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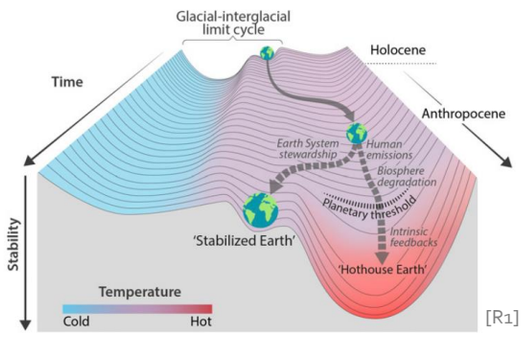
BUILDING FUTURE(S)

Environmental modelling of buildings and building stock dynamics for supporting active development within environmental boundaries

Context

Ecosystem Crises require Earth System Stewardship

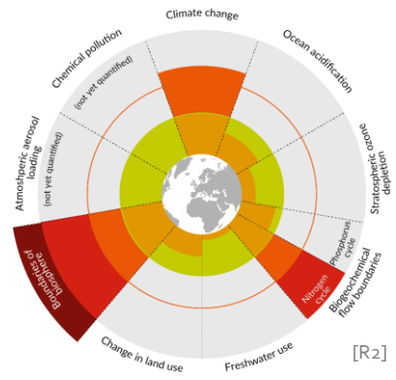
- Global agreement: World agreed to tackle the climate crisis by reducing GHG emissions to stay 'well below 2°C' (COP24).
- Sense of urgency: Feedback loops create real danger of ‚Hothouse Earth' state lock-in if action is delayed.
- Earth System Stewardship: We aim for reducing GHG emissions to net-zero to ensure long-term ‚Stabilized Earth'.



[R1]

Development within the Safe Operating Space

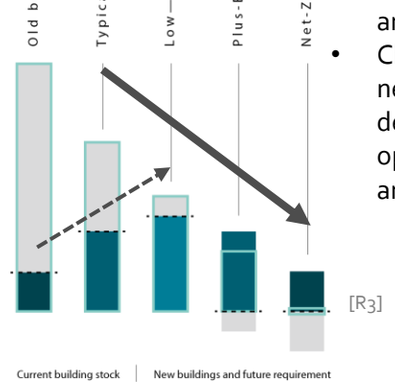
- It is a global challenge to adapt to climate change effects while at the same time staying within GHG emission budgets.
- Beyond GHG emissions, it is important to consider wider environmental implications, e.g. Planetary Boundaries.
- Challenge: To enable transition and long-term development of human societies within the 'safe operating space'.



[R2]

Buildings and Construction to transition to Net-Zero

- Construction and operation of buildings account for ~40% of global GHG emissions.
- Target: 'Net-zero' GHG emissions across across the full building life cycle (construction and operation).
- Challenge: Ensure transition to net-zero and long-term development within safe operating space for both new and existing buildings (stock).



[R3]

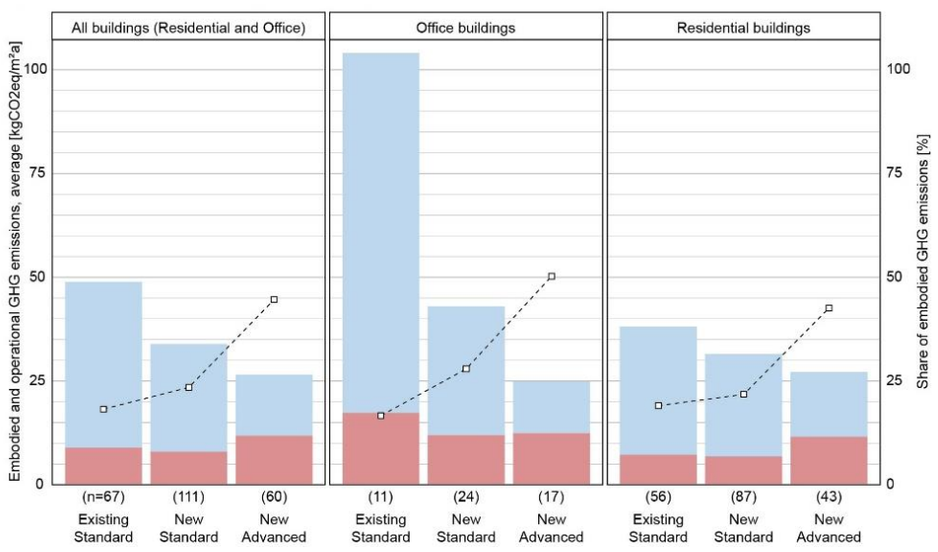
Research questions

1. What are the **environmental targets for 'buildings'** during transition and long-term?
   a. How can we define environmental budgets for buildings based on top-down targets?
   b. What are the environmental budgets for buildings and building stocks?
2. Which **building design features and strategies** enable meeting environmental targets?
   a. Which design strategies and features provide environmental benefits in current building practice?
   b. How can technological and social innovation further improve environmental performance?
3. How can we use the findings to test **scenarios for building stock development** within environmetal limits?
   a. How can we use the environmental data of buildings for modelling building stock development scenarios?
   b. What are the environmental synergies and trade-offs when applying promising building design strategies at macro-scale?

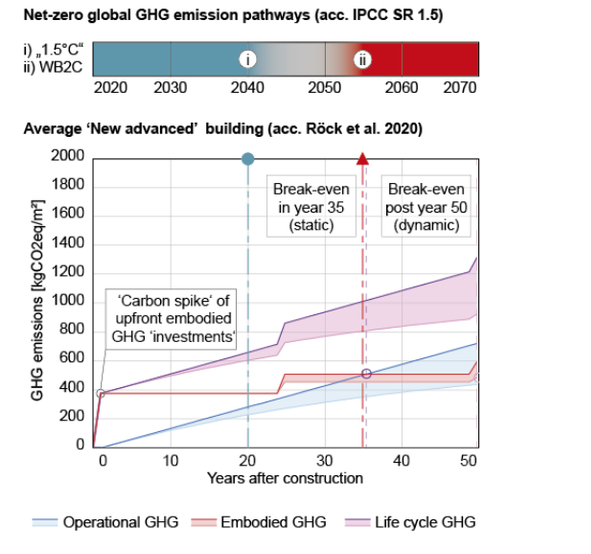
Results

Meta-study: Embodied GHG emissions: The hidden challenge for effective climate change mitigation [Röck et al. 2020]

- Method
  - Systematic analysis of 650+ building LCA cases, synthesis from 238 building results, harmonized (per m²GFA, RSP 50 years), categorized (by energy performance).
- Findings
  - Life cycle GHG emissions have reduced due to energy efficiency improvements. Meanwhile, embodied GHG emissions increased, now dominating the life cycle [see F1].
  - Upfront embodied GHG emissions lead to carbon spike (materials production) and dominate the first ~30 years (timeframe for effective climate change mitigation) [see F2].
  - Optimisation of full building life cycle is required to achieve net-zero GHG emissions within carbon budgets [see F3].



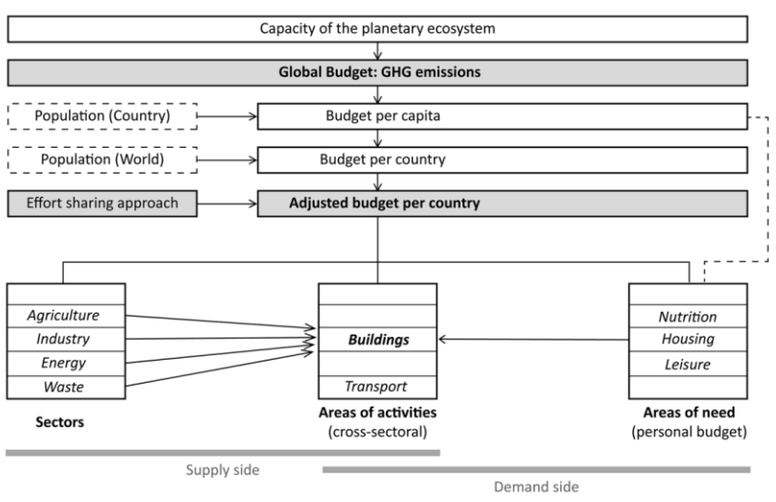
[F1]: Global trends of GHG emissions across the life cycle of buildings, for different building types, differentiated by energy performance class.



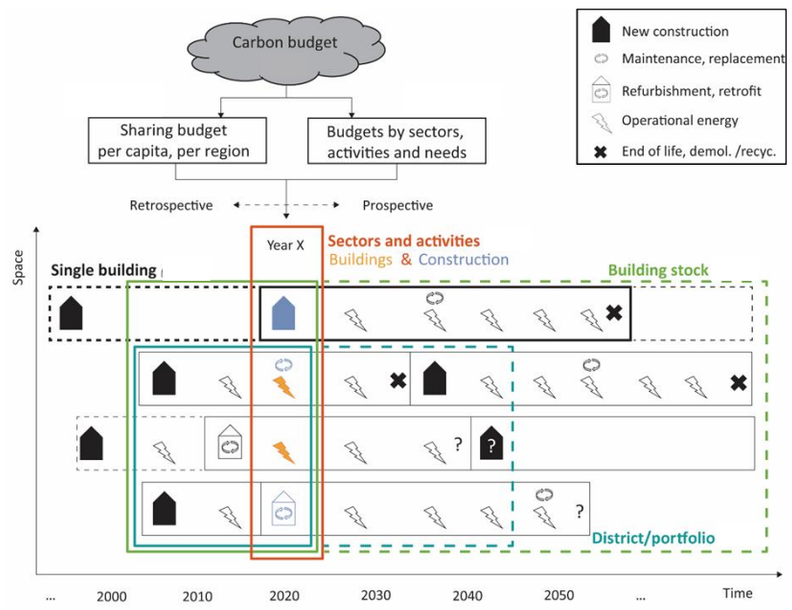
[F2]: Climate targets and temporal distribution of GHG emissions in the building life cycle.

Synthesis: Carbon budgets for buildings: harmonising temporal, spatial and sectoral dimensions [Habert et al. 2020]

- Context
  - Target values for creating carbon budgets for buildings are important for developing climate-neutral building stocks.
- Findings
  - A framework is proposed to accommodate these different perspectives and spatio-temporal scales towards harmonised and comparable cross-sectoral budget definitions [see F3].
  - This analysis highlights the crucial need to define the temporal scale, the roles of buildings as physical artefacts and their economic activities [see F4].
  - This will assist regulators and building design decision makers to coordinate and incorporate their specific responsibility at different levels or scale of activity to ensure overall compliance.



[F3]: Different points of view for defining budgets across activities. The industry sector includes construction product industry, construction industry and real estate industry.

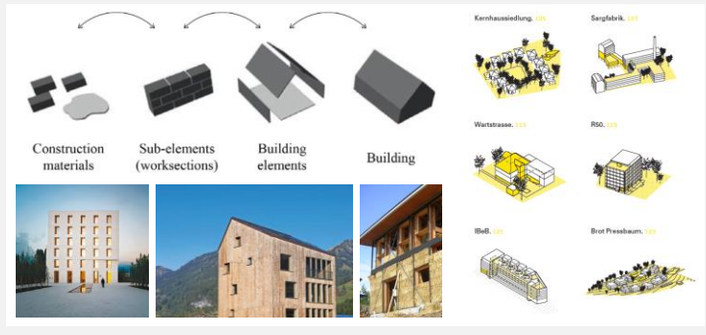


[F4]: Four perspectives on 'buildings' and related spatial and temporal scales.

Outlook

Next steps in this research will be:

1. **Life cycle assessment (LCA) of building case studies**
   - Technological innovation: Analysis of environmental potentials of buildings and building elements using bio-based or regenerative materials or innovative building energy concepts
   - Social innovation: Analysing potentials for increasing occupational density through innovative building typologies
2. **Building stock model development** and investigation of **scenarios for building stock development**
   - Building data transformation: For stock model with spatially and temporally explicit environmental building data
   - Analysis of development scenarios: Pathways within carbon budgets, investigating environmental synergies & trade-offs



Publications

- Röck M, Hollberg A, Habert G, Passer A. LCA and BIM: Visualization of environmental potentials in building construction at early design stages. Build Environ 2018;140:153–61. https://doi.org/10.1016/j.buildenv.2018.05.006
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- Habert, G., Röck, M., Steininger, K., Lupisek, A., Birgisdottir, H., Desing, H., … Lützkendorf, T. (2020). Carbon budgets for buildings: harmonising temporal, spatial and sectoral dimensions. Buildings and Cities, 1(1), 429–452. DOI: http://doi.org/10.5334/bc.47

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- [R3]: Passer A., Balouktsi M., Lützkendorf T., Kreiner H., IEA EBC Annex 57 - Guidance to including Embodied Energy & Embodied GHG Emissions in the decision-making process for SME's - Guideline for Construction Product Manufacturers, 2016, http://dx.doi.org/10.3217/978-3-85125-519-5

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