
ASHRAE
Building Decarbonization
An Overview and Introduction
Leading with Action



Population Growth

1.9 billion

24% increase in the next 30 years

Information Source:
(https://www.un.org/en/sections/issues-depth/population/)
The World Population Prospects 2019

Building Growth



2060: 2.5 trillion ft^2

230 billion m^2

Constructing an entire New York City every month

Information Source: https://architecture2030.org/new-buildings-operations/
By 2060, the world is projected to add 230 billion m^2 (2.5 trillion ft^2) of buildings, or an area equal to the entire current global building stock*. This is the equivalent of adding an entire New York City to the planet every 34 days for the next 40 years.
*UN Environment, Global Status Report 2017

Climate is Rapidly Changing

2015 UN Paris Agreement
2°C to 1.5°C

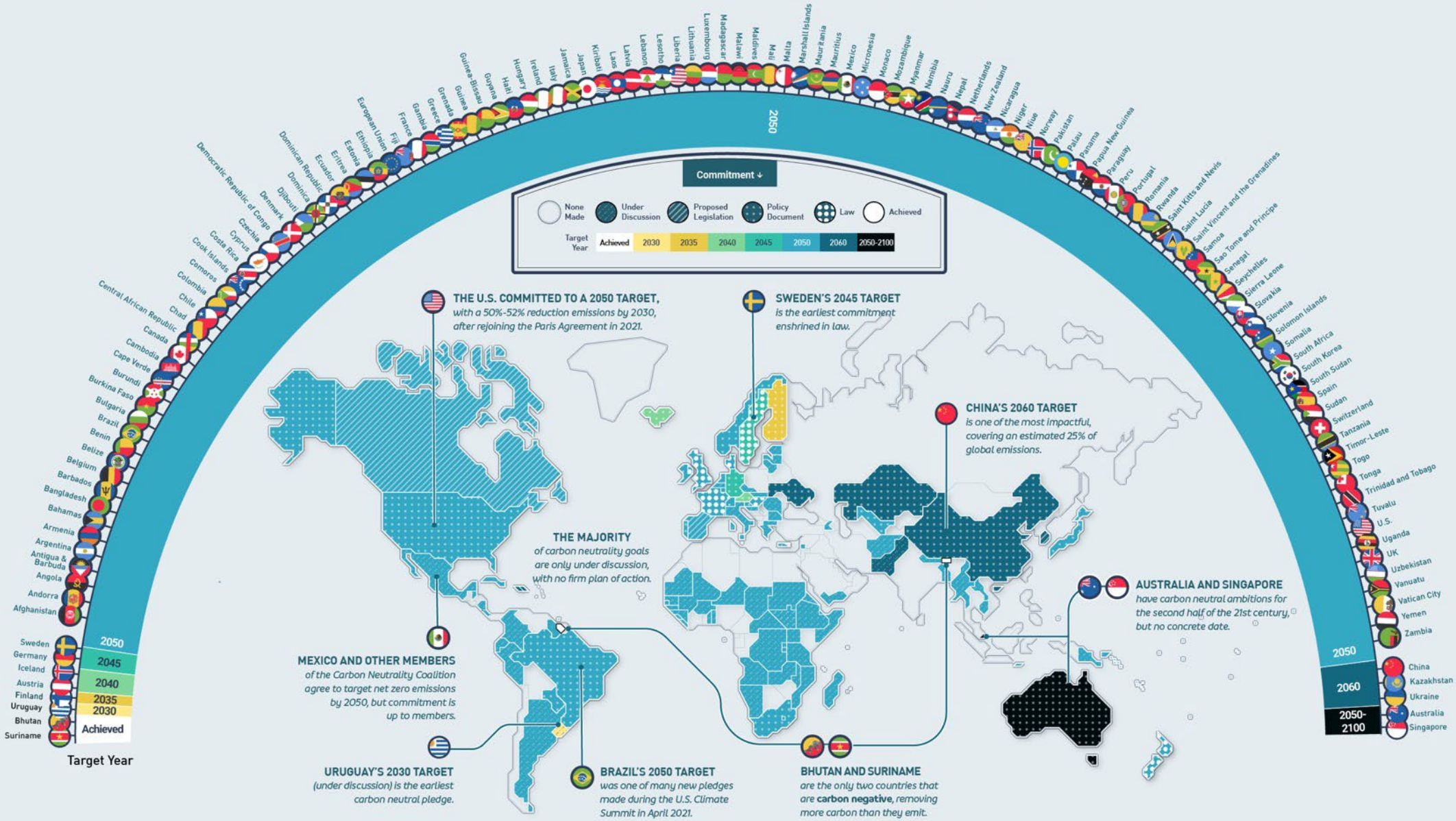
2018 UN IPCC Recommendation
1.5°C



In 2015, the Paris Agreement was adopted to limit the global temperature rise maximum at 2°C with a strong recommendation to retain it at 1.5°C

Information Source:
United Nations IPCC SR-15

Carbon Commitments by Country



Sources: Energy and Climate Intelligence Unit,
Carbon Neutrality Coalition, Climate Action Tracker

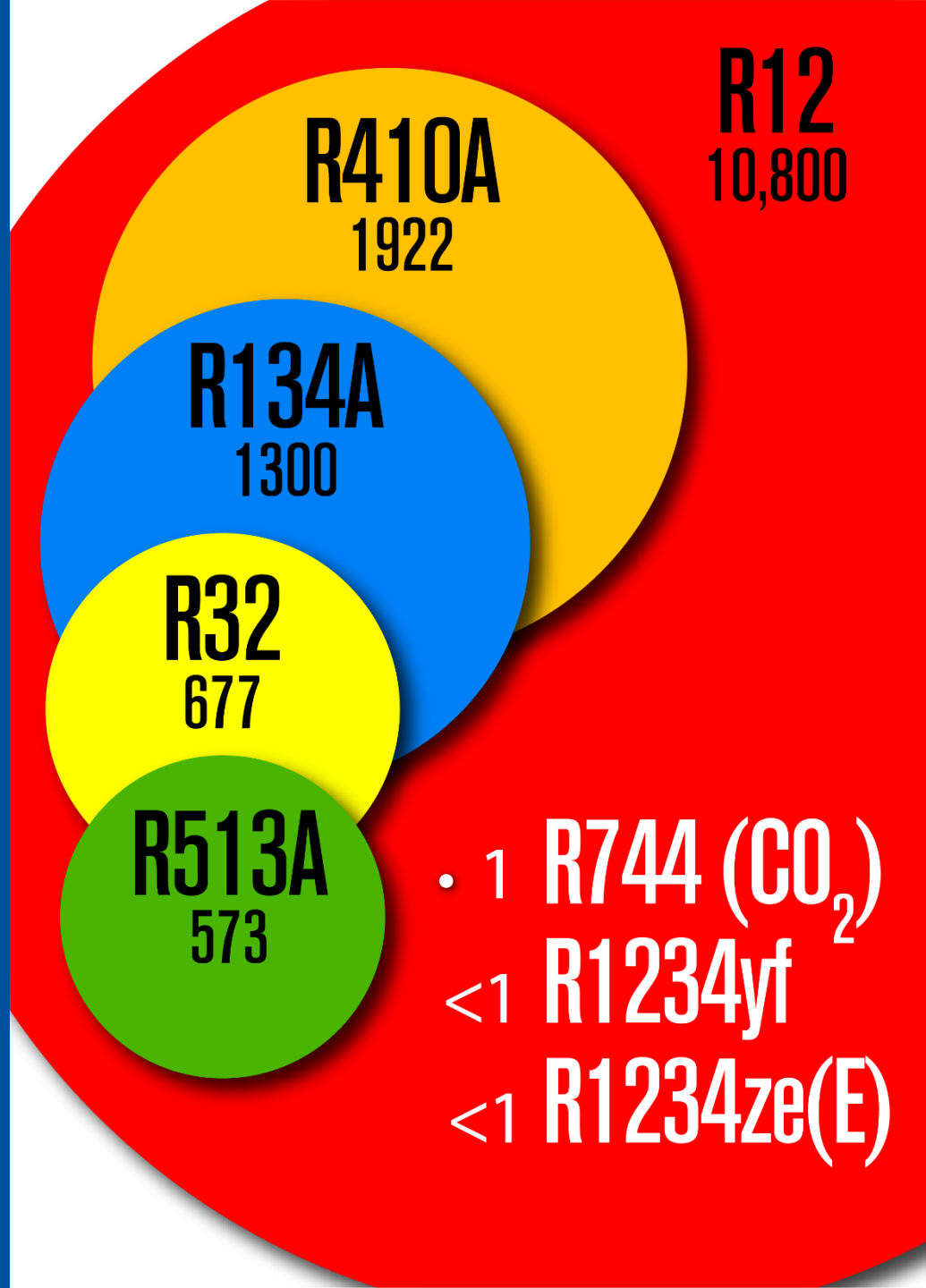


building decarbonization...

whole life = operational + embodied

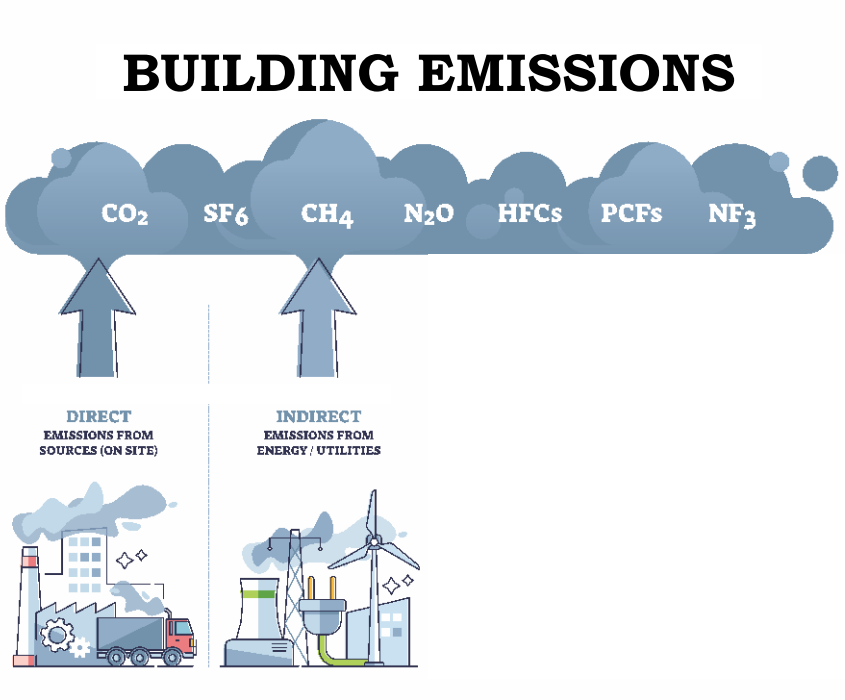
Carbon dioxide equivalent (CO_2e): a measure used to compare the impact of various greenhouse gases based on their 100-year time horizon global warming potential (GWP). CO_2e approximates the time-integrated warming effect of a unit mass of a given greenhouse gas relative to that of carbon dioxide (CO_2).

Global warming potential (GWP): an index for estimating the relative global warming contribution of atmospheric emissions of a particular greenhouse gas compared to emissions of an equal mass of carbon dioxide (CO_2)



Direct emissions: GHG emissions from sources owned or controlled by the reporting entity (primarily from on-site combustion of fossil fuels).

Indirect emissions: GHG emissions due to the activities of the reporting entity but occur at sources owned or controlled by another entity (primarily from electricity generated off-site to power buildings).



Whole building life cycle assessment (WBLCA): a methodology for assessing environmental impacts associated with all the stages of the life cycle of a building.

Environmental product declaration (EPD): an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products to enable comparisons between products fulfilling the same function.



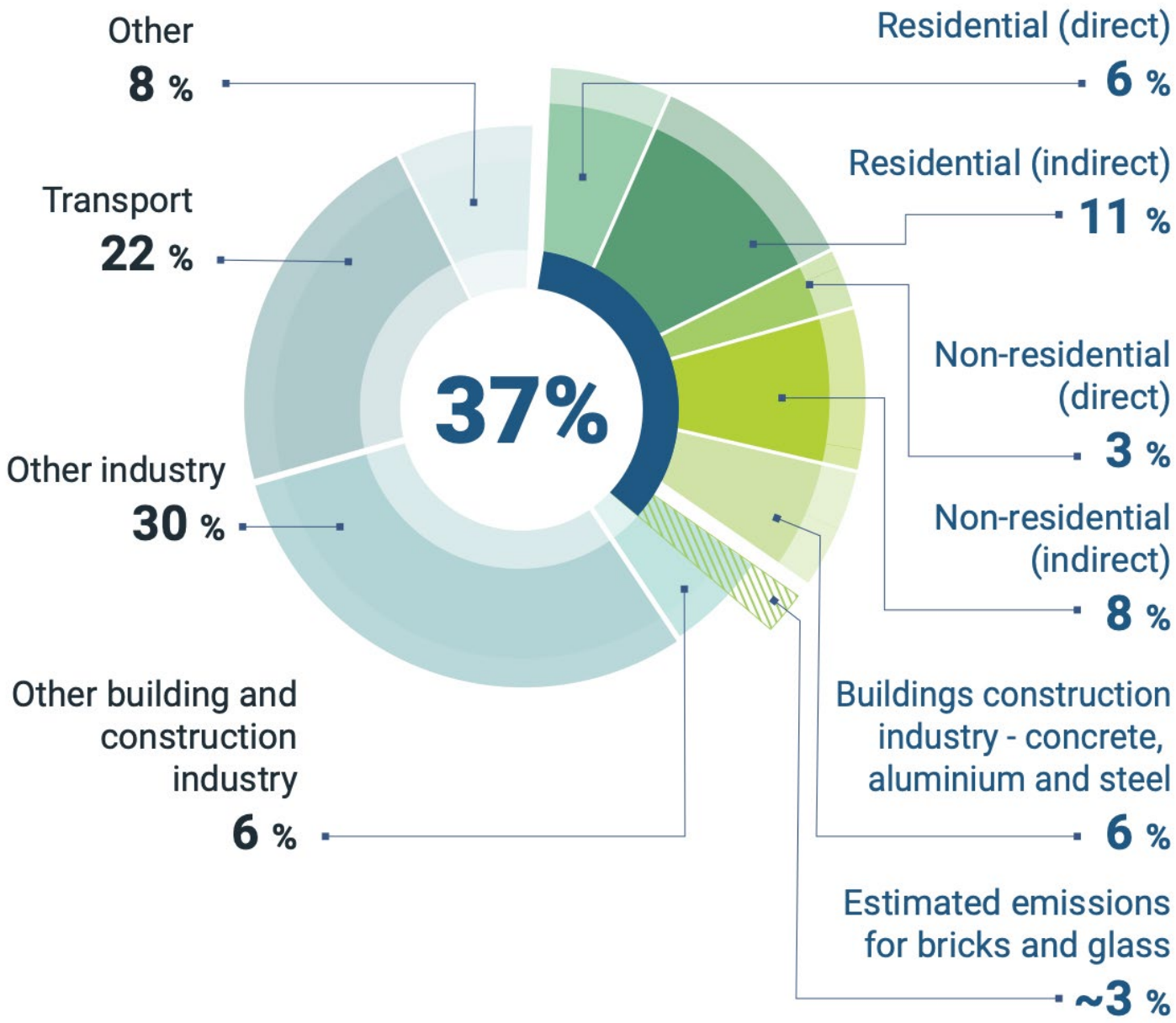
Building Performance Standards (BPS): a policy that requires building owners to meet performance targets by actively improving their buildings over time. These can include energy or emissions targets that buildings must meet to reduce energy and climate impacts.



Building Decarbonization



Understanding the Global Issue

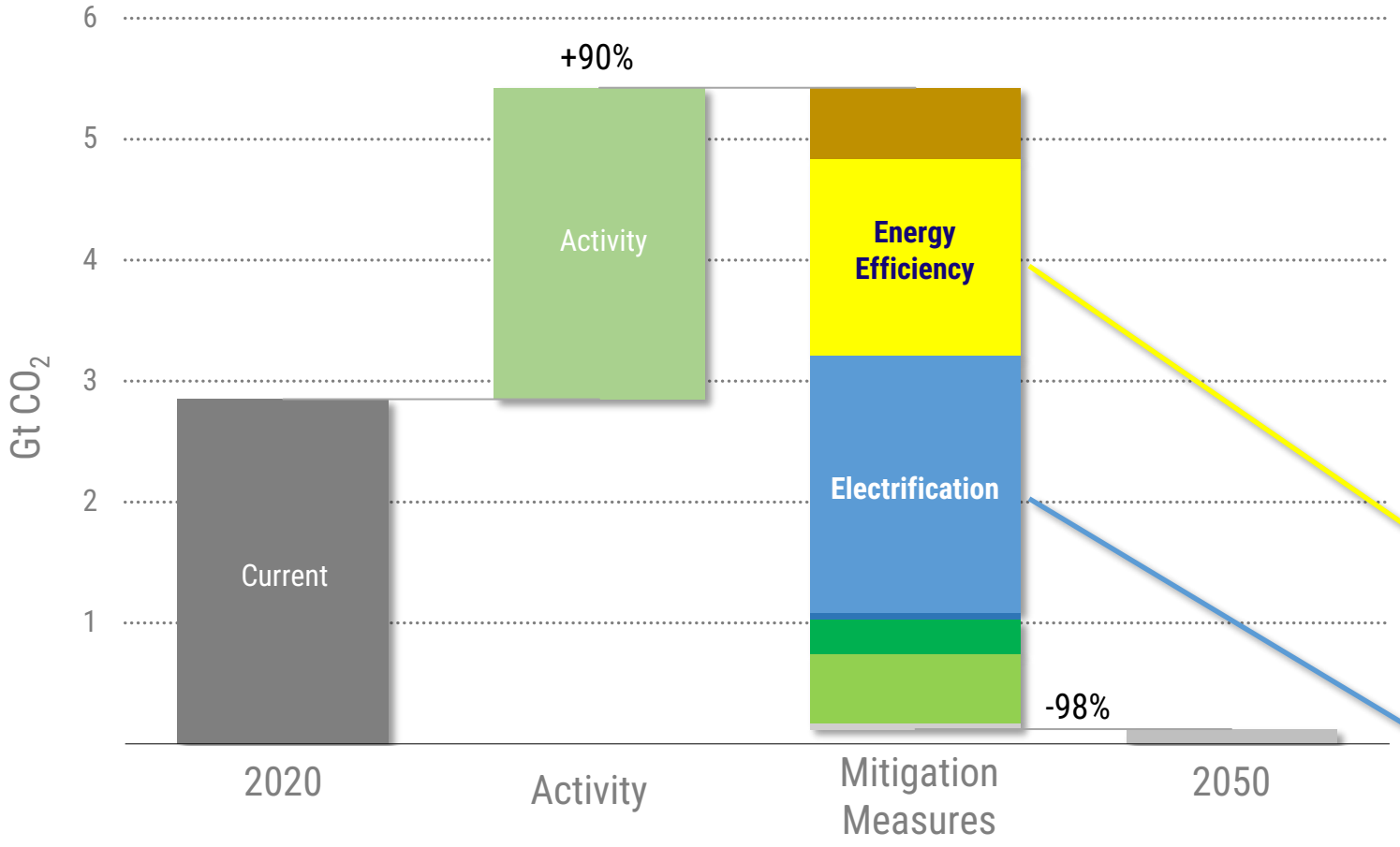


Source: IEA 2022. All rights reserved. Adapted from "Tracking Clean Energy Progress" (IEA 2022f).
https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction



Global building sector energy-related CO_2 emissions, 2021

Global direct CO_2 emissions reductions by mitigation measure in buildings in the 2050 NZE



Activity

Mitigation measures

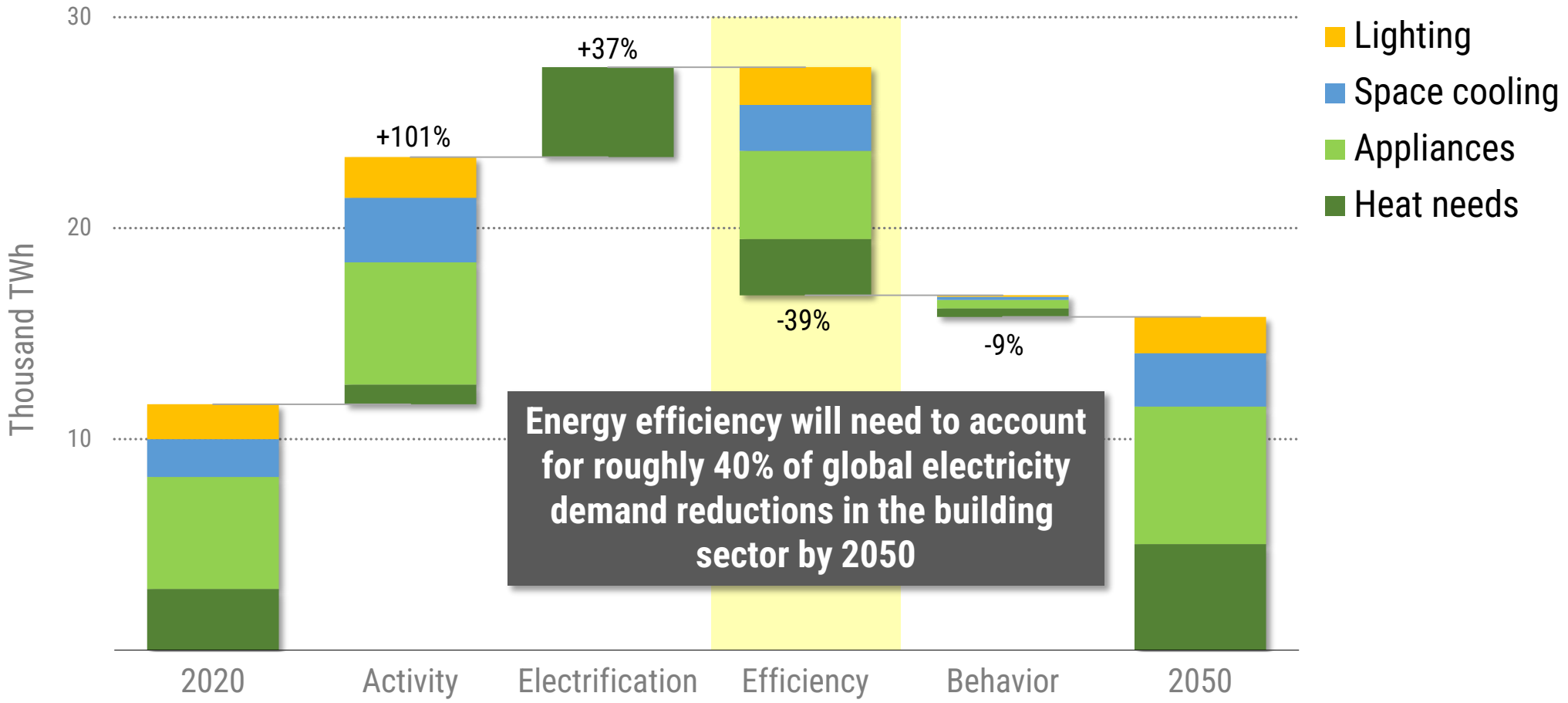
- Behavior and avoided demand
- Energy efficiency
- Electrification
- Hydrogen-based
- Bioenergy
- Other renewables
- Other fuel shifts

Energy efficiency will need to account for roughly 30% of global direct CO_2 emissions reductions by 2050

Electrification will need to account for roughly 40% of global direct CO_2 emissions reductions by 2050

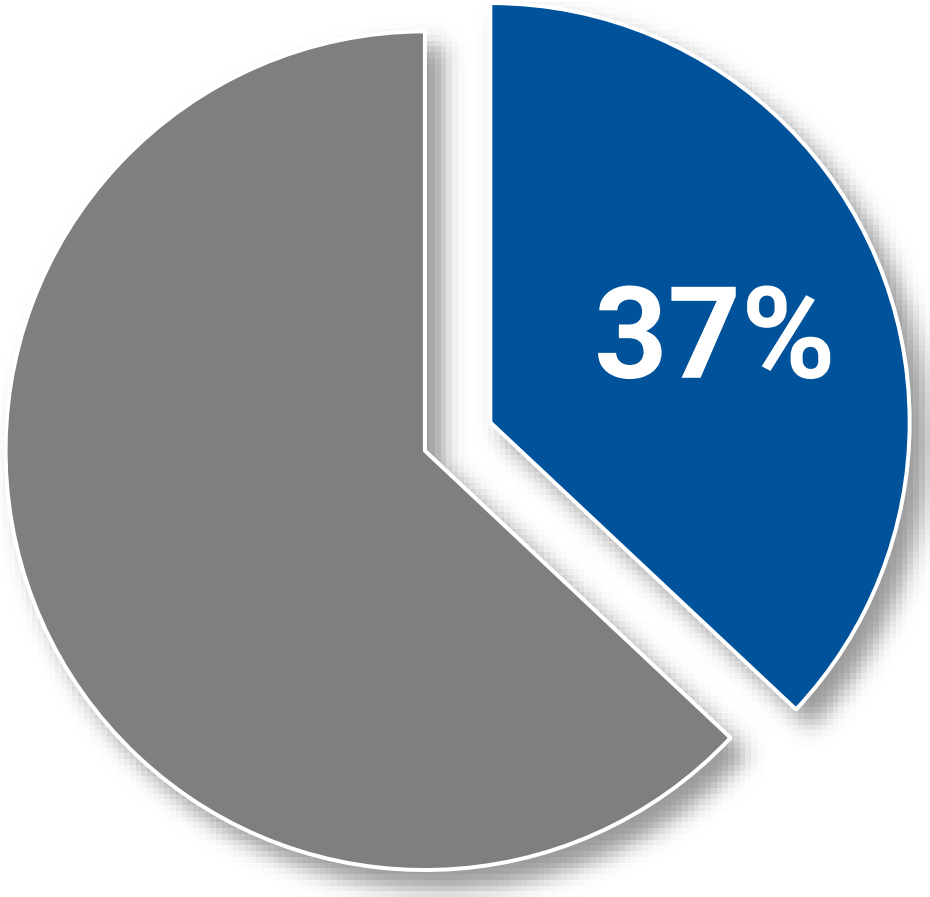
Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Global change in **electricity usage** by end-use in buildings



Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Energy efficiency is essential…



…for building operational carbon reduction to achieve NZE

Building whole life cycle carbon stages



Embodied

Product Stage (A1 – A3)

- A1: Raw material supply
- A2: Transport to factory
- A3: Manufacturing

Construction Stage (A4 – A5)

- A4: Transport to site
- A5: Construction and installation process

Use Stage (B1 – B7)

- B1: Use
- B2: Maintenance
- B3: Repair
- B4: Replacement
- B5: Refurbishment

End of Life Stage (C1 – C4)

- C1: Deconstruction / demolition
- C2: Transport to waste processing/disposal
- C3: Waste processing
- C4: Disposal of waste

Operational

- B6: Operational energy use
- B7: Operational water use

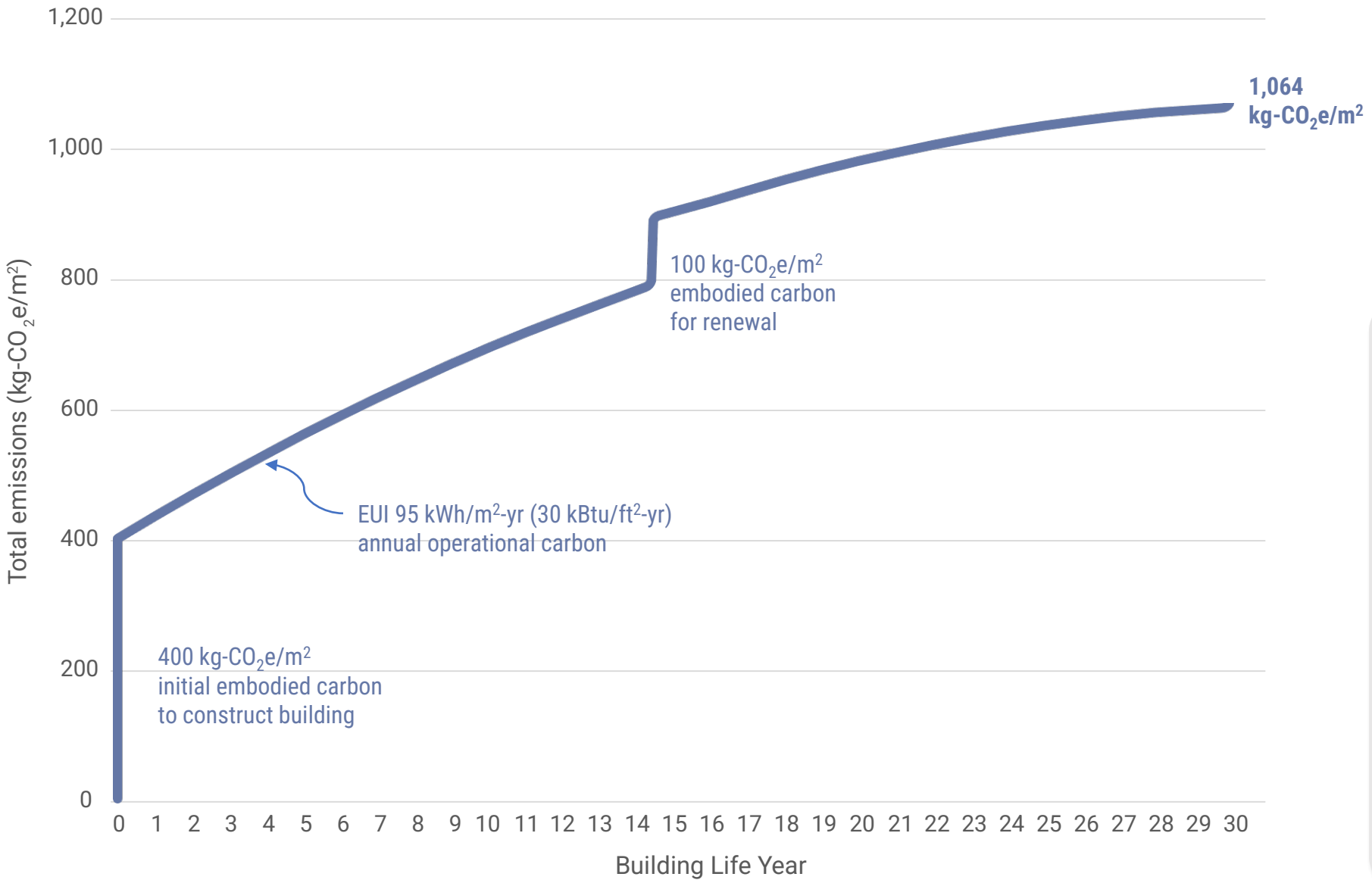
Circular Economy

Beyond the Building Life Cycle Stage (D)

- Benefits and Loads
- Reuse-Recovery-Recycling-Potential

Source: Figure based on EN 15978:2011

Sample building embodied and operational carbon

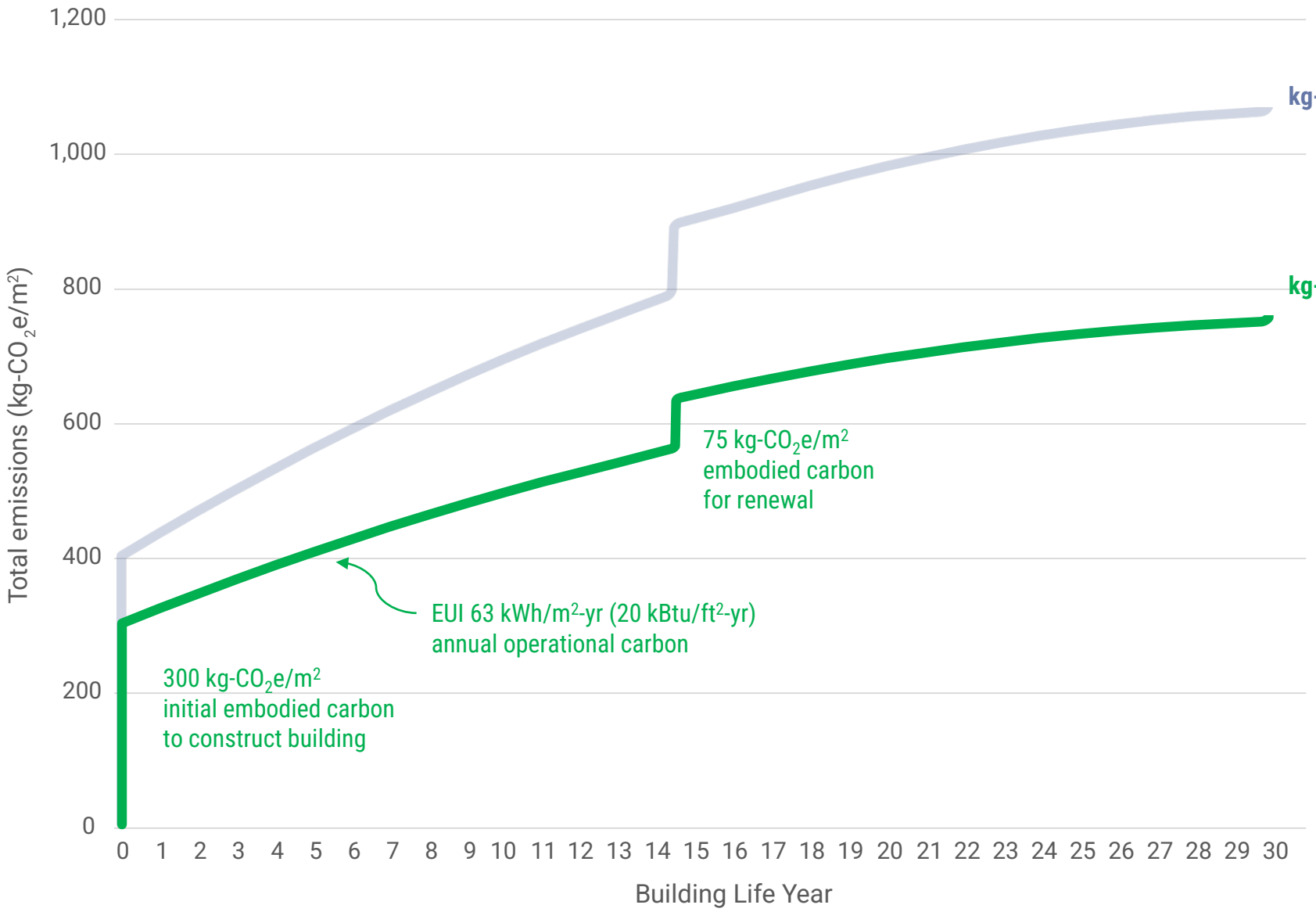


All electric building

Initial electric emission rate 371 gr/kWh
90% reduction in 30 years

	Scenario 1
Initial embodied carbon kg-CO_2e/m^2	400
Renewal embodied carbon kg-CO_2e/m^2	100
EUI operational carbon kWh/m^2-yr (kBtu/ft^2-yr)	95 (30)

Building embodied and operational carbon

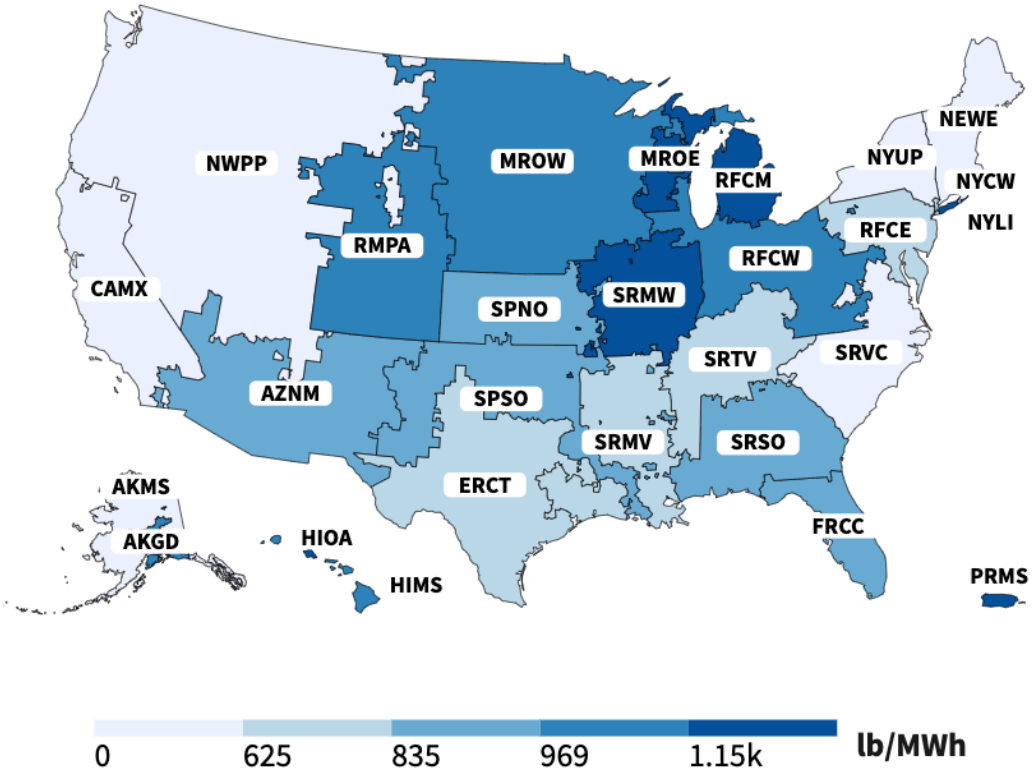


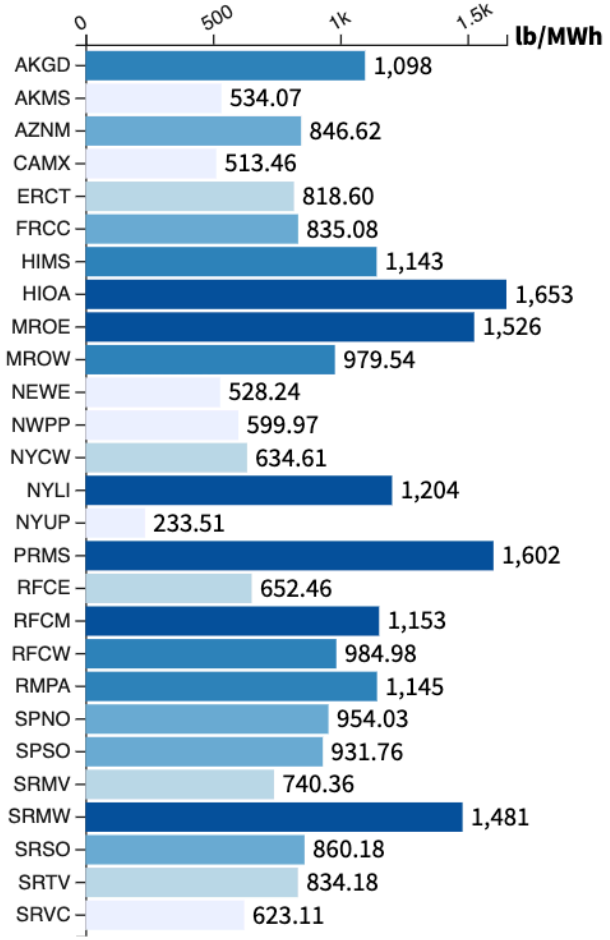
All electric building

Initial electric emission rate 371 gr/kWh
90% reduction in 30 years

	Scenario 1	Scenario 2
Initial embodied carbon kg-CO_2e/m^2	400	300
Renewal embodied carbon kg-CO_2e/m^2	100	75
EUI operational carbon kWh/m^2-yr (kBtu/ft^2-yr)	95 (30)	63 (20)

U.S. electricity CO_2e output emission rate by eGRID subregion, 2020





2020 U.S. average

818 lbs-CO_2e/MWh

371 kg-CO_2e/MWh

Source: EPA eGRID https://www.epa.gov/egrid/data-explorer


Net Zero by 2050
A Roadmap for the Global Energy Sector
International Energy Agency
iea
BEYOND THE BUSINESS CASE
WHY YOU CAN'T AFFORD NOT TO INVEST IN A SUSTAINABLE BUILT ENVIRONMENT
WORLD GREEN BUILDING COUNCIL
November 2021
nbi new buildings institute
Building Decarbonization Code
An overlay to model building codes on the path to net zero
Version 1.2 | August 2021
Codes for Climate
2021 GLOBAL STATUS REPORT FOR BUILDINGS AND CONSTRUCTION
Towards a zero-emissions, efficient and resilient buildings and construction sector
iea
RMI
Decarbonizing Homes
Improving Health in Low-Income Communities through Beneficial Electrification
Report / Oct 2021
GUIDE: BEST PRACTICES FOR ACHIEVING ZERO OVER TIME FOR BUILDING PORTFOLIOS
ULI Urban Land Institute
ADVANCING NET ZERO
WORLD GREEN BUILDING COUNCIL
Status Report June 2021
JRC SCIENCE FOR POLICY REPORT
Level(s) – A common EU framework of core sustainability indicators for office and residential buildings
August 2017
ipcc
INTERGOVERNMENTAL PANEL ON climate change
Climate Change 2022
Impacts, Adaptation and Vulnerability
Summary for Policymakers
WGII
WHO
UNEP
In collaboration with Accenture
Accelerating the Decarbonization of Buildings:
The Net-Zero Carbon Cities Building Value Framework
BRIEFING PAPER
JANUARY 2022
encord
BUILT ON GHG PROTOCOL
Construction CO_2e Measurement Protocol
A Guide to reporting against the Green House Gas Protocol for construction companies
wbcsd
Net-zero buildings
Where do we stand?
ARUP
NATIONAL ALLIANCES FOR BUILDINGS AND CONSTRUCTION
Long-term partnerships for the energy transition
PEEB
RMI
Reducing Embodied Carbon in Buildings
Low-Cost, High-Value Opportunities
Report / July 2021
LOCAL LAWS OF THE CITY OF NEW YORK FOR THE YEAR 2019
No 97
A LOCAL LAW
2022
ZERO CODE™
for
CALIFORNIA
California building energy standard for nonresidential, high-rise residential and hotel/motel buildings.
in collaboration with
AIA California
2030

We need simple, practical solutions

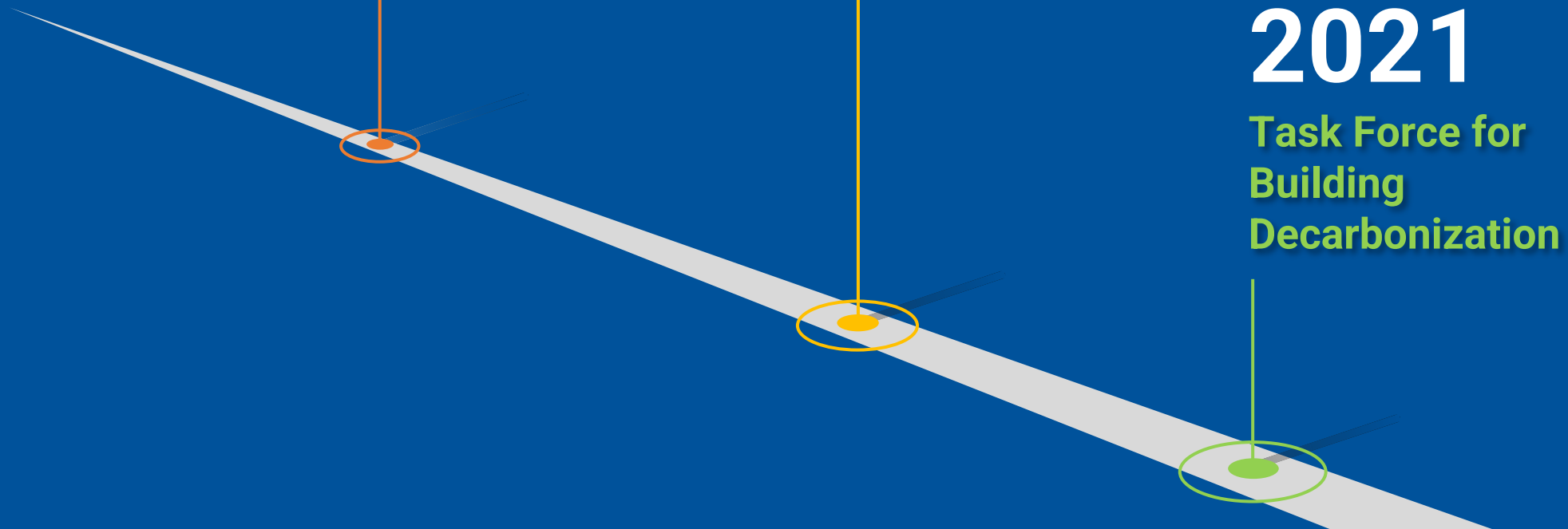


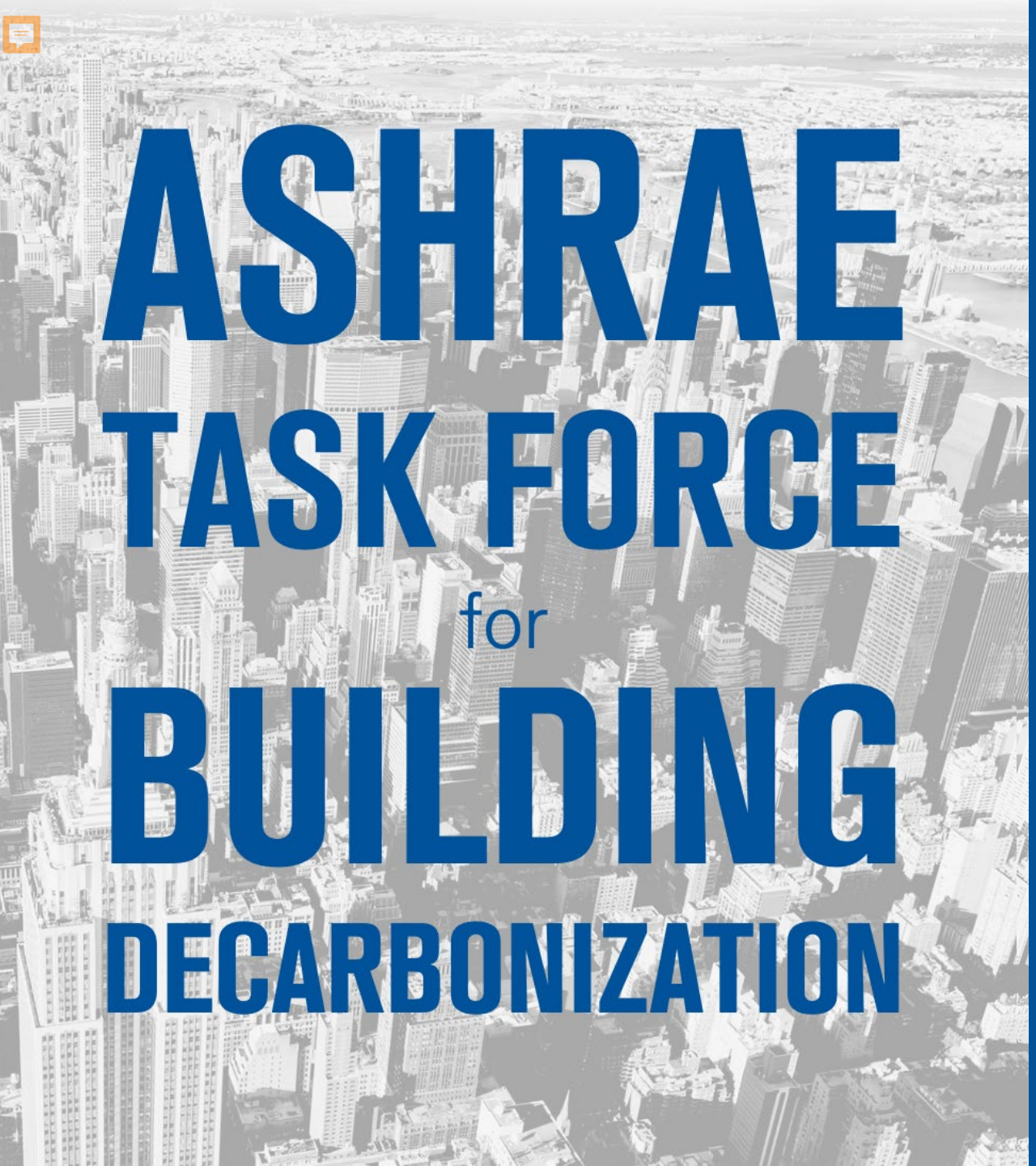
ASHRAE has a long history…

1975
ASHRAE Standard 90

2007
ASHRAE 2030 Net Zero Energy Goal

2021
Task Force for Building Decarbonization





ASHRAE TASK FORCE for BUILDING DECARBONIZATION

- two subcommittees and eight working groups
- over 150 volunteers from around the world
- have the technical expertise to address this issue

ASHRAE goals...

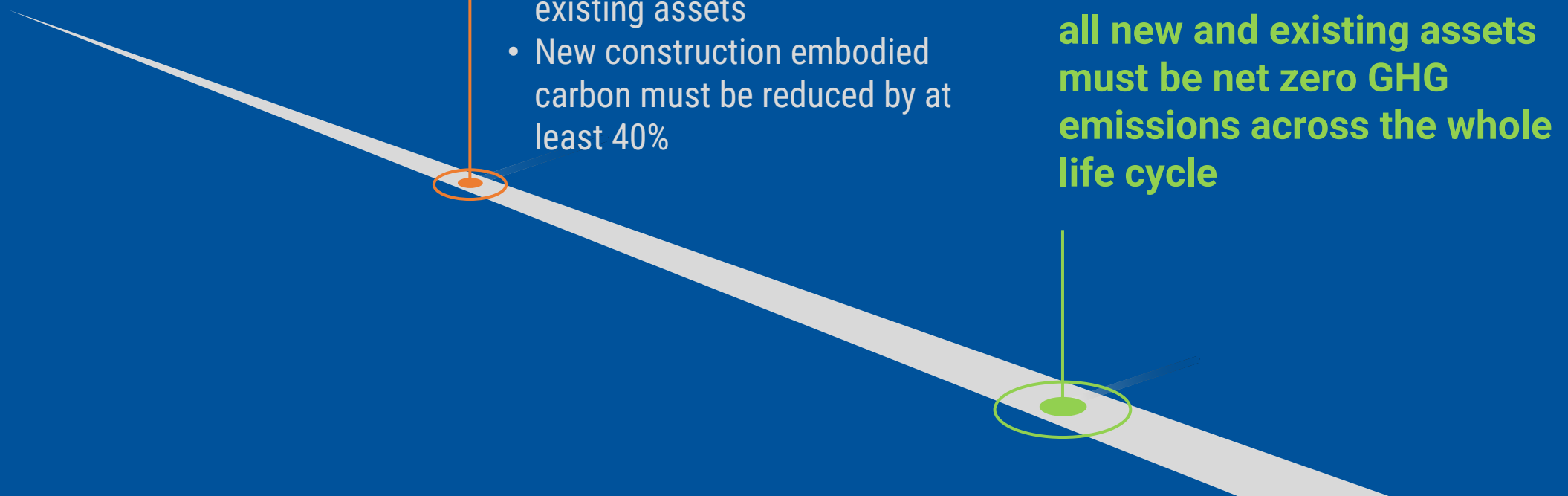
2030

the global built environment must halve its 2015 GHG emissions

- All new buildings must be NZE
- Widespread EE retrofits of existing assets
- New construction embodied carbon must be reduced by at least 40%

2050

all new and existing assets must be net zero GHG emissions across the whole life cycle



STANDARDS

EDUCATION

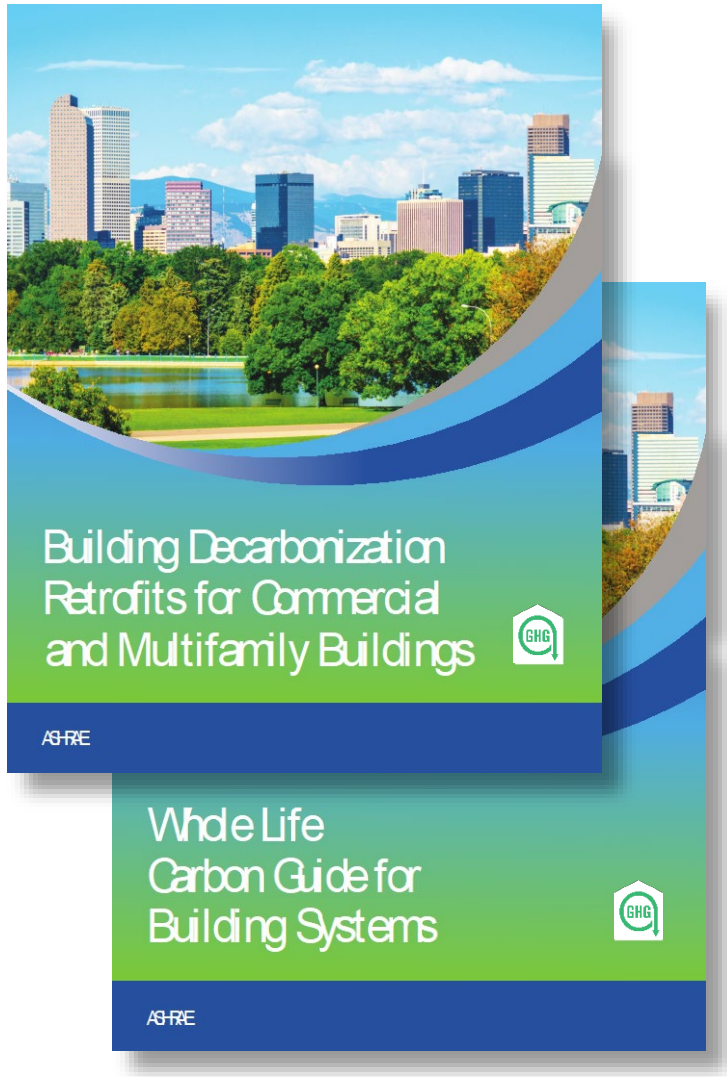
KNOWLEDGE
RESOURCE
HUB

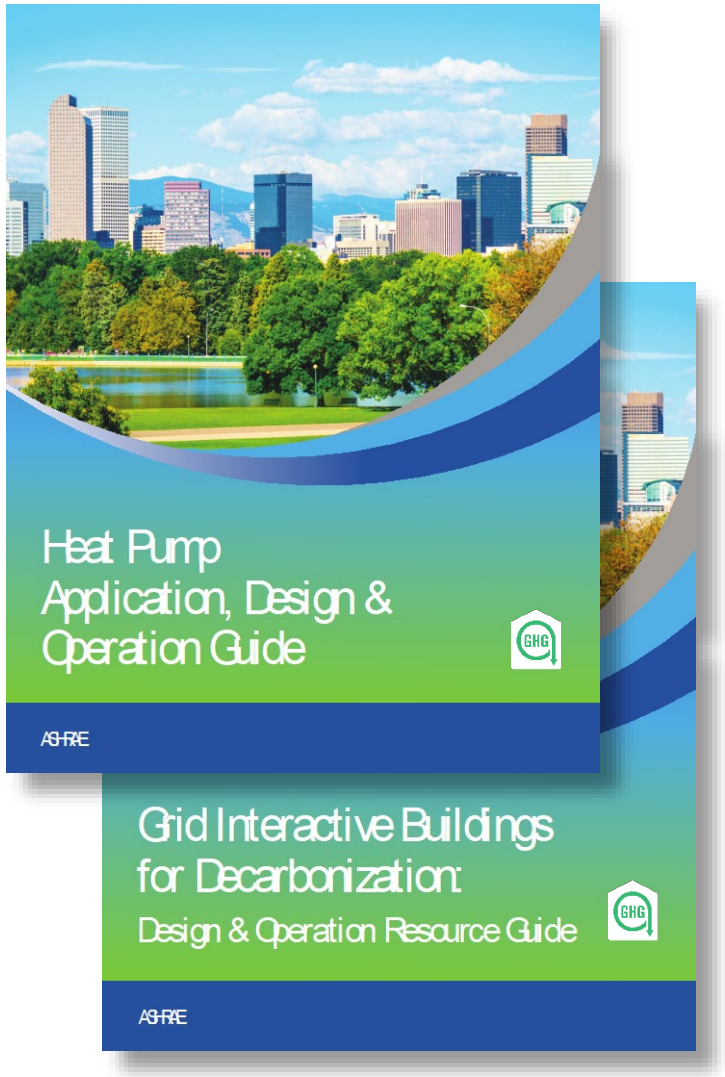
TECHNICAL
TOOLS

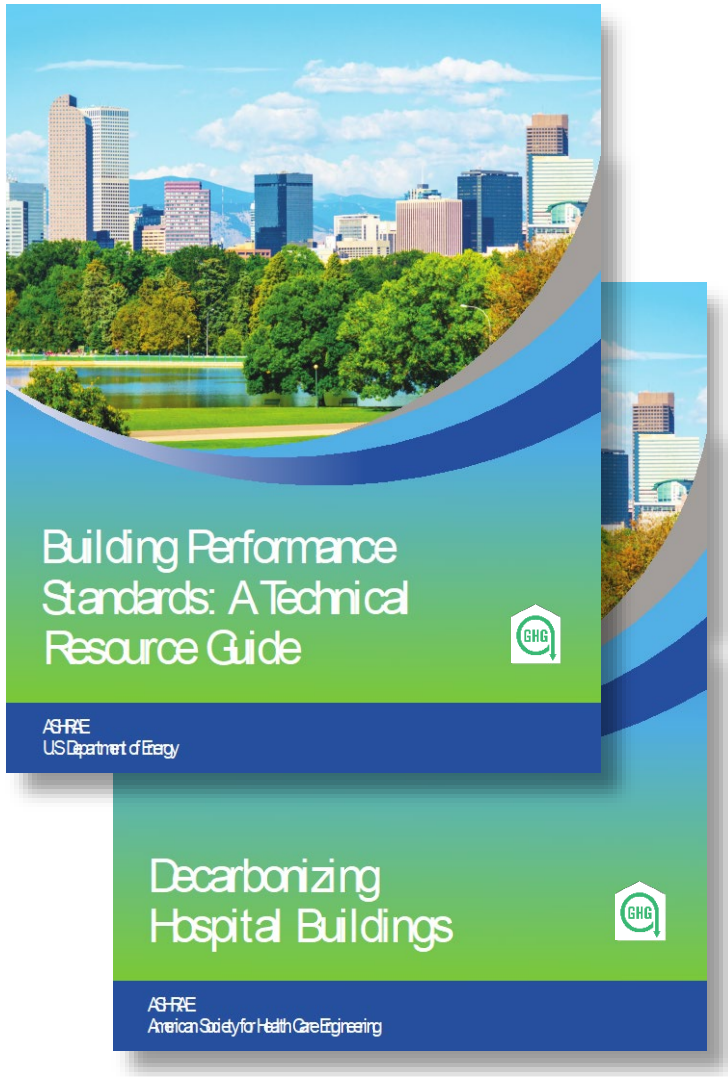
POSITION
DOCUMENT

Four Key Focus Areas

ASHRAE resources in development…







A pathway to building decarbonization...

Optimize Building Envelope

Building envelope

optimize building orientation and geometry to reduce energy use and maximize solar potential

Optimize Building Envelope

Energy Efficiency

Energy efficiency

will continue to remain #1 in the loading order of measures

Optimize Building Envelope

Energy Efficiency

Waste Energy

Utilize waste energy

optimize waste energy streams to reduce energy and water use

Optimize Building Envelope

Energy Efficiency

Waste Energy

Embodied Carbon

Embodied carbon

review options to reduce embodied carbon with entire life cycle carbon in mind

Optimize Building Envelope

Energy Efficiency

Waste Energy

Embodied Carbon

Electrify Loads

Electrify loads

this step is to use low carbon energy for heating, service water heating, and cooking

Optimize Building Envelope

Energy Efficiency

Waste Energy

Embodied Carbon

Electrify Loads

Low GWP Refrigerants

Low GWP refrigerants

lower GWP, reduce fugitive emissions, and maintain efficiency

Optimize Building Envelope

Energy Efficiency

Waste Energy

Embodied Carbon

Electrify Loads

Low GWP Refrigerants

Demand Management

Demand management

software systems integrated into buildings can help coordinate energy supply, reduce energy demand, and shift energy use

Optimize Building Envelope

Energy Efficiency

Waste Energy

Embodied Carbon

Electrify Loads

Low GWP Refrigerants

Demand Management

Carbon Free Energy

Carbon free energy

Utilize on- or off-site carbon free energy

Building Decarbonization



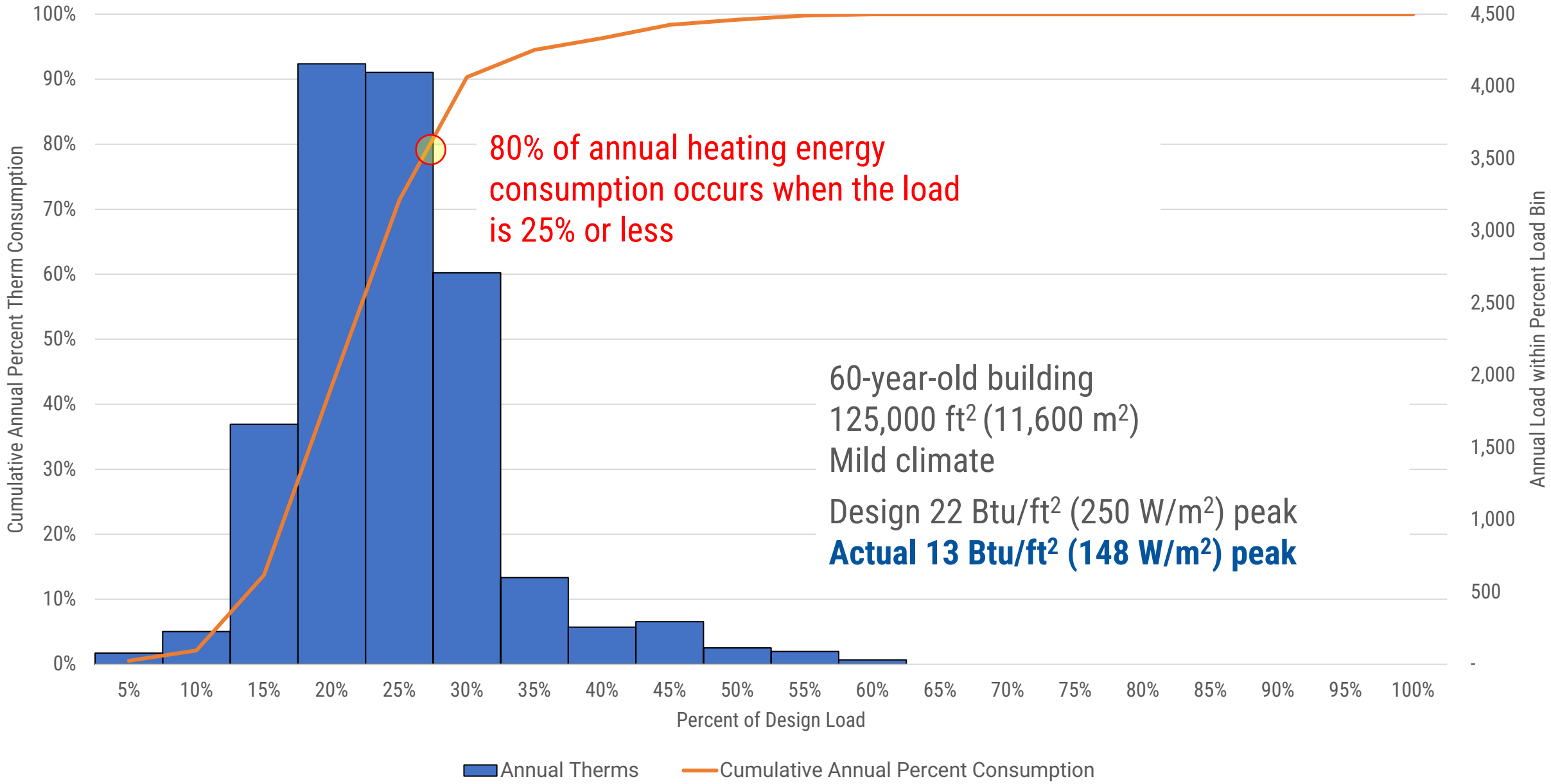
Emerging Issues & Opportunities

Emerging issues

- scalability of solutions
- electric grid infrastructure
- cold climates
- existing buildings
- economics –money matters!



Sample Building Annual Heat Load Profile





Opportunities

- equipment & system innovation
- advanced controls
- integrated solutions
- energy storage
- available incentives



How to contribute

- educate yourself
- educate colleagues
- educate clients
- educate partners
- educate policymakers
- educate the next generation of leaders


ASHRAE
Join us on the Journey to Zero!