

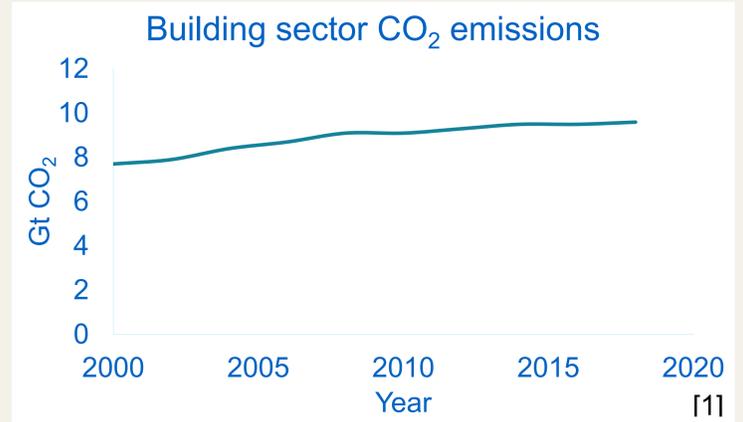
# Acting within the safe operating space – Designing buildings that are environmentally sustainable In an absolute sense

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## Need for an absolute view on environmental sustainability

- Environmental pressures connected to human activities are starting to affect the Earth's stable state, i.e. the Holocene state.
  - Building and construction projects are large contributors to several environmental issues
- Environmental assessments such as Life-Cycle Assessment (LCA) has contributed to reducing the relative environmental impact of buildings, e.g. emissions of CO<sub>2</sub> per m<sup>2</sup> built
  - Yet, total emissions and impacts keep increasing.
- LCA express the impact per function provided, not the total impact on the environment.
- Underline flaw of relative sustainability assessments, such as LCA, and the need for absolute environmental sustainability assessments (AESAs)
  - Quantify the total impact and relates this to relevant environmental boundaries



Focus of AESA

$$\text{Impact} = \text{Population} \times \text{Affluence} \left[ \frac{\text{function}}{\text{capita}} \right] \times \text{Technology} \left[ \frac{\text{Impact}}{\text{function}} \right]$$

Focus of LCA

## Absolute Environmental Sustainability Assessment

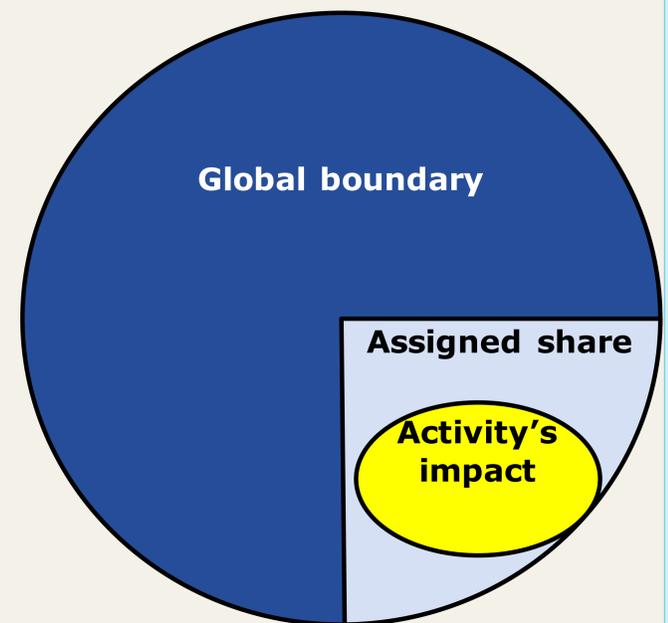
AESAs consist of three key components

- 1) Identifying relevant environmental boundaries
- 2) Assigning a share of the environmental boundary to the studied human activity
- 3) Quantifying environmental impact of studied human activity in metrics of the boundaries

### Activity's environmental impact

$$\frac{\text{Assigned share of boundary} \times \text{Global environmental boundary}}{\text{Activity's environmental impact}} \leq 1$$

- Assess if an activity can be considered sustainable relative to absolute environmental boundaries
  - Identify how large reductions are needed and which impact to focus on
- Allow for designing buildings that are actually environmentally sustainable. Not just better than the rest
  - Setting science based environmental reduction targets
- Life-cycle approach allow for identifying where reductions are needed to become absolute sustainable
  - Helps getting the focus right and make changes where it matters



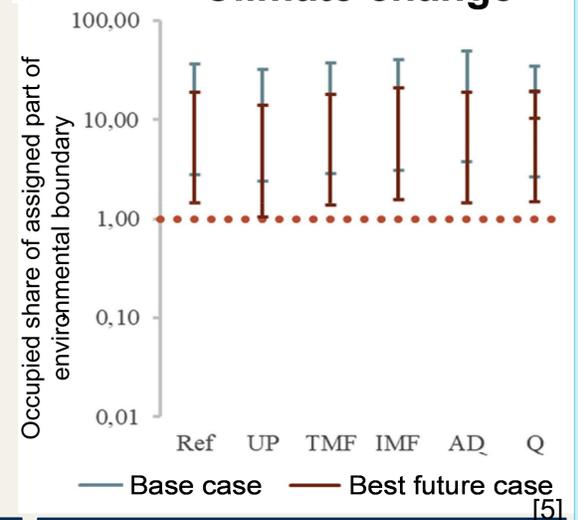
## Challenges for designing absolute environmentally sustainable buildings

- We analyzed four AESAs on buildings [ref 2,3,4,5] (covering nine houses) to identify key challenges and relevant strategies to achieve absolute sustainable buildings. See example of AESA results on figure.
- Overall, neither studies found the assessed buildings to be absolutely sustainable across all impact categories
  - Most important impact categories are climate change, water use, and nutrient emissions
- It was found that production of building materials and energy use during operation contributed most to environmental impacts and contribute most to exceeding the assigned environmental boundaries

### Main challenges for designing absolute environmentally sustainable buildings were found to be

- Generation and use of energy during building operation → fossil free, CCS; **building sector, all of society**
- Energy and resource use for production of building materials → fossil free, CCS; **building sector**
- Lack of material reuse and recycling after deconstruction → circular economy; **building sector**
- Per capita floor area is far to large to be sustainable → cultural change; **building sector, citizens**

## Climate change



## Conclusions

- AESA provide a new type of life-cycle based sustainability assessments.
  - Only method that allows for assessing if a building is sustainable in an absolute sense
- Needed to design and construct buildings that are good enough for humanity to live and act within the boundaries of the Earth
- Find that actors in the building sector can do a lot, but cannot not lift the entire challenge alone
- Integrated solutions involving all of society. New energy infrastructure and cultural change in housing demands

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