit basement. The lateral system for the building is the first of its kind, utilizing CLT shear walls and buckling-restrained braces (BRB) as ductile holddown elements. The Catalyst building, certified by the International Living Future Institute (ILFI), is one of the first zero-energy and zero-carbon buildings in North America.

02

Embodied Carbon Leaders at KPFF

KPFF has two designated Embodied Carbon Champions for our firm: Molly Seto of the San Francisco office and Shana Kelley of the Seattle office. However, **our leadership group for embodied carbon within our firm has had enormous growth** over the last few years. As we've expanded our focus on quantifying and making embodied carbon reductions on projects across our practice, several of our office locations have identified one or more leaders responsible for educating and advocating within their office. This distributed approach to leadership is essential in making sure we are constantly **growing our embodied carbon expertise** and that we are accounting for the regional differences of our projects.

SHANA KELLEY

Seattle, WA

MOLLY SETO

San Francisco, CA

KANE PITHEY

Los Angeles, CA

MATT HOFFMAN

Portland, OR

REID ZIMMERMAN

Portland, OR

ELLA YAZBECK

Seattle, WA

NICHOLAS MILEY

San Francisco, CA

Project Highlight >>

PAE Living Building

Portland, OR

Situated among century-old buildings in a historic downtown Portland district, the PAE Living Building is the first developer-driven and largest commercial urban living building in the world. It is a demonstration of the feasibility of developing competitive office space in city centers while achieving **net zero carbon emissions**. Winner of the ENR Regional Best Project, it was designed and engineered to meet the most rigorous sustainability standards.

A combination of on-site and off-site solar power, along with on-site energy storage, provides 105% of the building's energy demands. Freshwater is collected on-site, stored in an underground cistern, and treated to provide 100% of the building's freshwater demand, and 30 gallons of wastewater per day is collected, treated, and repurposed into fertilizer. The building can operate independent of city utilities.

The building's primary structure uses **mass timber** for its floors and columns, instead of steel or concrete, resulting in a reduced embodied carbon footprint. Exposed timber on the interior provides a 1-hour fire resistance rating for the Type III-A construction.
To allow the building to quickly return to operation after a seismic event, it was designed to a Risk Category IV performance level, providing **seismic resiliency** similar to hospitals and emergency services structures.

All project sustainability goals were delivered on budget and the office space is leased at competitive market rates. The PAE Living Building proves that it is possible to achieve net negative carbon sustainability in an urban office space environment.

03

Reduction Strategy

Much of our effort this year has been tied to our exploration of structural carbon reduction strategies on a variety of projects. A key element has been better understanding both the large and small variables in our designs that impact embodied carbon. Regardless of whether or not a project is pursuing specific environmental goals, we can influence carbon reduction through a number of strategies.

Structural System Selection

Many projects begin with specific environmental goals or considerations, addressing the embodied carbon impacts of different structural systems in requests for proposals and project interviews. These owners and architects expect **embodied carbon discussions** when we are exploring structural systems.

To guide teams in these early stages and have ready, relevant answers, we have focused on getting a comprehensive understanding of the impacts of structural system selection. We have done this by creating our own **in-house database of structural system life cycle assessments.** Even on projects without named sustainability goals, this database can help guide conversations when making structural systems choices.

PORTLAND INTERNATIONAL AIRPORT

MARY D. NICHOLS CAMPUS

CHILDRENS MUSEUM OF EAU CLAIRE

Project Highlight >>

Milgard Hall

Tacoma, WA

One of the best ways to lower the embodied carbon of the built environment is to compare the impacts of different possible structural systems, which typically account for a majority of the embodied carbon of a building. A great example of this is the **whole-building life cycle assessment** that KPFF performed for the new Milgard Hall building on the Tacoma Campus of the University of Washington, a building designed by Architecture Research Office (ARO). This new interdisciplinary building will house elements of the Milgard Business School, new labs for the School of Engineering and Technology, an expanded Global Innovation and Design Lab, a High Impact Practices learning space, and new classrooms.

To compare possible structural systems for this project, whole-building life cycle assessments were performed to examine the differences for timber, steel, and concrete structural systems. KPFF created separate models, including structure and enclosure, for all three scenarios to quantify the environmental impacts of each building with the Tally WBLCA software.

The report on the evaluation included a **transparent description of how biogenic carbon was evaluated** and the end of life assumptions used to determine the amount of carbon sequestered by the mass timber structure. In addition to environmental impacts over the whole life cycle of the building, embodied carbon impacts at the initial construction of the building were also provided.

A mass timber structure was ultimately selected for the building. This resulted in a carbon reduction for the whole building, with respect to an all concrete structure alternative, of 43% over the entire life cycle, with **over 1 million kilograms of carbon emissions avoided**. When looking at initial embodied carbon, the sequestered carbon in the mass timber structure offset nearly all the carbon emissions attributed to the non-wood portions of the structure, including the concrete and reinforcing in the foundations. The choice to use mass timber required coordination across the entire integrated design-build team, which was led by Anderson Construction, proving that **collaboration is key** in prioritizing carbon reductions in building designs.

Retrofits / Adaptive Reuse

A key reduction strategy that we are really excited about is adaptive reuse and retrofitting existing structures to create new spaces. **Retrofitting existing structures uses the carbon we have already spent** and can significantly increase the building's useful life. Retrofits have always been a part of our practice, but we are improving our ability to help clients quantify the environmental costs of retrofitting versus building new.

Project Highlight >>

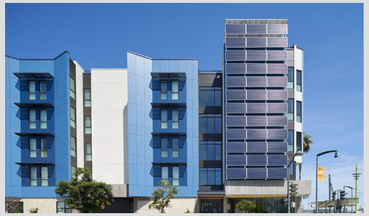
Edwin Lee Apartments

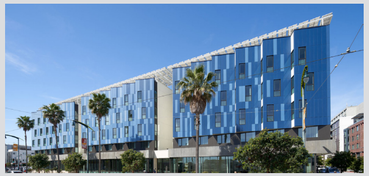
San Francisco, CA

"The Edwin Lee Apartments in San Francisco are a beautiful example of affordable housing done right," says Jeffrey Zhang, the project's manager. The complex accommodates 62 formerly unhoused veterans and 57 low-income families. A recipient of a 2022 COTE Award for sustainable design excellence, the building showcases thoughtfully selected materials and a focus on on-site renewable energy. The intent of the building design was to optimize material use with a focus on durability and carbon impact. The rental housing units are Type V residential construction over a Type 1 podium concrete structure featuring one-, two-, and three-bedroom apartments.

By using 70% cement replacement in the concrete structure and leaving the first floor exposed, the team reduced the building's carbon impact and the need for finish material.

The vertical solar panels on the south-facing facade were installed at the precise placement, angle, and spacing to ensure maximum solar energy output. With the solar canopy as well as panels on the roof, this infrastructure is expected to produce 90% of annual electricity requirements for the building's common areas.





Material Reuse

Even when reusing an entire structure is not an option, there are still opportunities to **incorporate elements from demolished projects in our new construction.** A great example of this is the Federal Center South project in Seattle, where we used 200,000 board feet of wood framing from an existing structure demolished on-site. This is roughly equivalent to the yield of 4 acres of Washington forest. This work required extensive cataloging of the existing framing, unique and flexible detailing, and structural testing to fully capture the capacity of the existing wood.

This past year we have explored new ways of detailing our current systems to consider end-of-life reuse. In collaboration with ZGF Architects, we are exploring CLT system design, using our experience lab testing composite CLT systems to help explore how these systems are disassembled.

200,000 BOARD FEET OF WOOD FRAMING USED FROM AN EXISTING STRUCTURE DEMOLISHED ON-SITE

System Efficiency

KPFF has always focused on **increasing structural efficiency** while still accounting for capacity and performance. Less structural material usually translates to lower costs, an important goal for many of our clients. Less structural material also means less embodied carbon impact. We have found that considering efficiency and embodied carbon together further emphasizes the importance of creating an efficient design.

FEDERAL CENTER SOUTH

Material Specification

Once the structural system has been selected, the next opportunity to reduce embodied carbon is material selection. We have made the biggest impacts through **changing how we specify high EC intensity materials** like concrete and steel. Several of our offices have implemented location-specific language requiring environmental product declarations (EPDs) and/or global warming potential (GWP) reductions on certain projects.

Keeping it Local

Embodied carbon reduction strategies need to vary depending on the location of the project. The knowledge base and information available regarding the embodied carbon of structural materials widely varies across the nation. This applies to information about local building materials (EPDs) as well as contractor knowledge. Each project's embodied carbon goals need to recognize this variability and be **customized for the project location**.

For example, many of our offices require reporting and reductions for embodied carbon in concrete submittals. Where EPDs are readily available, the specifications can be written to require a calculation of the reduction from a regional baseline. Where EPDs are not readily available, limitations on high embodied carbon constituents can be specified instead.

Being Flexible

We have learned to **stay flexible** when selecting embodied carbon reduction strategies. On multiple projects, specified materials became unavailable due to supply issues (for example, Type IL cement was unavailable from one of the main concrete suppliers in the Seattle area for a number of months due to shipping issues and a fly ash shortage in the San Francisco Bay Area). In these cases, we have to adjust and evaluate the impacts of the changes. In many cases we have been able to find alternate EC reduction pathways, such as the use of lower-carbon reinforcing steel or the use of alternative supplementary cementitious materials, to still maintain the reduction goals of the project.

04

Education Plan

In 2021, during KPFF's first year as a SE 2050 Signatory, we created a Structural Sustainability group made up of **sustainability champions** identified from each office. We held an inaugural two-day KPFF Sustainability Summit that year, where we each shared lessons learned and how our local markets were tackling sustainability in design. We concluded the summit with informational sessions on embodied carbon. Each sustainability champion then shared the knowledge they gained with their local office.

The KPFF Structural Sustainability group is currently planning a two-day **KPFF Embodied Carbon Summit** in 2023. The first summit focused on introducing sustainable practices to our Structural Sustainability group; the focus of our next Sustainability Summit will be to recap the progress made in each office and share knowledge, identify synergies, and advance our practice with respect to embodied carbon, LCAs, and EPDs.

In addition to the internal Sustainability Summits, KPFF provides avenues to share lessons and expertise within the firm between our regular meetings. We have created a firm-wide portal for structural sustainability on our Microsoft Teams hub that is accessible by all KPFF employees as a means to broadcast sustainability messages. We have many employees who actively give and attend presentations by the **Carbon Leadership Forum, ASCE,** and local **Structural Engineering Association** chapters and material suppliers. The message board allows us to advertise these presentations firm-wide. A resources section includes documents from SE 2050 as well as copies of internal presentations and resources. The **Question and Message Board** page allows structural engineers to share resources and get advice from engineers throughout the firm.

Some offices have started their own internal Sustainability Groups. These groups discuss a variety of sustainability topics, including the state of sustainable design practices within their local market and office, sharing sustainable design practices and how to advance them, and sustainability initiatives both inside and outside of the office. These office Sustainability Groups are a great way to **engage our younger staff** who are passionate about sustainability.

05

Knowledge Sharing

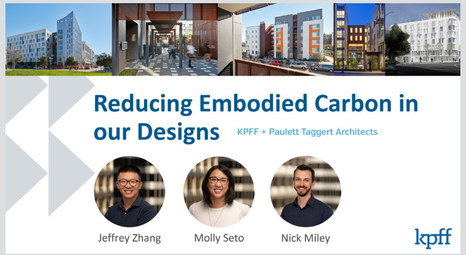
Our approach to **advocacy** for embodied carbon reduction over the last year focused on sharing our experiences, advocating on our local projects, and advocating in the wider industry.

As we have been developing our knowledge base for embodied carbon in structures, we have found ways to **share these lessons** in local and national organizations. As noted in the elective section, we participate in and present on embodied carbon topics related to structures in these organizations. We will continue to work on engaging and contributing in the coming year.

For our local projects, we proactively discuss pathways to embodied carbon reduction with architects, owners, jurisdictions, and contractors. One of the biggest roadblocks to embodied carbon reduction is reticence to change construction methods. By sharing evidence of projects **successfully implementing low-carbon strategies** and selectively test-running new materials or systems, we continue to move the needle forward.

As structural engineers, we have many opportunities to engage with contractors and suppliers on a wide range of materials for structural systems. We will continue to develop a better understanding of how the manufacturing processes for these materials contribute to EC while finding opportunities to **advocate for new and effective solutions.**

Presentation Highlight >>



Reducing Embodied Carbon in Our Designs

KPFF has given multiple presentations to our architectural clients to share our knowledge on embodied carbon. One such presentation was given to our partners at Paulett Taggart Architects in San Francisco. The Embodied Carbon Presentation by KPFF was specifically tailored to their firm and our work together. It was a very informative presentation giving insight into how our design decisions can impact the carbon footprint of our structure and how early decisions about our structural approach can help us significantly reduce the carbon footprint of our buildings.

06

Reporting Plan

KPFF's approach to measuring, tracking, and reporting embodied carbon is very much on a project-by-project basis. As the approach and resources highly depend on project goals and location, we utilize a host of different strategies and best match them to each specific project.

When calculating the embodied carbon of structural materials, we try to utilize the most **realistic EC intensities for materials** used on our projects, both for baseline and proposed models. For example, many of the markets that we work in do have extensive EPDs available for local concrete; however, some do not. We have found that the availability of EPDs for many structural materials is increasing for both local and regional materials. As EPDs continue to be uploaded to the Building Transparency tool, we will be able to filter industry and product EPDs there as well.

The software we use for **life cycle assessments** and for evaluating EC impacts on projects depends on the project's specific sustainability goals and certifications. Embodied carbon tracking software programs that have been commonly used on our projects include Tally, Athena, and EC3. Use of the TallyCAT tool is also being explored to better integrate Autodesk applications and EC3 on our projects.

The life stages included in the life cycle assessments we have done in the past depend on the purpose for performing the LCA. Where a choice between products for specific materials is being considered,

100 Stockton Project
San Francisco, CA

we will sometimes look only at the cradle to gate embodied carbon using EPDs. However, when looking at overall structural systems, we include more stages. Both LEED and ILFI certifications have different requirements for the life stages to include, so those requirements often control what is included. When producing reports outlining our findings, we always include a summary of what life stages are included.

When embodied carbon is being studied early on in a project, the material quantities may only be estimated from previous similar projects. For projects that are further along in design, many of our current structural projects are modeled in Revit, and we have found that this is one of the most accurate ways to extract material quantities. Timing of extraction of material quantities will vary depending on project goals.

07

Electives

We have reviewed the electives we included in our 2022 ECAP and we were able to achieve all those listed. It should be noted that the requirements for embodied carbon language in specifications and proposal language that featured our SE 2050 Commitment were implemented on many, but not all projects.

Reduction (1 required, 4 recommended)

✓ Submit a circular economy narrative describing how a project supports the circular economy. This can be done by incorporating re-use or design for deconstruction into at least one project.

See project highlight in the reduction strategy section of this ECAP on our Federal Center South project.

✓ Update your specifications to incorporate embodied carbon performance. Include embodied carbon in your submittal review requirements.

We continue to expand the use of requirements for EPD submittals and GWP reduction calculation in specifications on multiple projects.

✓ Communicate the embodied carbon impacts of different design options to clients with creative and effective data visualization.

✓ Compare different design options with embodied carbon as a performance metric during the project concept phase. Explain what you did and what the results changed (if anything).

See project highlight in this ECAP on our Milgard Hall project.

✓ Participate in a LEED, ILFI Zero Carbon, or similar project design charrette and speak to potential design considerations impacting embodied carbon.

✓ Collaborate with your concrete supplier to reduce embodied carbon in a mix design below an acceptable baseline (e.g. NRMCA regional baseline values).

During design for a large confidential hospital in San Diego, KPFF Los Angeles and San Francisco representatives engaged in multiple design-assist collaboration sessions with Cemex, a local San Diego concrete supplier. These design meetings allowed the team to better understand contractor capabilities with respect to EPDs, available mixes, and best practices for specifications. The team was able to move embodied carbon reduction forward together, rather than in a vacuum. These low carbon mixes are being implemented in this Acute Care Hospital Design in a way that was previously unprecedented.

✓ Incorporate sustainably harvested biogenic materials in at least one project.

Many of our projects incorporate timber structural members that are certified to be sustainably harvested by FSC, FSI, or through project-specific material tracking.

Education (2 required, 4 recommended)

✓ Provide a narrative of how the Embodied Carbon Reduction Champion will engage embodied carbon reduction at each office.
See the education section in this ECAP for more information about how our embodied carbon leads across our offices collaborate and educate our engineers.

✓ Present at least (1) webinar focused on embodied carbon and make a recording available to employees.

✓ Initiate an embodied carbon interest group within your firm and outline their goals. This group may more broadly address sustainability, but they must include embodied carbon.

See our Education Plan section for a description of internal KPFF Sustainability Groups.

✓ Create an Embodied Carbon digital resource wiki and/or forum on your firm's internal website for staff to create, share, and discuss embodied carbon educational resources.

✓ Engage with a CLF Regional Hub.

Several of our employees regularly attend CLF regional hub meetings and events. Shana Kelley in our Seattle office co-leads the CLF Seattle Hub.

Advocacy (2 required, 4 recommended)

✓ Describe the value of SE 2050 to clients.

✓ Publicly declare your firm as a member of the SE 2050 Commitment however you see fit.

When we first joined the SE 2050 commitment, a blog post describing the program and our work in adopting the commitment was posted on our website here: https://www.kpff.com/blog/news/post/kpff-is-a-signatory-of-se-2050. As we further develop and grow with the commitment, we will continue to post progress updates on our website at https://www.kpff.com/news/

✓ Give an external presentation on embodied carbon that demonstrates a project success or lessons learned.

- ✓ Engage with structural material suppliers in your region to communicate the importance of Environmental Product Declarations (EPDs) and low-carbon material options.
- ✓ Engage with local, state, and federal governments to communicate the importance of low-embodied carbon procurement and construction policies, and provide expert testimony to this effect.

See the Lessons Learned section in this ECAP for more information on our efforts to use our voice to advocate for low-embodied carbon policies.

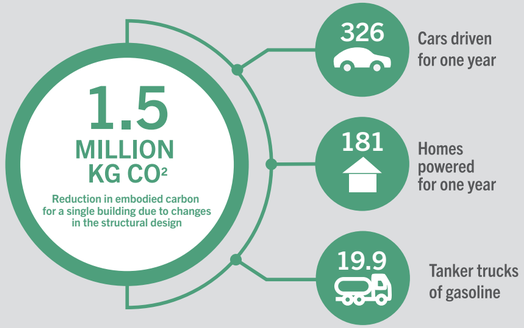
Reporting (1 required, 2 recommended)

- ✓ Submit a minimum of (2) projects per U.S. office with structural engineering services to the SE 2050 Database. You are not required to submit more than (5) total projects across your firm.
- ✓ For multi-office firms, describe how each office is measuring and reporting embodied carbon.

Each office individually decides how they are measuring and reporting embodied carbon. This year, we are planning another KPFF Embodied Carbon Summit to discuss if there are shared resources that we can share on how we report and measure embodied carbon. See our Education Plan section for more information.

- ✓ Propose other actions that promote the reporting of embodied carbon data and describe their value

Internal training for embodied carbon measurement: We have given presentations to several KPFF offices regarding the measurement of embodied carbon of both specific materials and of a whole building. Following our goal from last year, this year we have made new resources and webinars available to all interested employees firm-wide through our KPFF MS Teams Structural Sustainability page. We will continue to provide resources and presentations for the measurement of embodied carbon so more reporting takes place.



08

Lessons Learned

With the rapid expansion of embodied carbon knowledge and practice across our offices, we learned plenty of lessons during 2022. Below are a few examples:

Finding Our Voice

One of our biggest lessons learned this year has been that our design choices on our projects alone cannot create changes large enough to reduce the embodied carbon of the built environment by 2050. For larger changes to happen, we have realized that we must work on having an impact through code development, advocacy, and **work beyond our own projects**.

Participating in Code Writing

KPFF's work to impact change in codes has included the volunteer code work of Molly Seto and Shana Kelley. Molly will serve on the ASCE/SEI 7 Future Conditions of Environmental Hazards subcommittee, and Shana serves as the Sustainability Subcommittee chair for ACI 318 Building Code Requirements for Structural Concrete. Serving on committees like these have the **potential to create change in codes that are used across the world**.

Advocacy

One example of advocacy efforts that we have made in the last year is that the Seattle KPFF office signed on to a February 2023 support letter for embodied carbon limits in the Seattle Building Code. This letter, which was signed by many local designers and builders, encouraged the code advisory board to implement a proposal for **embodied carbon limits** for steel and concrete in larger projects in the City of Seattle.

Activating Younger Voices

While many of the leaders in our offices are involved in daily decision-making on projects that have the potential to impact embodied carbon, we have realized that many of our younger engineers want to be able to understand and impact environmental changes in their work as well. To encourage and develop this passion within our younger engineering group, we are working to develop internal groups and programs focused on embodied carbon to help educate and **empower our next generation of leaders**.

Seattle
Tacoma
Lacey
Spokane
Portland
Eugene
Sacramento
San Francisco
Los Angeles
Long Beach
Orange County
San Diego
Boise
Salt Lake City
Des Moines
St. Louis
Chicago
Nashville
Birmingham
Louisville
Cincinnati
Washington, DC
New York

kpff

KPFF is an Equal
Opportunity Employer
www.kpff.com

Cooley Landing, Palo Alto, CA