



UC Building Emissions



Larry Strain
Siegel & Strain Architects

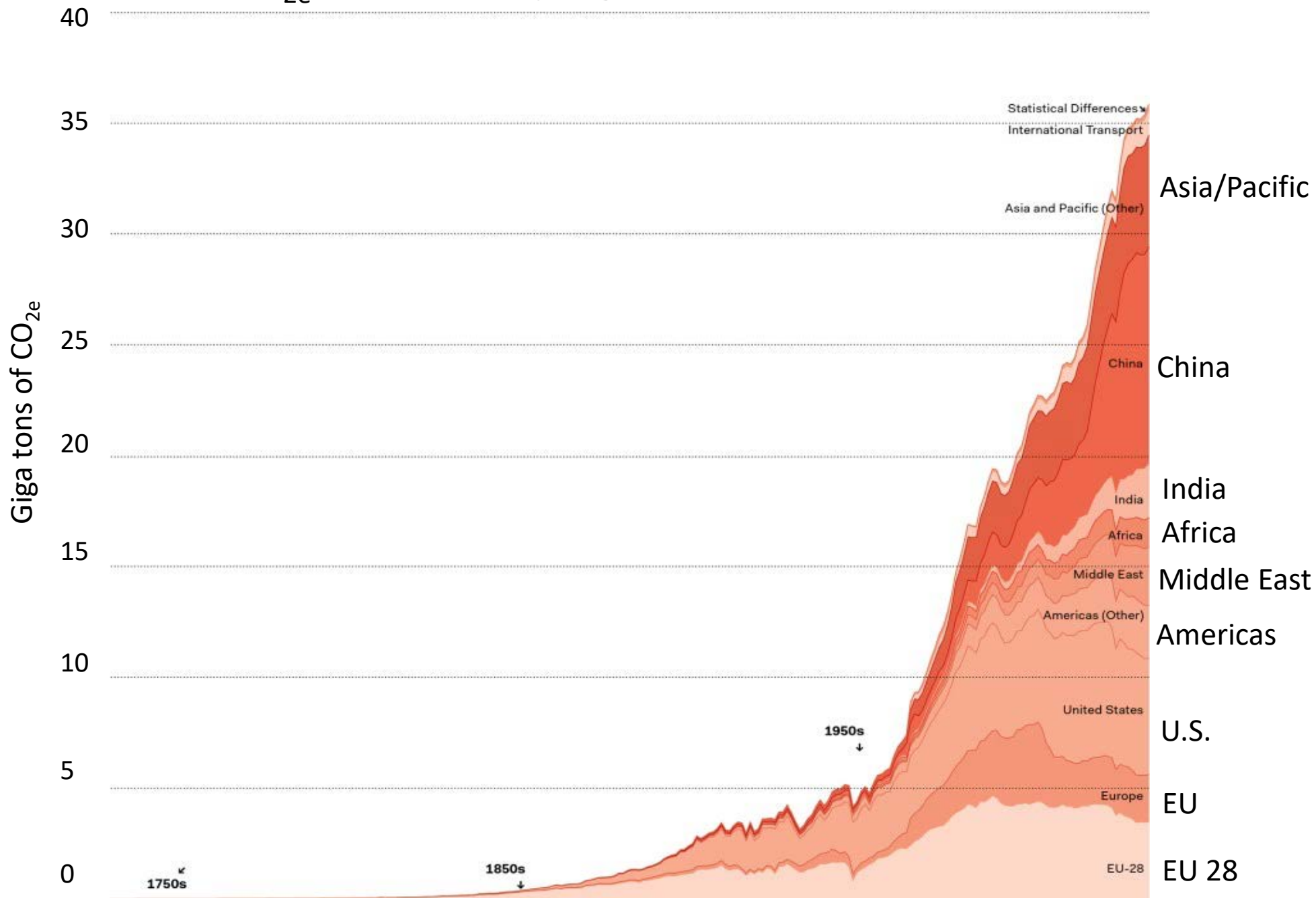
Kate Simonen
Carbon Leadership Forum



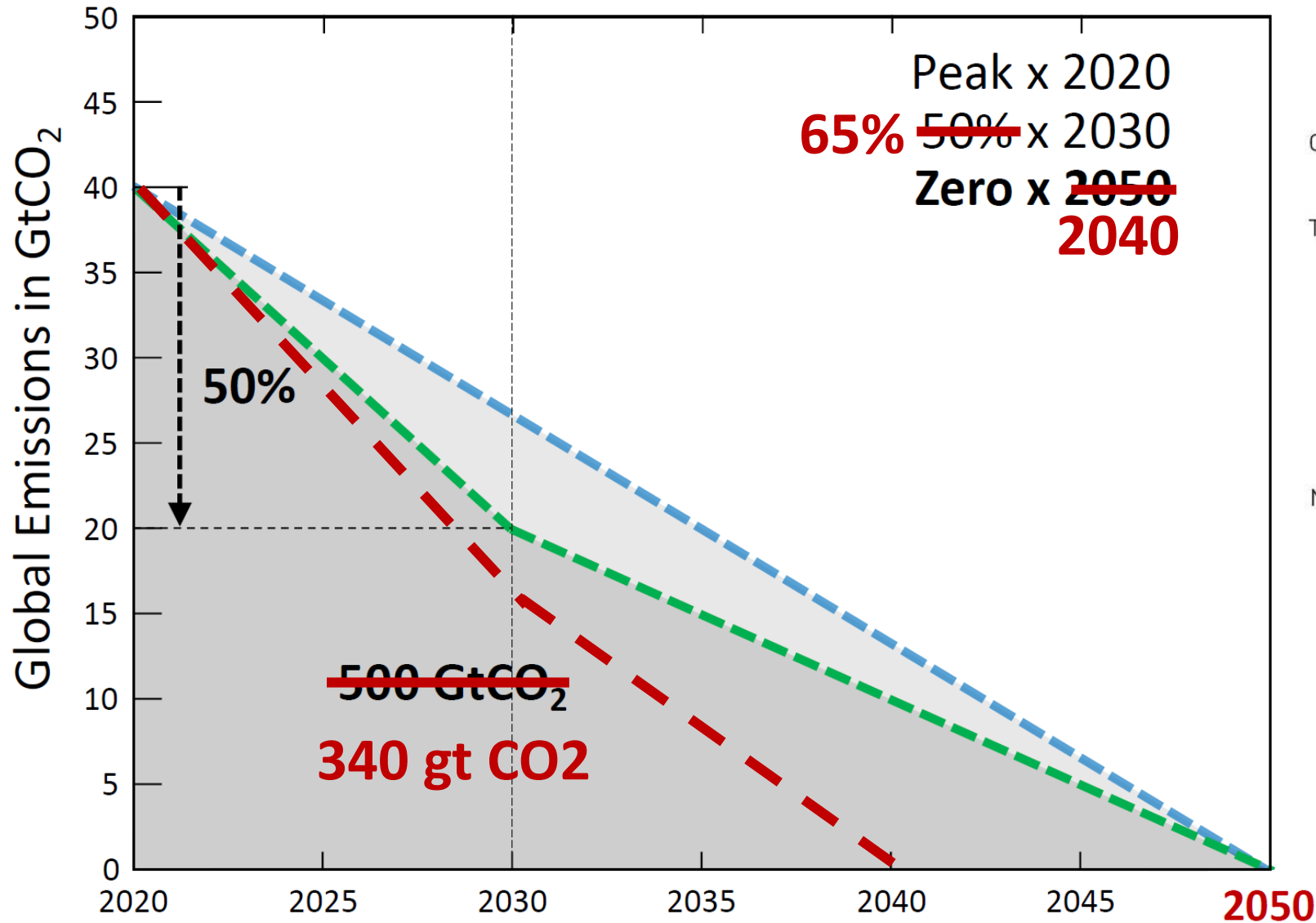
Embodied Carbon



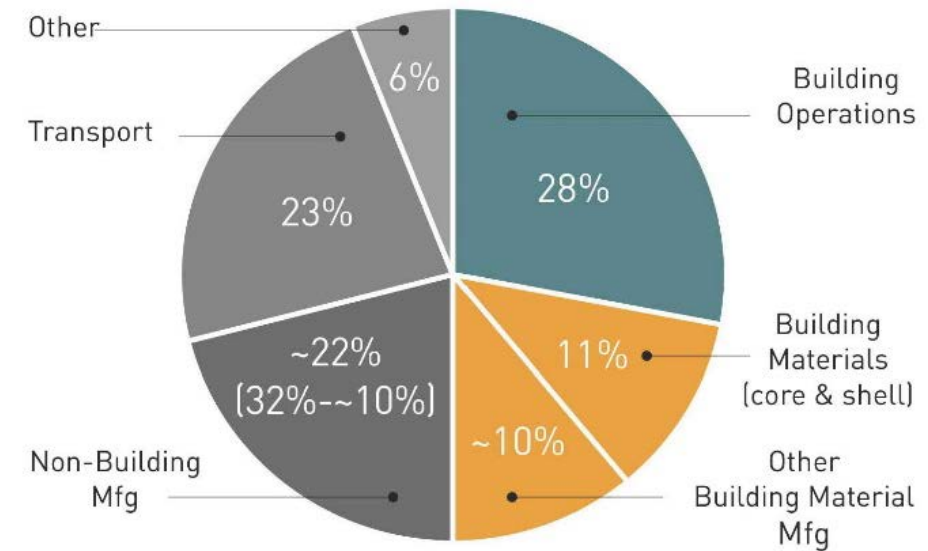
Global CO_{2e} emissions by region since 1750



Urgent Action is Required and Building are Key



Global CO₂ Emissions by Sector



Adapted from 2019 Global Status Report, Global Alliance for Building and Construction (GABC) and Architecture 2030.

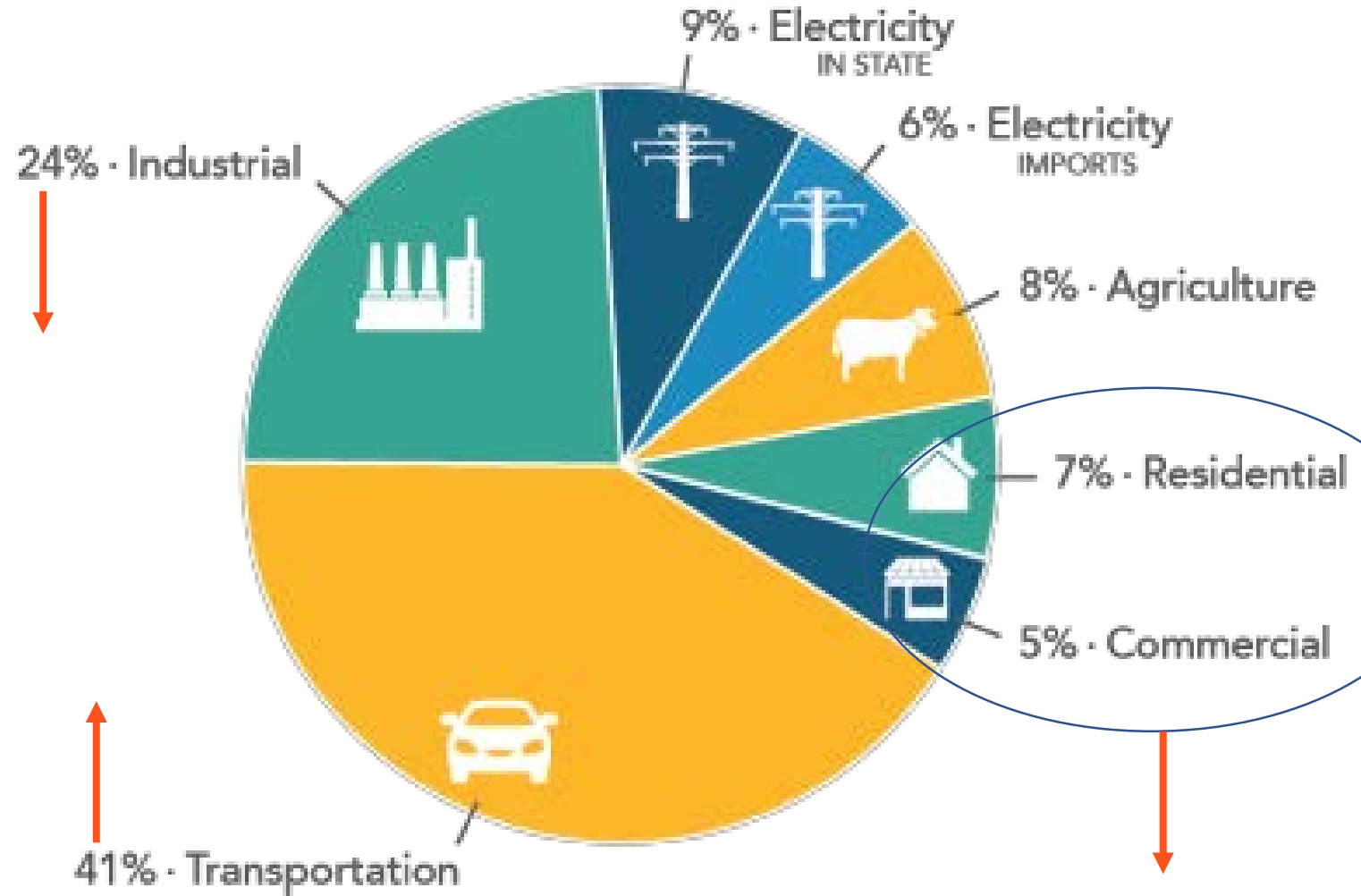
- The building and construction sector has a vital role to play in eliminating carbon, as it is responsible for at least 39% of global carbon emissions.

Source: Architecture 2030; Adapted from RealClimate.org "How much CO₂ your country can still emit, in three simple steps"; and IPCC SR15, Table 2.2



CALIFORNIA 2017 GHG EMISSIONS - 424.1 MMTCO₂

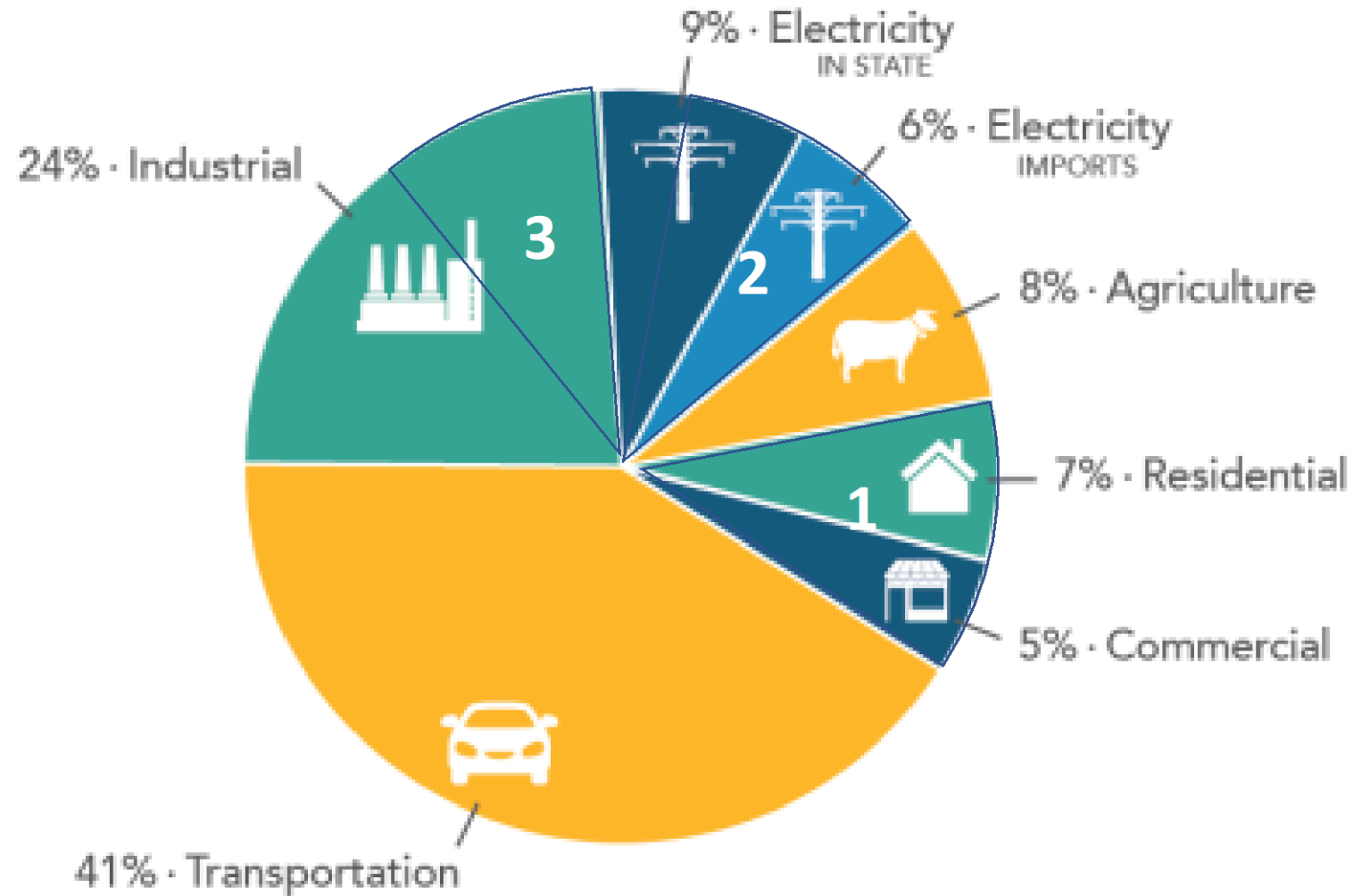
California Building Sector Emissions – 12% ?



CALIFORNIA 2017 GHG EMISSIONS - 424.1 MMTCO₂

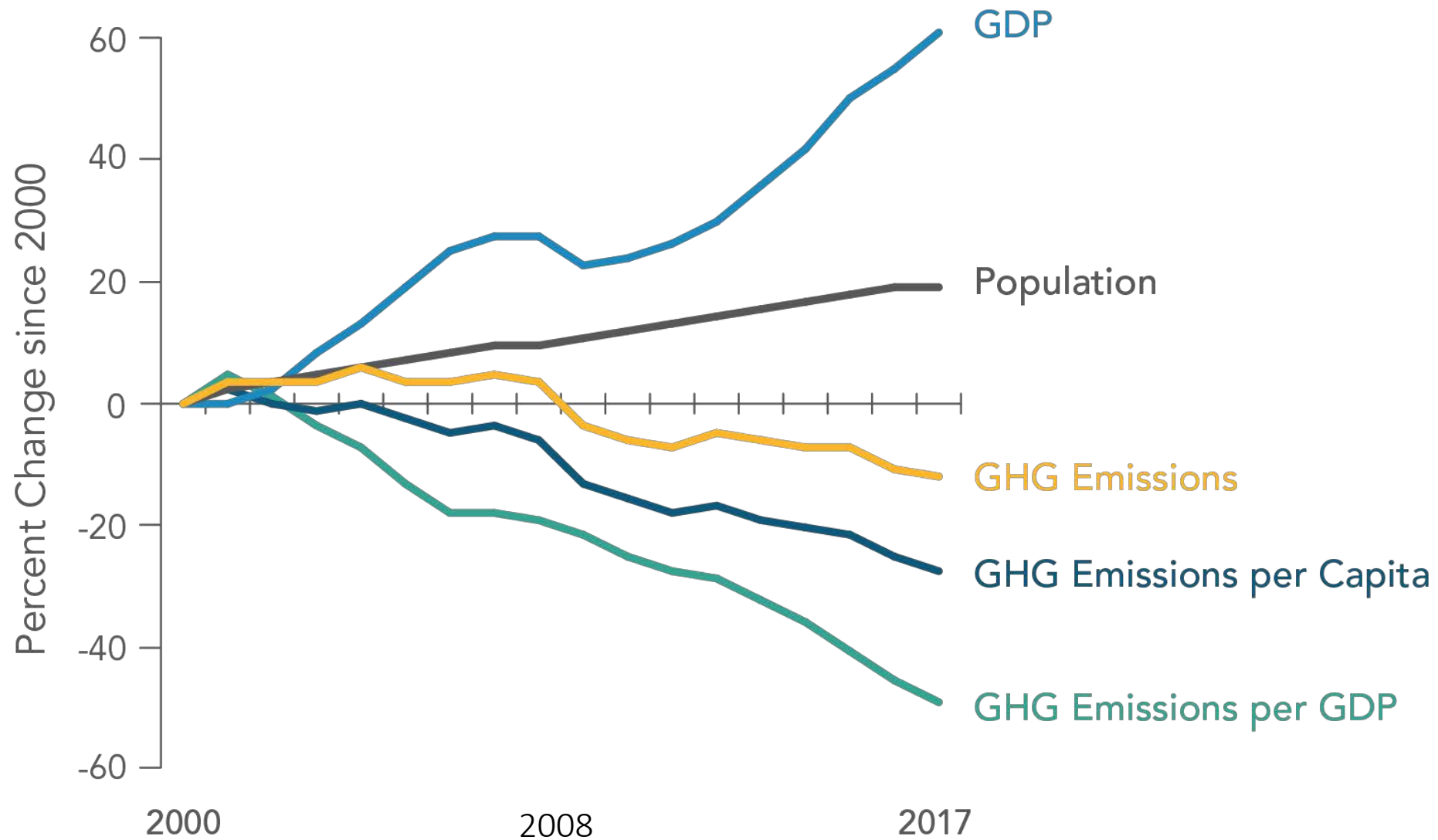
California Building Sector Emissions ~ 33%

1. **Scope 1** - Direct - 12%
on site combustion
2. **Scope 2** - Indirect ~ 11%
Electricity for buildings
3. **Scope 3** - Indirect ~ 10%
business travel, commuting
purchased goods & services
capital goods, **building materials**



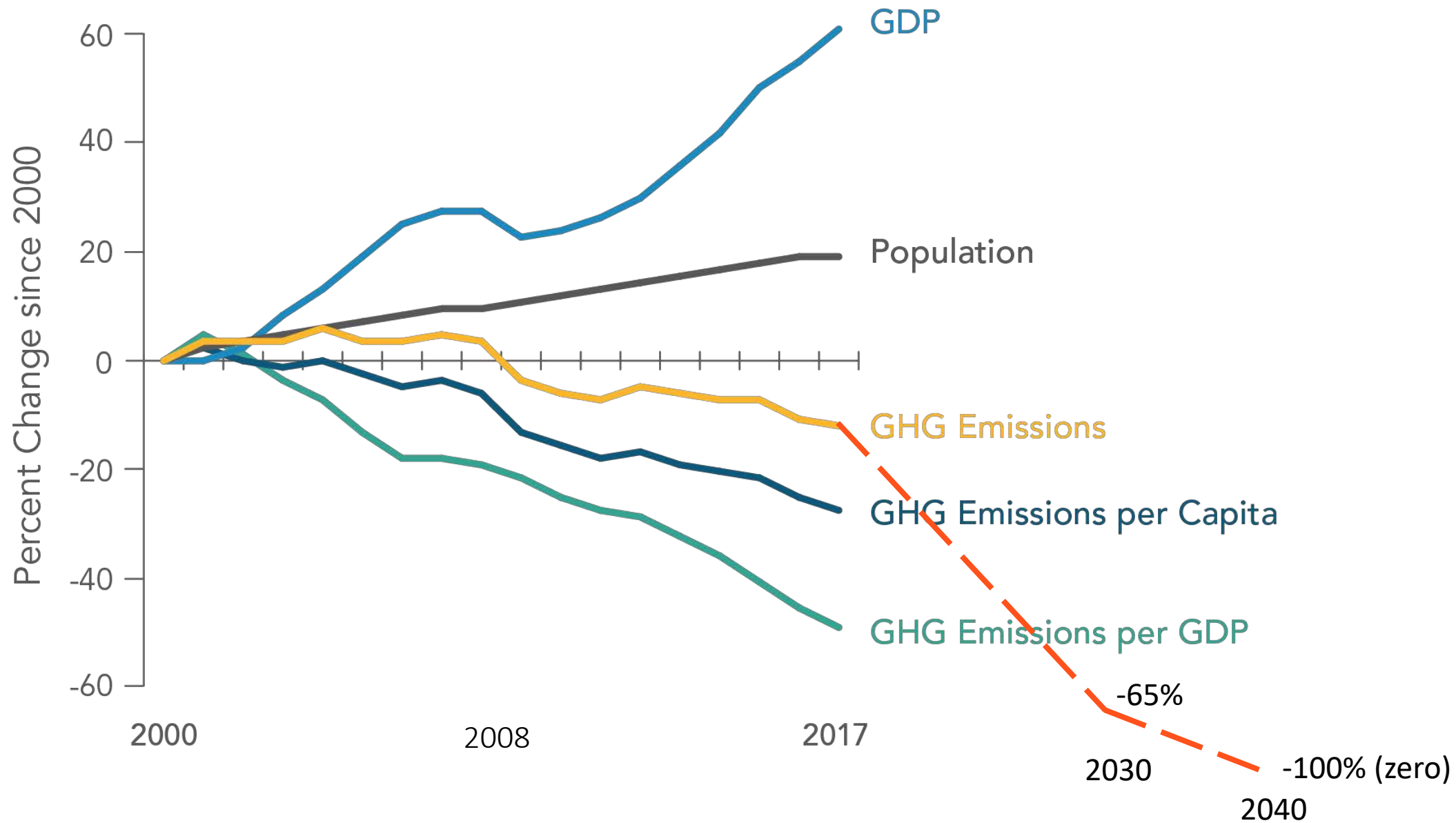


California GHG Emissions since 2000





California GHG Emissions since 2000





Scope 1, 2 & 3 Emissions for buildings

Scope 1 – Direct, on site combustion

Scope 2 – Indirect - electrical grid

Scope 3 – Indirect – off site impacts
including materials/construction
Embodied Carbon

Reduction Strategies

Increase Efficiency

Eliminate gas

Make new buildings electric

Convert Existing to electric

Clean electricity – PV's wind...

On-site – install clean energy

Off-site – purchase clean energy

Use fewer materials

Use lower carbon materials

Use carbon sequestering materials

Building Materials: Embodied Carbon and California Buy Clean Policy

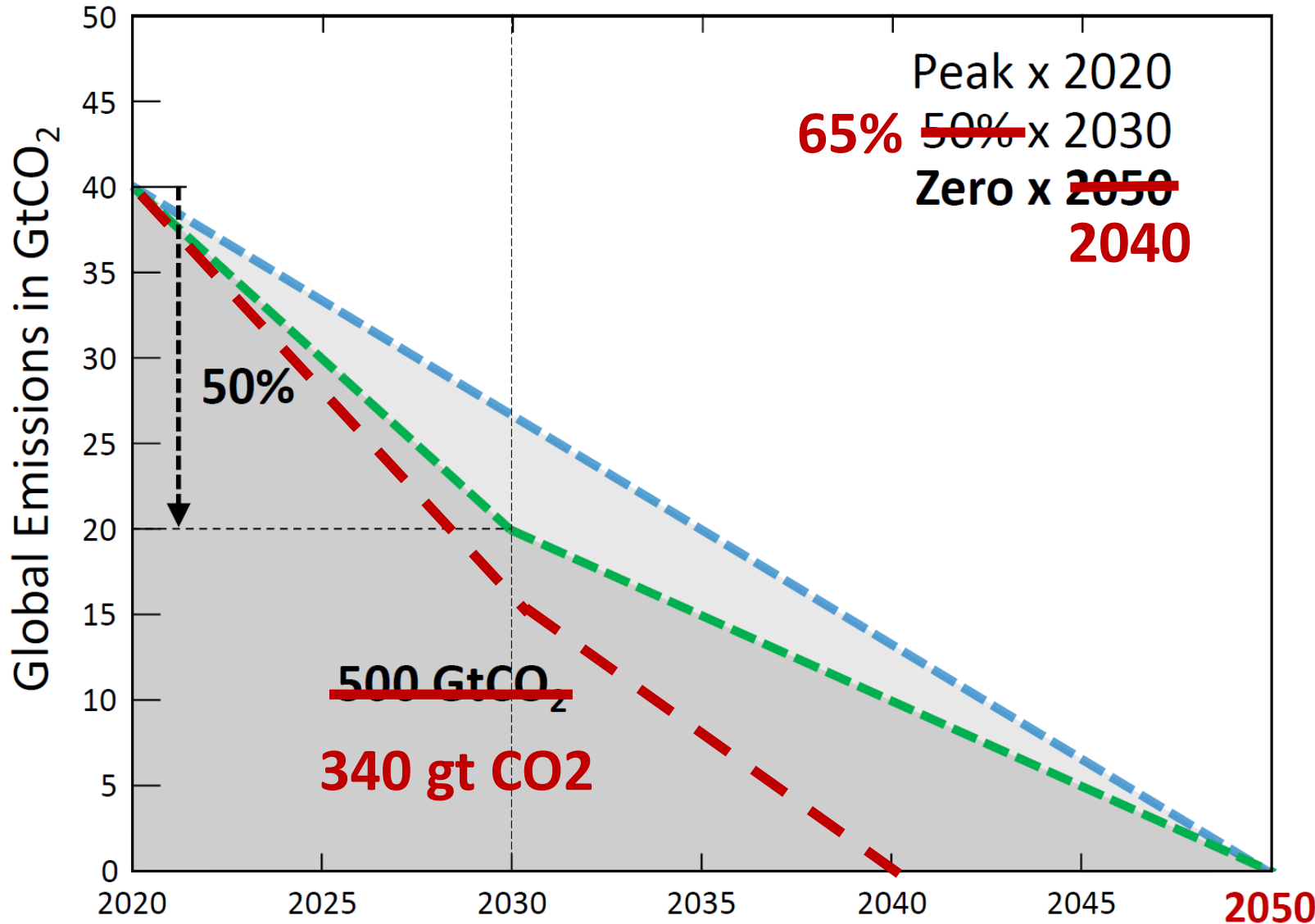
Kate Simonen, AIA SE

Director Carbon Leadership Forum

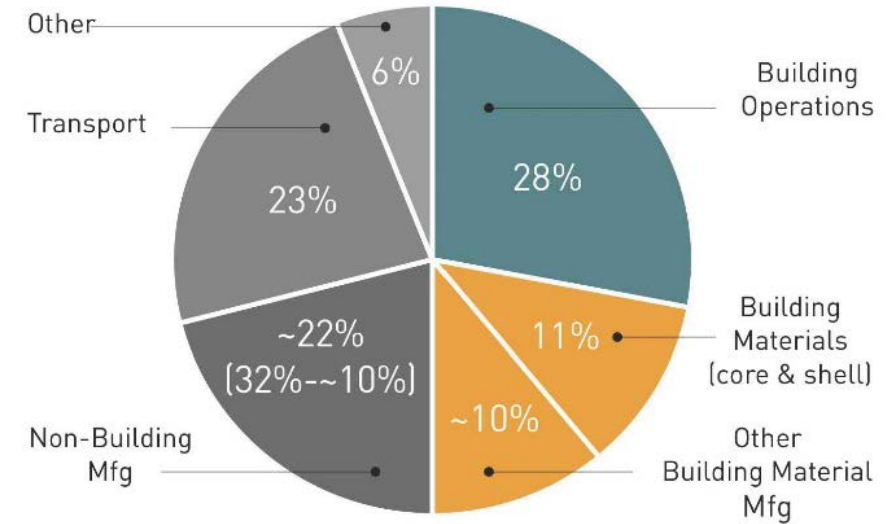
University of Washington

www.carbonleadershipforum.org

Science Based Targets: **Urgent Action is Required**



Global CO₂ Emissions by Sector

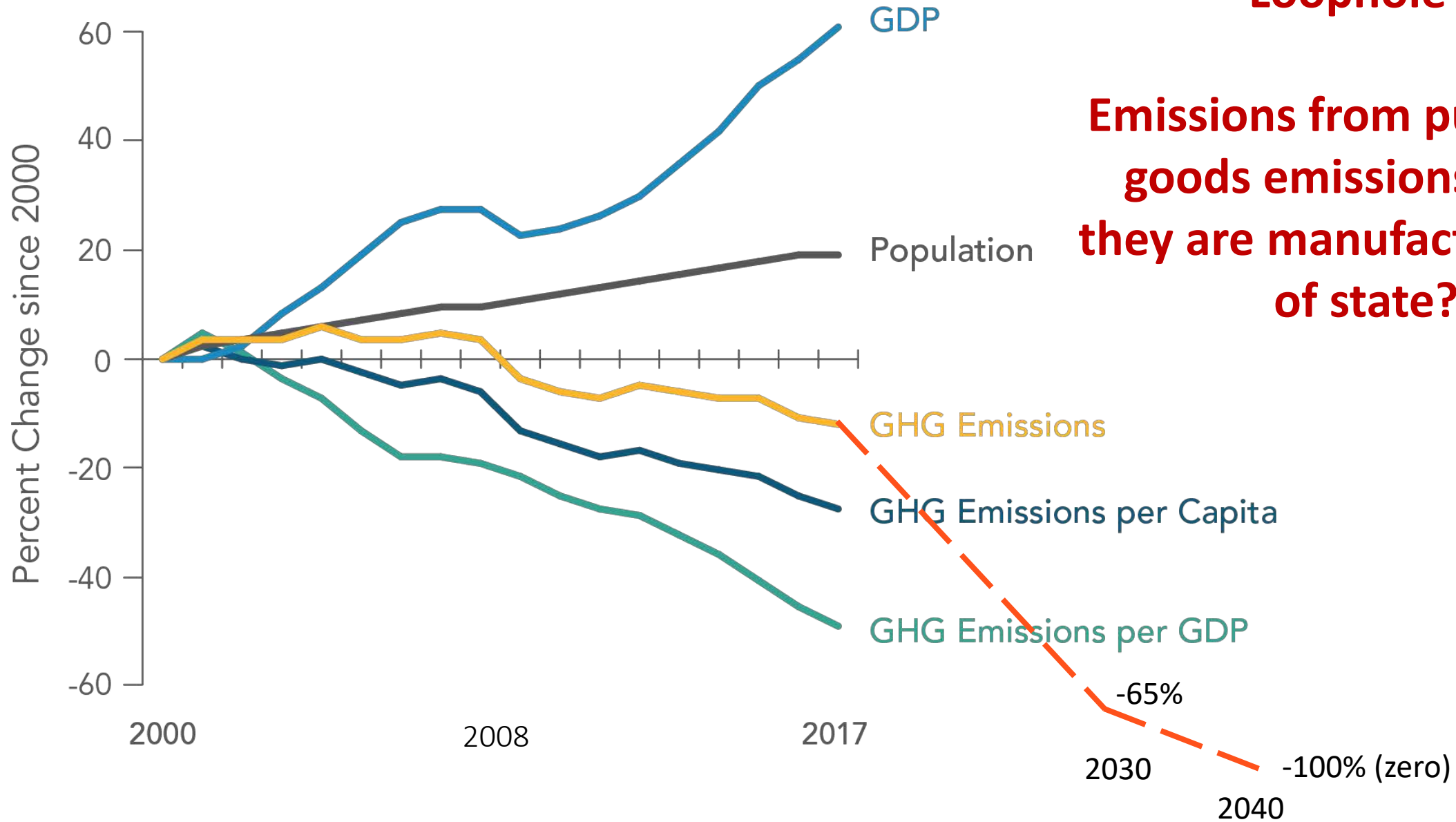


Adapted from 2019 Global Status Report, Global Alliance for Building and Construction (GABC) and Architecture 2030.

- The building and construction sector has a vital role to play in eliminating carbon, as it is responsible for at least 39% of global carbon emissions.



California GHG Emissions since 2000



What about the 'Carbon Loophole'?

Emissions from purchased goods emissions-when they are manufactured out of state?

Operating and Embodied Carbon



Embodied Carbon

Manufacture, transport and installation of construction materials

Scope 3

Operational Carbon

Building Energy Consumption

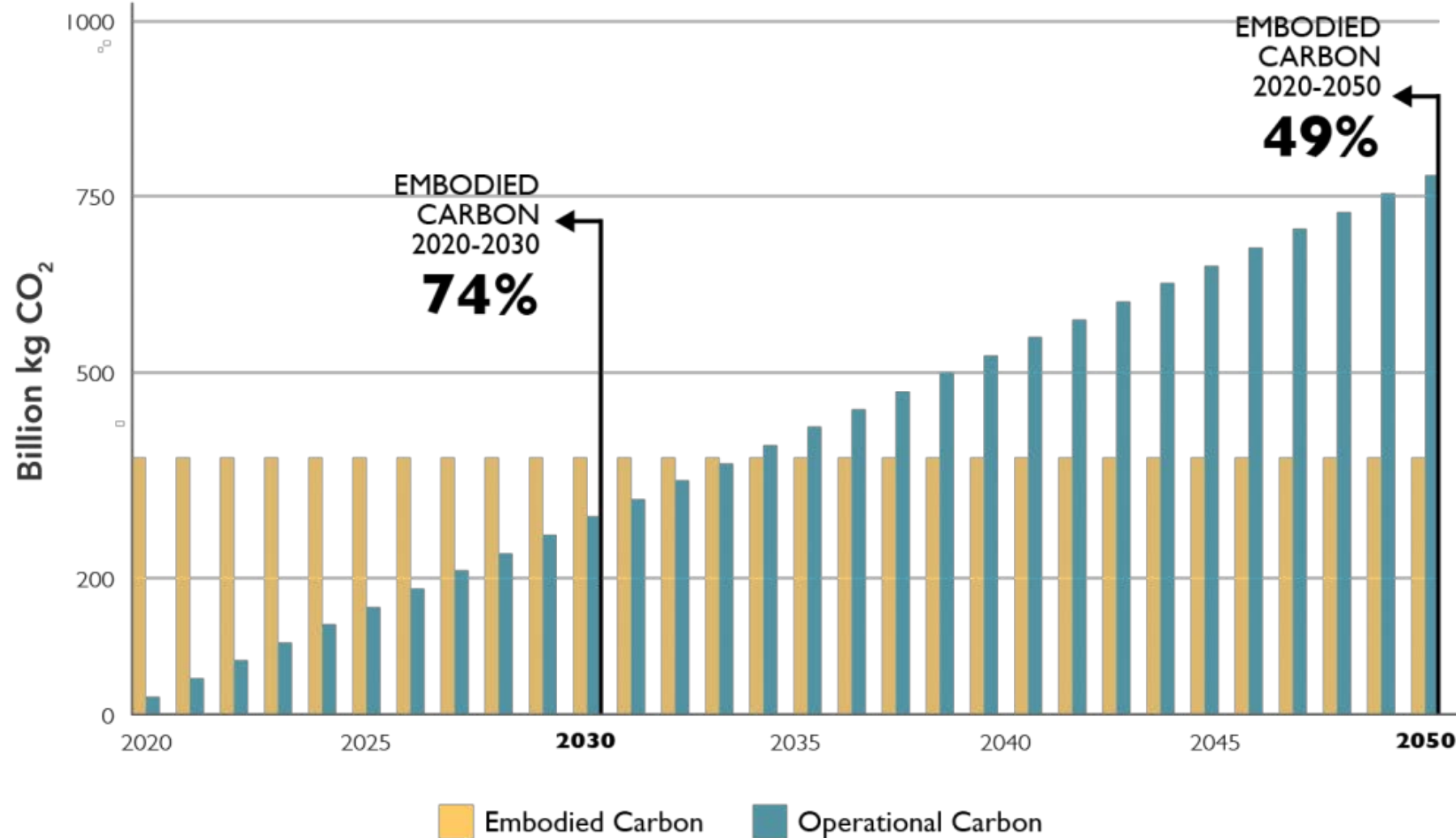
Scope 1+2

Total Carbon = Embodied Carbon + Operational Carbon

$$TC = EC + OC$$

Total Carbon Emissions of Global New Construction from 2020-2050

Business as Usual Projection



Emissions due to:

- Material extraction
- Transportation
- Manufacturing

Life Cycle Costing

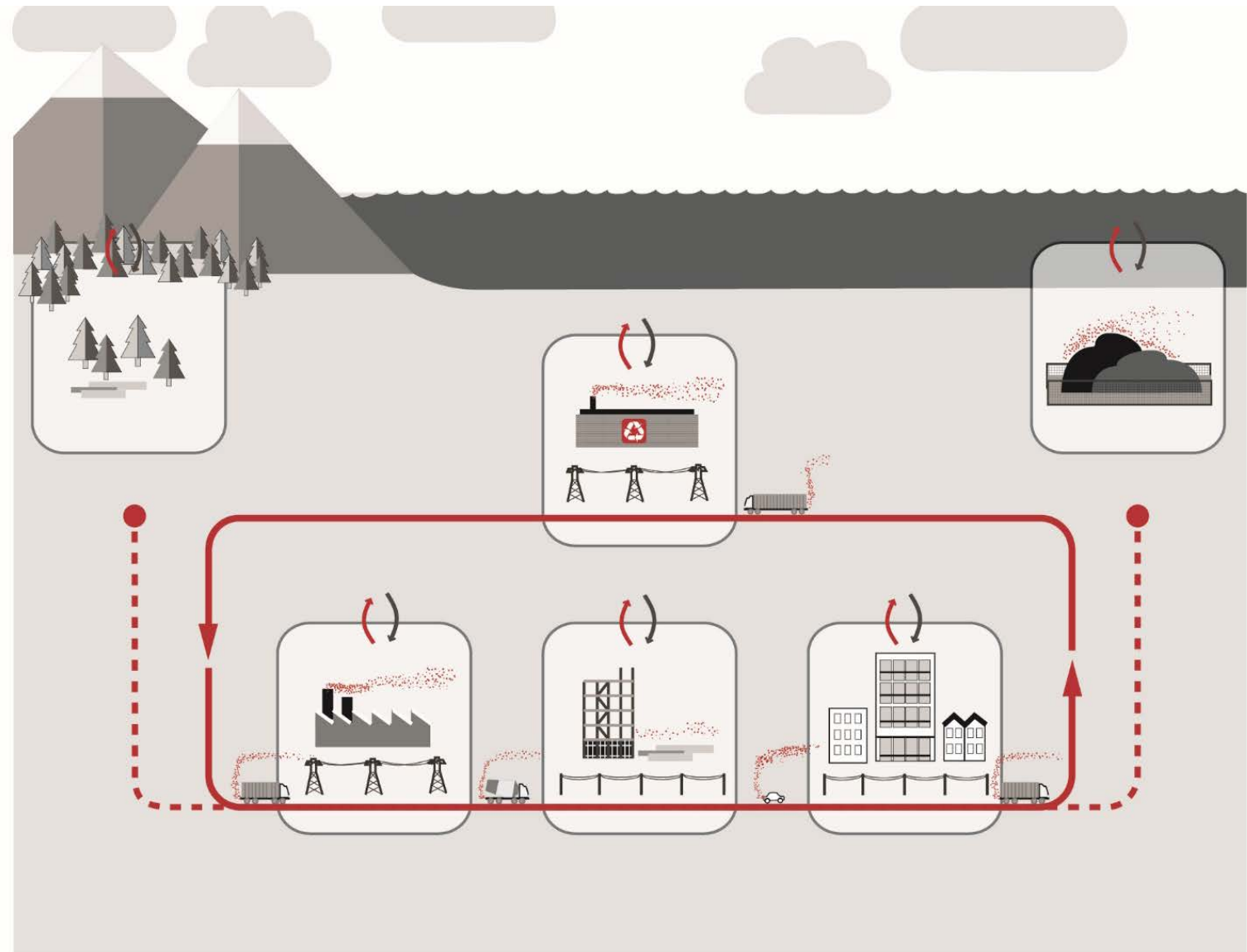
Economic

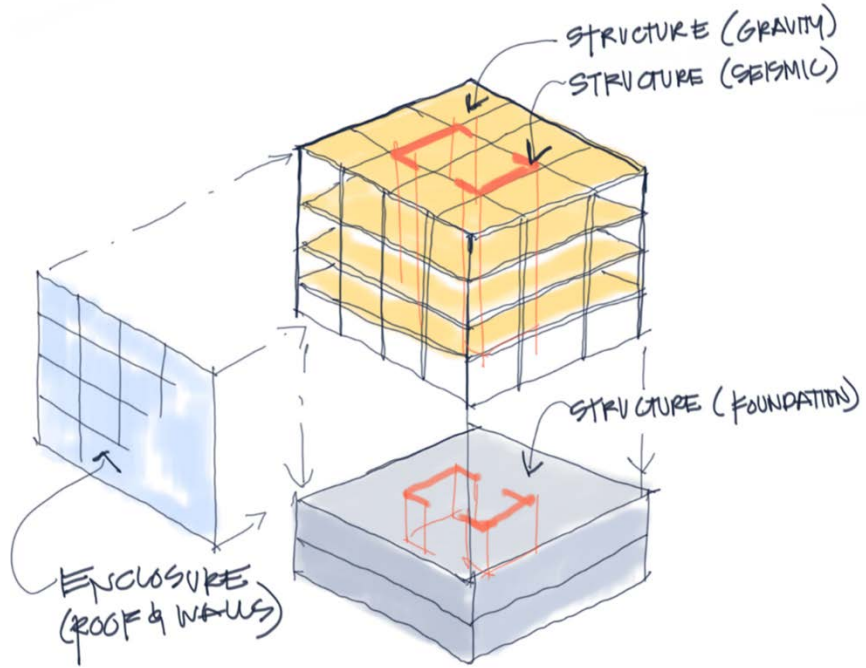
Dollars


Life Cycle Assessment

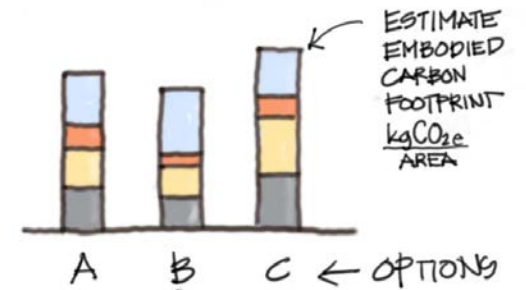
Environmental

'Carbon' etc.





EMBODIED EMISSIONS 
MANUFACTURING
TRANSPORTING
INSTALLING



MATERIAL QUANTITY ESTIMATE



EMBODIED CARBON PER UNIT MATERIAL



BUILDING EMBODIED CARBON (EC) ESTIMATE

Use Smart

Strategies

- Re-use buildings
- Smaller footprint
- Program efficiency

Build Smart

Strategies

- Alternate materials
- Efficient buildings
- Life cycle thinking

Buy Smart

Strategies

- Transparency
- Policy
- Codes/Specs

Reduce the emissions from building material manufacturing-(embodied carbon)

Use Smart

Strategies

- Re-use buildings
- Smaller footprint
- Program efficiency



**Rules of
Thumb**

Build Smart

Strategies

- Alternate materials
- Efficient buildings
- Life cycle thinking



[Athena](#) (free),
[OneClick
Tally](#)

Buy Smart

Strategies

- Transparency
- Policy
- Codes/Specs



**EPDs &
[EC3 Tool](#) (free)**

Environmental Product Declarations

Nutrition Facts	
Serving Size 2/3 cup (55g)	
Servings Per Container About 8	
Amount Per Serving	
Calories 230	Calories from Fat 40
% Daily Value*	
Total Fat 8g	12%
Saturated Fat 1g	5%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 160mg	7%
Total Carbohydrate 37g	12%
Dietary Fiber 4g	16%
Sugars 1g	
Protein 3g	



Life Cycle Impact Results (per m³)

Declared Unit: 1 m³ of 10,000 psi concrete at 28 days

OPERATIONAL IMPACTS	PerformX™ PECC10K
Plant Operating Energy (MJ)	38.6
On-Site Plant Fuel Consumption (MJ)	11.1
Concrete Batch Water (m ³)	1.68E-01
Concrete Wash Water (m ³)	1.91E-02
On-Site Waste Disposal (kg)	0.0
ENVIRONMENTAL IMPACTS	
Total Primary Energy (MJ)	3,017
Climate Change (kg CO ₂ eq)	445
Ozone Depletion (kg CFC 11 eq)	1.31E-08
Acidification Air (kg SO ₂ eq)	2.96
Eutrophication (kg N eq)	0.09
Photochemical Ozone Creation (kg O ₃ eq)	0.61

EPDs Enable Embodied Carbon Transparency

Environmental Product Declarations

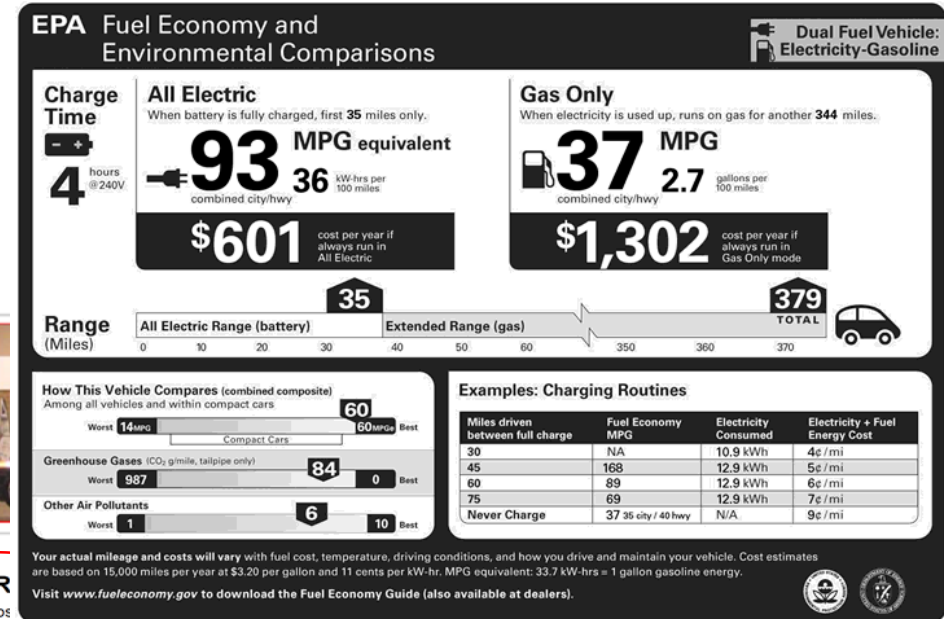
Nutrition Facts	
Serving Size 2/3 cup (55g)	
Servings Per Container About 8	
Amount Per Serving	
Calories 230	Calories from Fat 40
% Daily Value*	
Total Fat 8g	12%
Saturated Fat 1g	5%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 160mg	7%
Total Carbohydrate 37g	12%
Dietary Fiber 4g	16%
Sugars 1g	
Protein 3g	



Life Cycle Impact R

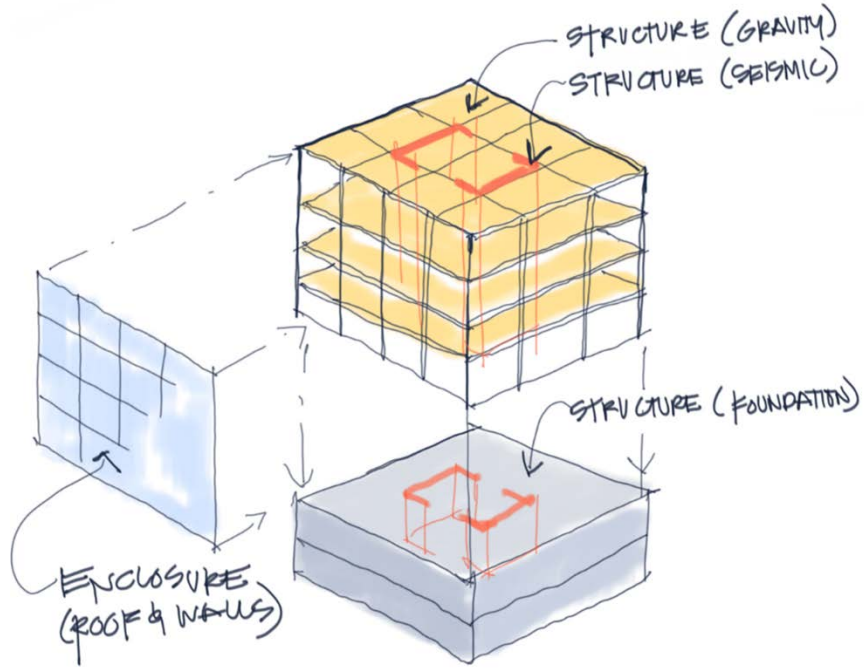
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EPD Results are like MPG

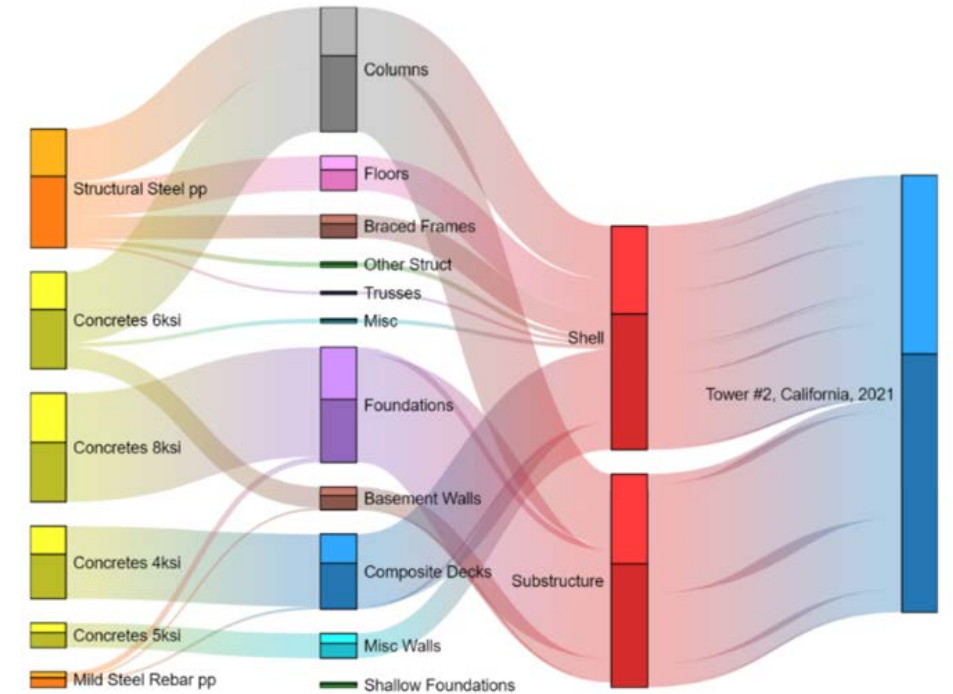
- Estimates based on standard assumptions (PCR)
- Known variability
- Directionally accurate



Life Cycle Impact Results (per m³)

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MATERIAL QUANTITY ESTIMATE



EMBODIED CARBON PER UNIT MATERIAL



BUILDING EMBODIED CARBON (EC) ESTIMATE

Lead Sponsors



Pilot Sponsors



Anonymous Owner



Association Sponsors



Material Sponsors



Early Adopters Sponsors



- Coughlin Porter Lundeen
- LeMessurier
- PCS Structural
- Nucor
- Saint-Gobain/Certainteed
- Salesforce
- SCS Global Services
- TK1SC
- Thornton Tomasetti
- WRNS Studio



Methodology Partners

- Arup
- Brightworks Sustainability
- Central Concrete Supply
- Katerra
- Kieran Timberlake
- LMN Architects
- National Ready Mixed Concrete Co
- Urban Fabrick
- WAP Sustainability

Technology Partners

- Autodesk
- Climate Earth
- mindful Materials powered by Origin
- Sustainable Minds
- Tally

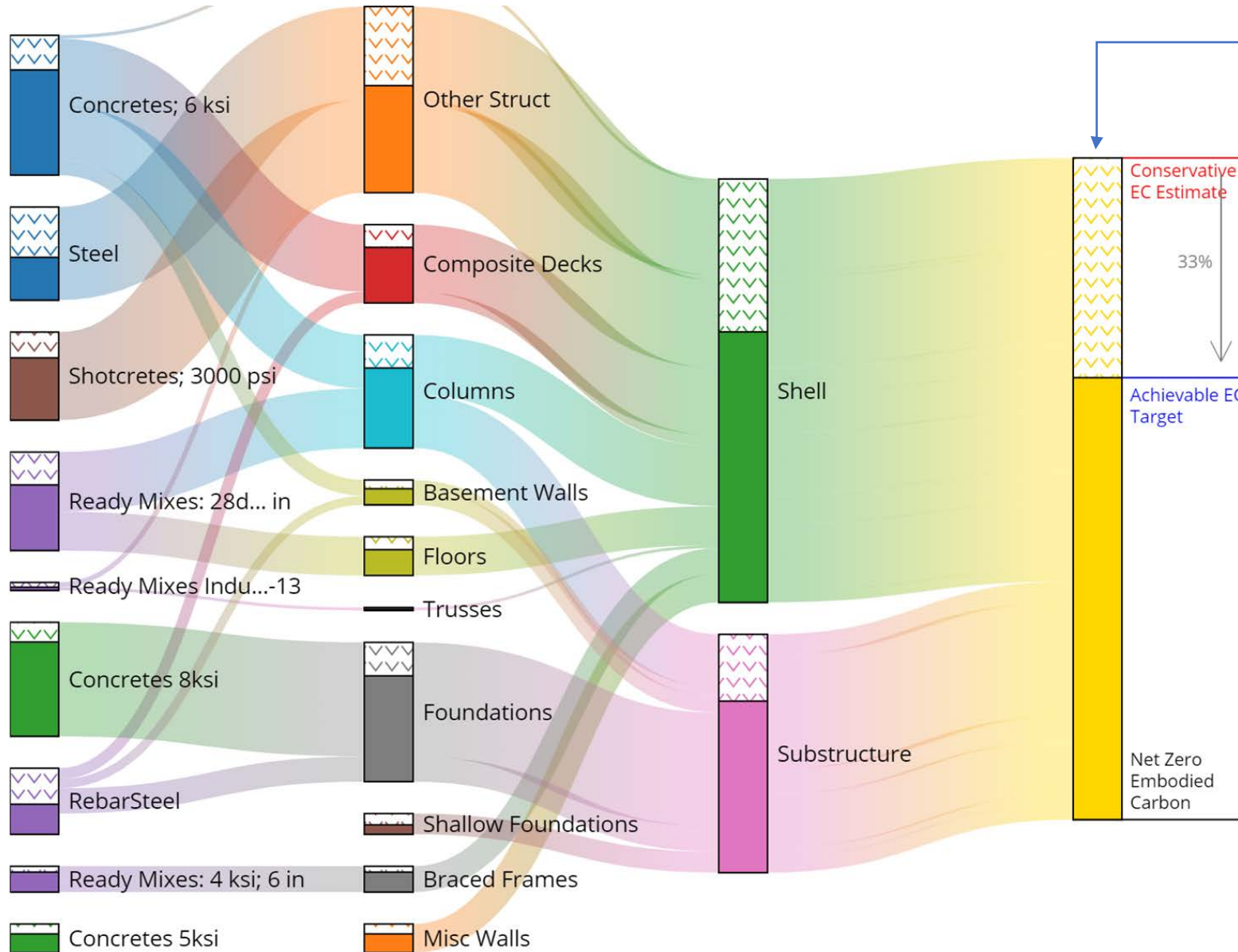
Project Leadership



UNIVERSITY of WASHINGTON



EC3: Interpreting Data at the Building Scale



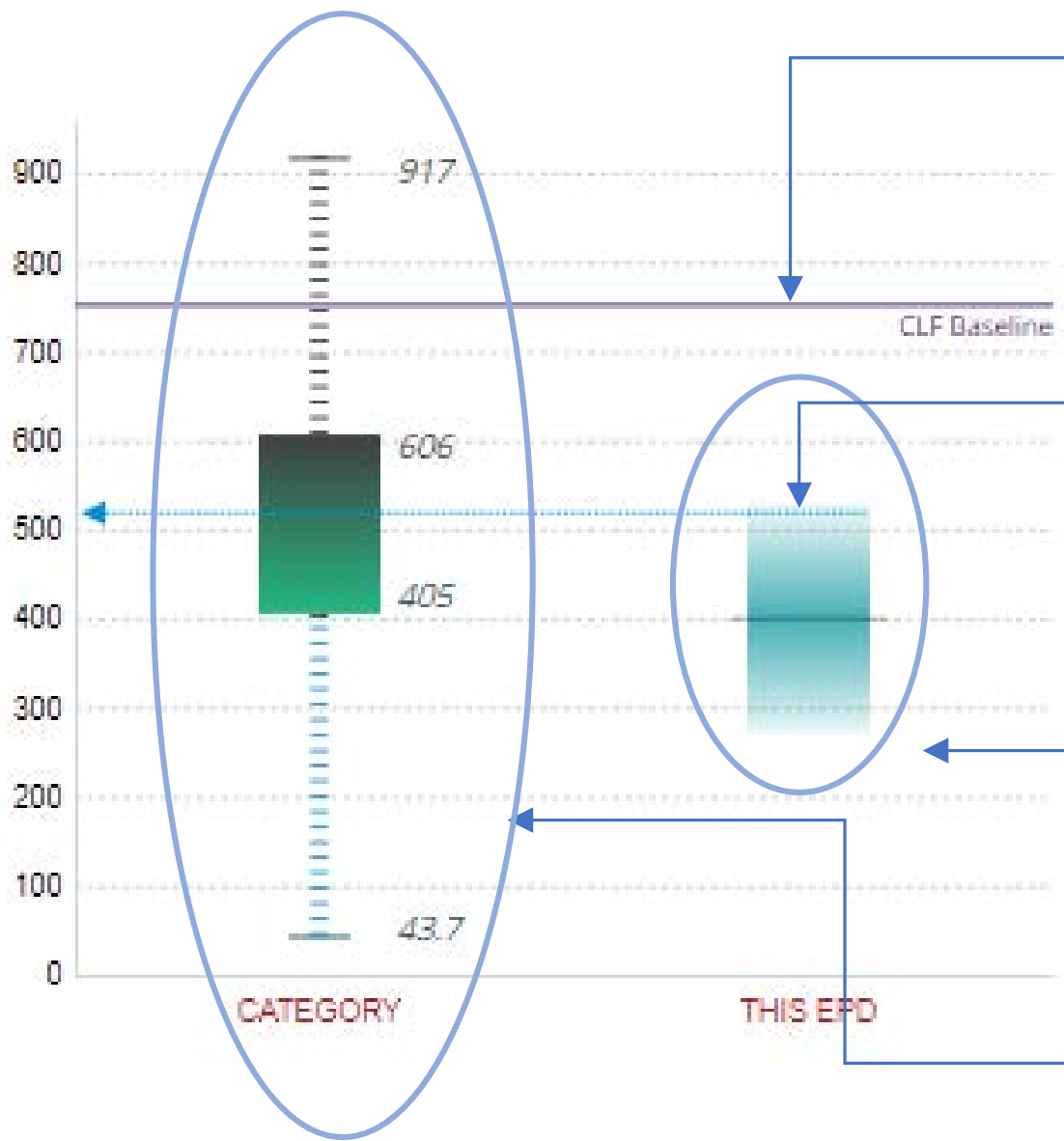
CLF Conservative Baseline:

If you don't know the supplier, don't assume 'average'

Target:

At least 20% of products in EC3 are below this

Interpreting the EC3 tool Data Visualization



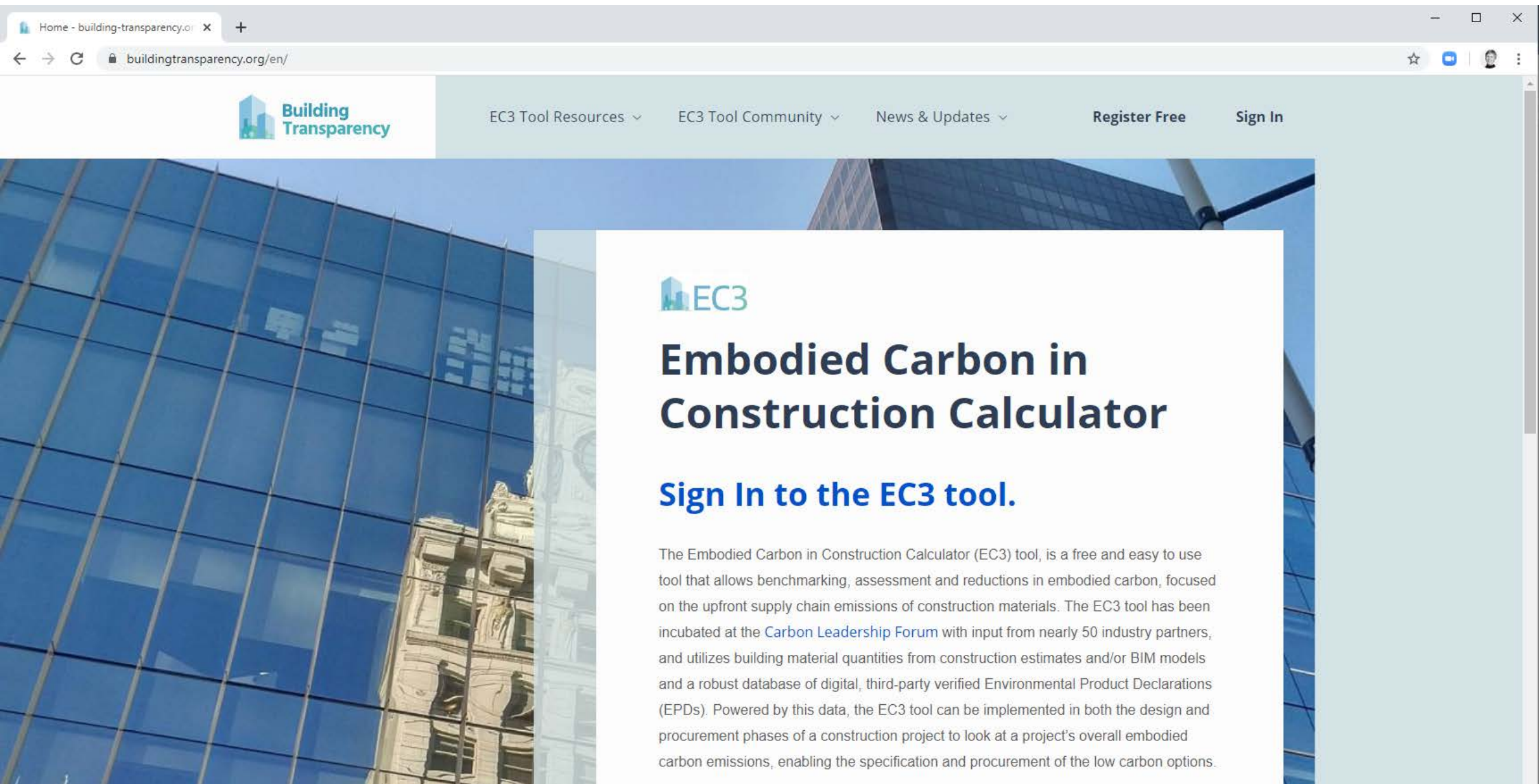
Baseline: CLF estimate of high embodied carbon of product

Burden of the doubt: Assume 'high' value not 'average'

Product: CLF estimate of embodied carbon precision


Selection: products with the same search criteria

<https://www.buildingtransparency.org>




Home - building-transparency.org

buildingtransparency.org/en/

 Building Transparency

EC3 Tool Resources ▾ EC3 Tool Community ▾ News & Updates ▾ Register Free Sign In

 EC3

Embodied Carbon in Construction Calculator

Sign In to the EC3 tool.

The Embodied Carbon in Construction Calculator (EC3) tool, is a free and easy to use tool that allows benchmarking, assessment and reductions in embodied carbon, focused on the upfront supply chain emissions of construction materials. The EC3 tool has been incubated at the [Carbon Leadership Forum](#) with input from nearly 50 industry partners, and utilizes building material quantities from construction estimates and/or BIM models and a robust database of digital, third-party verified Environmental Product Declarations (EPDs). Powered by this data, the EC3 tool can be implemented in both the design and procurement phases of a construction project to look at a project's overall embodied carbon emissions, enabling the specification and procurement of the low carbon options.

Our mission is to eliminate embodied carbon in buildings and infrastructure by inspiring innovation and spurring change through collective action.

Research

Robust, useful
data

Benefit:
Information you
can trust

Resources

The keeper of
knowledge on
embodied carbon

Benefit:
Accelerated
learning

Network

Brings together
the stakeholders
needed to enact
change

Benefit:
Collaboration
at its best

Initiatives

Supporting
SE2050, EC3 tool
and more!

Benefit:
Empowering rapid
impact

Sponsors

Supporting the
mission, driving
change

Benefit:
Recognition
Positive change



CARBON LEADERSHIP FORUM

Inspire, Inform and Enable Low Carbon Construction

MAGNUSSON
KLEMENCIC
ASSOCIATES

Structural + Civil Engineers



The American
Institute
of Architects

MITHÜN

STOPWASTE
at home • at work • at school

Carbon Innovations

THE RUSSELL FAMILY FOUNDATION



ARUP



CENTRAL
Stronger, Cleaner, Greener Concrete.

A U.S. CONCRETE COMPANY

Interface® KIERAN TIMBERLAKE



SKANSKA

Thornton Tomasetti



walter
p moore



bassetti
architects

CALLISON RTKL™

kpff

LeMessurier.



PCS
Structural Solutions

SIMPSON GUMPERTZ & HEGER



tk1sc



CONNECTING POLICY AND PRACTICE WITH DESIGN

ADRIAN SMITH + GORDON GILL | AIA SEATTLE | AMBIENT ENERGY | ARKIN TILT | BRIGHTWORKS | CLIMATE EARTH | COUGHLIN PORTER LUNDEEN | KATERRA | LMN ARCHITECTS | LUND OPSAHL | NATIONAL READY MIXED CONCRETE CO | NRMCA | SHKS | SIEGEL & STRAIN ARCHITECTS | WBNB STUDIO

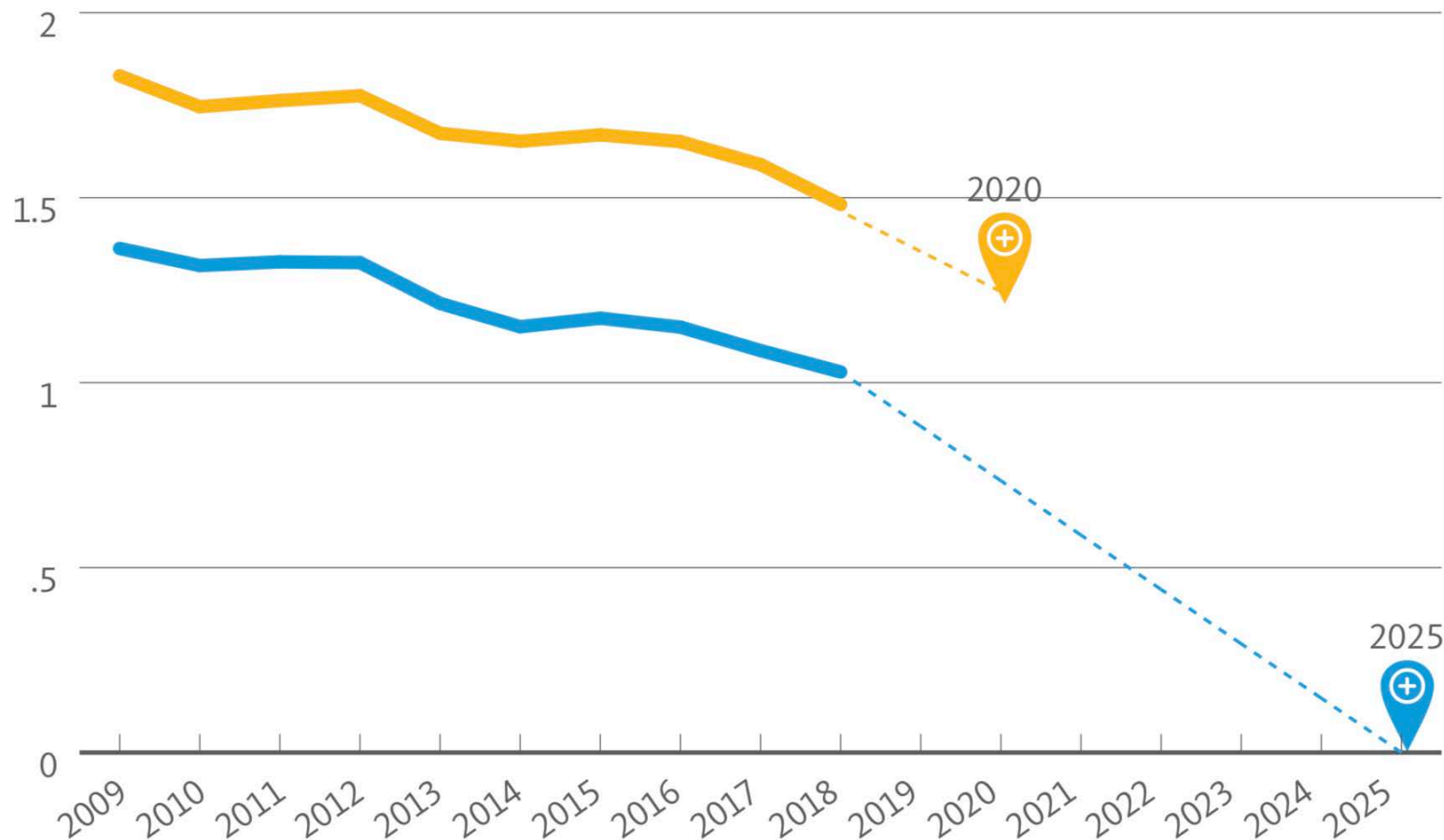
- What this means for UC capital plan 2020 – 2025
- Draft Carbon Calculator



UC GREENHOUSE GAS EMISSIONS COMPARED TO CLIMATE GOALS

(Million metric tons CO₂e)

- Scopes 1 (natural gas, campus fleet, fugitive) + 2 (purchased electricity)
- Scopes 1, 2 + 3 (campus commute, business air travel)



2013 - 2019

Scope 1 & 2 emissions
down 15%



2017 - 2018

Scope 1 emissions
(gas) down 3%
Scope 2 emissions (lect.)
down 14%



Goal: Climate neutrality
Scope 1 & 2 by 2025.
(some) Scope 3 by 2050



0

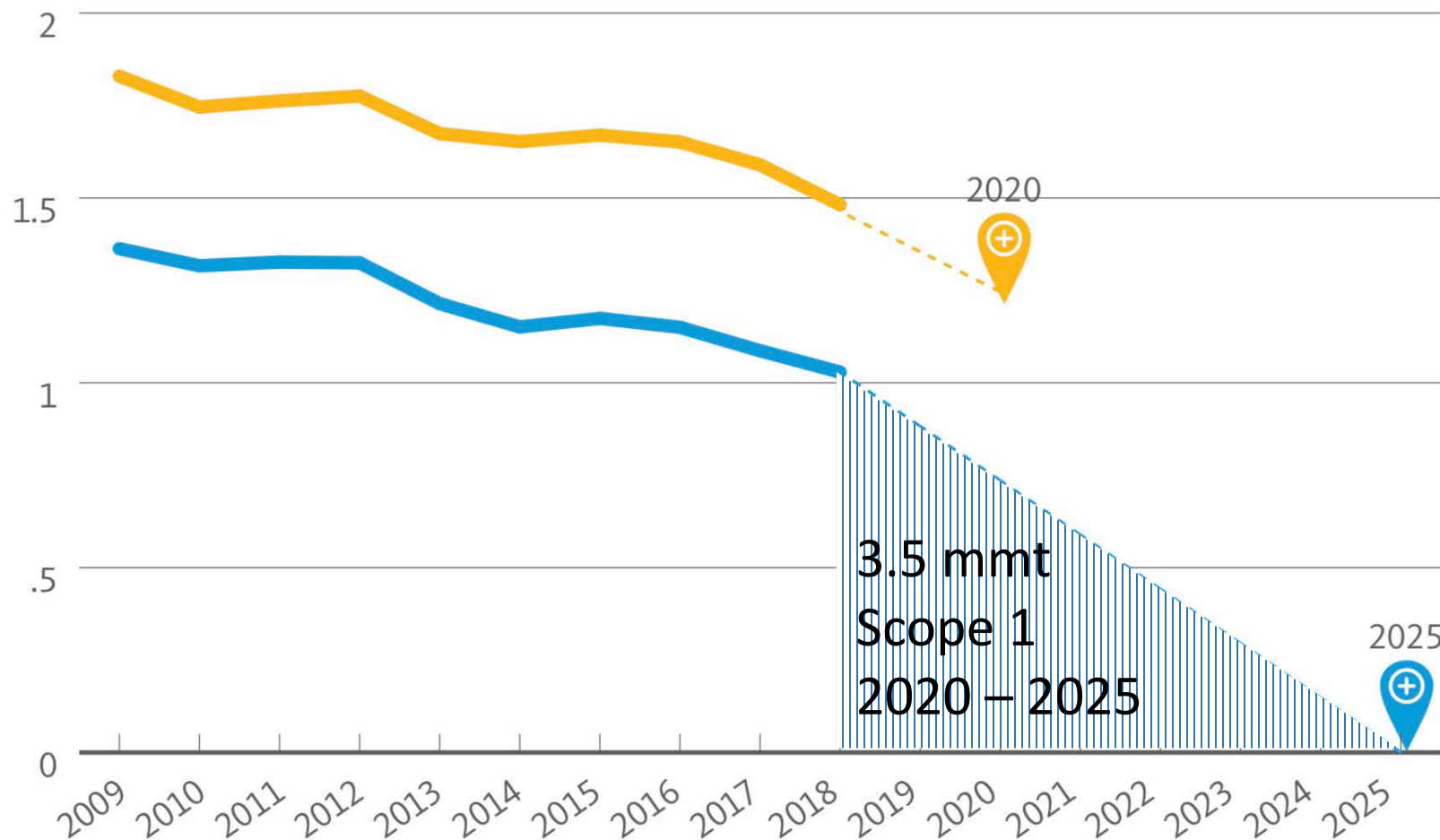
*University of California
Annual Report on
Sustainable Practices*



UC GREENHOUSE GAS EMISSIONS COMPARED TO CLIMATE GOALS

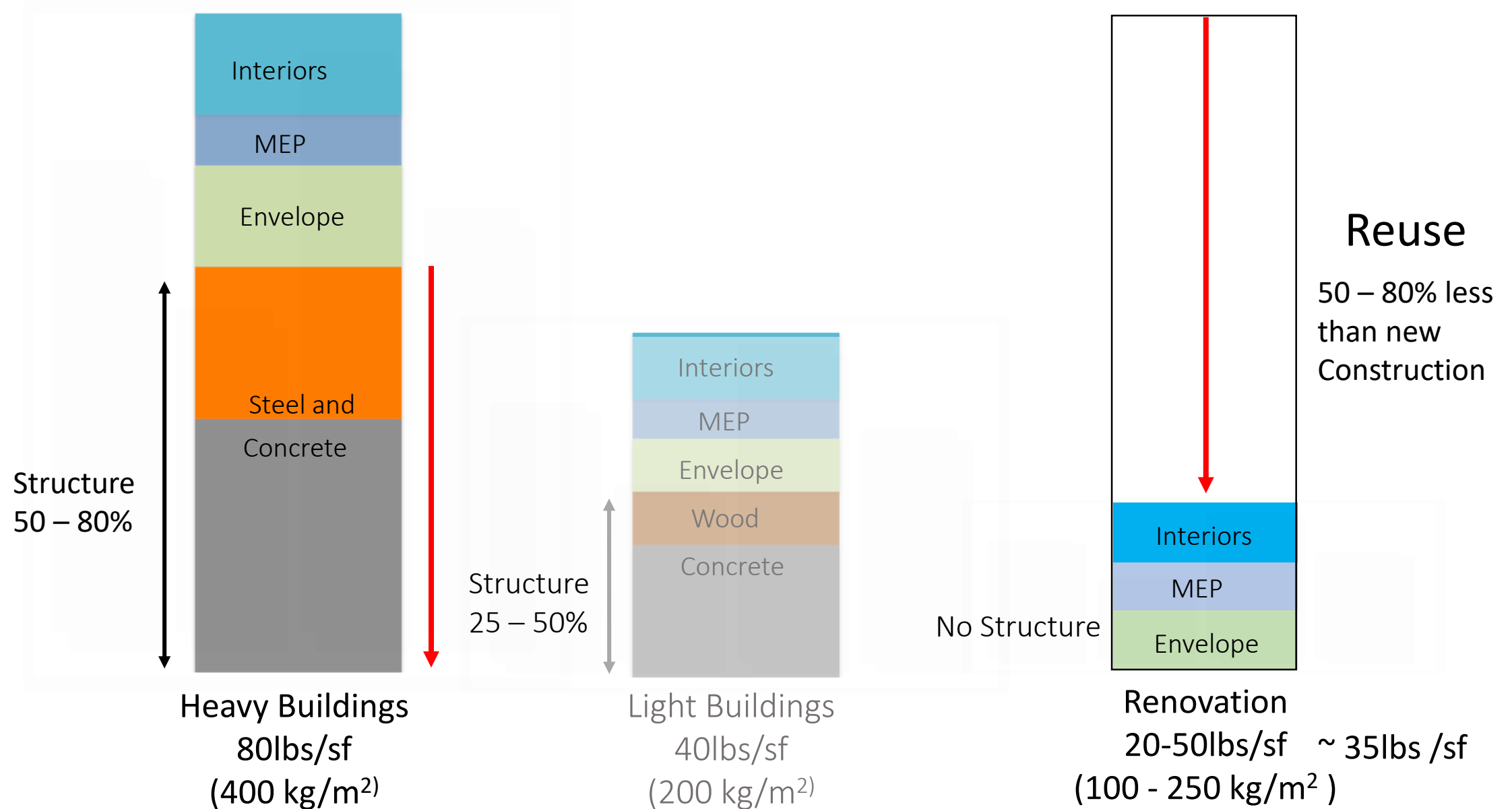
(Million metric tons CO₂e)

- Scopes 1 (natural gas, campus fleet, fugitive) + 2 (purchased electricity)
- Scopes 1, 2 + 3 (campus commute, business air travel)



What the about
the Embodied
Emissions
in scope 3?

Embodied CO₂ by Construction Type & Material

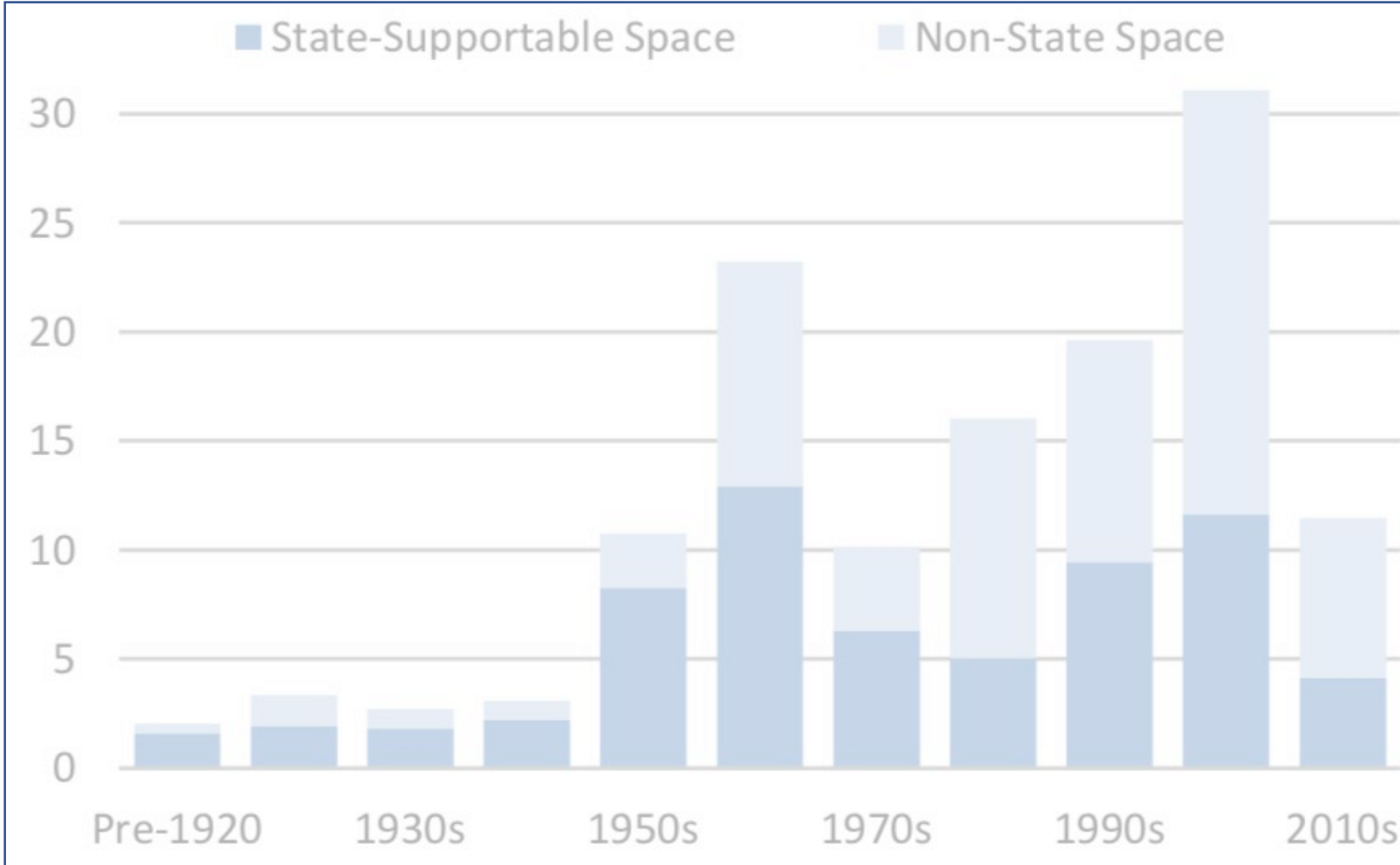




UC construction

Display A: Space by Decade of Construction

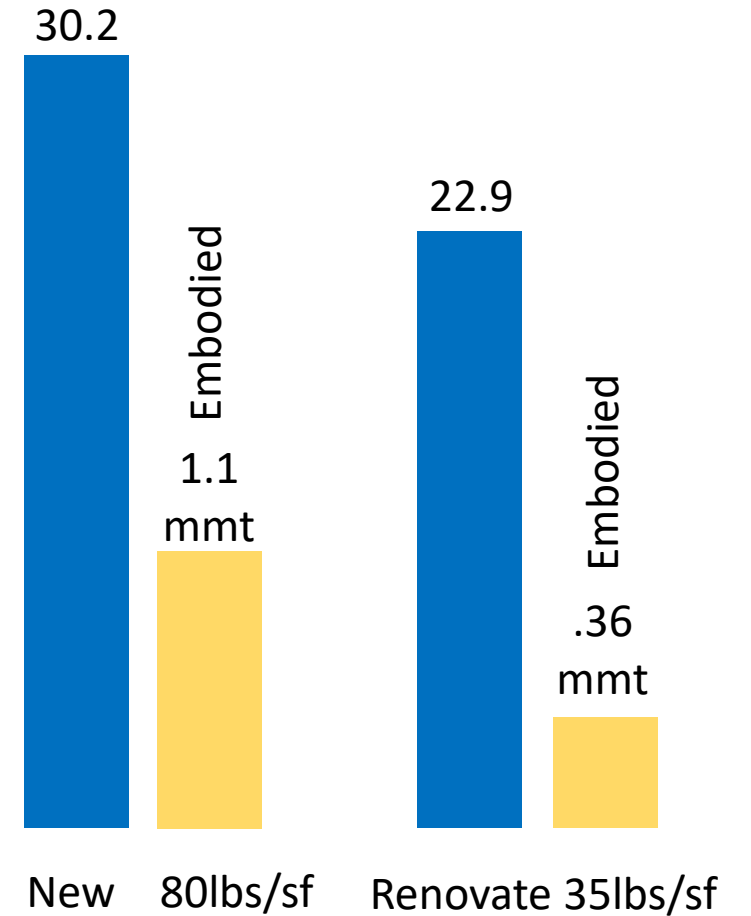
(Gross Square Feet in Millions) - 133 million gsf



UC Capital Financial Plan 2020 – 2025

- New construction - 30.2 million gsf
- Renovation - 22.9 million gsf

Embodied emissions ~ 1.5 mmt

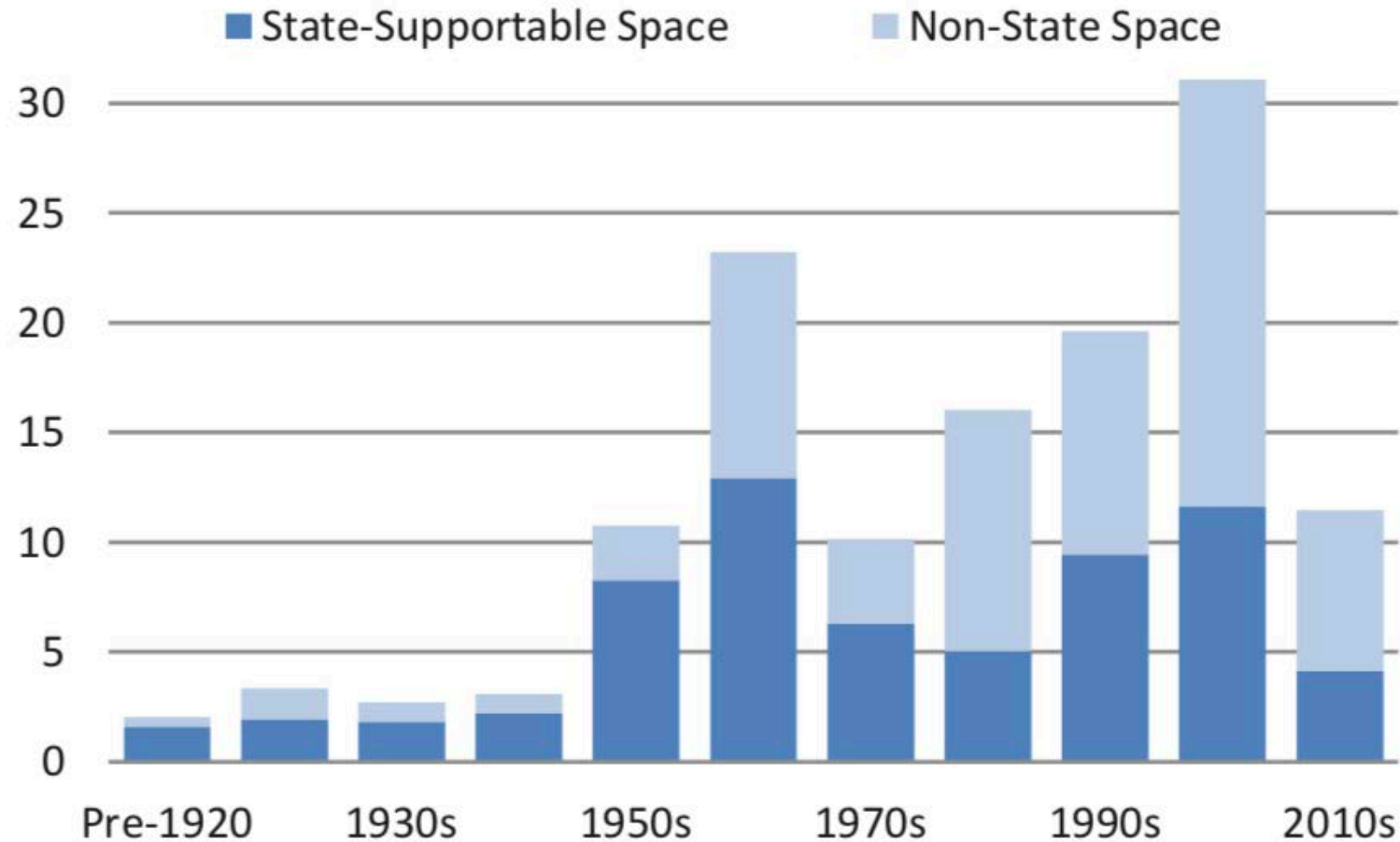




UC construction

Display A: Space by Decade of Construction

(Gross Square Feet in Millions) - 133 million gsf



Renovate + upgrade
133 million gfs
@ 35 lbs/sf = **2.1 mmt**

2.1

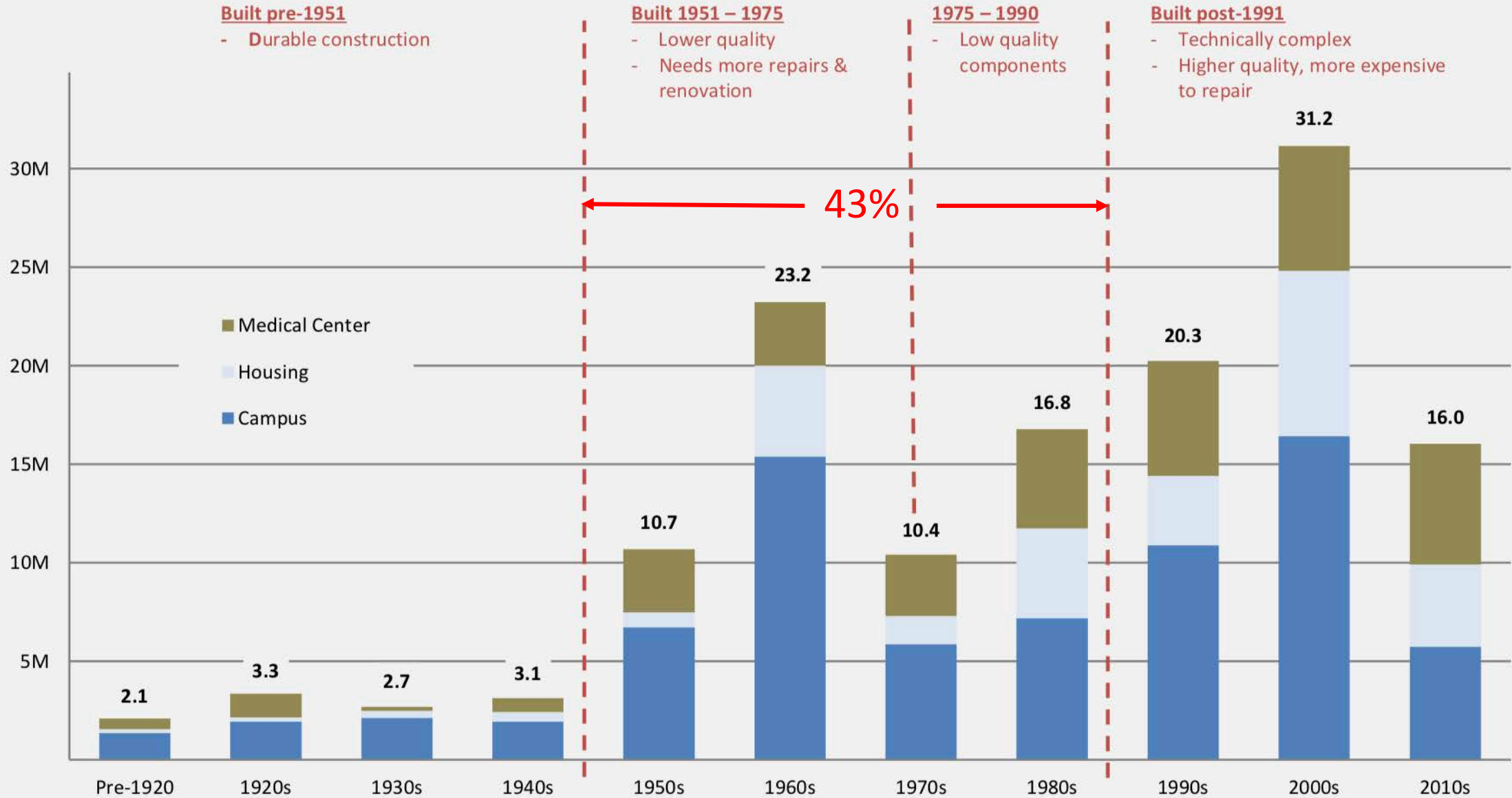
Embodied

Renovate 133 million gsf



Display 7. All Space by Decade of Construction

Total ~ 133 million sf

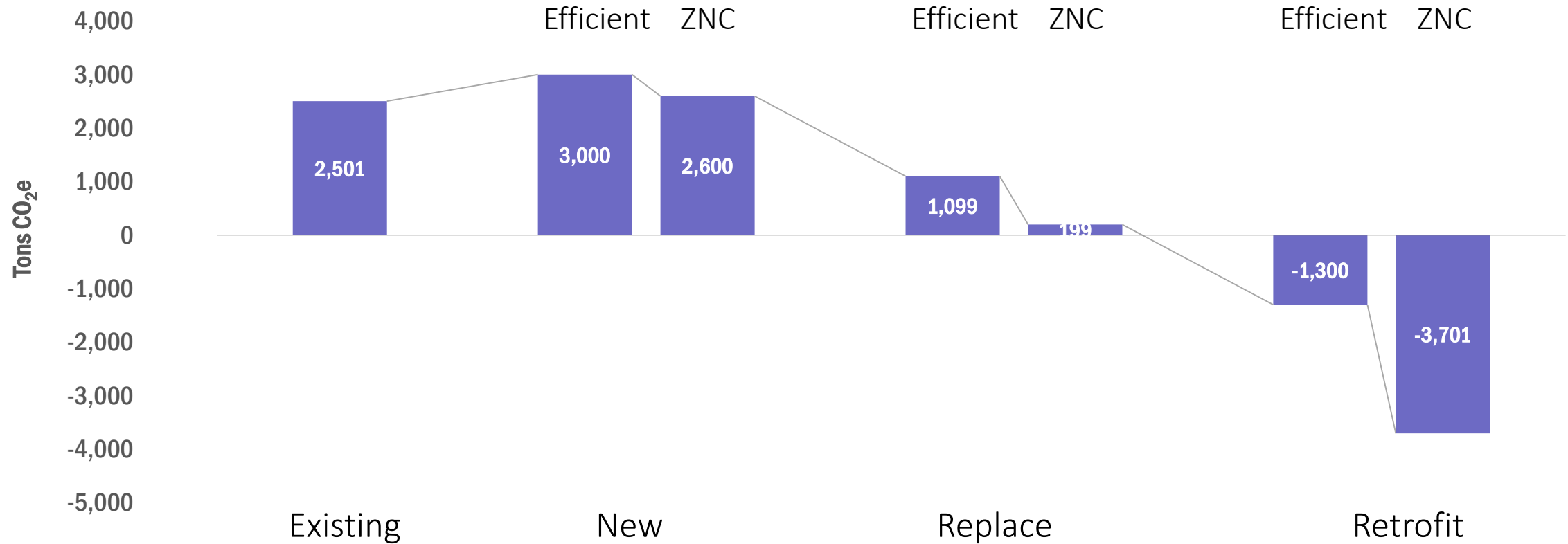


Characterization of campus building age factors is based on analysis by Sightlines. Sightlines specialize in higher education operations and management of facilities.

in millions of gross square feet

To Build or Not to Build - Carbon Calculator

CarbonPositive'20



To Build or Not to Build - Carbon Calculator

CarbonPositive'20

INPUTS DIRECTIONS → light green cells: click cell and select from dropdown using arrow to the right of cell, or enter value | dark green cells: default provided, can be overridden by entering project-specific value

PROJECT DATA

State	California	<i>select from dropdown</i>
Climate Zone	Mixed-dry/hot-dry	<i>select from dropdown</i>
Primary Use Type	Office	<i>select from dropdown</i>
Floor Area	5,000 sf	<i>enter value</i>
Operational Timeline	10 years	<i>enter value</i>

key climate dates: 2030 & 2040

EMBODIED EMISSIONS (KG/SF)

Construction Type		Wood Structure	Concrete or Steel Structure	Notes
Retrofit Existing	Efficient	12	12	Baseline Efficiency Retrofit + 2 kg/sf for RE
	ZNC	14	14	
New Building	Efficient	25	50	Baseline New Construction + 2 kg/sf for RE
	ZNC	27	52	
Replace Existing w/ New Building	Efficient	27	52	+ 2 kg/sf for Demo + 4 kg/sf for Demo + RE
	ZNC	29	54	

OPERATIONAL ENERGY AND EMISSIONS

Baseline EUI	59	kBtu/sf-yr
Electricity Fuel Split	62%	
Gas Fuel Split	38%	
Electricity Emissions Factor	0.0603	mt/mmBtu
Gas Emissions Factor	0.0659	mt/mmBtu
Electricity Emissions	11	mt/yr
Gas Emissions	7	mt/yr
Retrofit 2030 C Reduction	50%	
New Bldg 2030 C Reduction	80%	

RESULTS: TABLES

Building Type	Efficiency Category
Baseline	
New Building on Vacant Site	Efficient ZNC
New Building to Replace Existing	Efficient ZNC
Retrofit Existing Building	Efficient ZNC

Embodied Construction Description	Embodied Emissions (CO ₂ e, cradle to gate)			
	kg/sf Added	Added Tons	Avoided Tons	Total Tons
No construction or upgrade	0	0	0	0
New Construction	25	125	0	125
New Construction, RE	27	135	0	135
Demo, New Construction	27	135	0	135
Demo, New Construction, RE	29	145	0	145
Interiors, EE upgrades, MEP	12	60	-65	-5
Interiors, EE upgrades, MEP, RE	14	70	-65	5

Operational Efficiency Description	Operational Emissions (CO ₂ e, 10 years)		
	Added Tons	Avoided Tons	Total Tons
CBECS 2012	184	0	184
2030 Challenge	37	0	37
ZNC	0	0	0
2030 Challenge	37	-147	-110
ZNC	0	-184	-184
2030 Challenge	92	-92	0
ZNC	0	-184	-184

Total Operational & Embodied Emissions (tons CO ₂ e, 10 years)
184
162
135
25
-39
-5
-179



Compares

- Embodied carbon
 - Operational carbon
 - Avoided carbon
- over different time frames

Existing, New & Reuse Scenarios

- Existing Building – no change
- New Building – vacant site
- Replace Existing w/New
- Reuse & Retrofit Existing

Embodied Carbon*

**mostly from CLF Embodied Carbon Benchmarking study.*

Heavy Building
Concrete/Steel frame

80 lbs/sf
(400 kg/m²)



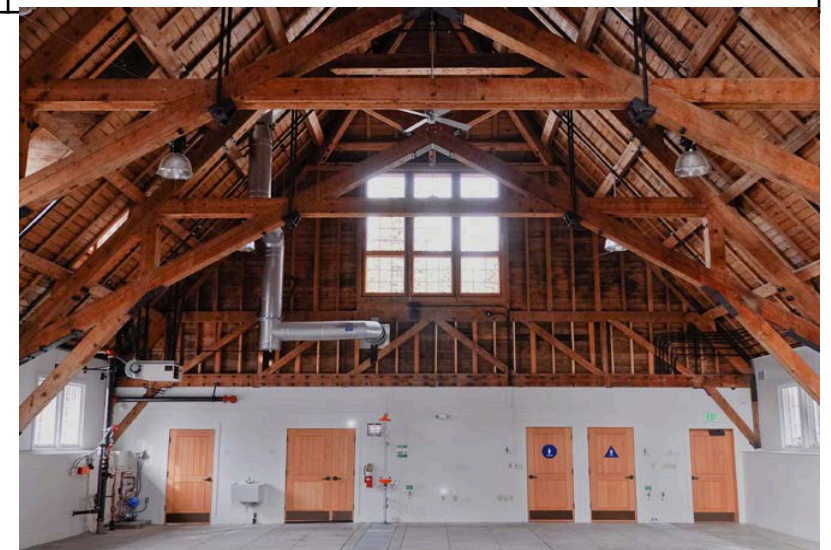
Light Building
Wood frame

40lbs/sf
(200 kg/m²)



Reuse Existing
Building

20lbs/sf
(100 kg/m²)



Operational Carbon

Existing	Efficient	Retrofit	ZNC
from CBECS 2012	80% less than existing	50% less than existing	0

PROJECT DATA

State	California	<i>select from dropdown</i>
Climate Zone	Marine	<i>select from dropdown</i>

Primary Use Type	Office	<i>select from dropdown</i>
Floor Area	50,000 sf	<i>enter value</i>

Operational Timeline	10 years	<i>enter value</i>
----------------------	-----------------	--------------------

To Build or Not to Build - Carbon Calculator

CarbonPositive'20

PROJECT DATA

State **California** *select from dropdown*


Climate Zone **Marine** *select from dropdown*

Primary Use Type **Office** *select from dropdown*


Floor Area **50,000 sf** *enter value*

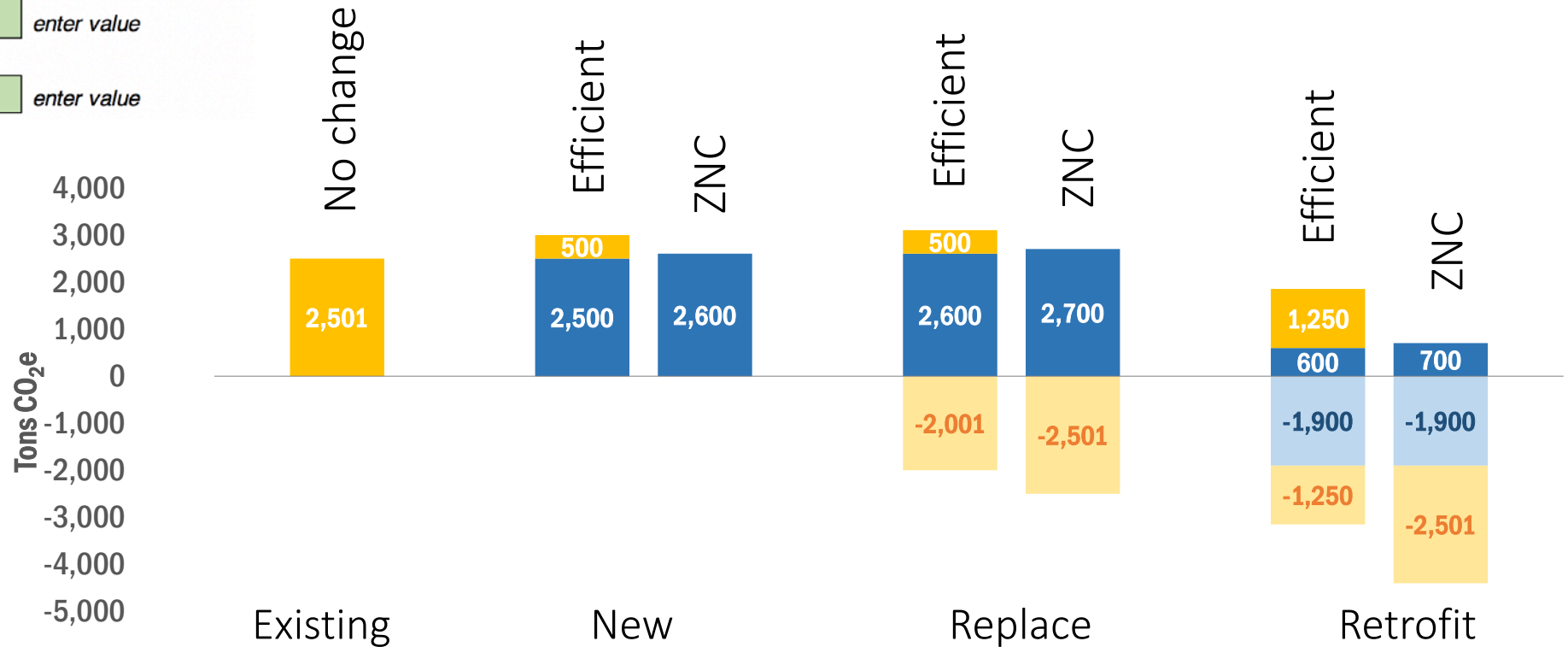
Operational Timeline **10 years** *enter value*

 Operational

 Operational avoided

 Embodied

 Embodied Avoided



To Build or Not to Build - Carbon Calculator

CarbonPositive'20

PROJECT DATA

State **California** *select from dropdown*

Climate Zone **Marine** *select from dropdown*

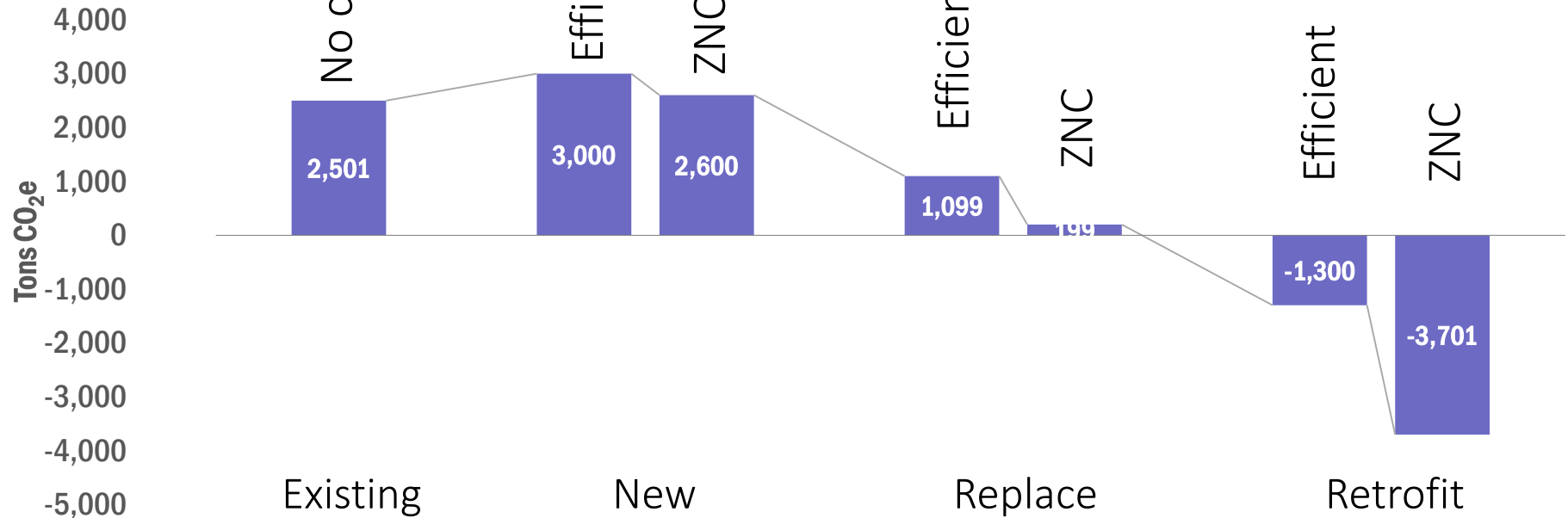
Primary Use Type **Office** *select from dropdown*

Floor Area **50,000 sf** *enter value*

Operational Timeline **10 years** *enter value*

 Total Emissions

Operational.
Embodied &
Avoided -





Thank You



Larry Strain
Siegel & Strain Architects

Kate Simonen
Carbon Leadership Forum



Questions?

LCA/LCC Resources Links

Build Awareness

1. [Watch](https://www.youtube.com/watch?v=0_6kx-vTO4) 3 min Gates video. Share with network. https://www.youtube.com/watch?v=0_6kx-vTO4
2. [Read](https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it) “The Urgency of Embodied Carbon and What you Can about it”
<https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it>
3. [Join](http://carbonleadershipforum.org/) the Carbon Leadership Forum to receive newsletters & resources and join network
<http://carbonleadershipforum.org/>

Implement in Practice

1. [Watch](http://carbonleadershipforum.org/embodied-carbon-network/webinars/) recorded webinars <http://carbonleadershipforum.org/embodied-carbon-network/webinars/>
2. [Read](http://carbonleadershipforum.org/projects/lca-practice-guide/) “LCA Practice Guide” <http://carbonleadershipforum.org/projects/lca-practice-guide/>
3. Join our online network. Post questions, engage in discussions. (tag interest in online form in mailing list submission) <http://carbonleadershipforum.org>

Build Capacity

1. [Follow](http://carbonleadershipforum.org/wp-content/uploads/2019/05/2019.05.23-LCA-Timeline-Diagram-2-page.pdf) “Road Map to Reducing Building Life Cycle Impacts” <http://carbonleadershipforum.org/wp-content/uploads/2019/05/2019.05.23-LCA-Timeline-Diagram-2-page.pdf>
2. [Review](http://carbonleadershipforum.org/wp-content/uploads/2019/11/EC3-Primer-for-AEC-Professionals.pdf) the “EC3 Tool Primer for AEC Professionals” <http://carbonleadershipforum.org/wp-content/uploads/2019/11/EC3-Primer-for-AEC-Professionals.pdf>
3. [Explore](https://materialpalette.org/) ‘The Carbon Smart Materials Palette’ <https://materialpalette.org/>