



Introduction of Building Decarbonization To London, On Chapter, Oct 24, 2022

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Acknowledgements

- Some Content from ASHRAE Seminar 7 in Las Vegas
- Intro & Fundamentals Don Brandt dbrandtz@aol.com
- Definitions
Ginger Scoggins gscoggins@engineereddesigns.com
- Position Document
Kent Peterson kent.peterson@p2sinc.com

Learning Objectives

- Fundamentals of building decarbonization
- Definition of common building decarbonization terms
- Review of ASHRAE Building Decarbonization Position Document
- Ontario & London, On efforts & Steps moving forward

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Building Decarbonization – Introduction & Fundamentals

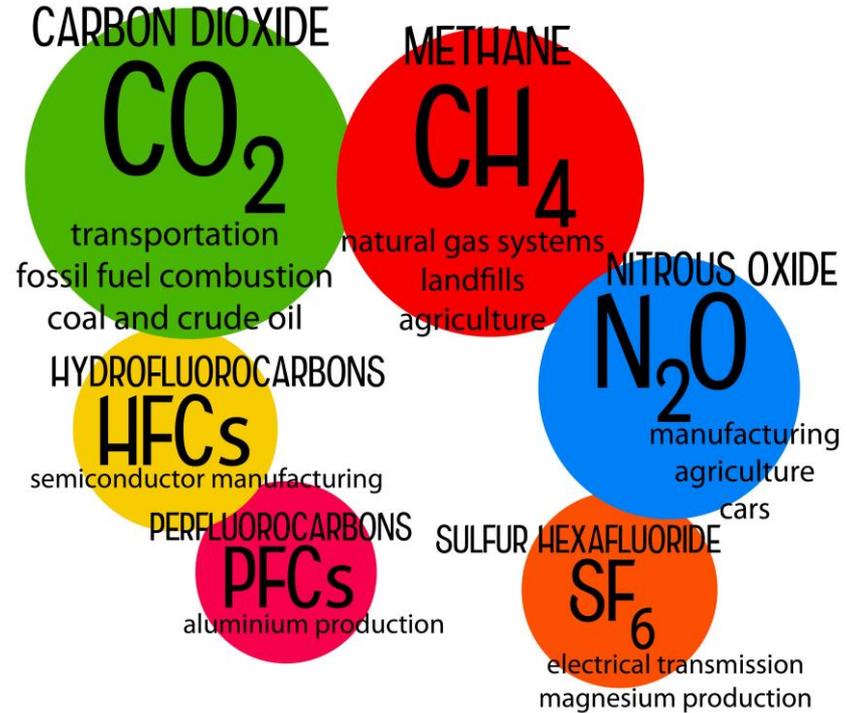
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Why Decarbonize Buildings?

- Climate change is the most formidable environmental challenge ever faced by society
- Aggressive and sustained reductions in carbon emissions are required to limit climate change
- Buildings represent 39% of global carbon emissions and the global building stock is expected to double by 2060
- New buildings have a 40-100 year lifetime, locking in high emissions for decades
- Urgent action is needed to minimize carbon emissions from the building sector

Greenhouse Gases

- Carbon dioxide
- Methane
- Nitrous oxide
- HFCs
- PFCs
- SF₆



Building Decarbonization

- Is the process of removing or reducing man-made carbon emissions related to buildings, with the goal to eliminate them altogether
 - Includes the reduction of carbon emissions in the manufacturing of many materials
 - Includes the reduction of carbon emissions in the operation of buildings

ASHRAE Focus is on the Built Environment

- The Task Force of Building Decarbonization (TFBD) was formed in Feb 2021 and revamped Jul 2022
- was originally 15 members with 10 working groups, now 6 members with 8 wg
- Global representation
- Total membership including working groups is over 100 volunteers
- Website:

<https://www.ashrae.org/about/ashrae-task-force-for-building-decarbonization>

Refrigerants

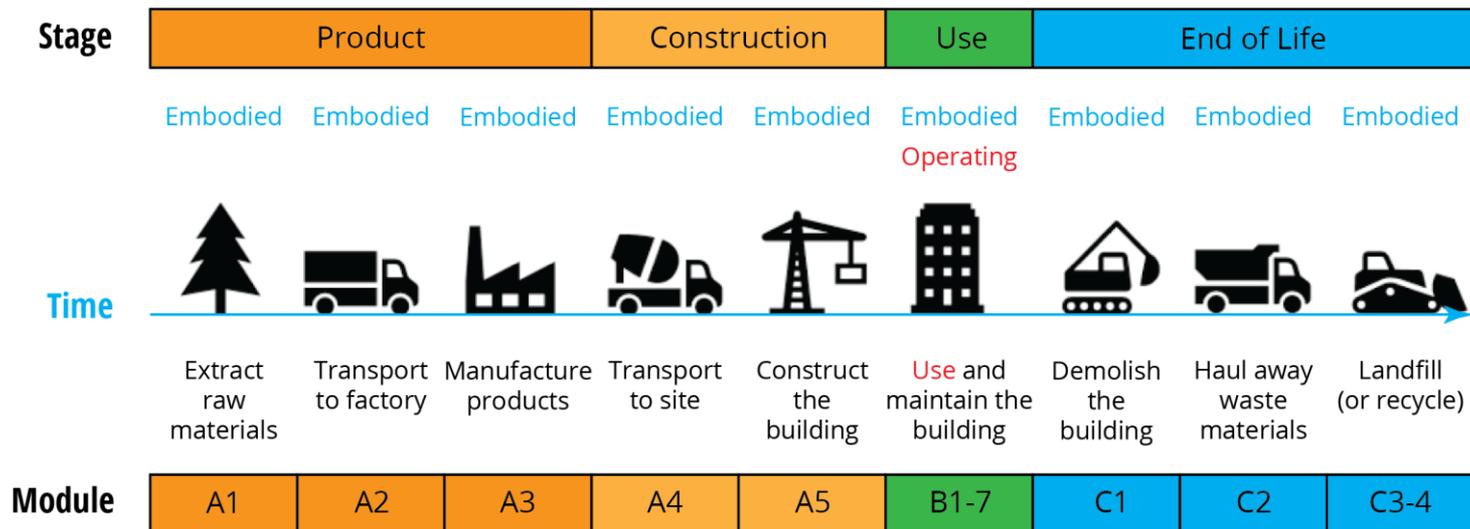
- Many currently used refrigerants have high GWP values
 - R-410A – 1920, A1
 - R-134A – 1430, A1
 - R-123 – 77, B1
 - Ammonia – Zero, A3
- New low GWP refrigerants will be available soon
 - R-454A – 238, A2L
 - R-1233zd – 1, A1
 - R-514A- 2, B1
 - R-513A – 573, A1
 - R-1234vf – 1, A2L



Good Building Decarbonization Design

- Optimize envelope
- Wall to window ratio by exposure
- Maximize daylight
- High performance HVAC system
- DOAS – dedicated outside air system
- LED lighting
- Site orientation
- On site renewable electric generation
- Parking for EV charging stations

Carbon Life Cycle of a Building



Embodied Carbon Life Cycle Approach. Adopted from EN15978.

Decarbonization Standards & Codes

- Many parts of the world are engaging in the building decarbonization movement to be net zero carbon by 2050
- One goal for the Task Force is to set the stage for integrating building decarbonization into ASHRAE standards
- The TFBD developed a list of existing codes & standards that are related to building decarbonization:

https://www.ashrae.org/file%20library/about/existing-standards-and-codes_.pdf

Decarbonization Standards & Codes

- Building performance standards (BPS) are an increasingly important policy tool for cities, states, provinces looking to reduce the carbon impact of their built environment to meet their climate commitments
- Aims to improve existing buildings' performance through use of measured data and the establishment of increasingly stringent performance requirements over time



Building Decarbonization – Definitions

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Building Decarbonization Terms

Carbon metric: a standard measure of carbon dioxide equivalent emissions (CO_2e) for greenhouse gases.

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).

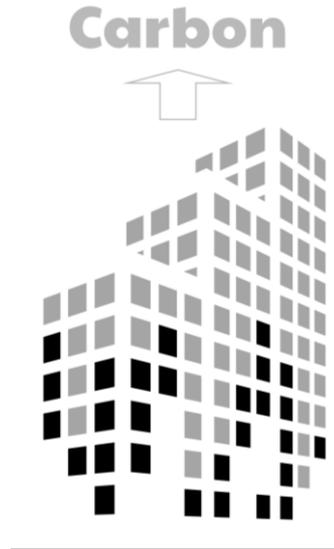


Building Decarbonization Terms

Operational carbon: the CO₂e emissions during the normal use of a building during its life.

Embodied carbon: All the CO₂e emitted in producing materials. It is estimated from the energy used to extract and transport raw materials as well as emissions from manufacturing processes. Embodied carbon of a building includes all the emissions from the construction materials, the building process, all the fixtures and fittings inside as well as from deconstructing and disposing of it at the end of its lifetime.

End of life carbon: the CO₂e emissions to decommission the building at its end of life.

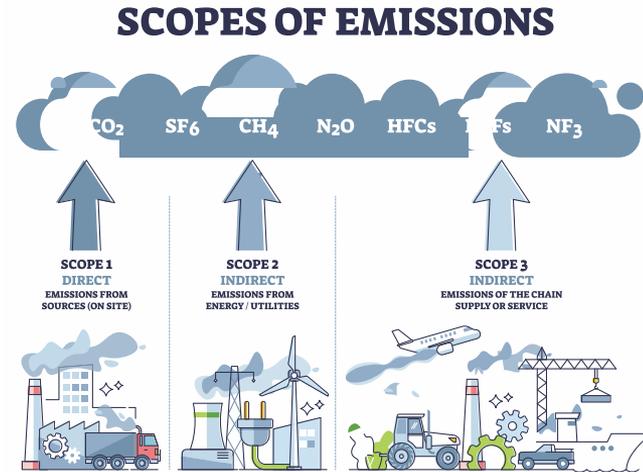


Building Decarbonization Terms

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

Life cycle assessment (LCA): a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service.



Building Decarbonization Terms

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.

Electrification: Building electrification refers to replacing direct fossil fuel use (e.g., natural gas, propane, heating oil) with electricity use in a way that reduces overall emissions while lowering other air pollutants.

Heat pump system: a vapor compression refrigeration system that can be reversed to either heat or cool.



Building Decarbonization Terms

Renewable energy: energy that is collected from renewable resources that are naturally replenished on a human timescale. It includes sources such as sunlight, wind, hydropower, tides, waves, biomass, and geothermal heat.

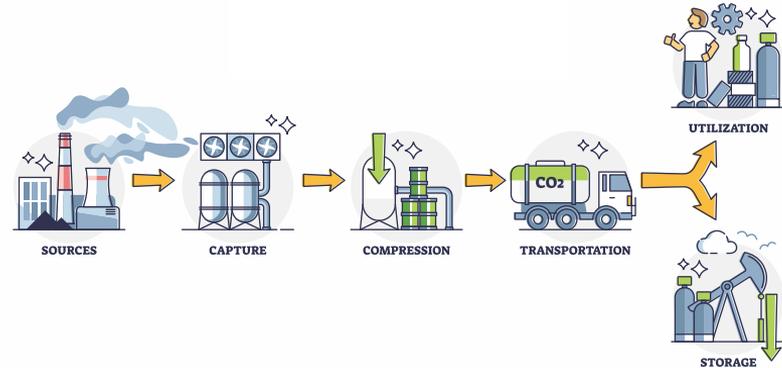
Building Performance Standards (BPS): a policy that requires building owners to meet performance targets by actively improving their buildings over time. These can include energy or emissions targets buildings must meet to improve energy efficiency and reduce climate impacts.



Building Decarbonization Terms

Carbon capture and storage (CCS): the process that captures emitted carbon dioxide, transports it to the storage site, and deposits it in such a way that it does not enter the atmosphere. It involves capturing, transporting, and depositing emitted greenhouse gases from fuel power stations and industries.

Site carbon sequestration: the process of long-term capturing and storing of carbon dioxide at the site to prevent it from entering the atmosphere. This allows the stabilization of carbon in solid and dissolved forms to avoid the increase in temperature atmosphere. Carbon sequestrations can be biological and geological.





Building Decarbonization – Position Document

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Acknowledgements

ASHRAE Building Decarbonization Position Document Committee members

- Costas Balaras
- Jim Edelson
- Dru Crawley
- Roger Hedrick
- Clay Nesler
- Elizabeth Tomlinson
- Paul Torcellini

ASHRAE Building Decarbonization Position Document

- ASHRAE Position Documents are approved by the Board of Directors and express the views of the Society on a specific issue.
- The purpose of these documents is to provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound and relevant public policy.

Building Decarbonization Position Document Committee

- Title, Purpose & Scope and committee membership approved in June 2021
- Committee began meeting in July 2021 and met twice every month
- Goal was to have the position document available by annual meeting. Has now been approved by task force
- Requires approval of
 - Document Review Subcommittee (DRSC),
 - TechC (in coordination with TFBD, Director of Government Affairs and cognizant TCs),
 - and the Board of Directors

Building Decarbonization Primer

- Buildings are built for a purpose
- Buildings must provide a healthy environment and enhance occupant wellbeing
- Buildings can be the places where individuals and teams can thrive and reach their collective potential, through increased productivity and collaboration
- Buildings can be designed and built to minimize energy and carbon emissions

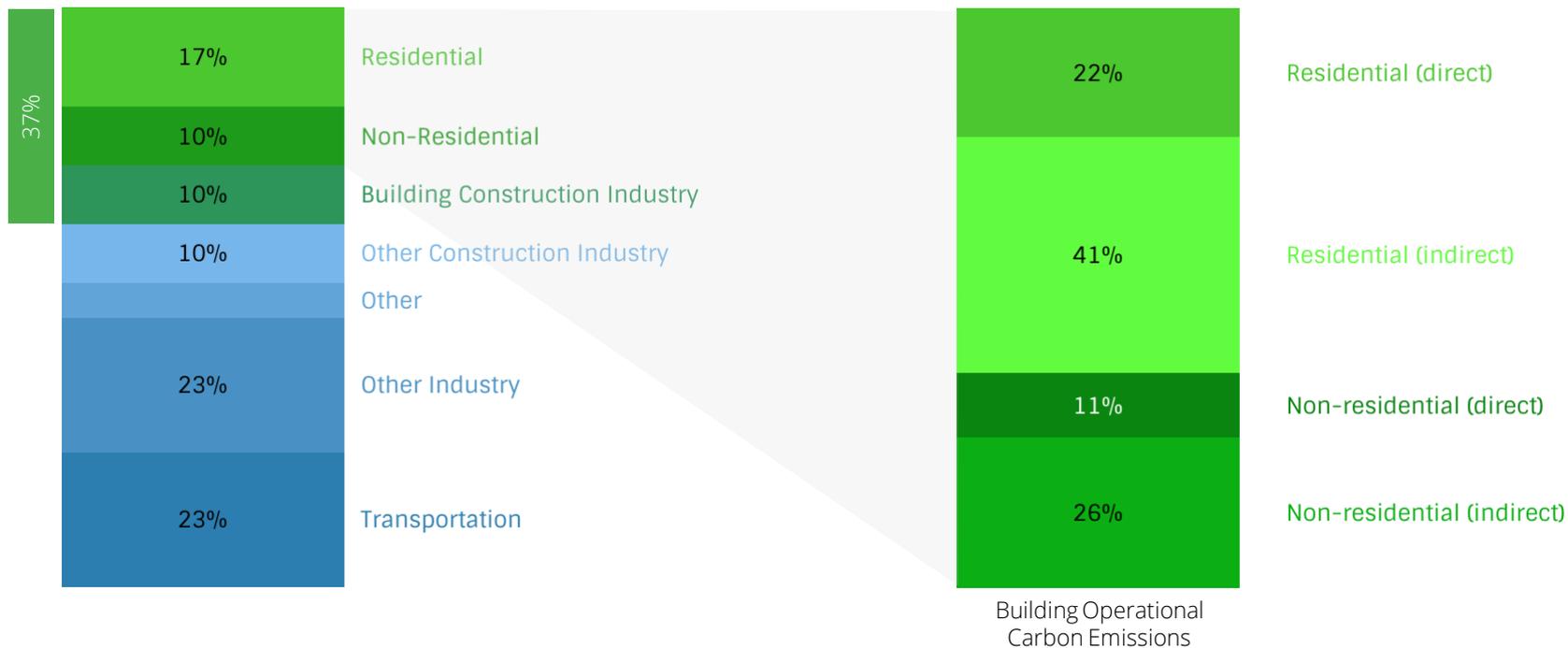
Building Decarbonization Primer

- HVAC&R systems have direct and indirect carbon emissions from energy use, refrigerant emissions, and embodied emissions
- Direct emissions and indirect carbon emissions are determined by where the actual emissions occur
- Onsite emissions are typically direct emissions

Building Decarbonization Primer

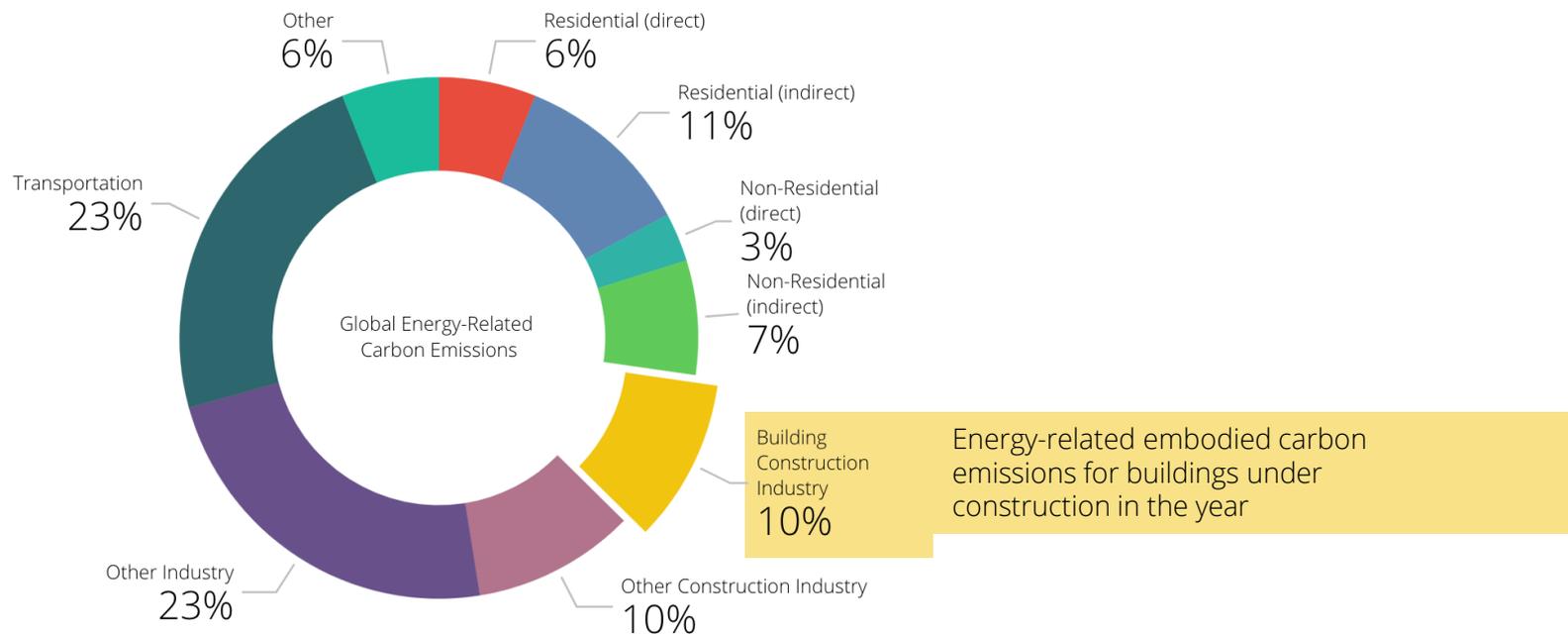
- Building decarbonization involves building design, construction, operation, and occupancy
- The primary means for reducing operating carbon emissions will be:
 - Aggressive energy efficiency
 - Electrification of building energy needs
 - Decarbonization of the electrical grid and delivered fuels

Global energy-related carbon emissions, 2020



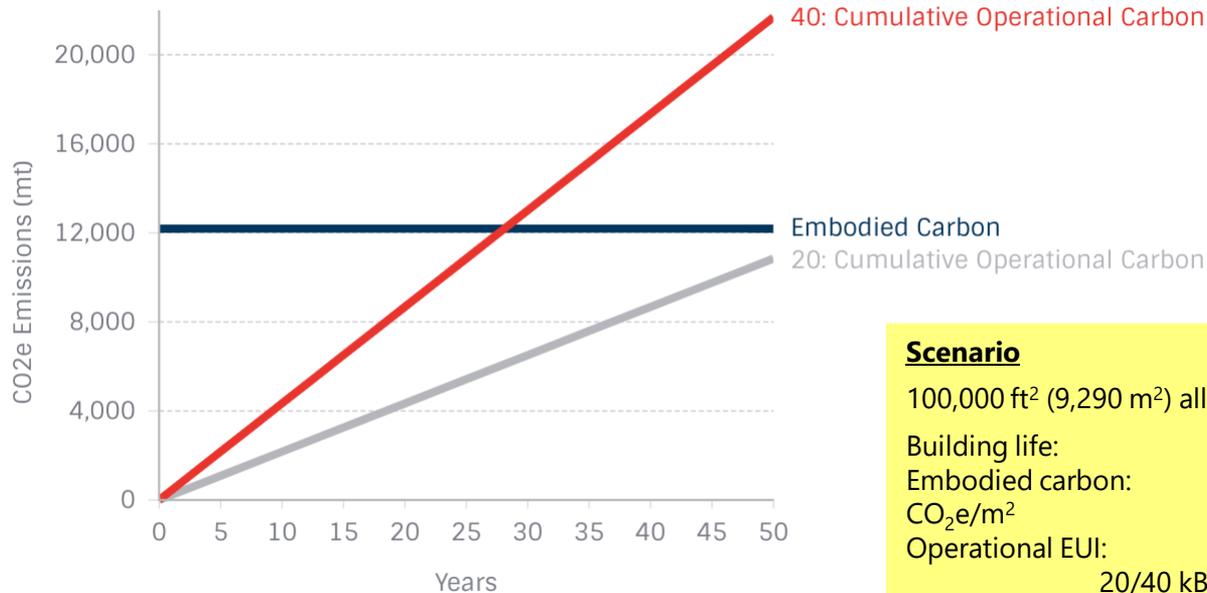
Source: IEA, Global energy use and energy-related CO₂ emissions by sector, 2020, IEA, Paris
<https://www.iea.org/data-and-statistics/charts/global-energy-use-and-energy-related-co2-emissions-by-sector-2020>

Global energy-related carbon emissions, 2020



Source: IEA, Global energy use and energy-related CO₂ emissions by sector, 2020, IEA, Paris
<https://www.iea.org/data-and-statistics/charts/global-energy-use-and-energy-related-co2-emissions-by-sector-2020>

Why new building embodied carbon is important



Scenario

100,000 ft² (9,290 m²) all-electric building

Building life: 50 years

Embodied carbon: 400 kg-

CO₂e/m²

Operational EUI:

20/40 kBtu/ft²-yr

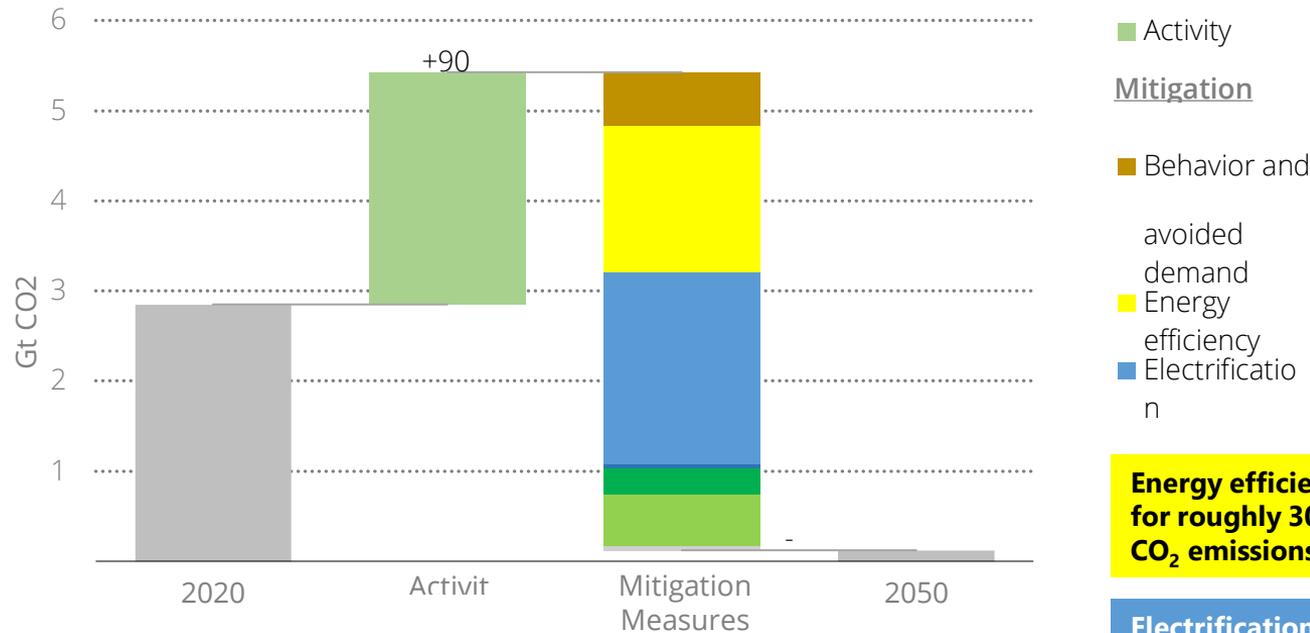
(63/126

kWh/m²-yr)

Grid emissions:

370 gr-CO₂e/kWh

Global direct CO₂ emissions reductions by mitigation measure in buildings in the 2050 NZE

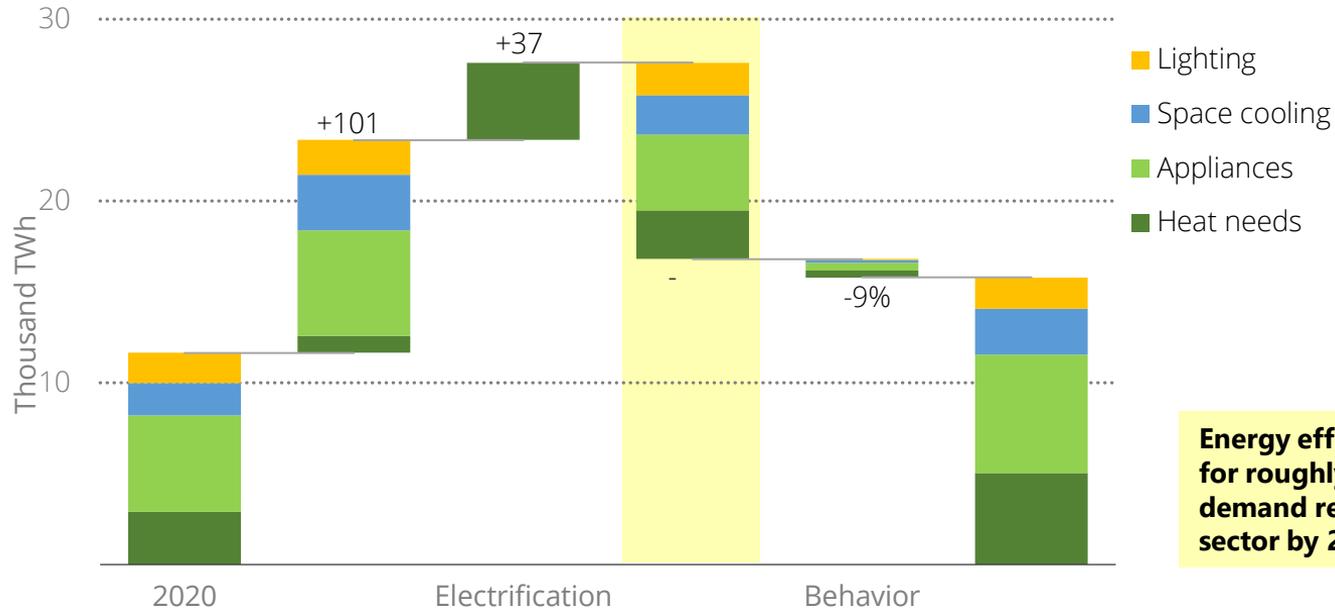


Energy efficiency will need to account for roughly 30% of global direct CO₂ emissions reductions by 2050

Electrification will need to account for roughly 40% of global direct CO₂ emissions reductions by 2050

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

Global change in electricity demand by end-use in the buildings sector



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

Building Decarbonization Position Document

- Global building industry needs standards, guidance, tools, and training
- ASHRAE must partner with other national and global organizations to help provide solutions
- ASHRAE has been addressing these issues:
 - Climate Change Position Document
 - Standards
 - Handbooks
 - Education
 - Task Force for Building Decarbonization

ASHRAE Standards

Standard	Energy Efficiency	Operational Carbon Emissions	Embodied Carbon Emissions	Refrigerant Emissions	Renewables
15:2019 Safety Standard for Refrigeration Systems				✓	
34:2019 Designation and Safety Classification of Refrigerants				✓	
90.1-2019 Energy Standard for Buildings Except Low-Rise Residential Buildings	✓	⊗			
90.2:2018 Energy Efficient Design of Low-Rise Residential Buildings	✓				
90.4-2019 Energy Standard for Data Centers	✓				
100-2018 Energy Efficiency in Existing Buildings	✓				



Included in Standard



Carbon calculation methodology included in Standard



Under consideration



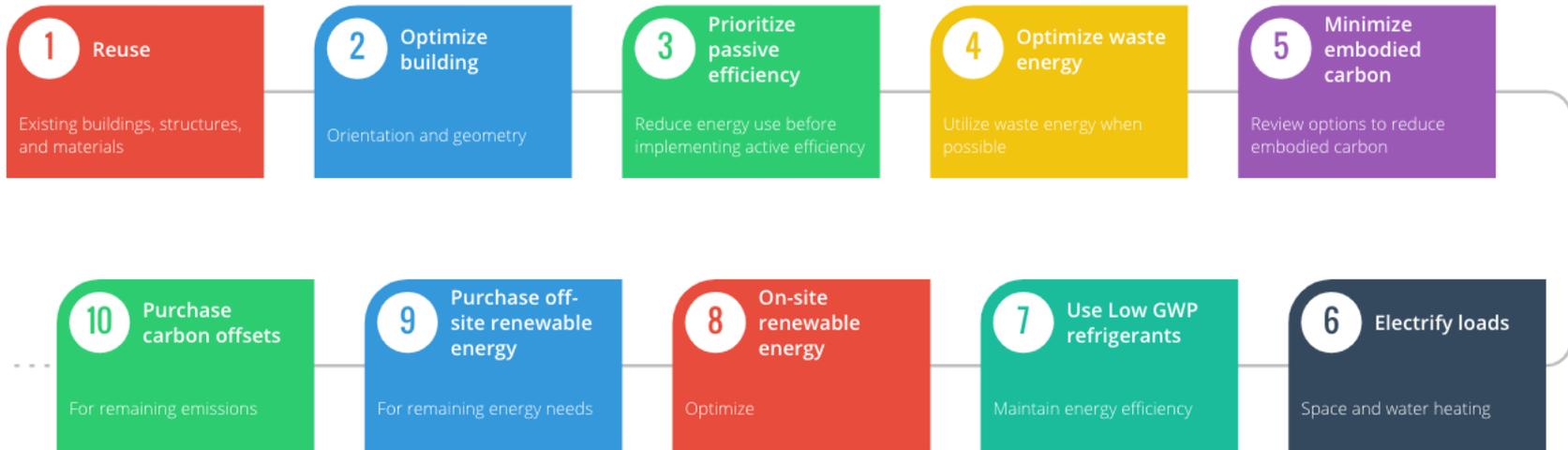
Included in proposed Standard



Carbon calculation methodology included in proposed Standard

Standard	Energy Efficiency	Operational Carbon Emissions	Embodied Carbon Emissions	Refrigerant Emissions	Renewables
105:2014 Standard Methods of Determining, Expressing and Comparing Building Energy Performance and Greenhouse Gas Emissions	✓	✓			✓
189.1-2020 Standard for the Design of High-Performance Green Buildings	✓	✓	✓	⊗	✓
189.3-2021 Construction and Operation of Sustainable High-Performance Health Care Facilities	✓	✓	✓	✓	✓
227P: Passive Building Design Standard	✓			✓	
228P: Standard Method for Evaluating Zero Net Energy and Zero Net Carbon Building Performance		✓		✓	✓

Building Decarbonization Design Principles



Opportunities

- Energy efficiency – substantial untapped potential in both new and existing buildings
- Electrification – assuming a decarbonized power sector, using electricity for heating, cooling, and hot water needs, instead of fossil fuels, can greatly reduce a building's emissions
- Renewable energy – utilize renewable energy
- **Embodied carbon** – reduce embodied carbon by reviewing alternatives
- Refrigerants – utilize low GWP refrigerants (HFO and HFO/HFC blends)

Challenges

- Existing buildings – many challenges but integrated solutions typically work best
- Return on investment – most capital expenditures for improved performance are based on understanding the real costs and returns
- Embodied carbon – lack of industry standards or code for whole building carbon life cycle assessment

Conclusion

- The decisions that ASHRAE members make in design, manufacturing, and building operation management have a substantial impact on building-related carbon emissions
- ASHRAE standards, guidance and education can significantly impact those decisions
- As a result, ASHRAE and its members have a critical role in decarbonizing the built environment

Bibliography

- IEA, Global energy use and energy-related CO2 emissions by sector, 2020, IEA, Paris
- International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Position Document



ASHRAE Position Document on Building Decarbonization

Approved by ASHRAE Board of Directors
June 26, 2022

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Abstract

- This position document recommends embracing building decarbonization strategies to reduce building greenhouse gas (GHG) emissions. Buildings provide many benefits to society but have a significant worldwide environmental impact due to their GHG emissions. The building industry accounts for roughly 40% of global GHGs, and the global building stock is expected to double by 2060. As society faces the challenge of mitigating climate change, ASHRAE's position is that decarbonization of buildings and their systems must be based on a holistic analysis including healthy, safe, and comfortable environments;

Abstract continued

- energy efficiency; environmental impacts; sustainability; operational security; and economics. By 2030, the global built environment must at least halve its 2015 GHG emissions, whereby
 - all new buildings are net zero GHG emissions in operation,
 - widespread energy-efficiency retrofits of existing assets are well underway
- Embodied carbon of new construction is reduced by at least 40%

Executive Summary

- The buildings we live and work in are responsible for roughly 40% of energy-related greenhouse gas (GHG) emissions. As jurisdictions across the planet confront climate change, the term decarbonization is being used to describe practices or policies that reduce GHG emissions. The standard metric used to quantify GHGs is carbon dioxide equivalent (CO₂-eq). Using a common metric helps evaluate different sources of GHGs in terms of their potential to impact the atmosphere—also referred to as their global warming potential (GWP).

Executive Summary cont'd

- This position document presents ASHRAE's position on decarbonizing buildings along with recommendations for moving forward. ASHRAE membership has the expertise, mission, and vision to directly address decarbonization in both existing and future buildings while continuing to provide a healthy and sustainable built environment for all. The global policies and commitments driving the transformation in building design and performance are broadly motivated by climate change, and the global building stock is expected to double by 2060. In response to this call for action, many countries' public and corporate entities have set goals to be carbon neutral prior to 2050.

Executive Summary cont'd

- Now is the time to turn these commitments and goals into action. By 2050, at the latest, all new and existing assets must have net zero GHG emissions across their whole life cycles. Building decarbonization encompasses a building's entire life cycle, including building design, construction, operation, occupancy, and end of life. Building construction, energy use, methane, and refrigerants are the primary sources of GHG emissions. Building life-cycle assessment involves consideration of operational and embodied emissions. Operational emissions are generally from energy use. Embodied emissions include GHG emissions associated with building construction, including extracting,

Executive Summary cont'd

- manufacturing, transporting, and installing building materials, as well as the emissions generated from maintenance, repair, replacement, refurbishment, and end-of-life activities. Embodied emissions also include refrigerant releases across the building life cycle. As new technologies develop and our understanding of the environmental effects of technology grows, ASHRAE is committed to continued efforts relating to building decarbonization in the following areas:

Executive Summary cont'd

- I• Research and standards development
- • Design and equipment applications
- • Technical guidance and training •
- Regulatory guidelines and measures
- • Educational resources and outreach

Design Measures

The following building decarbonization design measures can help guide early decision making:

- Reuse existing buildings, structures, and materials whenever possible.
- Optimize building envelope, orientation, and geometry to reduce energy use and maximize solar potential.
- Implement passive and active energy-efficiency measures.
- Use waste energy streams.
- Minimize embodied carbon in new construction materials and construction.
- Use energy-efficient electrification of space and water heating.
- Use low-GWP refrigerants and minimize refrigerant volume while maintaining energy efficiency.
- Use grid-integrated control systems to optimize building energy storage and increase demand flexibility.
- Use renewable energy resources on site and/or off site.
- Provide for effective long-term O&M.

2022-23 TFBD

More targeted focus – project driven \$1.8 Mil by board

- Led by Kent Peterson Chair and Don Colliver VC
- 2 subcommittees operational and products and services

Operational subcommittee

- Each Working group (wg) is a specific project with projected completion dates attached

Products and services subcommittee

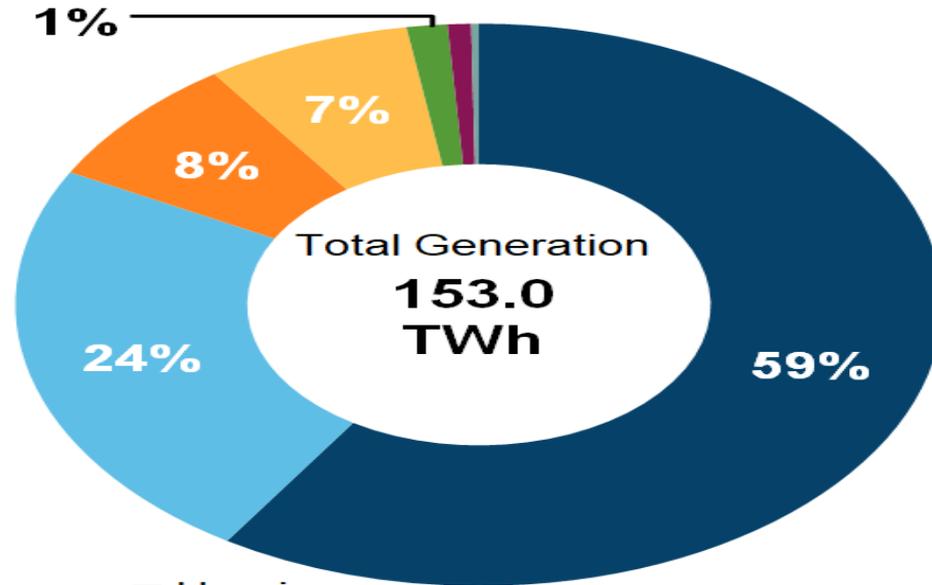
- Website and knowledge hub wg
- Training and education wg



Building Decarbonization – Ontario & London, On

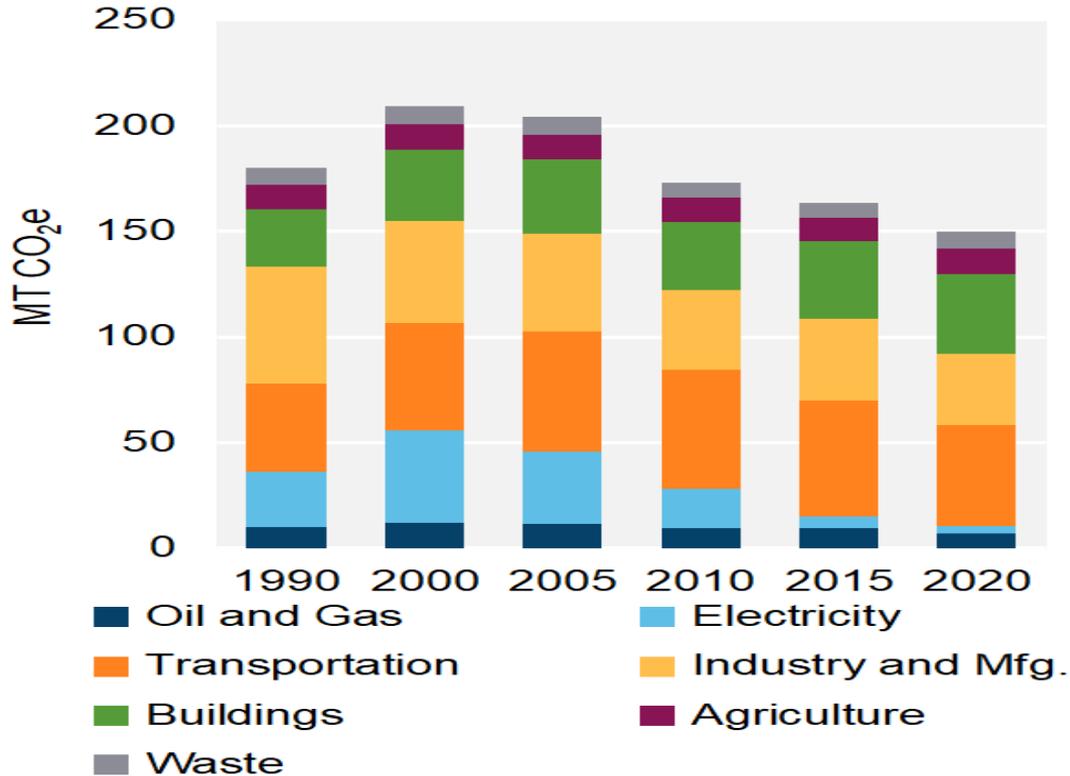
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Ontario – Electricity Generation 2019



- Uranium
- Hydro
- Wind
- Natural Gas
- Solar
- Biomass / Geothermal (1%)
- Petroleum (0.3%)

Ontario – GHG Emissions By Sector



Ontario – Decarbonization Efforts

Adopt 2020 NEBC with Single Tier (Tier 1 lowest). Currently have own Building Code

No plans to adopt Net Zero Energy

Cancelled Conservation First Frameworks which Eliminated Renewable Energy Projects in Works. Cancelled EV rebates.

Only province with Mandatory Benchmarking for Large Buildings (Energy and Water Reporting Benchmarking (EWRB)) 50,000 sq ft (4645 sq m). Just Reporting

Ontario – Decarbonization Efforts Cont'd

Independent Electricity System Operator (IESO) 21-24 Budget capped by Ministry. Approx 40% below 2017 Levels. Administer Save On Energy Program

Grid Modernization - Advanced Metering and Non-Wire Alternatives

One Reactor coming offline in 2024. Study due by Oct 7 on what can be done. Using Natural Gas is easiest alternative. Just announced trying to keep this reactor online till 2026 but need approval. Also looking at feasibility of refurbishment.

London, On – Decarbonization Efforts

London climate emergency action plan based on a 1.5 deg c temp rise for green house gas emissions. Goals of 55% reduction from 2005 levels by 2030, 65% reduction by 2035, and 75% reduction by 2040. Reduce, restrict, or phase out fossil fuel as primary source of heat in all new buildings as of 2030.

City of London CityGreen program identifies initiatives designed for citizens to make greener choices.

EVE Park Townhouse net zero project combines cutting edge energy efficiency and electric vehicle features without conceding comfort or aesthetics. Micro grid with community battery.

No natural gas lines and solar panels. Will produce as much energy as development uses.



Building Decarbonization – Next steps

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Operational subcommittee Based On Jul 1/22 start

- Building decarbonization retrofit guide wg – 18 mo
- Heat pump application & operation guide wg-9 mo
- Healthcare decarbonization design guide wg - 12 mo
- Building performance standard resource technical guide wg – 6 mo

Operational subcommittee based on Jul 1/22 start date cont'd

- Guide for designing and operating grid- interactive buildings for decarbonization wg – 12 mo
- Building decarbonization whole life design guide wg – 12 mo
- Engage tc's and other technical entities and work with other organizations

Training and Education Working group

- Heat Pump Applications Professional Development Seminar (PDS) – Fall 2023
- Decarb Retrofits for Existing Buildings PDS – Winter 2024
- Decarb Audit PDS - Depends on Std 211 updates
- Decarb Design Professional Certification – SY 24-25

Planned Building Decarbonization Upcoming Presentations

ASHRAE Learning Institute (ALI) Courses – 3 hrs ea \$ being revised

1. Fundamentals – Intro to Decarbonization Dru Crawley
2. Systems & Equipment – Equipment options for Decarbonization

Artorius Reyes

3. Applications – Operation of Buildings from Decarbonization perspective Doug Cochrane in progress

CRC's - Spring & Fall Offer to update any CRC with a technical session on decarbonization

International Decarbonization Conference Athens Greece Oct 5-7

Speakers from all over the world. Sharing of best practices

Atlanta winter meeting – Jan 2023 track on decarbonization

Decarbonization conference in Washington, DC Oct 2023 Dates TBC

Questions?



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