TU Delft

Towards Circular HVAC Design: An Assessment Framework for Early Design Stages

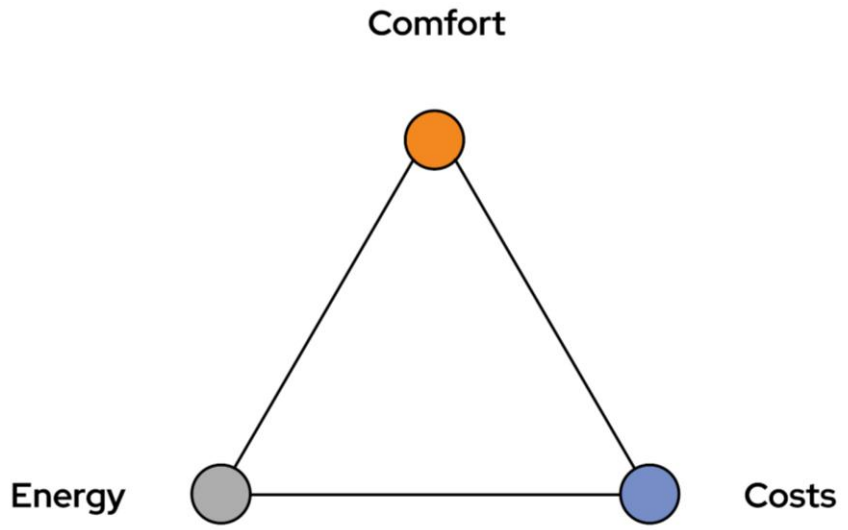
Sasja van Andel

October 7, 2026



Traditional HVAC design approach

- Focus on performance, energy and costs
- Role of design:
  - Weighing trade-offs
  - Find solutions for different contexts and inputs



HVAC's overlooked impact

- The construction industry is a large material consumer
- Embodied carbon of building services estimated:
  - 15-50% for new construction
  - up to 70% for renovations

(Sustainable Markets Initiative, 2024; Copper8 et al., 2024)



Increasing material importance



Decarbonization of energy mixes



Focus on energy-efficiency

Material replacement due to energy-renovations

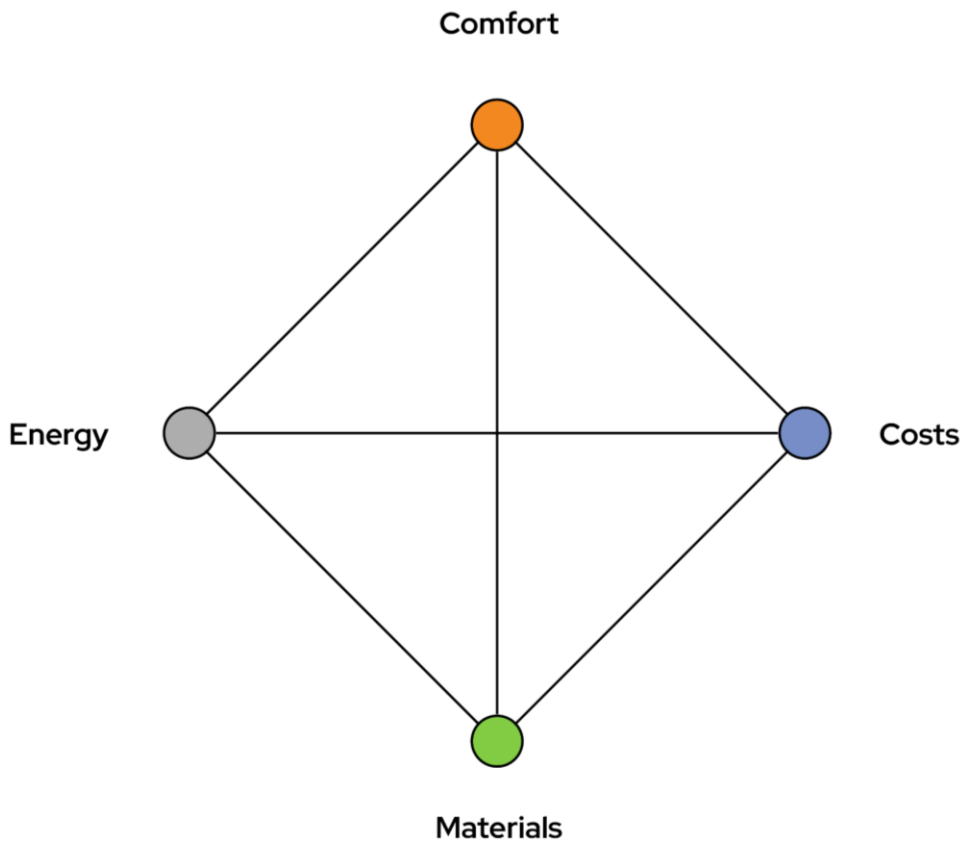


Critical materials

Security of supply is not self-evident

Necessary design shift

Integrating material aspects in the design process by adopting a circular approach



Adopting circularity in design – in practice

Many strategies and various interpretations of circularity

- Recyclability
- Repairability
- Environmental impact
- Critical materials
- …

Adopting circularity requires custom-made solutions



Industry feels lost



Industry thinks they are fully circular

Our aim

To develop a design assessment framework to support industry professionals such as building services consultants, installers and architects in applying circular design principles and making integrated design decisions.

Our aim – **method**

To develop a design assessment framework to support industry professionals such as building services consultants, installers and architects in applying circular design principles and making integrated design decisions.

Define circularity aspects by analyzing existing circular design frameworks and HVAC specific programs of requirements

Define comfort, cost and energy-related criteria based on literature and together with HVAC experts within our consortium

Integrate defined aspects in a **design assessment framework**

Defining circularity aspects

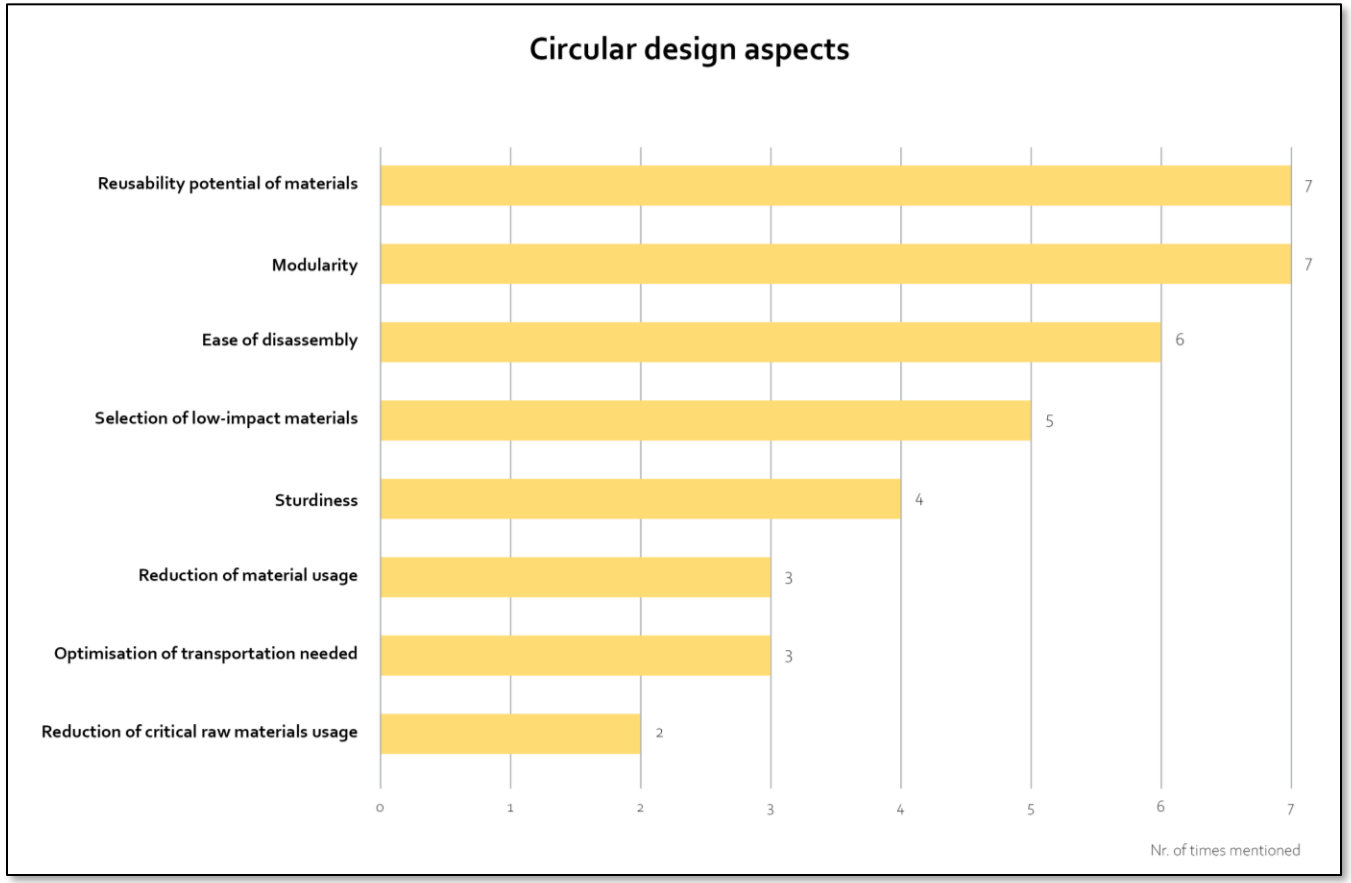
Goal: to identify circular design aspects that can be influenced by the designer.

Analyzed:

- 5 circular (HVAC) design frameworks
- 3 circular HVAC-specific programs of requirements

Criteria:

- Designer influence
- Mentioned at least twice
- Put very similar aspects together, e.g. durability and sturdiness



Defining other HVAC design aspects

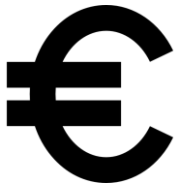


Comfort

Thermal comfort,
Indoor air quality,
Acoustic comfort



Energy



Costs

Investment costs,
Energy costs,
Maintenance costs



Maintenance



Warranty

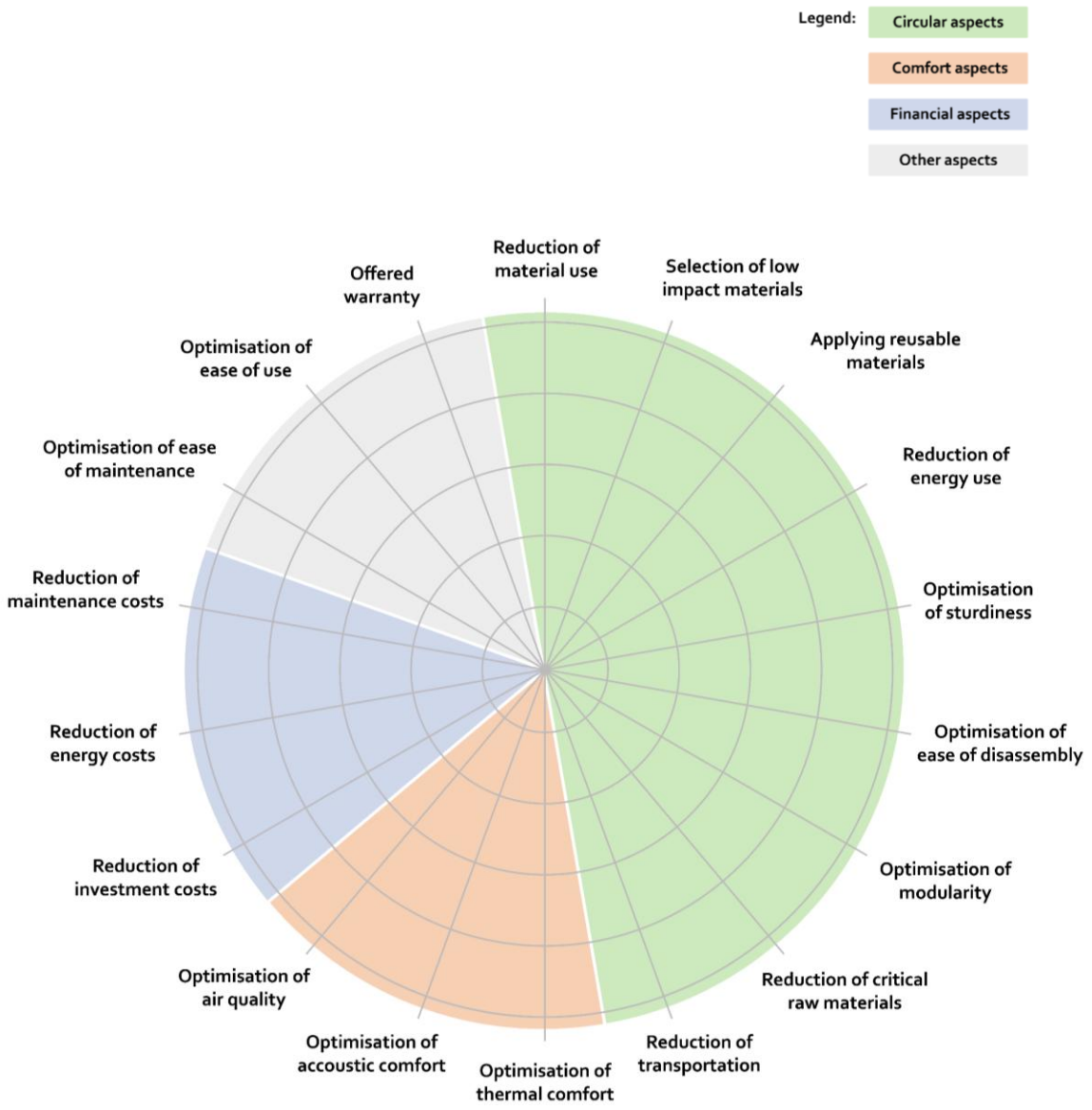


User interaction

Design assessment framework

Usable in early design stages when impactful choices can still be adjusted

Based on expert judgement

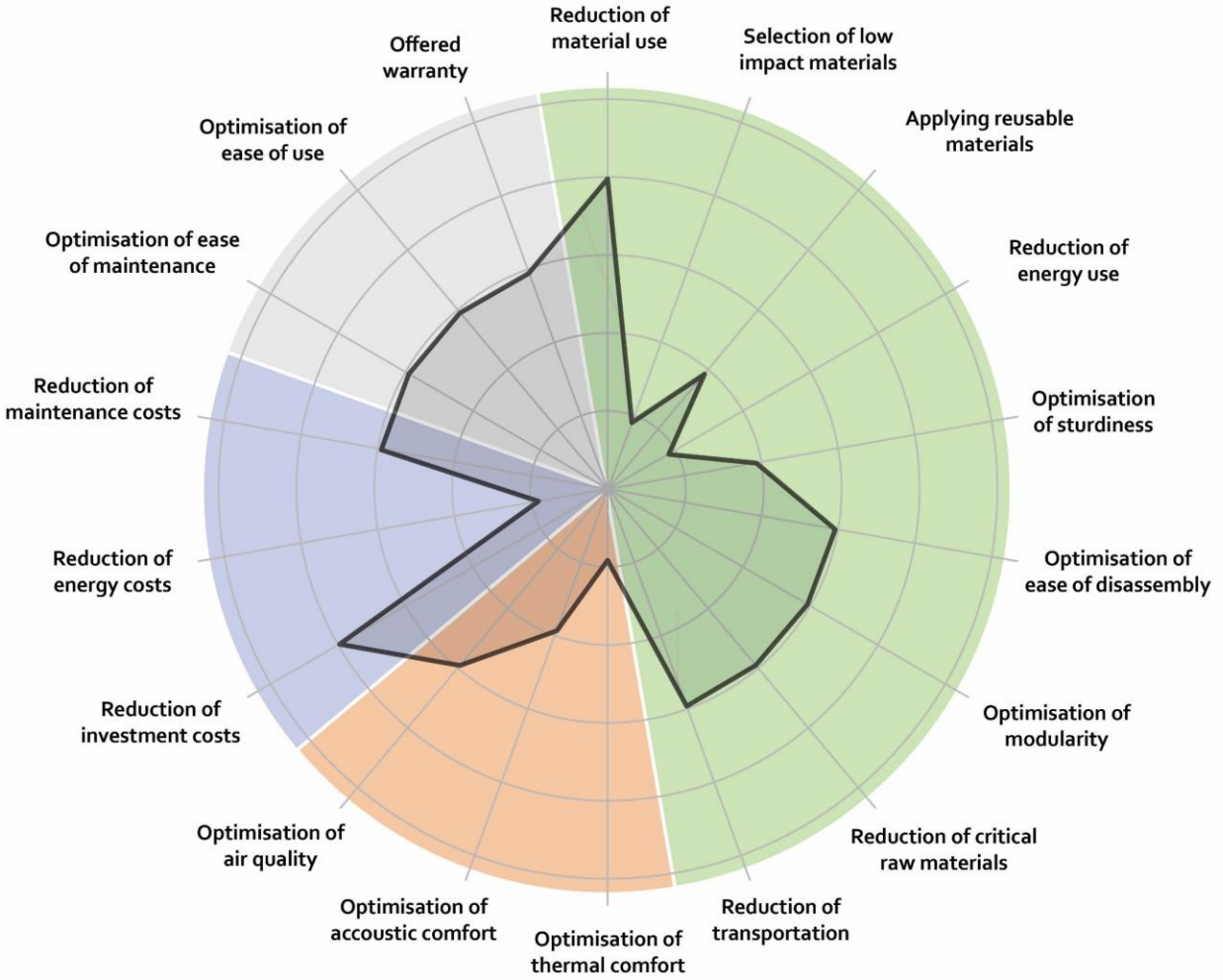


Example renovation

Present in current apartment:
Central heating boiler with 5 years of remaining service life, System C ventilation, piping, and radiators.

Expected service life after renovation:
20 years.

Maintaining the existing building:
Replace the central heating boiler once.



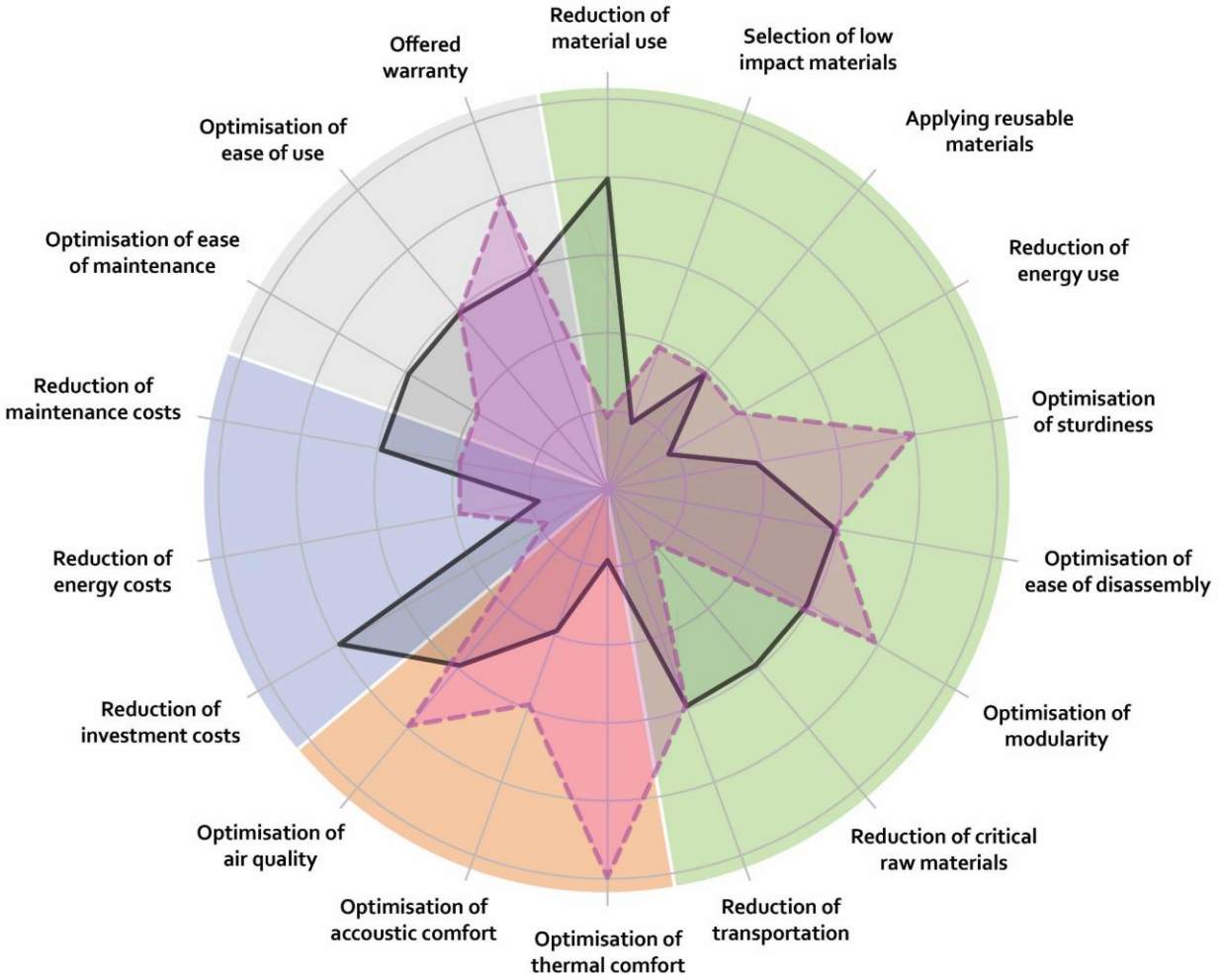
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Installation concept A:
Apply cavity wall insulation, install a hybrid heat pump, install a new Type D ventilation system, and install air conditioning.



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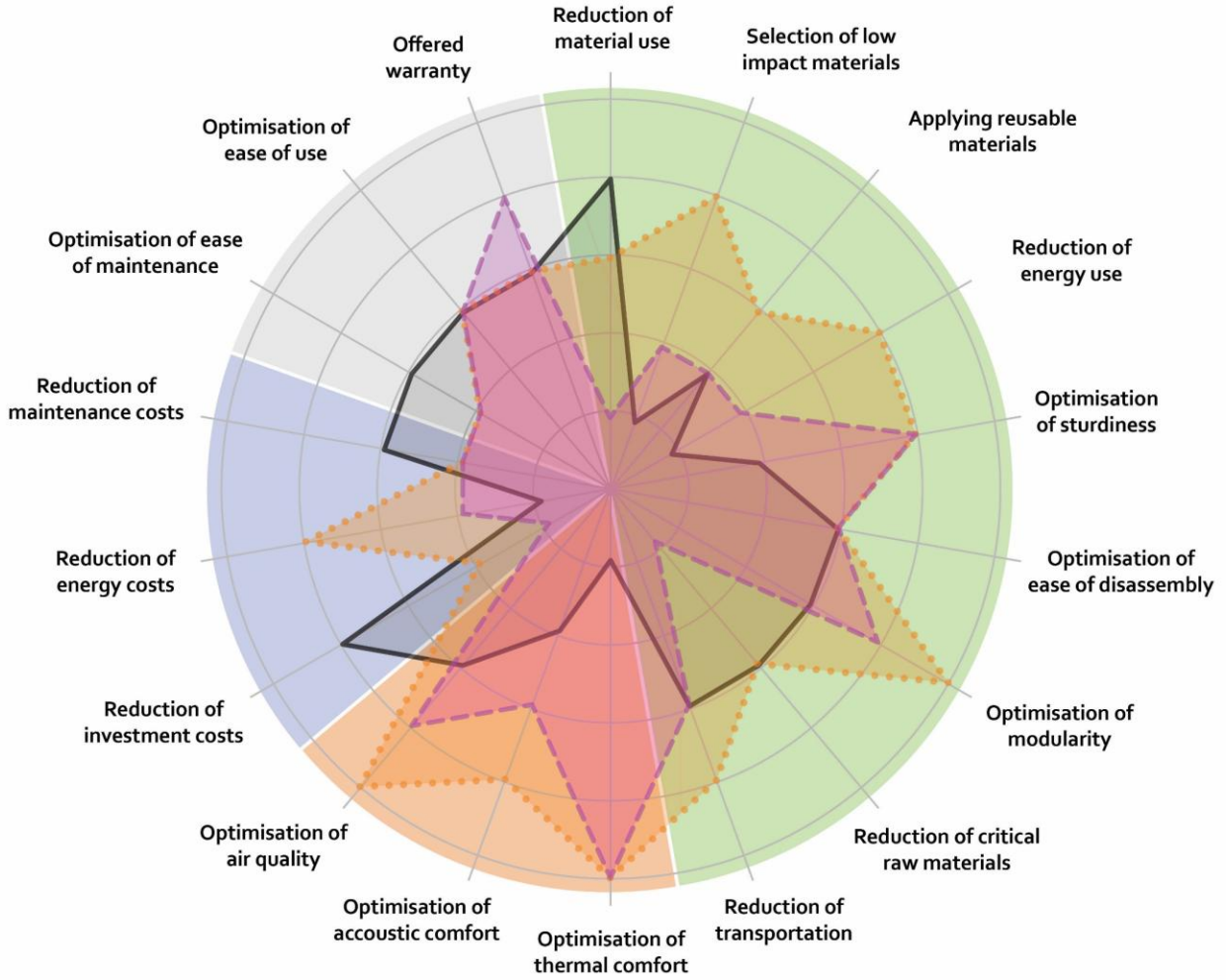
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Installation concept A:
Apply cavity wall insulation, install a hybrid heat pump, install a new Type D ventilation system, and install air conditioning.

Installation concept B:
Apply biobased cavity wall insulation, reuse the existing central heating boiler in a hybrid heat pump system, upgrade the ventilation system to a Type D ventilation system, and install solar shading.



Why use the framework?



Design considerations are made visual



Completeness check



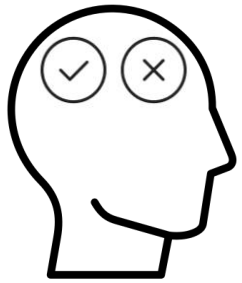
Identifying trade-offs that need further analysis

Limitations



Trade-offs remain

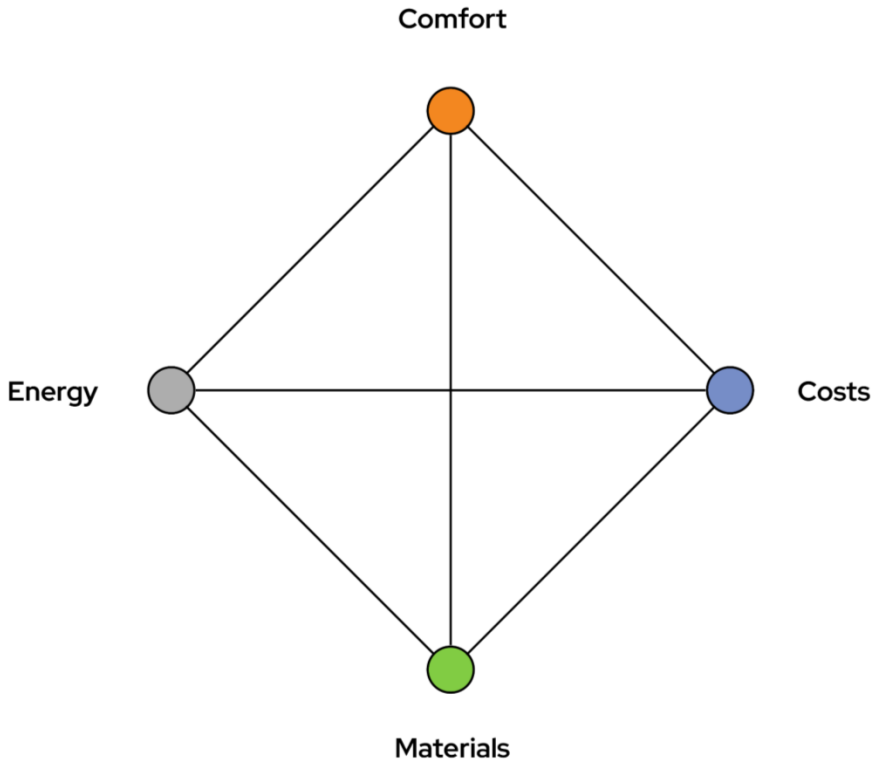
Weighting or setting priorities is important to make decisions

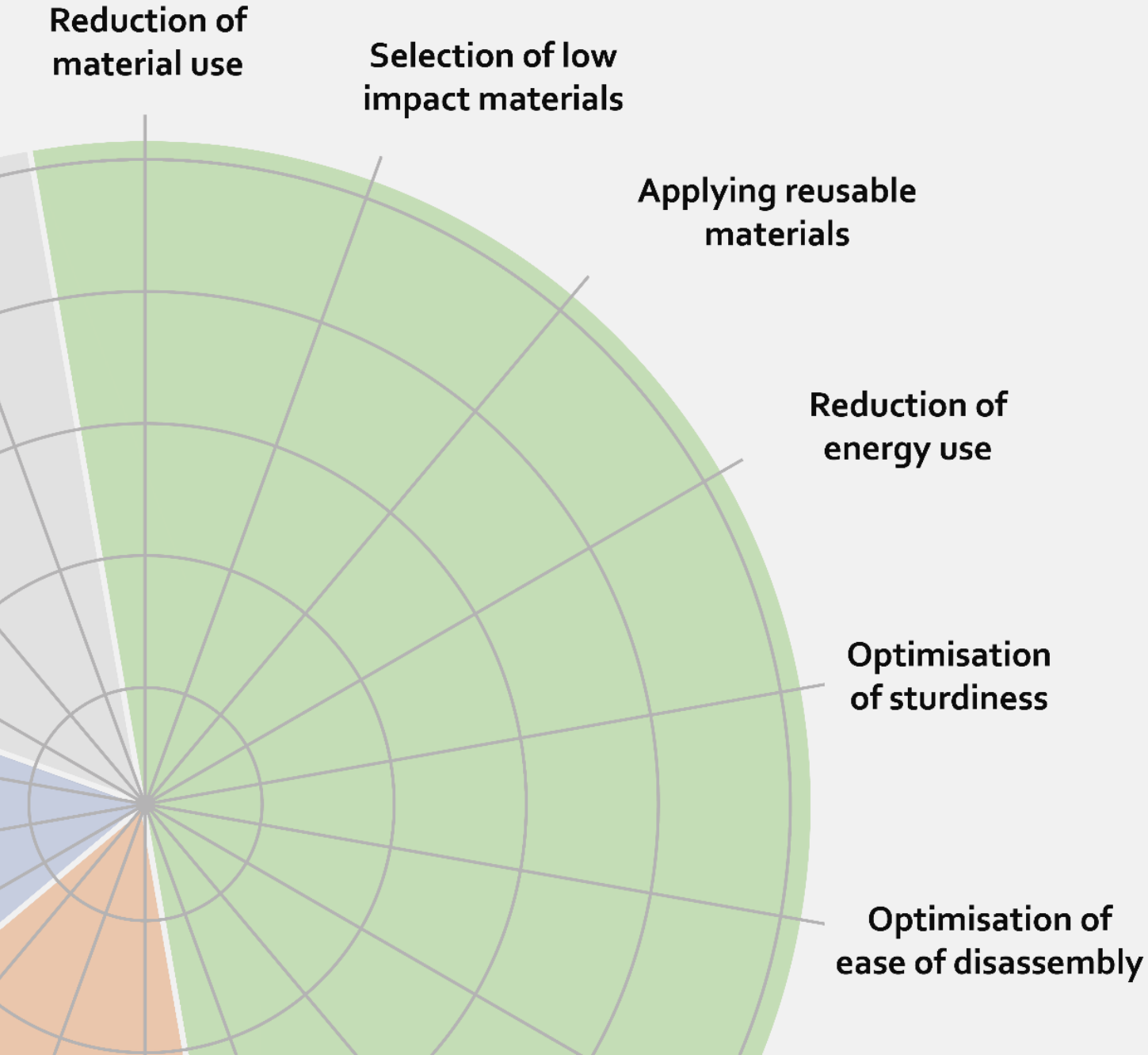


Subjectivity may reinforce bias

Conclusions

- Design processes need to change
- There are no one-size-fits-all solutions
- Critical thinking and careful consideration of trade-offs are key




Reduction of material use
Selection of low impact materials
Applying reusable materials
Reduction of energy use
Optimisation of sturdiness
Optimisation of ease of disassembly

Thank you