P5

BUILD TO BE BACK

Exploring remountable construction on Dutch university campuses

Lynn J. Kamphuis

18 June 2025

CONTENT

CONTENT

What do these buildings have in common?

The Valley, Amsterdam
Housing & office

Echo, Delft
Education

Boijmans van Beuningen, Rotterdam
Art depot

What do these buildings have in common?

The Valley, Amsterdam
Housing & office

Echo, Delft
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Boijmans van Beuningen, Rotterdam
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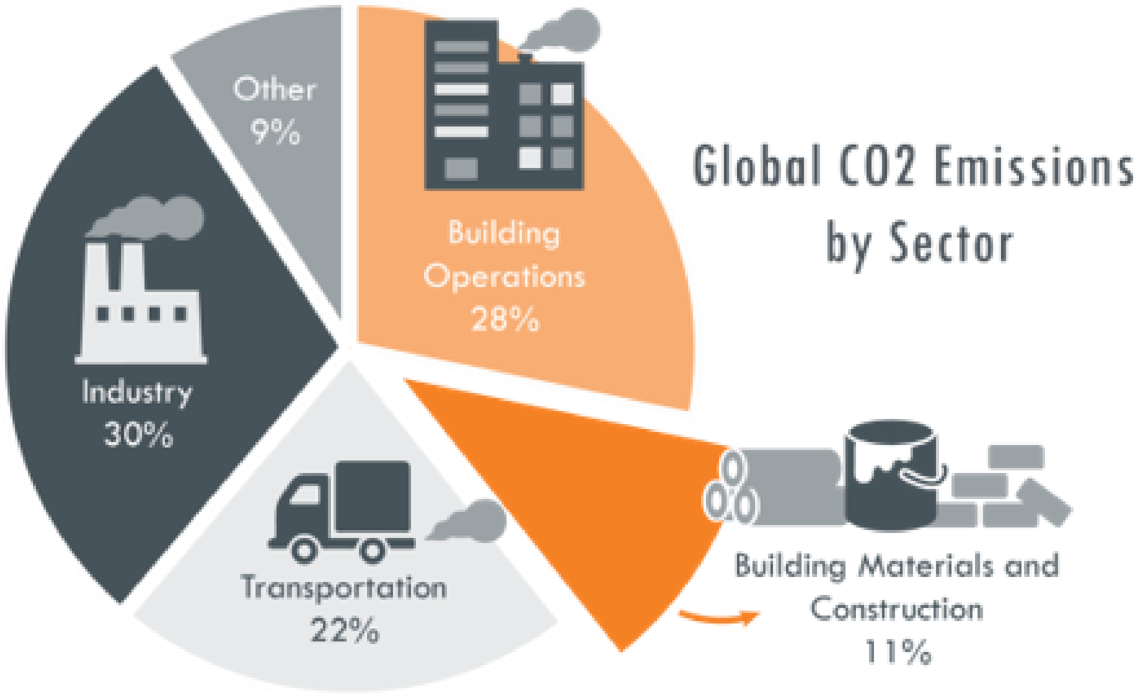
CIRCULARITY

Why?

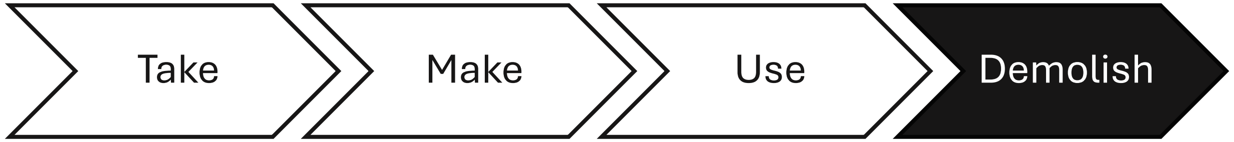
Urgency



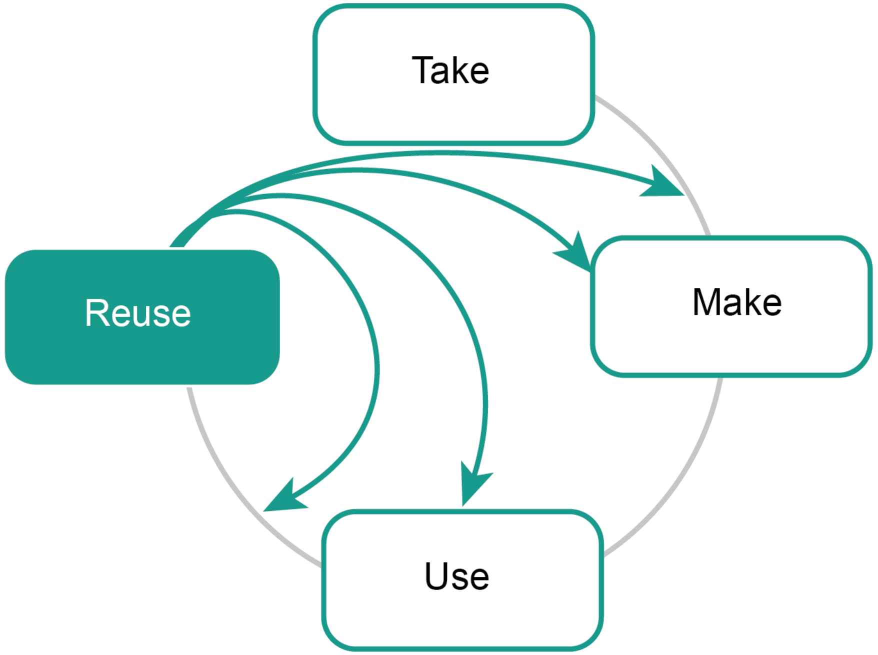
(dgbc, n.d.)

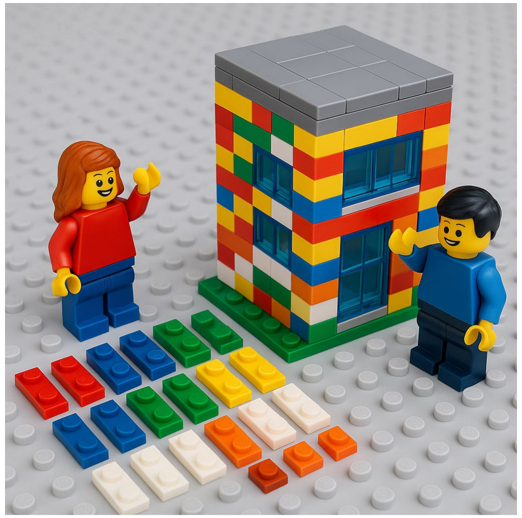
Circular construction

Linear economy



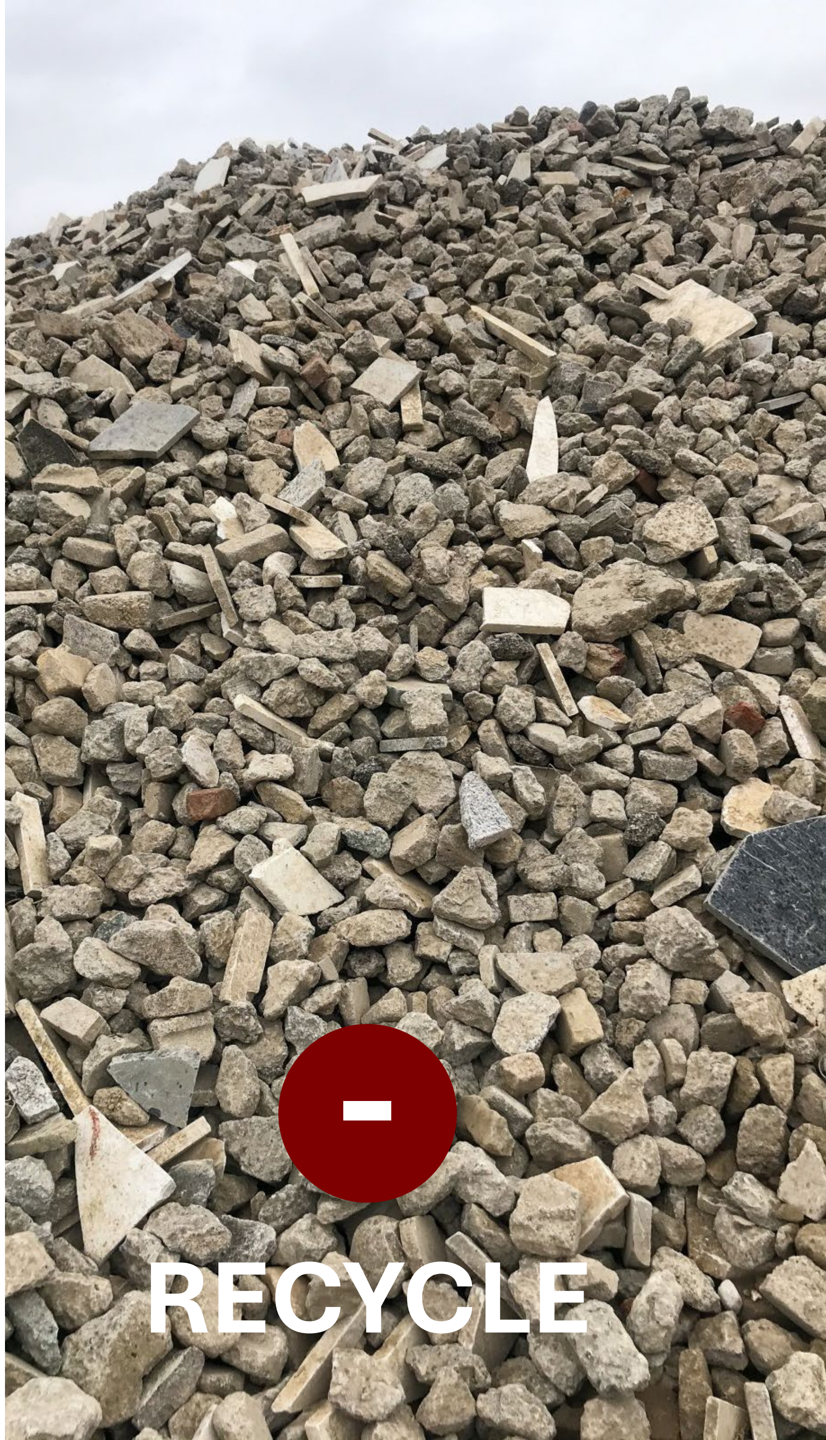
Circular economy






REUSE


REFURBISH


RECYCLE

What do these buildings have in common?

NO END-OF-LIFE SCENARIO

The Valley, Amsterdam
Housing & office

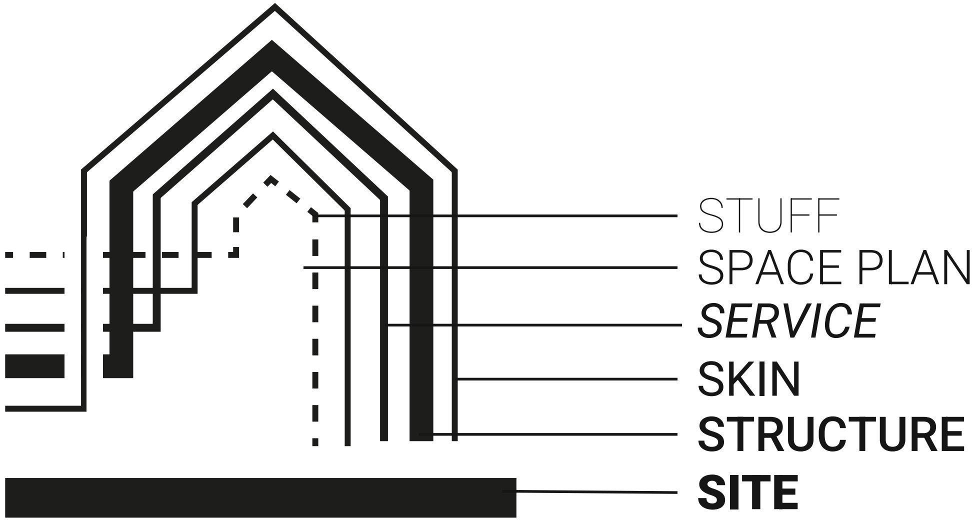
Echo, Delft
Education

Boijmans van Beuningen, Rotterdam
Art depot

FALSE? CIRCULARITY

Buildings

Buildings



(Brand, 1994)

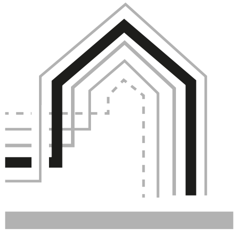
Buildings

Site

Eternal

Buildings

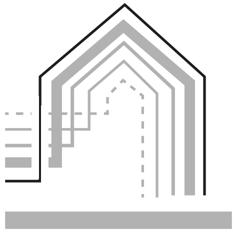
Structure
30-200 years

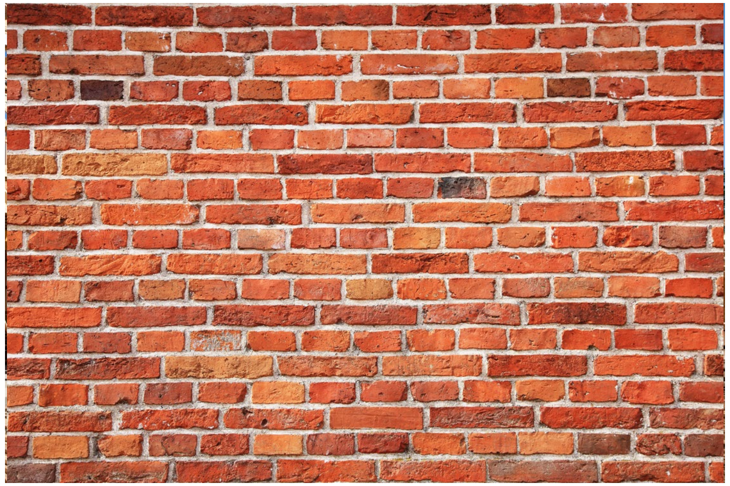


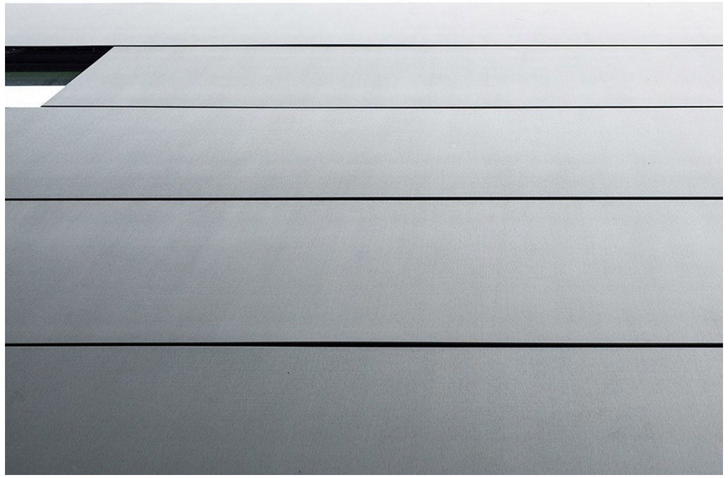
Buildings

Skin

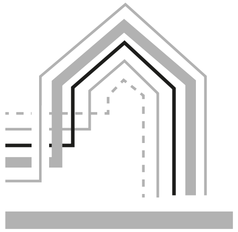
20-50 years







Buildings



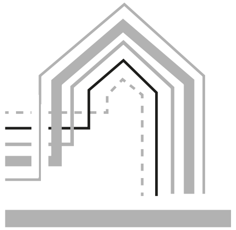
Services

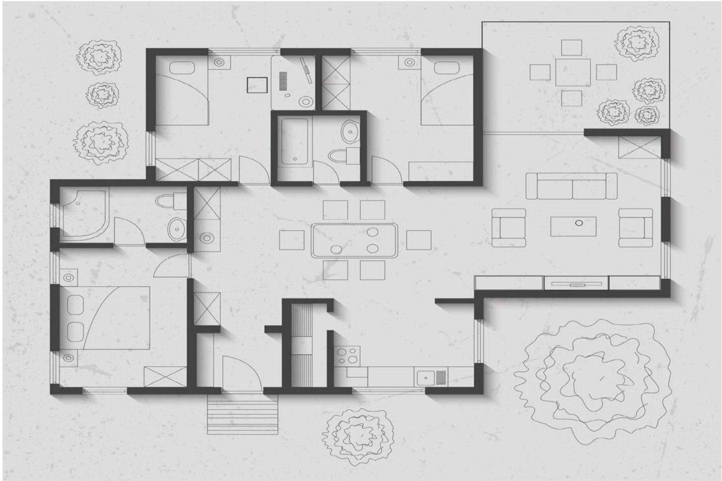
15-25 years

Buildings

Space plan

3-15 years

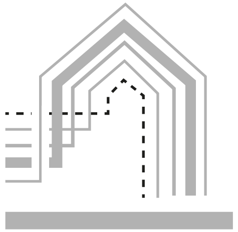


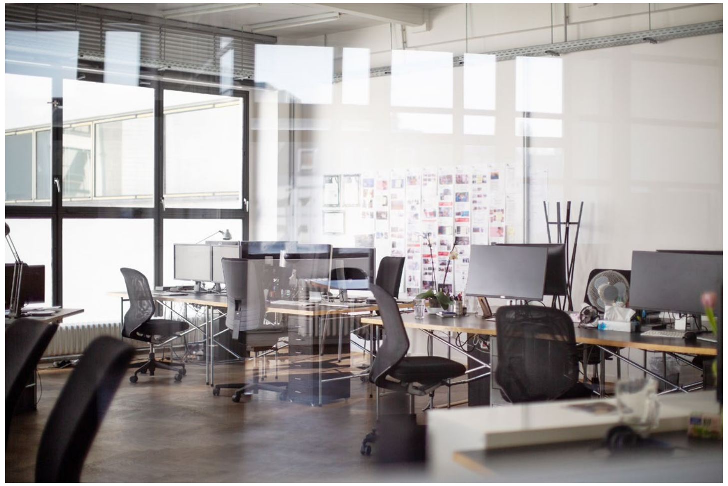


Buildings

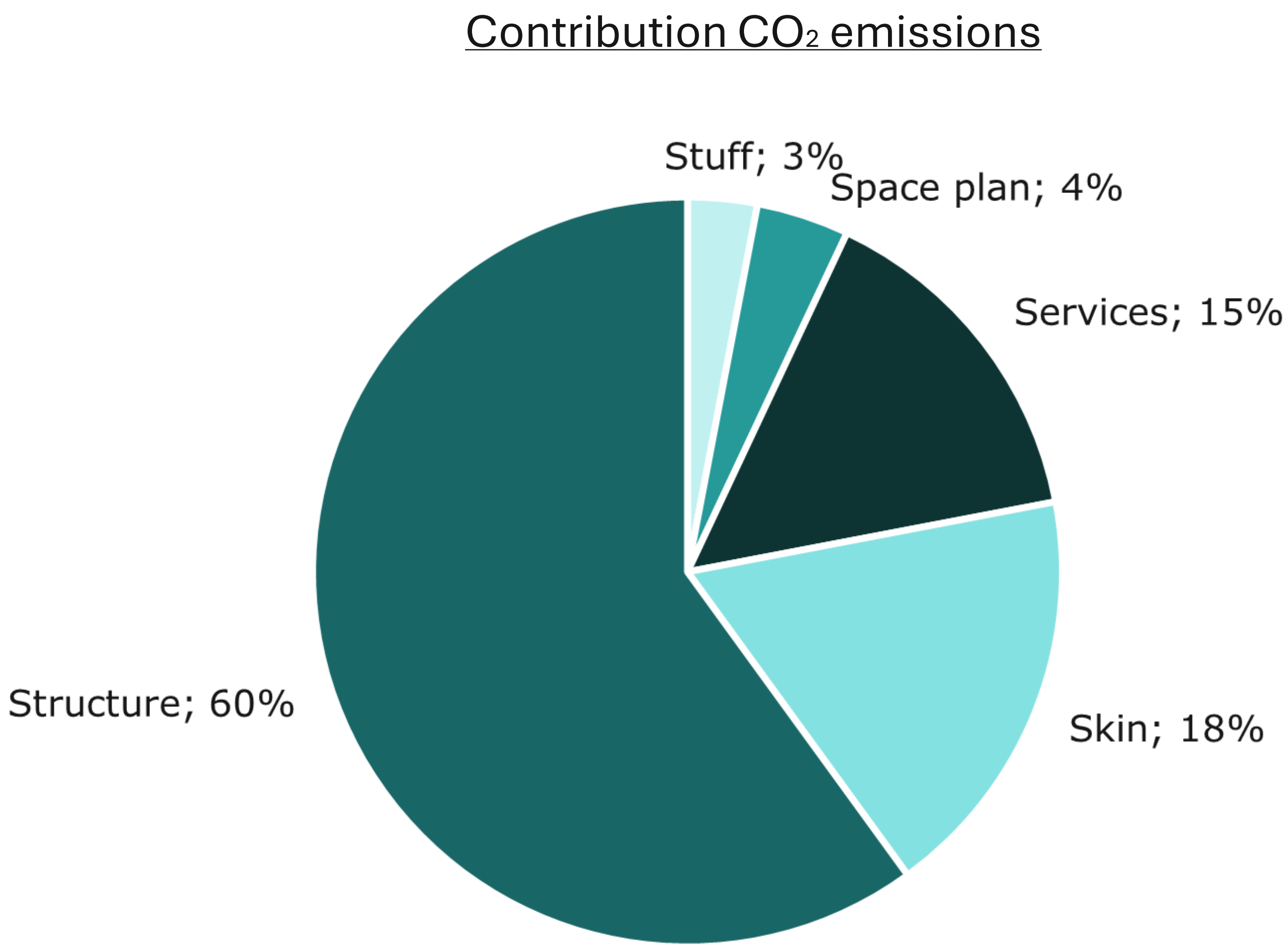
Stuff

1 month - 7 years



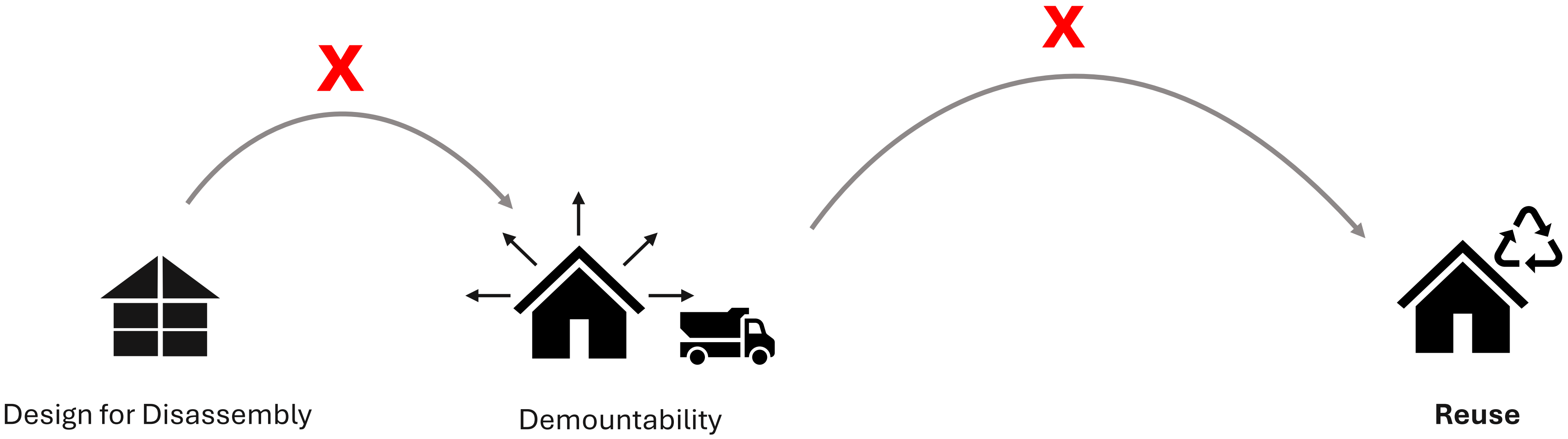


Reuse impact

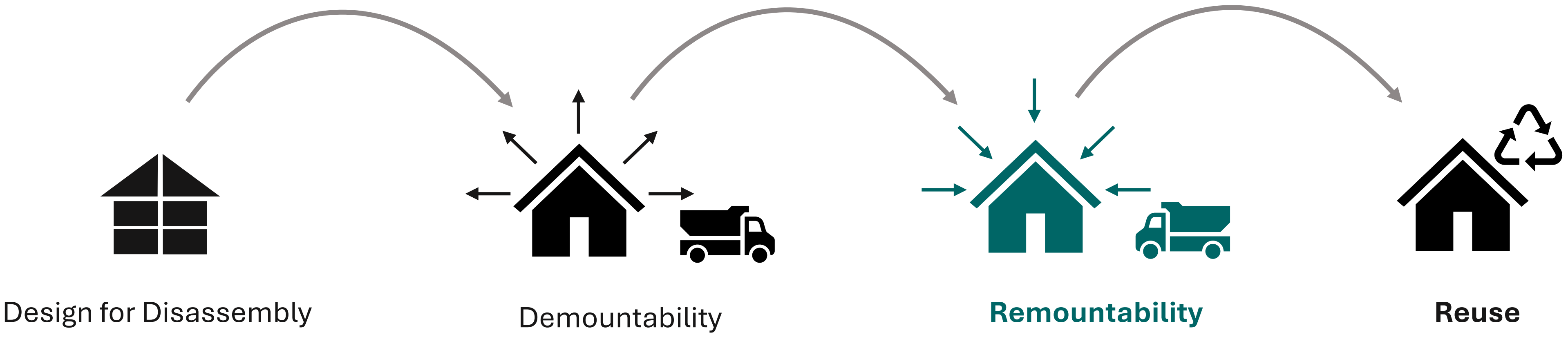


(dgbc, n.d.)

Circular construction strategies



Circular construction strategies



*“Designing a building in such a way that, after it has been built, it can be dismantled and **rebuilt** elsewhere”*

Research context

Dutch university campuses

Ideal living labs

for circular construction strategies

- Long term ownership
- Available land + buildings
- Access to knowledge
- Self-managing
- Public mission
- Frontrunning ambitions

CONTENT

Research questions

How can Dutch universities integrate remountability in the construction processes of their campus buildings?

Main research question

Integrating remountability on university campuses

Research questions

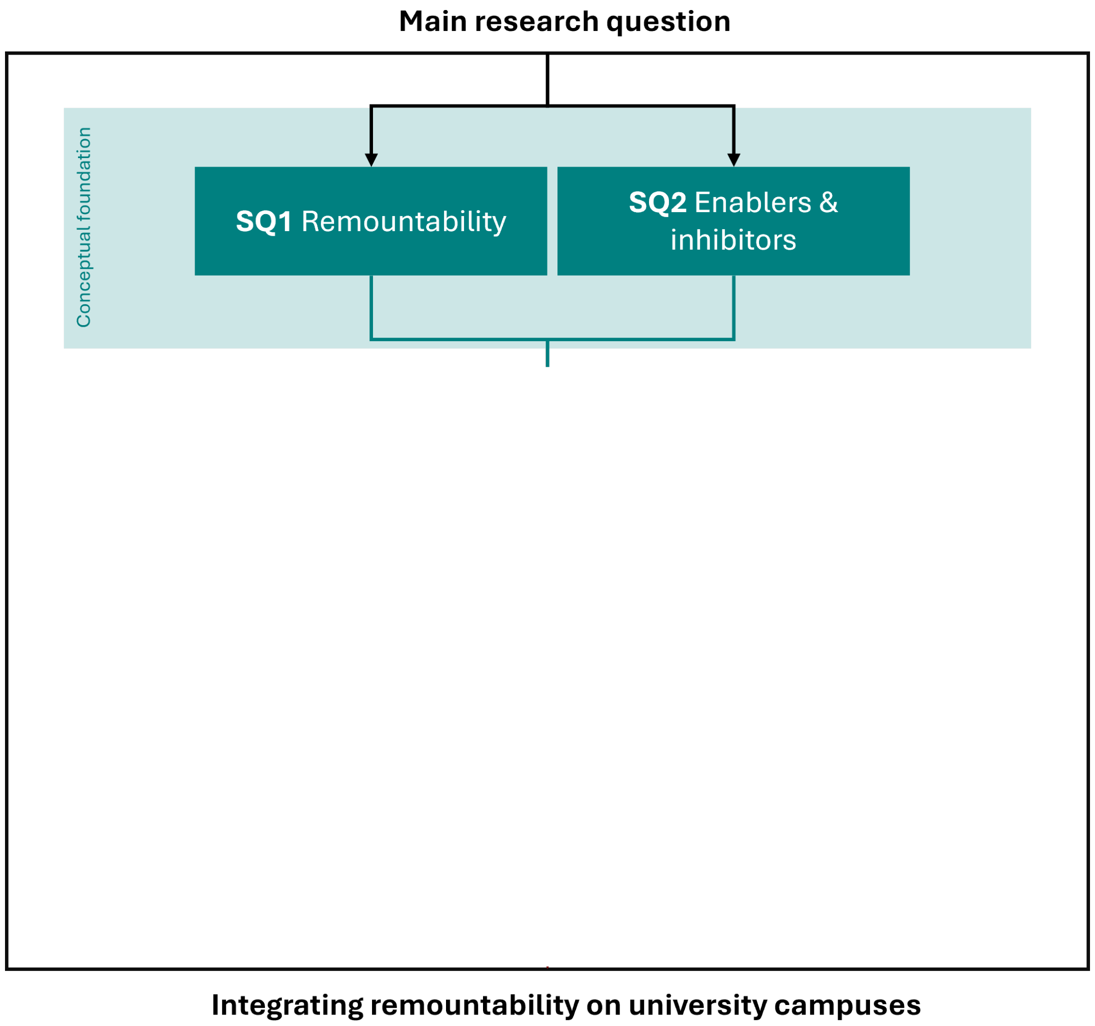
1. What strategies does a remountability process encompass in practice?

Main research question

Integrating remountability on university campuses

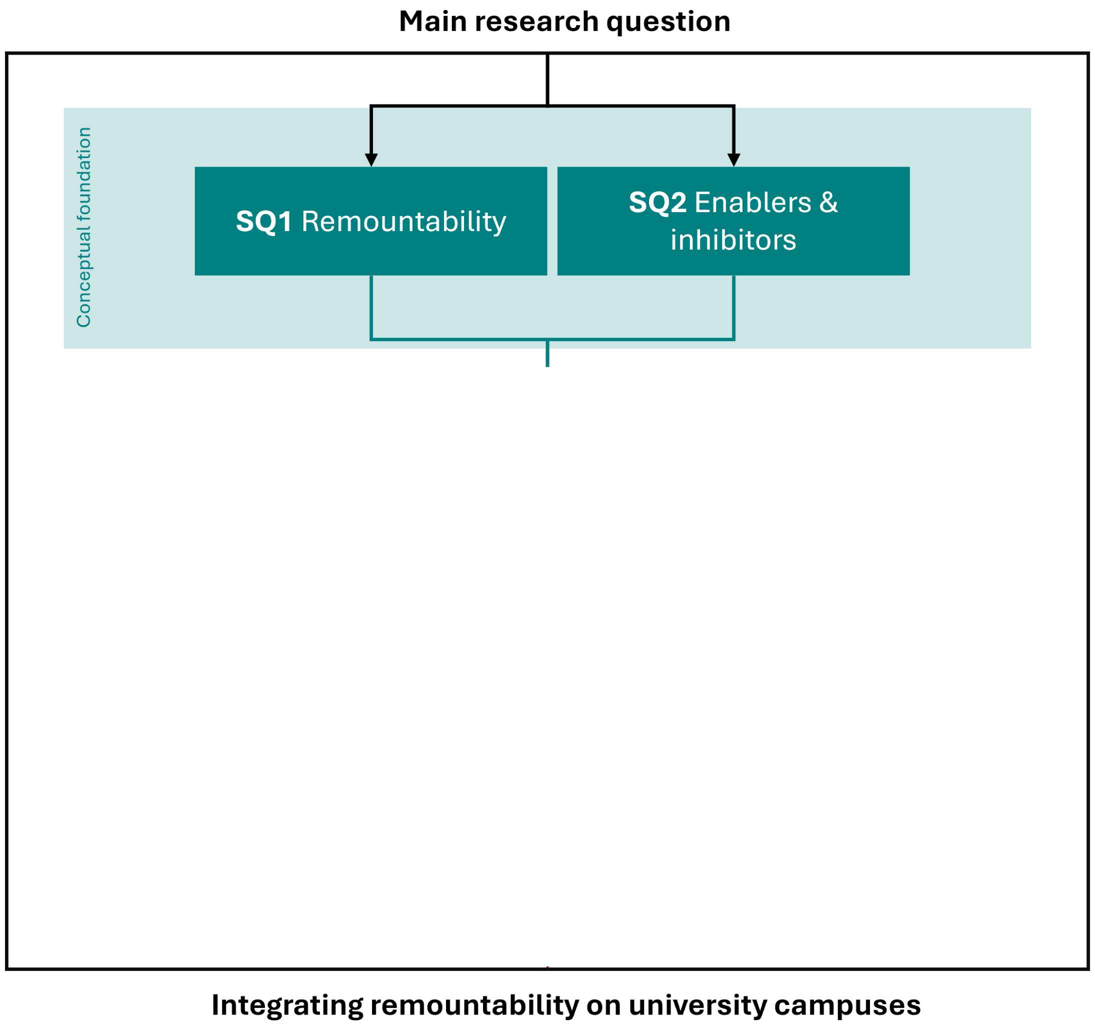
Research questions

2. What are enablers and inhibitors of remountability in the built environment?



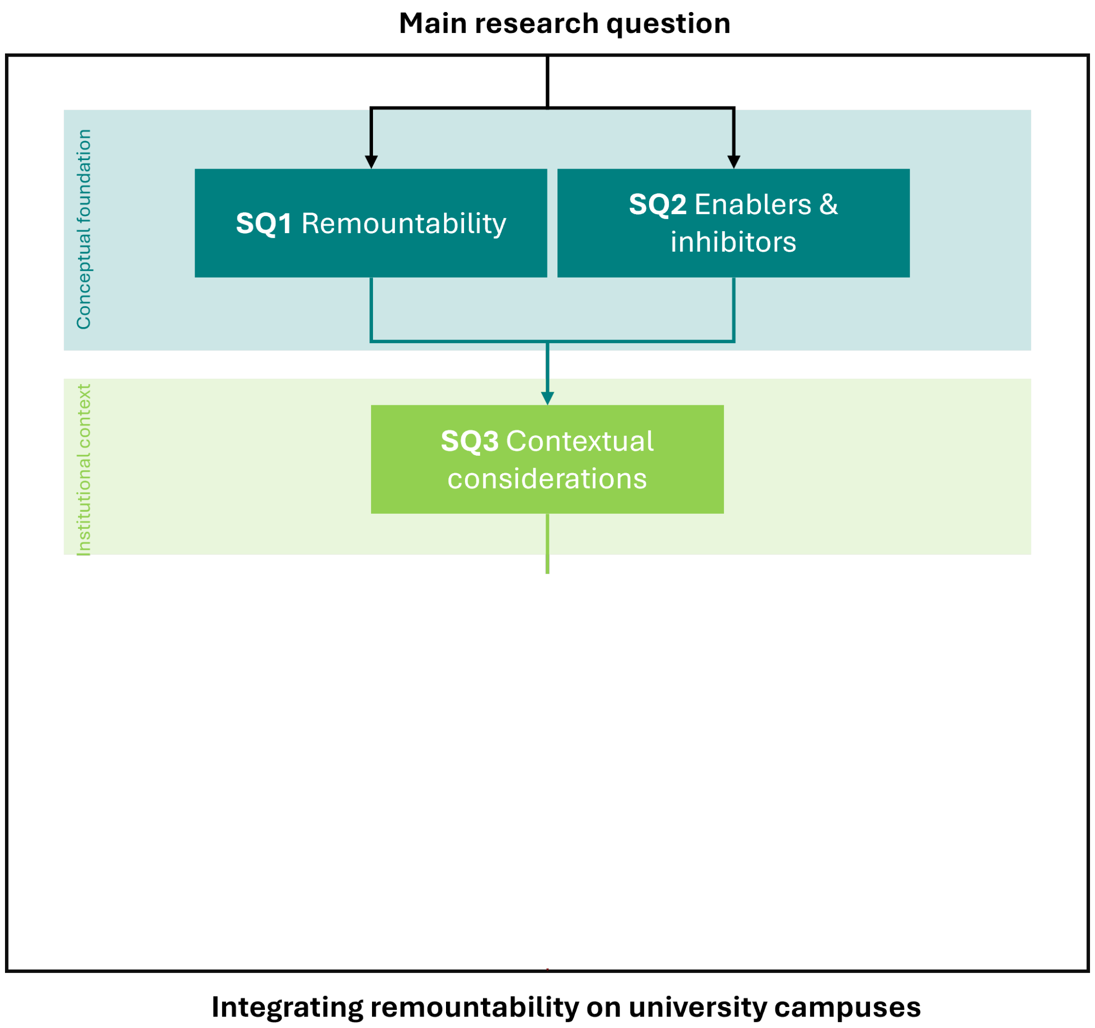
Research questions

3. What are contextual considerations for universities that influence the integration of innovations in the construction process of their buildings?



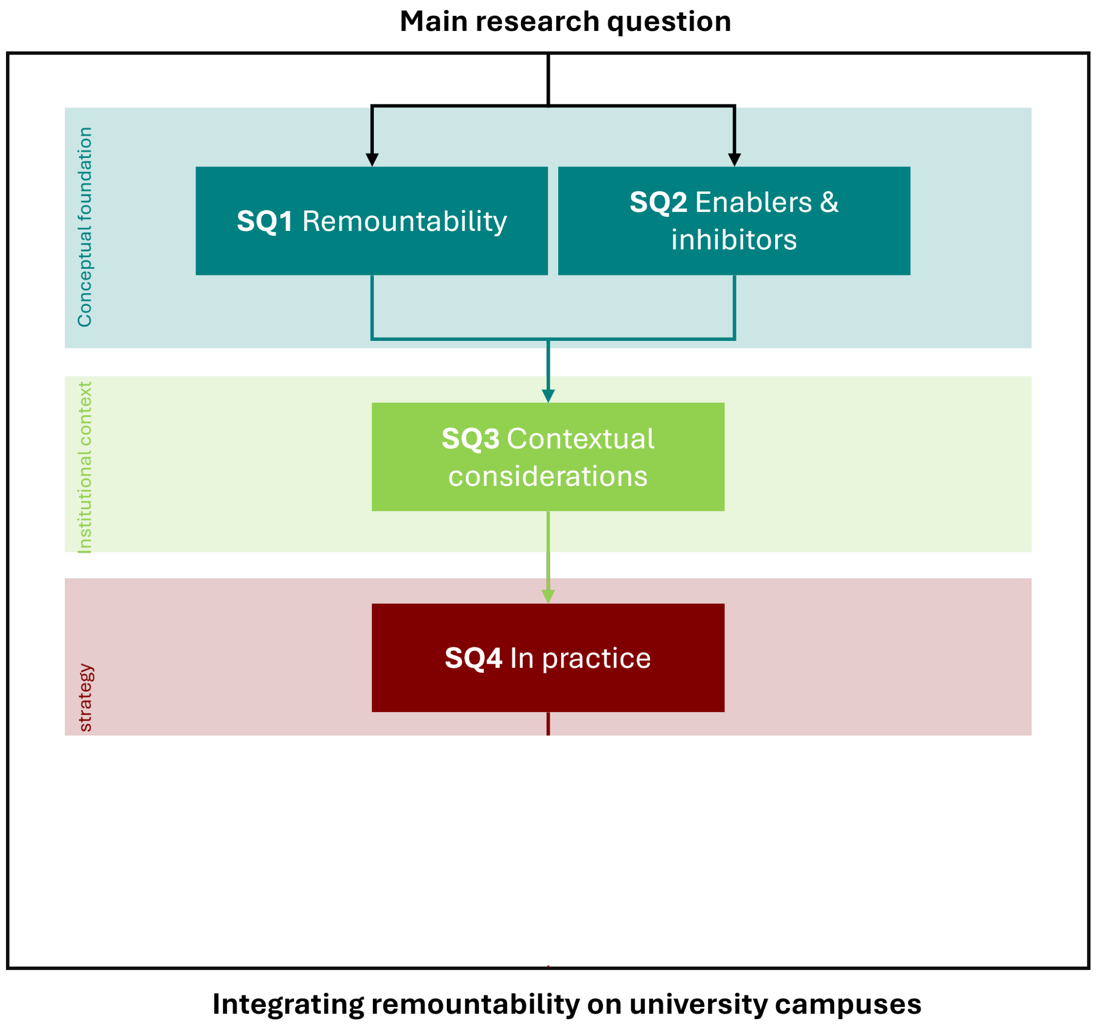
Research questions

4. How is remountability practically applied in Dutch university buildings?



Research questions

5. What needs be done to increase the integration of remountability in the construction process of future campus buildings?



CONTENT

Findings SQ1

What strategies does a remountability process encompass in practice?

3 interviews

- *Active* strategies: building construction and user interference
- *Passive* strategies: building design
- *Operational* strategies: during the project phases

Overview of practical strategies for facilitating remountable construction: reuse aspects and thematic relevance	Multiple reuse aspect									Interviews reference(s)			Related theme (link to SQ4)					
	Active			Operational			Passive											
Strategies	DfD	Disassembly	Reassembly	DfD	Disassembly	Reassembly	DfD	Disassembly	Reassembly	1.1	1.2	1.3	Culture	Governance	Financial	Site	Construction system	Building information
Build exactly as designed.		●	●							✓								x
Use bio-based materials for missing parts.			○								✓						x	
Choose alternative raw materials.											✓						x	
Handle parts with care to keep them reusable.		●	●								✓✓						x	
Plan logistics using 'first in, last out'.		●	●							✓✓		✓					x	
Keep a digital inventory for reuse tracking.	●	●	●							✓✓	✓							x
Ensure experts are present on site.		●	●							✓		✓✓				x	x	
Check components for damage and defects.		●	●							✓✓							x	x
Stay flexible throughout the construction phases.					●	●				✓✓	✓✓	✓✓	x					
Work cooperatively for better efficiency.				●	●	●						✓	x					
Log the process and lessons learned.				○	○	○				✓	✓✓	✓✓						x
Teach practical construction skills to students.												✓	x					
Keep the client informed and aligned.				●	●	●						✓✓						x
Have legal experts handle permits and rules.				○	○	○					✓	✓		x				
Spread enthusiasm within the project team.				●	●	●				✓✓	✓✓	✓	x					
Allow investment shifts during the project.				○	○	○				✓					x			
Use the same team for (re)assembly and disassembly.					●	●				✓			x				x	
Set and communicate a clear budget.				○	○	○				✓					x			
Analyze risks and financial guarantees.				○	●	●				✓		✓		x	x			
Make clear tasks and role agreements.				○	●	●				✓	✓✓	✓✓	x					
Promote a circular mindset in all parties.				●	●	●				✓✓	✓✓		x					
Design with large, disassemblable parts.							●	●	●		✓						x	
Design with prefab elements to enable reuse.							●	●	●		✓✓						x	
Prioritize second-hand materials in design.							●				✓						x	
Use and maintain BIM models throughout the process.							●	●	●	✓✓	✓✓	✓✓						x
Take extra time to design for reuse.							●				✓✓	✓					x	
Include long-term reuse potential in planning.							○			✓✓	✓	✓					x	
Design for fast and low-cost execution.							○	○	○	✓		✓			x		x	
Standardize parts for easy reuse.							○	●	●	✓	✓✓						x	
Ensure in design for technically feasible disassembly.							○	●		✓							x	

Mentioned by nr. of participants n =1
Mentioned by nr. of participants n ≥1

● = a fully supportive strategy for DfD/Dis./Rea.
○ = a strategy that could help DfD/Dis./Rea.
Blank = not applicable

✓ = mentioned/relevant by interviewee
✓✓ = strongly emphasized by interviewee

x = related

Findings SQ1

Main take-away:
- **Operational strategies**

For example:
- Keep the client aligned and informed
- Document the process and lessons
- Be enthusiastic

Findings SQ2

What are enablers and inhibitors of remountability in the built environment?

Literature review

Reuse projects

EF1	Building and component characteristics
EF2	Collaboration and ownership
EF3	Presence of a motivated and capable team/organisational commitment
EF4	Economic viability
EF5	Legislative support
EF6	Digital technologies on material tracking
EF7	Match disassembly and design projects with comparable building volumes
EF8	Overlap disassembly and design phases
EF9	Early information setting and sharing
EF10	Approach uncertainties with a flexible attitude

IF1	Lack of expertise
IF2	Technical complexities with building products/materials
IF3	Economic infeasibility of innovative strategies
IF4	Tendency to follow traditional paradigms
IF5	Lack of data and warranty on old material
IF6	Legal and legislative restrictions

Campuses as living labs

EF11	Clear role for campus managers
EF12	Innovative campus visions
EF13	A bridge between theoretical research and practical know-how
EF14	Availability of tools to manage perceived risks
EF15	The availability of a suitable location and time on campus
EF16	Raising awareness

IF7	Conflicting goals with other projects on campus
IF8	Lacking a detailed project plan
IF9	Conflicts between experts on campus
IF10	The project having an informal character

Findings SQ3

What are contextual considerations for universities that influence the integration of circular construction processes to their building projects?

Findings SQ3

What are contextual considerations for universities that influence the integration of circular construction processes to their building projects?

Stimulating considerations:

1. **Ambitious sustainability goals**
2. **Growing preference for adaptive reuse**
3. Policy and economic pressure
4. Clear roles during RE development
5. Market influence
6. Evolving procurement strategies
7. Openness to innovative finance models
8. **Increasing focus on long-term adaptability**
9. Starting knowledge sharing network

Hindering considerations:

1. Inconsistent engagement
2. Lack of formal stakeholder engagement channels
3. **Traditional constructed buildings (asbestos)**
4. **Specialized building requirements**
5. Underdeveloped circular supply chains
6. Holding on to linear business models
7. Financial and valuation challenges
8. No direct legal obligations
9. Insurance challenges
10. Equal building standards
11. Stricter municipal sustainability demands
12. Lack of standardization
13. **Difficulty quantifying long-term circular benefits**

SQ1 SQ2 SQ3

Case studies

Overview of practical strategies for facilitating remountable construction: reuse aspects and thematic relevance	Multiple reuse aspect									Interviews reference(s)			Related theme (link to SQ4)					
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Plan logistics using 'first in, last out'.		●	●							✓✓		✓					x	
Keep a digital inventory for reuse tracking.	●	●	●							✓✓	✓							x
Ensure experts are present on site.		●	●							✓		✓✓				x	x	
Check components for damage and defects.		●	●							✓✓							x	x
Stay flexible throughout the construction phases.					●	●				✓✓	✓✓	✓✓	x					
Work cooperatively for better efficiency.				●	●	●						✓	x					
Log the process and lessons learned.				○	○	○				✓	✓✓	✓✓						x
Teach practical construction skills to students.												✓	x					
Keep the client informed and aligned.				●	●	●						✓✓						x
Have legal experts handle permits and rules.				○	○	○					✓	✓		x				
Spread enthusiasm within the project team.				●	●	●				✓✓	✓✓	✓	x					
Allow investment shifts during the project.				○	○	○				✓					x			
Use the same team for (re)assembly and disassembly.					●	●				✓			x				x	
Set and communicate a clear budget.				○	○	○				✓					x			
Analyze risks and financial guarantees.				○	●	●				✓		✓		x	x			
Make clear tasks and role agreements.				○	●	●				✓	✓✓	✓✓	x					
Promote a circular mindset in all parties.				●	●	●				✓✓	✓✓		x					
Design with large, disassemblable parts.							●	●	●		✓						x	
Design with prefab elements to enable reuse.							●	●	●		✓✓						x	
Prioritize second-hand materials in design.							●				✓						x	
Use and maintain BIM models throughout the process.							●	●	●	✓✓	✓✓	✓✓						x
Take extra time to design for reuse.							●				✓✓	✓					x	
Include long-term reuse potential in planning.							○			✓✓	✓	✓					x	
Design for fast and low-cost execution.							○	○	○	✓		✓			x		x	
Standardize parts for easy reuse.							○	●	●	✓	✓✓						x	
Ensure in design for technically feasible disassembly.							○	●		✓							x	

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EF12	Innovative campus visions
EF13	A bridge between theoretical research and practical know-how
EF14	Availability of tools to manage perceived risks
EF15	The availability of a suitable location and time on campus
EF16	Raising awareness

Driving considerations:

1. **Ambitious sustainability goals**
2. Growing preference for adaptive reuse
3. Policy and economic pressure
4. Clear roles during RE development
5. Market influence
6. Evolving procurement strategies
7. **Openness to innovative finance models**
8. **Increasing focus on long-term adaptability**
9. Starting knowledge sharing network

Findings SQ4

How is remountability practically applied in Dutch university buildings?

Exploratory multiple case study

Coding table (ATLAS.ti)

Based on the enablers & inhibitors of SQ2

Findings SQ4

Coding table (ATLAS.ti)

Based on the enablers & inhibitors of SQ2

Davis et al., (2015)

Theme	Sub-theme	Factor	Literature code
Culture	(1A) Team	Collaboration and ownership	EF2
		Presence of a motivated and capable team/organisational commitment	EF3
		Clear role for campus managers	EF11
		Presence of expertise	IF1
		Conflicts between experts on campus	IF9
	(1B) Mindset	Approach uncertainties with a flexible attitude	EF10
		Innovative campus visions	EF12
		Raising awareness	EF16
		Tendency to follow traditional paradigms	IF4
Governance	(2A) Legal	Legislative support	EF5
		Legal restrictions	IF6
Financial	(3A) Feasibility	Economic viability	EF4
		Economic infeasibility of innovative strategies	IF3
Site	(4A) Availability	The availability of a suitable location and time on campus	EF15
	(4B) Relation to other projects	Conflicting goals with other projects on campus	IF7
Construction system	(5A) Project plan	Having a detailed project plan	IF8
		The project having an informal character	IF10
	(5B) Design	Design based on available second-hand components	EF7
		Having overlapping project phases	EF8
	(5C) Execution	Building and component characteristics	EF1
		Availability of tools to manage perceived risks	EF14
		Technical complexities with building products/materials	IF2
Building information	(6A) Data storage	Digital technologies on material tracking	EF6
		Presence of data and warranty on old material	IF5
	(6B) Data analysis	Early information setting and sharing	EF9
		A bridge between theoretical research and practical know-how	EF13

Findings SQ4 3 university-based cases

P-Olympos
Parking garage
University of Utrecht

Techbank
Office
Technical University of Twente

Flux
Education
Technical University of Delft

How did <u>your construction process</u> go and what are <u>the lessons learned</u>?

Findings SQ4 P-Olympos

→ Is built for reuse in 15 years

Lessons learned:

+ Detailed project plan was set up beforehand

+ A cooperating team was crucial

+ Having reference buildings was very helpful for designing

+ Roles and responsibilities were very clear

- No clear responsibility on Building Information Model was made

Findings SQ4 Techbank

→ Is reassembled for second-life

Lessons learned:

+ Building Information Model was updated from the beginning

+ Design of components were kept simple

+ Team was very enthusiastic and innovative

- Slow decision-making in second life obstructed the process
- In the procurement phase: many sub-contractors were not convinced/ready

Findings SQ4 Flux

→ Is built for reuse in 10 years

Lessons learned:

+ A clear goal was set by the client

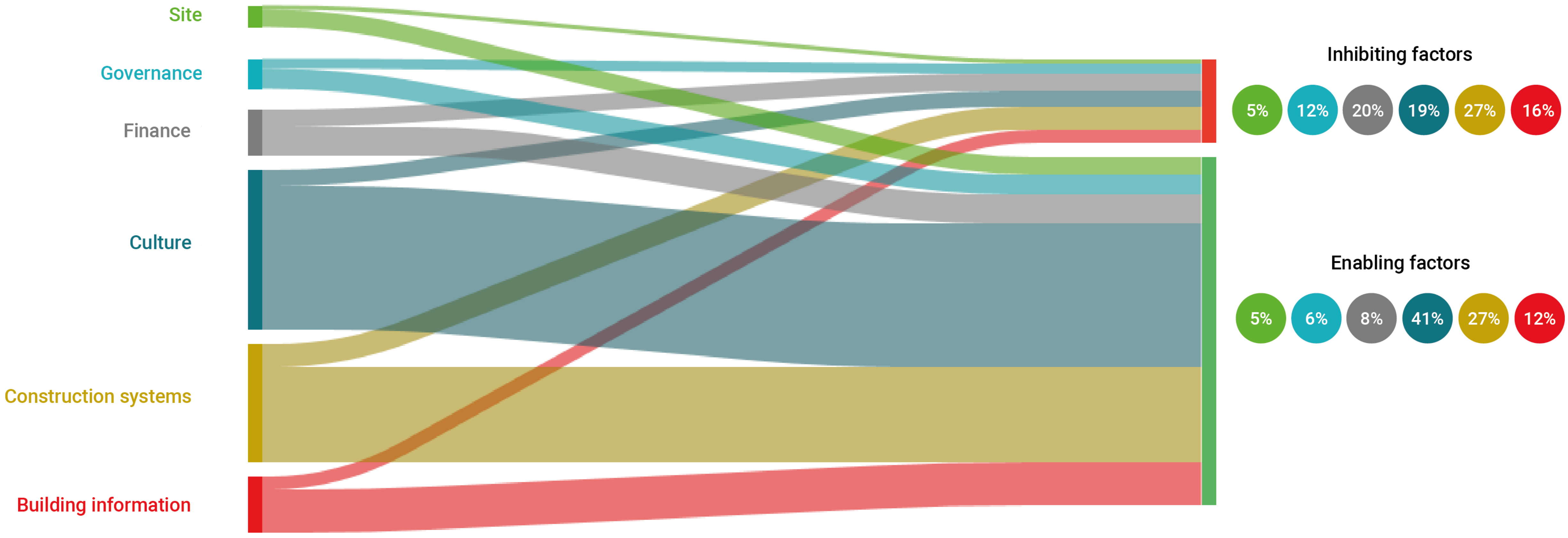
+ Having an experienced circular contractor worked efficient

+ The university board cooperated right from the beginning

- Slow decision-making from university project team created hesitancy

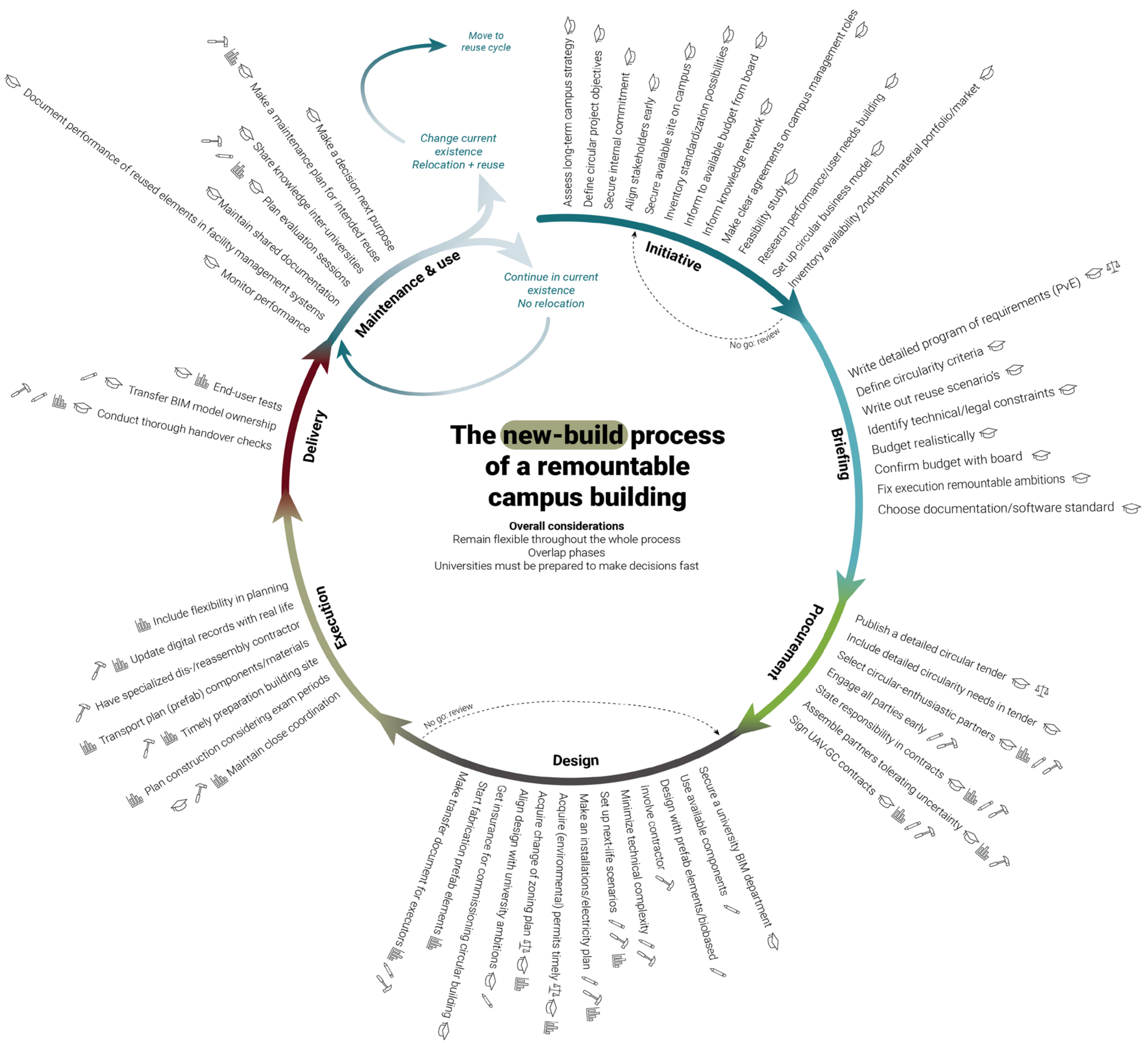
- Environmental research was not completed during design

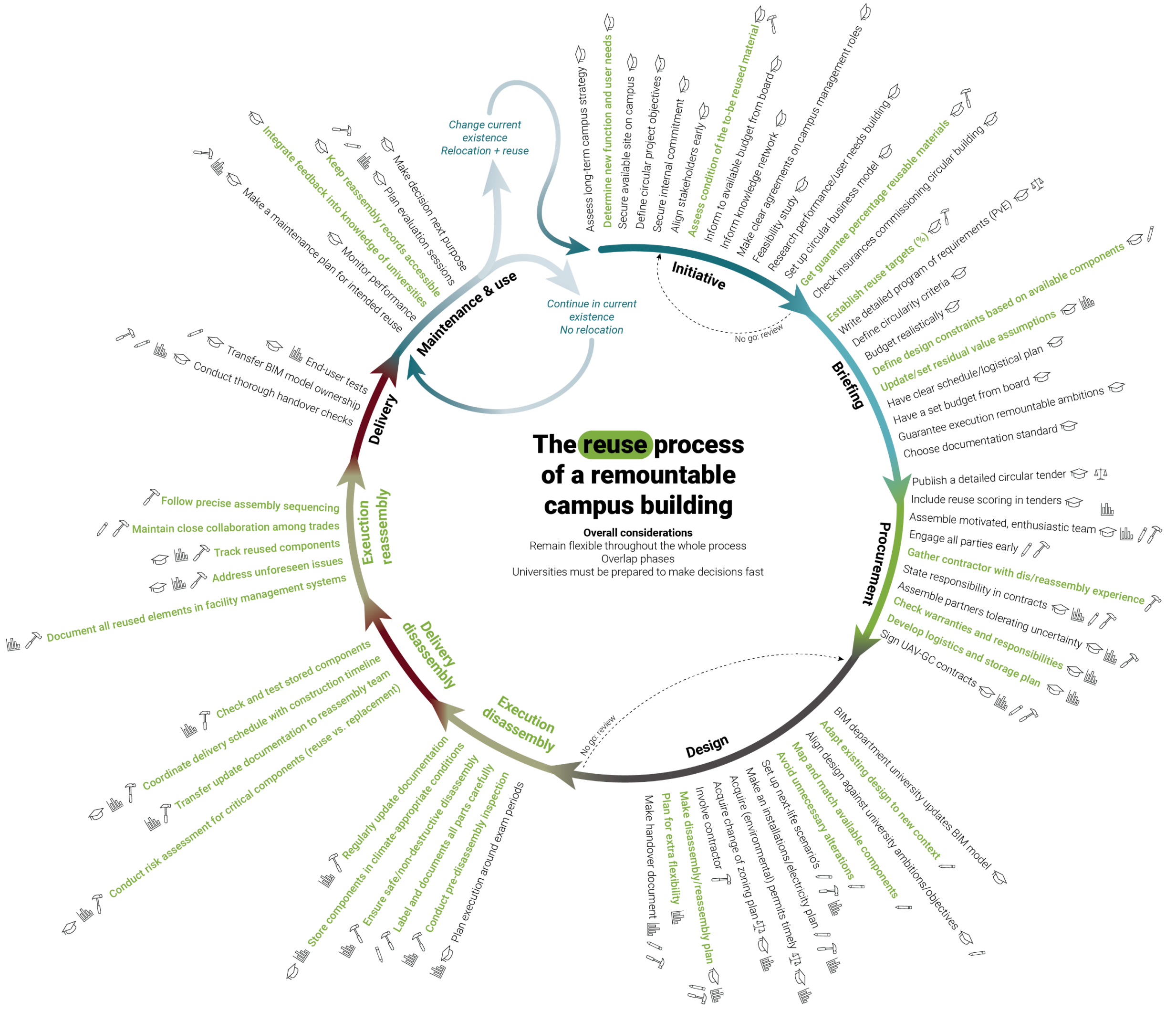
Findings SQ4 Total



Findings SQ5

What needs be done to increase the integration of remountability in the construction process of future campus buildings?

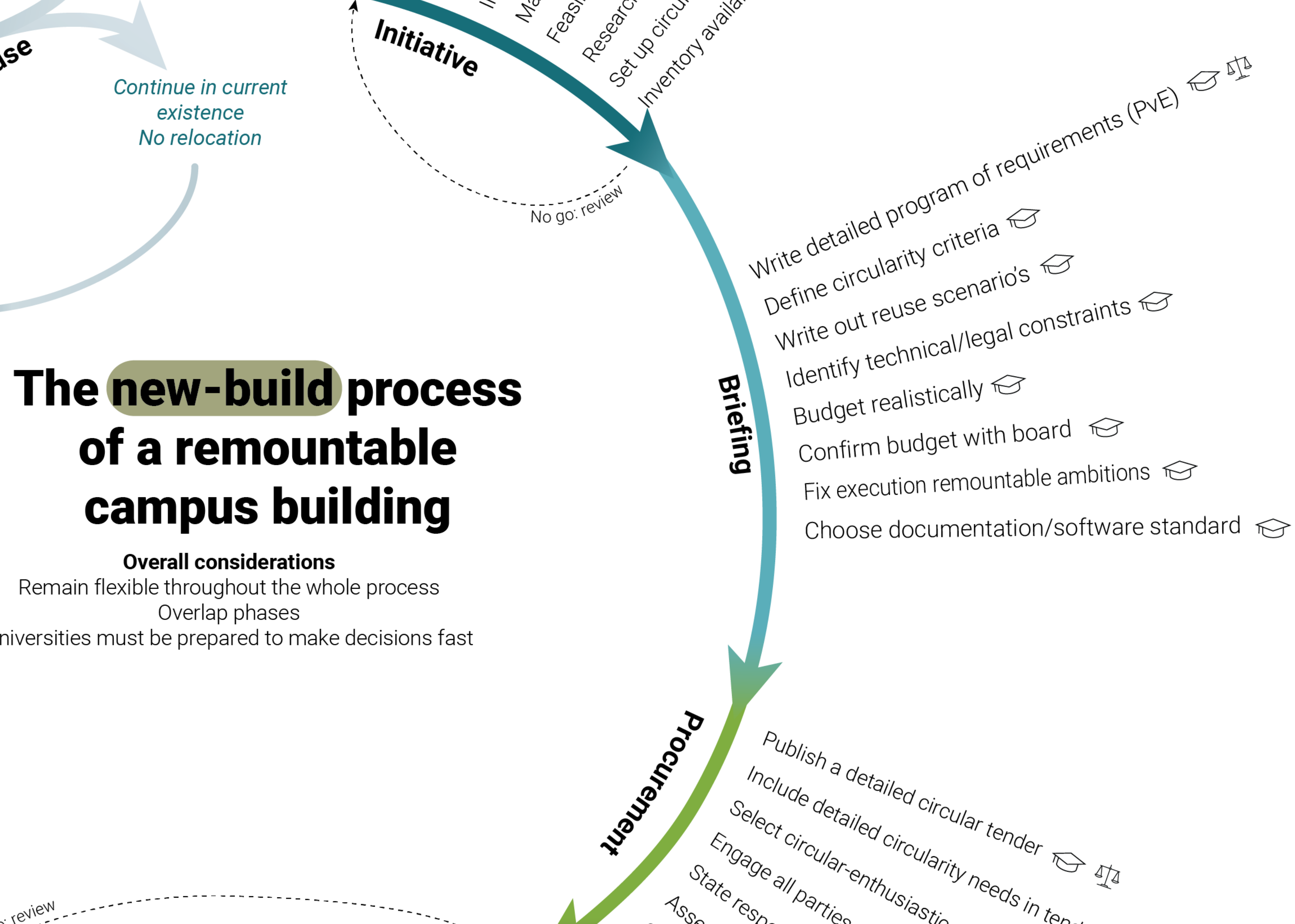


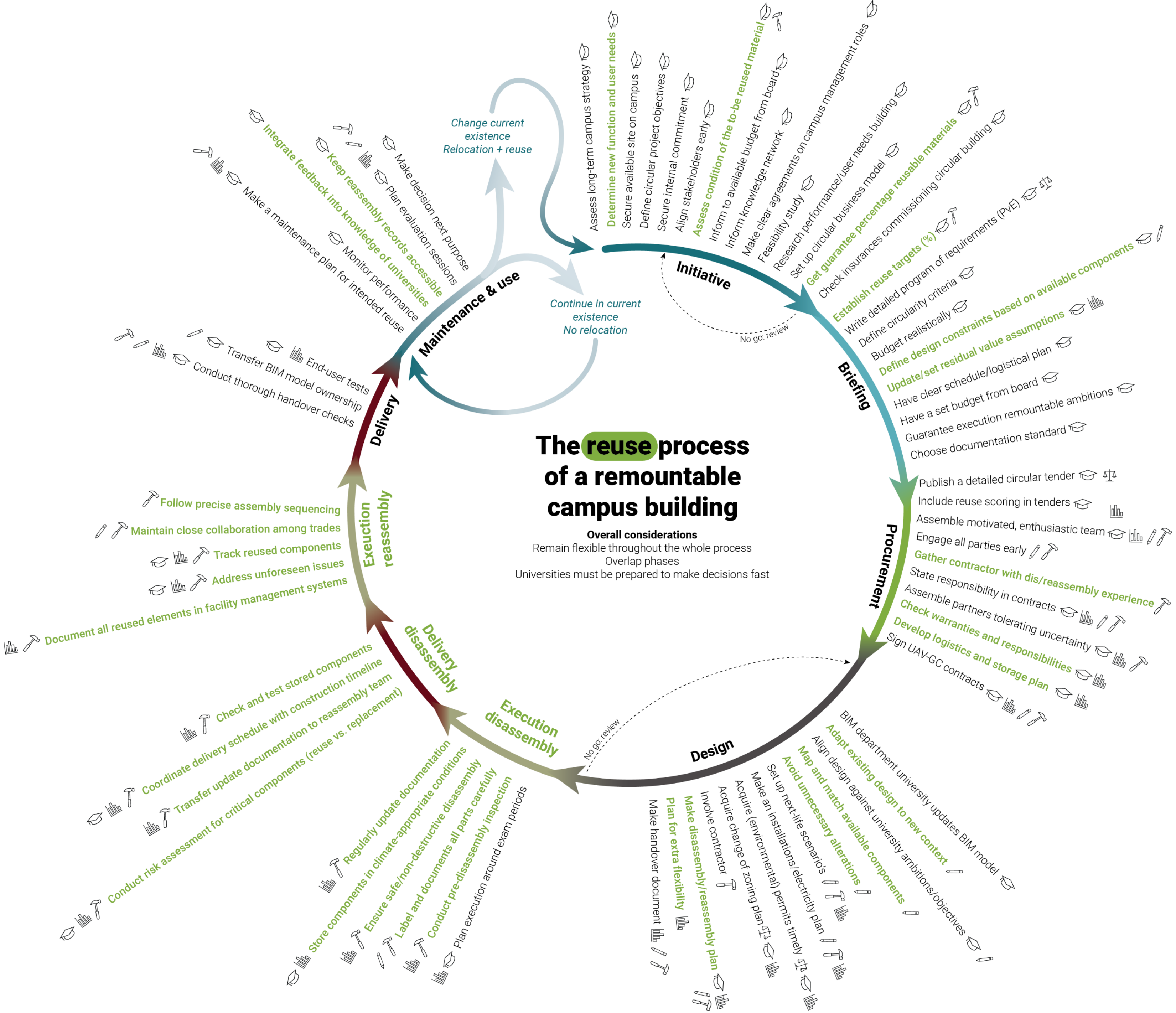


The new-build process of a remountable campus building
Overall considerations
Remain flexible throughout the whole process
Overlap phases
Universities must be prepared to make decisions fast
Initiative
Assess long-term campus strategy
Define circular project objectives
Secure internal commitment
Align stakeholders early
Secure available site on campus
Inventory standardization possibilities
Inform to available budget from board
Inform knowledge network
Make clear agreements on campus management roles
Feasibility study
Research performance/user needs building
Set up circular business model
Inventory availability 2nd-hand material portfolio/market
No go: review
Briefing
Write detailed program of requirements (PvE)
Define circularity criteria
Write out reuse scenario's
Identify technical/legal constraints
Budget realistically
Confirm budget with board
Fix execution remountable ambitions
Choose documentation/software standard
Procurement
Publish a detailed circular tender
Include detailed circularity needs in tender
Select circular-enthusiastic partners
Engage all parties early
State responsibility in contracts
Assemble partners tolerating uncertainty
Sign UAV-GC contracts
Design
Secure a university BIM department
Use available components
Design with prefab elements/biobased
Involve contractor
Minimize technical complexity
Set up next-life scenarios
Make an installations/electricity plan
Acquire (environmental) permits timely
Acquire change of zoning plan
Align design with university ambitions
Get insurance for commissioning circular building
Start fabrication prefab elements
Make transfer document for executors
No go: review
Execution
Include flexibility in planning
Update digital records with real life
Have specialized dis-/reassembly contractor
Transport plan (prefab) components/materials
Timely preparation building site
Plan construction considering exam periods
Maintain close coordination
Delivery
End-user tests
Transfer BIM model ownership
Conduct thorough handover checks
Maintenance & use
Document performance of reused elements in facility management systems
Make a maintenance plan for intended reuse
Make a decision next purpose
Share knowledge inter-universities
Plan evaluation sessions
Maintain shared documentation
Monitor performance
Continue in current existence
No relocation
Change current existence
Relocation + reuse
Move to reuse cycle

The new-build process of a remountable campus building

Overall considerations
Remain flexible throughout the whole process
Overlap phases
niversities must be prepared to make decisions fast





The reuse process of a remountable campus building
Overall considerations
Remain flexible throughout the whole process
Overlap phases
Universities must be prepared to make decisions fast
Initiative
Assess long-term campus strategy
Determine new function and user needs
Secure available site on campus
Define circular project objectives
Secure internal commitment
Align stakeholders early
Assess condition of the to-be reused material
Inform to available budget from board
Inform knowledge network
Make clear agreements on campus management roles
Feasibility study
Research performance/user needs building
Set up circular business model
Get guarantee percentage reusable materials
Check insurances commissioning circular building
No go: review
Briefing
Establish reuse targets (%)
Write detailed program of requirements (PvE)
Define circularity criteria
Budget realistically
Define design constraints based on available components
Update/set residual value assumptions
Have clear schedule/logistical plan
Have a set budget from board
Guarantee execution remountable ambitions
Choose documentation standard
Procurement
Publish a detailed circular tender
Include reuse scoring in tenders
Assemble motivated, enthusiastic team
Engage all parties early
Gather contractor with dis/reassembly experience
State responsibility in contracts
Assemble partners tolerating uncertainty
Check warranties and responsibilities
Develop logistics and storage plan
Sign UAV-GC contracts
Design
BIM department university updates BIM model
Adapt existing design to new context
Align design against university ambitions/objectives
Map and match available components
Avoid unnecessary alterations
Set up next life scenario's
Make an installations/electricity plan
Acquire (environmental) permits timely
Acquire change of zoning plan
Involve contractor
Make disassembly/reassembly plan
Plan for extra flexibility
Make handover document
No go: review
Execution disassembly
Plan execution around exam periods
Conduct pre-disassembly inspection
Label and documents all parts carefully
Ensure safe/non-destructive disassembly
Store components in climate-appropriate conditions
Regularly update documentation
Delivery disassembly
Conduct risk assessment for critical components (reuse vs. replacement)
Transfer update documentation to reassembly team
Coordinate delivery schedule with construction timeline
Check and test stored components
Execution reassembly
Document all reused elements in facility management systems
Address unforeseen issues
Track reused components
Maintain close collaboration among trades
Follow precise assembly sequencing
Delivery
Conduct thorough handover checks
Transfer BIM model ownership
End-user tests
Maintenance & use
Make a maintenance plan for intended reuse
Monitor performance
Integrate feedback into knowledge of universities
Keep reassembly records accessible
Plan evaluation sessions
Make decision next purpose
Change current existence
Relocation + reuse
Continue in current existence
No relocation

End-user tests
BIM model ownership
Conduct thorough handover checks
Delivery
Exeuction reassembly
Follow precise assembly sequencing
Maintain close collaboration among trades
Track reused components
Address unforeseen issues
Document all reused elements in facility management systems
Delivery disassembly
Check and test stored components
delivery schedule with construction timeline
documentation to reassembly team
(reuse vs. replacement)

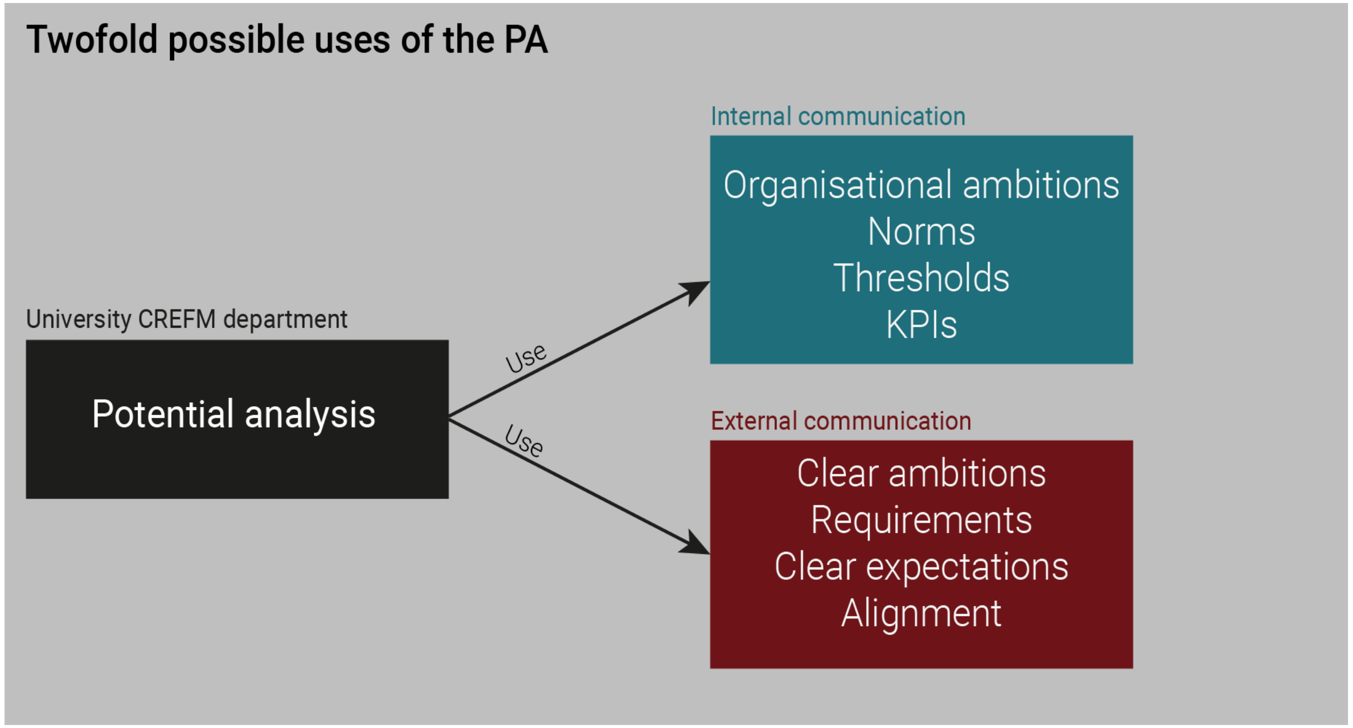
Findings SQ5

Findings SQ5

Expert panel

Potential analysis

- Purpose: get a **positive** focus on what is **possible** ☺



Findings SQ5

Category	#	Potentials	Description	Time horizon *Short (0-2y) middle (2-5 y) Long (5+ y)*	Scale *Material, component, building, campus (= neighbourhoods), network (= region)* (CBE, 2017)
Material potential and future proofing	1	**Availability of materials in existing portfolio**	Looking at what is already existing, provides a lot of existing materials and components in university campus portfolios and beyond.	Short	Material / component / building / campus
	2	**Evolving market dynamics of supply and demand**	Increasing uptake of circular construction, sparks an increase to the availability of second-hand materials. Simultaneously, growing awareness among clients, developers, architects, and contractors may accelerate demand for these materials, including biobased options. This shift could encourage a design approach that starts with available materials rather than predetermined needs.	Long	Network / material / component
	3	**Degree of disassembly**	Show how the materials and components are individually demountable for future adaptations.	Middle	Component / building
	4	**Degree of reassembly**	Show how the materials and components can be reused at the end of their lifecycle.	Middle - long	Component
	5	**Standardization of campus buildings**	Constructing for disassembly and reassembly comes with standardized components which stimulates reuse.	Long	Building / campus
Environmental impact and circularity	6	**Environmental impact (MPG)**	Protecting the environment. Doing a so called *Milieuprestatie Gebouw* (MPG) gives insight in the total environmental impact of a singular lifetime of a building. In the Netherlands the MPG is part of the building code (Bouwbesluit).	Short	Building / campus
	7	**CO_2 impact and storage**	• Calculating the material bound CO_2 emissions of the building provides the CO_2 impact of the production of the materials and also the construction process. • Calculating the material bound CO_2 storage shows the amount of CO2 storage in (reusable) building materials) saved from the atmosphere.	Middle	Materials / component / building
	8	**Reduced dependency on global supply chain**	Reusing local building elements and using bio-based/recycled materials reduce dependence on imported materials.	Middle	Network
	9	**Value retention (monetarv – emotional)**	• Reusing buildings or components and materials can contribute to preserving existing material and immaterial value towards the future which can give a financial benefit. • Reusing building components or entire structures can evoke a sense of nostalgia and strengthen people's connection to a building.	Short	Component / building / campus
Value creation and economic potential	10	**Value creation (monetary – emotional)**	• When a building is able to adapt throughout its lifespan, it maximizes its (monetary) value. Reusing building components and materials is also a strategy to add (financial) value to portfolio assets without generating waste. • Reusing buildings or components also creates emotional value by preserving memories, fostering a sense of continuity, and reinforcing a connection to the past.	Long	Building / campus
	11	**Branding and image enhancement**	Circular buildings or components can contribute positively to the image/reputation of an institution.	Middle	Campus / network
	12	**Affordable living spaces**	Reusing existing buildings or components offers significant potential to create attractive and affordable living spaces and thus addresses current student housing challenges.	Middle – long	Network
	13	**Cost reduction on specific components**	Construction in a circular manner rather than traditional, provides also certain cost reductions: • Material purchasing costs • Flexible ownership (e.g. renting) costs • Material transportation costs • Residual value	Short	Materials / component / building
	14	**Flexibility and adaptability in future performance needs**	Implementing circularity and adaptability to buildings creates buildings to be open for future performance needs and also responsive to contextual dynamics.	Long	Building / campus
Innovative universities	15	**Knowledge sharing among universities**	Having a circular building allows for more knowledge sharing on circular construction amongst universities. Amongst other things, by showcasing practical examples.	Middle	Campus / network
	16	**Material sharing among universities**	Having demounted building components allows for material sharing amongst universities or beyond.	Middle	Materials / component / network
	17	**Engagement of faculties**	Adopting more disassembly and reassembly construction practices stimulates looking at available materials first, when designing a new building or renovation.	Short – middle	Campus / network

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Findings SQ5

Main take-aways:

- Focus on what **is** there
- Acknowledge **future value**
- **Exchange knowledge** to be effective

CONTENT

Discussion

1. **Universities pursuing remountability**

    Complex / long term value?

2. **Applicability to other contexts**

    University-exclusive / transferable?

3. **The role of the persisting culture**

    Blame / collaboration?

4. **Responsible for the shift**

    Universities / government / designers?

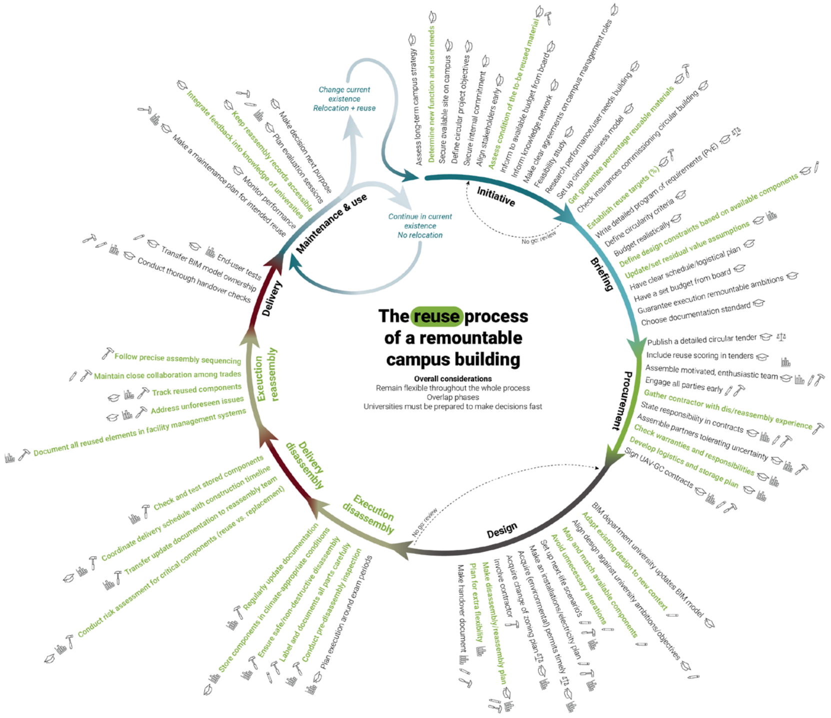
Limitations

1. Process model = theoretical until tested in practice
    - Does contain advice from practice
    - Universities must apply
2. Establishing a potential analysis in <1 month…
    - Limited time
    - Another MSc thesis/PhD
    - Further research necessary

CONTENT

Conclusion

How can Dutch universities integrate remountability in the construction processes of their campus buildings?



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Conclusion

1. Remountability is **promising**, yet underdeveloped
2. **Operational strategies** are key to implementation
3. **Context** of campuses can both enable and inhibit circularity
4. **Mindset shifts** are more urgent than technical innovation
5. Universities can and should **lead** in circular construction

CONTENT

Recommendations

Future research:

- Empirically test and evaluate the process model
- Compare buildings beyond the (Dutch) university context
- Dive into the potentials for mindset and cultural changes

For practice:

- Commit (!) to circular construction
- Appoint a circularity captain
- Evaluate other projects
- Push for legislative and financial reform
- Use the potential analysis in early phases

BUILD TO BE BACK

Thank you!

Lynn J. Kamphuis