

# Quantification and visualization of embodied impacts using Building Information Modelling

Presenter: **Martin Röck**, Graz University of Technology

Co-Authors: Alexander Passer, Graz University of Technology  
Guillaume Habert, ETH Zürich

Session title: Session 4.11: BIM for Sustainability (2)

Date: 6 June 2017, 16:30-18:00



Organisers:



International Co-owners:



# future in process...

EXPLORING SUSTAINABILITY,  
PARTICIPATION AND THE  
BUILDING LIFE CYCLE



Organisers:



International Co-owners:



Sustainable Buildings  
and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

[ ]

That's earth.  
That's us.



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



# what is...?

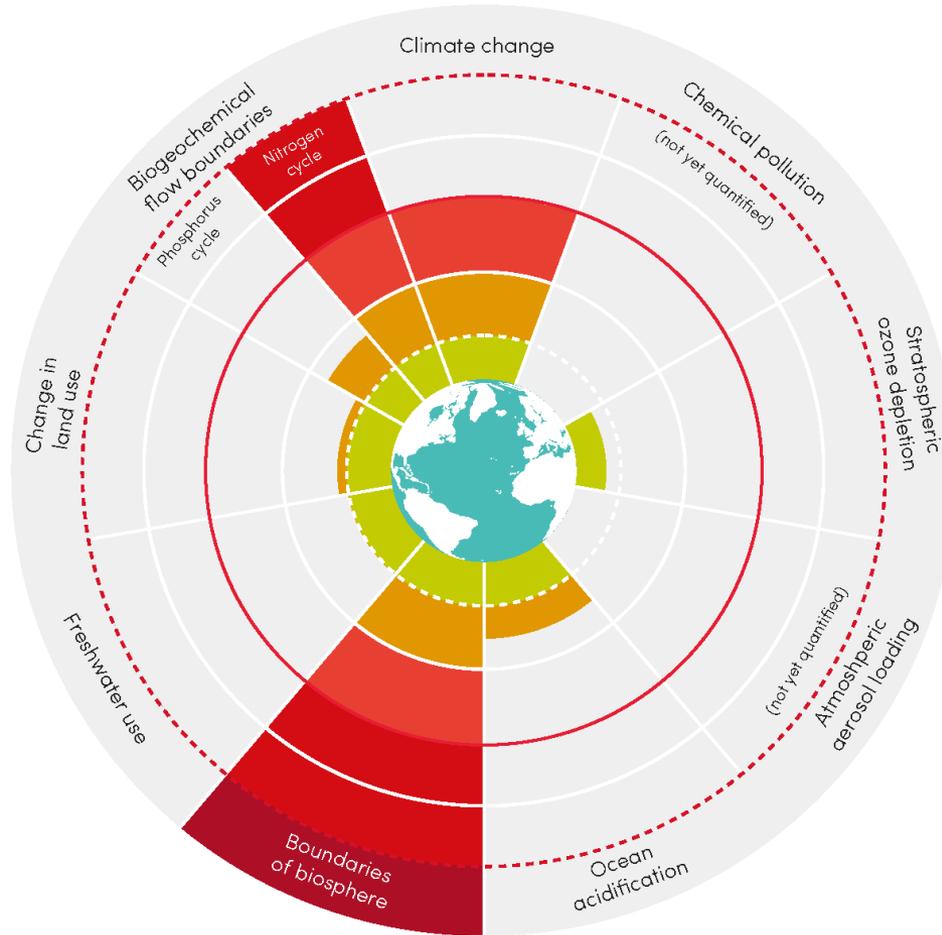


FIGURE ACC. TO  
ROCKSTRÖM ET AL,  
NATURE, 2009



Organisers:

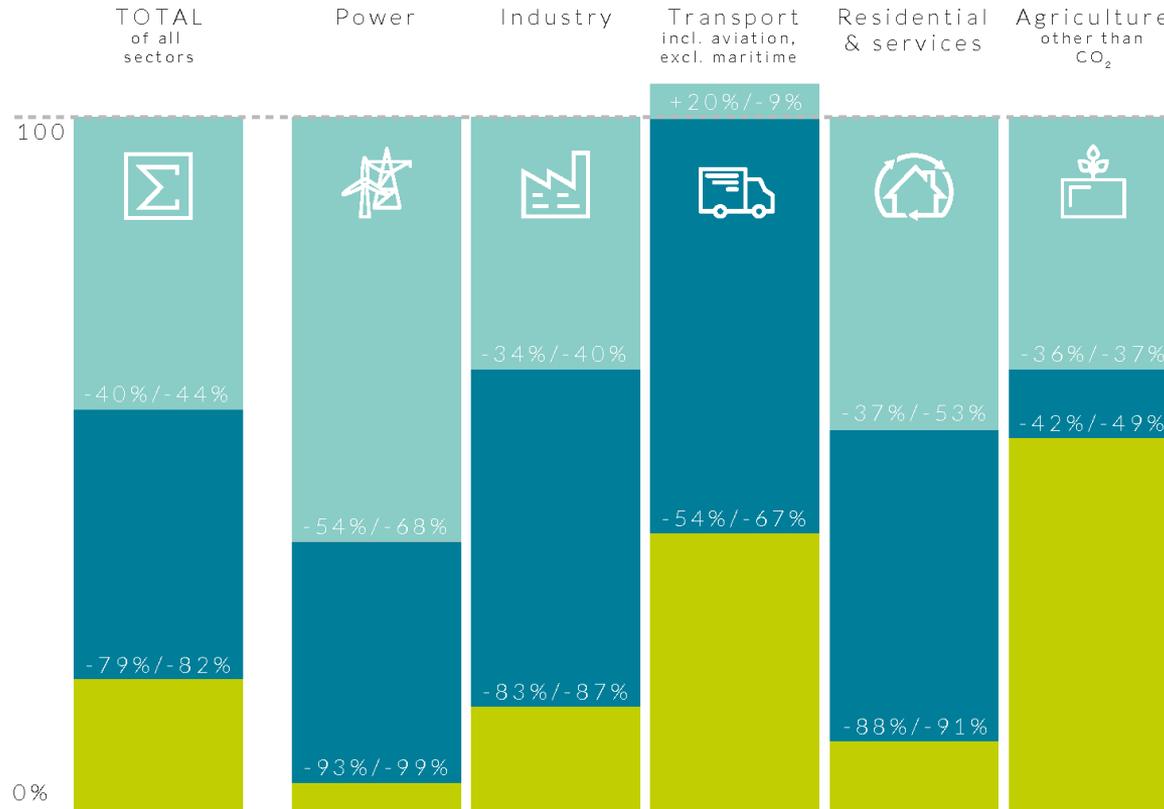


International Co-owners:



Global Alliance  
for Buildings and  
Construction

# what it also is...!



-- GHG emissions in 1990 [CO<sub>2</sub>eq] and reductions [%] until 2030, 2050

ACC. EUROPEAN COMMISSION, 2012



Organisers:



International Co-owners:



**challenge.**

## **How to integrate sustainability in the architectural design process?**



Organisers:



International Co-owners:

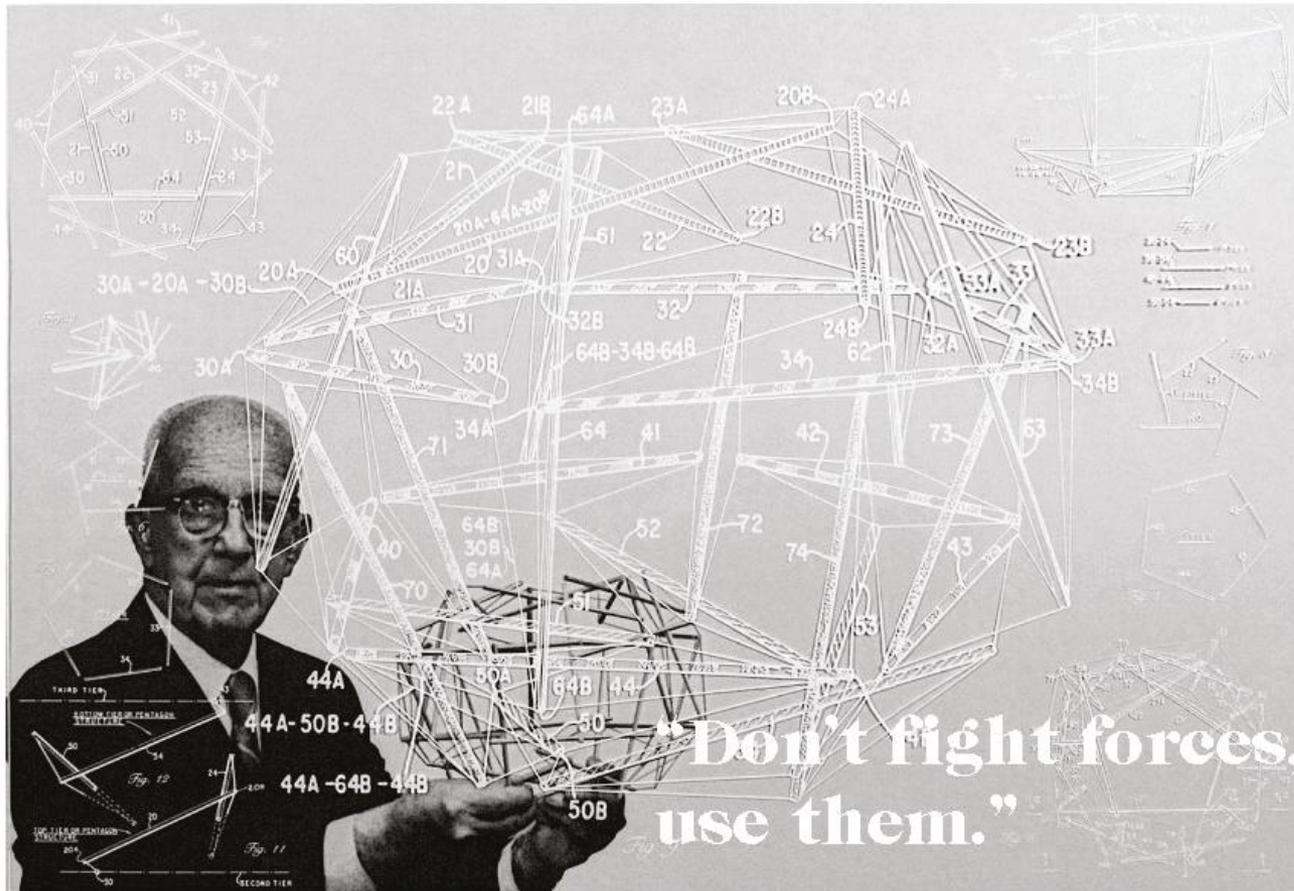


Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

**mindset.**



**“Don't fight forces,  
use them.”**

RICHARD BUCKMINSTER FULLER



Organisers:



International Co-owners:



**methods.**

## Participatory Design Process (PDP)



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

**methods.**

Participatory Design Process (PDP)

Environmental Life Cycle Assessment (LCA)



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



# methods.

Participatory Design Process (PDP)

Environmental Life Cycle Assessment (LCA)

Building Information Modelling (BIM)



Organisers:



International Co-owners:

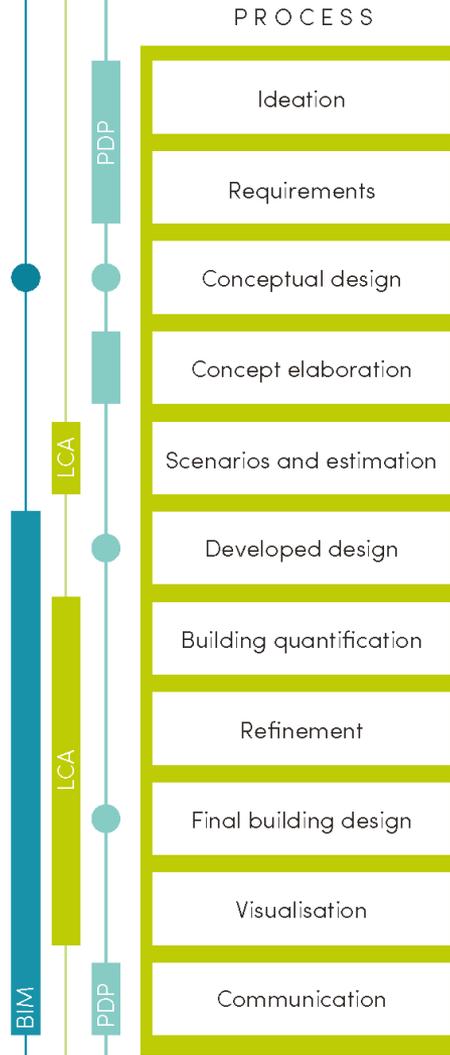


Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# process steps.



## SUSTAINABLE BUILDING DESIGN



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# participatory design process.



Organisers:



International Co-owners:



Sustainable Buildings  
and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

atmosphere.



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



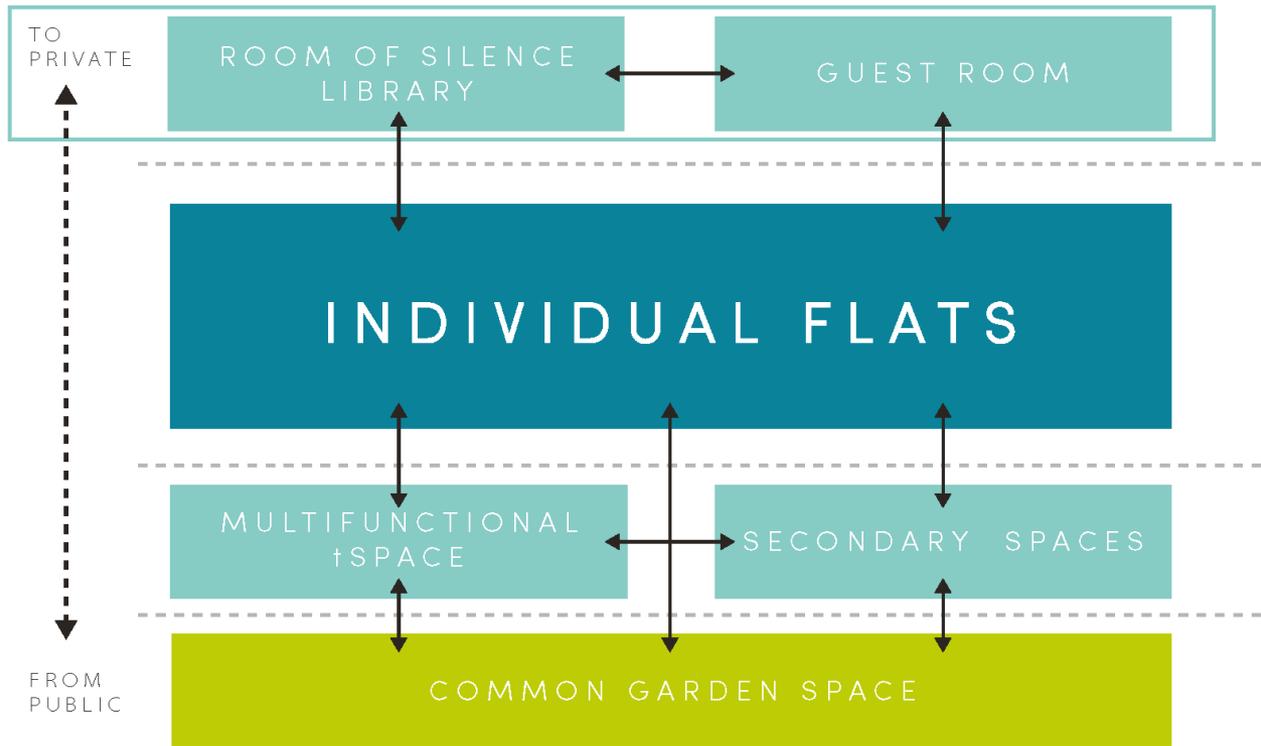
Global Alliance  
for Buildings and  
Construction

mood.





# spaces & relations.



Organisers:



International Co-owners:



research.

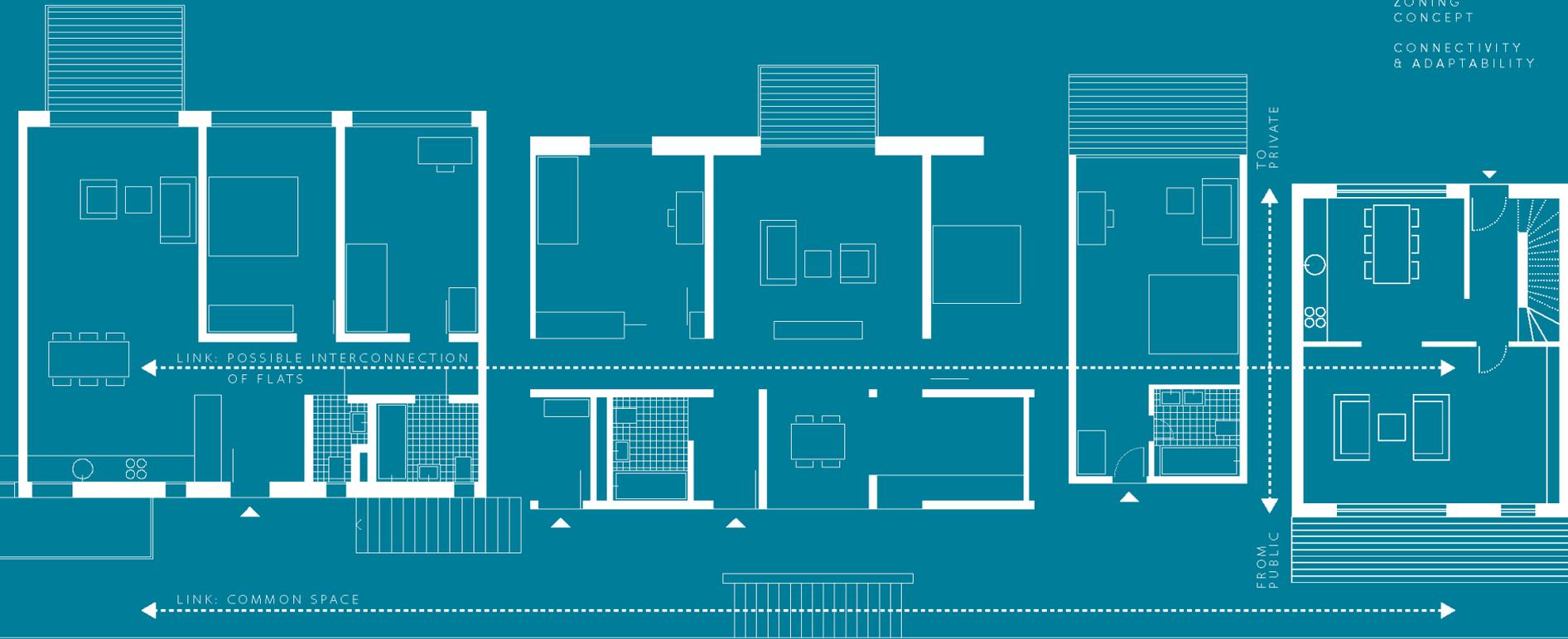
WHAT DOES  
A GOOD  
FLOORPLAN  
LAYOUT LOOK  
LIKE?

SPATIAL  
LAYOUT  
RESEARCH



# spatial concept.

ZONING  
CONCEPT  
CONNECTIVITY  
& ADAPTABILITY



Organisers:

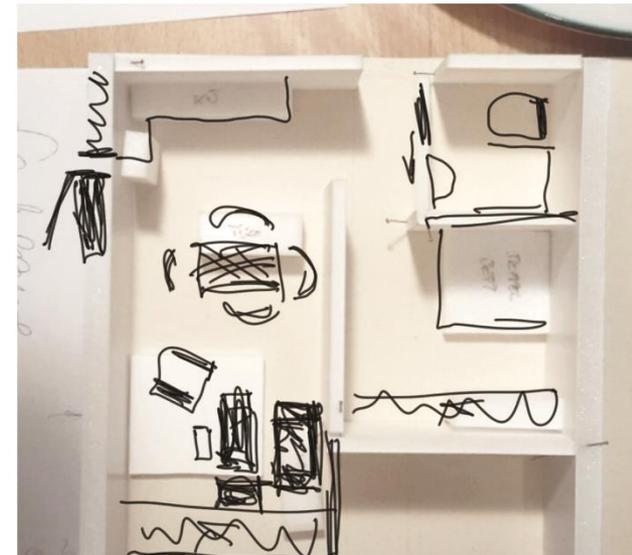
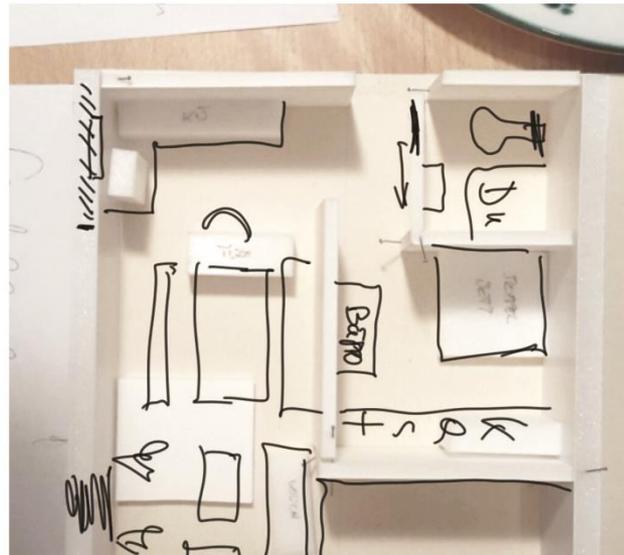
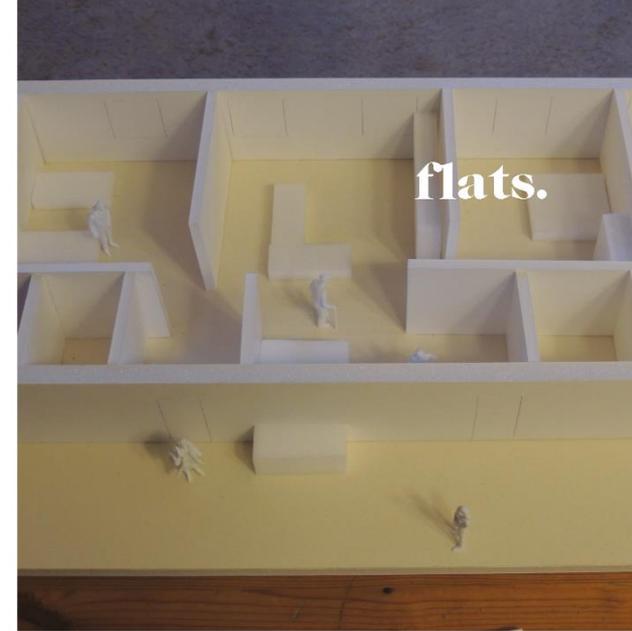
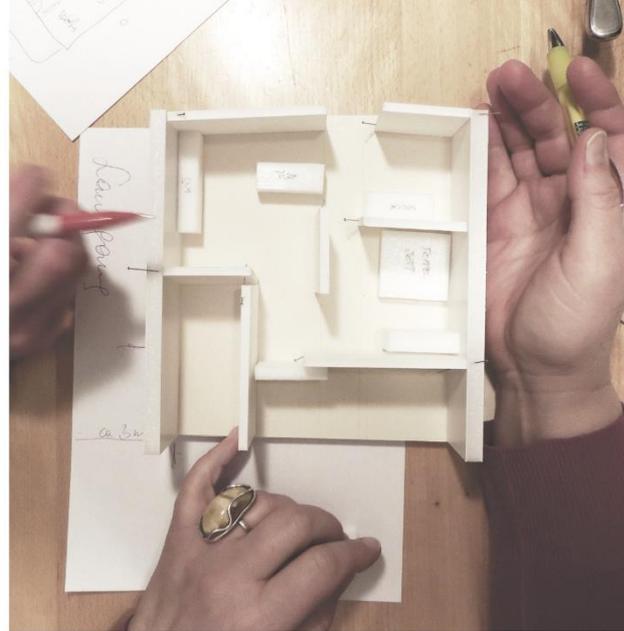


International Co-owners:

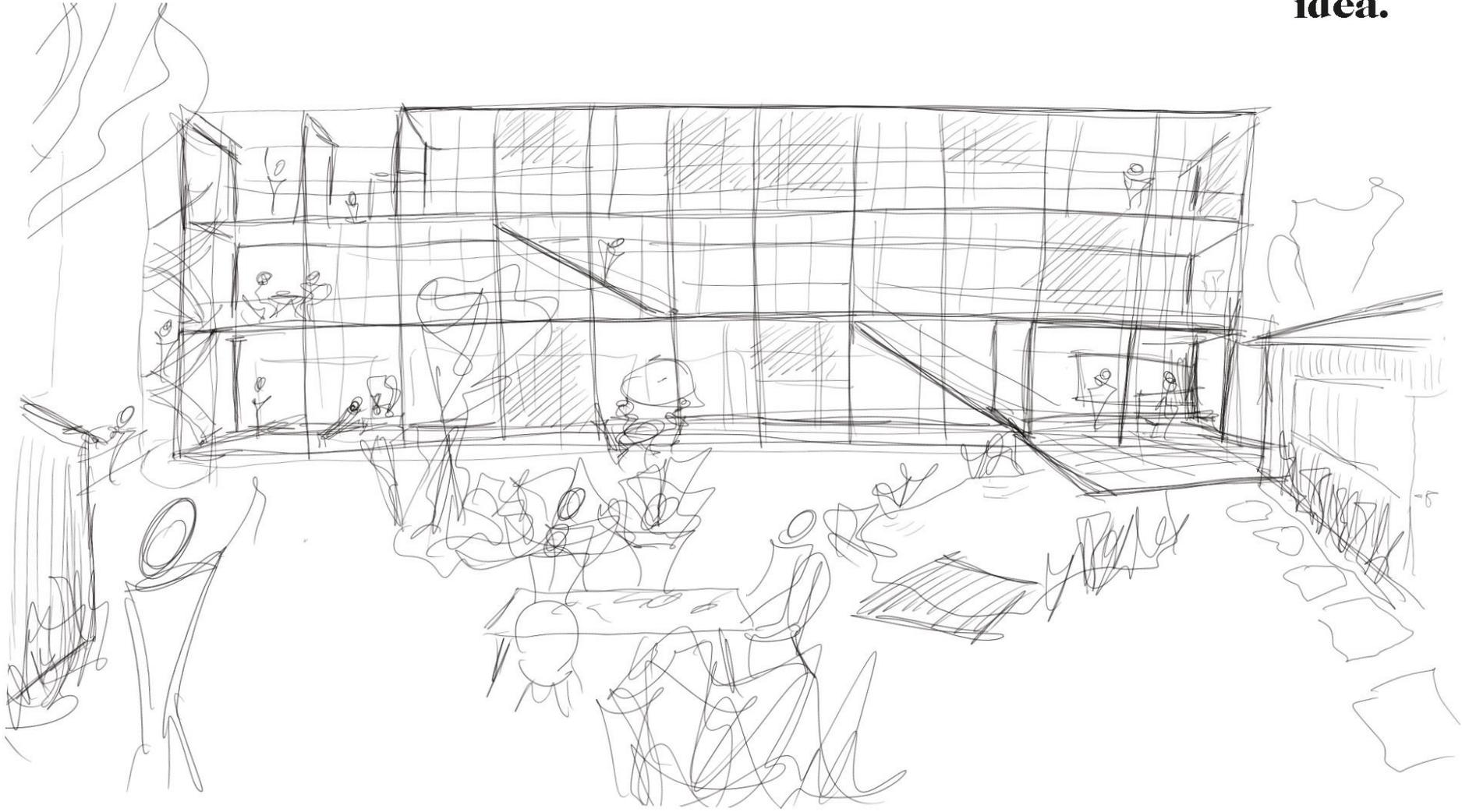


# co-housing sufficient and affordable

- small  
1-2 people  
40-65 m<sup>2</sup>
- medium  
2-3 people  
65-95m<sup>2</sup>
- large  
3+ people  
95-130m<sup>2</sup>



**idea.**



Organisers:



International Co-owners:



# What about the environment? How do we know what's "good"?



Organisers:



International Co-owners:



# life cycle assessment.



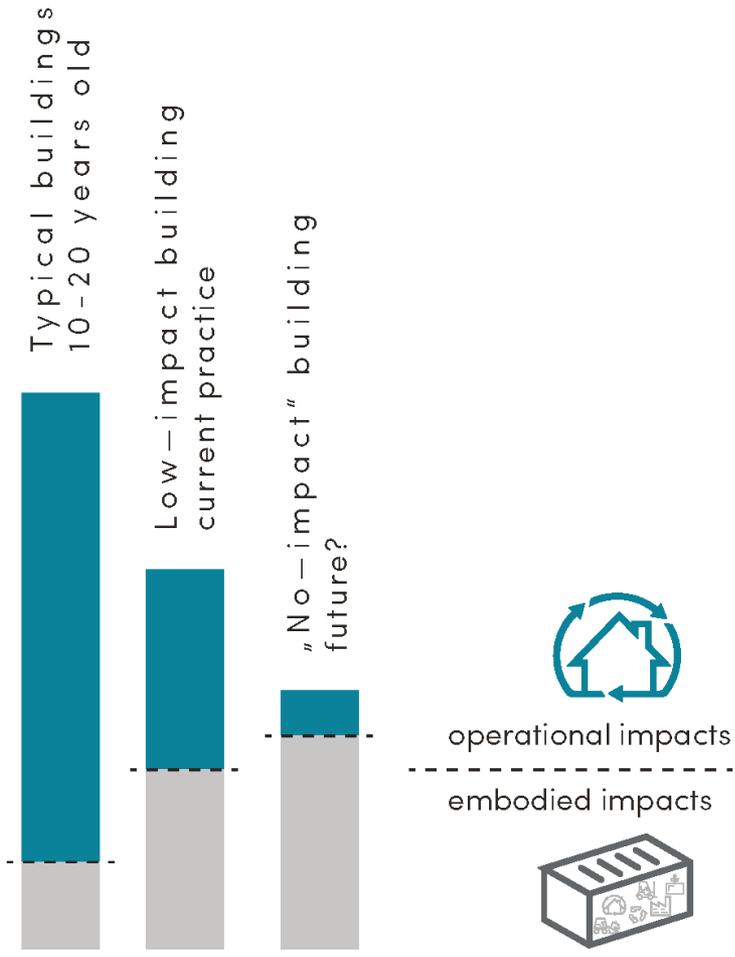
Organisers:



International Co-owners:



# design relevance.



operational impacts

embodied impacts



# building information modelling.



Organisers:



International Co-owners:



**dimensions.**

3D  
Geometry



Model



Organisers:



International Co-owners:

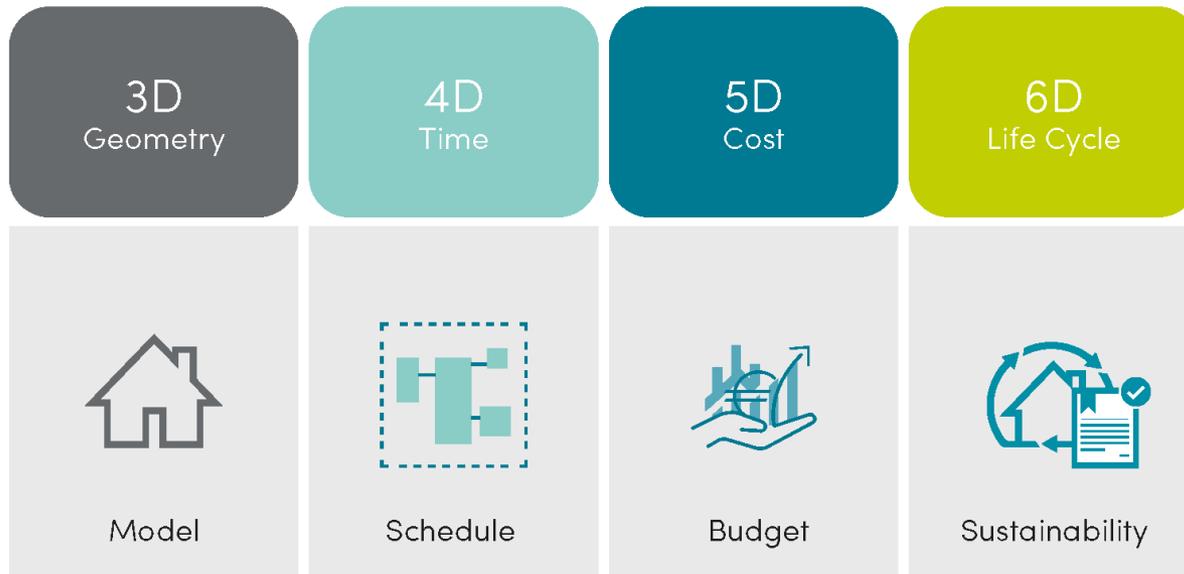


Sustainable Buildings  
and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# dimensions.



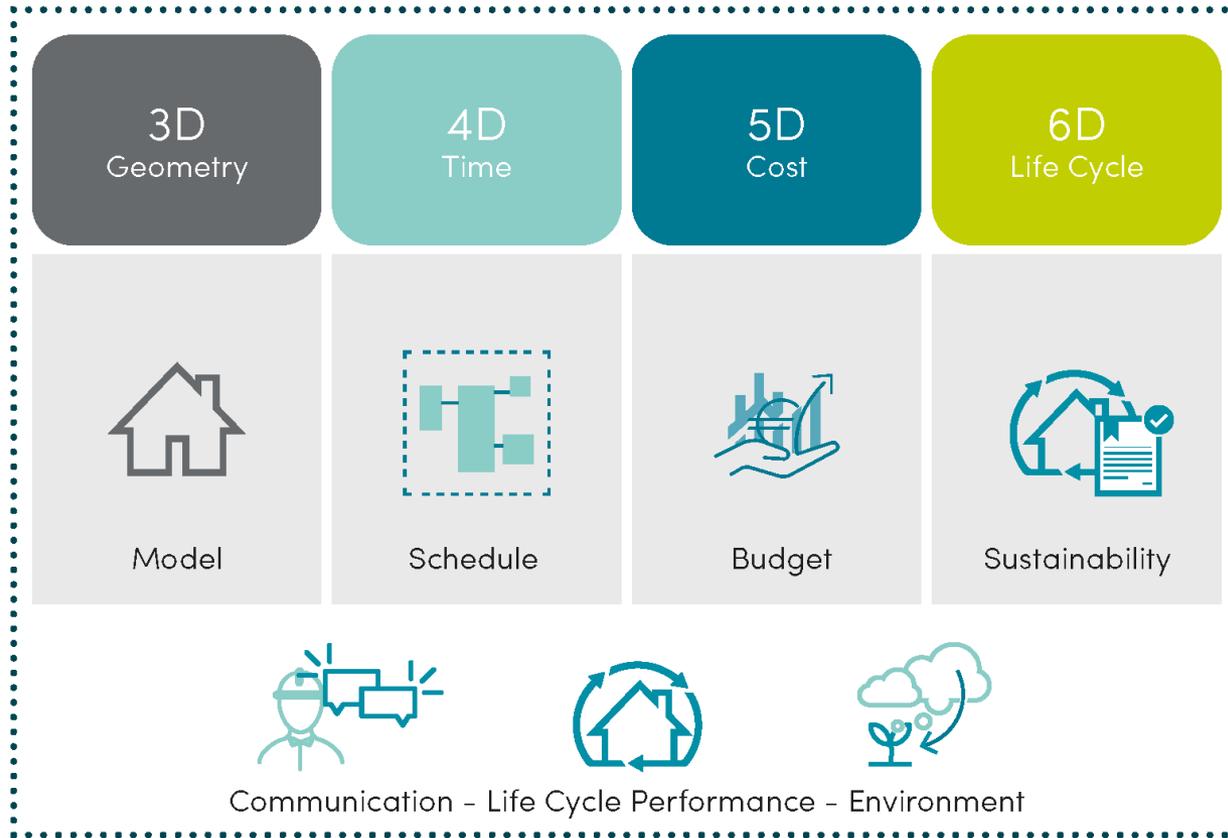
Organisers:



International Co-owners:



**dimensions.**



Organisers:



International Co-owners:



**workflow.**

Design



Organisers:



International Co-owners:

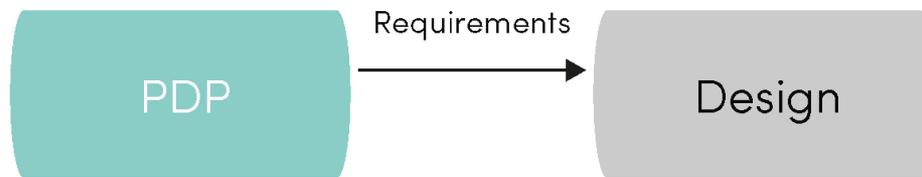


Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# workflow.



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# workflow.



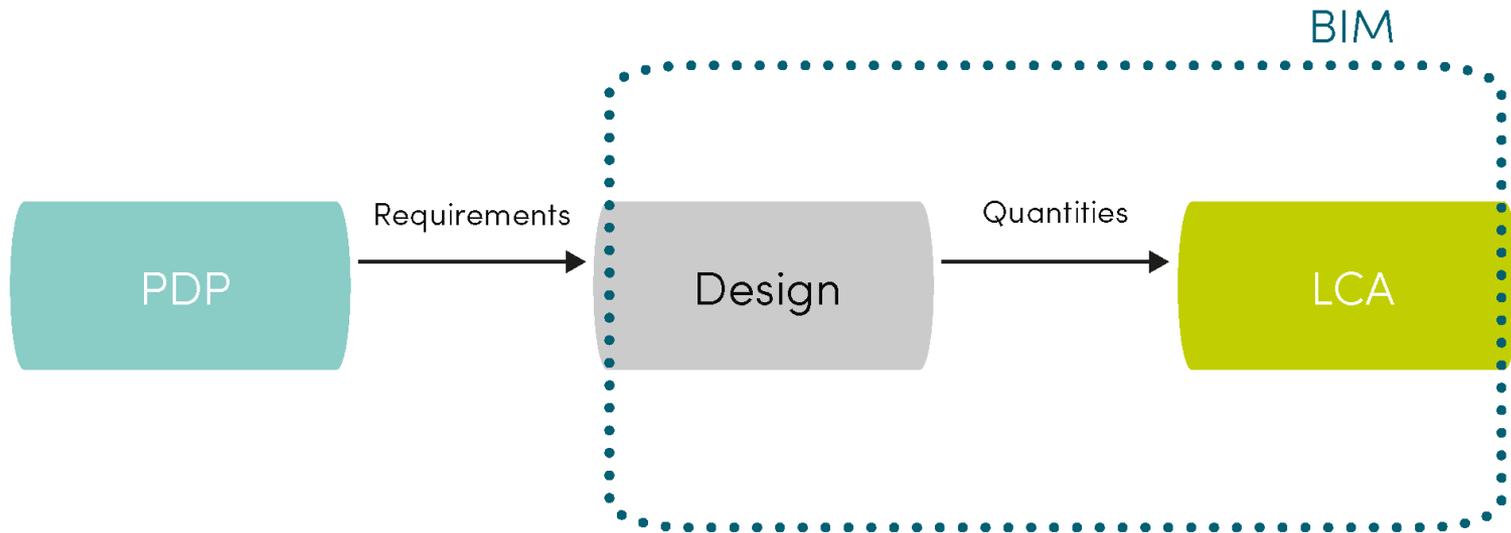
Organisers:



International Co-owners:



# workflow.



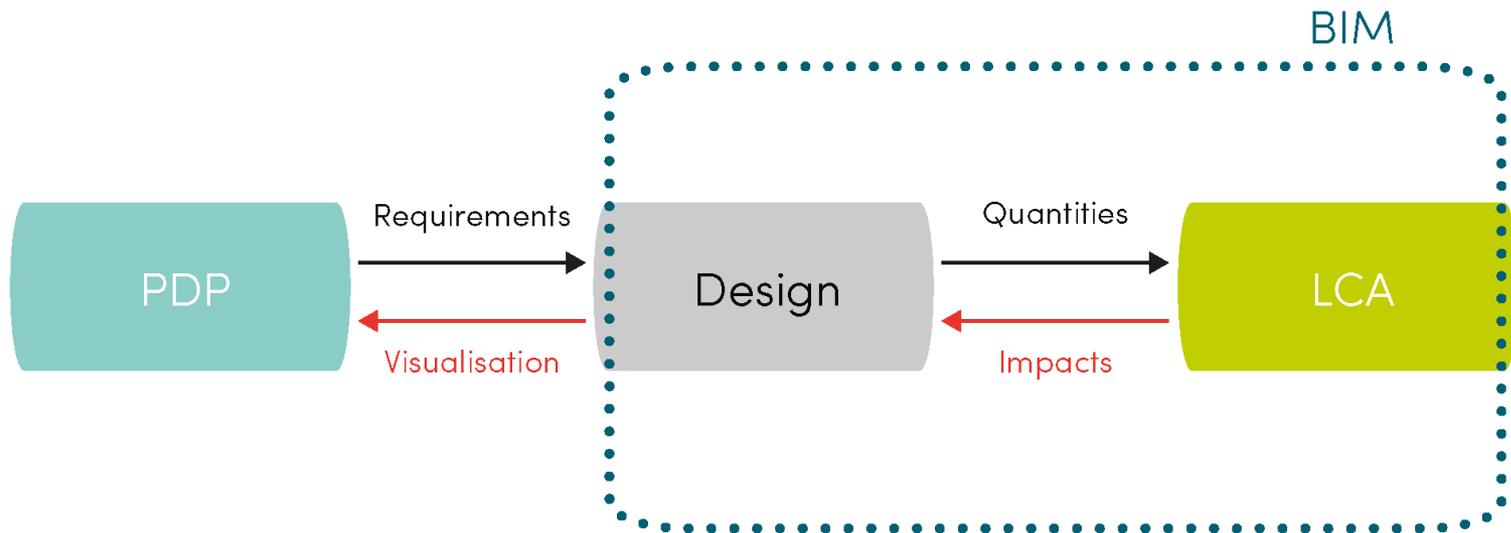
Organisers:



International Co-owners:



# workflow.



Organisers:



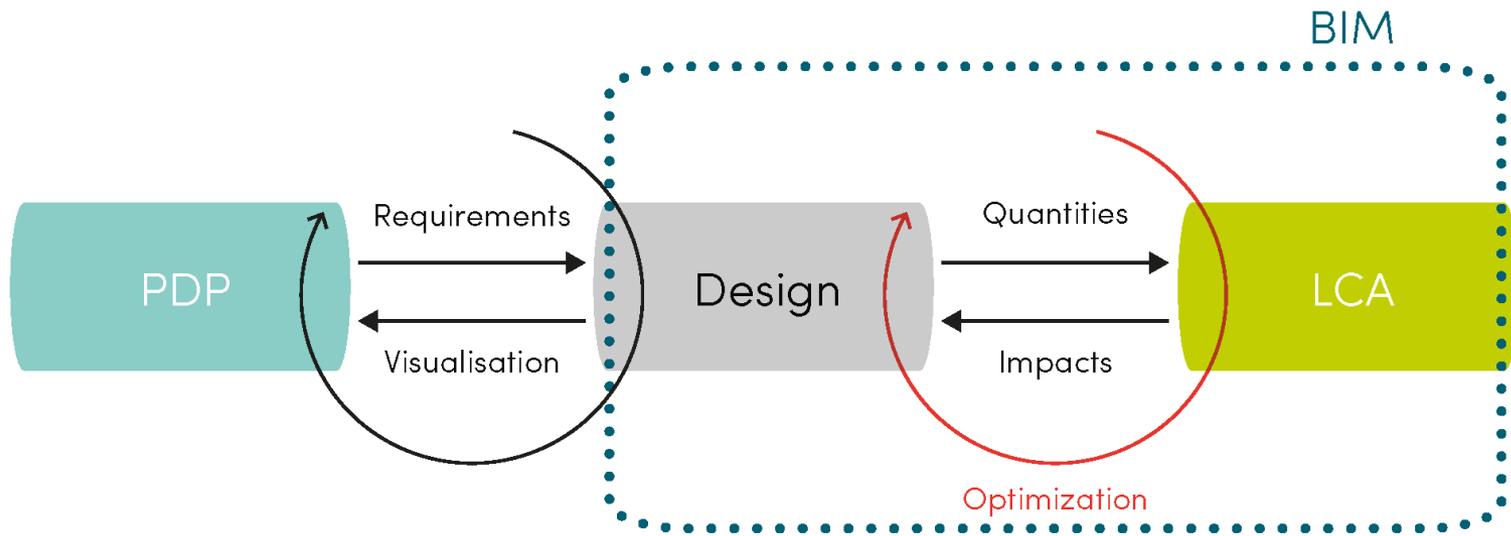
International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



# workflow.



**results.**



Organisers:



International Co-owners:

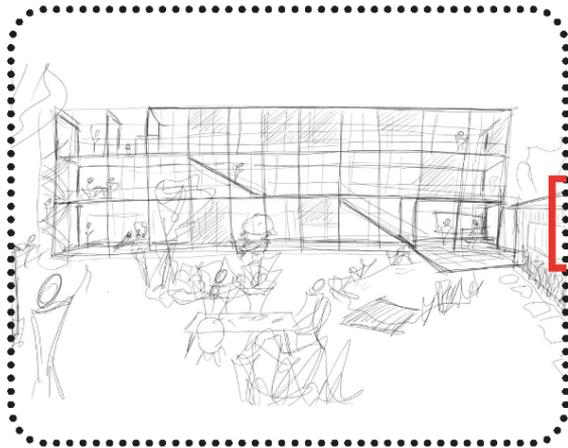


Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability

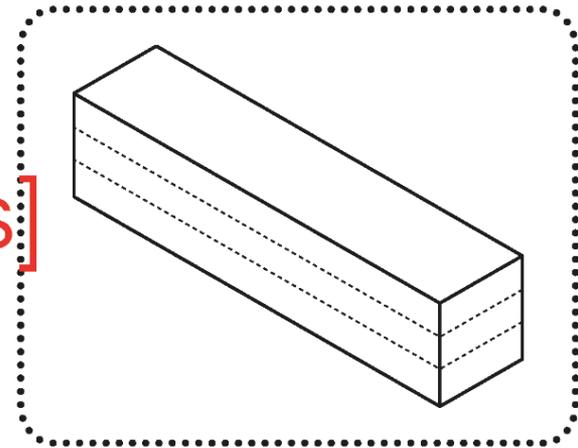


Global Alliance  
for Buildings and  
Construction

**assessment.**



[m<sup>2</sup>]  
[functions]  
[shape]



...

Organisers:

International Co-owners:

# scenario analysis.

Construction Profile

Energy Standard

Energy Mix



Organisers:

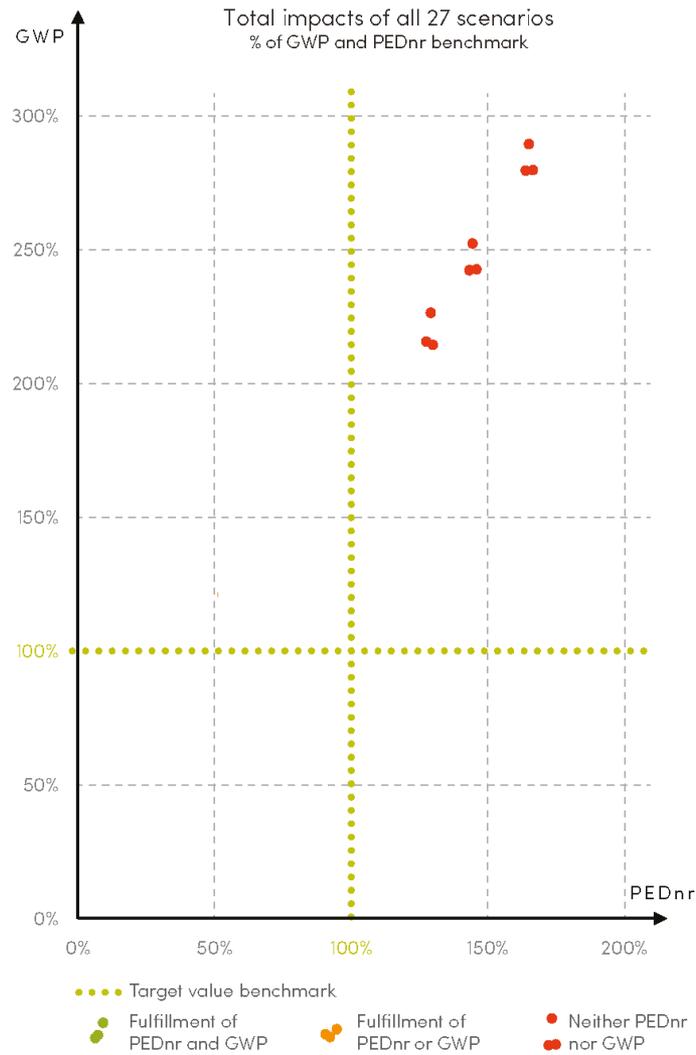


International Co-owners:



conventional  
oil, gas, grid EU

# scenario results.



Organisers:



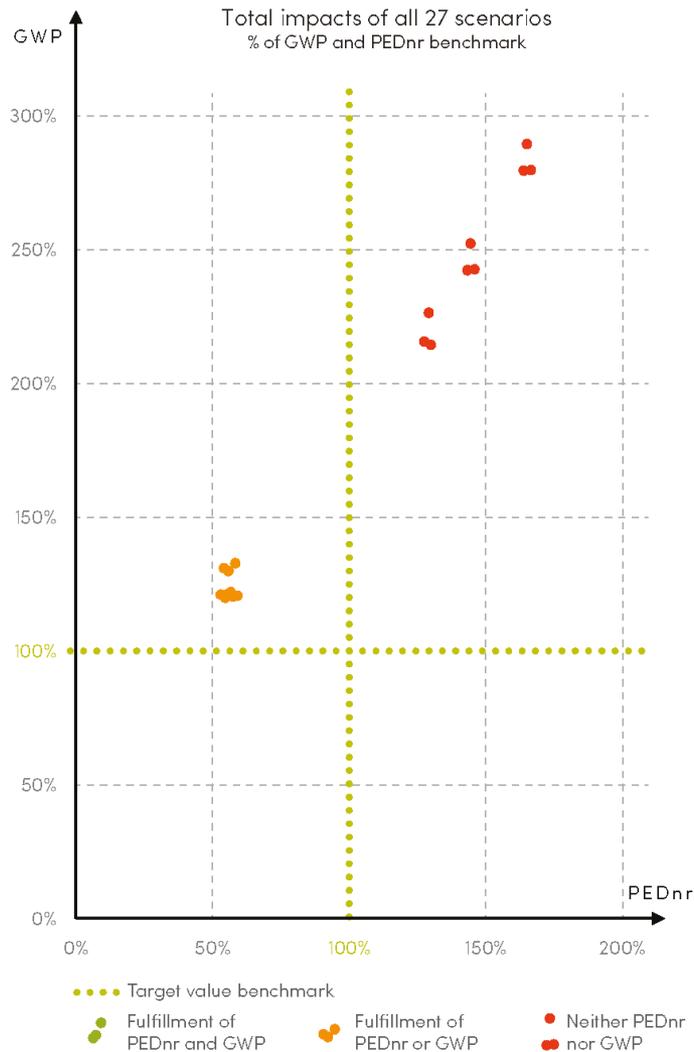
International Co-owners:



conventional  
oil, gas, grid EU

renewable  
biomass, grid AT

# scenario results.

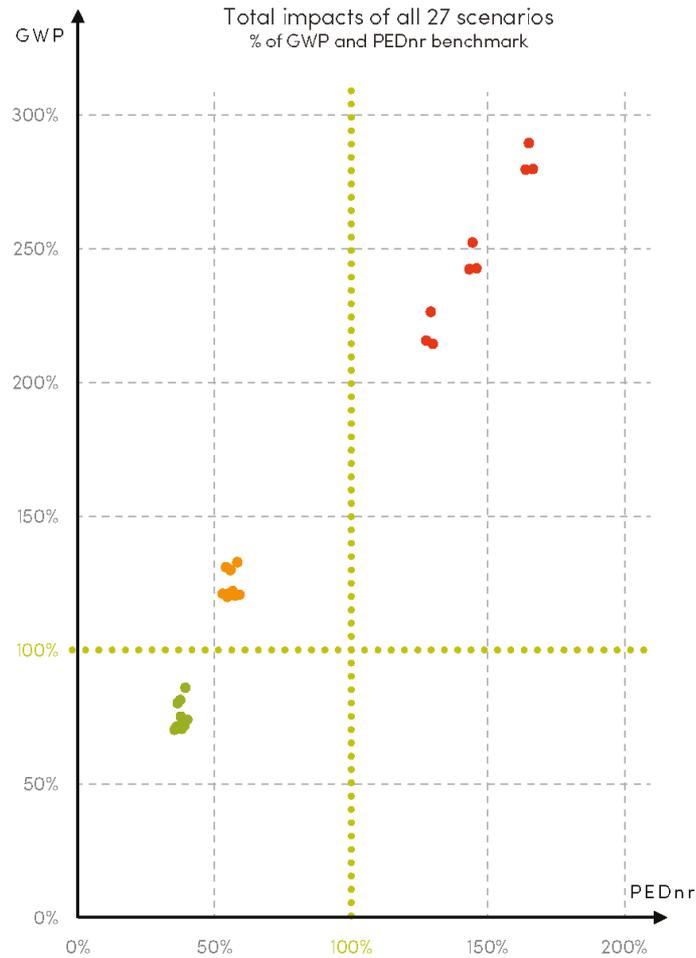


# scenario results.

conventional  
oil, gas, grid EU

renewable  
biomass, grid AT

renewable  
HP, PV own/grid



- Target value benchmark
- Fulfillment of PEDnr and GWP
- Fulfillment of PEDnr or GWP
- Neither PEDnr nor GWP
- Neither PEDnr nor GWP

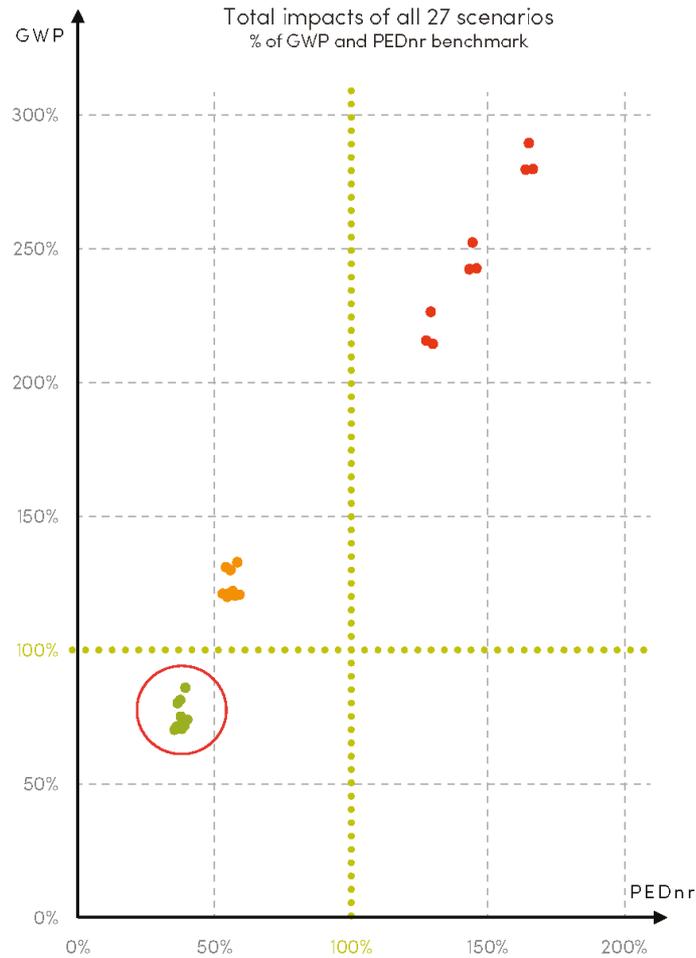


# scenario results.

conventional  
oil, gas, grid EU

renewable  
biomass, grid AT

renewable  
HP, PV own/grid



- Target value benchmark
- Fulfillment of PEDnr and GWP
- Fulfillment of PEDnr or GWP
- Neither PEDnr nor GWP
- Neither PEDnr nor GWP



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability

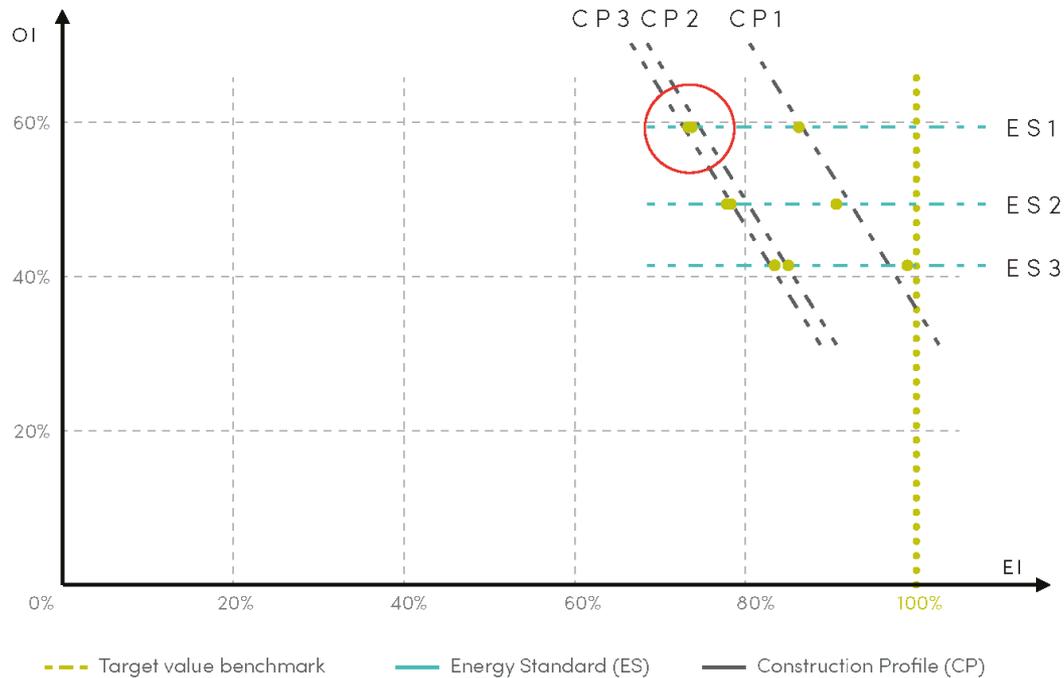


Global Alliance  
for Buildings and  
Construction

# scenario results.

construction profile  
& energy standard

Embodied and operational impacts of scenarios 19-27 (all EM3)  
% of GWP benchmark



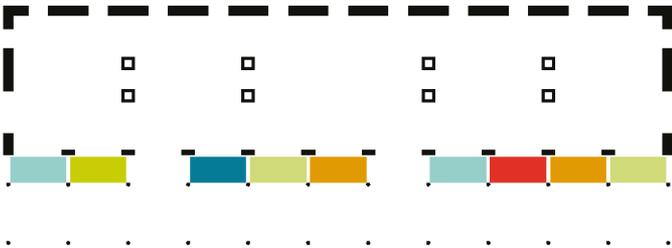
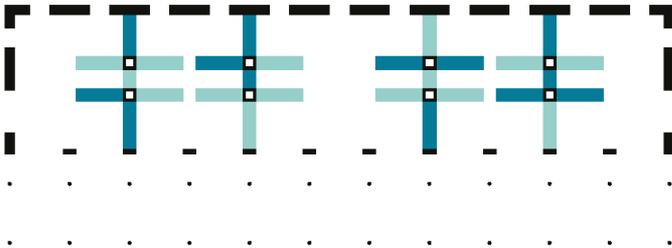
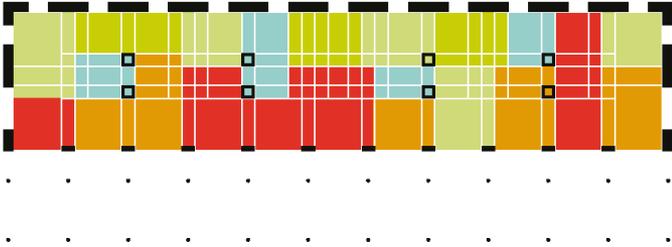
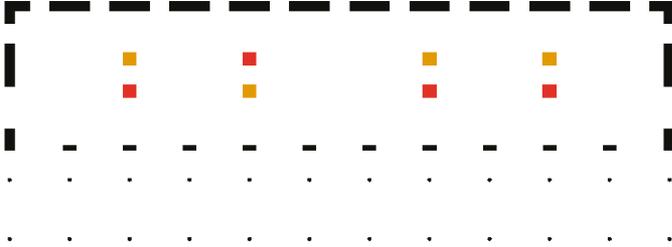
Organisers:



International Co-owners:



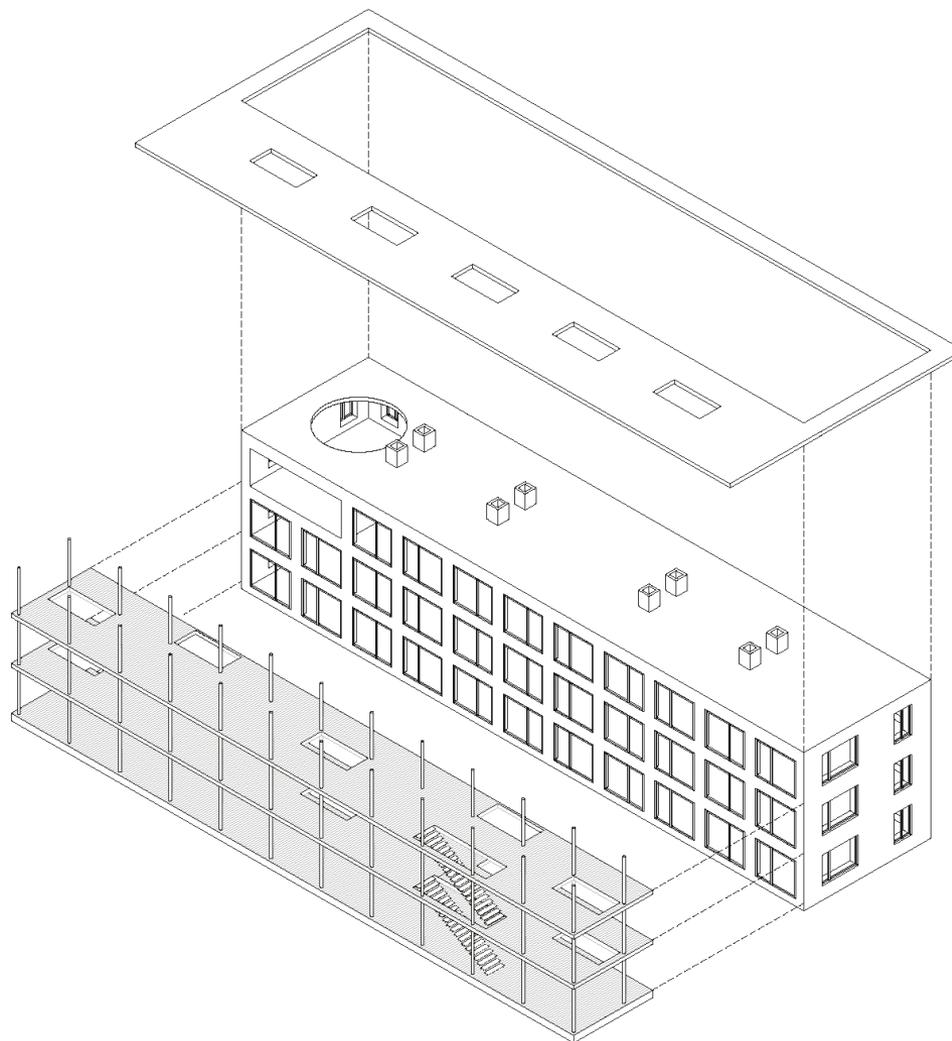
# spatial concept.



International Co-owners:



**model.**



Organisers:



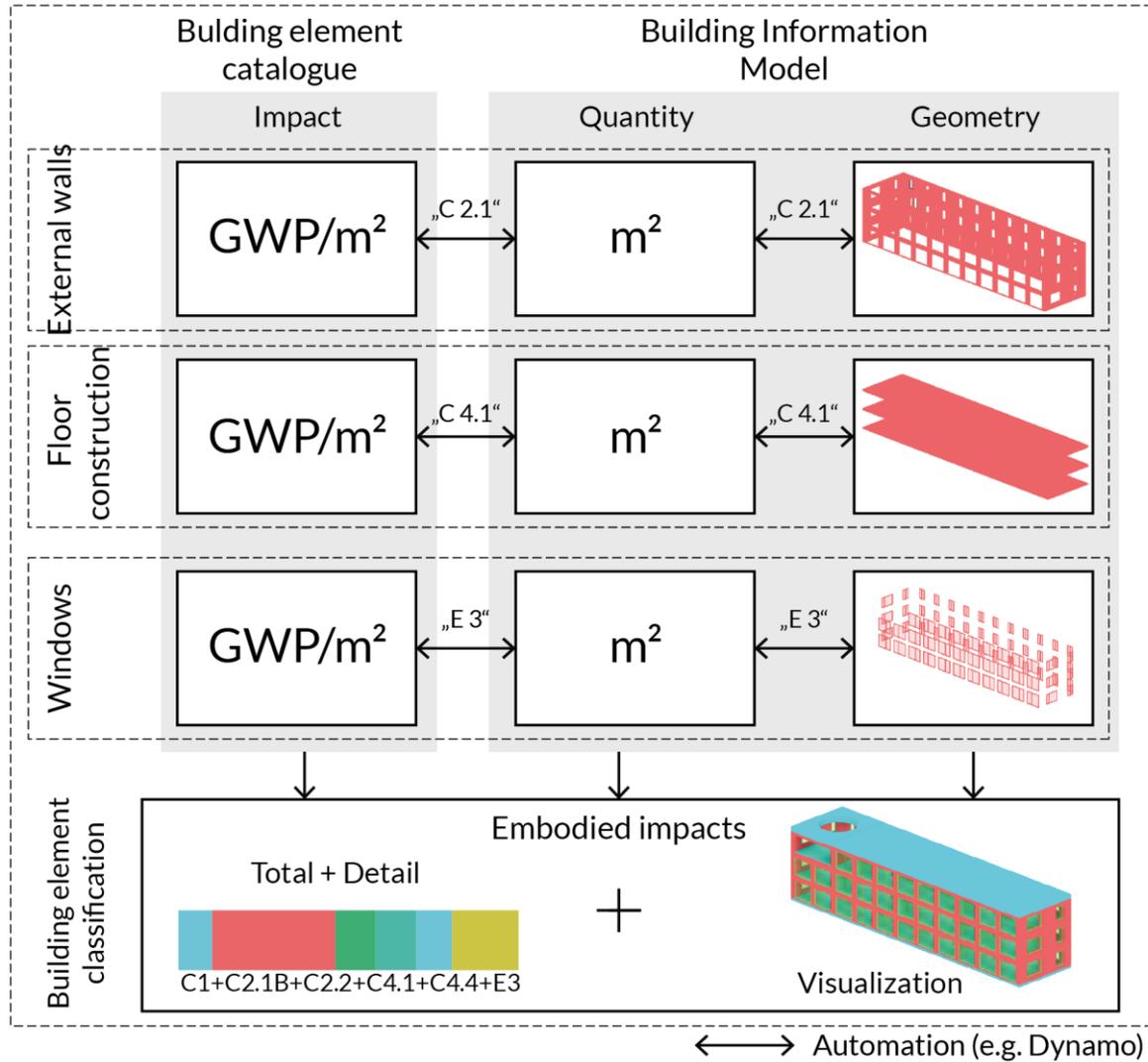
International Co-owners:



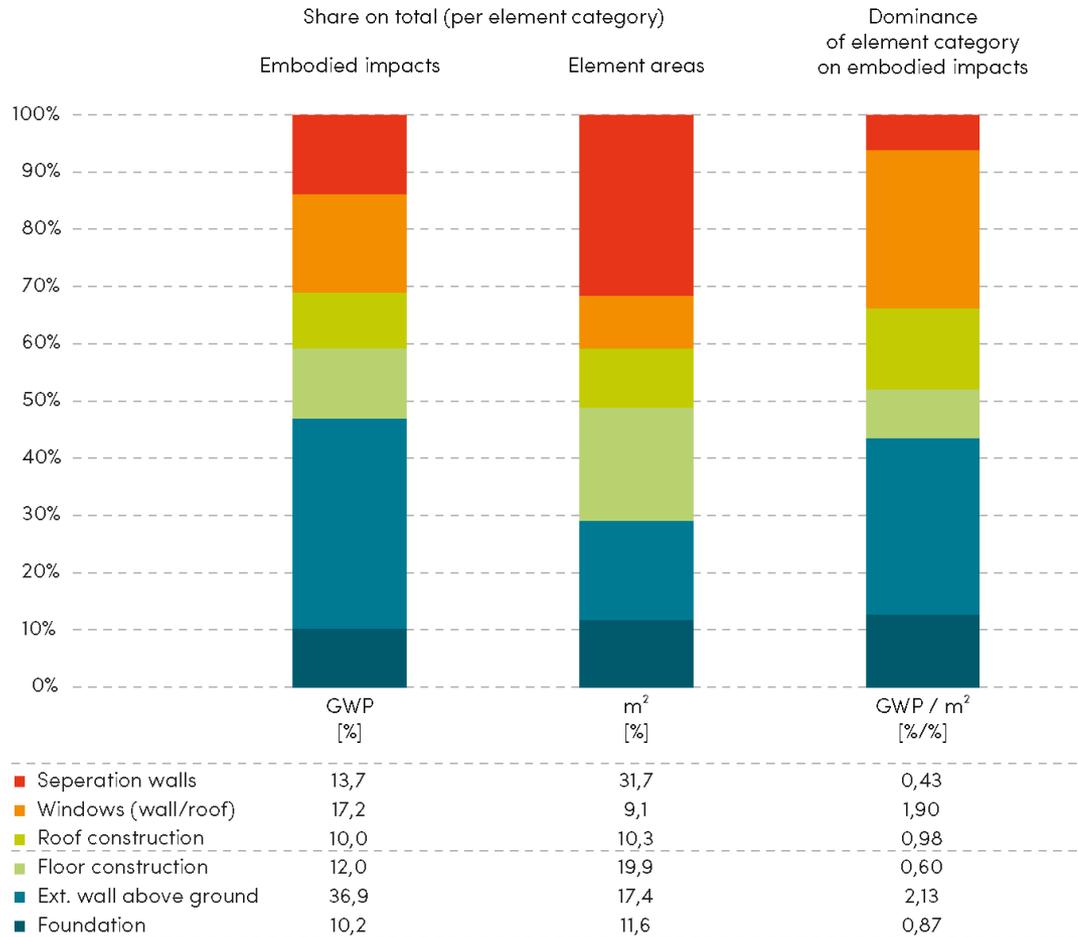
Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



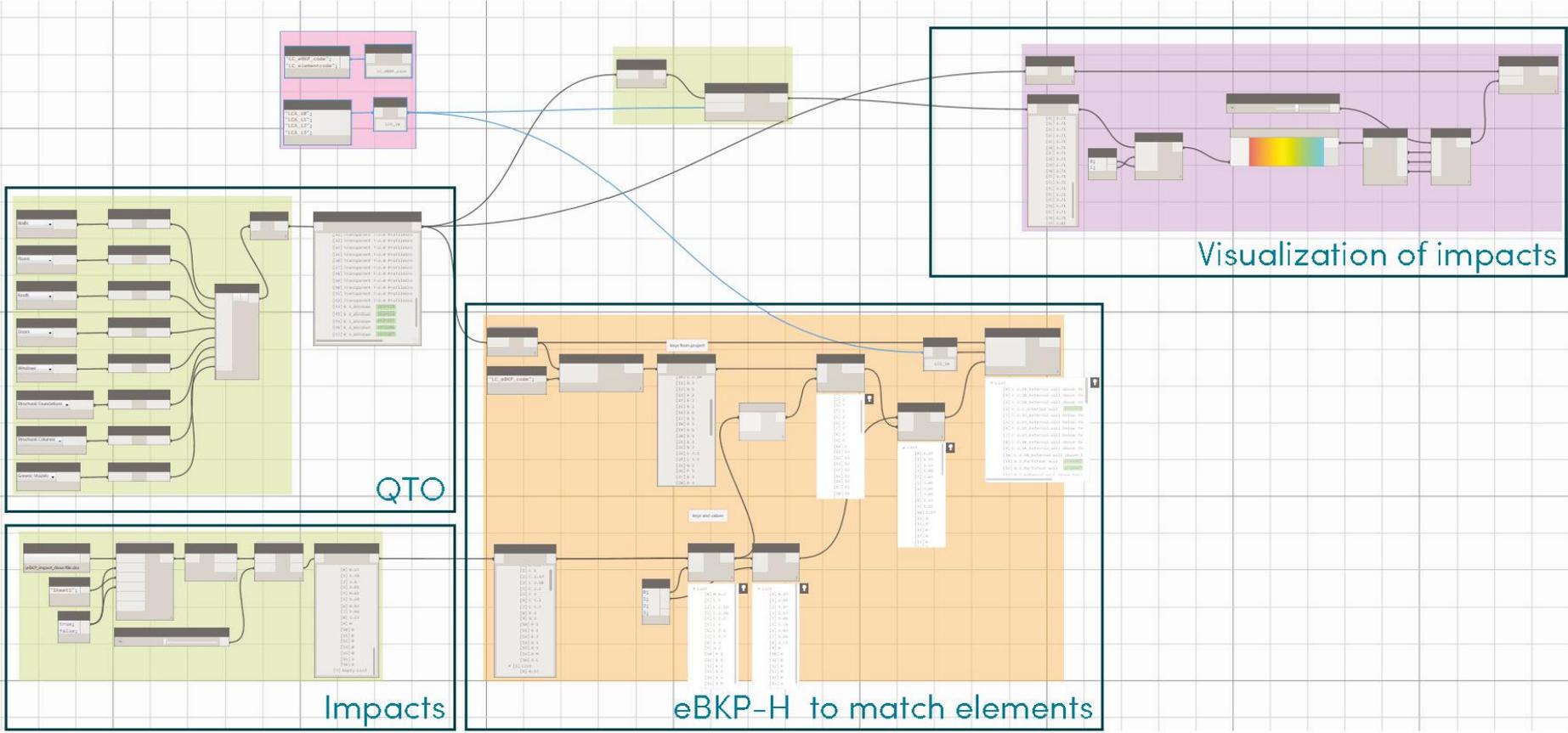
Global Alliance  
for Buildings and  
Construction



# detailed results.



# automation.

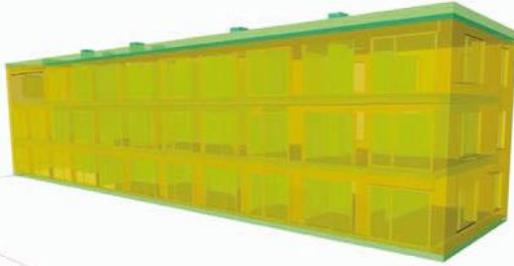


VISUAL SCRIPTING  
IN DYNAMO / REVIT



# visualisation.

1:



Embodied impacts (GWP) per building element area.  
[kgCO<sub>2</sub>eq/m<sup>2</sup>]

3:



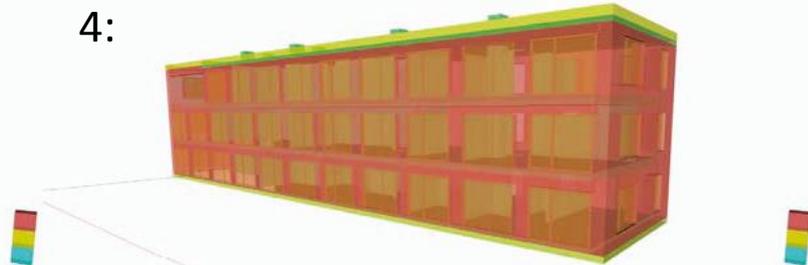
Share of element category on total embodied impacts.  
[% of total GWP]

2:



Share of element category on quantified areas.  
[% of total m<sup>2</sup>]

4:



Dominance of element category on assessment results.  
[% total m<sup>2</sup> to % total GWP]

EMBODIED IMPACTS PER BUILDING ELEMENT, SHARE ON TOTAL EMBODIED IMPACTS AND AREAS. DOMINANCE ANALYSIS OF BUILDING ELEMENTS.

**community.**



Organisers:



International Co-owners:



**community.**



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

**conclusion.**



Let's take the challenge



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

**conclusion.**



Let's take the challenge

Use the tools



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# conclusion.



Let's take the challenge

Use the tools



Building life cycle



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# conclusion.



Let's take the challenge

Use the tools



Building life cycle

Embrace sustainability



Organisers:



International Co-owners:



## conclusion.



Let's take the challenge

Use the tools



Building life cycle

Embrace sustainability



Design quality matters

**Martin Röck**

Working Group Sustainability Assessment

Graz University of Technology

[martin.roeck@tugraz.at](mailto:martin.roeck@tugraz.at)

[agnhb.tugraz.at](http://agnhb.tugraz.at)

# Thank you



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction