



THE FUTURE ENVELOPE

TOWARDS ZERO CARBON BUILDINGS



15-16 December 2022 Bolzano/Bozen

The challenge in decarbonising, optimising operational and embodied carbon in facade design to achieve net zero

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LIVING FUTURE EUROPE

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Collaborations

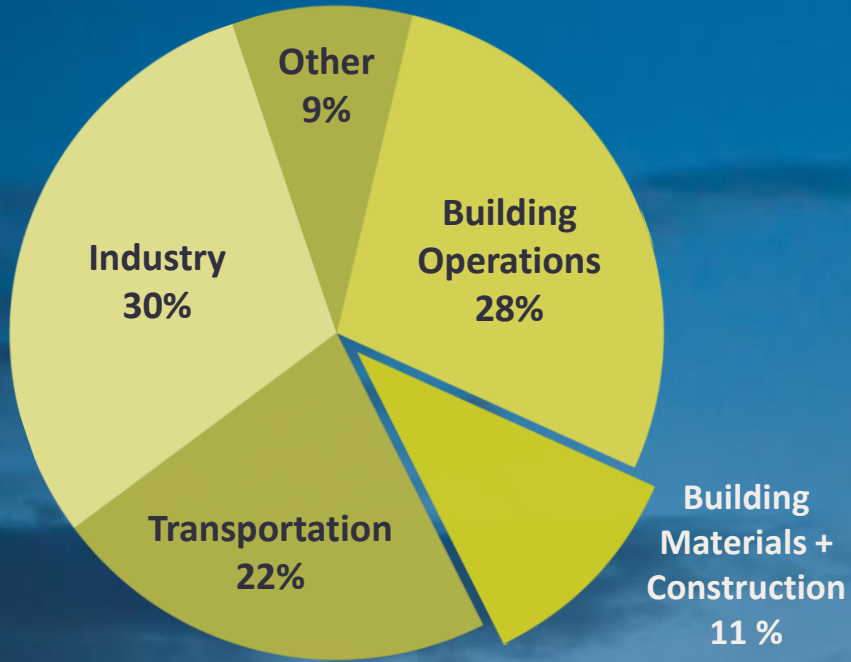


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Global CO₂ Emissions by Sector

THE BUILDING SECTOR HAS A CARBON PROBLEM

39% of global CO₂ is from building operations and building materials + construction!

By 2060, 23 mio. ha real estate
will be constructed or
renovated...

**The equivalency to New
York City every 34 days**

A photograph of an industrial facility at night, with various structures, pipes, and lights illuminated against a dark sky. A large green rounded rectangle is overlaid on the top left.

OPERATIONAL
ENERGY CONSUMED

A close-up photograph of a welding process, showing a bright blue flame and a shower of bright yellow sparks radiating from the point of contact. A large green rounded rectangle is overlaid on the bottom right.

EMBODIED
MATERIALS PRODUCED

A circular logo with a white border and the text 'ZERO CARBON CERTIFICATION' inside.

ZERO **CARBON**
CERTIFICATION



ZERO CARBON CERTIFICATION





ZERO **CARBON**
CERTIFICATION

OPERATIONAL
CARBON

EMBODIED
CARBON





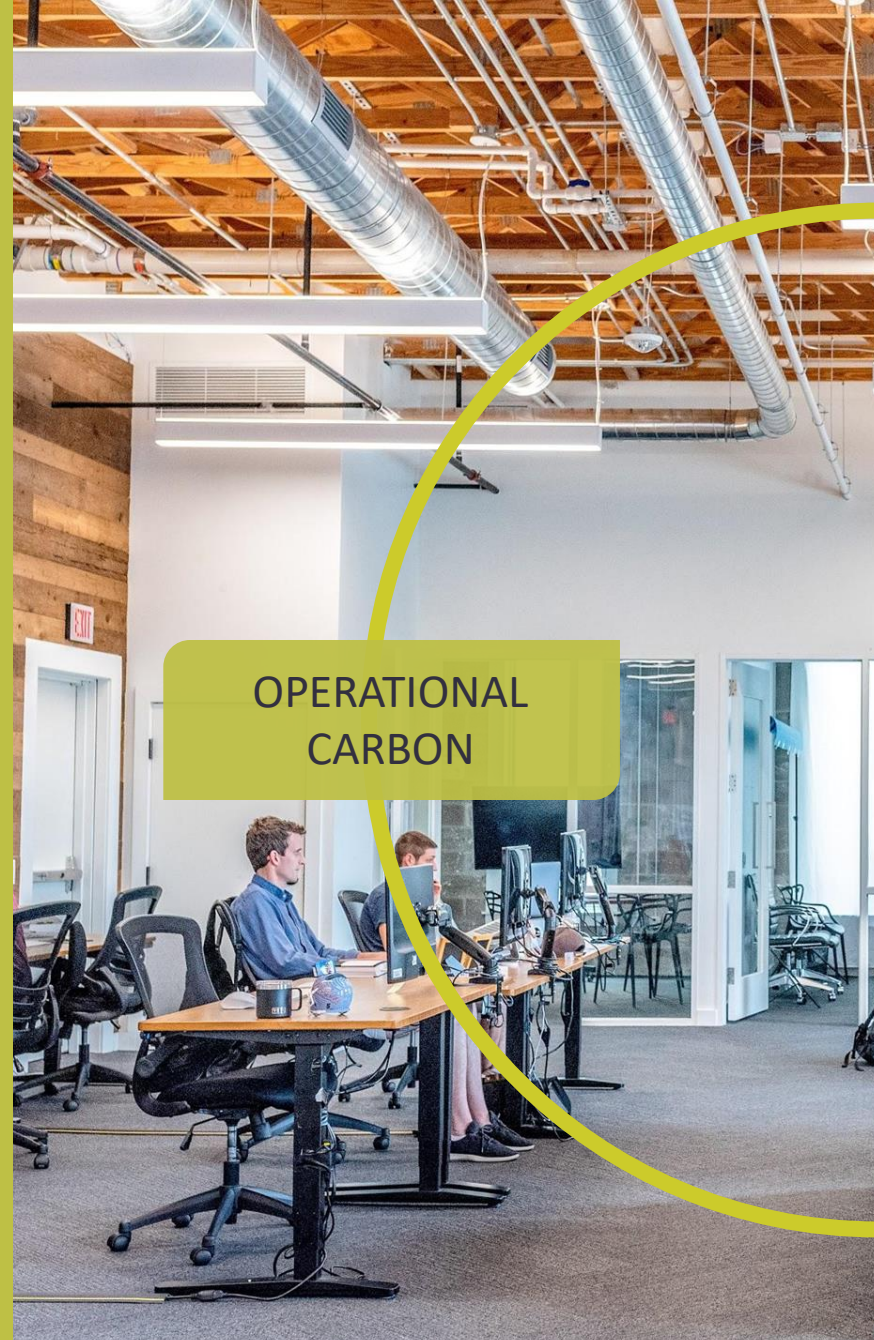
REDUCE

site energy consumption +
eliminate new combustion*

OFFSET

with installed or procured
renewable energy

*New buildings



OPERATIONAL
CARBON





REDUCE

Carbon in primary materials*

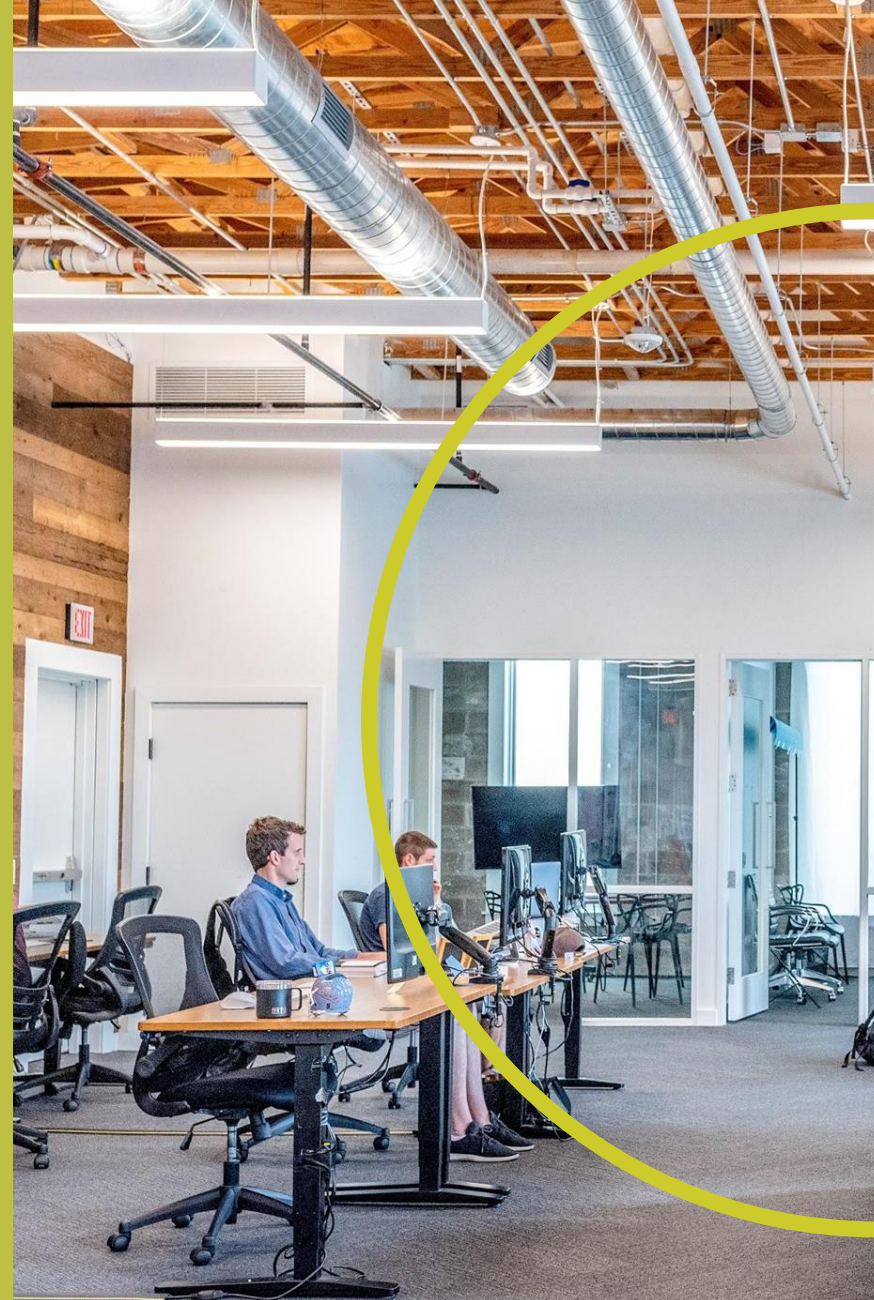
DISCLOSE

Reduction strategies + total embodied carbon

OFFSET

Sequestering materials or carbon offsets**

*New buildings ** New materials only



EMBODIED
CARBON

VALUE OF ZERO CARBON

Build trust with your stakeholders.

Demonstrate verifiable carbon reduction in
both operational and embodied carbon



“It has to make money, and it is.
This is a building that makes
great financial sense for
institutions.”

-Denis Hayes, CEO, Bullitt Foundation



Photo: Nic Lehoux



*“All major, new Salesforce office interiors...
will pursue International Living Future
Institute’s Zero Carbon Certification by 2030.”
– Salesforce Step Up Declaration*



Google, 6 Pancras Square, London

CERTIFIED

"These design strategies, rooted in adaptability and functionality, have resulted in lower renovation costs and significant carbon savings."



**LIVING FUTURE
EUROPE**

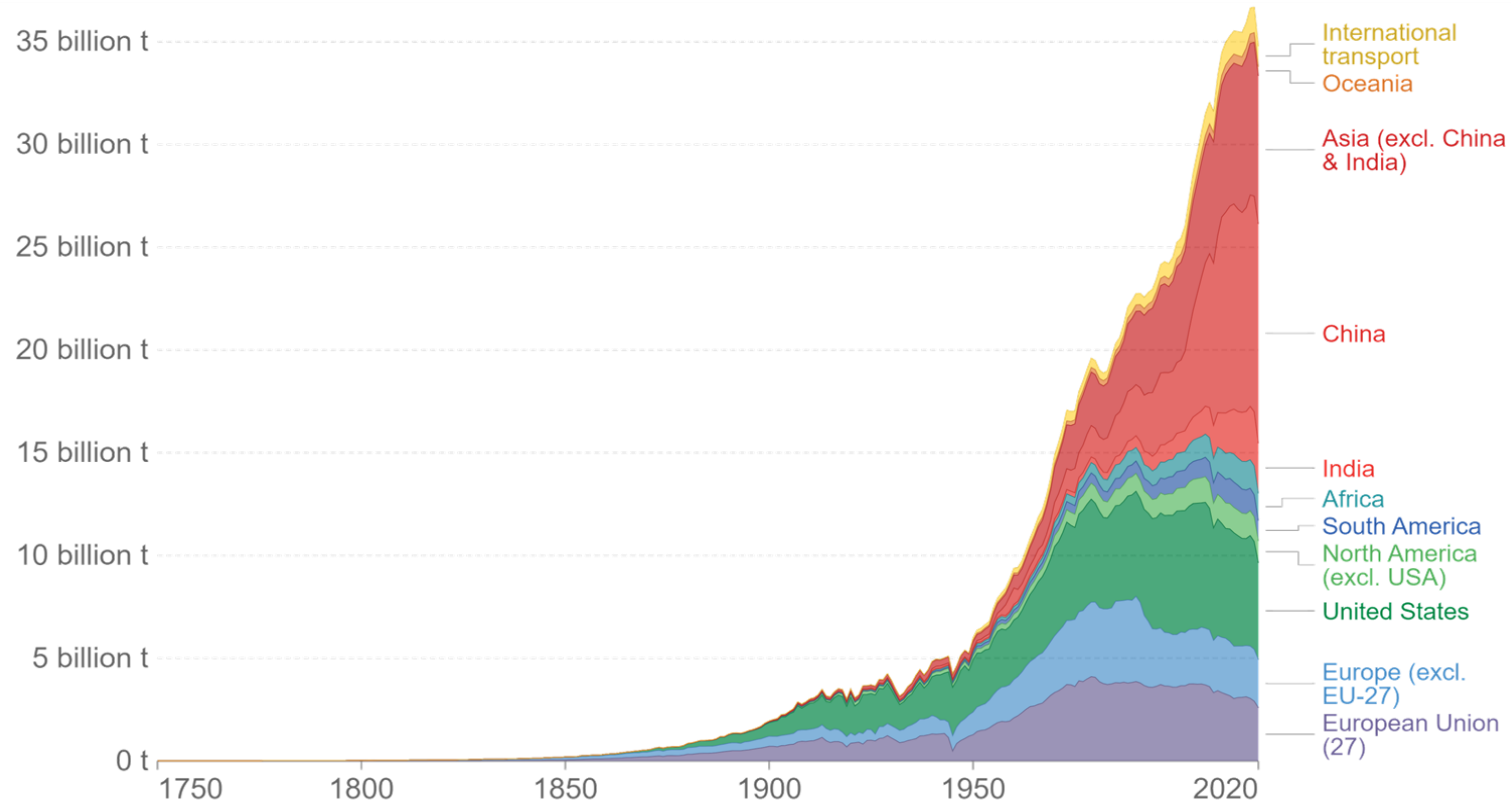




70
REGISTERED PROJECTS AROUND THE WORLD



Annual Global CO2 Emissions by Region



What is the role of façades on the Global CO2 Emissions?

Source: Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Note: This measures CO₂ emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.

How to Calculate the Total CO2 Emissions?



*Operational
Carbon*

+



*Embodied
Carbon*

=



*Total
Carbon Emissions*

How to Calculate the Total CO2 Emissions?

Embodied Carbon



Extract raw materials



Transport to factory



Manufacture products



Transport to site



Construct the building



Maintain the building



Demolish the building



Haul away waste materials



Landfill / recycle

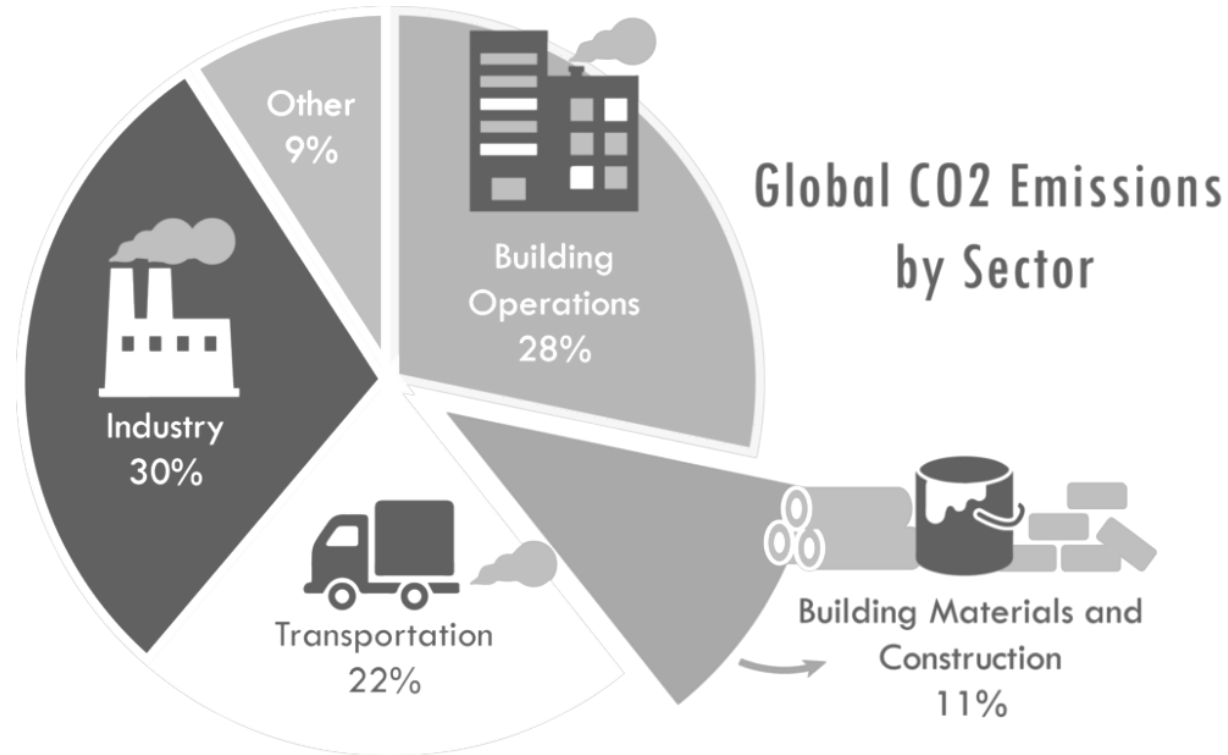


Use the building

X Life Span of the building

Operational Carbon

Global CO2 Emissions by Sector



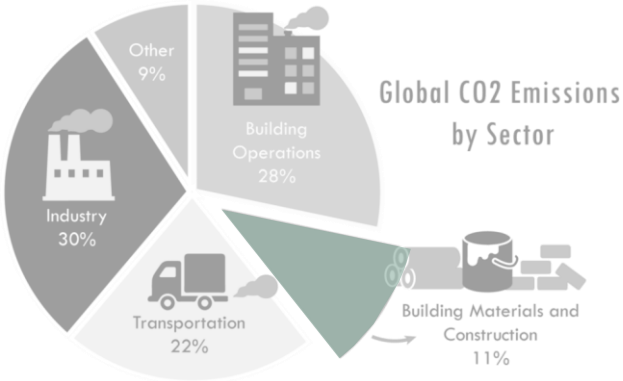
28% Building Operations

11% Building Materials and Construction

What is the role of façades on this 39% of CO2 Emissions?

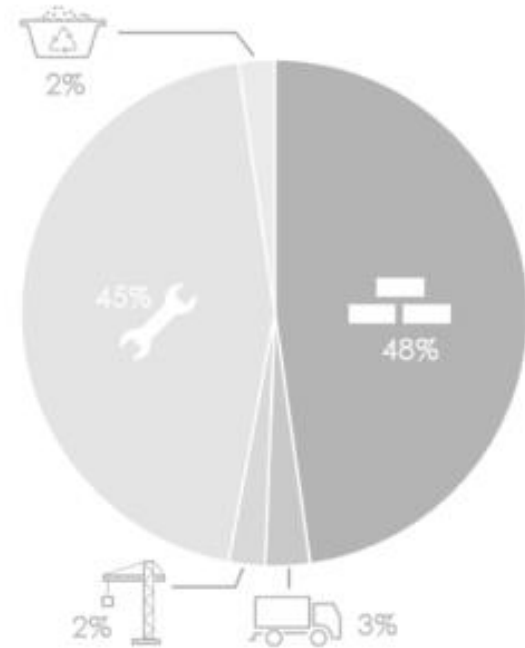
Source: © 2018 2030, Inc. / Architecture 2030. All Rights Reserved. Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

Façade Impact on the Building Embodied CO2 Emissions



The façade has an impact of around 16% of the Building Operations CO2 Emissions.

- Products/materials (A1-A3)
- Transport (A4)
- Construction (A5)
- Maintenance and replacements (B1-B5)
- End of life disposal (C1-C4)

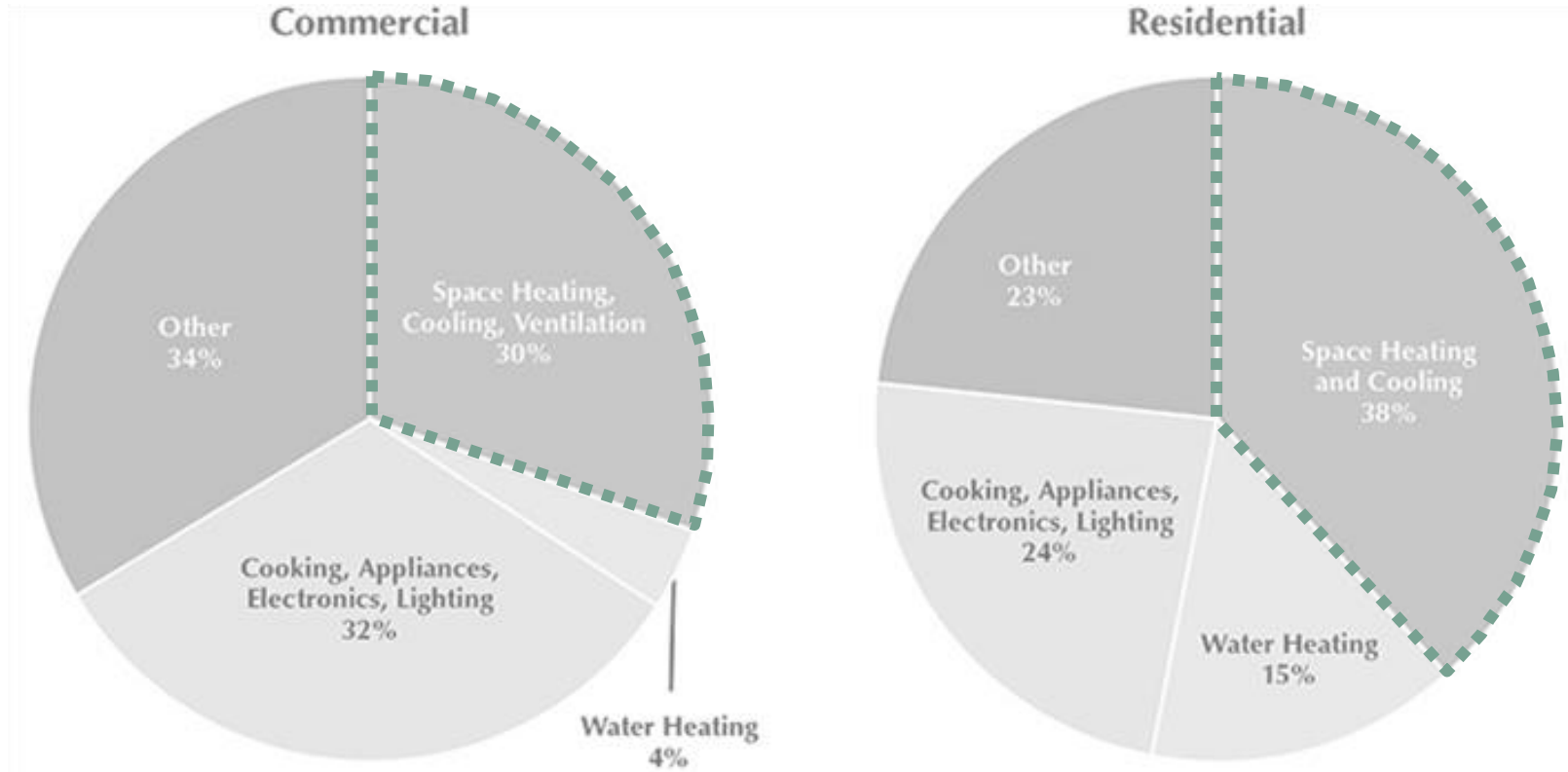
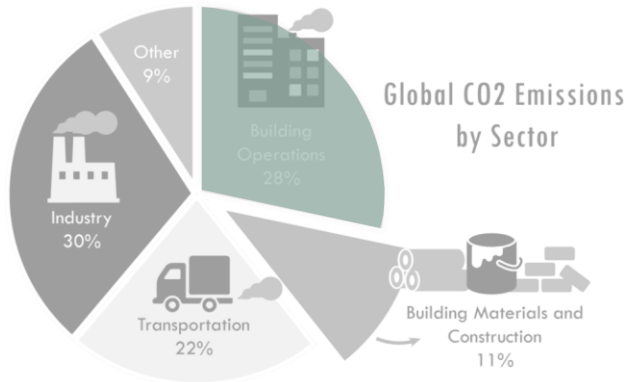


Average split of embodied carbon per building element:

- **48%** - Superstructure
- 17% - Substructure
- **16%** - Façade
- 15% - MEP
- 4% - Internal finishes

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018 (Washington, DC: U.S. Department of Energy, 2018), <https://www.eia.gov/outlooks/aeo>.

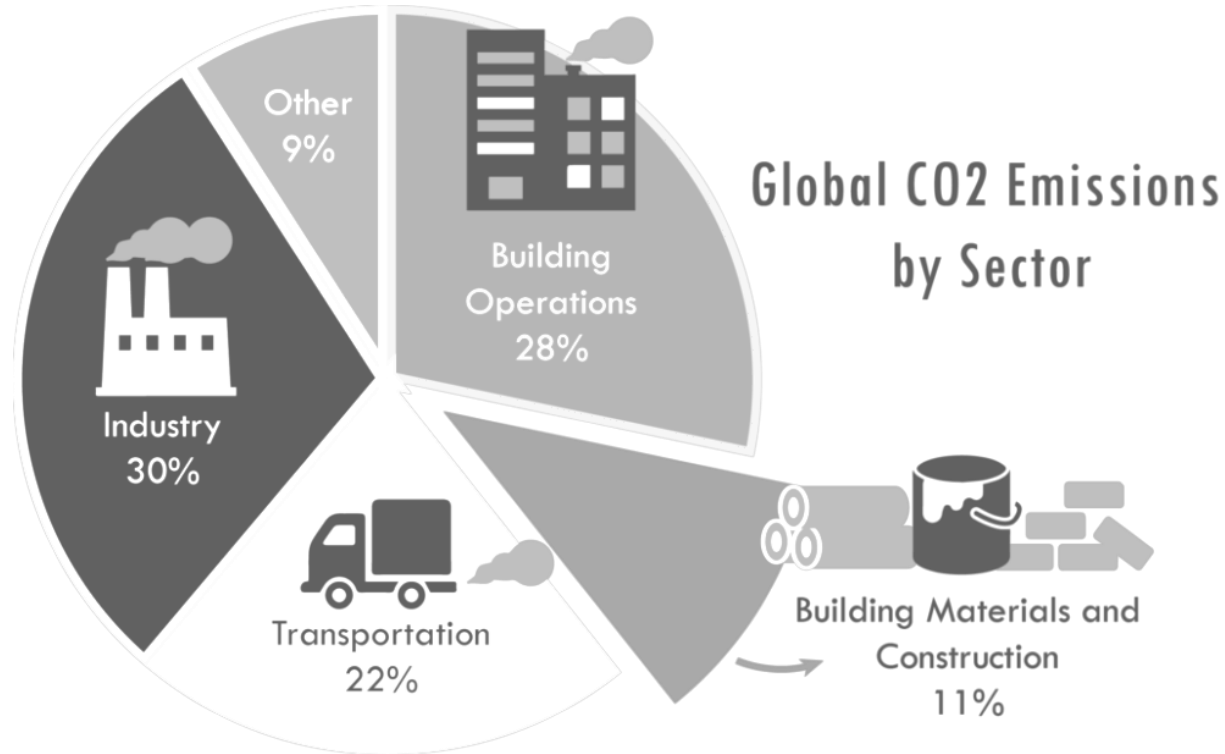
Façade Impact on the Building Embodied CO2 Emissions



The façade has an impact of around 34% of the Building Operations CO2 Emissions.

Source: U.S. Energy Information Administration, Annual Energy Outlook 2018 (Washington, DC: U.S. Department of Energy, 2018), <https://www.eia.gov/outlooks/aeo>.

The Façade Impact is 11.2% of the Global CO2 Emissions



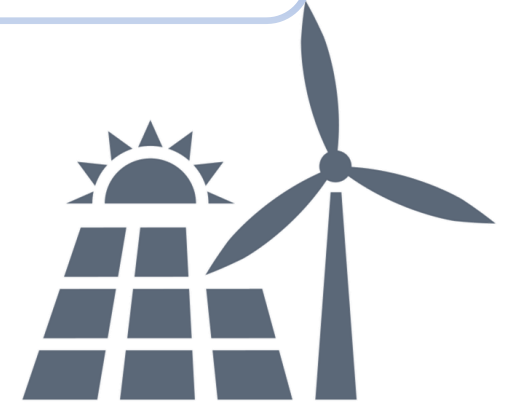
9.5% from Building Operations

1.7% from Building Materials and Construction

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

Case Study

Bases of the case study



<i>Fixed Parameters</i>	<i>Location</i>	<i>Building type and use</i>	
<i>Variable Parameters</i>		<i>Façade thermal performance</i>	<i>Available renewable energy</i>

The aim of this case study is to understand the relation between embodied carbon and operational carbon in facades, to find an optimal solution.

Case Study

Bases of the case study:

Fixed parameters

Location: Red Sea, Saudi Arabia
 Building Use: Residential



Variable Parameters

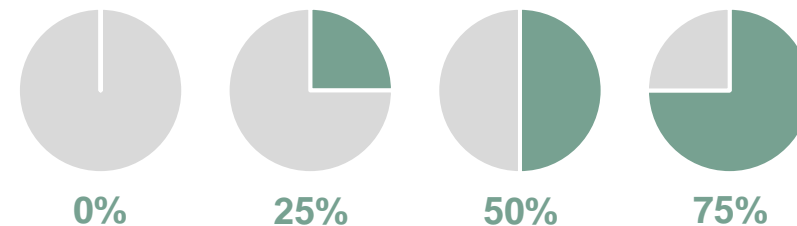
Opaque façades options

Options	Overall U-Value
Option 1	0.31 W/m2.K
Option 2	0.25 W/m2.K
Option 3	0.21 W/m2.K
Option 4	0.16 W/m2.K

Fenestration façades options

Options	U-value
Option 1	2.2 W/m2.K
Option 2	1.9 W/m2.K
Option 3	1.9 W/m2.K
Option 4	1.5 W/m2.K

Available renewable energy



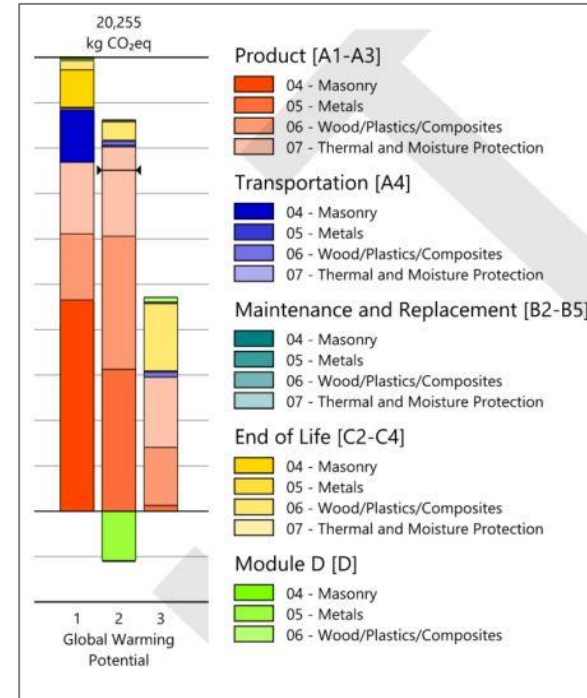
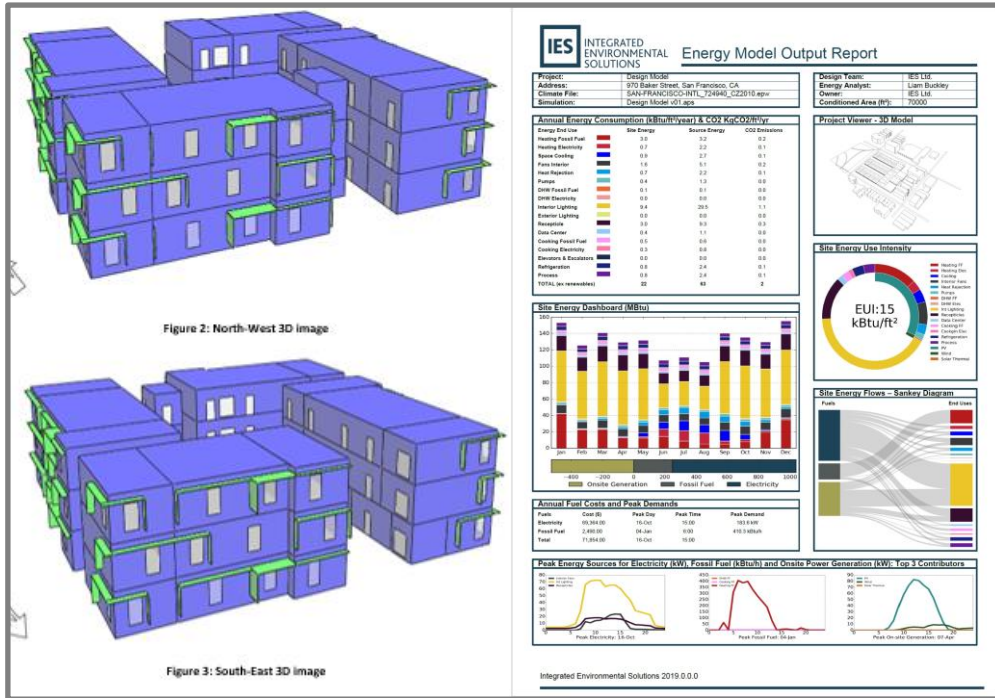
Methodology – Analysis Process

Total CO2 Emissions (Analysis focused on the façade)

Operational CO2 x 50 years (building life span)

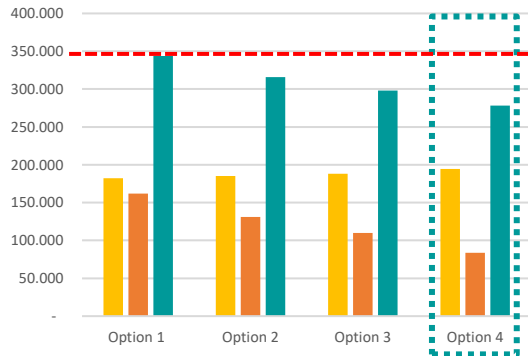


Embodied CO2



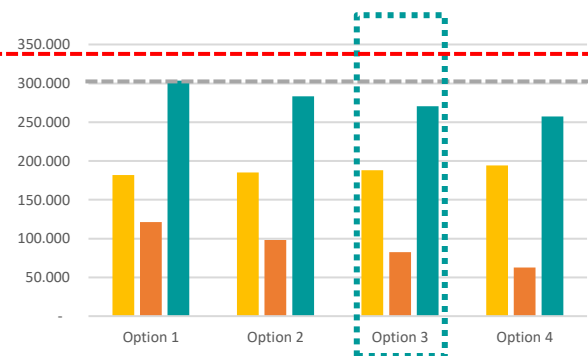
*The embodied carbon analysis just include the façade elements.

Opaque Façades Summary



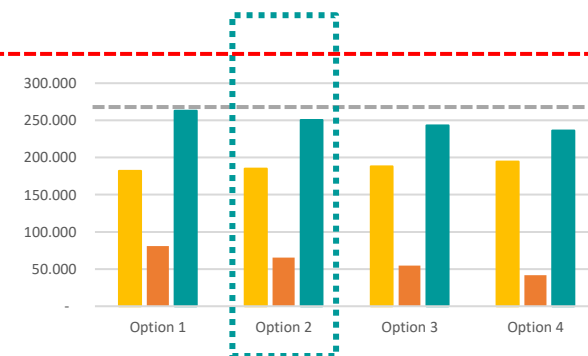
Analysis 1:

- Prefer option: Option 4
- 7 years energy pay back
- Total CO2 Emissions: 278,126 kg CO2 eq



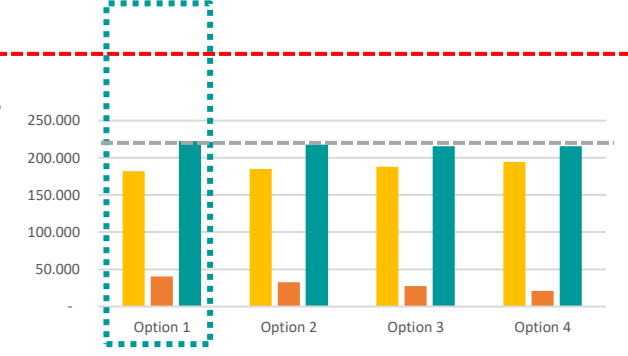
Analysis 2:

- Prefer option: Option 3
- 7 years energy pay back
- Total CO2 Emissions: 270,528 kg CO2 eq



Analysis 3:

- Prefer option: Option 2
- 9 years energy pay back
- Total CO2 Emissions: 250,430 kg CO2 eq



Analysis 4:

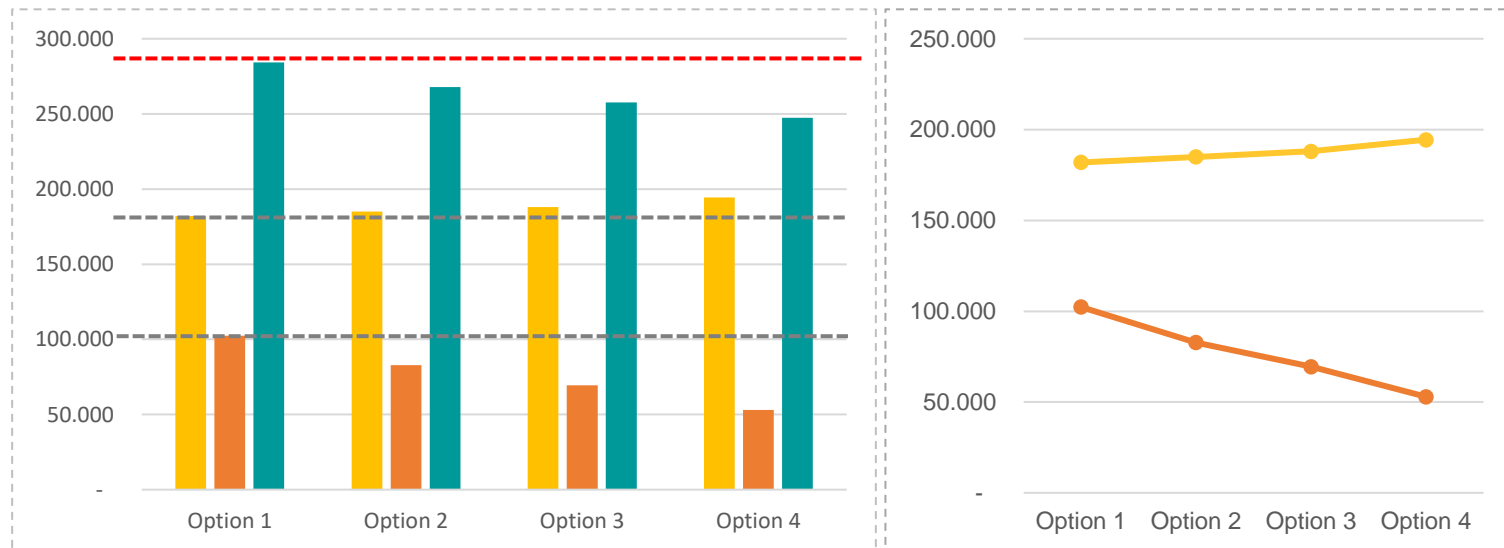
- Prefer option: Option 1
- 0 years energy pay back
- Total CO2 Emissions: 222,431 kg CO2 eq

Opaque Wall - Fifth Case of Analysis



Average grid decarbonisation — From 100% fossil fuel to 25% of fossil fuel energy and 75% renewable energy in 50 years.

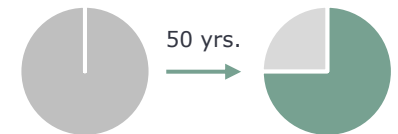
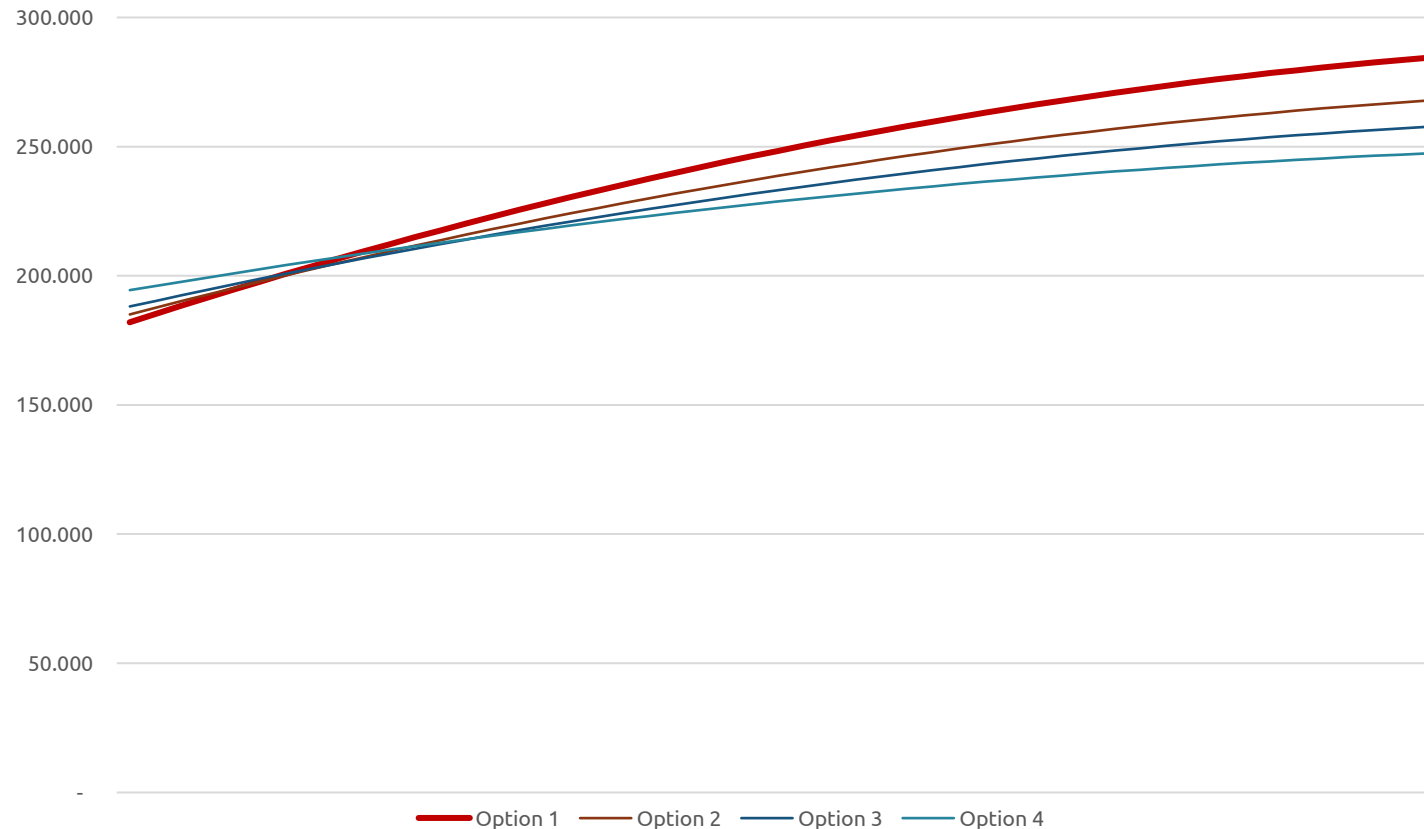
	Total Embodied Carbon (kg CO ₂ eq)	Total Operational Carbon (50y)(kg CO ₂ eq)	Total (kg CO ₂ eq)
Option 1	181,971	102,365	284,336
Option 2	184,992	82,778	267,770
Option 3	188,072	69,538	257,610
Option 4	194,394	52,960	247,354



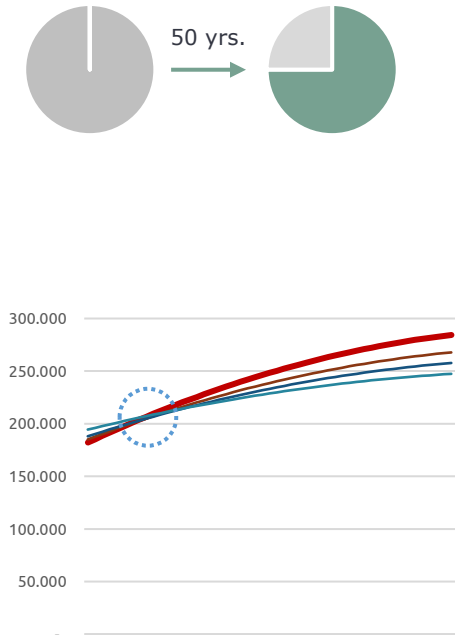
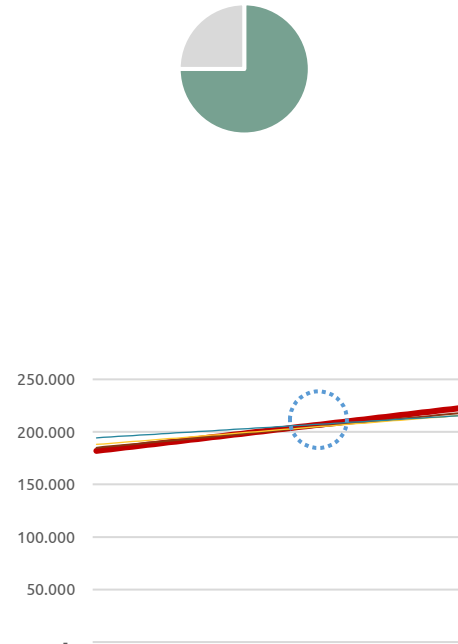
■ Total Embodied Carbon (kg CO₂ eq)
■ Total Operational Carbon (50y)(kg CO₂ eq)
■ Total (kg CO₂ eq)

Opaque Wall - Fifth Case of Analysis

Average grid decarbonisation _ From 100% fossil fuel to 25% of fossil fuel energy and 75% renewable energy in 50 years.



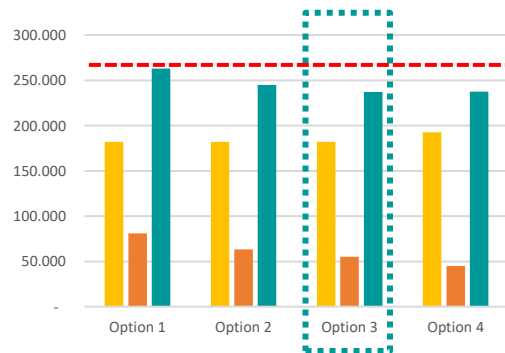
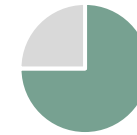
Key Findings



CO₂ IMPACT

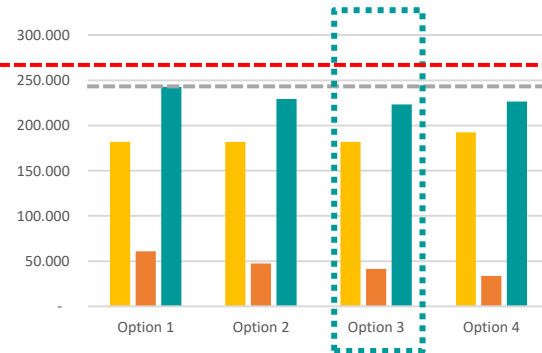


Fenestration Façade Summary



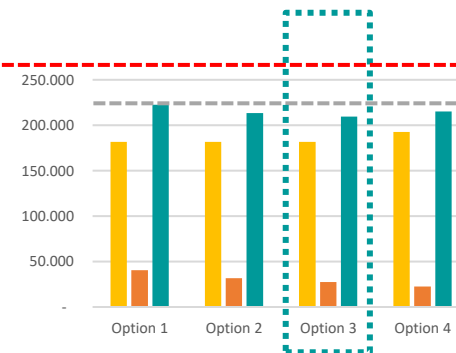
Analysis 1:

- Prefer option: Option 3
- 1 year energy pay back
- Total CO2 Emissions: 237,115 kg CO2 eq



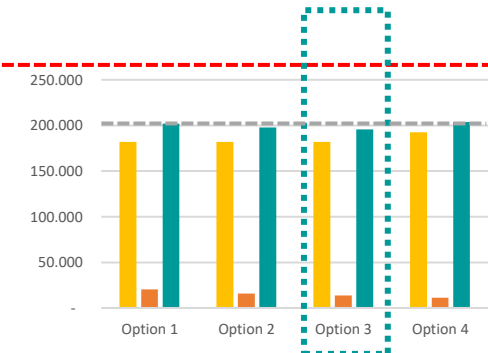
Analysis 2:

- Prefer option: Option 3
- 1 year energy pay back
- Total CO2 Emissions: 223,329 kg CO2 eq



Analysis 3:

- Prefer option: Option 3
- 1 year energy pay back
- Total CO2 Emissions: 209,543 kg CO2 eq



Analysis 4:

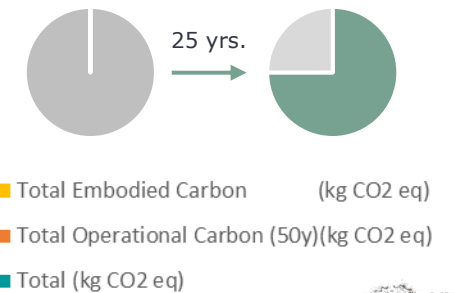
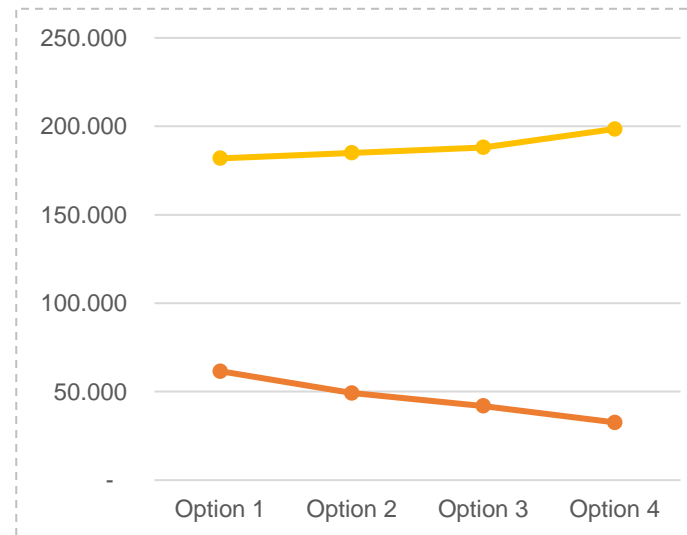
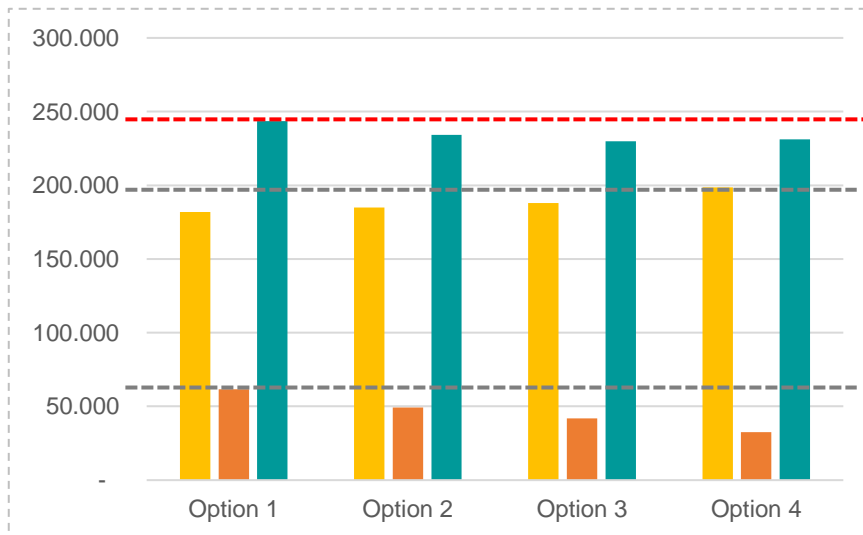
- Prefer option: Option 3
- 1 years energy pay back
- Total CO2 Emissions: 195,757 CO2 eq

■ Total Embodied Carbon (kg CO2 eq)
■ Total Operational Carbon (50y)(kg CO2 eq)
■ Total (kg CO2 eq)

Fenestration Façade - Fifth case of analysis

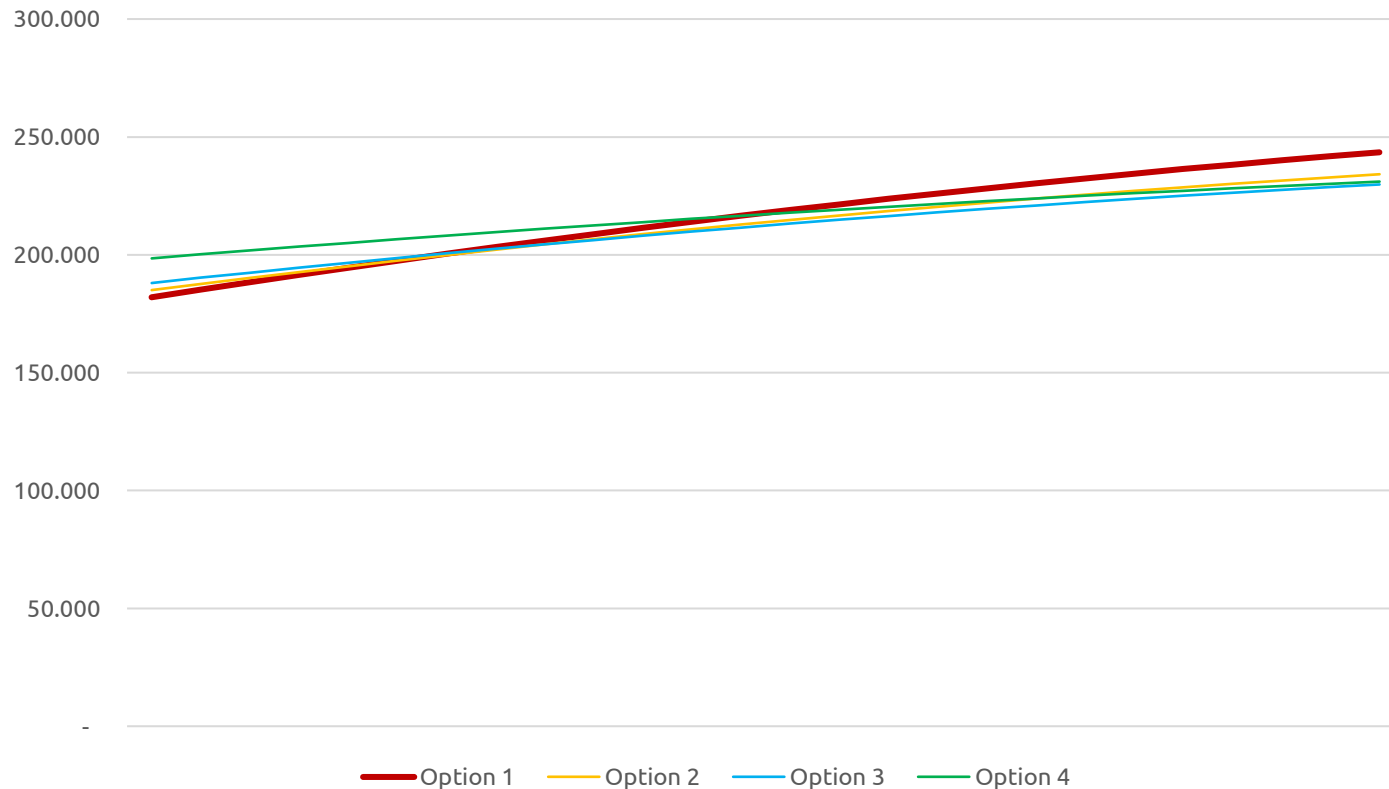
Average grid decarbonisation _ From 100% fossil fuel to 25% of fossil fuel energy and 75% renewable energy in 25 years.

	Total Embodied Carbon (kg CO2 eq)	Total Operational Carbon (25y)(kg CO2 eq)	Total (kg CO2 eq)
Option 1	181,971	61,531	243,502
Option 2	184,992	49,203	234,195
Option 3	188,072	41,819	229,892
Option 4	198,540	32,555	231,095

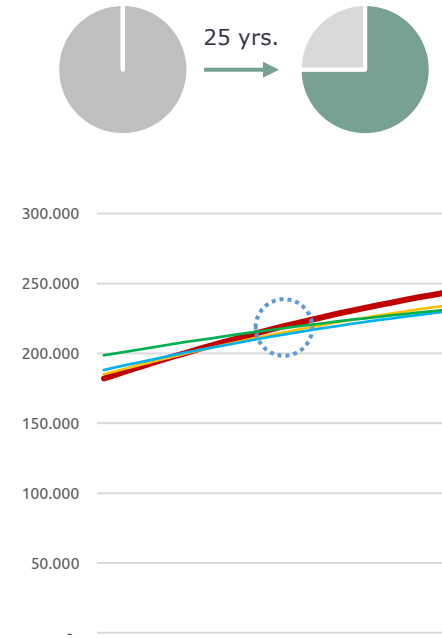
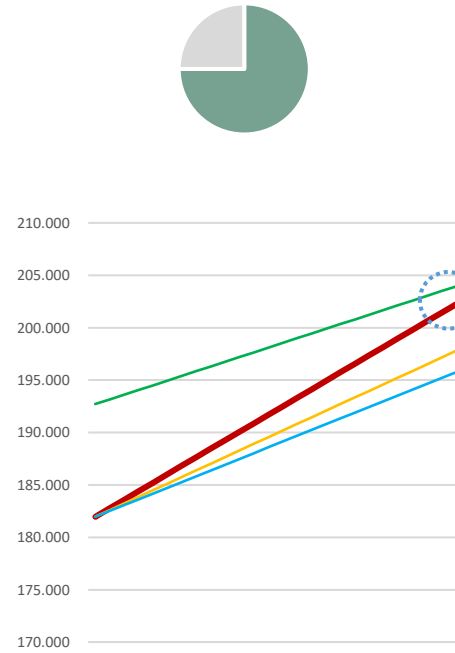
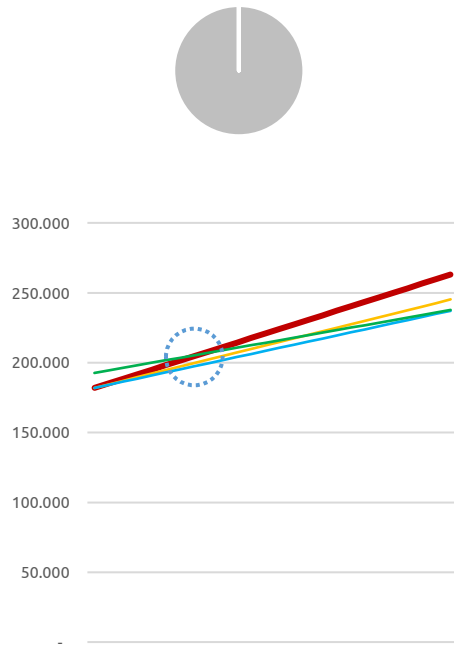


Fenestration Façade - Fifth case of analysis

Average grid decarbonisation _ From 100% fossil fuel to 25% of fossil fuel energy and 75% renewable energy in 25 years.



Key Findings



CO₂ IMPACT



Targeting both embodied and operational carbon

Targeting both embodied and operational carbon emissions for reduction together, rather than operational alone, a greater overall reduction should be achievable for a given cost in the long run.



*Operational
Carbon*



*Embodied
Carbon*



*Total
Carbon
Emissions*

Market Design Trends

With the current increase of WWR, it is clear that the embodied and operational impacts must be considered hand in hand to understand the whole life carbon impact of increasing (or decreasing) the WWR.



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Thank you!

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