Environmental impacts of modular construction for affordable housing

Matt Roberts
Center for the Built Environment

CBE
CENTER FOR THE BUILT ENVIRONMENT

Overview

Modular versus traditional construction

- Differences between traditional and modular construction from a life cycle perspective

Goal of study

- Investigate if modular construction can reduce embodied carbon impacts

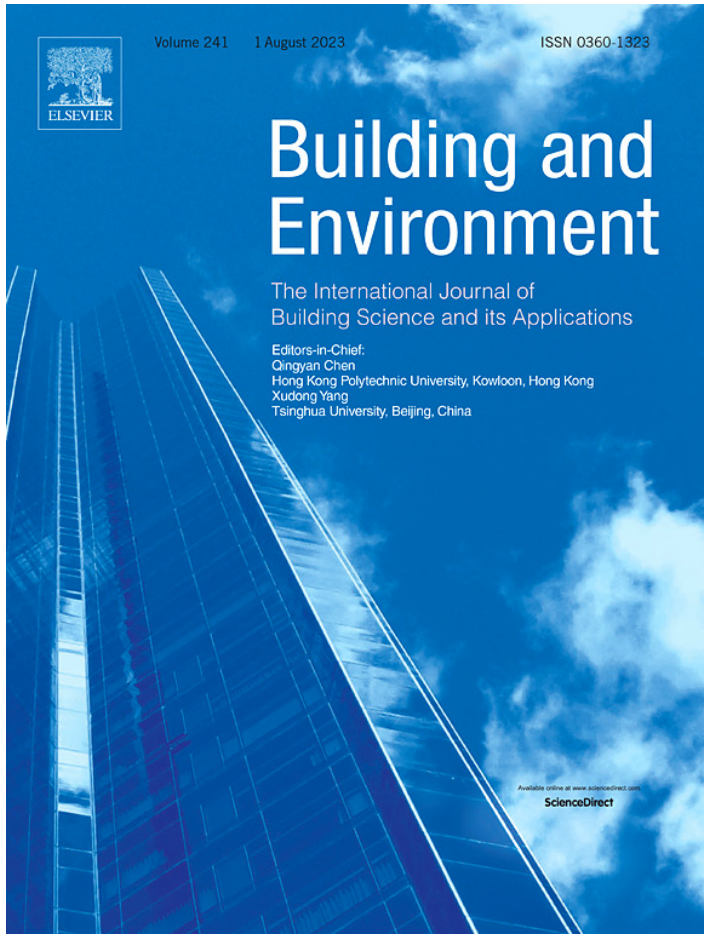
Modular in context

- Is modular the solution?

Decarbonization versus resiliency

The Mayfair Station, Lowney Architecture. Source: ©Emily Hagopian

Associated Study

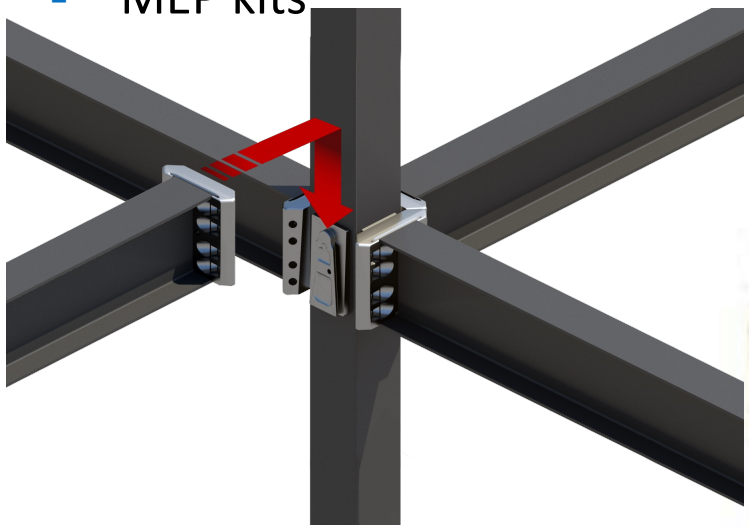


Greer, F., Horvath, A. 2023. Modular construction's capacity to reduce embodied carbon emissions in California's housing sector. Building and Environment. 240 (2023) 110432. https://doi.org/10.1016/j.buildenv.2023.110432

Forms of Modular Construction

Prefabricated

- Prefabricated steel
- Timber framing (i.e., trusses)
- Precast concrete
- MEP kits



https://www.conxtech.com/conx-systems/

Panelized

- Factory-built wall, floor, roof elements

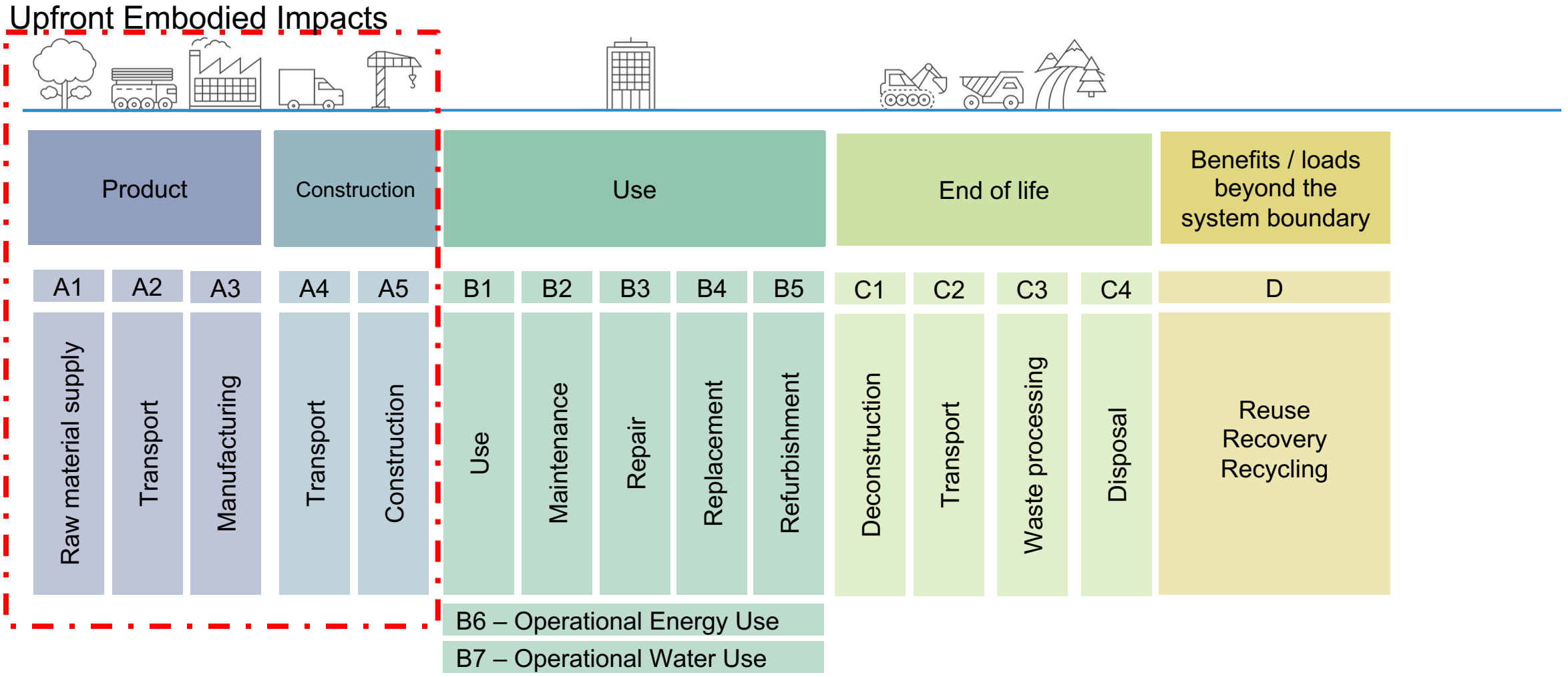
https://arpanel.eu/sandwich-panels/

Modular

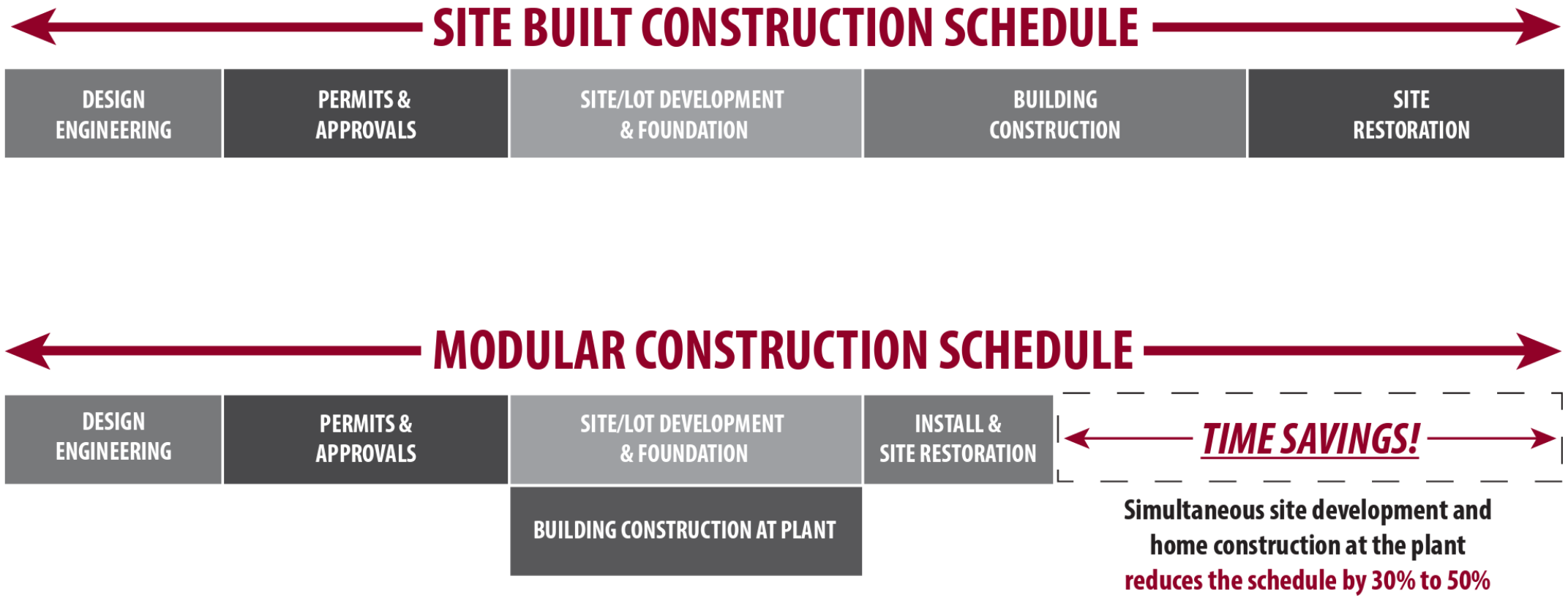
- Fully completed volumetric “pods”

Source: ©Emily Hagopian

Life cycle assessment framework – EN 15978



Comparison to Traditional Construction



Source: https://www.modular.org/industry-analysis/

Comparison of Life Cycle Impacts

Construction

Traditional

A4

Transport of raw materials to site

A5

Construction of building from raw materials on-site

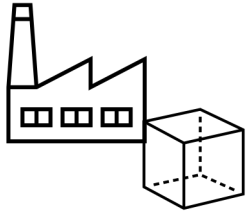
Modular

A4.a

Transport of materials to manufacturing facility

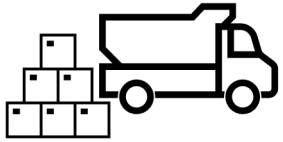
A5.a

Fabrication of modular units



A4.b

Transport of modular units to site

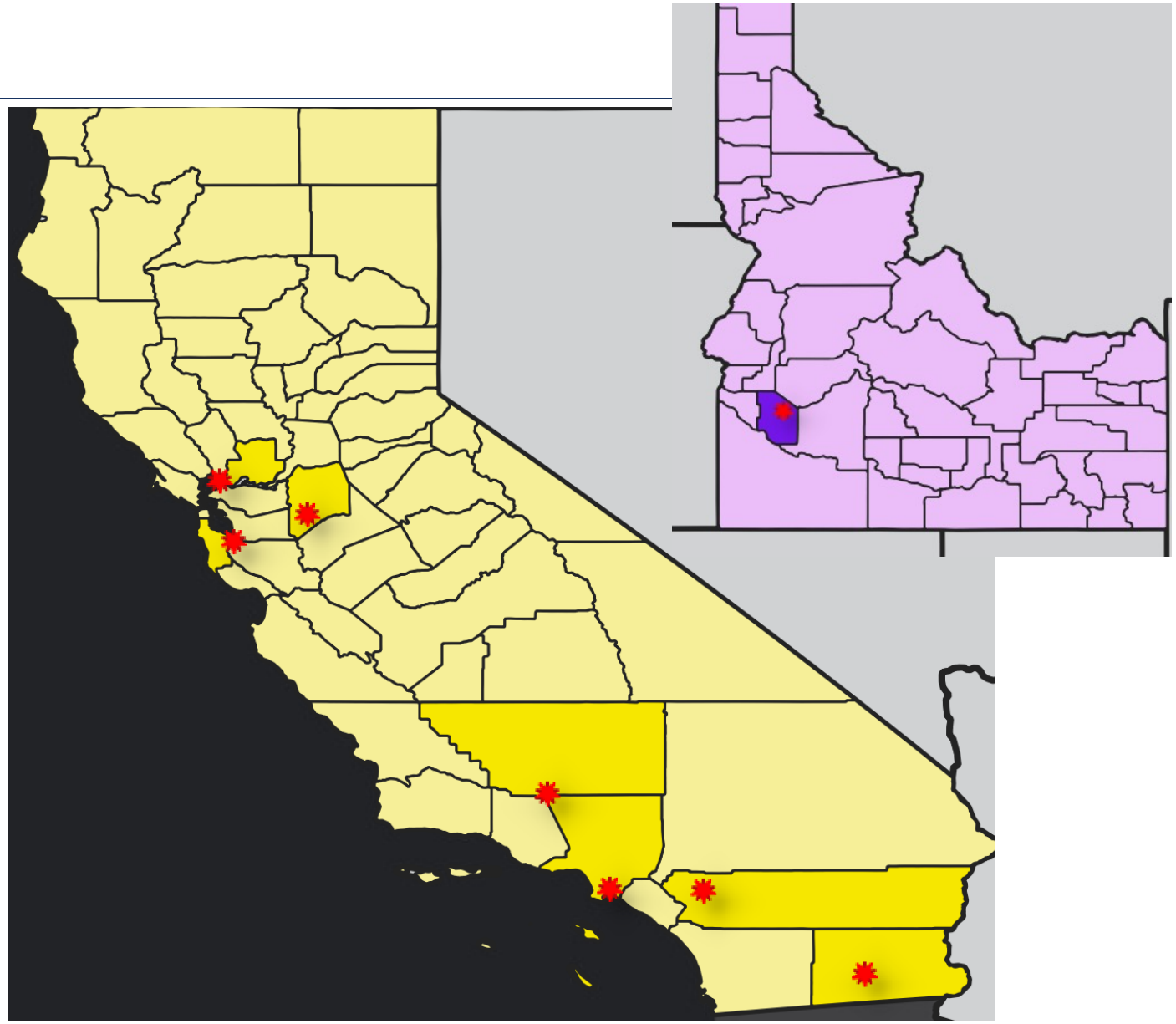


A5.b

Connection of modular units on-site

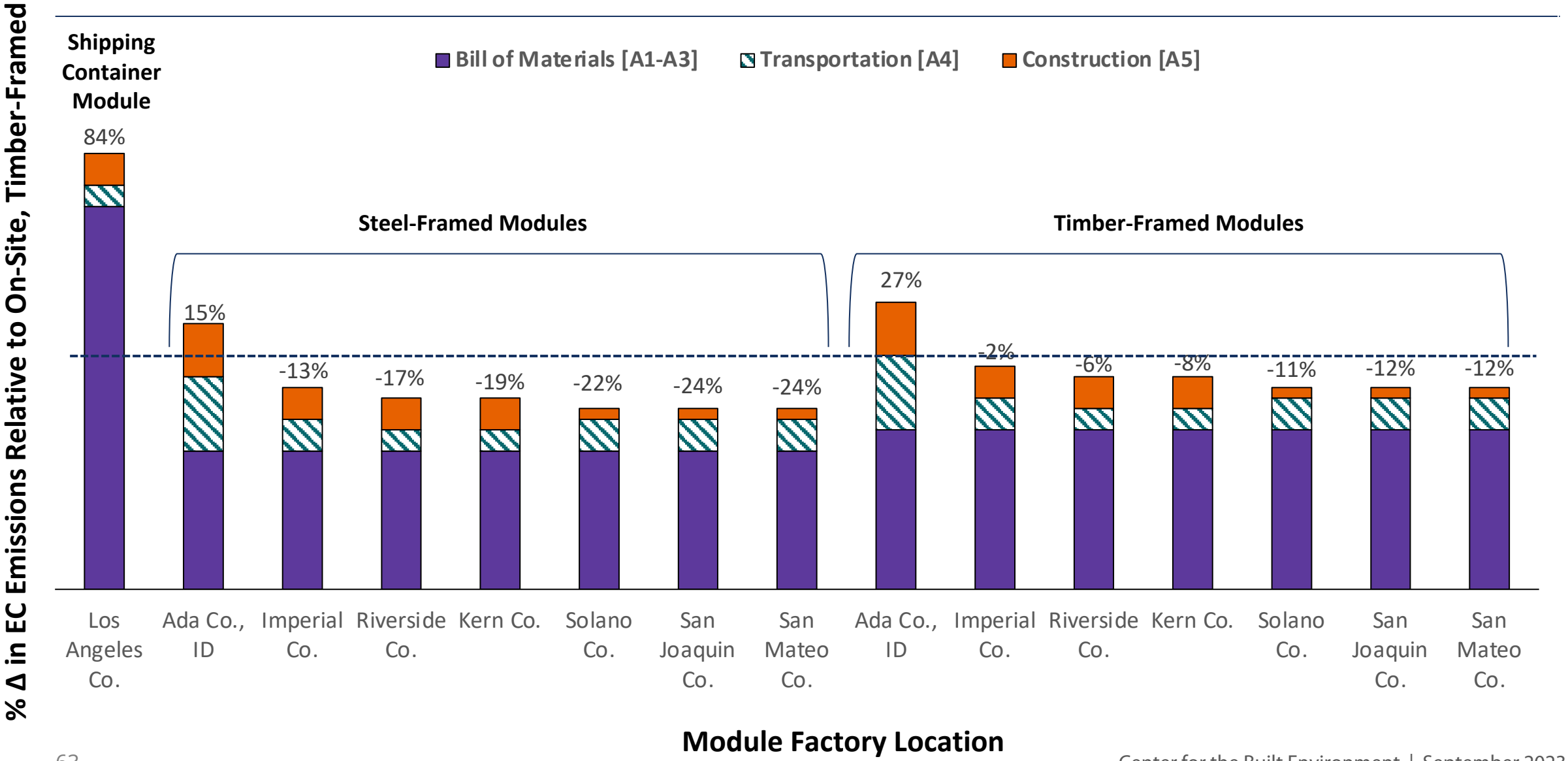
Novelty of Study

- **Models prototypical modular constructions**
- **Includes multiple modular typologies**
- **Scaled to number of housing units needed in each county**
- **Assesses different combinations for each county**

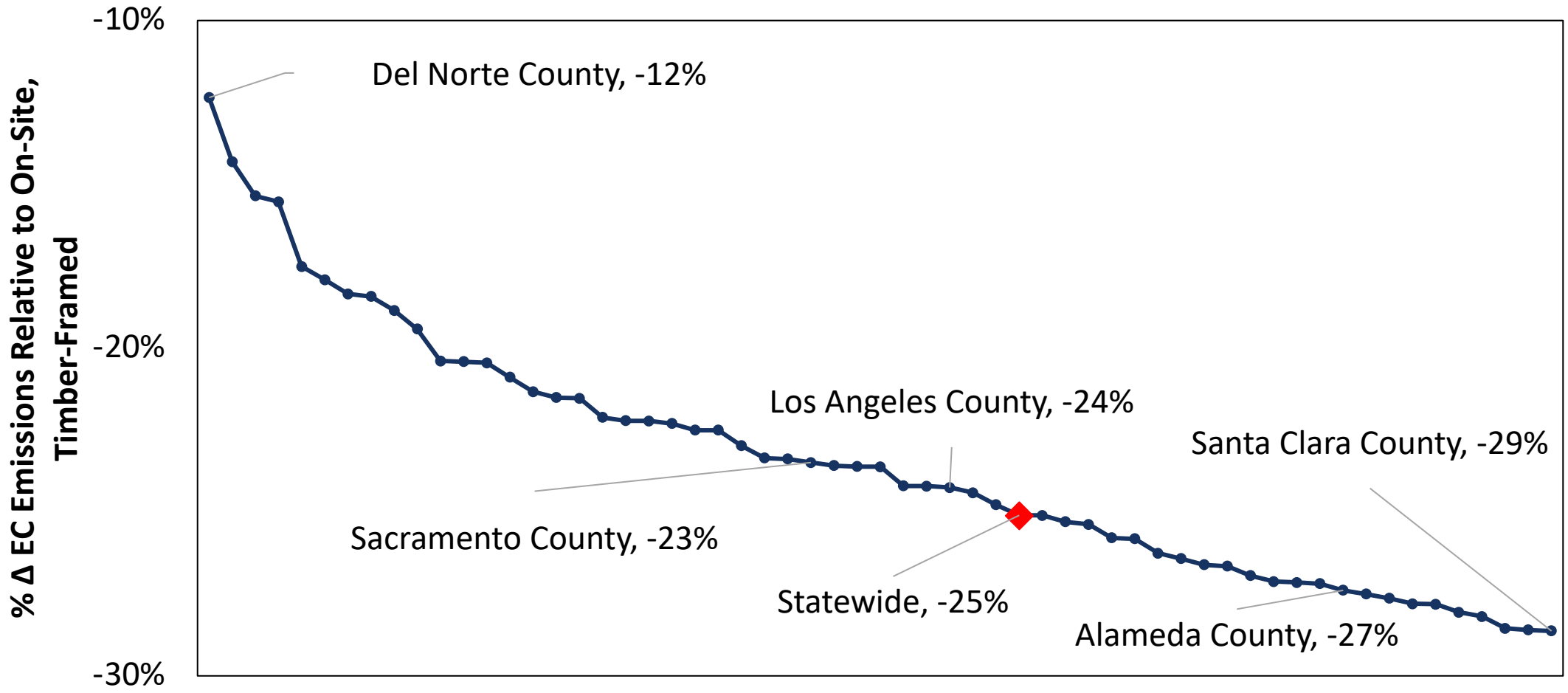


Will modular construction help California reduce embodied carbon emissions in the housing sector ?

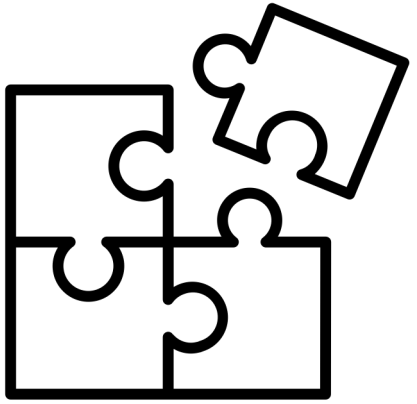
Results: Comparing all modular types statewide to on-site, timber-framed



Results: Monte Carlo analysis – randomized (n = 15,000) allocation of modular types (except shipping container) compared to on-site, timber-framed by county



Is modular the solution?



Modular Capacity

- Factory capacities (**~5,000-10,000 units/year**)
- Housing need (**2.5 million units by 2030**)

Adaptive Reuse

- 18.4 million square foot of vacant real estate in San Francisco
- Up to 35-50% savings in embodied carbon
- Minimizes waste and reduces burden on raw materials

Space

- Do our buildings need to be this size?

Decarbonization versus Resiliency

Decarbonization

Build Less
Build Smart
Build Efficiency
Eliminate Waste
Low-Impact Materials
Renewables
Bio-Based Materials
Reuse

More Redundancy
Stronger Systems
Added Building Elements & Systems
Design for Higher Loads
Islanding & Self-Sufficiency
Design for Extremes

Resiliency

Q&A

We welcome your questions! Please use the microphone to be heard by all attendees.

CBE
CENTER FOR THE BUILT ENVIRONMENT

PAE

David Baker Architects