

Towards Whole Life Carbon

LUKE LEUNG, BEMP, P ENG, PE, LEED FELLOW, ASHRAE FELLOW

SOM

This presentation does not represent the official stand of ASHRAE, it is the current opinion of the Embodied Carbon/LCA Task force.



Shaping Tomorrow's Built Environment Today

What Are You Looking For?

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HELLO LUKE

ABOUT

TECHNICAL RESOURCES

PROFESSIONAL DEVELOPMENT

CONFERENCES

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ASHRAE FORMS TASK FORCE FOR BUILDING DECARBONIZATION

Group will address the critical subject of reducing greenhouse gas emissions associated with buildings

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03 Mar 2021 Resources Atlanta, GA

ASHRAE Forms Task Force for Building Decarbonization

FOR IMMEDIATE RELEASE

MEDIA CONTACT:

Karen Buckley Washington



2. WORK GROUPS:

Research Knowledge Hub

Reducing Operational Carbon

Carbon Sequestration on Building Sites

Grid-Building Intersection

Building Performance Standards and Commissioning

Standards and Codes

Appliance and Equipment Standards

Training and Education

Decarbonization Position Document

Embodied Carbon/LCA

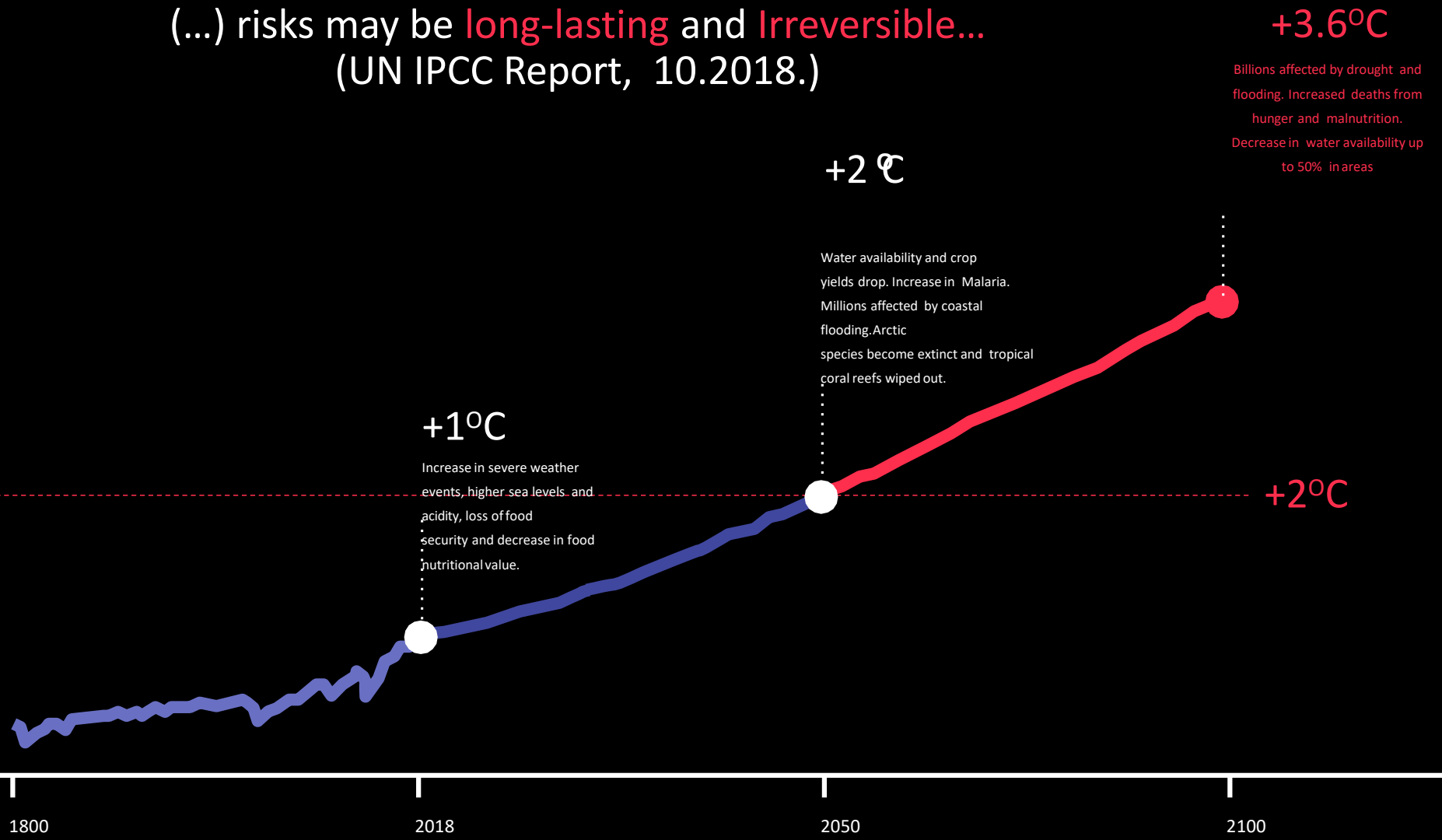
Climate Change

LCA

Case Studies

Climate Change

(...) risks may be **long-lasting** and **Irreversible...**
(UN IPCC Report, 10.2018.)



+3.6°C

Billions affected by drought and flooding. Increased deaths from hunger and malnutrition. Decrease in water availability up to 50% in areas.

+2°C

Water availability and crop yields drop. Increase in Malaria. Millions affected by coastal flooding. Arctic species become extinct and tropical coral reefs wiped out.

+1°C

Increase in severe weather events, higher sea levels and acidity, loss of food security and decrease in food nutritional value.

+2°C

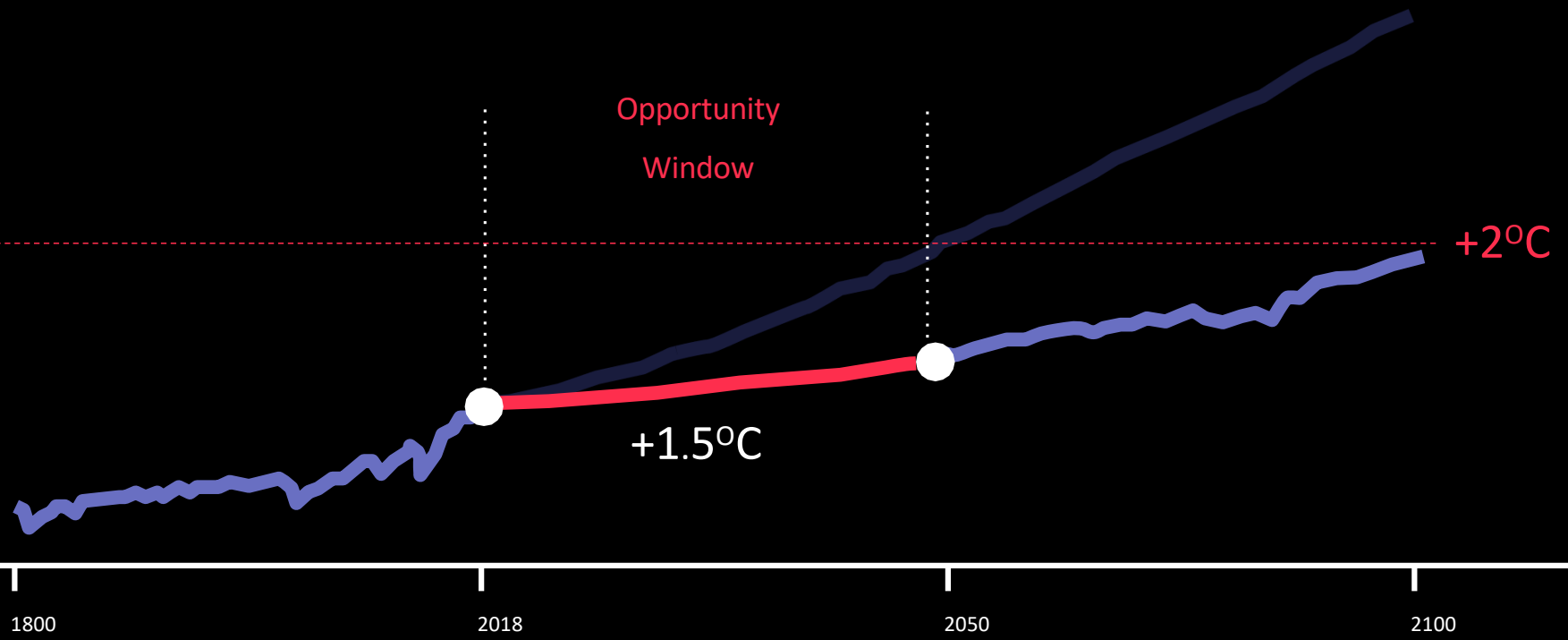
1800

2018

2050

2100

(...) 1.5°C would require “rapid and far-reaching” transitions in land, energy, industry, buildings, transport, and cities...45 percent reduction by 2030, reaching ‘net zero’ around 2050
(UN IPCC Report, “Summary for Policy Makers”, 2018)



2015 Paris Agreement





* On January 20, 2021, President Biden informed the UN Secretary-General of the United States' return to the agreement effective February 19, 2021.

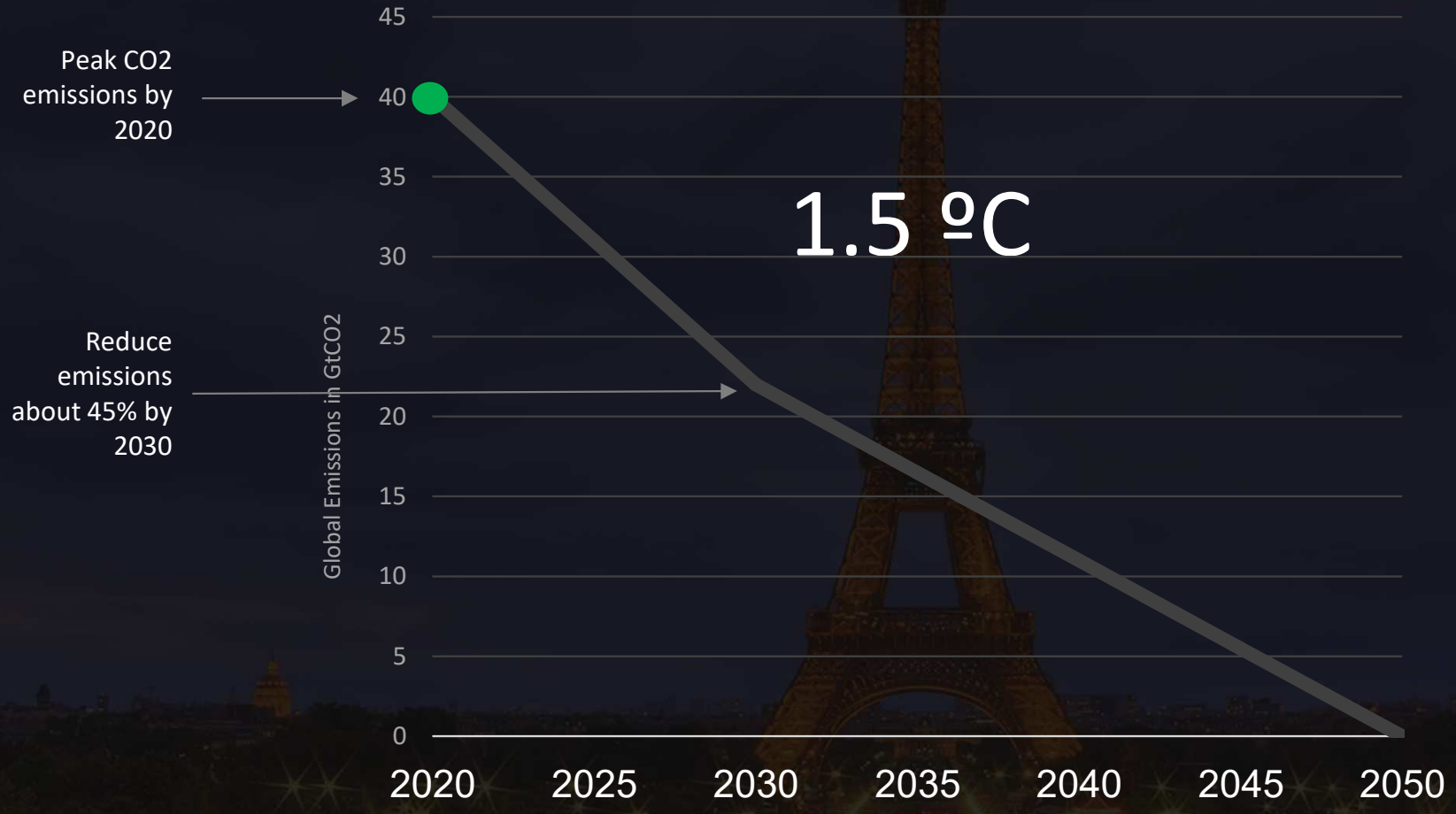
Source: UNFCCC



* On January 20, 2021, President Biden informed the UN Secretary-General of the United States' return to the agreement effective February 19, 2021.

Source: UNFCCC

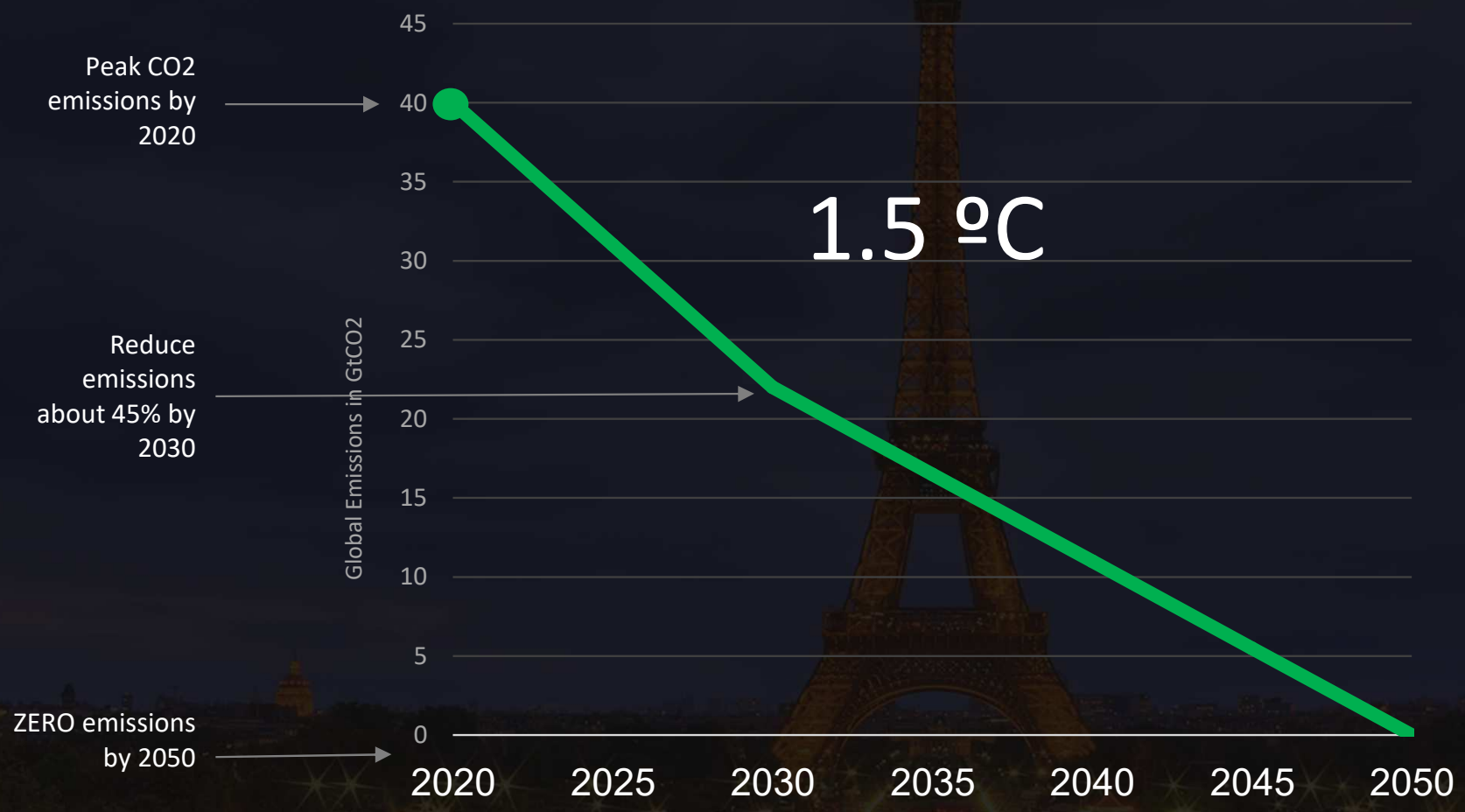
UN IPCC Road Map to 2050 Zero Carbon Economy



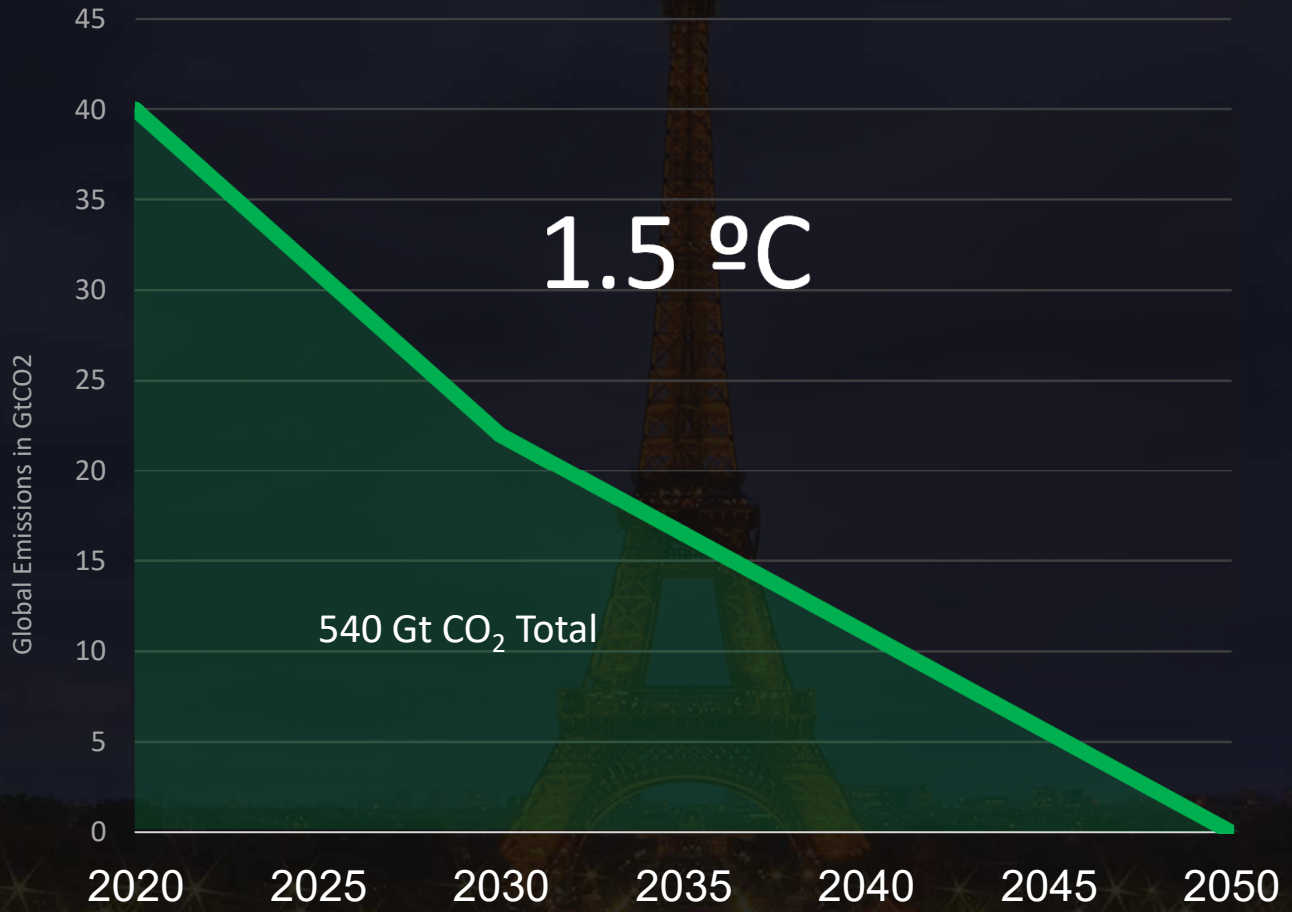
UN IPCC Road Map to 2050 Zero Carbon Economy



UN IPCC Road Map to 2050 Zero Carbon Economy

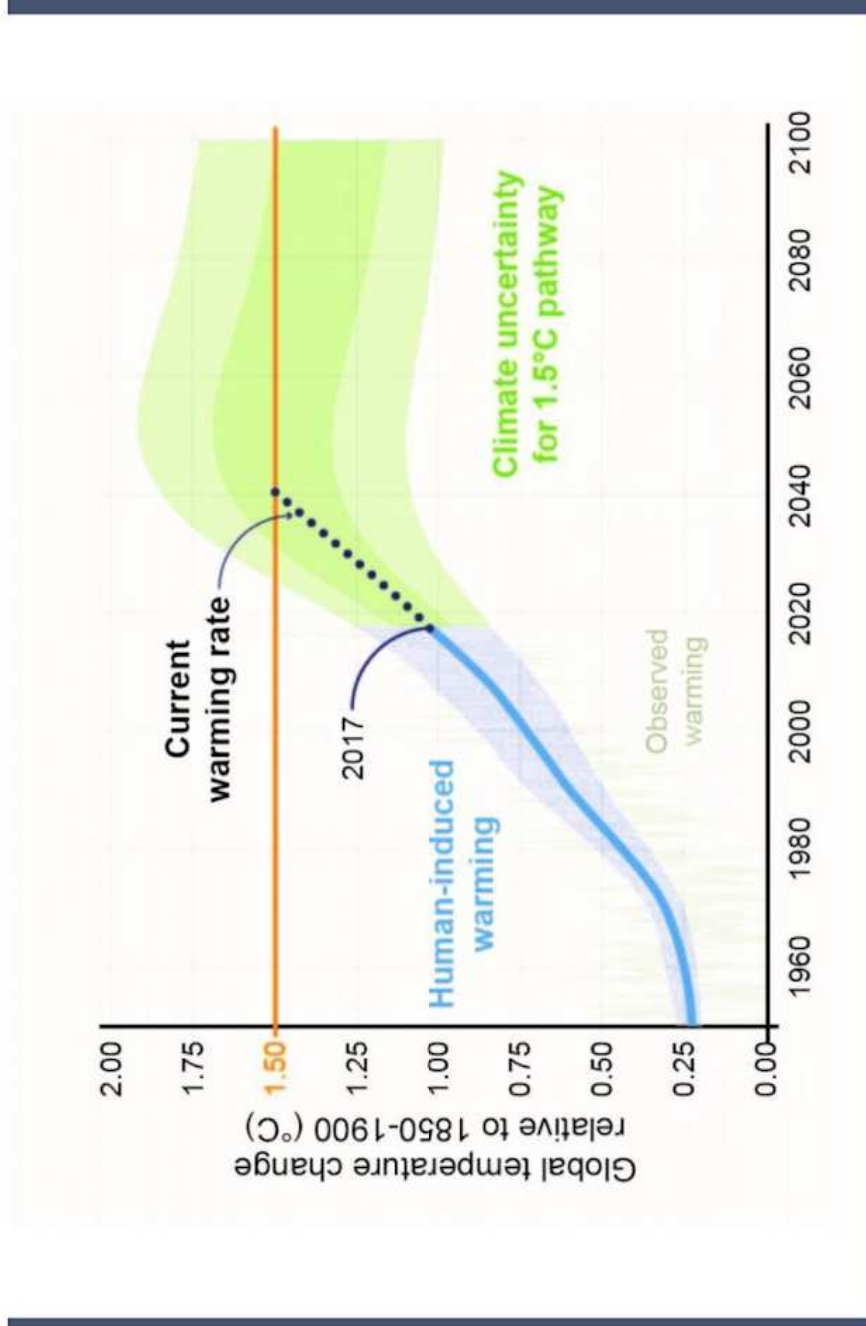


Road Map to 2050 Zero Carbon Economy



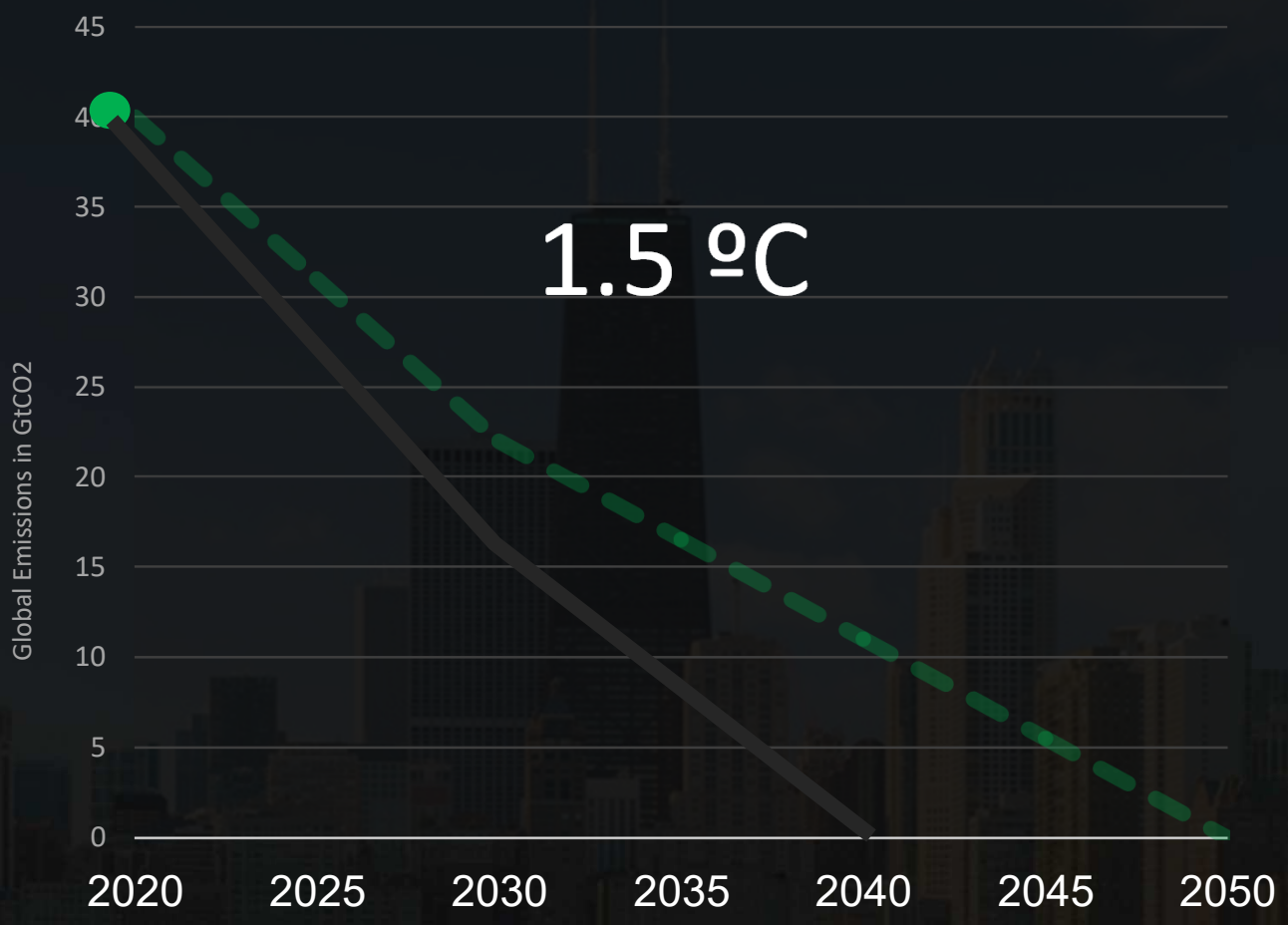
Road Map to 2050 Zero Carbon Economy



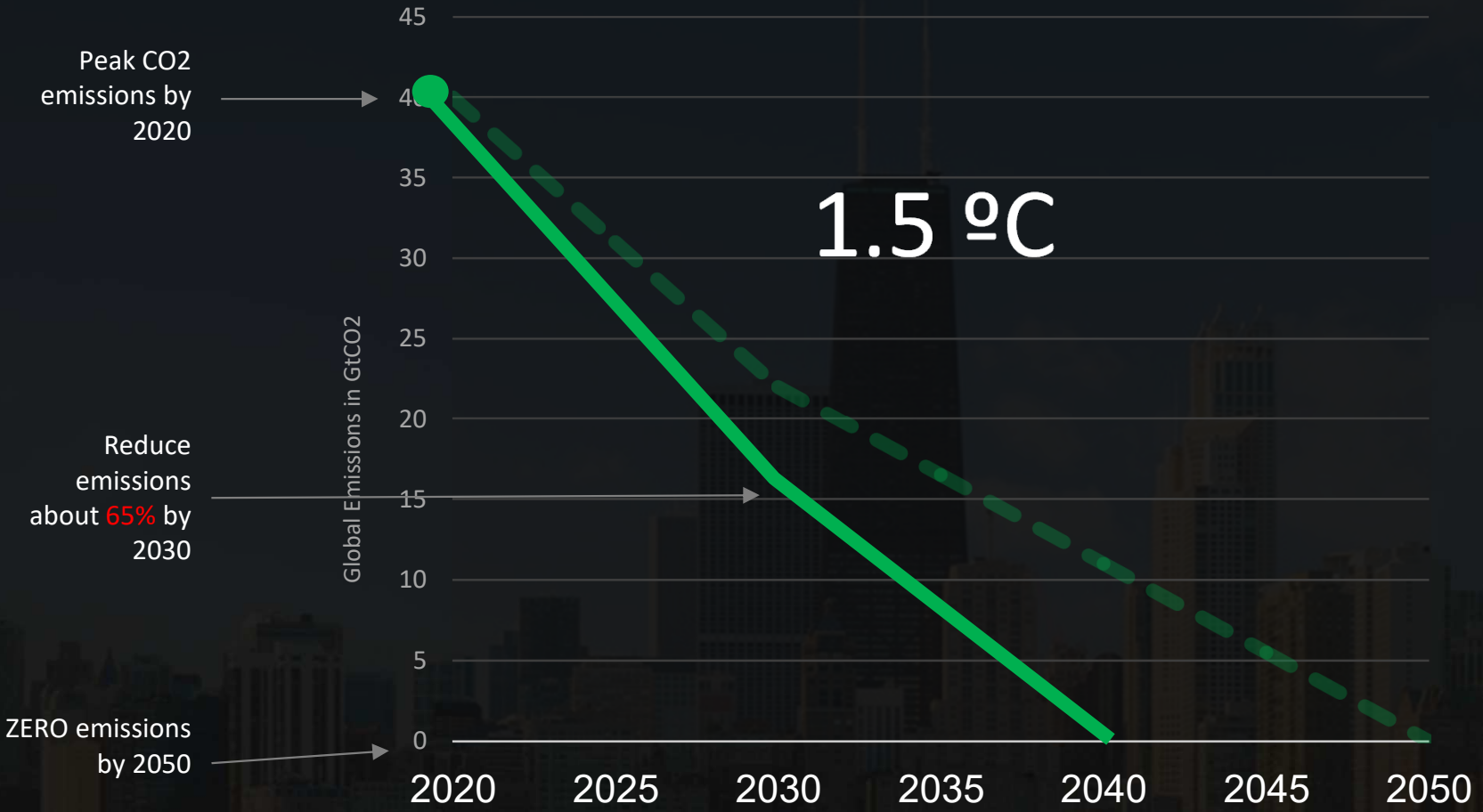


At the present rate, global temperatures would reach 1.5°C around 2040. Stylized 1.5°C pathway shown here involves emission reductions beginning immediately, and CO₂ emissions reaching zero by 2055.

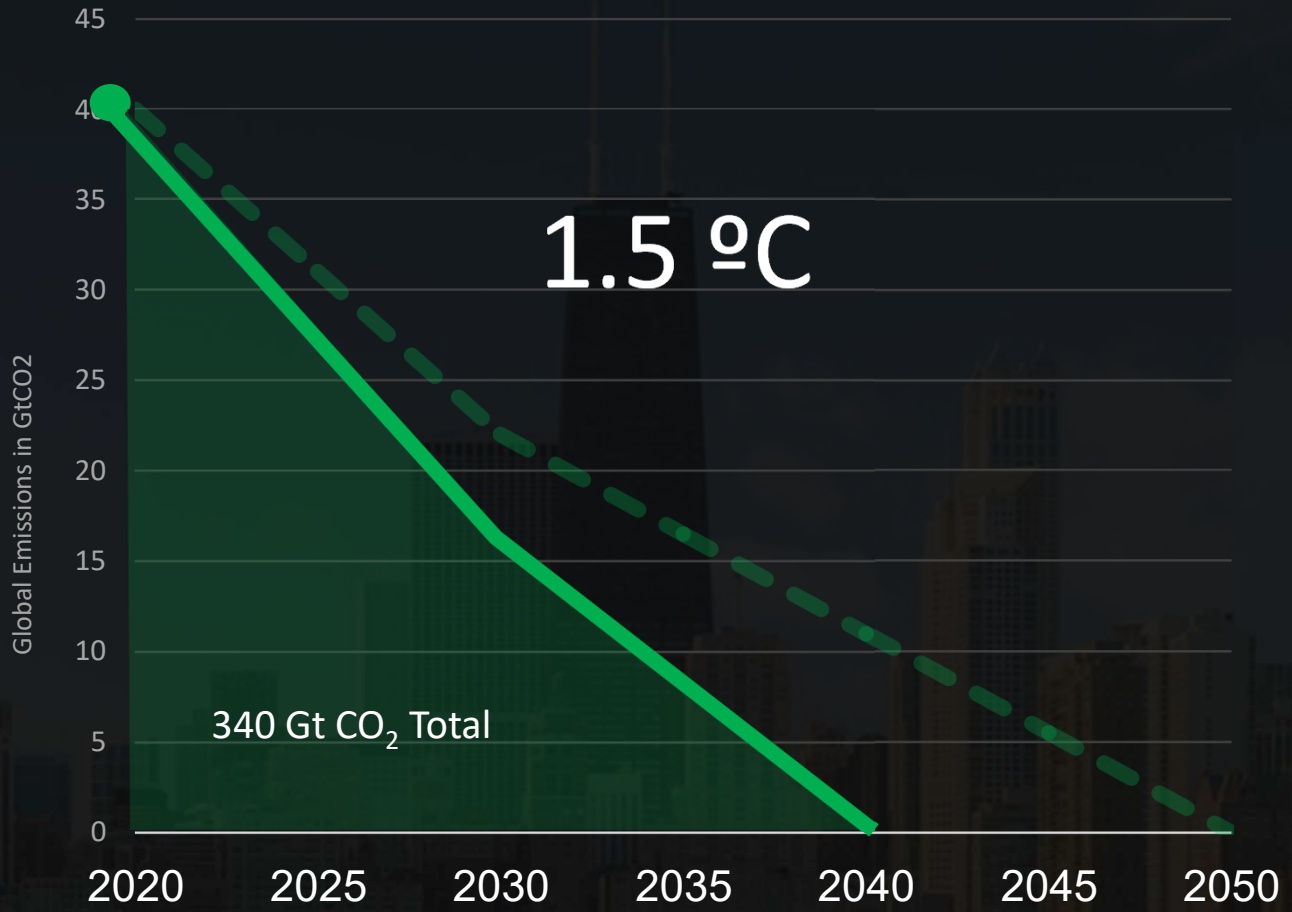
AIA LFRT Summit Road Map to 2040

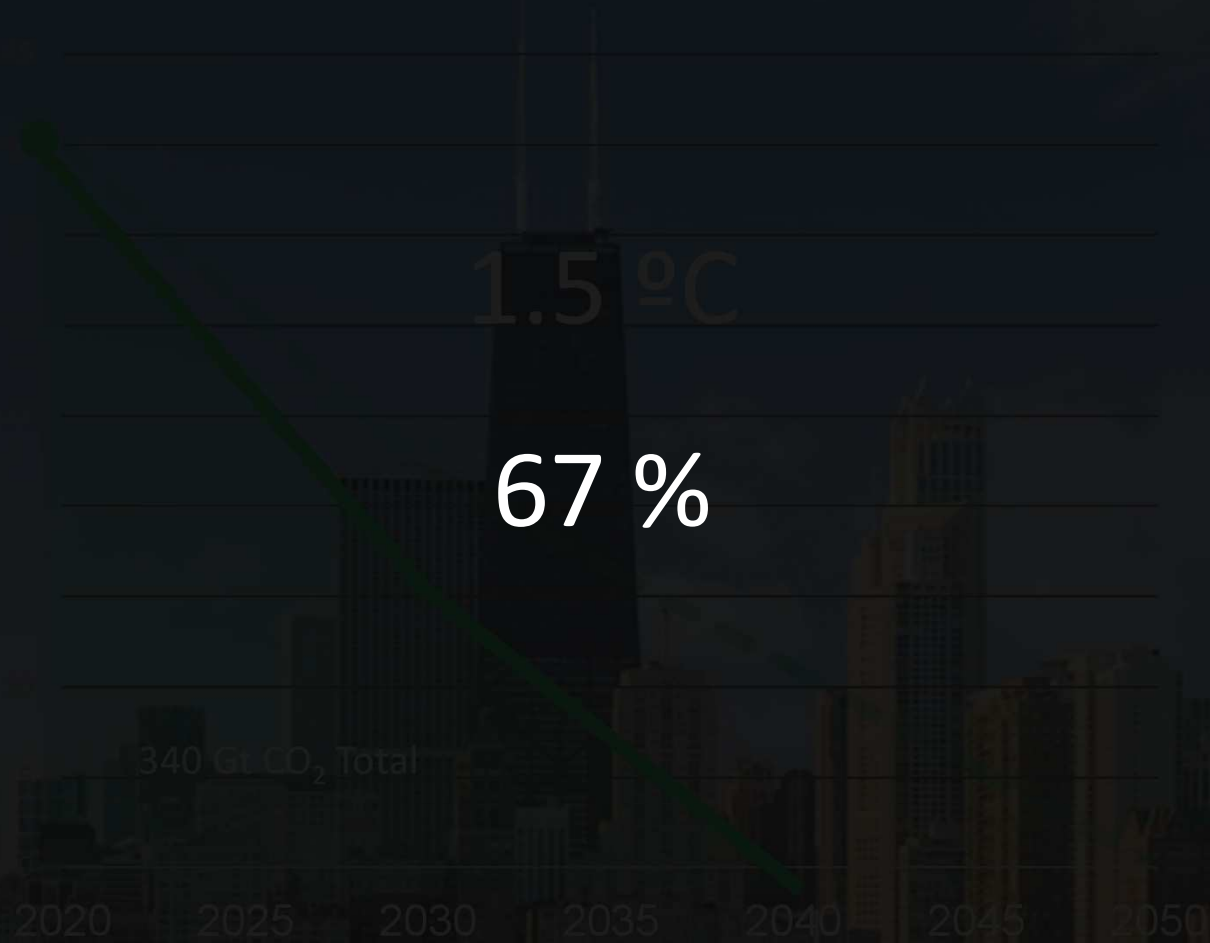


AIA LFRT Summit Road Map to 2040



AIA LFRT Summit Road Map to 2040





2035 All Renewable Grid



100% Renewable Energy in New York

THE WALL STREET JOURNAL.

U.S. Edition | June 20, 2019 | Print Edition | Video

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New York Lawmakers Near Landmark Deal on Greenhouse Gas Emissions

Bill to mandate an 85% reduction by 2050 would be the most stringent in the country

- **70% Renewable by 2030**

The New York Times

New York to Approve One of the World's Most Ambitious Climate Plans

The state would pledge to eliminate net greenhouse gas emissions by 2050, with all its electricity coming from carbon-free sources.



New York will be required to get 70 percent of its electricity from renewable sources by 2030, and shift entirely to carbon-free power a decade later.
Benjamin Norman for The New York Times

San Francisco Banned Gas

- NOV 13, 2020

NOV 13, 2020



The San Francisco Board of Supervisors voted unanimously on Tuesday to ban natural gas in new buildings, meaning that stoves, furnaces and water heaters will no longer burn gas. Credit: Arterra/Universal Images Group via Getty Images

New homes, offices and restaurants in San Francisco will soon be powered by electricity alone.

The city's Board of Supervisors voted unanimously on Tuesday to ban natural gas in new buildings, meaning that stoves, furnaces and water heaters will no longer burn gas for heat. The city cited cost savings, public health benefits and the urgent need to wind down greenhouse gas emissions to help curb the rapidly warming climate for the move.

Jurisdiction	Status	Approach			Systems			Add-Ons											
		Natural Gas Infrastructure Ban	All-Electric Reach	Electric-Preferred	Whole Building	Water Heating	Space Heating	Low Rise Residential	City-Owned Properties	High Rise Residential	Hotel	Retail	Office	Restaurant	Life Sciences	Additional Solar	Electric Vehicles	Low Carbon Concrete	Natural Gas In Lieu Fee
Alameda	Approved	X			X			X											
Berkeley	Approved	A		B	X			X	X	X	X	X	X	X		B	X	X	
Brisbane*	Second Reading		X		X			X	X	X									
Carlsbad	Approved		X			X		X								X			
Davis	Approved			X	X			X											
Healdsburg	Second Reading		X			X		X	X	X	X	X	X	X					
Los Gatos*	Second Reading		X		X			X											
Marin County	Approved			X	X			X	X	X	X	X	X	X			X	X	
Menlo Park*	Approved		X			X		X	X	X	X	X	X	X		X	X	X	
Mill Valley	Approved			X	X			X	X	X	X	X	X	X			X	X	
Milpitas	Approved			X	X			X	X	X	X	X	X	X			X	X	
Morgan Hill	Approved			X	X			X	X	X	X	X	X	X					
Mountain View*	Approved		X		X			X	X	X	X	X	X	X			X	X	
Pacifica	Second Reading		X			X		X	X	X	X	X	X	X					
Palo Alto*	Approved		A	B	X			A	B	B	B	B	B	B			X	X	
Saratoga	Approved		X			X		X	X	X	X	X	X	X			X	X	
San Jose*	Approved	A		B	X			A	B	B	B	B	B	B		B	X	X	
San Luis Obispo	Second Reading			X	X			X	X	X	X	X	X	X		X	X	X	X
San Mateo	Approved			X	X			X	X	X	X	X	X	X			X	X	
Santa Monica	Approved			X	X			X	X	X	X	X	X	X			X	X	
Santa Rosa	Approved		X		X			X	X	X	X	X	X	X					
Windsor	Approved	X	X		X			X	X	X	X	X	X	X					

*City Council opted to go beyond staff recommendation

A and B indicate different approaches as applied to specific building types.

San Francisco Net Zero - SEPT 17, 2019

2022 – commercial buildings over 500,000 square feet;
2024 – commercial buildings over 250,000 square feet;
2030 – commercial buildings over 50,000 square feet.

OFFICE OF THE MAYOR
SAN FRANCISCO



LONDON N. BREED
MAYOR

FOR IMMEDIATE RELEASE:

Tuesday, September 17, 2019

Contact: Mayor's Office of Communications, 415-554-6131

***** PRESS RELEASE *****

BOARD OF SUPERVISORS VOTES UNANIMOUSLY TO POWER SAN FRANCISCO'S DOWNTOWN WITH 100 PERCENT RENEWABLE ELECTRICITY

Board of Supervisors approves Mayor London Breed's legislation to require large commercial buildings to use renewable or greenhouse-gas free hydroelectricity

San Francisco, CA — The Board of Supervisors today voted unanimously to approve Mayor London N. Breed's legislation to transition private commercial buildings of 50,000 square feet and larger to 100 percent renewable electricity. Almost half of San Francisco's citywide emissions come from buildings, and half of those emissions come from the commercial sector. San Francisco has already reduced its greenhouse gas emissions 36 percent below 1990 levels.

The new clean electricity requirement is the first of its kind in the nation. The law will reduce emissions from the City's largest commercial buildings by an additional 21 percent to accelerate San Francisco's drive towards 100 percent renewable electricity by 2030. The legislation was co-sponsored by Supervisors Vallie Brown, Ahsha Safai, Aaron Peskin, Matt Haney, Rafael Mandelman, and Hillary Ronen.

"We must continue to lead the way in the fight against climate change, and we know that the building sector is a major contributor of climate-changing greenhouse gases," said Mayor Breed. "Transitioning our large buildings to 100 percent renewable energy is an important step towards making San Francisco an even more sustainable city and continuing the progress we have made with CleanPowerSF."

The legislation calls for the City's largest commercial buildings to procure 100 percent renewable electricity from any of the City's electricity providers by 2022. Then, starting in 2024, additional buildings will be subject to the requirement, eventually encompassing all commercial buildings 50,000 square feet or larger. The requirement is currently phased-in chronologically to ensure adequate renewable electricity is available for procurement:

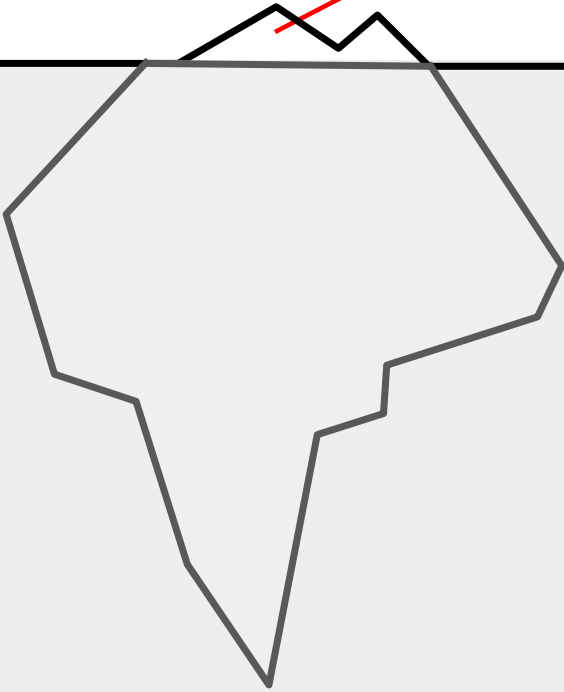
- 2022 – commercial buildings over 500,000 square feet;
- 2024 – commercial buildings over 250,000 square feet; and,
- 2030 – commercial buildings over 50,000 square feet.

The legislation is part of the Mayor's vision of an "all-electric City" in which 100 percent renewable electricity replaces the use of fossil fuels in the building and transportation sectors. San Francisco's emissions primarily come from the transportation and the building sectors, with each sector responsible for 46 and 44 percent of the City's emissions, respectively. Cross-sector

1 DR. CARLTON B. GOODLETT PLACE, ROOM 200
SAN FRANCISCO, CALIFORNIA 94102-4681
TELEPHONE: (415) 554-6141

Building Carbon Emission Standards

- NYC - LL97
- DC - L22-257
- MA - LCFS
- CA - LCBB



More to come!

City of Boston

Table 1: CO₂e Emissions Standards by Building Use

Building use	Emissions standard (kgCO ₂ e/SF/yr.)					
	2025 - 2029	2030-2034	2035-2039	2040-2044	2045-2049	2050-
<u>Assembly</u>	7.8	4.6	3.3	2.1	1.1	0
<u>College/ University</u>	10.2	5.3	3.8	2.5	1.2	0
<u>Education</u>	3.9	2.4	1.8	1.2	0.6	0
<u>Food Sales & Service</u>	17.4	10.9	8.0	5.4	2.7	0
<u>Healthcare</u>	15.4	10.0	7.4	4.9	2.4	0
<u>Lodging</u>	5.8	3.7	2.7	1.8	0.9	0
<u>Manufacturing/ Industrial</u>	23.9	15.3	10.9	6.7	3.2	0
<u>Multifamily housing</u>	4.1	2.4	1.8	1.1	0.6	0
<u>Office</u>	5.3	3.2	2.4	1.6	0.8	0
<u>Retail</u>	7.1	3.4	2.4	1.5	0.7	0
<u>Services</u>	7.5	4.5	3.3	2.2	1.1	0
<u>Storage</u>	5.4	2.8	1.8	1.0	0.4	0
<u>Technology/Science</u>	19.2	11.1	7.8	5.1	2.5	0

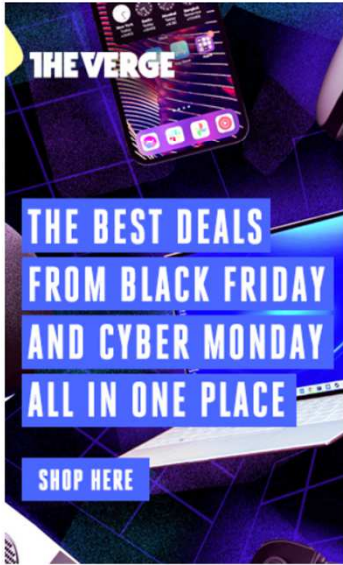
UK Net Zero by Law - Jan 27, 2019

The UK is now committed by law to the most aggressive climate target in the world

The country also went two whole weeks without burning coal for electricity.

By Umair Irfan | Updated Jun 27, 2019, 4:37pm EDT

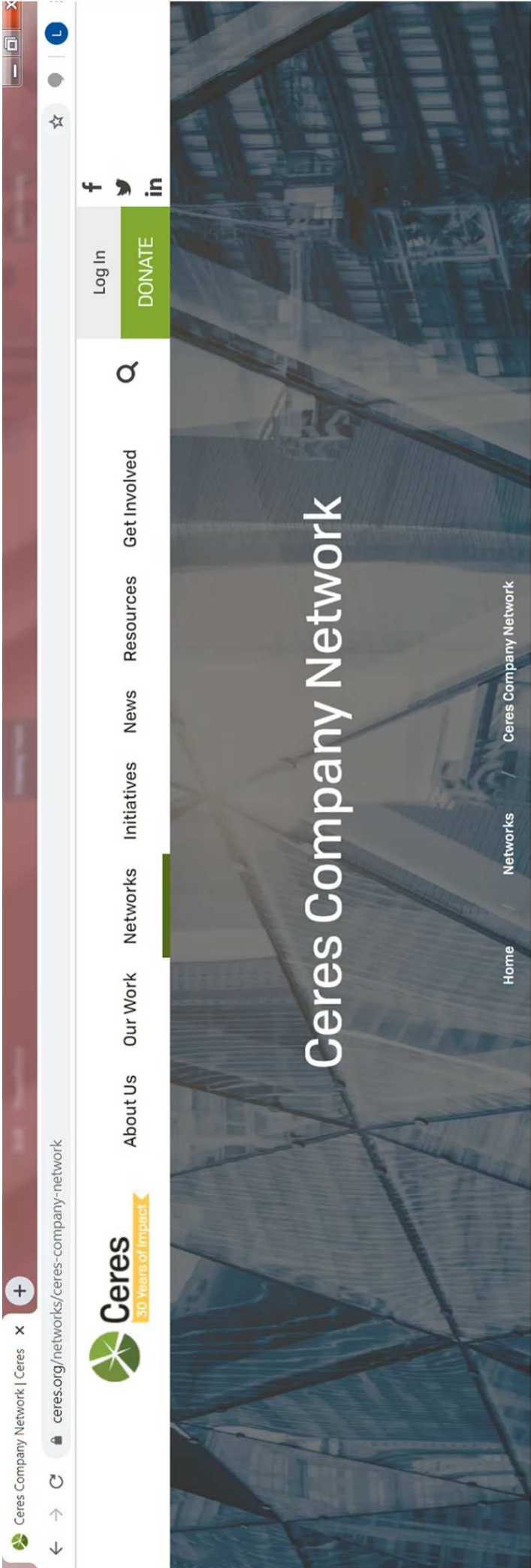
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Microsoft will be carbon negative by 2030

Jan 16, 2020 | [Brad Smith - President](#)






[f](#) [t](#) [in](#)

Ceres' Company Network comprises 50+ companies, nearly 75 percent of them Fortune 500 firms. Through direct stakeholder engagement, standard-setting, regular benchmarking, and strong collaborations with coalitions like **We Mean Business**, Ceres moves companies to raise their ambition on robust sustainability goals and improve resiliency in their operations and supply chains.



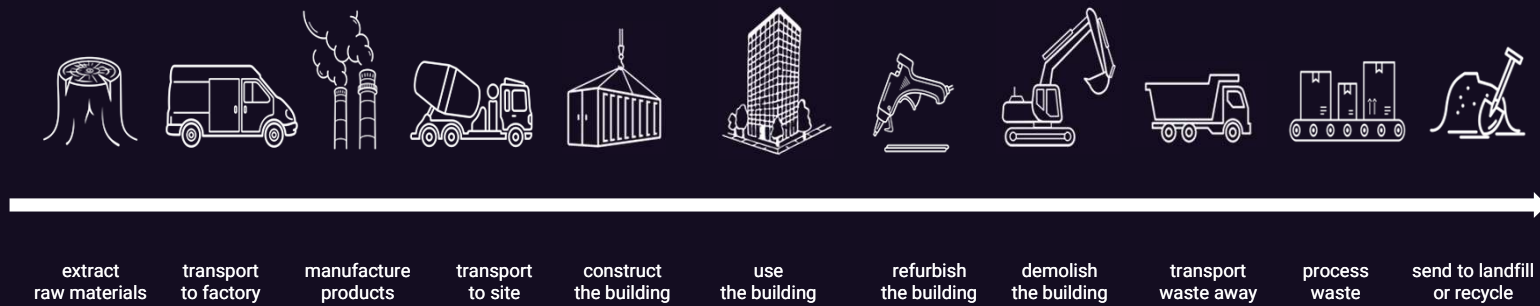
LCA

A satellite image of Earth showing a large portion of the globe. The image is dominated by white and grey clouds, with some brown and green landmasses visible. The text is overlaid on the top left portion of the image.

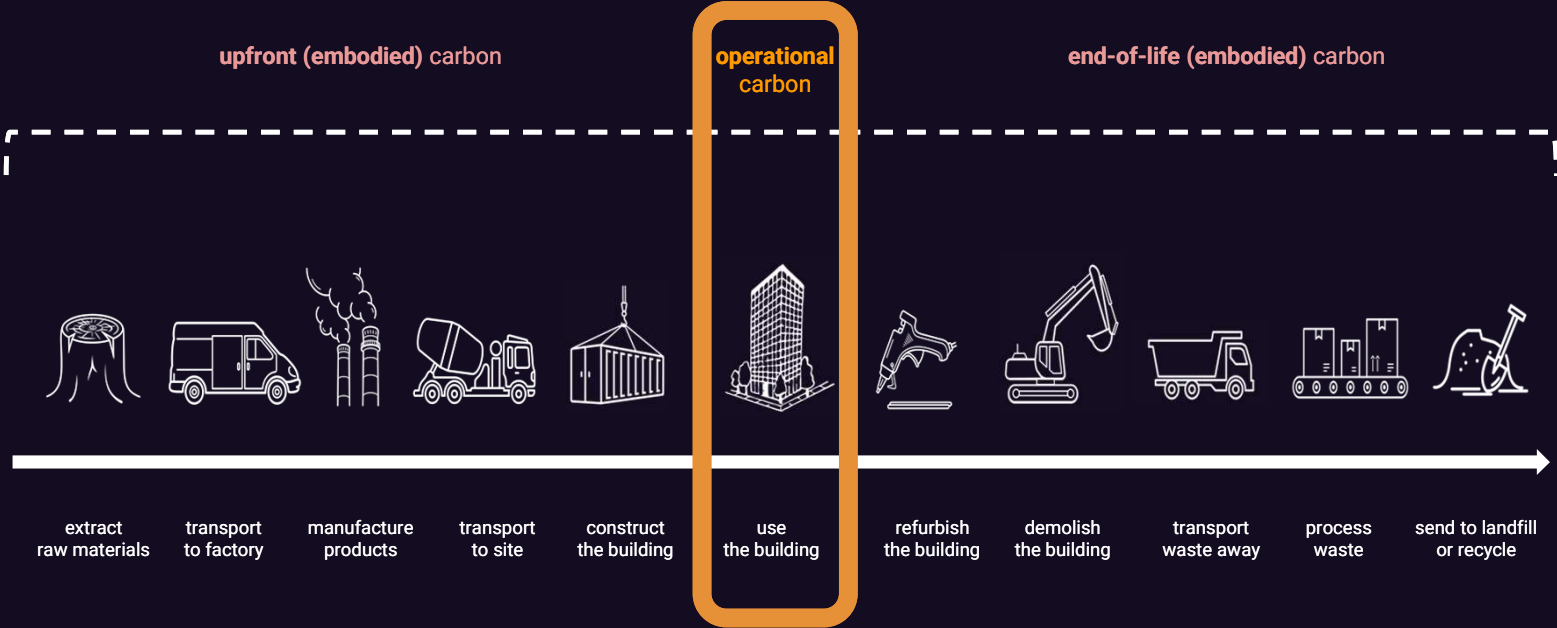
Buildings and infrastructure
account for nearly 39% of all
global CO₂ emissions.

业态配比
PROGRAM PROPORTION

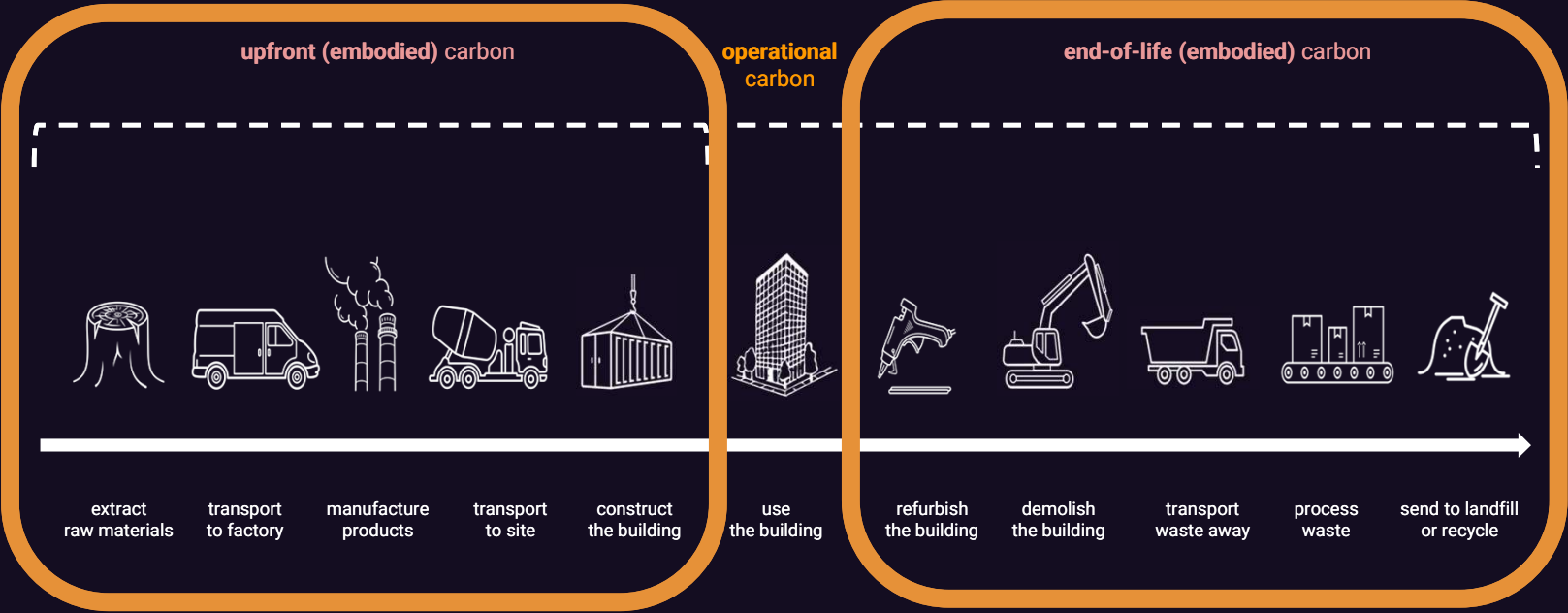
Carbon



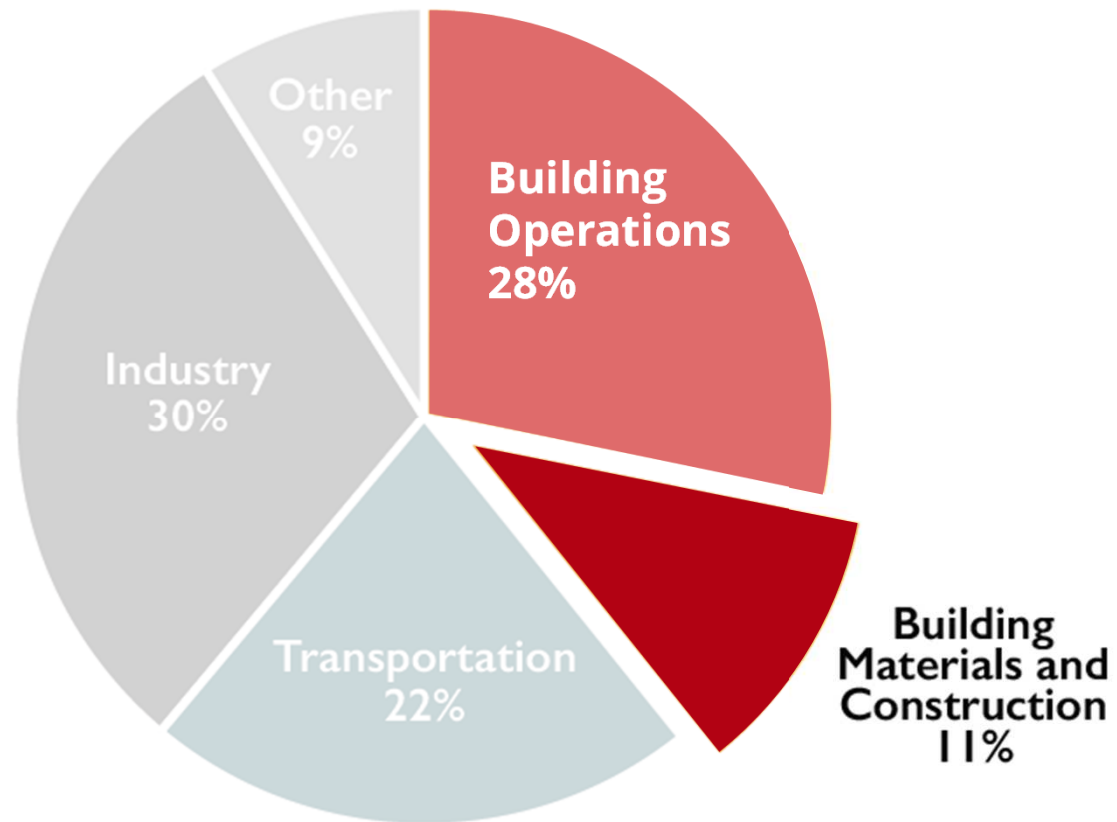
Carbon: Operational



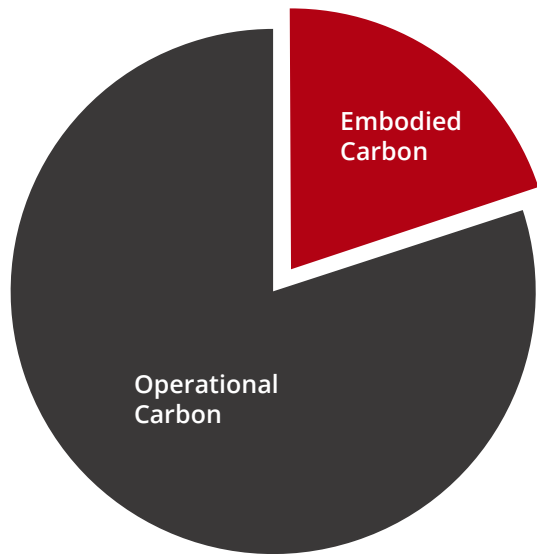
Carbon: Operational



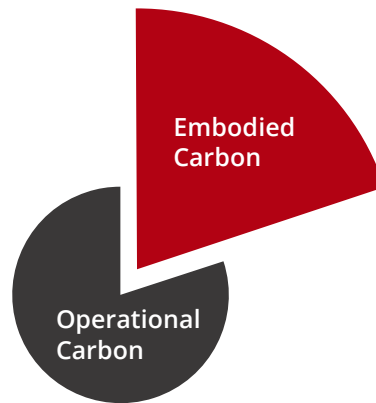
Global CO₂ Emissions by Sector



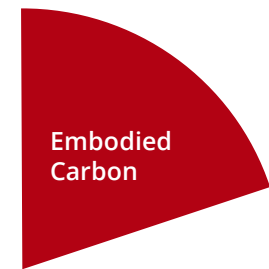
Source: © 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017



Typical Building



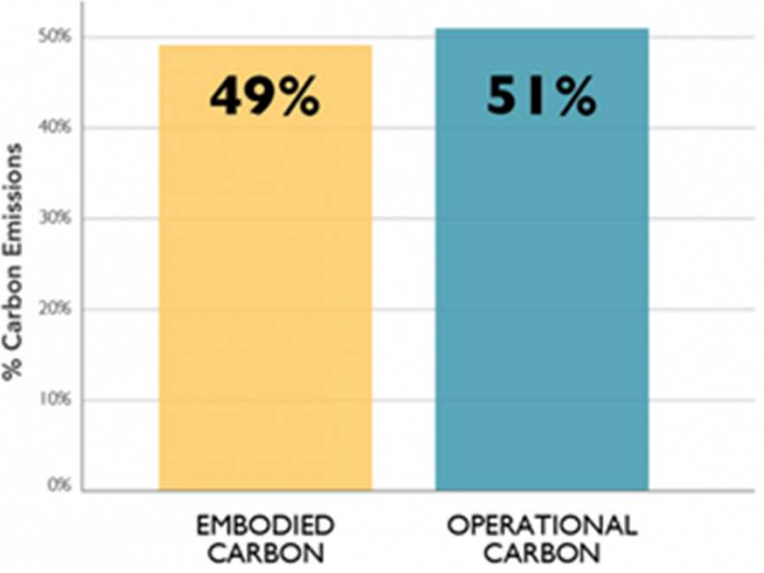
High Performance Building



Net Zero Operation Energy Building

Carbon: Operational vs. Embodied

Total Carbon Emissions of Global New Construction
from 2020-2050
Business as Usual Projection



2020 – 2050

49%

© 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

Life Cycle Carbon – Embodied Carbon, EN 15975



Life Cycle Analysis



Life Cycle Carbon – Operating Carbon



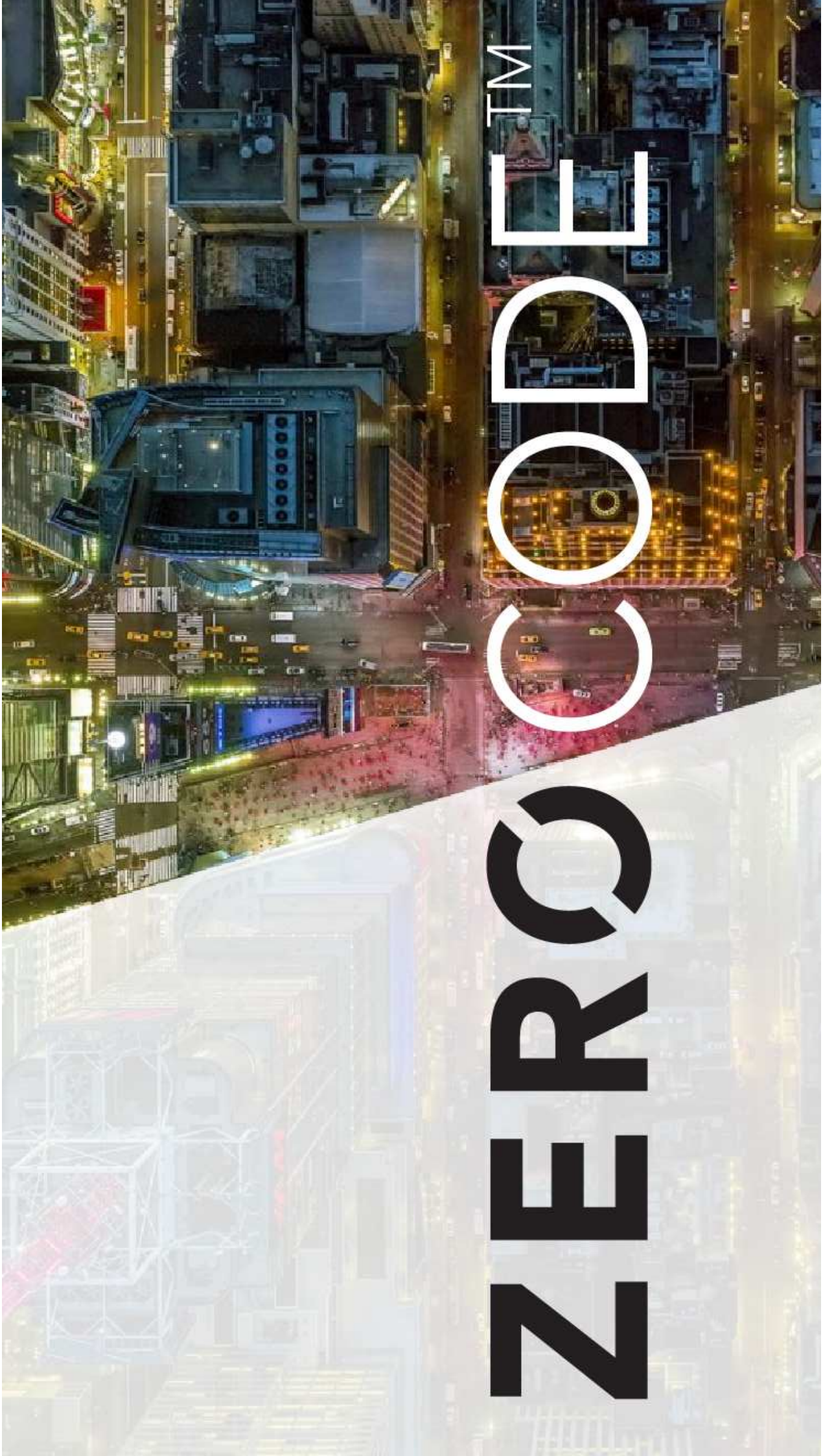
Life Cycle Carbon – Operating Carbon



ZEROC

CODE

TIME





First Net Zero School in New York City

FAÇADE
CLERESTORY/
VISION WINDOWS



PERIMETER
DISPLACEMENT/
INJECTION UNITS



CLASSROOM/
CORRIDOR
DASHBOARD SYSTEM



SLOPED
CEILINGS AND
90% DAYLIT
CLASSROOMS



98% DAYLIT
OFFSET
CORRIDORS



DOAS LOW-
POWER HVAC
SYSTEM



LOW-ENERGY
KITCHEN
EQUIPMENT



GREENHOUSE



VEGETABLE
GARDEN



SOLAR
THERMAL



PHOTOVOLTAIC
PANELS



98% DAYLIT
OFFSET CORRIDORS



GREEN ROOF



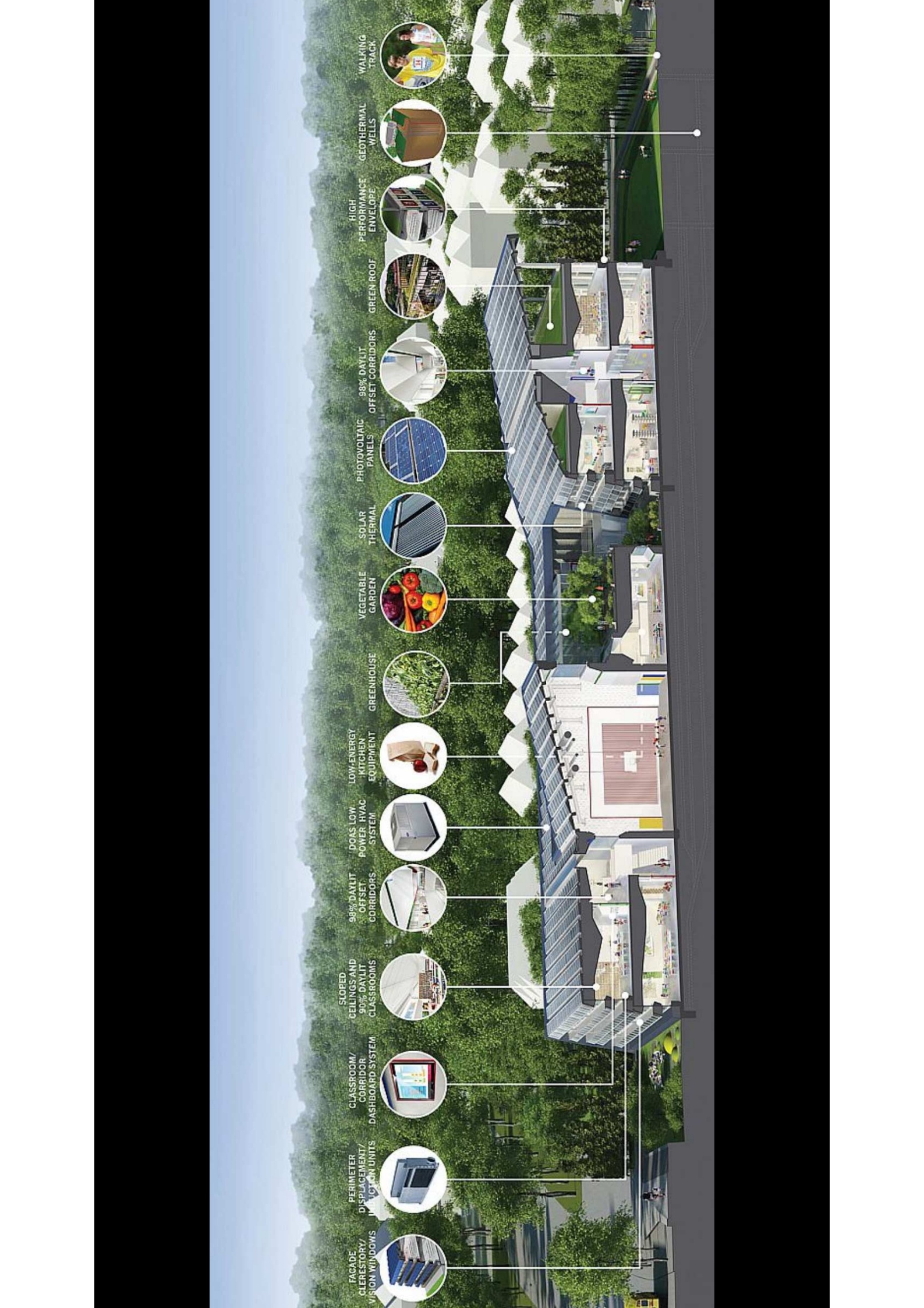
HIGH
PERFORMANCE
ENVELOPE

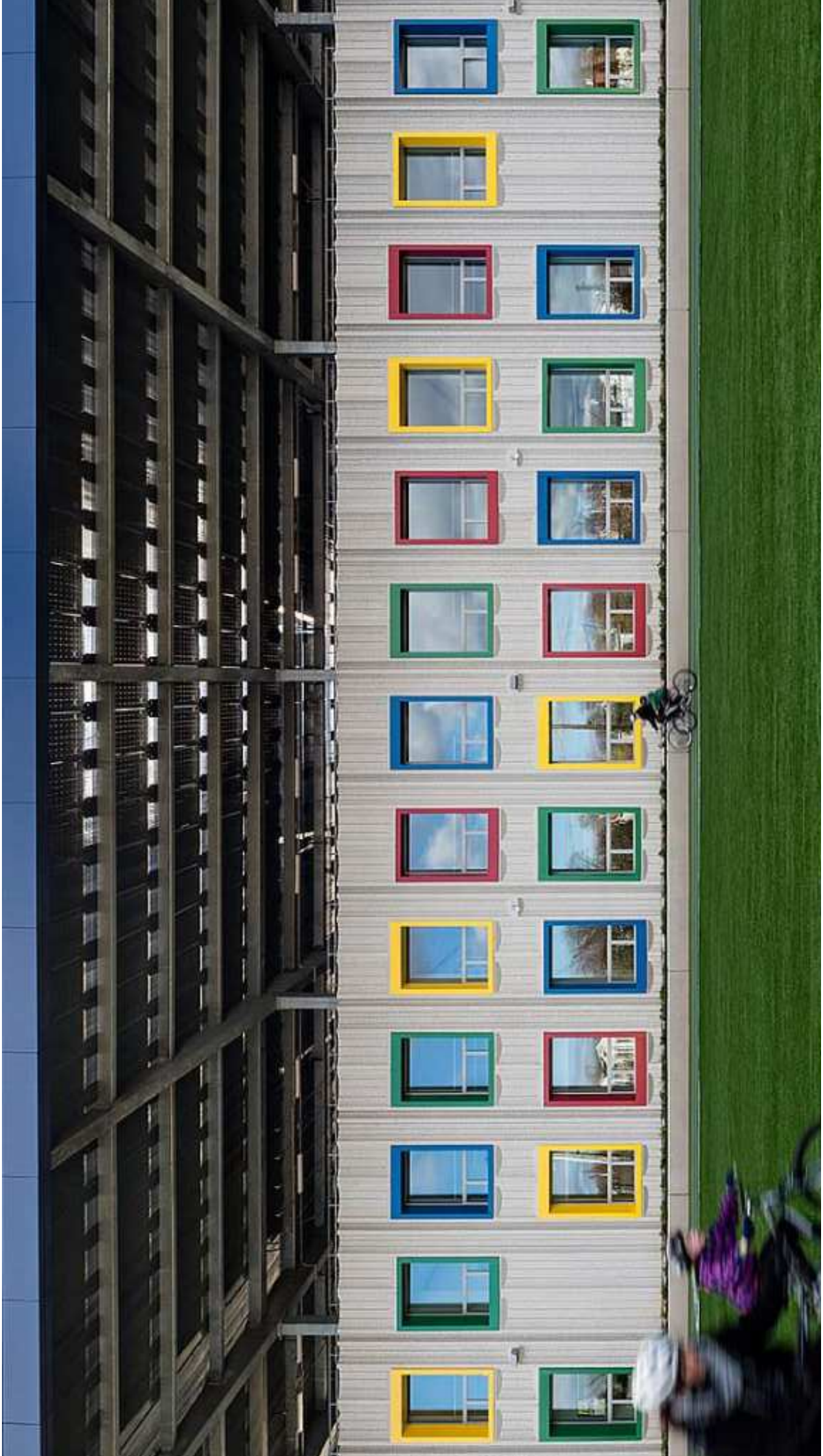


GEOTHERMAL
WELLS



WALKING
TRACK

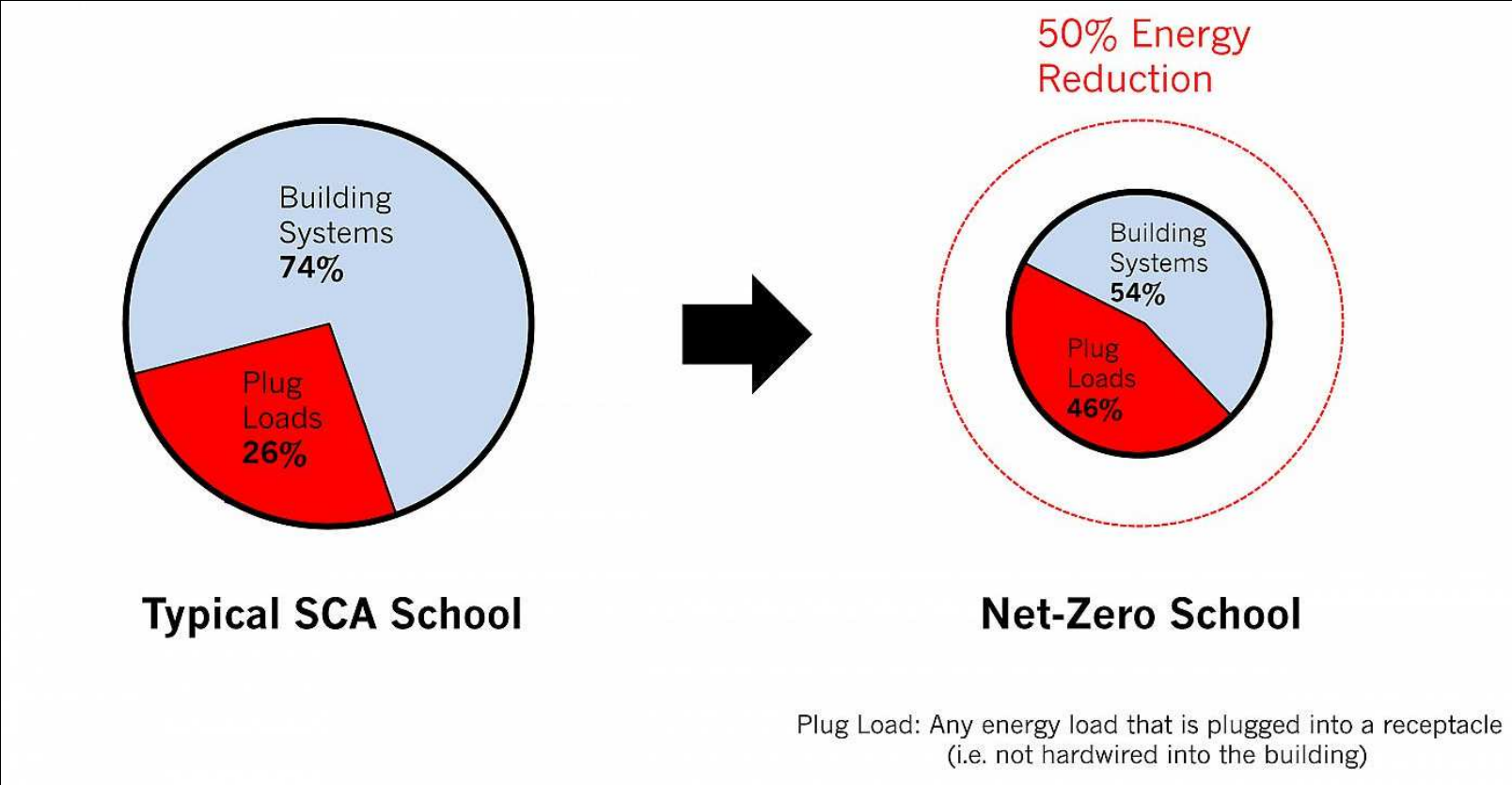






First Net Zero Energy School in New York City

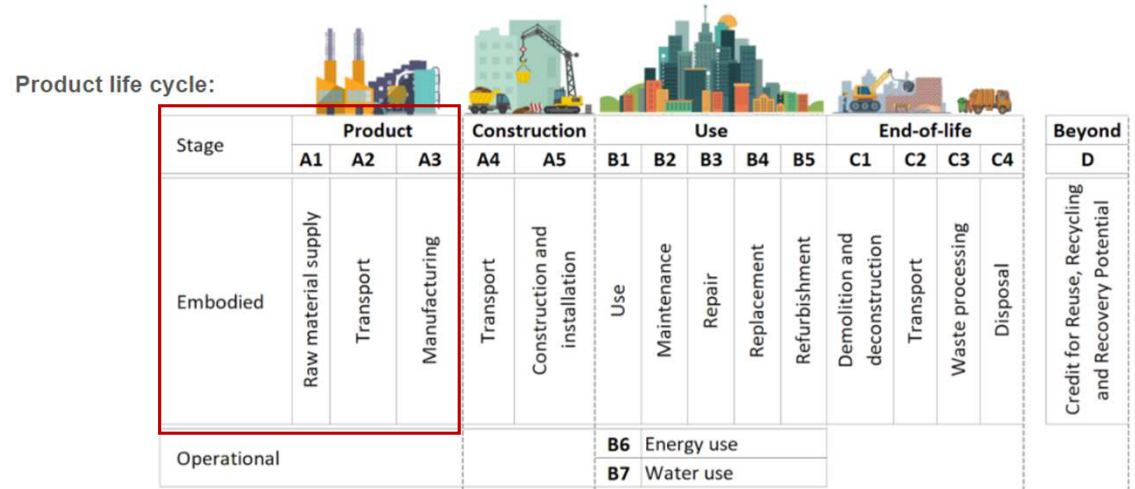
Plug loads



Life Cycle Carbon – Embodied Carbon



MEP spec analogue



L. MEP Equipment Global Warming Potential (GWP)

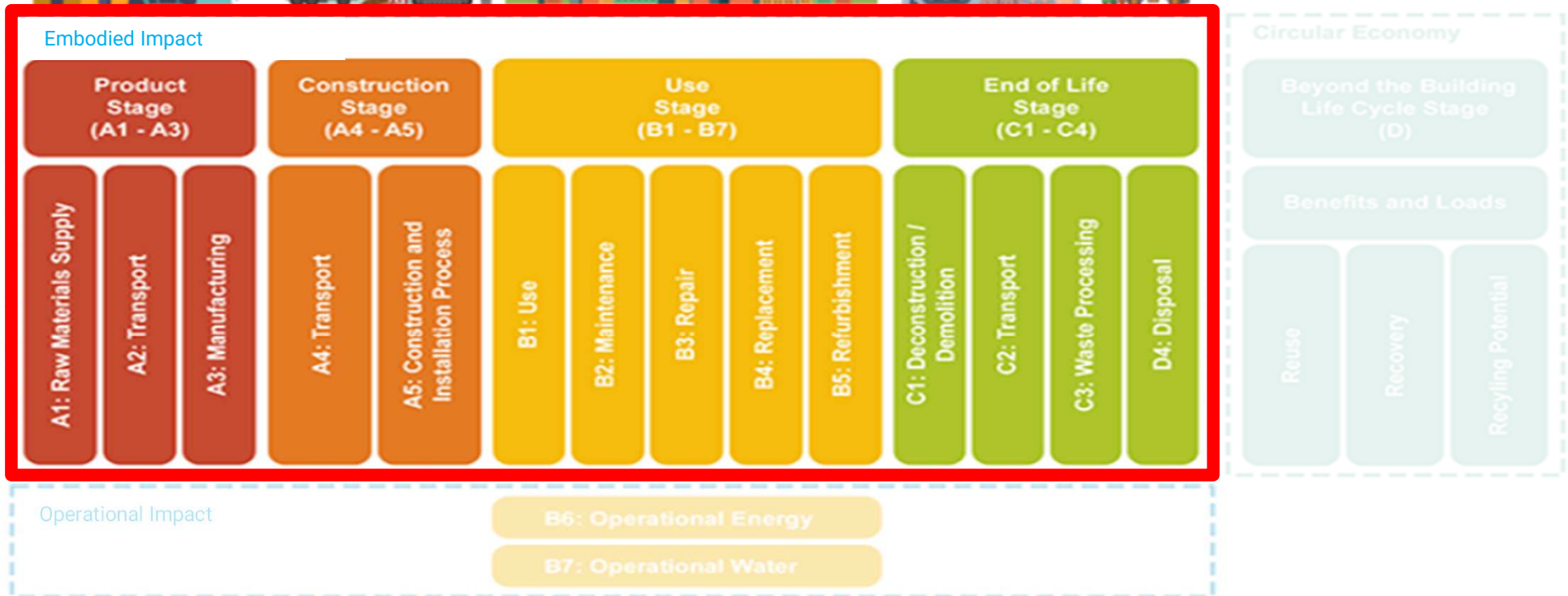
- The design intent for select MEP equipment contribution to the Project Carbon Budget is that the total CO₂e of the product life-cycle assessment stages A1-A3 does not exceed the value listed in the tables below.

Product	kgCO ₂ e/ton of cooling capacity
Water cooled chiller	135
Air cooled chiller	150
VRF system	120
Heat pump	110

EXAMPLE FIGURES,
NOT ACTUAL VALUES

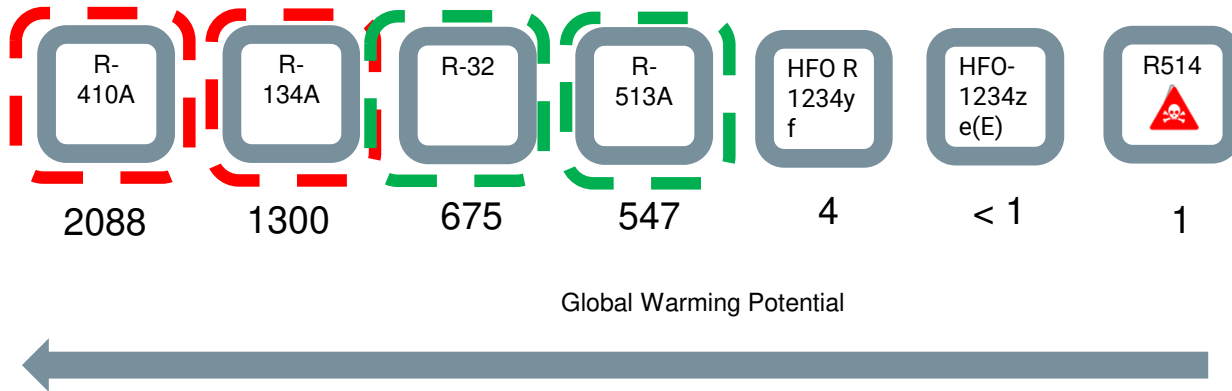
- Third-party verified Environmental Product Declarations (EPDs) in accordance with ISO 14025 shall be submitted for each product confirming the A1-A3 contribution of GWP.

Life Cycle Carbon – Embodied Carbon



REFRIGERANT GLOBAL WARMING POTENTIAL (GWP)

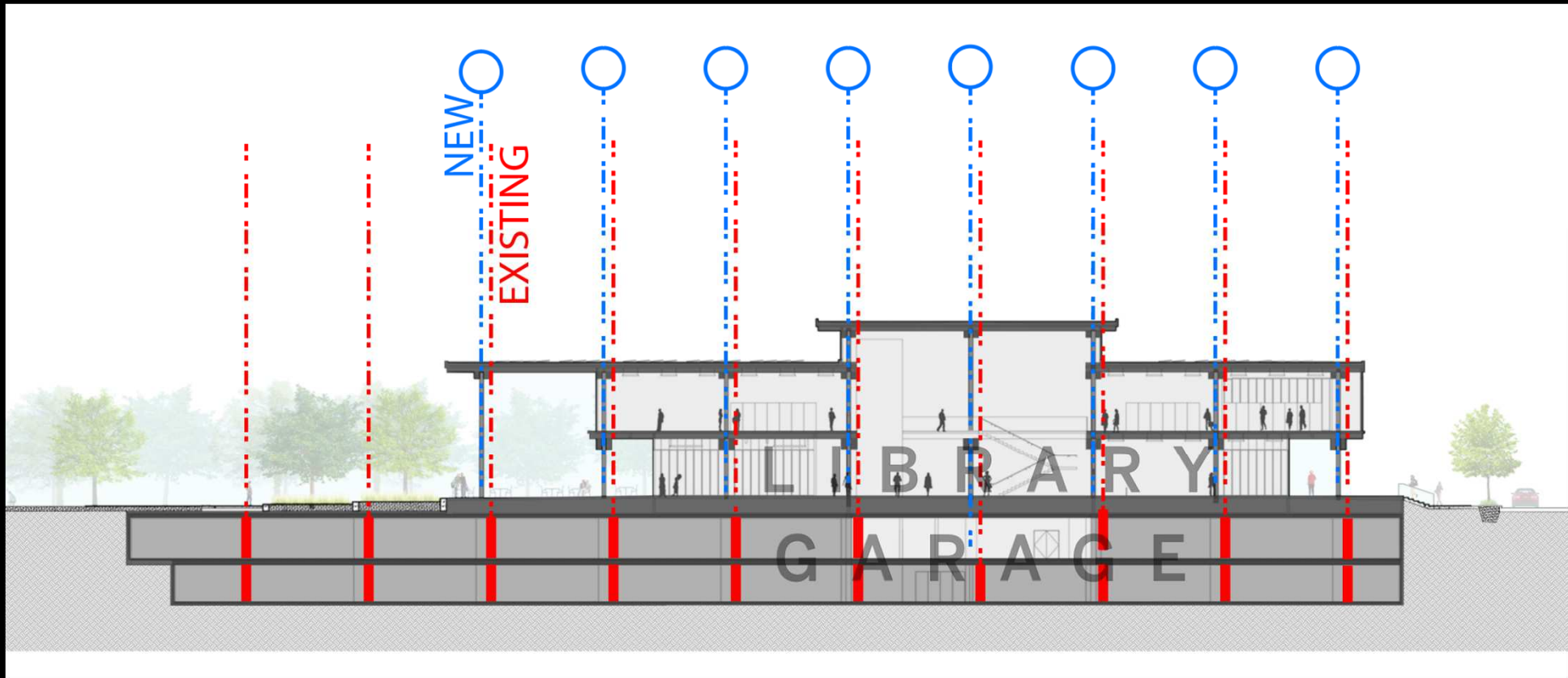
Refrigerant Comparison



Long Beach Main Library



Long Beach Main Library



LONG BEACH MAIN LIBRARY | ADAPTATION OF PARKING GARAGE

DEMO & NEW: 100 lb CO₂eq PSF

REUSE: 35 lb CO₂eq PSF

Long Beach Main Library

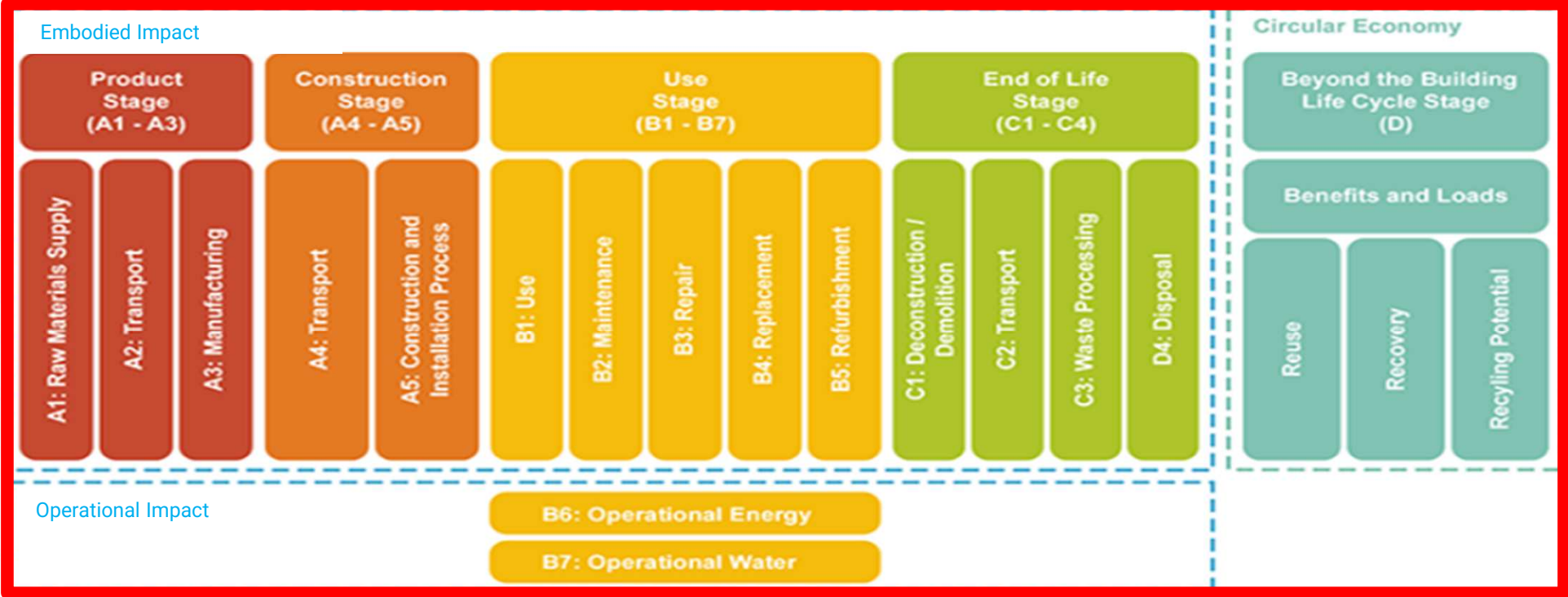


LONG BEACH MAIN LIBRARY | ADAPTATION OF PARKING GARAGE

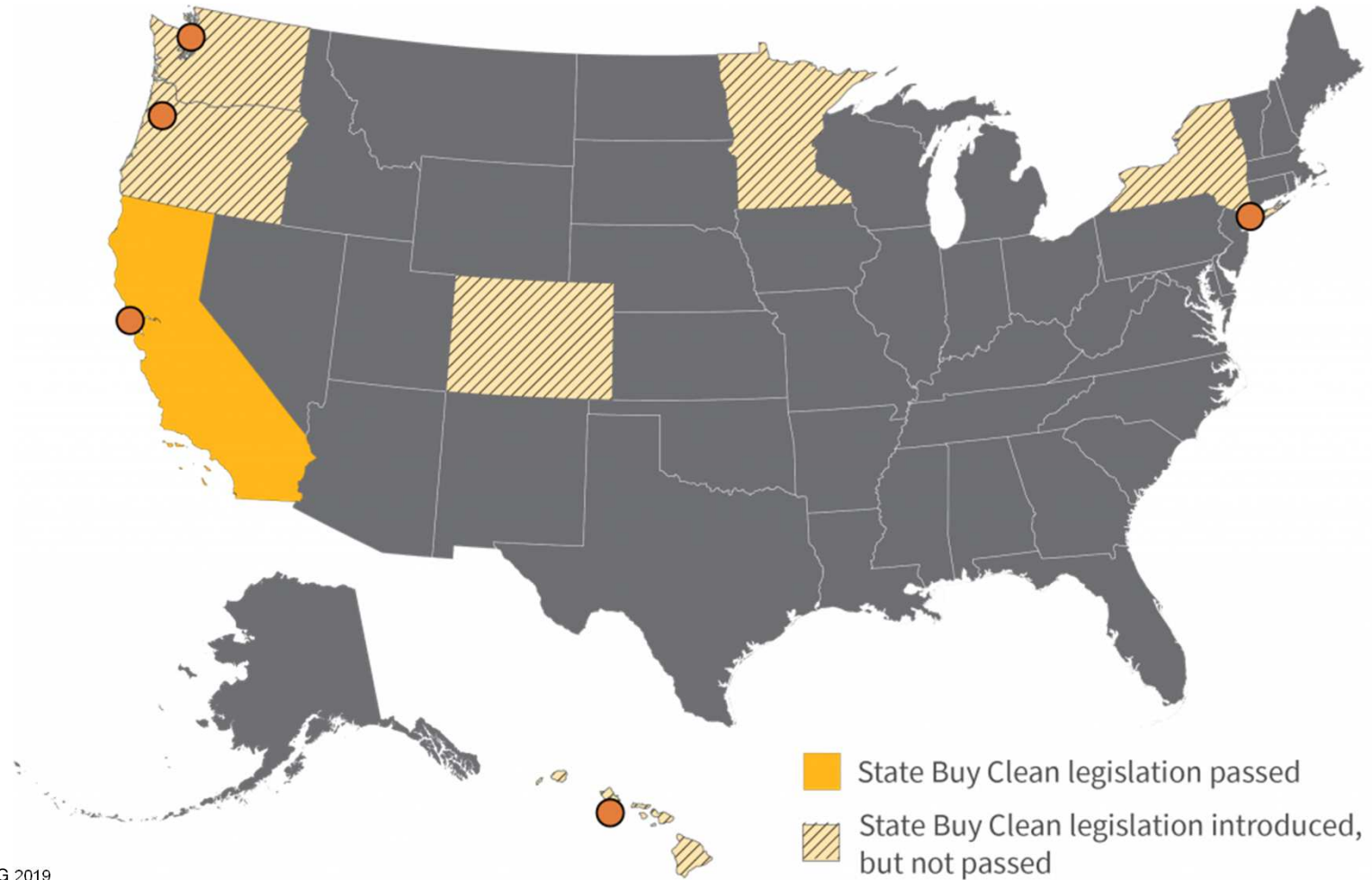
CONCRETE: 70 lb CO₂eq PSF

TIMBER: 35 lb CO₂eq PSF

Life Cycle Carbon – Whole Life Carbon



Top Down - "Buy Clean"



Developers' Letter

			
			JOIN.

Supporting Signatories: Architects, Interior Designers, Engineers, Consultants and Contractors.

Supporting Signatories: Manufacturers.

Supporting Signatories: Industry Groups

					
				JOIN.	

Developers' Letter

“....we are making the following statements: - Our procurement requirements, including RFPs and specifications will now begin to include requests for data on areas of holistic ESG impact of materials, starting with embodied carbon data. Equivalent building products with data developed and documented in compliance with nationally and internationally recognized standards will be prioritized over those without...”

Request for ESG data of Building Materials: Starting with Embodied Carbon

Initial Release Date: January 28th, 2021

Dear Building Material Partner,

Over the past year the world has fundamentally changed. The pandemic has made us realize how quickly our social and economic stability can be disrupted at a global scale.

More importantly, we have realized that this is just the beginning. Environmental issues are a far greater threat to long-term societal and economic stability. Of these, climate change is arguably the most urgent.

Over the past decades, changes in climate have affected certain areas of the world more acutely than others. However, the severity, frequency and number of people and areas affected has now become global and is steadily getting worse.

This doesn't have to be the case.

The real-estate industry accounts for approximately 49% of global carbon emissions, of which 21% are from building materials (11% and an estimated 10% from architectural and interior finish materials respectively). As an industry, we play a critical role in addressing climate change.

However, we must do so while considering other ESG issues as well. Unfortunately, reliable information on the embodied carbon of products and other ESG (Environmental, Social Governance) impacts of building materials remain incredibly difficult to find.

Whether it be climate health (embodied carbon), human health, societal health, ecosystem health or product circularity, the lack of data on critical ESG impact areas of building materials renders holistic informed decision-making highly complex.

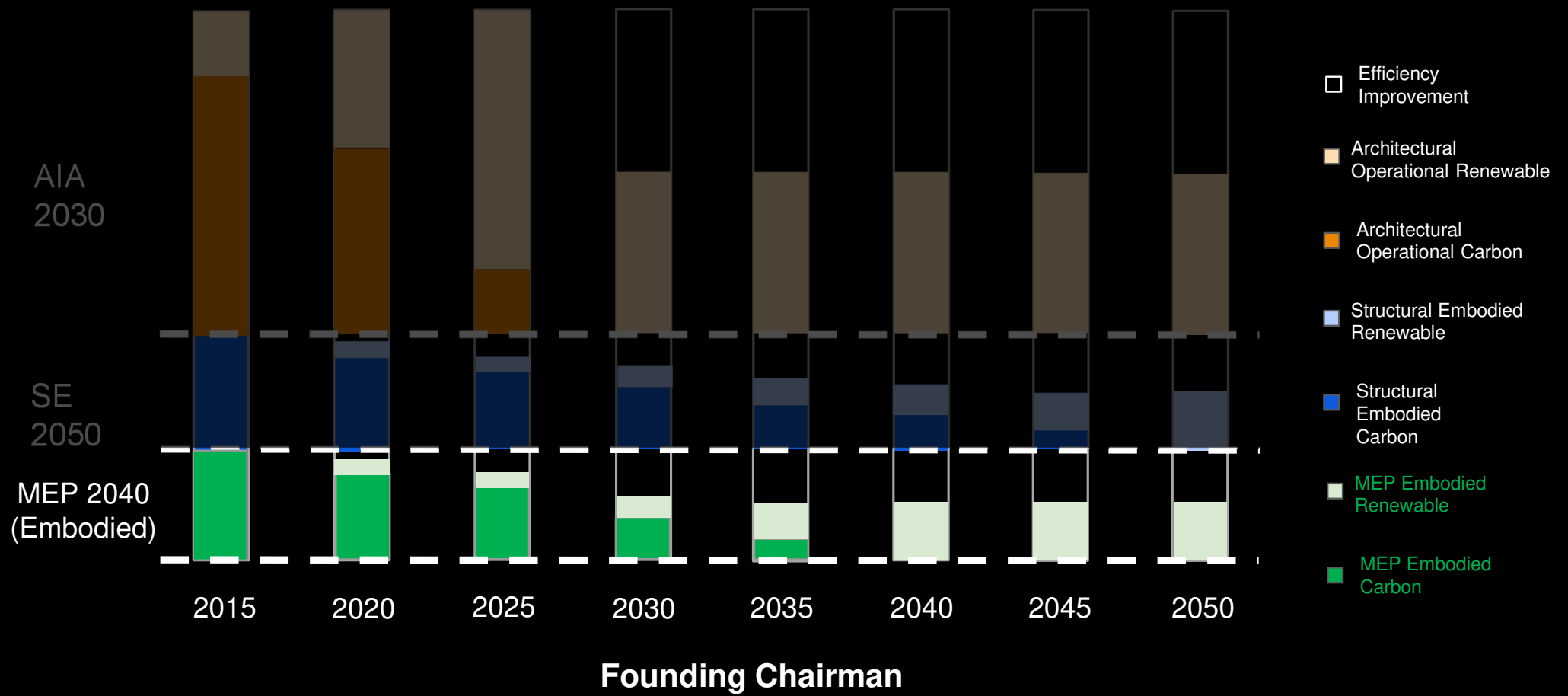
We realize that the tools and know-how exist to generate this data. We also realize that many building manufacturers have been waiting for a clear market request.

Most importantly, we realize that this clear market request must come from building owners. It must also be supported by their Consultants, Architects, Engineers and Contractors. Equally importantly, we believe that this information must be made publicly available.

To this effect, we are making the following statements:

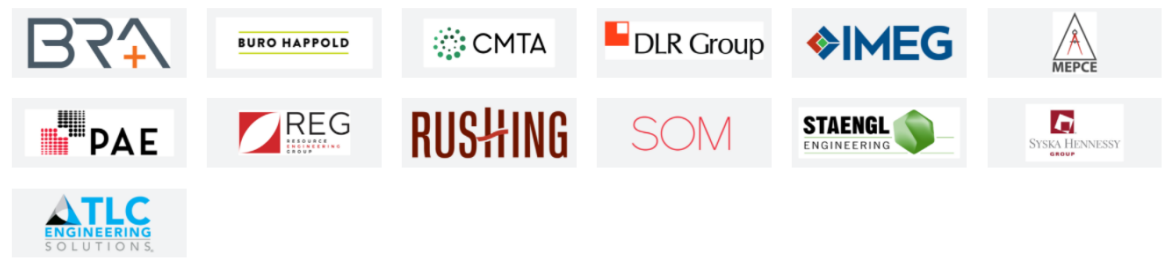
- Our procurement requirements, including RFPs and specifications will now begin to include requests for data on areas of holistic ESG impact of materials, starting with embodied carbon data. Equivalent building products with data developed and documented in compliance with nationally and internationally recognized standards will be prioritized over those without.
- Of the products with data, to the maximum extent practicable as data and tools continue to become available, further prioritization will be placed on the following:

AIA 2030 + SE 2050





The MEP 2040 Commitment is intended for MEP engineering and design firms. Companies and organizations that are not MEP firms are recognized as Supporters of the Commitment (see below).



SIGN THE COMMITMENT

<https://carbonleadershipforum.org/mep2040/>

MEP 2040 Commitment Supporters

Do you represent an MEP manufacturer, an NGO, a trade association, or any other organization wanting to demonstrate support for this initiative? Success depends on an industry-wide effort, so your support is welcome!



English



AIA, RIBA, UK
Building Services
Engineers Declare
Climate and Biodiversity
Emergency

- Evaluate all new projects against the aspiration to contribute positively to mitigating climate breakdown, and encourage our clients to adopt this approach.
- Upgrade existing buildings for extended use as a more carbon efficient alternative to demolition and new build whenever there is a viable choice.
- Include life cycle costing, whole life carbon modelling and post occupancy evaluation as part of the basic scope of work, to reduce both embodied and operational resource use.
- Adopt more regenerative design principles in practice, with the aim of providing building services engineering design that achieves the standard of net zero carbon.
- Collaborate with clients, architects, engineers and contractors to further reduce construction

Signatures:

95

Advance M&E Design
AECOM
Apex Acoustics Ltd
Arup
Atelier Ten
Atkins
Atmos Lab
BDP
BOOM Collective
Box Twenty Consulting Engineers Ltd
Brinson Staniland Partnership
Bryden Wood
BSE3D
Build Test Solutions
BuroHappold Engineering
CAD21
Cavendish Engineers
chapmanbdsp
Chartwell Energy Solutions Ltd.
Cion Solutions Ltd
CJ Design Partnership
collaborate + create limited
Cundall
Drees & Sommer UK Ltd
DSA Engineering Ltd

DSSR
Elementa Consulting
Energylab Consulting Ltd
Engineering Services Consultancy
eTool
Etude
EVORA EDGE
FHP Engineering Services Solutions
Frankham Consultancy Group
Greengauge Building Energy Consultants
Griffiths Evans
Hilson Moran
Hive Design Partnership
Hoare Lea
Hulley & Kirkwood CE Ltd
Humblebee
Hurstwood Environmental Consulting
Hydrock
i3 Solutions Group Ltd
IES Ltd
Inkling
InTandem Systems Ltd
Integration
Jones King Partnership
Julie Godefroy Sustainability

KJ Tait Engineers Ltd
Max Fordham LLP
Meinhardt UK Ltd
Mesh Energy
Method Consulting LLP
Mg partnership
MHBC Cumming
Mott MacDonald
MZA Consulting Engineers
One Creative Environments
Patrick Parsons
Perfect Circle JV Ltd
Pick Everard
PM group
QCIC Group
QuinnRoss Consultants Ltd
Ramboll UK
Redotec LLP
Ritchie+Daffin
Roberts Environmental Ltd
Scotch Partners
Services Design Solution Ltd
Six Cylinder Limited
Skelly and Couch
SOAP Retrofit Ltd

Sonas Energy
Steensen Varming
Sustainable Acoustics
TGA Consulting Engineers LLP
Thornley & Lumb Partnership Ltd
Troup, Bywaters + Anders
Tuckers Consultancy
Twinn Sustainability Innovation
University - Brunel University London
University - City, University of London
University - Leeds, School of Civil Engineering
University - London South Bank
University - Sheffield, Dept Civil & Structural Engineering
Warm: Low Energy Building Practice
Waterman Group
We Design For...
Webb Yates Engineers
WSP
WYG
XC02

Bottom Up - MEP Embodied Carbon Letter



Date: January 28, 2021

Re: Embodied carbon information needs for the MEP industry

Dear MEP Equipment Manufacturer,

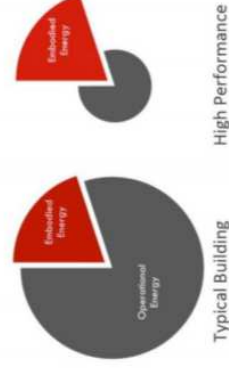
As the need to decarbonize the building industry becomes more crucial, we as MEP engineers are frequently challenged to design efficient, effective building systems that reduce the total carbon footprint of new construction and renovation projects. This letter is a call to action. **Please join us for a panel discussion with key industry leaders on February 11, 2021 at 11 am CST/noon EST.**

Embodied carbon: The new challenge

For the past 20+ years, our industry was focused on energy reductions, but recently there has been a shift to minimizing operational carbon through strategies related to energy efficiency, utility source selection, and integration of renewable energy. Having achieved good progress in reducing operational carbon, our focus is now moving to the embodied and life cycle carbon associated with the materials and systems found in buildings. Simply put, embodied carbon looks at the carbon impacts associated with extracting, manufacturing, and transporting materials to the jobsite, while life cycle analysis (LCA) accounts for impacts over the full lifecycle of a material, which in addition to manufacturing and transportation, includes impacts related to use, end of life, as well as recycling and recovery, if applicable.

As shown in the graphic below, as operational carbon decreases, embodied carbon becomes a larger piece of the carbon footprint and begs the attention of the design community.

Operating vs Embodied Carbon



<http://carbonleadershipforum.org/>

Embodied carbon of building services equipment



TM65: 2020



Embo
servi

Embodied carbon of building services equipment

Embodied carbon of building services equipment

MEP EMBODIED CARBON



1. Tools and Analysis

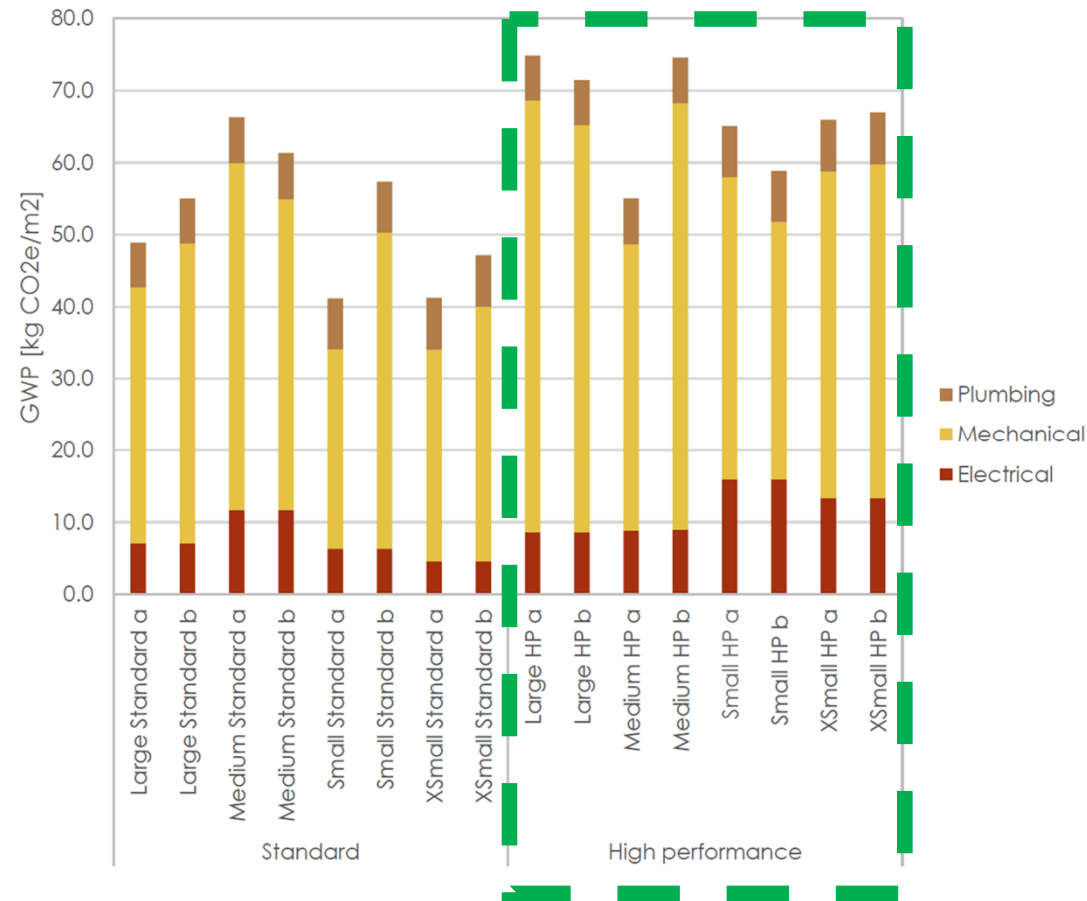


2. Benchmarking



3. Targets

MEP EMBODIED CARBON – OFFICE

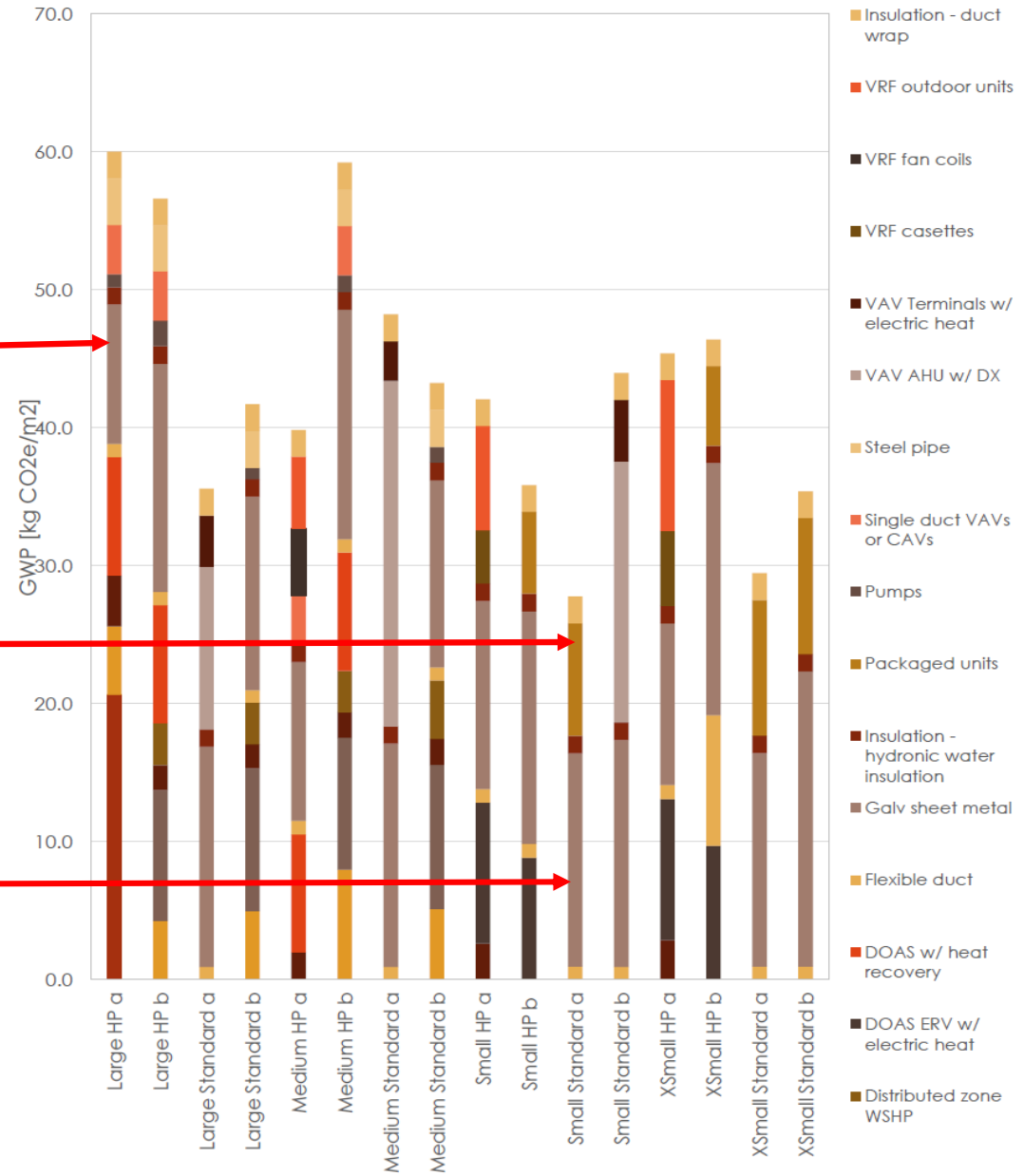


MEP EMBODIED CARBON - OFFICE

Chiller, Boilers, AHU, Chilled Beams

Roof Top Package Unit

Galvanized Steel



EPD



EPD Transparency Summary

COMPANY NAME

Spray Polyurethane Foam Alliance

PRODUCT TYPE

Building Envelope Insulation

PRODUCT NAME

Closed-Cell, Medium-Density Spray Polyurethane Foam Insulation

PRODUCT DEFINITION

Closed-cell, medium-density (2.0 lb/ft³) spray polyurethane foam insulation. Spray polyurethane foam is made on the jobsite by combining methylene-diphenylene diisocyanate (MDI or A-side) with an equal volume of a polyol blend (B-side).

PRODUCT CATEGORY RULE (PCR)

Building Envelope Thermal Insulation ULE 2011

CERTIFICATION PERIOD

10/10/2013 – 10/10/2018

DECLARATION NUMBER

13CA29310.101.1



LIFECYCLE IMPACT CATEGORIES

The environmental impacts listed below were assessed throughout the product's lifecycle – including raw material extraction, transportation, manufacturing, packaging, use, and disposal at end of life.

	ATMOSPHERE			WATER		EARTH	
	<p>Global Warming Potential refers to long-term changes in global weather patterns – including temperature and precipitation – that are caused by increased concentrations of greenhouse gases in the atmosphere.</p>	<p>Ozone Depletion Potential is the destruction of the stratospheric ozone layer which shields the earth from ultraviolet radiation that's harmful to life, caused by human-made air pollution.</p>	<p>Photochemical Ozone Creation Potential happens when sunlight reacts with hydrocarbons, nitrogen oxides, and volatile organic compounds, to produce a type of air pollution known as smog.</p>	<p>Acidification Potential is the result of human-made emissions and refers to the decrease in pH and increase in acidity of oceans, lakes, rivers, and streams – a phenomenon that pollutes groundwater and harms aquatic life.</p>	<p>Eutrophication Potential occurs when excessive nutrients cause increased algae growth in lakes, blocking the underwater penetration of sunlight, needed to produce oxygen and resulting in the loss of aquatic life.</p>	<p>Depletion of Abiotic Resources (Elements) refers to the reduction of available non-renewable resources, such as metals and gases, that are found on the periodic table of elements, due to human activity.</p>	<p>Depletion of Abiotic Resources (Fossil Fuels) refers to the decreasing availability of non-renewable carbon-based compounds, such as oil and coal, due to human activity.</p>
CMV TRACI	27.6 kg CO ₂ -Equiv.	1.15E-08 kg CFC 11-Equiv.	0.18 kg O ₃ -Equiv.	0.78 mol H ⁺ Equiv.	8.99E-04 kg N-Equiv.		

FUNCTIONAL UNIT The functional unit of the product is 1 m² of insulation material with a thickness that gives a design thermal resistance RSI = 1 m²·K/W and with a building service life of 60 years. Material Contents refers to B-side chemicals. The A-side is made from a blend of polymeric methylene diphenyl diisocyanate (pMDI).





Environment

EPD

ENVIRONMENTAL IMPACT INDICATORS

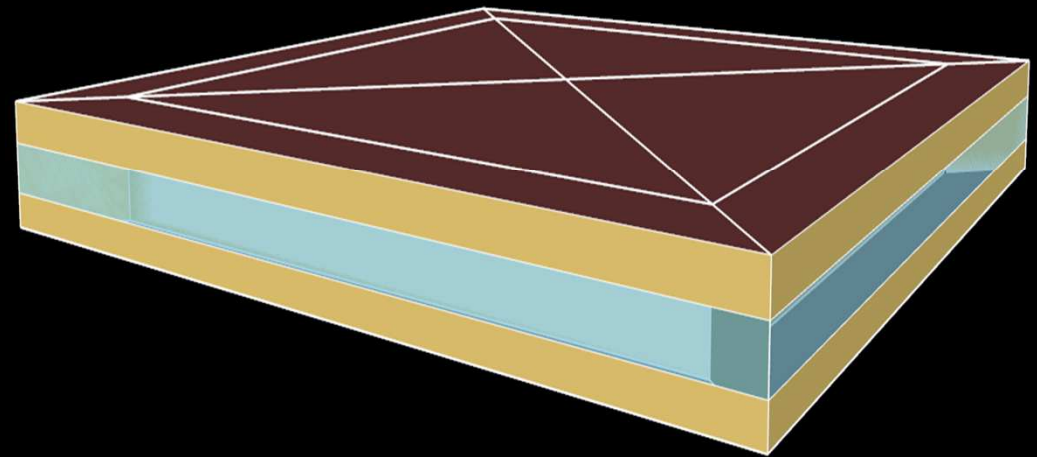
The following mandatory indicators are included to quantify the potential environmental impacts of the Hotel. Characterisation factors used for each impact category are in accordance with EN 15804+A1(2013).

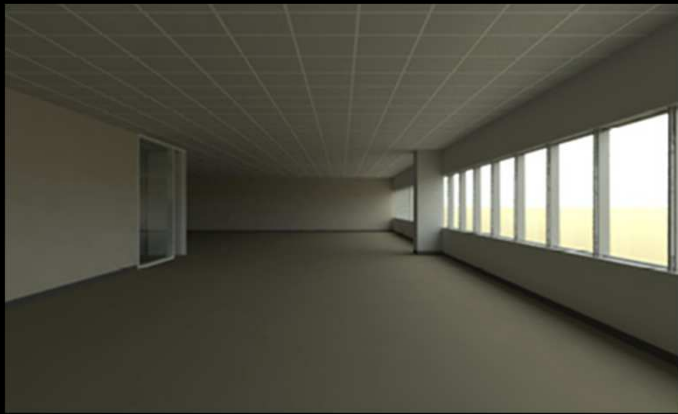
 GWP	Global warming potential (GWP)	Emissions that contribute to climate change (also known as the greenhouse effect). It is measured in kg of CO ₂ e equivalents over 100 years.
 ODP	Ozone depletion potential (ODP)	The potential impact of emissions of synthetic gases on the ozone layer. It is measured in kg of CFC-11 equivalents.
 AP	Acidification potential of land and water (AP)	Emissions which increase the acidity of the environment. It is measured in kg of SO ₂ equivalents.
 EP	Eutrophication potential (EP)	The addition of nutrients to water bodies reduces the oxygen levels available to support aquatic life. It is measured in kg of PO ₄ ³⁻ equivalents.
 POCP	Photochemical ozone creation potential (POCP)	Contribution to air pollution in the form of smog. It is measured in kg of C ₂ H ₄ equivalents.
 ADPE	Abiotic depletion potential for non-fossil resources (elements, ADPE)	The potential impact of consuming non-renewable elements and mineral resources. It is measured in kg of Antimony (Sb) equivalents.
 ADPF	Abiotic depletion potential for fossil resources (fossil, ADPF)	The potential impact of consuming non-renewable fossil fuel resources. It is measured in MJ net calorific value.

Case Studies

ASSUMPTIONS

- 25,000 sf in Chicago, IL
- ASHRAE 90.1-2016 Constructions
- **System Options**
 - Variable Air Volume (VAV) System with Hot Water Reheat Coils, Central Chiller and Boiler Plant with Cooling Tower
 - Air Cooled Variable Refrigerant (VRF) System
- **Façade Options**
 - 40% WWR IGU
 - 90% WWR IGU
 - Double Skin Façade with Internal Blinds





40% WWR

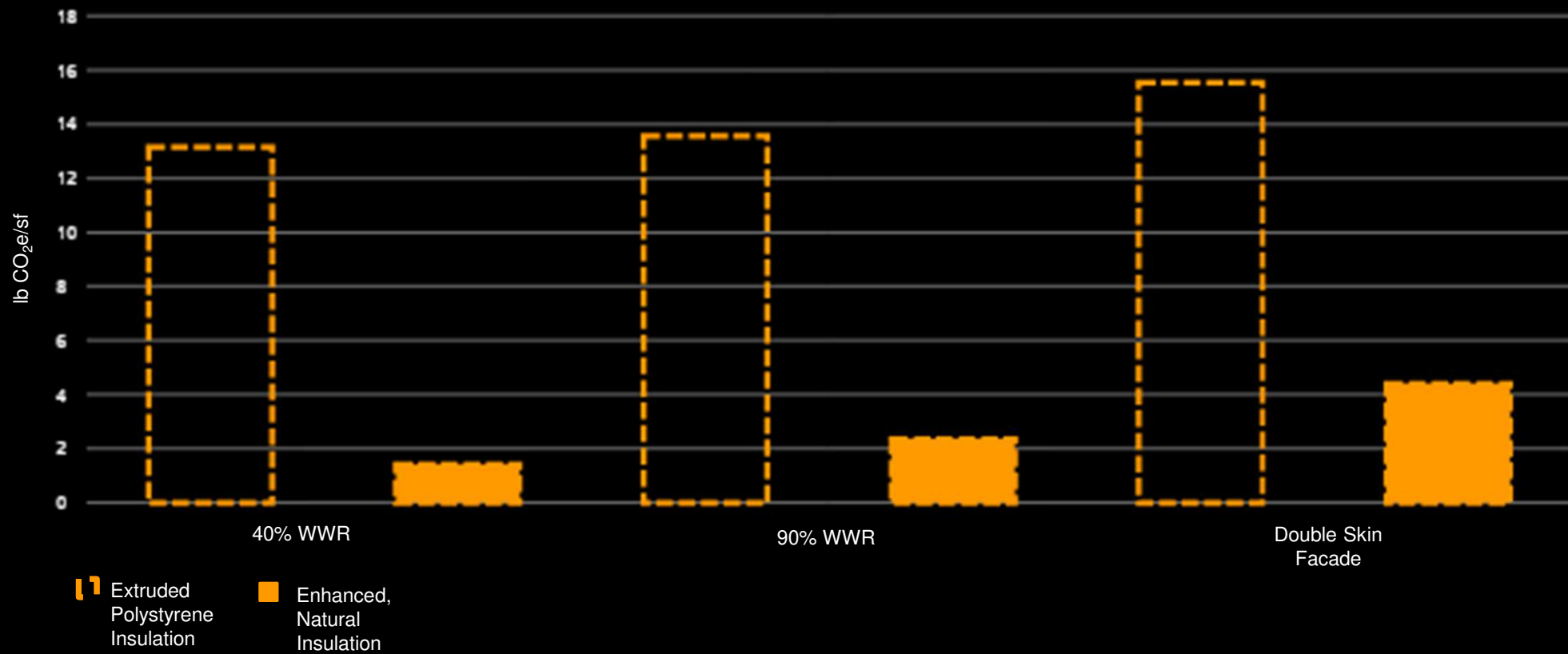


90% WWR



Double Skin
Facade

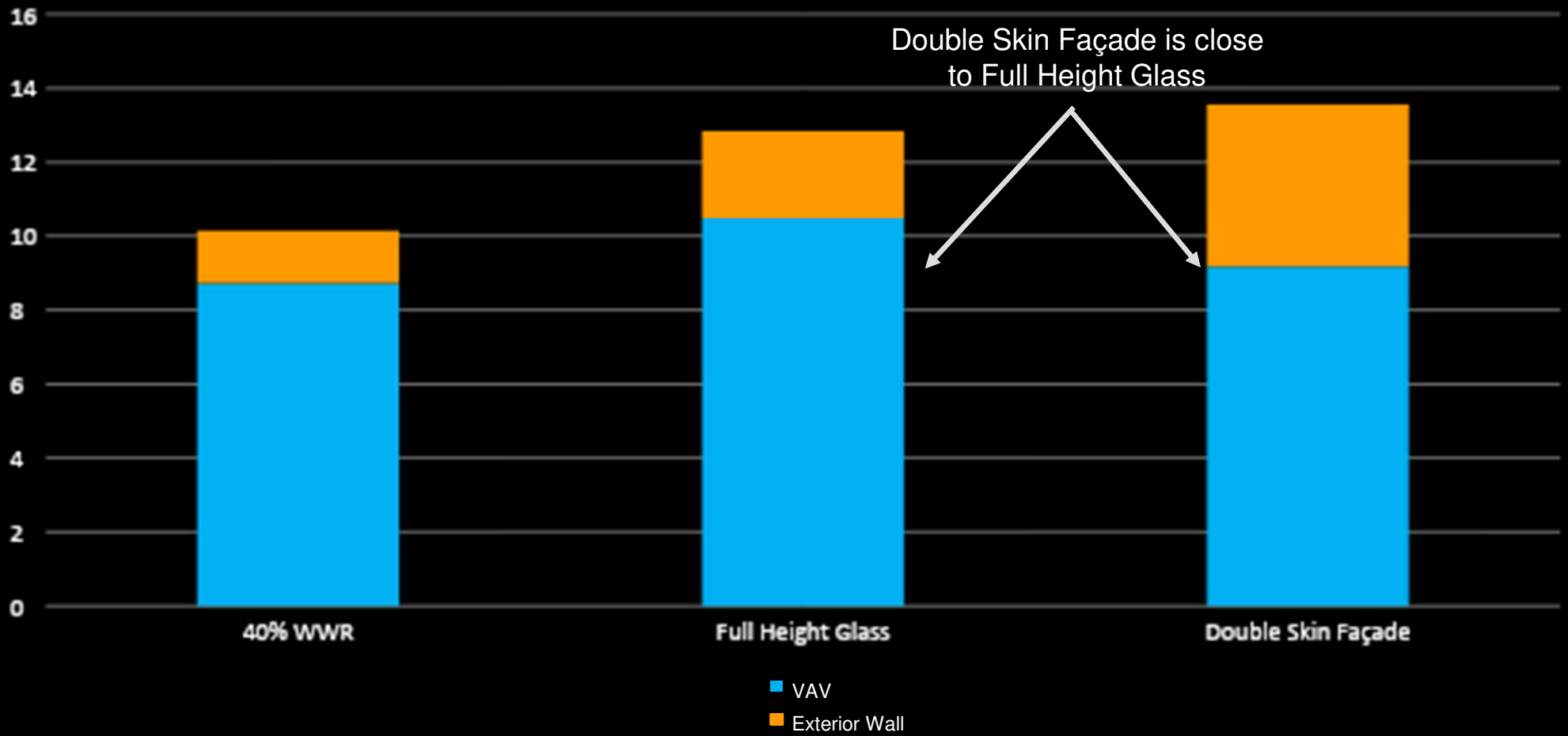
EMBODIED CARBON ARCHITECTURAL ASSEMBLIES



GREENBUILD 2020

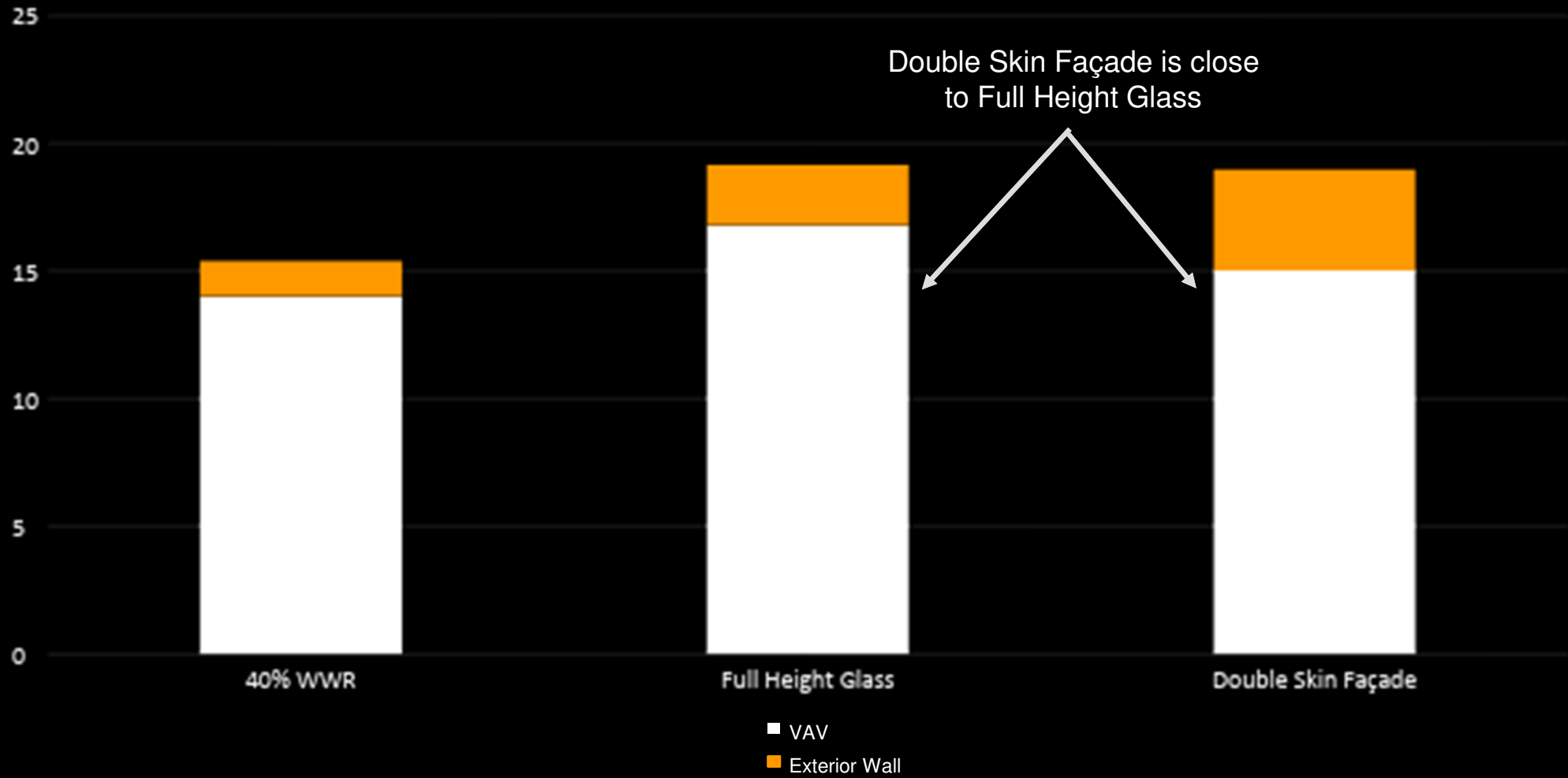
SKIDMORE, OWINGS & MERRILL

EMBODIED AND OPERATING CARBON - VAV ARCHITECTURE ASSEMBLIES + MEP



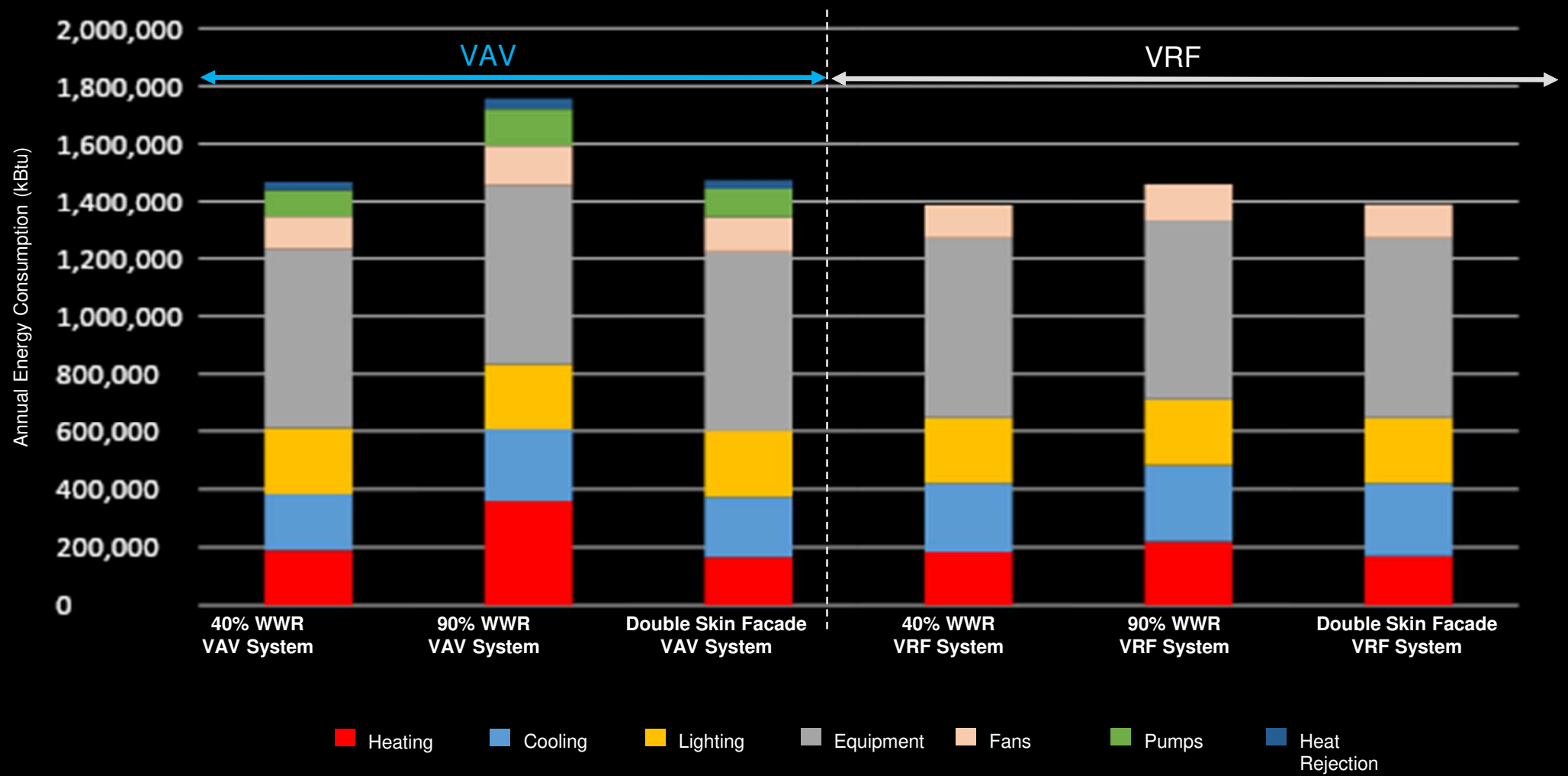
EMBODIED AND OPERATING CARBON - VRF

ARCHITECTURE ASSEMBLIES + MEP

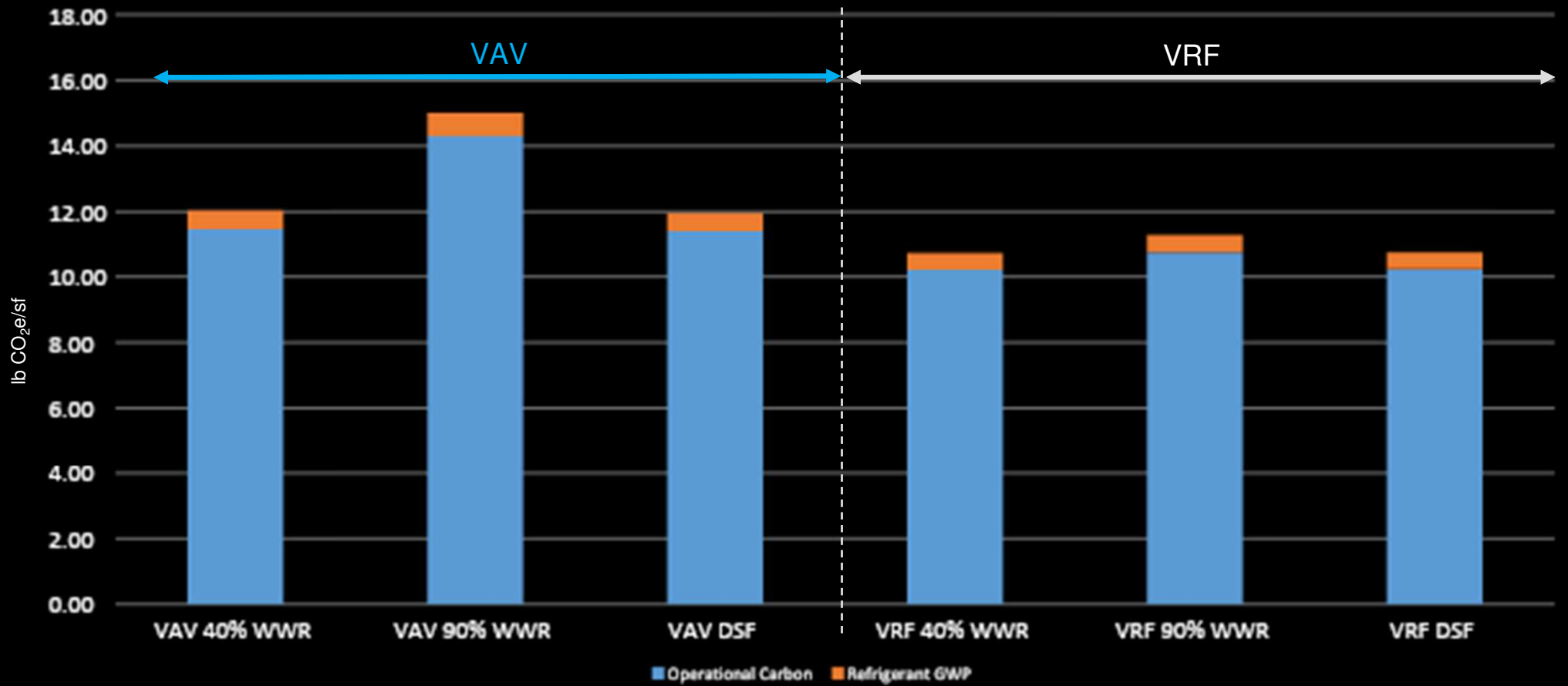


ENERGY ANALYSIS

SYSTEMS AND FACADE COMPARISON



OPERATIONAL CARBON SYSTEMS AND FACADE COMPARISON

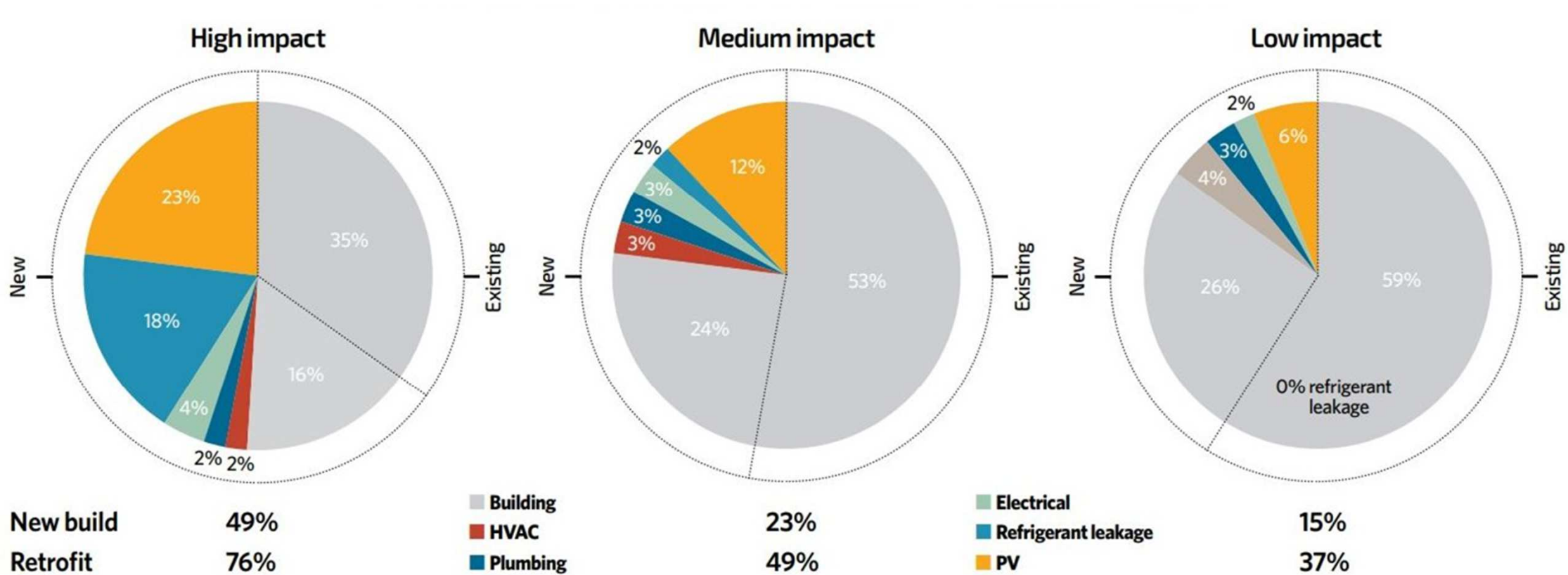




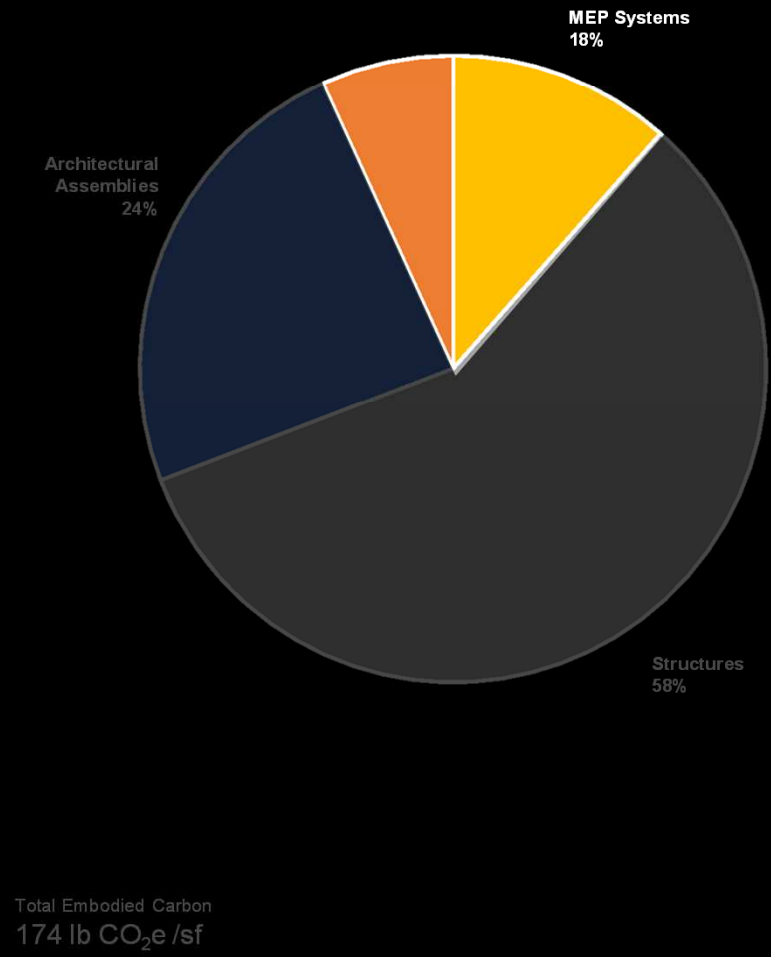
DPR
CONSTRUCTION



MEP Embodied Carbon Compared to the Whole Building

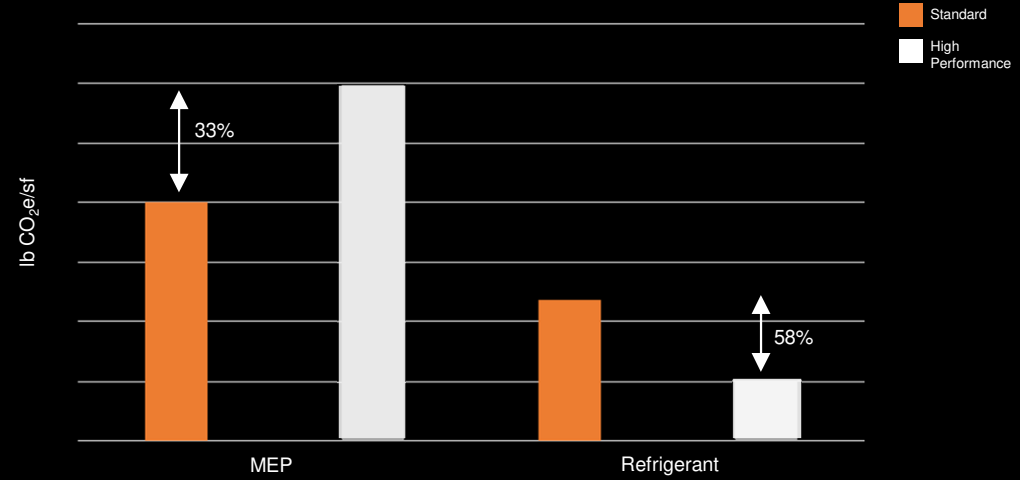


MEP EMBODIED CARBON



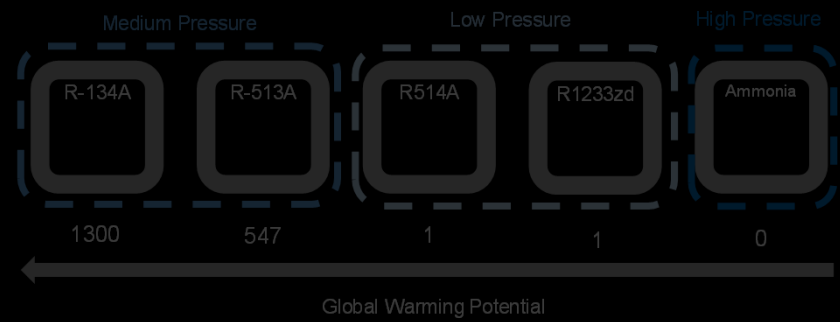


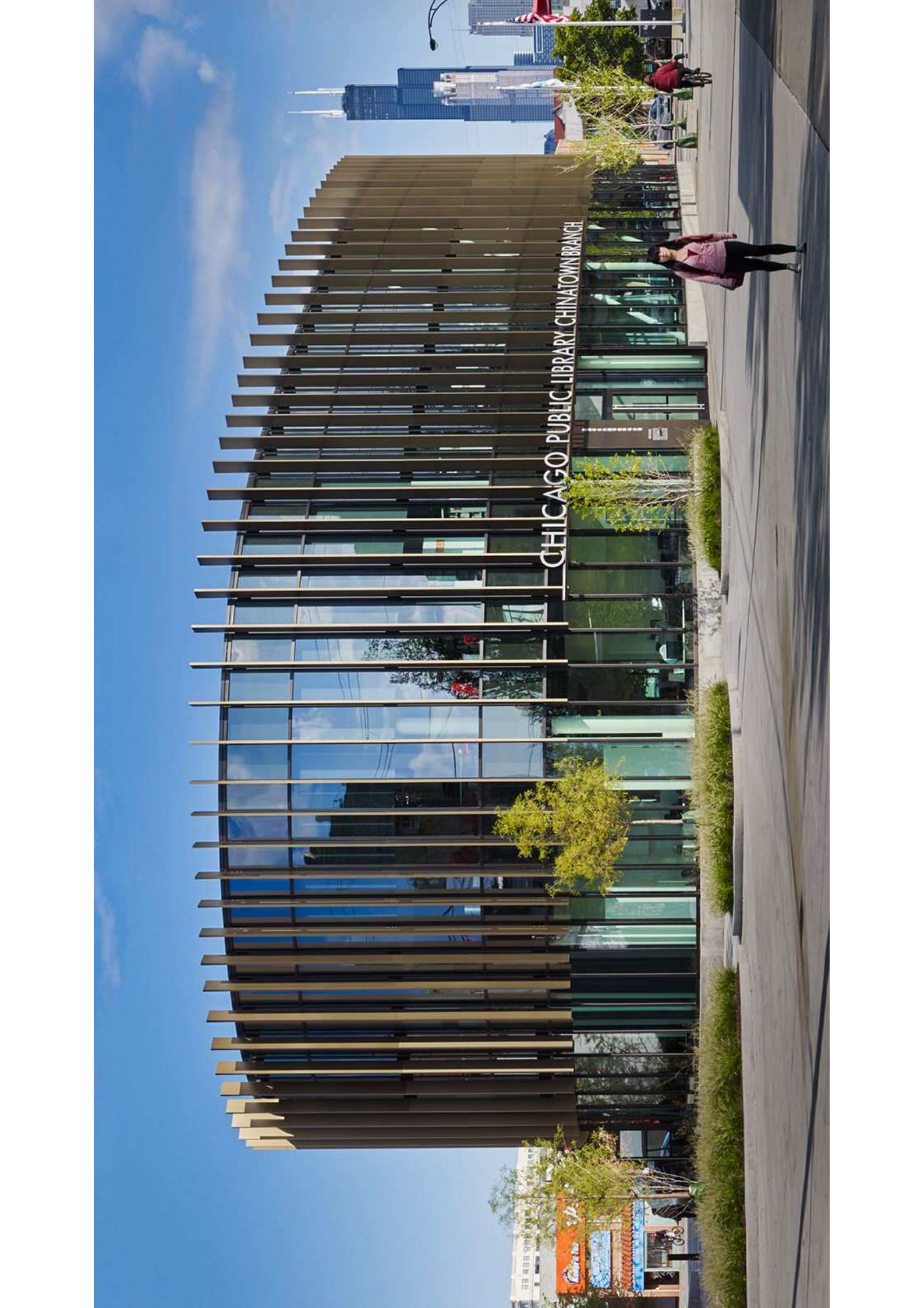
By System and Working Fluid



Source: Life Cycle Assessment of Mechanical, Electrical, and Plumbing in Commercial Office Buildings (Carbon Leadership Forum – 2019)

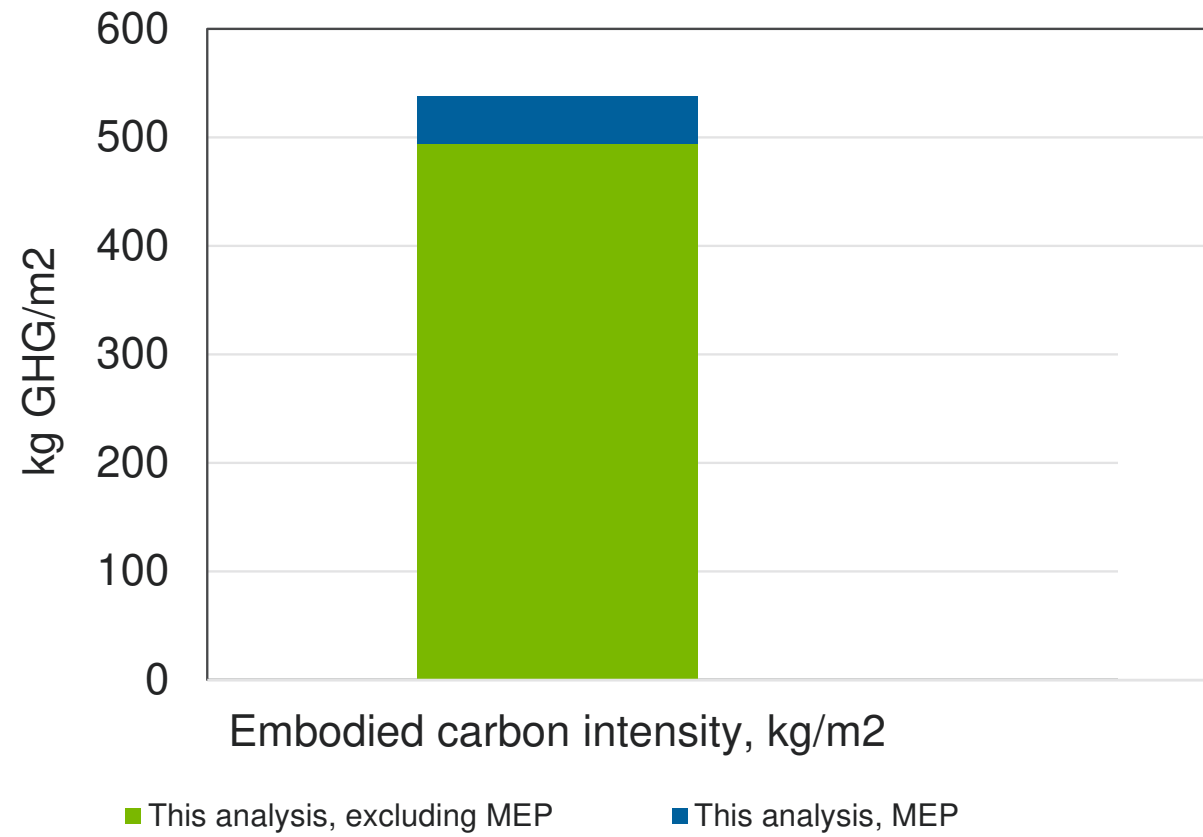
Refrigerant Comparison





CHICAGO PUBLIC LIBRARY CHINATOWN BRANCH

Embodied Carbon



Embodied Carbon Target Alignment

Introduction

This document has been produced to provide alignment in Embodied Carbon measurement and comparisons. The industry needs to standardise performance and reporting scopes to meet IPCC recommendations for urgent emissions reductions. LETI have worked with RIBA, the GLA, IStructE and the UKGBC to produce this document.

A key issue the industry faces is the lack of consistent measurement, leading to mis-aligned benchmarks, project targets and claims.

Alignment in methodology is considered the interim step towards developing net zero carbon targets that reflect the UK's carbon budget. Targets will only be useful once measurement is consistent. The UKGBC's 2021 Whole Life Carbon Net Zero Roadmap project will generate sectoral carbon budget estimates, which will assist in future more detailed building-level target setting.

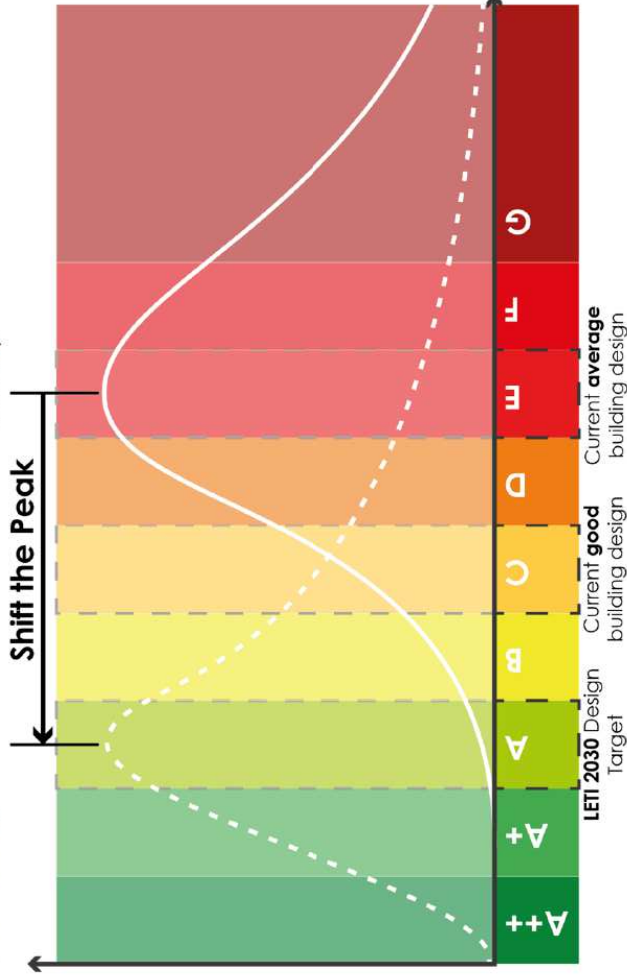
This paper summarises the following key points:

- The industry must push for Embodied Carbon reporting on all projects.
- A rating system should be introduced to allow quick comparison of ambition across various typologies and portfolios
- Total embodied carbon targets have been introduced
- Targets for retail have been developed
- LETI and RIBA now have consistent embodied carbon target
- Data disclosure and breakdowns are key to ensuring reporting is valid and comparable.
- There are two scopes that should be reported against: Upright Carbon (modules A1-5, excluding embodied carbon sequestration), and total Embodied Carbon (A1-5, B1-5, C1-4, including sequestration).

The Case for Letter Bandings

It is suggested that a rating system that allows comparison of embodied carbon ambition across typologies and facilitation of conversations about embodied carbon with key decision makers. Using a letter rating system, which is already familiar in the context of Display Energy Certificates will allow industry professionals to talk about an "A rated" building and know that they are talking about the same level of ambition regardless of the project. A rating system can support competition across various levels of ambition, something which is particularly useful in portfolio reporting (either for building owners or in schemes like the RIBA practice survey).

Current best-practice performance is considered to be a C rating, while a B and above is considered a robust stretch target. Though only 4 typology rating bands are provided currently, the methodology can be repeated for other typologies or scopes of work as more data becomes available. The bandings do not currently differentiate between new build or refurbishment. Part of the rationale for this is that refurbishment projects will find it easier to achieve good performances and this provides an incentive for retrofit. It is expected that as more data is collected for ranges of retrofit, the bandings could be adapted if necessary.



Using the ratings

The LEI position is that for buildings that are currently in the design stage:

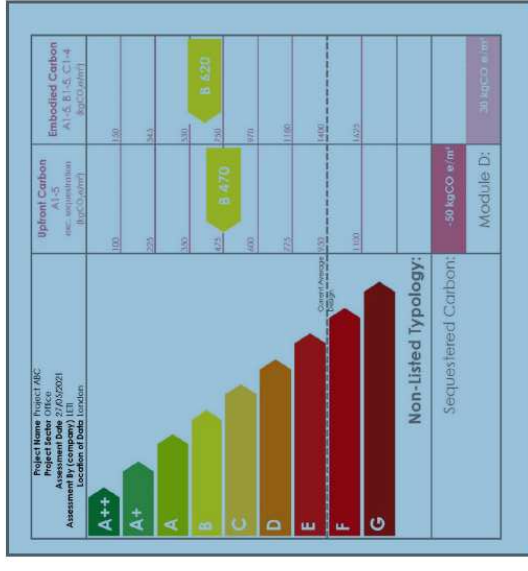
- Average design achieves an E target)
- Good design achieves a C (LEI 2020 target)
- LEI 2030 design target achieves an A

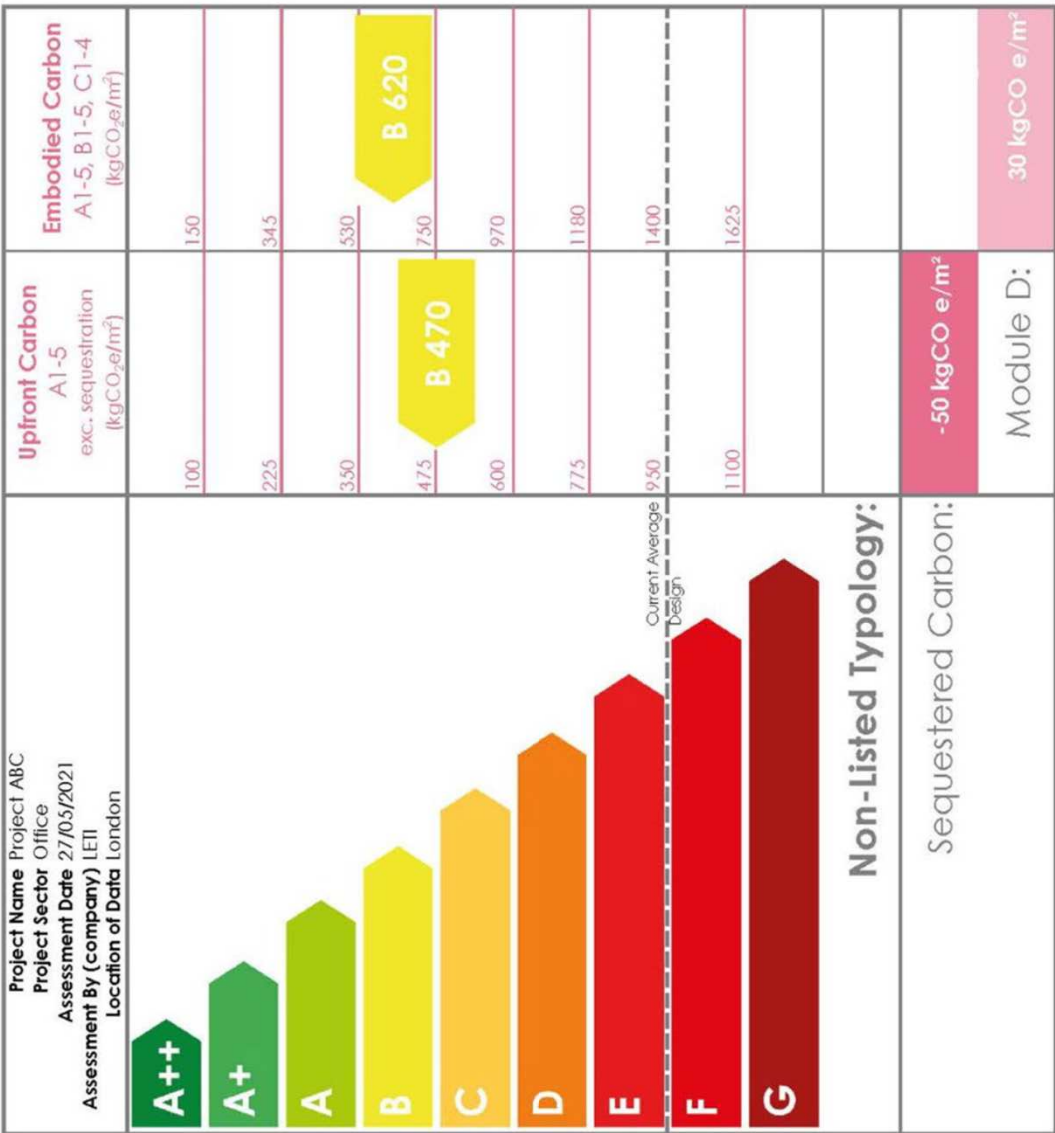
The RIBA 2030 Climate Challenge built performance is equivalent of a B rating (note that this assumes practical completion in 2030, so designed earlier).

Signposting

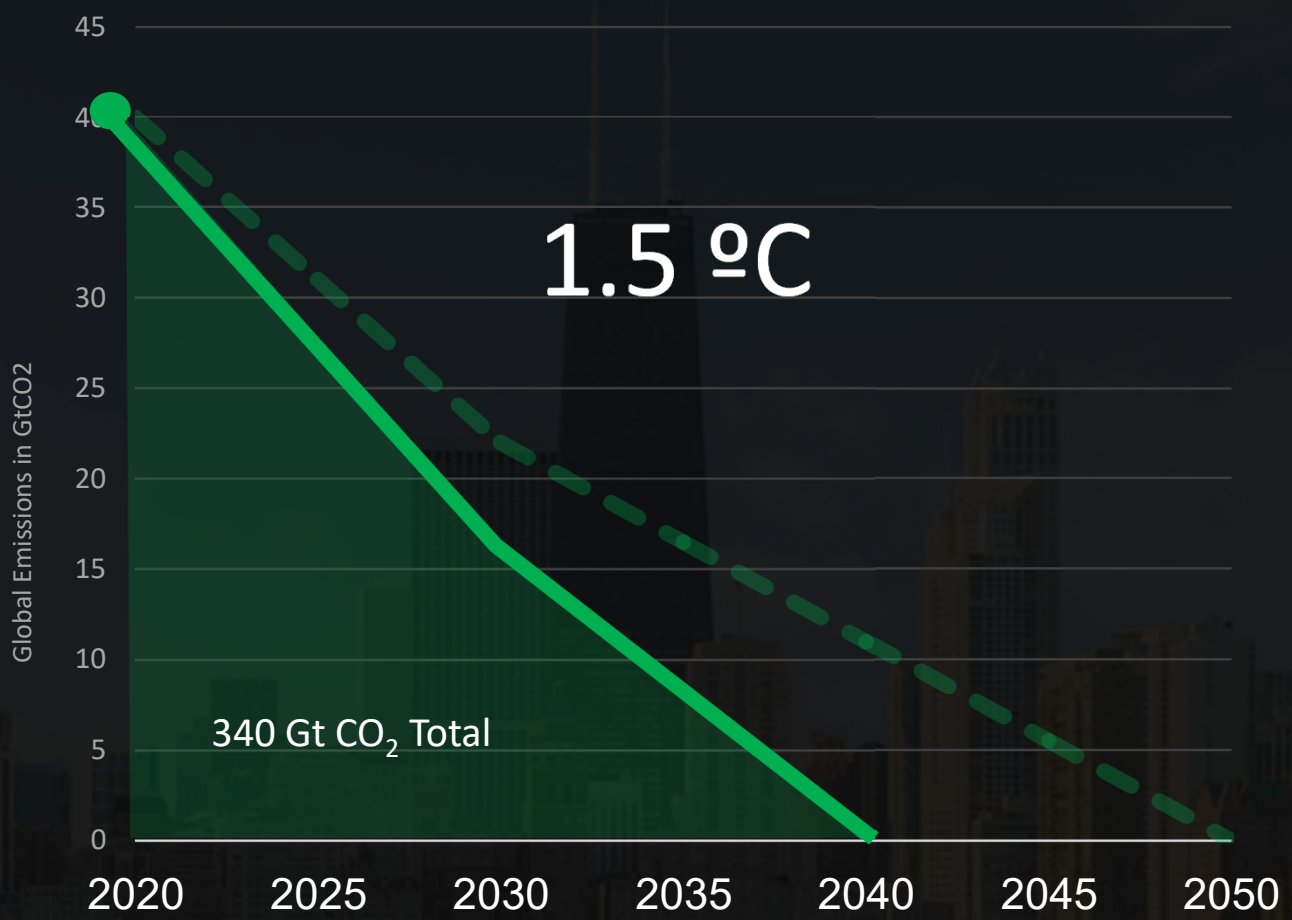
This document is designed to be read with other LEI documents including the:

- LEI Embodied Carbon and Primer
- One Pagers
- Net Zero Carbon Definitions
- Reporting templates on the LEI website
- FAQs available on the LEI website





AIA LFRT Summit Road Map to 2040



Towards Whole Life Carbon

LUKE LEUNG, BEMP, P ENG, PE, LEED FELLOW, ASHRAE FELLOW

SOM