BUILD TO BE BACK

L.J. Kamphuis

Master thesis
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Exploring remountable construction on Dutch university campuses

“JE MOET NIET TE SNEL “NEE” ACCEPTEREN OF OPGEVEN.”

Michael van der Gaag

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Exploring remountable construction on Dutch university campuses

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Cover picture: Temporary Court, Amsterdam. By Lucas van der Wee

ABSTRACT

As the construction sector remains a major contributor to global emissions and resource depletion, academics, governments and worldwide industries urge for a shift from a linear to a circular economy. Circular strategies such as standardization and demountability are increasingly promoted. However, remountability, the purposeful disassembly, reassembly and reuse of building components into new contexts, remains an underexplored yet critical component of circular reuse. This research investigates how Dutch universities can integrate remountability into the construction processes of their campus buildings, given their long-term spatial commitments, public role and frontrunning ambitions in sustainable innovation.

This exploratory study combines multiple qualitative methods. A literature review, semi-structured interviews and case studies of three university projects are used to identify key strategies, enabling and inhibiting factors and contextual considerations. An expert panel assembled for a validation of the propositions . The findings demonstrate that operational strategies, such as digital documentation, flexible planning, and early contractor involvement, are central to efficient remountable construction. Additionally, cultural and organisational mindset shifts are revealed as crucial conditions for implementation. Based on these insights, the research proposes a process model and a potential analysis to guide and inspire the integration of remountability in Dutch university campus developments.

The outcomes contribute to both academic understanding and practical application of remountability in construction, offering universities a structured yet adaptable framework to lead in the transition toward circular construction practices.

Keywords: *Remountability, university campus, reuse, design for disassembly, disassembly , reassembly*


own picture

PREFACE

After 10 months here it finally is: my master thesis. I never thought these months would go by so fast, since I had heard to many a-motivating stories from master students before me. But eventually, nothing could be further from the truth because time flew by.

I want to start by expressing my gratitude to my university supervisors. Thank you Ad, for keeping a critical eye during our meetings, while at the same time allowing me to make my own choices (and mistakes). I also wanted to thank you for your responses on my e-mails, which were quicker than from any other professor I have experienced. Thank you Alexandra, for checking in on me and highlighting the more personal side of doing research, where you reminded me that research should be fun and enjoyable. Thank you both for helping me through this master thesis!

A big thank you goes out to my supervisors from cepezedprojects. First to Menno for the support from day one and showing me the practical side of the construction sector. To Michael, for our discussions which helped me get out of my tunnel vision. Thank you Florien, for bringing joy and laughter to our balcony and for providing the needed distractions with your stories. Of course, I want to thank everyone at cepezed and cepezedinterieur for the warm welcome and the talks at the coffee corner.

Then, I would like to thank all participants of this research, for taking the time to meet with me and giving me your enthusiastic, helpful insights that led to this thesis you are reading right now.

A very important thank you goes to my fellow students during my time in Wageningen, Norway and Delft. I have had an amazing student-life experience, worth its weight in gold. Starting fresh and coming through a pandemic and picking it up again would not have been the same without you.

Another highly important thanks goes to my friends and (former) housemates for making life during and after study so much fun. Activities to look forward to every week and memorable moments I will never forget, have defined my last couple of years and I look forward to many more.

A special thank you to Lucas, for being there for me during this thesis in the high, but especially in the low moments. When I did not believe in my research anymore, you always talked me up. When I needed a snack, fun activity or just a hug, you would make time. I do not thank you enough but know that I always appreciate you and would do the same in return if needed.

I want to end with a moment of gratitude to my father, mother and sister. You are always thrilled when I come home and have supported me in every decision that I have made during my student time, which means the world to me. Although I sometimes take this for granted, I cherish all these moments and love you unconditionally.
Without you all, this thesis and its process would not have turned out the same. My most sincere thank you.

Enjoy reading!

Lynn

EXECUTIVE SUMMARY

Introduction
The construction sector struggles to keep pace with rapidly evolving societal and environmental demands, as most buildings are still based on a linear economy model that leads to high energy use and CO_2 emissions. Now, academics, politicians and industries world-wide have started advocating for a shift to circular construction, which promotes reuse and sustainability. Nonetheless, current circular practices remain limited and fragmented and while strategies as demountability are gaining attention, remountability, being the purposely reintegration of used building components into new structures for the purpose of multiple reuse cycles, through design for reuse, disassembly and reuse, remains largely unexplored despite its crucial role in circular strategies. Dutch university campuses offer a promising context to investigate an innovative construction strategy as remountability due to their variety of building functions, frontrunning ambitions and evolving spatial needs.

This research focuses on a significant gap between theoretical circular strategies and real-world application: the effective integration of remountability in a dynamic context. While some demonstration projects exist, the broader adoption of remountable building strategies faces key challenges in terms of the attitude of actors, extensive finances and documentation.

The aim of this research is to explore how remountable construction practices can be embedded into university campus development. This research provides both future research and practical recommendations that contribute to the stimulation of integration of remountability in campus context, but also in different physical (public) contexts. The main research question is:

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

This research is conducted in twofold with mixed methods. First, a theoretical framework is established through an extensive literature review on remountability principles, theoretical enablers and inhibitors of remountability, reuse and circularity on campus, Dutch university contexts itself and a traditional construction process. The second part consist of empirical research where a combination of interviews, case studies, and an expert panel provided practical insights into the integration of remountability in different situations and from different actor perspectives.

Findings
The semi-structured interview findings are structured around three key components: the practical strategies of remountability, enablers and inhibitors and the contextual role of universities.
First, the research defines remountability as a process involving intended design, reversible connections, structured disassembly and the potential for reassembly in future projects. Also, the identification of key points that support this have come up such as using material passports, planning for disassembly from the start and applying circularity criteria in tenders.

Second, three major challenges emerged across projects:

- Mismatch of information: there is limited access to accurate data on material reuse potential and unclear component documentation.Mismatch between material supply and project planning: second-hand components are often not available for the intended project or not qualified to be reused.
- Unaligned mindsets: relevant project stakeholders, both from the demand and supply side, often express hesitancy, scepticism and eventually unwillingness to cooperate in remountable or reuse projects due to the perceived novelty, risks and financial and regulatory barriers.

To address these, a strategic framework was developed, offering actionable key points, linked to actors, tools and process phases.

Third, the findings show that Dutch universities are well-positioned to lead circular construction efforts due to their frontrunning character, long-term spatial commitment and intrinsic motivation of staff. However,

they face cultural and institutional barriers, including risk aversion, regulatory complexity and specific faculty-related functional constrains. Remountability requires proactive management, new business models and alignment with broader campus visions.

Based on these findings, a process model was created, combining technical and organisational key points for integrating remountability into various project phases. This model is flexible and adaptable to specific building types and stakeholder settings. It functions as a practical guide to embed circularity in campus construction projects. Additionally, in response to the crucial mindset shifts in the industry, a potential analysis was established with listed potentials emphasizing the opportunities in circular construction.

Conclusion
Dutch universities can integrate remountability by applying a flexible process model that outlines key actions per construction phase, tailored to the building's status. This model combines all research insights and can be adapted to different project contexts, serving as a practical and inspirational guide. Additionally, fostering a cultural mindset shift by recognising and acting on remountability's broader potential can help embed circular thinking within institutional strategies.

Discussion
This research identifies five key discussion points on integrating remountability in university construction. First, while universities are well-positioned to lead in remountable construction, the value of remountability should be weighed per project based on strategic, environmental or educational goals. Second, the process model offers practical guidance, but its impact remains unquantified and vulnerable to external factors like politics or market shifts. Third, although tailored to the university context, the model's core principles are transferable to other sectors, provided institutional differences are acknowledged. Fourth, a risk-averse culture in construction remains a major barrier; the potential analysis helps shift focus from liability to opportunity. Finally, the responsibility for enabling remountability must be shared. Namely because, governments also play a crucial role in creating supportive regulatory and financial conditions.

Limitations
The findings reflect a specific moment in time and may shift as policy or market conditions evolve. Interview data is limited in scope and reflects subjective perspectives. The process model remains theoretical until tested in practice. Lastly, while cultural mindset emerged as a key factor, it was only explored preliminarily due to time constraints, suggesting clear recommendations for future research.

Recommendations
Based on the outcomes, the following recommendations are for future research:

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

In addition, five are also established for practice:

- Commit to circular construction in strategies and procurements
- Invest in an internal remountability team
- Integrally evaluate remountable reference projects
- Push for legislative and financial reform
- Normalise the use of the potential analysis in early phases

SAMENVATTING

Introductie
De bouwsector verandert maar lastig mee met de dynamische maatschappelijke en milieueisen van vandaag de dag. Dit is te merken doordat het grotendeel van de gebouwen nog steeds worden gebouwd volgens een lineair economisch model dat leidt tot een hoog energieverbruik en CO_2-uitstoot. Wereldwijd pleiten wetenschappers, beleidsmakers en bedrijven inmiddels voor een transitie naar circulair bouwen, dat hergebruik en duurzaamheid centraal stelt. Toch blijft de daadwerkelijke toepassing van circulaire strategieën in de bouw beperkt. Terwijl strategieën zoals demontabel bouwen toenemende aandacht krijgen, blijft remontabiliteit, het doelgericht bouwcomponenten hergebruiken in nieuwe bouwwerken, met als doel meerdere levenscycli via ontwerp voor hergebruik, demontage en remontage, grotendeels onbenut, ondanks haar essentiële rol binnen circulaire bouwstrategieën.
Nederlandse universiteitscampussen vormen een kansrijke context om remontabiliteit als innovatieve bouwstrategie te onderzoeken vanwege hun diversiteit aan functies, frontrunning ambities en continu veranderende ruimtelijke behoeften.

Dit onderzoek richt zich op de mismatch tussen theoretische circulaire strategieën en de toepassing ervan in de praktijk: het effectief integreren van remontabiliteit in een dynamische context. Hoewel er enkele voorbeeldprojecten bestaan, stuit bredere toepassing op knelpunten rondom de mindset van actoren, financiële haalbaarheid en benodigde documentatie.

Het doel van dit onderzoek is om te verkennen hoe remontabel bouwen kan worden geïntegreerd in de ontwikkeling van Nederlandse universiteitscampussen. Het onderzoek biedt zowel aanbevelingen voor vervolgonderzoek als praktische handvatten die niet alleen bijdragen aan toepassing in campusomgevingen, maar ook in bredere (publieke) fysieke contexten. De centrale onderzoeksvraag luidt:

Hoe kunnen Nederlandse universiteiten remontabiliteit integreren in het bouwproces van hun campusgebouwen?

Het onderzoek is uitgevoerd via een gemengde methode. Allereerst is een theoretisch kader opgesteld op basis van literatuurstudie over de principes van remontabiliteit, bevorderende en remmende factoren, circulariteit op campussen, de Nederlandse universitaire context en traditionele bouwprocessen. Het tweede deel bestaat uit empirisch onderzoek waarbij interviews, casestudy's en een expertpanel praktijkinzichten boden over de toepassing van remontabiliteit in verschillende situaties en vanuit diverse actorenperspectieven.

Resultaten
De resultaten van de semi-gestructureerde interviews focussen op drie hoofdonderdelen: de praktische strategieën voor remontabiliteit, bevorderende en belemmerende factoren en de rol van universiteiten.
Ten eerste wordt remontabiliteit gedefinieerd als een proces van doelgericht ontwerp, omkeerbare verbindingen, gestructureerde demontage en de mogelijkheid tot heropbouw in toekomstige projecten. Aandachtspunten hierbij zijn onder meer het gebruik van materialenpaspoorten, het plannen van demontage vanaf de ontwerpfase en het hanteren van circulaire criteria in aanbestedingen.

Ten tweede kwamen drie belangrijke uitdagingen naar voren:
- Mismatch van informatie: beperkte toegang tot betrouwbare data over hergebruikspotentieel en onduidelijke documentatie van componenten.
- Mismatch tussen materiaalbeschikbaarheid en projectplanning: tweedehands componenten zijn vaak niet beschikbaar of voldoen niet aan de eisen van het project.
- Ongemotiveerde mindsets: actoren aan zowel vraag- als aanbodzijde tonen terughoudendheid vanwege de nieuwheid, risico's en financiële en wettelijke obstakels.

Om deze uitdagingen aan te pakken, is een strategisch raamwerk ontwikkeld met concrete aandachtspunten, gekoppeld aan betrokken actoren, hulpmiddelen en fasen in het bouwproces.

Ten derde blijkt uit het onderzoek dat Nederlandse universiteiten goed gepositioneerd zijn om een vooraanstaande rol te spelen in circulair bouwen, dankzij hun langetermijnvisie, publieke karakter en intrinsieke motivatie van medewerkers. Toch worden zij ook geconfronteerd met culturele en institutionele barrières, zoals risicomijdend gedrag, complexe regelgeving en functionele beperkingen per faculteit. Remontabiliteit vereist dan ook proactief opdrachtgeverschap, nieuwe verdienmodellen en aansluiting op bredere campusstrategieën.

Op basis van deze bevindingen is een procesmodel ontwikkeld dat zowel technische als organisatorische aandachtspunten bevat voor de integratie van remontabiliteit in de verschillende projectfasen. Het model is flexibel en toepasbaar op uiteenlopende gebouwtypes en projectstructuren. Daarnaast werd, als reactie op de noodzakelijke culturele omslag in de sector, een potentie-analyse opgesteld waarin kansen van circulair bouwen worden belicht.

Conclusie
Nederlandse universiteiten kunnen remontabiliteit integreren door gebruik te maken van een flexibel procesmodel dat de aandachtspunten per bouwfase beschrijft, afgestemd op de status van het gebouw. Dit model combineert alle onderzoeksinzichten en fungeert als een praktisch en inspirerend instrument. Daarnaast kan het stimuleren van een culturele verandering, door het herkennen en benutten van de bredere potentie van remontabiliteit, helpen om circulair denken structureel toe te passen in de organisatie.

Discussie
Het onderzoek levert vijf centrale discussiepunten op. Ten eerste: hoewel universiteiten geschikt zijn als koplopers, moet per project worden afgewogen of remontabiliteit strategisch, ecologisch of onderwijskundig waardevol is. Ten tweede: het procesmodel biedt praktische handvatten, maar de effectiviteit ervan is (nog) niet gekwantificeerd en gevoelig voor externe invloeden. Ten derde: hoewel afgestemd op de universitaire context, zijn de kernprincipes overdraagbaar naar andere sectoren mits contextverschillen worden meegenomen. Ten vierde: de heersende risicomijdende cultuur vormt een aanzienlijke barrière; de potentie-analyse kan helpen het denken te verschuiven van aansprakelijkheid naar mogelijkheden. Tot slot: het realiseren van remontabiliteit vraagt om gedeelde verantwoordelijkheid, waarbij ook overheden een sleutelrol spelen in ondersteunend beleid en financiële prikkels.

Limitaties
De bevindingen zijn contextgebonden en weerspiegelen een momentopname in een veranderlijke sector. De interviews bieden een breed perspectief, maar blijven subjectief en beperkt in aantal. Het procesmodel is conceptueel en nog niet getoetst in de praktijk. Ten slotte werd de rol van culturele mindsets pas laat in het onderzoek erkend, waardoor dit slechts verkennend kon worden onderzocht — wat direct aanleiding vormt voor toekomstig onderzoek.

Aanbevelingen
Op basis van de resultaten zijn dit de aanbevelingen voor toekomstig onderzoek:
- Test en evalueer het procesmodel in praktijkprojecten
- Meet de impact van de geïdentificeerde sleutelpijlers
- Vergelijk gebouwen buiten de (Nederlandse) universitaire context
- Verdiep je in cultuur- en mindsetveranderingen binnen organisaties

Op basis van de resultaten zijn dit de aanbevelingen voor de praktijk:
- Veranker circulariteit en remontabiliteit in strategie en inkoopbeleid
- Investeer in een intern team voor remontabel bouwen
- Evalueer referentieprojecten integraal en deel inzichten tussen universiteiten
- Zet in op wet- en regelgeving en financiële hervormingen
- Gebruik de potentie-analyse standaard in de initiatieffase van projecten

LIST OF ABBREVIATIONS

AR	Adaptive reuse
BIM	Building Information Model/Modelling
CE	Circular Economy
CSB	Case study booklet
DfD	Design for disassembly, reassembly and reuse
KPI	Key Performance Indicator
PA	Potential analysis
TUD	Technical University of Delft
UT	University of Twente
UU	University of Utrecht

(cepezed, n.d.-b)

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INTRODUCTION

1 INTRODUCTION

1.1 A SHIFT IN THE BUILT ENVIRONMENT

While our society changes quickly, the contemporary construction sector does not change accordingly. Building requirements are constantly evolving due to changing functional needs, technological advancements, and market dynamics, factors that buildings often fail to keep pace with. Most existing buildings are constructed according to a linear economy, meaning a take-make-use-dispose system without consideration for future reuse or an end-of-life scenario (Van Gulck & Steeman, 2024). Such a traditional building process is shown in figure 1. Consequently, it is not surprising that the building industry is a significant energy user and one of the largest CO_2 emitters in Europe. 40% of energy consumption and 36% of greenhouse gas emissions come from buildings in the form of construction, usage, renovation, and demolition (European Commission, 2020). The construction sector directly impacts the use of raw materials, chemicals, electricity and connected services (Bertino et al., 2021).

Researchers, governments and industries worldwide are now recognizing the need to shift from a linear to circular economy (CE), considering new strategies and services that diminish the environmental impact of construction and allow reuse of building components to reduce waste and costs (Bertino et al., 2021). There are plenty of literature studies which underline that in order to move from a linear to circular economy we need to change our way of building (Bertino et al., 2021; Hamida et al., 2022, 2024; Ness & Xing, 2017; Remøy & Wilkinson, 2012; Van Gulck & Steeman, 2024). Legislative demands of European and national governments also emerge, forcing the building sector towards more sustainable practices (BREEAM-NL, n.d.; European Commission, 2020; NEN, 2024; RVO, 2024; UNFCCC, 2016). However, circular construction approaches in the built environment are still in their infancy (Pichlmeier & Lindner, 2024).

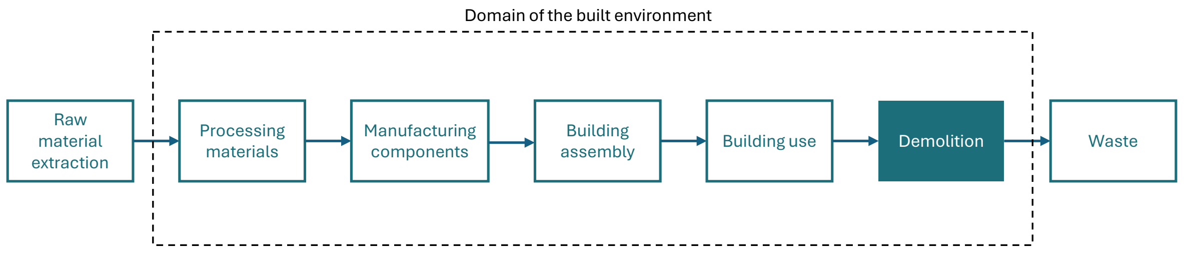


Figure 1: Linear construction process for most existing buildings (Crowther, 2005)

1.2 NOVEL STRATEGY

The primary goal of circular construction is to maintain the use of products, components, materials, buildings, and infrastructure for as long as possible, thereby minimizing waste and resource consumption and reducing the construction sector's environmental impact (Van Gulck & Steeman, 2024). In recent years, multiple articles and publications have been devoted to circular strategies within the built environment, such as Design for Disassembly (DfD), standardization, shareability, disassembly, reassembly and more. There are plenty of circular design principles established in literature that are, in theory, clearly defined. However, there is a common misconception that applying DfD principles automatically ensures straightforward disassembly. Similarly, disassembly alone does not guarantee reuse (Yang et al., 2025). While demountability (in Dutch: losmaakbaarheid) is increasingly discussed and applied in both theory and practice, the concept of remountability (in Dutch: vastmaakbaarheid) remains surprisingly underexplored. The practical and strategic challenges of reattaching and integrating used components have received little academic attention, despite their crucial role in enabling true reuse. To even reach the stage of remountability it implies that other (circular) strategies, such as initial assembly, careful disassembly and material traceability need to be successfully executed beforehand. Remountable construction is a term rooted more from practice than from theory, and no universal definition currently exists. Yet how different strategies interrelate to get to remountability, and which actors are essential for enabling them, remains largely unknown and underexplored which is an instigator for this research.

1.3 NOVELTY IN CONTEXT

To explore how remountability can be meaningfully applied in real-world settings, it is essential to study contexts where spatial transformation, long-term adaptability, and sustainability are pressing concerns. University campuses offer an ideal context for exploring remountability due to their unique characteristics and evolving spatial demands. As circular construction principles gain attention, Dutch universities have increasingly embedded circular development strategies into their organisational visions. The COVID-19 pandemic further accelerated the need to rethink the physical role of the campus, prompting a shift from the traditional focus on permanence and institutional presence, toward more flexible and virtual spatial options (Den Heijer, 2021). This shift highlights the challenge of balancing space efficiency with the enduring symbolic value of university buildings.

The twenty-first century Dutch university campuses comprise not only from educational buildings anymore. Thousands of facilities nowadays serve diverse functions, including education, housing, offices, leisure, and infrastructure (Den Heijer, 2021). These dynamic, multifunctional environments require constant redevelopment, particularly concerning the existing building stock, posing logistical and material challenges within circular construction frameworks. However, universities' access to knowledge networks, technological expertise, and long-term planning horizons position them as ideal testing grounds for innovative building practices, such as remountability (Du Preez et al., 2022). Moreover, as anchor institutions with deep social and cultural ties, universities bear a responsibility to develop sustainable and future-proof real estate strategies. Flexible construction solutions like remountability support both environmental goals and institutional continuity (Den Heijer, 2011; Harris & Holley, 2016).

1.4 PROBLEM STATEMENT

The transition to a circular building economy is essential, as the construction sector remains a major contributor to global emissions. While various circular building strategies, such as demountability, have gained traction in both theory and practice, the approach of remountability remains conceptually vague and underexplored in construction processes. Its integration, particularly within existing building portfolios, is limited and poorly understood.

University campuses, characterized by their own ownership, real estate management and pulbic mission, offer a unique opportunity to lead in innovative construction practices like remountability. With strong sustainability ambitions and their role as knowledge hubs, universities are well positioned to act as living labs for circular innovation. However, incorporating remountability into campus construction processes is a complex and largely unrealized challenge, requiring shifts across design, procurement, and execution. This underdeveloped area calls for targeted research into how remountability can be structurally embedded in the construction process of university campus buildings.

Figure 2: Problem statement (own illustration)

1.5 SCIENTIFIC AND SOCIAL RELEVANCE

The novelty of this research lies in the application of a specific circular adaptation practice within an existing built context that is typically seen as a frontrunner in technological and construction innovation: the university campus. While the shift from a linear to a circular economy has been widely advocated in academic literature (Brand, 1994; Hamida et al., 2022; Ness & Xing, 2017; Pinder et al., 2017; Remøy & Wilkinson, 2012; Van Gulck & Steeman, 2024), the practical implementation of circular principles within real-world construction settings remains limited.

Although circularity is not a new concept, traced back to foundational work from Boulding, (1966), Pearce & Turner (1990) and Stahel & Reday-Mulvey (1981), its operational translation into built environments is still underdeveloped. While demountability, which is the ability to disassemble components for potential reuse, is frequently cited in circular construction literature and practice, remountability, which goes a step further by emphasizing purposeful reassembly into new configurations, remains largely overlooked (Bertino et al., 2021; Hamida et al., 2022; Yang et al., 2025). Its absence may reflect its novelty, but emerging cases suggest it holds significant potential for advancing circular construction (cepezed, n.d.-a; Van Gulck & Steeman, 2024).

This study contributes to the scientific discourse by critically examining remountability within an actual socio-economic ecosystem: Dutch campuses. University campuses are increasingly regarded as living labs due to their integrated functions and long-term development strategies (Den Heijer, 2021; Du Preez et al., 2022). Scientifically, this research enhances understanding of how remountability can be embedded in the circular construction process. Practically, it responds to an urgent need: Dutch campuses are rapidly evolving portfolios that include educational, office, leisure, infrastructure, and housing facilities, all of which require continual, user-driven adaptation.

The social relevance of this research is equally clear. Universities are public institutions with strong cultural, educational, and innovation mandates. Their leadership in adopting circular practices can influence broader industry standards and stimulate systemic change. Investigating remountability on campus not only serves institutional goals but also provides replicable insights for circular building strategies more broadly.

1.6 RESEARCH AIM

The overarching aim of this research is to design a process model for Dutch universities on how to effectively integrate remountability in their construction processes. During the research it became clear that there is an equal, if not bigger, need for an established framework to change traditional construction culture and mindset. This evolvement is further explained in Chapter 7: Proposal.
The purpose of this research is to promote a long-term shift from linear to circular construction practices in the built environment, through its theoretical demonstration on versatile campus environments of frontrunning Dutch universities. This purpose does not change with the evolved deliverable.

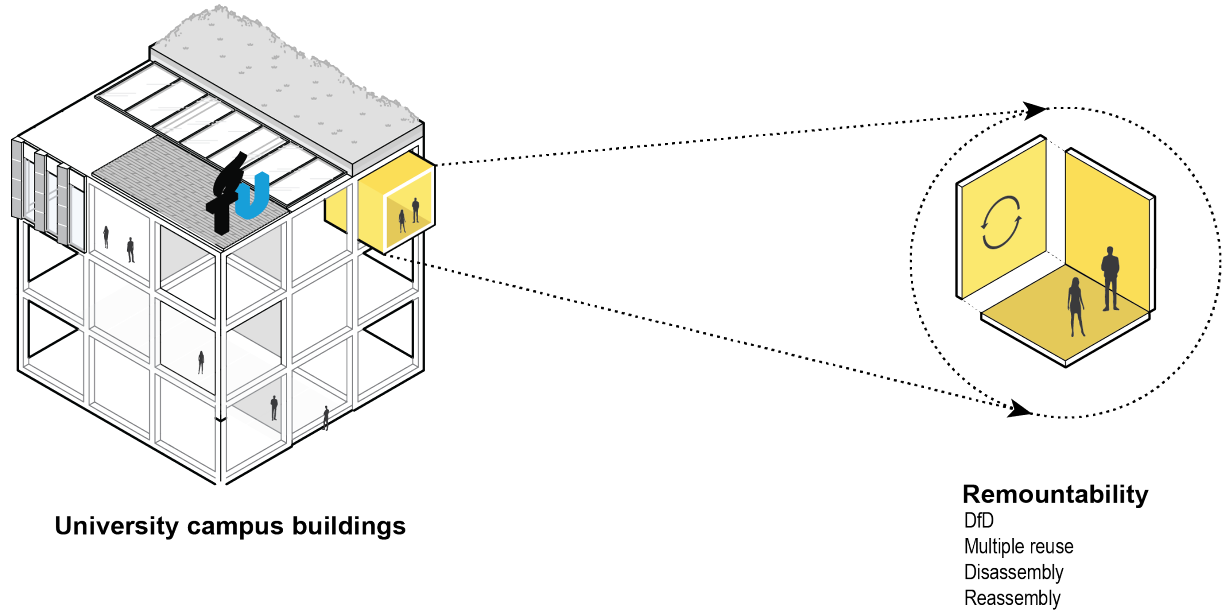


Figure 3: Phenomenon of interest. Designed on personal request by I. Avdić

METHODOLOGY

2 METHODOLOGY

This chapter provides an overview of the research questions, methodology and accompanying methods, data collection, ethical considerations, and research output. This overview is also shown in figure 4.

2.1 RESEARCH QUESTIONS

To go in on the challenges concerning the integration of remountability in campus real estate, the following question is central in this research:

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

This question is assisted by five sub-questions that aim to define and understand the key concepts of this research within context. Each sub-question has a specific focus and therefore purpose.

SQ1. *The concept of remountability in the built environment*

What strategies does a remountability process encompass in practice?
Purpose: to define remountability within the context of the built environment and distil its practical strategies for applying this practice to existing buildings.

SQ2. *Enablers and inhibitors*

What are enablers and inhibitors of remountability in the built environment?
Purpose: to explore the factors that facilitate or hinder the implementation of remountability, providing insights into the opportunities, challenges and dynamics that affect its adoption and effectiveness within the industry.

SQ3. *Considerations*

What are contextual considerations for universities that influence the integration of circular construction processes to their building projects?
Purpose: to analyse contextual considerations that affect the practical integration of innovations in a specific institutional setting.

SQ4. *In practice*

How is remountability practically applied in Dutch university buildings?
Purpose: to show the current uptake of remountability in practice and examine how it is applied in three relevant cases on university campuses in the Netherlands, highlighting practical examples, challenges and potential benefits.

SQ5. *Increasing uptake*

What needs be done to increase the integration of remountability in the construction process of future campus buildings?
Purpose: to identify and explore potential advancements, strategies and solutions necessary to overcome current challenges or limitations in the integration of remountability in university campus construction projects, including stakeholders, legislation, procurements and maintenance.

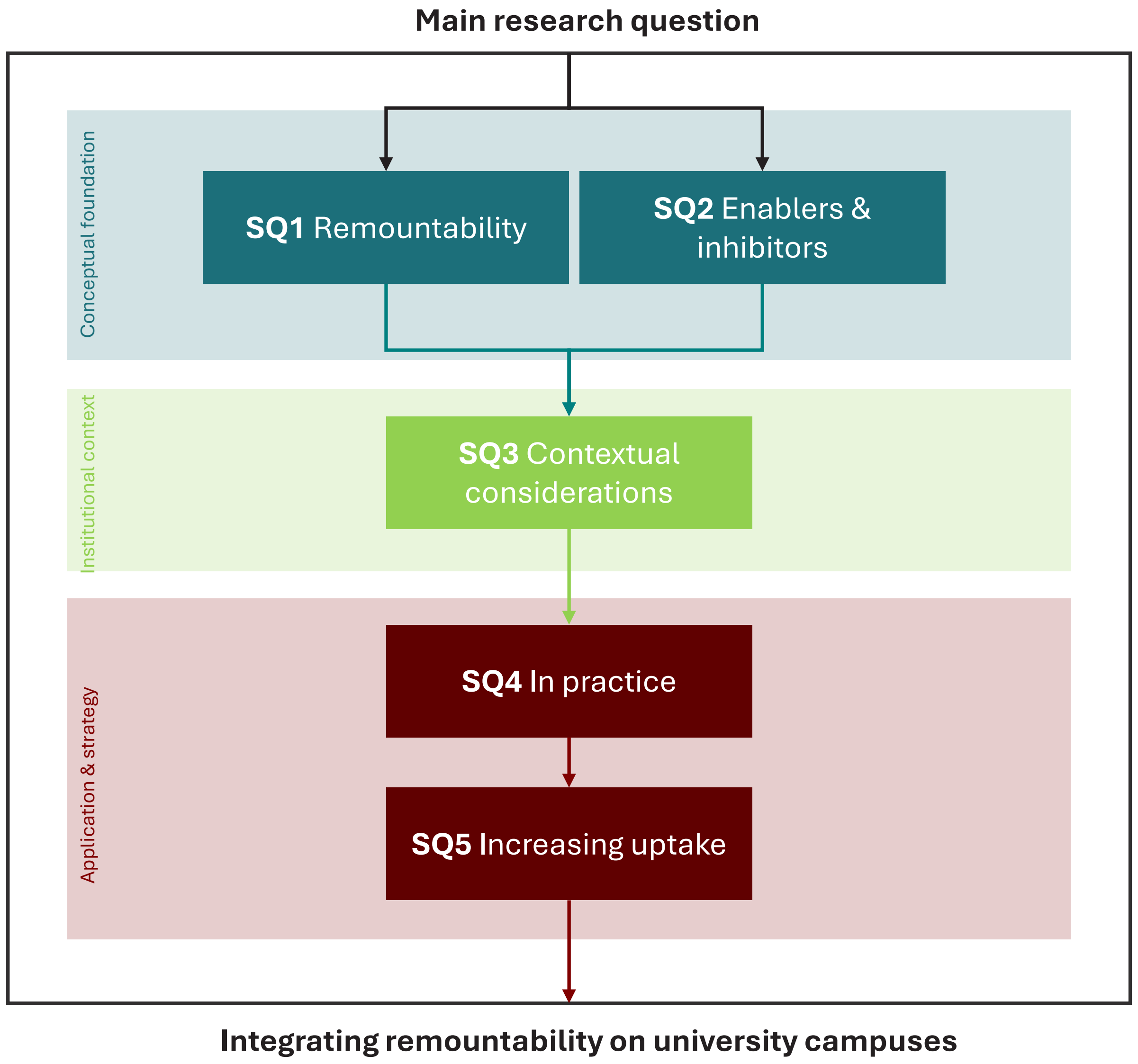


Figure 4: Conceptual model (own illustration)

2.2 RESEARCH DESIGN

A mix of methods is used in this thesis as shown in the research design in figure 5. This research is structured in three phases, being desk research, empirical research and validation. The sequence of methods turned out to be fluid due to varying methods per sub-question, new insights emerging during empirical research and changing methods for deliverables. This evolvement will become clear over de discourse of this thesis.

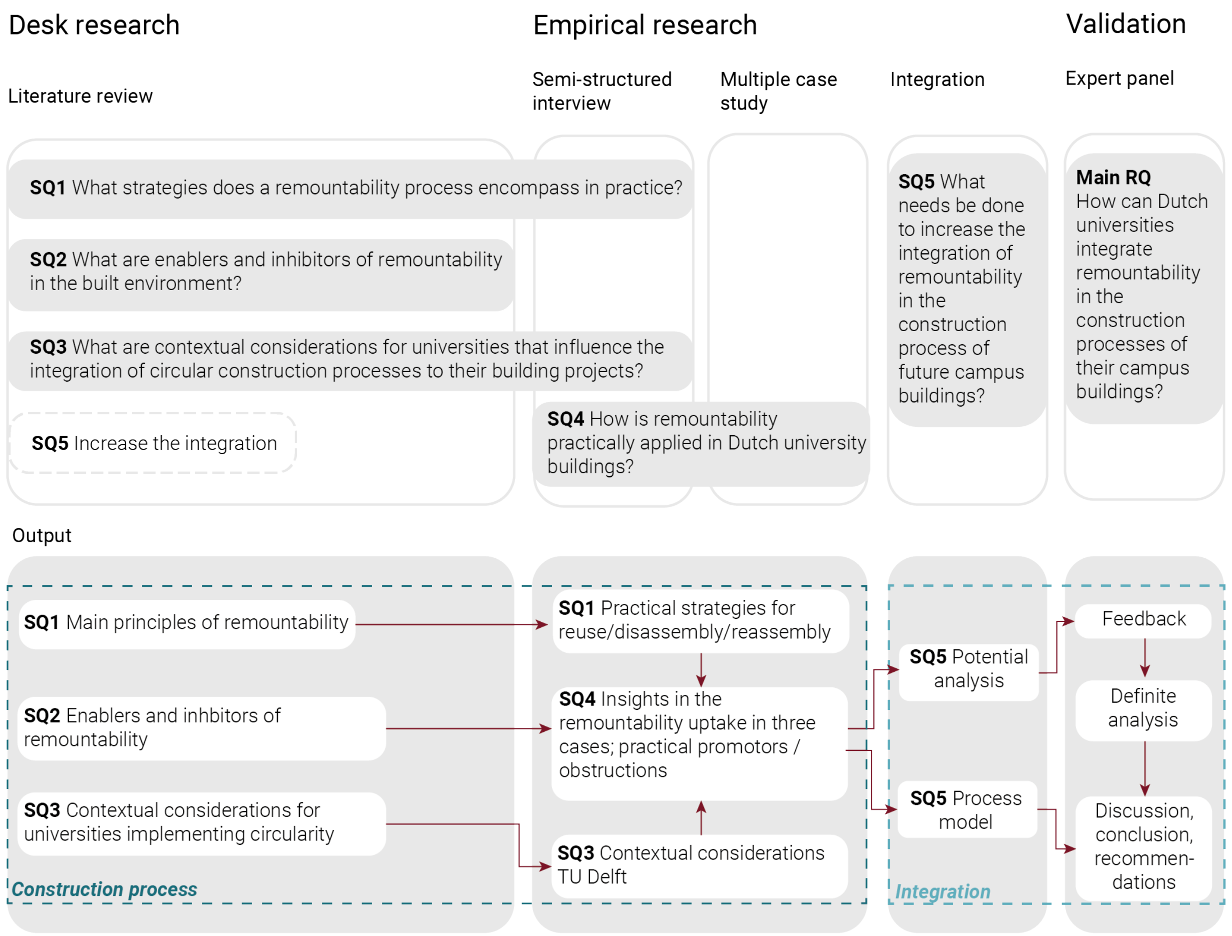


Figure 5: Research design (own illustration)

2.3 RESEARCH METHODS

This research is exploratory and descriptive and applies multiple methods that are qualitative in nature. Following Manerikar & Manerikar (2014), the main research question investigates an emerging phenomenon within a specific institutional context that has previously not been studied in depth. Consequently, the research approach is exploratory, aiming to seek both theoretical and practical insights into remountability as a circular construction strategy, while also proposing effective ways for the practical integration (Manerikar & Manerikar, 2014).

This research is guided by a 'how'-question, which indicates that in order to propose a process model for remountability on campus, the characteristics and its principles are described. The conclusion of this research is an answer to an emerging gap that is investigated in real-life case studies. The combination of exploratory and descriptive research lead to outcomes that create more understanding of the complexity of this phenomenon and promote a shift.

Since this research requires descriptions and exploring actors' perceptions, qualitative research methods are suitable (Blaikie & Priest, 2020). Qualitative research methods are especially appropriate, as they allow studying phenomena within their real-world contexts, a crucial consideration for the building industry where external factors can bias process perceptions. By executing qualitative research, this research focuses on exploring the human dimensions of the subject. The next paragraph sets out the methods for the five sub-questions. Varying purposes cause for different methods per sub-question. The specific qualitative methods applied include a literature review, semi-structured interviews, and case study analyses (Blaikie & Priest, 2020).

2.3.1 Methodology overview

Table 1 depicts a methodology overview for each sub-question of this research.

Sub-question	Literature review (both academic and grey)	Semi-structured interviews	Multiple case study	Expert panel
SQ1	X	X		
SQ2	X			
SQ3	X	X		
SQ4		X	X	
SQ5	X			X

Table 1: Overview of methods per sub-question (own table)

2.3.2 Literature review

This research starts with conducting a comprehensive literature review to provide a background and context and to form a bridge between the project and status quo with respect to each research question (Blaikie & Priest, 2020). Literature will be reviewed for sub-question 1, 2, 3 and 5 and it will serve as the foundation for the empirical research and help establish its boundaries. According to Bryman (2012), literature review serves to identify the theories and methodologies used in previous studies, to examine any conflicting perspectives and their underlying reasons, and to determine the key contributors within the field.

The review consists of secondary data in the form of academic articles and peer-reviewed studies. Database TU Delft Library is used to find the used articles. Hereafter, the snowballing technique (meaning: using a relevant article's reference list to find more articles) led to more relevant articles.
Inclusion criteria such as publication recency and relevance to research questions were strictly followed. Both criteria together provided a solid foundation for this study's analysis.
To find relevant, specific academic literature, search queries were formed by identifying key concepts and relevant keywords in combination with Boolean operators like AND, OR, and NOT. Filters such as publication date, peer-reviewed status, and subject area further narrowed the scope.

Most of the information and insights regarding the sub-questions will be drawn from academic papers and industry-specific professional literature. However, since the research focuses on the Dutch context and market, additional data will be sourced from books and reports that detail and analyse various projects in the Netherlands.

The findings from this review will provide essential input for subsequent phases of the research.
Since remountability is a relatively new concept, this literature review will have a large share in finding out what remountability means in the context of the built environment. A clear understanding of core concepts is essential for conducting thorough interviews and developing comprehensive case studies. The prospect of creating a process model and potential analysis can only be enhanced by a solid literature review as foundation.

2.3.3 Semi-structured interviews

Based on (Groat & Wang, 2013), rather than studying multiple cases from the surface, it is more beneficial to take single cases in-depth. Interviewing is a method that allows for insights in the complexities of processes and projects. Following the problem statement, circular construction approaches are emerging in the industry and remountability remains largely unexplored. The majority of the supply and demand side of the construction industry fail to consistently integrate remountability or its principles into their construction process. That is the reason why the empirical part of this research goes more in-depth with interviews to fully comprehend the characteristics and practical requirements of remountability, aligning and extending with literature.

The purposes of the interviews are

1. To get a practical understanding of remountability compared to literature and finding out reason for the enablers or inhibitors of it in the industry.
2. To gain an understanding of the (a)motivation of universities to develop their current and new buildings conform circular building strategies and connect this to the enablers and inhibitors of remountability.

To get a better grasp of remountability as a circular construction approach, semi-structured interviews with Dutch pioneers are held. Three selected participants are pioneering with remountability in projects, making them suitable for knowledge sharing on practical strategies. During the interviews of sub-question 1, the following topics are addressed: definition, traditional vs. circular building process, in practice and stakeholders. The interview questions of sub-question 1 are to be found in Appendix A.

Regarding sub-question 3, to understand the perception of Dutch university campuses on circular construction, two participants from Technical University of Delft (TUD) were chosen to interview. One interviewee has research insights on circularity in campus buildings and one on the practical implementation of it on campus. They are experts when it comes to circularity and construction on Dutch university campuses which indicates their relevance for this research. The following topics are addressed during the interviews with experts on whom the questions are based: strategy and policy, financial factors, technical and infrastructural demands, legislation, organisational and cultural factors, cooperation and evaluation and success.
The interview questions of SQ3 are to be found in Appendix A.

The interview questions for both topics are structured in such a way that the interviewee understands them, because it is not given that the pioneers and experts are familiar with academic terminology used in this research.
The (unsigned) consent form for the semi-structured interviews is to be found in Appendix B.

2.3.4 Multiple case studies

The second method of the empirical study concerns a qualitative multiple case study approach. This method is useful to investigate new phenomena in society (Blaikie & Priest, 2020; Meyer, 2001; Yin, 2009). Case studies as research methods are determined by the research questions, the emergence of the phenomenon and the richness or frequency of the phenomenon (figure 6) (Yin, 2009). Case studies can also extent and improve theoretical propositions since multiple cases are studied in different contexts and thus giving evidence of where theory will or will not hold (Bryman, 2012).
The case study in this research aims to explore the possible integration of remountability in campus construction. Based on Yin (2009), the validity of a case study requires an explicitly defined methodological approach and directions of theory. This research follows the processes depicted in figure 7.

The phenomenon of interest in this case study is remountability in campus buildings, specifically, their implementation and facilitating and obstructing aspects during the process. As stated by Meyer (2001), any case must be specified in terms of phenomenon of interest, context, and boundaries.

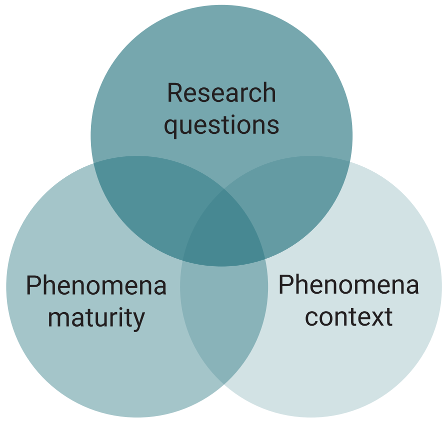


Figure 6: Determining factors of a case study (Yin, 2009)

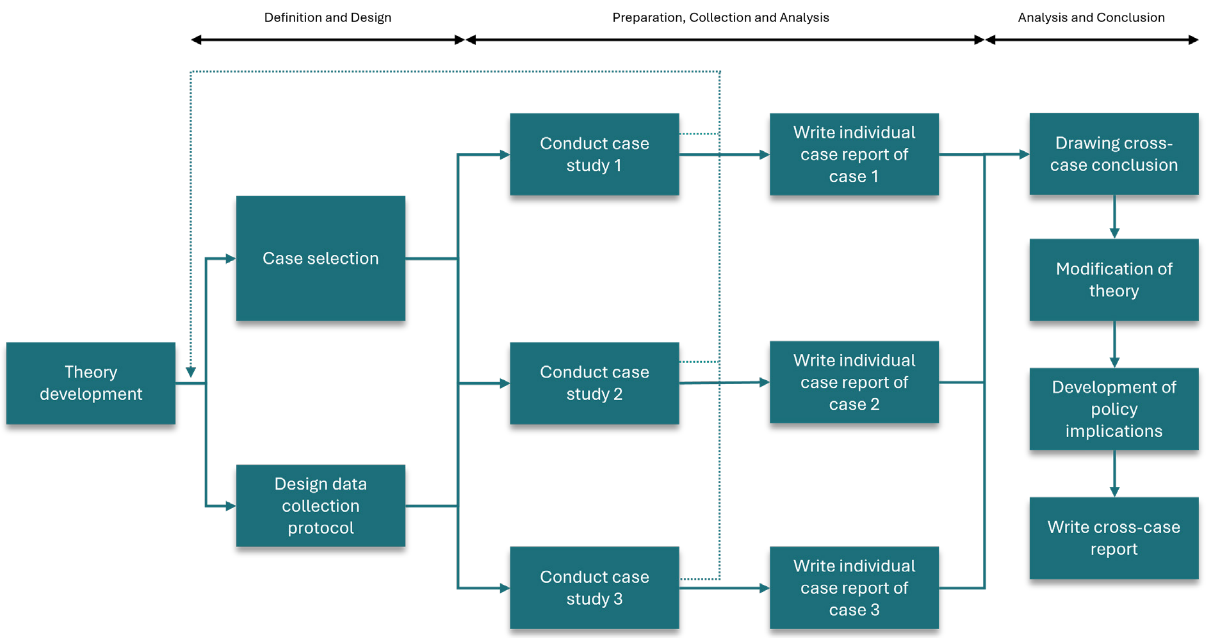


Figure 7: Typical process of multiple case study research (Yin, 2009)

2.3.4.1 Selection criteria

The boundaries of a phenomenon and its context are never entirely controllable or clear (Yin, 2009) since researchers often deal with a complex dynamic interacting with the phenomenon (Groat & Wang, 2013). Varying context can help in discovering and understanding patterns across heterogeneous cases and with that expand existing theory.
To ensure a focused selection of cases that provide meaningful insights into remountable campus buildings, there are eight selection criteria for choosing the case studies, namely:

1. Geographical scope [case boundary]: the case must be located in the Netherlands.
2. Type of institution: the case must involve a Dutch university.
3. Timeframe: the case must concern a construction from the last 5 years.
4. Realized projects: preferably focus on campus buildings that are constructed and in use, allowing for analysis of outcomes and impacts.
    a. Advanced proposals: Consider projects in advanced planning or construction phases if they include detailed designs and stakeholder commitments.
2. Alignment phenomenon of interest: the case must incorporate the key principles of remountable construction defined in Chapter 3.1 Remountability [read: DfD, disassembly, reassembly].
3. Collaborative partnerships: the case involves collaboration with external stakeholders (e.g., industry, architects, government).
4. Educational integration: projects that integrate into one of the five university campus functions (Den Heijer, 2021).

The selection criteria are summarized in table 2.

Criteria	Alternative
Located in the Netherlands	
Part of a Dutch university	
Developed in the last 5 years	
Construction is completed	Construction is planned
Incorporate key principles of remountable construction	
Involvement of external stakeholders	
Belongs to one of the five university campus functions	

Table 2: Overview of selection criteria (own table)

2.3.4.2 Sampling

The cases are selected through purposive sampling because with this phenomenon it is very unlikely to find samples randomly and there is no available list beforehand. Cases are needed relating to a particular phenomenon, so selection will be a matter of judgement as to which buildings are suitable. A selected diversity of cases in terms of locations and remountability features allows for an analytical overview, showing different patterns across a heterogenous sample (Blaikie & Priest, 2020).

2.3.4.3 Case selection

From the purposive case selection came the following three buildings as research cases (see table 3). Information on the cases can be found in the case study booklet (CSB) which is to be found in Appendix CSB which is explained in Chapter 6.1 Approach.

Criteria	Cases	1	2	3
	Name	P-Olympos	Temporary Court/Techbank	Flux
	University	University of Utrecht	TU Enschede	TU Delft
	Function	Parking	Office/education	Education
1 Located in the Netherlands		x	x	x
2 Part of a Dutch university		x	x	x
3 Developed in the last 5 years		x	x	x
4 Construction is completed		x	N/a	x
4a Construction is planned		N/a	x	N/a
5 Incorporate key principles of remountable construction		x	x	x
6 Involvement of external stakeholders		x	x	x
7 Belongs to one of the five university campus functions		x	x	x

Table 3: Case selection via purposive sampling (own table)

2.3.5 Expert panel

The third empirical method of this research is an expert panel with the aim for gathering valuable feedback on the established potential analysis. An expert panel consists of specialists from various fields who come together to discuss a specific topic with the aim of reaching consensus. This approach is particularly valuable for addressing complex issues that require input from multiple disciplines, which is often the case with development projects in the built environment.
Expert panels are effective for validation and feedback in research, especially when different stakeholders are included, such as project developers, contractors, clients, and academics. Multiple types of stakeholder must be present at the panel, as findings of a mixed group are considered more reliable than those of a single profession (Rocha et al., 2016).

For this research, after purposive sampling, three experts were invited to join the panel. The first being a project developer for a university, second a PhD candidate on the Built Environment and third a PhD candidate on Adaptive Reuse.

The objectives of organizing this expert panel for this research are to:

- Validate the identified potentials;
- Validate the setup of the PTA;
- Discuss the relevancy and rightful belonging of each potential;
- Expand and refine PTA;
- Evaluate the PTA as a framework for mindset shifts.
- Evaluate the PTA for future research.

The panel for this research had the following elements: introduction, describing the identified potentials, discussion, scoring, closing. The results of the expert panel is described in chapter 7.5.
The (unsigned) consent form for the expert panel is in Appendix C.

2.4 DATA ACCESS AND COLLECTION

To gain easier access to relevant data and insights in the field, a graduate internship was arranged at cepezedprojects which is a (re)development firm specialized in circular construction, design, and development. This collaboration offers valuable expertise in:

- Advising on circular strategies within the built environment.
- Providing technical knowledge and insights on the application of circular construction methods.

In addition, cepezedprojects supports the research by:

- Offering access to a broad portfolio of remountable building cases, facilitating case study selection.
- Sharing in-house expertise from professionals with relevant experience.
- Enabling connections with external experts who may contribute valuable perspectives or serve as interview candidates.
- Providing ongoing guidance throughout the research process.

2.5 DATA PLAN AND ETHICAL CONSIDERATIONS

The data management plan for this research is designed based on the types of data used and the methods for its collection, processing, and sharing. Sensitive data that is expected to be collected includes: (1) interview recordings and notes, and (2) documentation of case analysis. All recordings and notes involving participants will only be collected with their informed consent.

Most of the data generated in this research will be owned and managed by the researcher who takes full responsibility for securely storing and handling the data after the study concludes. Interim data will be stored on both a hard drive and external drive, while the final thesis will be made publicly accessible in a repository and also stored on an external drive for personal safekeeping. Once the data is processed, any raw documentation and additional materials will be deleted and rendered untraceable.
The research ensures that participants are protected from harm at all stages. Before participating, they will be fully informed about the objectives of their participation. Participation is entirely voluntary, and participants are not required to answer any questions that make them uncomfortable or violate their

privacy or ethical beliefs. Additionally, all statements and descriptions from participants will be anonymized to prevent ethical violations after publication.

2.6 RESEARCH OUTCOMES

This research builds upon existing knowledge by extending it with new empirical insights. The results are a structured construction process model and a potential analysis both tailored specifically to support the integration of remountability in the (re)developments of university campus buildings. To arrive at these final deliverables, the research will produce the following intermediate outcomes:

- Overview of case study analyses;
- A case study booklet with project details
- Interview coded analysis and findings from the semi-structured interviews;
- Expert panel analysis and expert insights;
- A process model for integrating remountability into campus building projects;
- A potential analysis with stimulations for a mindset shift and/or realisation;
- The final thesis report.

2.7 DISSEMINATION AND AUDIENCE

This research means to contribute to both academic discourse and practical implementation, aiming to reach several target groups:

- **Universities and specficially the Campus Real Estate and Facility Mainentance department:** this research offers a practical, phase-based overview of remountability dos and don'ts, making it easier to manage and implement circular strategies on campus. It promotes circular construction not only in new developments, but also in the transformations and renovations of existing buildings, aligning with contemporary organisational tasks.
- **Project developers:** the insights offered will support developers in engaging more effectively with remountable construction and therefore stimulate the shift from a linear model to a circular economy. The research also enables developers to optimize procurement strategies, improve operational efficiency, strengthen market positioning, and reduce risks.
- **Architects and contractors:** the structured, phase-by-phase outline of the remountability process, in the process model, enables supplying parties to better coordinate their activities. By shifting focus from the entire building to the value of individual components, remountability encourages earlier and closer collaboration across disciplines, leading to more efficient resource use and lower project risks. The potential analysis, when refined in further research, offers more clarity in expectations from clients on circularity matters.

3 THEORETICAL FRAMEWORK

This chapter defines the key concepts of the research by reviewing academic and non-academic literature. It builds on past studies of circular construction to explore remountability (SQ1), the enablers and inhibitors of circularity (SQ2) and innovations on Dutch university campuses (SQ3). The review offers an initial overview of practical strategies and contextual factors, establishing clear definitions and research boundaries essential for integrating remountability in campus environments.

3.1 REMOUNTABILITY

Within the field of the built environment, construction strategies such as disassembly, reassembly and the use of second-hand components contribute to the shift toward a circular economy (Hamida et al., 2023; Pichlmeier & Lindner, 2024; Yang, 2022). One emerging concept in the sector is remountability. There is no universal definition of the term to be found in literature (Kooij, 2020), which leads to the assumption that the term originates from the industry itself.

Remountability is often seen as demountability (or disassembly), which refers to the ability to take building components apart without damage, allowing for their reuse in new contexts and reducing waste (Hamida et al., 2023). Remountability cannot be used as a synonym because it extends beyond demountability by focusing on not just the disassembly but extends to the reassembly of components (Kooij, 2020) and reusing the building and/or components (Bouwakkoord Staal, 2024; Kooij, 2020), facilitating their transformation to meet new functional or technical requirements (Van Gulck & Steeman, 2024). Positioned higher in the hierarchy of circular economy actions, remountability aligns closely with the “reuse” principle, the second most preferred action after “refuse” (Van der Kooij, 2020).
In an interview, the company cepezedprojects explains remountability as “Designing a building in such a way that, after it has been built, it can be dismantled and rebuilt elsewhere” (Bouwakkoord Staal, 2024). This definition emphasized a clear goal, reuse, and three core principles (in blue): design, disassembly and reassembly (figure 8). The following paragraphs will explore each of these principles in more detail, outlining their role in enabling remountability within the built environment.

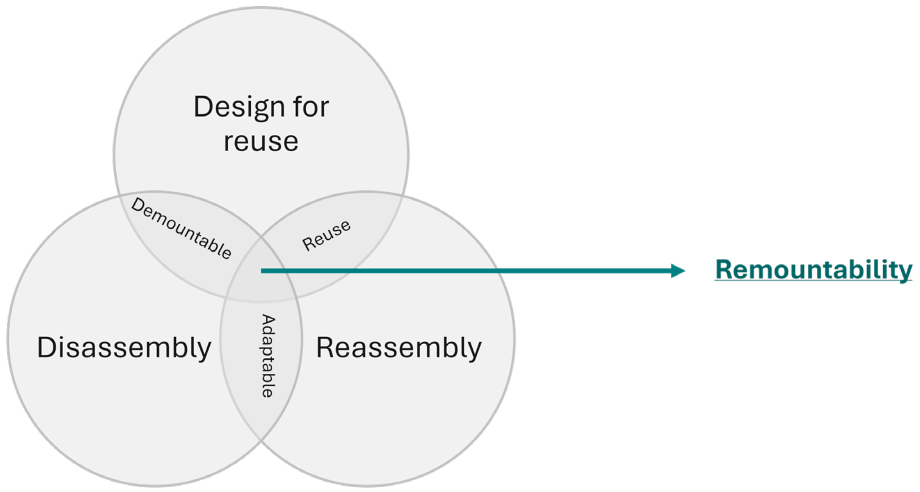


Figure 8: Remountability with its founding principles (own illustration)

3.1.1 Design for reuse

A crucial aspect of achieving remountability is Design for Disassembly, reuse, and reassembly. DfD allows for maintenance, repair, and the recovery of building components at the end of their lifecycle, supporting reuse either in their original form or in new contexts (Bertino et al., 2021; Khanalizadeh Taromi, 2023; Kooij, 2020; Ottenhaus & Leardini, 2022). Over time, DfD contributes to reducing material consumption and environmental impact by enabling multiple lifecycles for components (Kooij, 2020).

To achieve this, component and connection design must ensure ease of separation and adaptability to new assemblies(Pichlmeier & Lindner, 2024). Various authors have proposed DfD guidelines, tailored to different layers of building design as described by Brand (1994). Table 4 categorizes these guidelines into six dimensions: layout, materials, connections, component characteristics, disassembly conditions, and communication. These reflect best practices gathered from both academic and professional sources (Bogue, 2007; Boothroyd & Girard, 1996 as cited in Ottenhaus & Leardini (2024); Crowther, 1999; Kanters, 2018; Nordby, 2009; Smith et al., 2012)

However, technical design guidelines alone are not sufficient. Akinade et al. (2017) emphasize that non-technical factors, such as legislation, policies, and a shift in industry mindset, are equally important. Embedding DfD into early planning and design stages is key to enabling future reuse (Khanalizadeh Taromi, 2023). Yet, misconceptions exist: applying DfD principles does not automatically guarantee effective disassembly or reuse (Yang et al., 2025)

There are also trade-offs. Remountable components can have a higher initial environmental impact due to the use of materials like metal connectors or additional layers to meet performance standards (Vandenbroucke et al., 2015). Although remountable components may have a higher initial environmental impact, this is often compensated over time because reusing them reduces the need to produce and use new materials in the future (Stahel & Reday-Mulvey, 1981; Van Gulck & Steeman, 2024).
At the same time, the practical value of reused components is not stable. It depends on age, degradation and performance characteristics such as Rc-values (de Architect, 2022). Predicting the end-of-life or reuse potential of components is challenging, as it depends on future unknowns, including technological developments and market conditions (Het Nieuwe Normaal, 2024).

To guide practice, formal institutions have begun to standardize DfD. The ISO 20887:2020 standard, published by NEN, provides a structured framework for integrating DfD into sustainable building design. It outlines principles such as accessibility, reversibility, standardization, and minimal finishing, and supports practices that facilitate reuse and reduce waste at the end of a building’s life (ISO, 2020; Khanalizadeh Taromi, 2023).

Together, these insights show that while DfD provides a powerful foundation for remountability, its success depends on an integrated approach: combining smart technical design with systemic changes in planning, knowledge-sharing, and institutional support.

Authors	Product structure/building layout	Materials	Connections	Component characteristics	Disassembly conditions	Communication
Kanters (2018)	- Use of simple, modular design - Use open building systems flexible for future function changes - Use layered building elements - Ensure deconstructions stability - Use of separated building systems	Minimize number of different materials - Design durable - Lightweight materials - Use durable materials - Use high quality materials - Use non-toxic materials - Use recycled/recyclable materials	- Accessible connections - Use mechanical joints	- Minimize number of different components - Avoid adhesives and secondary finishes - Reasonable size for handling - Common tools for deconstruction - Ensure assess to components	- Develop disassembly plan in design stage - Prefabrication - Allow parallel disassembly instead of sequential	- Documentation of used materials - As-built drawings - Have a disassembly plan - Provide identification of components and material types - Have the right skills and competence in the design team for DfD
Bogue (2007)	- Modularity - Standardization - Minimise components/variants	- Mono materials - Recyclable	- Minimize nr. of joints - Have accessible joints - Have visible joints - Easy to disassemble - Use fasteners instead of adhesives	- Lightweight - Robust/ durable - Non-hazardous	- Automated disassembly - No need for specialised procedures - No need for specialized tools	
Smith et al. (2012)	- Layers can be easily removed in the same direction as the target component - Placing target component close to the boundary and close to each other		- Single direction removal - Single-translation motions	- Single direction removal	- Easy to disassemble	
Nordby (2009)	- Durable design - Standardization - Suitable layering (Brand)	- Limited material selection - Accessible information	- Flexible connections	- Accessible information		-Share information
Crowther (1999)	- Build buildings in layers - Easily accessible - Open buildings - Standardization - Regular grid	- Lightweight	- Use mechanical connections - Standardized connections	- Minimise nr of components - Permanent component identification - Lightweight components		
Boothroyd & Girard (1996) as cited in Ottenhaus & Leardini	- Functional units - Easily accessible	- Have few components identities - Separable - Non-harmful - Recyclable			- Easy to disassemble	

Table 4: DfD guidelines for buildings from various authors

3.1.2 Demountability

For remountable building components to become available, a secure demountability (or disassembly) process is required (Douglas, 2006). The objective of demountability is to reduce demolition waste through systematic disassembly of buildings, maximizing the reuse and recycling of materials (Akinade et al., 2017; Yang et al., 2025). Disassembly can occur element-per-element or layer-by-layer. The efficiency of demounting relies on DfD incorporated beforehand (Yang et al., 2025).

Already in the former century, Brand (1994) emphasized that buildings must not be seen as a solid entity, but rather as a collection of independent layers with different lifespans (figure 9). Subsequently, disassembly often follows a layer-to-layer approach, also called the sequential or linear approach. However, independent disassembly (parallel) happens when several components can be disassembled simultaneously due to their independent locational relationship (Deniz & Dogan, 2014; Sanchez & Haas, 2018). Choosing a disassembling approach depends highly on the interdependence of components and its adjacent parts (Sanchez & Haas, 2018).

Demountability and remountability are intrinsically connected, not as synonymous concepts, but with demountability serving as a foundational component within the broader remountability process. Stating Van Vliet et al. "[...] demountability is not a goal, but a means to enable reuse" (2021, p. 7). Het Nieuwe Normaal confirms this by stating "Demountability is a prerequisite for making circular construction possible: an indetachable object cannot be harvested and therefore cannot be reused (in a high-quality manner)" (2023, p. 22).

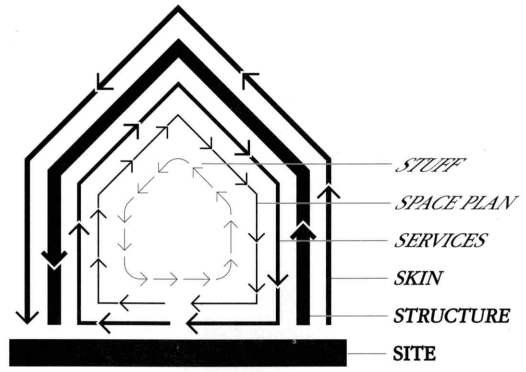


Figure 9: Shearing layers of Brand (1994)

Demountability is most effectively and efficiently achieved when the components are prefabricated or standardized. But when deconstruction is not explicitly considered in the design phase of buildings, this condition is rarely met as less than 1% of the existing buildings can be demounted entirely (Khanalizadeh Taromi, 2023). This is the case for most existing buildings, which are originally built with the notion of permanence, following linear principles (Bertino et al., 2021; Hamida et al., 2022; Khanalizadeh Taromi, 2023; Kooij, 2020). This is partly the reason why demountability is not executed on a large scale (cepezed, n.d.-a). Demountability comes with many challenges (Yang et al., 2025). Rios et al. (2015) studied seven demountability challenges and the existing gap between theory and practice: (1) there is the uncertainty and different quality and quantity of second-hand material, (2) components can get damaged during disassembly and transportation due to the absence of a coherent disassembling plan, (3) salvaged materials and components have a negative association compared to new ones, (4) transportation of disassembled materials is less beneficial environmentally and economically, (5) designers do not often consider a building's end of life scenario, but keep designing for permanence, (6) the time and cost differences between disassembly and demolition, (7) there is a present lack of quantifying the benefits of disassembly, and lastly, 8) costs are often a hinderance to disassembly but are influenced by variables as labour, transport, removing hazardous materials, local and regional supply and demand for components, components conditions (Rios et al., 2015).

Although there are various reasons for avoiding disassembly in a building process, this strategy is getting more acknowledged and is gaining attention, as there are increasingly more reports published serving as a disassembly manual or assessment. They contain definitions, purposes and technical aspects, but most predominantly an index of the degree of demountability for different building components, in some cases based on equations. Elements such as crossings, connections and their accessibility are getting assessed on how demountable they are (Het Nieuwe Normaal, 2024; Khanalizadeh Taromi, 2023; PIANOo, 2019; Van Vliet et al., 2021). Innovative demountable components and buildings are even taken into practice nowadays as the demountable channel plate floors (figure 10)(cepezed, 2024) and the Temporary Court, which is an example in many demountability guides (figure 12).
This growing body of knowledge highlights the importance of demountability as a measurable and actionable aspect of sustainable construction practices, paving the way for its broader implementation in the industry. Furthermore, according to Kanters (2018) the use of Building Information Modelling (BIM) is increasing. With BIM, the level of information detail becomes greater as well as the material specification, element location and maintenance status. This can serve as an important tool for disassembly, but also for the use of DfD.

Another emerging concept that uplifts the demountability potential is a material passport. With de- and remountability, buildings are seen as resource repositories (Bertino et al., 2021), holding all kinds of materials from different building layers (Brand, 1994). Material passports function as a list of building components, their original position, how to reuse, reclaim or recycle them. It is an upcoming concept that is now beginning in mainly European countries, and it is related to circular economy initiatives. In essence, the passport holds data on building components, their characteristics, an overview of all products of those buildings (window frames, doors, wooden beams, glass panels etc.), and raw materials (steel, wood etc.), and of their presence, also after demounting (Gepts et al., 2019 as cited in Bertino et al., (2021).

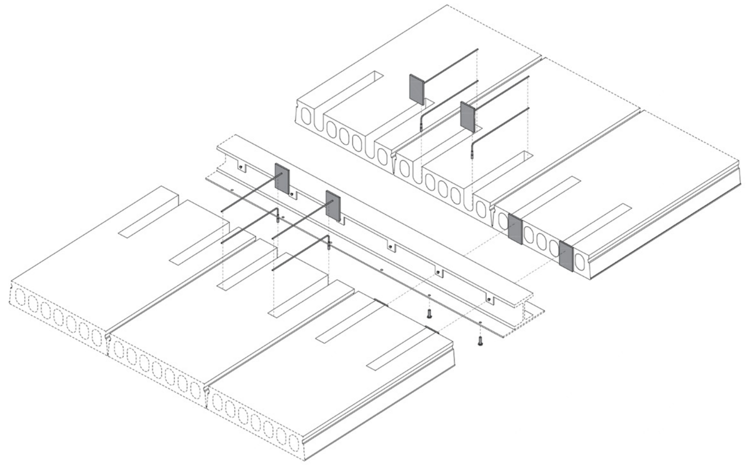


Figure 10: Top and bottom: Demountable channel plate floors (cepezed, 2024)

3.1.3 Reassembly

After emphasizing the significance of design for reuse and demountability, the logical next step is reassembly, as disassembly and reuse hold no purpose without it. Remarkably, there are multiple guidelines published for evaluating the degree of demountability (in Dutch: losmaakbaarheid), but an evaluation for the degree of reattaching these components is not available. An adequate assessment tool for remountability (in Dutch: vastmaakbaarheid) remains absent, while this is crucial for the reuse of building components. Moreover, in literature there is an explicit focus on disassembly and reuse, whereas reassembly is not mentioned as a significant part but is integrated in the process (Hamida et al., 2024; Khanalizadeh Taromi, 2023; Pichlmeier & Lindner, 2024; Yang et al., 2025).

Before reassembly can commence, a quality assessment is necessary to verify that the value of the component complies with the technical and legal standards.
As stated in Chapter 3.1.2 Demountability, to bear an efficient reassembly process, disassembled components must be stored according to the first-in (highest floor), last out (lowest floor) principle. This ensures that the components are transported and reassembled on the building site at the right sequence. This efficiency is enhanced by using the so-called floor-by-floor assembly, meaning that the units are transferred linearly and distributed evenly, offering better structural stability. However, a zone-by-zone assembly may cause angled load paths through the building structure. Figure 11 illustrates an basic example in which the reconstruction or removal of the structure in Zone 3, adjacent to Zone 4, may pose a risk of structural collapse in Zone 4 due to a pyramid structure and thus higher centre of gravity if appropriate safety measures are not implemented (Yang et al., 2025).

In conclusion, facilitating remountability requires a broader perspective than is currently offered in most literature and practice. While much attention is given to disassembly and reuse, the absence of structured guidelines or assessment tools for reassembly presents a critical gap. Without addressing how components are reattached, technically, legally, and logistically, the process of reuse remains fragmented. Therefore, advancing remountability as a viable circular strategy demands equal emphasis on the conditions and requirements for safe and efficient reassembly.

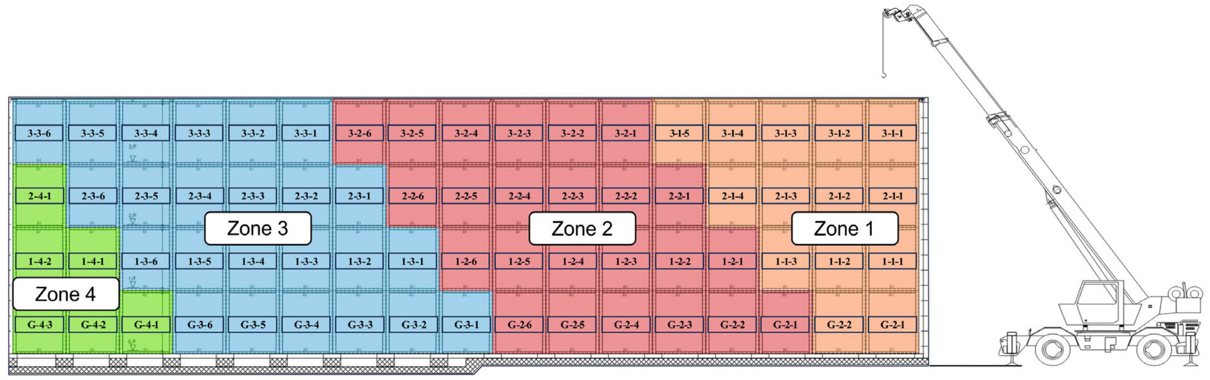


Figure 11: The disassembly and reassembly sequence involved assigning a unique label to each of the 68 modular units. In these labels, the first character denotes the building floor, the second character indicates the zone, and the third character represents the sequential number of each modular unit on the corresponding floor (Yang, 2025).

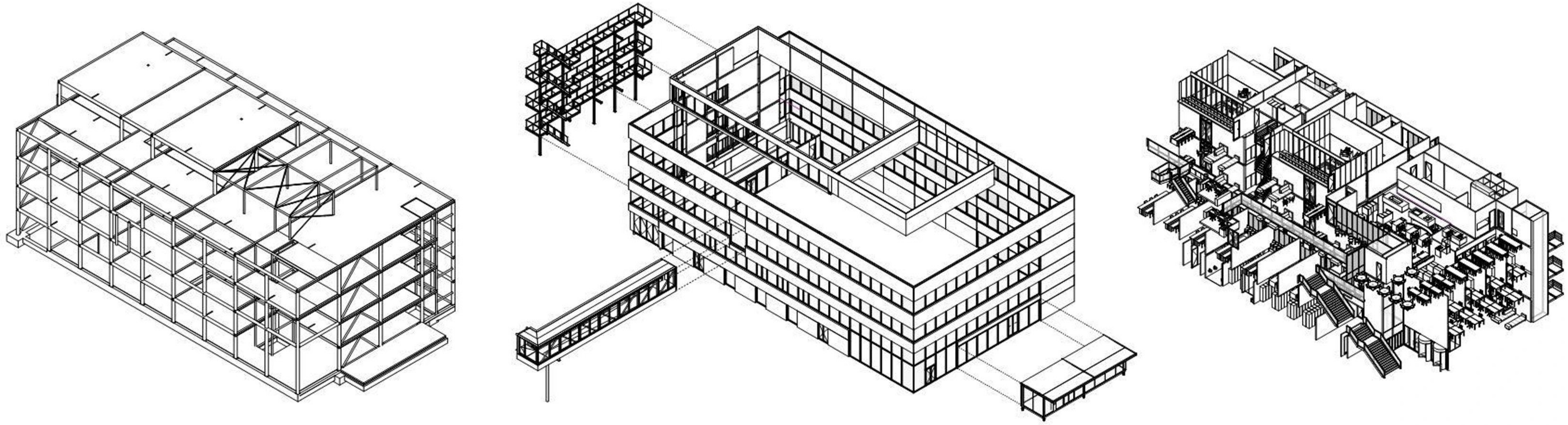


Figure 12: Exploded view showing the demountability of the Temporary Court Amsterdam (cepezed, n.d.-b)

3.1.4 Multiple reuse cycles

The core objective of remountability is to enable the reuse of a building and/or its components across multiple life cycles. In contrast, non-remountable components reflect traditional linear construction practices, where future reuse is not considered in the design phase, resulting in a single-use cycle. Following Van Gulck & Steeman (2024), this research adopts a multi-cycle perspective, viewing each reuse or transformation of a component as the beginning of a new lifecycle within the building's overall lifespan (figure 13).

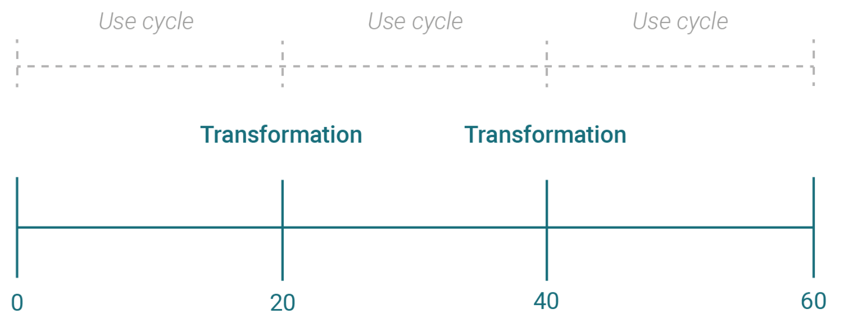


Figure 13: Visualisation of how multiple reuse cycles are considered (Van Gulck & Steeman, 2024)

Generally, reuse comes with its challenges in the form uncertainty in future scenarios of the building and the future technical performance of the disassembled components. Feasible disassembly does not automatically translate to reuse (Yang et al., 2025). The likeliness of reusing a component diminishes, for example, if a component shows decay, damage or corrosion (Hooff, 2021; Ottenhaus & Leardini, 2022). The impairment in the quality proposes the biggest hinder in their reuse. Consistent DfD can contribute to overcoming some obstacles, but the effects of aspects such as type, climate conditions and duration are still underestimated. Moreover, the quality between the components at the time of disassembly can vary significantly. Van Den Berg et al. (2020), state that the availability of transportation, storage and repair services play a crucial role in the option of reusing. Especially storage is a new factor with reuse that both theory and practice take note on (cepezed, 2022; Pichlmeier & Lindner, 2024; Yang et al., 2025). It is uncommon that after disassembly components can go directly from location A to location B since the disassembly happens in various phases, in a particular order. The inner walls, for example, cannot be reassembled before the floors are in place. That is why in the process of reuse, storage of the units requires specific attention. Often, the rule of first-in last-out is followed, which makes reassembling of components easier as they are in the right order. In many cases when reuse of disassembled components is intended, the difficulties come from a misunderstanding due to a lack of knowledge on the entire disassembly process until reuse. Therefore, the disassembly process must be thoroughly investigated (Yang et al., 2025).

Hamida et al. (2024) propose several practical recommendations for enabling reuse in the built environment:

1. Project developers and architects should facilitate efficient future change while diminishing waste through using demountable components and integrating flexible building installations;
2. Project developers need to update building passports and maintain them to assure reuse of building assets later on;
3. New building models must integrate strategies aimed at circularity, including cost-benefit aspects;
4. Research must explore possibilities of sharing knowledge on circular building adaptability strategies and their practical adoption.

Understanding remountability as a multi-cycle approach highlights the need to embed flexibility, documentation, and logistical foresight into every stage of the building process. Without such integration, the potential for meaningful reuse remains limited—turning circular ambitions into missed opportunities.

3.1.5 Strategies

Having discussed the three key principles of remountability, each principle requires different building strategies during the construction process in order to succeed. The definition of building strategies can be derived from Hamida et al. (2024) as solutions and actions that facilitate certain building practices. Or in other words, building strategies are practical approaches to implement DfD, disassembly and reassembly effectively.
Hamida et al. (2024) have established three categories for circular building adaptability strategies:

- **Passive strategies:** promote CBA through building design (Hamida et al., 2024) (e.g. standardizing building layout (Hamida et al. 2022);
- **Active strategies:** promote CBA through building construction and user interference (Hamida et al., 2024) (e.g. supplying transferable components (Hamida et al., 2022);
- **Operational strategies:** promote CBA through interference in the process (Hamida et al., 2024) (e.g. "[...] procuring the service of buildings instead of ownership, respectively" (Hamida et al., 2022, p. 17).

These types can be applied to different circular building practices, also encompassing remountability and its principles.

3.2 ENABLERS AND INHIBITORS

Research on remountability highlights the need to carefully evaluate enabling and inhibiting factors that influence these processes either positively or negatively. These factors are essential to enable multiple reuse cycles and advance the transition toward the circular reuse of modular buildings (Hamida et al., 2024; Yang et al., 2025). The enabling factors facilitate the implementation of remountability principles whereas inhibiting factors obstruct them. Hamida et al. (2024) advice practitioners to consider these factors, as understanding the promotors and obstructers of circular building practices allows for an evaluation of efficiency and effectiveness.

3.2.1 Enabling factors

Multiple articles mention enabling factors for remountable, reuse, disassembly or reassembly projects. These factors are bundled in the following table (5).

Enabling factors		Description	Source
1	Building and component characteristics	Availability of flexible size, configuration, and physical and spatial features of the building	(Du Preez et al., 2022; Hamida et al., 2023; Pichlmeier & Lindner, 2024; Yang et al., 2025)
2	Collaboration and ownership	The presence and nudging towards collaboration and partnership among the actors and stakeholders of the project. Also, the persistence of same ownership during those collaboration.	(Acharya et al., 2018; Giorgi et al., 2020; Hamida et al., 2023; Iyer-Raniga, 2019; Kanters, 2018, 2020; Ness & Xing, 2017; Yang et al., 2025)
3	Presence of a motivated and capable team	The presence of a skilled team in combination with the existence of a shared aim among the engineering team for promoting circularity.	(Acharya et al., 2018; Giorgi et al., 2020; Hamida et al., 2024; Holzmann, 2014; Iyer-Raniga, 2019; Kanters, 2020; Ness & Xing, 2017)
4	Economic viability	Monetary cost of reusing old building materials and affordability of using second hand building products in comparison to new materials.	(Hamida et al., 2024; Yang et al., 2025)
5	Legislative support	Application of supportive policies and regulations that facilitate the implementation of adaptable and circular building solutions.	(Acharya et al., 2018; Eguchi et al., 2011; Giorgi et al., 2020; Iyer-Raniga, 2019)
6	Digital technologies on material tracking	Utilization of technologies as BIM, material passports and renewable energy systems to enable reuse/disassembly/reassembly.	(Cai & Waldmann, 2019; Eguchi et al., 2011; Giorgi et al., 2020; Iyer-Raniga, 2019; Ness & Xing, 2017; Yang et al., 2025)
7	Design based on available second-hand components	"[...] matching disassembly and design projects, targeting at the maximisation of the number of salvaged components from a donor reapplied in receiver buildings." (p. 391).	(Conceição et al., 2024)
8	Overlap disassembly and design phases	"Overlapping disassembly and design phases may enable reuse of building components by shortening the project execution times allowing for attractive investment savings." (p. 391).	(Conceição et al., 2024)
9	Share information early in the process	Being transparent and often exchange information between the partners allows them to identify and address issues in time. This anticipates shockers which could obstruct the disassembly/reassembly process.	(Conceição et al., 2024; Du Preez et al., 2022; Kanters, 2020; Pichlmeier & Lindner, 2024)
10	Approach uncertainties with a flexible attitude	Taking on a flexible and creative attitude enables the comprehension and alteration of uncertain processes as reuse/disassembly/reassembly of building components.	(Conceição et al., 2024; Du Preez et al., 2022; Kanters, 2020)

Table 5: Overview of the enabling factors with explanation based various sources (own table)

3.2.2 Inhibiting factors

Multiple articles mention inhibiting factors for remountable, reuse, disassembly or reassembly projects. These factors are bundled in the following table (6).

Inhibiting factors		Description	Source
1	Lack of expertise	Lack of knowledgeable and skilled practitioners in the technical solutions of reuse/disassembly/reassembly. Also, the lack of awareness hinders the take-up of circular principles.	(Acharya et al., 2018; Eguchi et al., 2011; Giorgi et al., 2020; Hamida et al., 2023; Iyer-Raniga, 2019)
2	Technical complexities with building products/materials	Poor adaptability degree and maladaptive design hinder circular building practices. Use of random materials and/or overlooking DfD principles hampers reuse and disassembly of building components/materials	(Giorgi et al., 2020; Hamida et al., 2024; Iyer-Raniga, 2019)
3	Economic infeasibility of innovative strategies	Monetary constraints and financial issues are key inhibitors of circular projects. Especially the lack of financing, cost-ineffectiveness and high labour costs are bottlenecks	(Cai & Waldmann, 2019; Eguchi et al., 2011; Giorgi et al., 2020; Hamida et al., 2024; Kanters, 2020)
4	Tendency to follow traditional paradigms	Tendency for organisations and individuals to act market conservative and the attitude of practitioners to stick to the linear economy instead of CE hampers the application of reuse/disassembly/reassembly of materials and multi-use of assets.	(Cai & Waldmann, 2019; Giorgi et al., 2020; Hamida et al., 2024; Iyer-Raniga, 2019; Kanters, 2020)
5	Lack of data and warranty on old material	Lack of adequate, detailed building records on the used building materials and their performance hinders the applicability of circular practices. Quality of materials are not known, and reusability is not guaranteed.	(Cai & Waldmann, 2019; Giorgi et al., 2020; Hamida et al., 2024)
6	Legal and legislative restrictions	Inadequate legislation is a barrier to circularity in construction. This is a primary barrier for building adaptability. Rigidity of ruling legislation can limit strategies aimed at circularity as reuse, disassembly and DfD.	(Acharya et al., 2018; Eguchi et al., 2011; Giorgi et al., 2020; Hamida et al., 2024; Kanters, 2020)

Table 6: Overview of the inhibiting factors with explanation based various sources (own table)

3.3 Circularity on campus

3.3.1 Campuses as living labs

For over 15 years, sustainability has been high on the agenda of Dutch universities, culminating in a collective commitment to reduce energy use and CO_2 emissions by 2020, and by 50% by 2030 (Den Heijer, 2021). When it comes to physical university campuses, Den Heijer (2011; 2016; 2021) identifies fourteen themes that currently influence spatial functions (table 7). Among these, sustainability is relevant to all building functions (Den Heijer, 2021). As the only theme applicable to all building functions, it is evident that sustainability, or circularity, is highly relevant to campus buildings.

themes		office (desks)	meeting rooms	lecture hall (large)	classroom (small)	study places	exam space	event space	library	laboratory	workshop	storage	circulation (inside)	residential	retail & leisure	related business	infrastructure
theme 1	workplace	X	X						X			X				X	
theme 2	hybrid learning			X	X	X	X										
theme 3	faculty home	X	X	X	X	X	X	X	X	X	X	X	X		X		
theme 4	laboratories									X						X	
theme 5	non-academic													X	X	X	X
theme 6	heritage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
theme 7	opening hours	X	X	X	X	X	X	X	X	X	X	X	X		X		X
theme 8	circulation space												X				X
theme 9	smart tools	X	X	X	X	X	X	X	X	X	X				X		X
theme 10	sustainability	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
theme 11	silence	X				X	X		X					X			
theme 12	storage	X							X	X	X	X		X	X	X	
theme 13	showroom	X						X		X	X		X			X	X
theme 14	high- & no tech		X	X	X	X	X	X	X			X					X

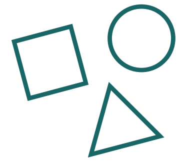
Table 7: Sustainability is a relevant theme for all space functions (Den Heijer, 2021)

Physical university campuses are ideal living labs (Den Heijer, 2021; Du Preez et al., 2022). There are six academically supported reasons that state why university campuses to be suitable for living labs.

Long term ownership
Universities are generally place-bound, meaning that they have tied to a location due to investments and/or the relationship with a community. Characterizations of universities are a long-term spatial commitment and a strong attachment to place (Harris & Holley, 2016). Pilot projects or spatial innovations can therefore be tested in the same environment for a longer period of time.

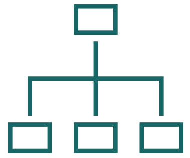
Figure 14: All icons originate from Microsoft

Available land and building types
Campuses contain a range of building functions, spread over their land. Den Heijer (2021) identifies five functions, namely education, office, infrastructure, housing and leisure. This availability of land and spaces, in combination with the functional variety, makes them ideal living labs for circular building innovations.



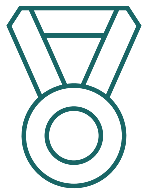
Access to knowledge
By doing inter-disciplinary research, universities are significant knowledge hubs and implementation sites. Researchers and also external partners, collaborate worldwide to get the best, most accurate results. Simultaneously, the physical campuses have evolved into integrated ecosystems for circular research, experimentation and innovation, making these places an increasing part of the socio-economic ecosystem. Universities can even use their own network to improve sustainability at their own campus (Du Preez et al., 2022). (Dutch) universities committing to research in a real-life setting, by using their own campuses as living labs, is one of the best ways to make use of these knowledge networks (Rymarzak et al., 2022).

Self-managing organization
Since 1995 is campus ownership in the Netherlands transferred from the state to universities themselves. This means that from that moment on, universities can make their own choices about the purpose of their land, real estate, management and maintenance (Den Heijer, 2011).
A recent trend that has been seen is that development on campus building traditionally responded to peaks in demand. But now there is a shift is now occurring where developments are increasingly supply-driven. Existing real estate stock and available environmental and financial resources are now often the instigators of redevelopment initiatives, rather than purely organisational or user needs (Den Heijer, 2021). Subthemes such as waste reduction and circularity are integrated into Dutch campus strategies, responding to the lifecycle challenges of campus resources (Den Heijer, 2021).



Public mission
The fifth reason why universities are suitable as living labs is that universities commonly serve a public, social-purpose mission rather than a profit-driven mission (Den Heijer, 2021; Harris & Holley, 2016). Democracy, equity and social justice are core values that stimulates universities to be a force of change (Harris & Holley, 2016). Additionally, universities carry a core responsibility to lead the transition towards more sustainable and efficient practices (Den Heijer, 2021).

Frontrunning ambitions
Finally, and perhaps the most important reason for universities as living labs is the frontrunning ambitions that universities have (Den Heijer, 2011). Research that is done at university is often ambitious and innovative, with a goal to evoke change (Du Preez et al., 2022). Campuses are not only ideal for testing frontrunning innovations, Verbano and Nosella (2010) even state that campus managers can use these innovations "to wield technology as a strategic lever" (p. 355). Starting at their own campuses, whereafter the campus borders can be crossed (Verbano & Nosella, 2010).



In conclusion, university campuses are quite ideal to function as a living lab. However, practically implementing circular building strategies on campuses remains a novelty. Reality points out that, for example remountability is not an integrated strategy in Dutch campus construction projects. Reason for this is that campus managers are required to strategically balance innovation against financial considerations and risk, resulting in a web of both drivers and barriers (Du Preez et al., 2022). The following chapters highlight the different enabling and inhibiting factors of implementing innovation on campuses as living labs.

3.3.2 Enablers

According to Du Preez et al. (2022) there are four enabling factors when considering the implementation of innovations on campuses as living labs:

1. The role of campus managers in creating living labs: managers are not always aware that they are implementing something new and thereby contributing to universities objectives education, research and sustainability. Clarification of their role should enable living labs on-campus more clearly. This feature can be broken down into six parallel tasks that a campus manager can provide to facilitate or enable living labs on campus, each with an assigned proportion:
   - Providing data – 5%: supplying relevant data;
   - Participating – 5%: filling in questionnaires or interviews about workloads and implementation decisions;
   - Facilitating – 37%: hosting the innovation on the campus, minus management responsibilities;
   - Implementing 21%: building and maintaining the innovation;
   - Networking with partners – 28%: connecting, linking and liaising project partners, funders and researchers.
   - Driving strategic decisions – 4%: driving the innovation project in cooperation with government and research partners (Du Preez et al., 2022).
2. The development of expertise, depending on strategically aligned projects and academic expertise: an innovative vision is needed to which the innovation aligns. If there is no fit, it requires more time, money and effort. The innovation also requires knowledgeable experts that provide a synergy and clear focus area.
3. Room for diversions: since innovations are basically new and uncertain in many ways, managerial room is needed for changes and flexibility.
4. A facilitator to match theoretical knowledge (academics) with practical implementation (project developers): supporting "knowledge brokers" to match opportunities and facilitate partnerships.

From the perspective of an innovative project itself, Du Preez further highlights four important features that influence the probability of implementation (2022). If these features are in favour of the university, chances increase that the innovation is implemented:

- The innate uncertainty of the innovation;
- The availability of tools to manage the perceived risk;
- The expected time and location on campus for the innovation;
- The physical aspects, consisting of size, number of plausible repetitive implementations and level of building integration.

The physical features combined with the campus manager's role are crucial for the implementation of an innovation.
These drivers are incorporated as enabling factors in the continuing table 8, since they convey drivers for campuses that promote the implementation of phenomena as remountability.

Enabling factors		Description	Source
11	A clear role for campus managers in living labs	Managers must be aware that they are implementing something new and thereby contributing to universities objectives *education*, *research* and *sustainability*. Clarification of their role should enable living labs on-campus more clearly.	(Du Preez et al., 2022)
12	Innovative campus visions	The university in question must have a campus vision with which the innovation aligns. Without this alignment, the obstructing aspect time, money and effort will rise for campuses as living labs.	(Du Preez et al., 2022)
13	Have a facilitator of partnerships and opportunities	A facilitator to match theoretical knowledge (academics) with practical implementation (project developers): supporting "knowledge brokers" to match opportunities and facilitate partnerships.	(Du Preez et al., 2022; Holzmann, 2014)
14	Availability of tools to manage perceived risks	There must be tools to manage the risks that can occur during the innovation implementation in living labs.	(Du Preez et al., 2022)
15	Clear geographical location and timeframe	Timeframe must not exceed 5 years, location must one of in the following: Traditional laboratory/Field laboratory or regulation free zone/Building(s) (internal)/Buildings(s) (external)/ Outdoor/Virtual/Cloud or business system	(Du Preez et al., 2022; Mankins, 2009)
16	Raising awareness	Raising awareness among stakeholders in the sector is crucial for adopting reuse/disassembly/reassembly. Specifically for campuses, raising awareness for the implementation of the innovation is crucial for organisational and strategic intents.	(Du Preez et al., 2022; Pichlmeier & Lindner, 2024)

Table 8 Continuing overview of the enabling factors for Dutch universities (own table)

3.3.3 Inhibitors

It is not uncommon that the balancing act of campus managers, when it comes to implementing innovative practices comes across difficulties, especially when campus managers intend to adopt a project which a sustainable innovative character. Since the university is, in essence, a public institute, it seeks an equilibrium between the objective's education, research, societal impact, and since recent decades, environmental impact. Not surprisingly, conflicts arise between departments regarding testing innovations, risks aversity and being highly sustainable (Du Preez et al., 2022). According to Du Preez et al., there are five barriers for integrating innovations for building innovations on campus:

1. Conflicting goals within several project goals;
2. Lacking details of the project;
3. An ideal solution for one project may not be favourable for the entire portfolio;
4. Conflicts may arise between experts that result in difficulties during execution from those who disagree;
5. Innovational projects are perceived as informal experiments (2022).

The level of dealing with these challenges differs highly per university nowadays. Implementing innovation for sustainable development requires a clear strategic vision supported by organisational commitment. This involves raising awareness, establishing robust structures, allocating sufficient resources, and building networks that effectively connect innovators with implementers on a consistent basis (Holzmann, 2014).
These challenges are incorporated in the inhibiting factors table (continued in table 9) of this research since they convey barriers for campuses that obstruct the implementation of phenomena as remountability.

Objectives for universities change with contemporary trends, becoming more corporate and focussing on sustainability, circularity, innovation and social impact. This has implications for its real estate and therefore requires a different mindset. The complexity of managing innovation projects on-campus lies also in financial issues, possible compliance issues, their uniqueness, uncertainty, unproven performance and the possibility of reputational damage of these risks all together. To extent this list, novelties naturally require more in terms of time, money, and effort compared to standardized construction affairs (Damanpour & Wischnevsky, 2006).
Innovations bring risks that make risk assessment central to implementing innovations. Knowing the need

for technology, difficulty in technology development and possible consequences of technology must be central criteria to decision-making for campus management who safeguard future users and processes on-campus (Du Preez et al., 2022). The Technology Readiness Level (TRL), also used in Horizon 2020 of the European Union, is used to judge the maturity of an innovation and in real-life contexts, frequently only TRL level 6 or higher are implemented (Ministerie van Economische Zaken, 2023). Strategic management of innovations must entail a clear overview of potential benefits and risks of the innovation (financially, legally, technologically, reputationally). Mapping the risks allows for adequate responses (accept, avoid, transfer, mitigate) when needed (Bowers & Khorakian, 2014).

Inhibiting factors		Description	Source
7	Conflicting goals with other projects on campus	There are certain goals for projects or buildings on campus that conflict with each other in terms of time, money, prospect.	(Du Preez et al., 2022; Phillips & Bana e Costa, 2007)
8	Lacking a detailed project plan	Innovation projects (on campus) regularly lack details.	(Du Preez et al., 2022; Phillips & Bana e Costa, 2007; Pichlmeier & Lindner, 2024)
9	Implementation conflicts	"Individually optimal solutions may not be the best portfolio options (as implementation of some innovations (for example using direct current) may disallow other innovations on campus (e.g., using hydrogen)" (p. 2)	(Du Preez et al., 2022; Phillips & Bana e Costa, 2007)
10	Conflicts between experts on campus	The judgement of experts may be conflicting which causes problems in the implementation phase from those that are in opposition (implementation of innovation projects are often coming from one side)	(Du Preez et al., 2022; Phillips & Bana e Costa, 2007)
11	The project having an informal character	Many innovation projects are seen as "hobby projects", causing disapproval.	(Du Preez et al., 2022; Phillips & Bana e Costa, 2007)

Table 9: Continuing overview of the inhibiting factors for Dutch universities (own table)

The enablers and inhibitors identified in SQ2 help explain the success or failure of specific strategies discussed in SQ1 and clarify which contextual factors from SQ3 must be addressed to implement them effectively.

3.4 THE CONSTRUCTION PROCESS

A construction process must be examined carefully for effective management (Winch, 2009). Basically, a construction process constitutes a range of steps and decisions until the work is finished (Baird, 2014). According to Ould (1995, cited in Kagioglou et al., 2006) a process can be one-time, systematically repeated or random. This identifies two process types: 1) starting at an initiative and end at one moment in time, and 2) a process that starts and continues existing. Traditional building construction aligns with the first type, while circular construction also aligns with the second type. Winch (2009), describes a general construction process in his book Managing Construction Projects, using several phases and its inherent activities as shown on the next pages (figure 16).

Putting it technically, the process starts at A until reaching point B. Point A can be defined as input and B serves as output (Kagioglou et al., 2006). As Bulletpoint (1996, as cited in Kagioglou et al., 2006) suggests, an ideal construction process should include clear and predictable inputs, follow a logical sequence, consist of well-defined tasks, and result in a foreseeable outcome. Van Hout (2021) depicts this as follows (figure 15). However, in reality, construction processes rarely meet these characteristics. They are often unpredictable, lack clearly defined inputs, and involve uncertain, ever-changing tasks people have to respond to (Winch, 2009). This makes construction complex and challenging. Projects in this field operate in environments full of uncertainty, where the end result might be known, but the path and methods to achieving it tend to evolve continuously (Winch, 2009; Bulletpoint, 1996, as cited in Kagioglou et al., 2006). As such, trying to make projects more predictable is not the point.

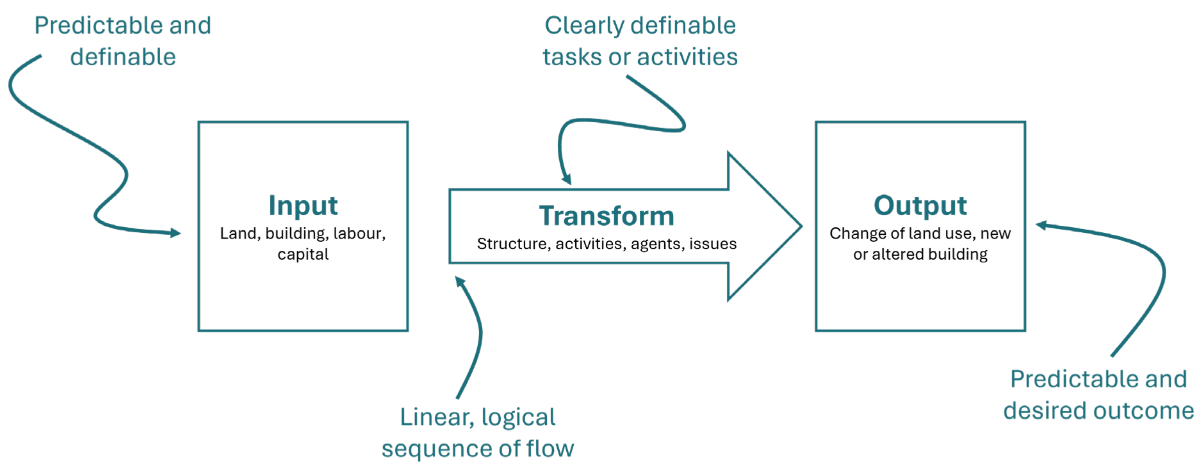


Figure 15: A general process in technical terms (Van Hout, 2021 based on Kurul, 2003)

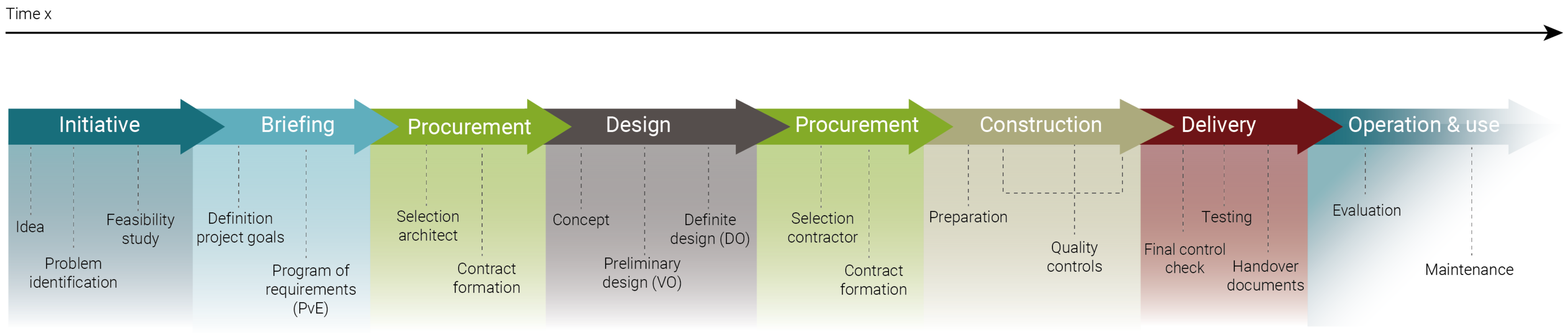


Figure 16: Traditional timeline as described by Winch (2009) (own illustration)

The definition of a process depends heavily on its context, purpose, and market conditions. The Walnut model (figure 17) from the Swedish Defence University, illustrates this by showing how teams must define both their goals (the content) and the methods to achieve them (the process), shaped by the collaborative context (Vollebregt, 2018). In adaptive reuse (AR), this "how" reflects the way teams make decisions and communicate.

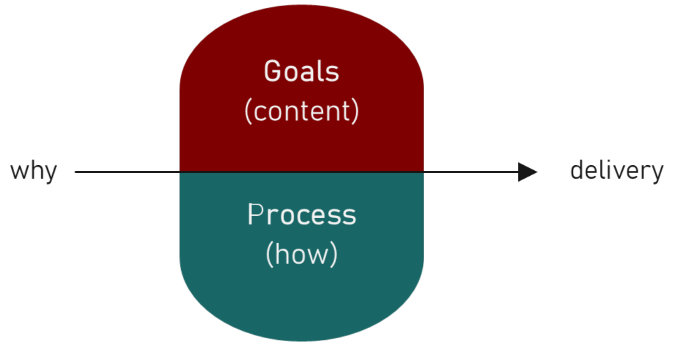


Figure 17: Walnut model showing the dependences of processes (own illustration based on Vollebregt, 2018)

Finally, the development process spans the entire lifecycle of a building from initial idea through to final use and must balance social and economic goals. According to Kurul (2003), development is about transforming land through construction or renovation to achieve these intended outcomes.
In examining construction projects, it is valuable to differentiate between various levels within the process. According to Kagioglou et al. (2007), a construction process can be broken down hierarchically into a process, subprocesses, activities, and individual tasks. A model should therefore include the overall process, its phases, daily activities, and the individuals responsible for each action.

Adaptive reuse is viewed as a process because it involves transforming a building's function from one use (input A) to another (output B) (Andriessen, 1999). Unlike typical development projects, AR involves existing structures, for this research university campuses, with their inherent, specific imperfections, adding further uncertainty to the process (Lou et al., 2020). In this context, the "content" in the Walnut model is unclear or incomplete, yet the approach (the process) should still be outlined in advance.
Therefore, instead of attempting to define the entire reuse process through a rigid, step-by-step manual or timeline, it is more effective to describe it in terms of flexible principles and core components that can guide the project.

3.4.1 Second-life process

Understanding the process is essential for effective project management, as emphasized by Winch (2010). In the case of AR with remountability, having a clear understanding of the process is crucial for identifying matters to improve. However, an AR process is difficult to define, as it intersects with various specialist domains, such as project development, renovation, policy, value creation, marketing, and redesign, which all depend heavily on the specific context, project, and building (BOEi, 2009).

As Kurul (2003) notes, reusing existing buildings is inherently a form of development activity. Both reuse and new-build projects typically include an initiative phase, a preparatory phase involving program and feasibility studies, followed by design, construction, delivery, and long-term use (Andriessen, 1999). Although complex, several studies have outlined the adaptive reuse process in phases, often resembling the traditional development cycle. Van Hout (2021) has made an overview of AR phases according to literature (table 10).
Yet, what distinguishes AR processes from traditional construction is 1) that reuse projects demand more extensive research in the initial stages and 2) involve higher uncertainty. This prior research is vital due to the existing value, conditions and limitations of the building. The early phases are therefore more complicated and less predictable than in new-build developments (figure 18) (Pallada, 2017).
Furthermore, activities such as stakeholder analysis, market feasibility, and assessments of the building's structural and material condition are for AR processes even more essential to avoid problems later in the project. Specifically during the design phase, a deep investigation into the condition of the structure and

Nozeman et al. (2008) *New-build*	**Andriessen (1999)** *Reuse*	**Bond (2011)** *Reuse*	**Kurul (2007)** *Reuse*	**Pallada (2017)** *Reuse heritage*	**Vervloed (2013)** *Reuse heritage*
Initiative phase	Initiative	Market feasibility	Initiation	Idea forming	Initiative
	Definition		Emergence of the initial scheme	Refining ideas	Research reuse
					Definition
Development stage		Design	Pre-application negotiations		Design
			Planning application		
	Design	Financing	Design detailing & tendering	Feasibility	Elaboration
	Pre-construction	Regulation		Contract negotiations	
Realisation phase	Realisation	Construction	Construction, marketing & sales	Preparation and execution	Execution
Exploitation phase					Aftercare

Table 10: Adaptive reuse process phases (various sources, overview made by Van Hout (2021)

materials is crucial to avoid unforeseen issues during execution and to ensure the project aligns with its intended use (Bond, 2011; Dyson et al., 2015; Langston, 2011).
During the process the continuous involvement of more stakeholders, additional regulations and the need for specialized knowledge and creative financing are requirements that make reuse projects inherently more complex than new-build (Bond, 2011). Adaptive reuse requires a holistic understanding of the building's values and potential (Mısırlısoy and Günçe (2016) as cited in Van Hout, 2021). Ultimately, it is this intensive and context-specific research that most clearly differentiates adaptive reuse from traditional new-build processes (Kurul, 2003).

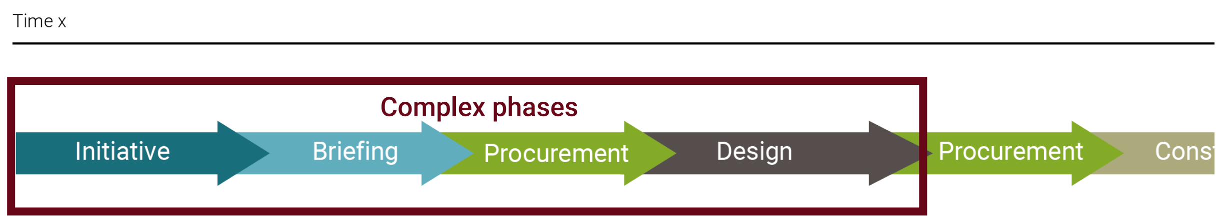


Figure 18: The complex phases of adaptive reuse (own illustration)

3.4.2 Stakeholders

The success of remountable construction strategies depends heavily on stakeholder involvement, particularly their roles and influence throughout the process (Chan et al., 2004). Winch (2009) defines stakeholders as actors who perceive a direct benefit or loss from a project and categorizes them as internal (demand and supply side) or external (private and public). However, remountable projects require a broader interpretation of these roles. Unlike traditional projects, they demand early and close collaboration with multiple structural engineers and specialised suppliers, as the focus shifts from the building as a whole to the value of its components (cepezed, n.d.-a; de Architect, 2022). Developers and disassembly companies are also forced to adapt, often working with niche contractors (cepezed, n.d.-b). Conflicts among stakeholders are common in adaptive reuse and remountable projects, making mutual understanding of goals and contributions essential (Aigwi et al., 2020). Table 11 presents an overview of relevant stakeholders, building on Winch's model and including actors specific to remountable campus projects.

Internal stakeholders		**External stakeholders**	
Demand side	*Supply side*	*Private*	*Public*
Client	Architects	Local residents	Regulatory aspects
Financiers	Engineers	Local landowners	Local governments
Client's employees	Principal contractors	Environmentalists	National governments
Client's customers	Trade contractors	Conservationists	
Client's tenants	Material suppliers	Archaeologists	
University CRE department	Façade partners	Non-governmental organisations (NGO)	
University Facility department	Mechanical contractor	Students	
University Maintenance department	Electrical contractor		
University board	Steel construction contractor		
	Building physics		

Table 11: Project stakeholders according to Winch (2009). Blue stakeholders are included when doing a remountable project based on (cepezed, n.d.-b) and the red stakeholders are added who are relevant to this research.

FINDINGS
REMOUNTABILITY

4 FINDINGS REMOUNTABILITY

4.1 APPROACH

This chapter describes the findings for sub-question 1: *What strategies does a remountability process encompass in practice?* The interviews were conducted between 18 February 2025 and 25 February 2025. The location varied from on site to online due to time constraints. Interviewees were chosen based on their role and experience in construction processes. Three people were interviewed in total. The length of the interviews ranged from 45 to 60 minutes. An overview of the interviews can be found in the following table.

	Codes	Function	Date
SQ1	**1.1**	Project developer	18-02-2025
	1.2	Program manager sustainability	20-02-2025
	1.3	Project leader	25-02-2025

Table 12: Participant overview sub-question 1

4.2 PRACTICAL STRATEGIES

The following Sankey diagram was established after performing the interviews with remountable construction experts from the supply side (figure 19). As laid out in Chapter 3.1.5, Strategies, Hamida et al. (2024) have distinguished three types of building strategies, which can also be used for circular construction practices. The active strategies mentioned in the interviews relate to building construction and actions on the construction site, the operational strategies mentioned in the interviews relate to the construction process and interferences and influences on the process and the passive strategies mentioned in the interviews relate to the design of the building. The strategies mentioned in the interviews are linked to the principles of this research.
Looking at the right side of the diagram, operational strategies, needed for a remountability project, were mentioned the most in regard to contributing type of strategies (38). Second-most mentioned strategies were active (33). Passive strategies that are needed for a remountability project were mentioned the least

Figure 19: Sankey diagram linking remountability principles with strategy types (own illustration)

(18). Going to the left side, most strategies relate to disassembly (42), followed by reassembly (38) and design for disassembly (21).

4.2.1 Strategy framework

Based on the qualitative data collected from three semi-structured expert interviews, a framework of practical strategies was developed to support remountable construction (table 13). These strategies were derived through deductive coding and aligned with three core reuse phases: Design for Disassembly, disassembly, and reassembly, each occurring within three project stages: active, operational, and passive.

The table below summarizes the strategies in compact form, linking each to the specific reuse principle they address. The dot symbols indicate the level of applicability:

● = directly supportive of the reuse aspect
○ = potentially supportive or indirectly relevant
Blank = not applicable

Additionally, the right-hand columns connect each strategy to interview references and broader thematic categories, linking this outcome to sub-question 4. These themes reflect structural settings that influence the strategy's effectiveness in practice.

Strategies highlighted in red were mentioned by more than one interviewee, indicating broader consensus or recurring relevance across cases. Symbols ✓ and ✓✓ further indicate how frequently or strongly the strategy was emphasized in the interviews.

This matrix allows for an integrated understanding of what strategies are relevant, how they function across the reuse process, and under what thematic conditions they are most effective.

4.3 CONCLUSION

The findings indicate that operational strategies are most critical to the implementation of remountability in circular construction, followed by active, construction-site-related measures. Passive strategies, despite their foundational role in DfD, are referenced least, which highlights a practical focus on execution over design in current practices.
The strategies mentioned by all three interviewees, were being flexible (operational), documenting the process (operational), log lessons learned (operational), increase enthusiasm (operational), make clear agreements (operational), digitalize in BIM models (passive) and have a long-term vision for the building (passive).
The prominence of disassembly and reassembly principles across strategy types indicates a focus on lifecycle extension through component reuse. The analysis shows that the design phase is crucial enabling disassembly, reassembly, and ultimately, the reuse of building components and without the foundation being formed in this phase, reuse is not possible.
The identified strategies in SQ1 form the technical and procedural foundation for interpreting the practical relevance of barriers and enablers discussed in SQ2 and provide a baseline for evaluating current practices in SQ4.

Overview of practical strategies for facilitating remountable construction: reuse aspects and thematic relevance	Multiple reuse aspect: Active – DfD	Active – Disassembly	Active – Reassembly	Operational – DfD	Operational – Disassembly	Operational – Reassembly	Passive – DfD	Passive – Disassembly	Passive – Reassembly	Interviews reference(s): 1.1	1.2	1.3	Related theme (link to SQ4): Culture	Governance	Financial	Site	Construction system	Building information
Strategies																		
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 $n \geq 1$

● = 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

Table 13: Overview of practical strategies for facilitating remountable construction: reuse aspects and thematic relevance (own table)

FINDINGS
CONTEXTUAL CONSIDERATIONS

5 FINDINGS CONTEXTUAL CONSIDERATIONS

5.1 APPROACH

This chapter describes the findings for sub-question 3: *What are contextual considerations for universities that influence the integration of circular construction processes to their building projects?* The interviews were conducted between 25 February 2025 and 6 March 2025. Location was on site. Two to four people were interviewed for this sub-question, both part of the TU Delft but with varying occupations. The length of the interviews was both approximately 60 minutes. An overview of the interviews can be found in the following table.

	Codes	Function	Company	Date
SQ3	i1	Campus expert	Technical University of Delft	25-02-2025
	i2	Campus expert	Technical University of Delft	06-03-2025

Table 14: Participant overview sub-question 3

5.2 CONSIDERATIONS

It is clear that universities in the Netherlands are increasingly positioning themselves as frontrunners in sustainability, which converts in establishing ambitious long-term goals for circular building construction. At the Technical University of Delft, it is no different. But while sustainability is an overarching objective, defining circularity quantitatively and integrating it into all construction-related decision-making is still evolving in practice. This conclusion is also drawn by two TUD campus experts (i1, i2), who explain multiple reasons for the uptake and its difficulties on campus grounds. Following is an overview of the current uptake and constraints mentioned in the interviews for the TUD to integrate circular construction practices to their building developments.

Organisational culture and community engagement
First and foremost, the TUD is actively increasing their circular construction uptake. Within the TUD faculties and departments, the extent to which circular construction principles are embraced varies across faculties and disciplines (i1). While the Architecture and Built Environment faculty and the facility department are generally proactive in circularity research, other faculties exhibit limited engagement in the circularity of their building. These faculties are not ignorant on circular practices but focus more on sustainability in their field of expertise (i2).
Universities are often expected to "practice what they preach," meaning that their own campuses serve as demonstrative testbeds for circular innovations. This is also what the facility department of TUD carries out in their daily operations. They state that a large share of the motivation for circular construction practices on campus comes from intrinsic curiosity and liking from the employees. They want to work on circular project rather than traditional pathways. The approval of the uptake of circularity depends, however, on higher hierarchical approval (i2).
At TUD, student activism and public discourse also influence circular-related decisions, as evidenced by student and employee efforts to prevent the demolition of the skyline forming EWI building (i1, 2). However, large scale community-driven circular initiatives lack formalized channels for influencing policy, which may indicate the need for better stakeholder engagement strategies.

The existing portfolio
The current campus portfolio is merely filled with existing real estate, necessitating a relatively stronger need for adaptive reuse and renovation instead of new construction (i1,2). Consequently, the take-on of reuse and adaptation projects is increasing over new construction and demolition. The contemporary socio-economic context, entailing an enhancing sustainable mindset, governmental policies and economic cutbacks, disallows for existing campus buildings to be demolished (i2). But adaptations are easily said than done, since they are often restrained by the presence of hazardous materials, such as asbestos in window frames, limiting the reuse potential of structural components on skin, structure and space plan level (i1, 2). But more importantly, the existing buildings are originally built traditionally and thus not meant for disassembly or resource recovery, which regularly complicates reuse of existing components on structure, skin level in the portfolio (i1).
Another point raised by the participants, is the obstruction of material reuse and flexible, circular building designs by some unique functions within university buildings. Laboratories, technical equipment and specialized installations require strict noise regulations, ventilation requirements, safety standards, and absence of vibrations (i1, 2). These buildings require concrete in their foundation disallowing large scale circularity options as CLT constructions (i2).

Procurement practices and market interaction
Universities exert significant market influence through procurement mechanisms (i1, 2). Architecture bureaus and contractors are eager to develop a project on university campuses due to the unique spatial features (e.g. landowners, end-users, ambition etc.) (i2). Yet, circularity-focused supply chains remain underdeveloped as fundamental challenge being the misinformation between supply and demand. In other words, universities do not always have a clear understanding of their specific technical circularity requirements and thus cannot convey them in tenders. While suppliers do not always publicly share their capabilities or their availability of reused materials (i1). Nevertheless, when universities and suppliers come together, a cooperation works well.

"We [university and suppliers] enhance each other, because the university writes out a procurement with circularity demands, and the architects or contractors put in that extra step. They have creative ideas in this regard and a lot of brainpower. That works well together." Campus expert 2

In response, procurements are evolving with new circular practices. Propositions are made based on building performance with circular solutions rather than adhering to predefined material specifications.
Also, tender submissions entailing material efficiency and waste reduction are more often rewarded, thereby disincentivizing excessive material usage (i1).
However, still most business models within the construction industry remain predominantly linear, necessitating a realignment of market incentives to foster a truly circular built environment.

Financial and economic constraints
One of the primary barriers of integrating circularity in the construction of university buildings is the financial viability. While universities are increasingly acknowledging that circular building methodologies yield long-term economic benefits, like reductions in material scarcity risks, carbon taxation, and overall lifecycle costs, their current financial models do not incorporate these savings (i1). The higher initial investment can be a hinder to adopt circular construction projects (i1, 2).
The interviewees also highlighted the public nature of Dutch universities, noting that investments in real estate are funded with public resources. As a result, opting for higher costs associated with circular construction, compared to traditional methods, requires careful justification (i1). In this context, the ambition to act as a frontrunner and the presence of circularity principles in the university's strategic vision serve as key motivations to pursue such projects (i2).
Another notable economic constraint is the lack of a commercial incentive to invest in circular constructions. TUD sees their buildings as means for operational functions rather than profit generating units (i1). Once a building is built on campus, it will remain in the portfolio of TUD and is not likely to be sold to commercial parties (i1, 2).
These uncertainties are reasons for the exploration of alternative finance models such as renting circular buildings instead of leasing, which is already the case with FLUX (i1). Nevertheless, current short-term budget constraints and austerity measures complicate significant investments in circular constructions. Real estate investments, whether circular or not, must be financially planned (i1, 2).

Legal aspects and risk
Unlike commercial real estate developers, universities operate without direct legal obligations to comply with circular construction mandates, either at the national or European level (i1, 2). Instead, they adhere more often to voluntary sustainability frameworks, such as Het Nieuwe Normaal (i1). This shows that there is more of an internal commitment rather than external legislative pressure (i1, 2).
A critical, yet often overlooked, barrier to circular construction is the perceived risk associated with non-

Figure 20: Birdview of TU Delft campus (Mecanoo, n.d.).

traditional materials and construction methodologies. This also holds for the context of Dutch universities. Both interviewees note that reuse projects on-campus are having a harder time getting insurances approved. Insurance companies are more hesitant to join in on an adaptational reuse project than new construction due to the perceived risk associated with non-traditional materials and construction methodologies (i1, 2). Insurers frequently view circular building components as high-risk due to the lack of long-term performance data, making it sometimes difficult to obtain financial backing for large-scale implementation. Implementing structured risk assessments and developing standardized insurance models for circular materials could enhance confidence among investors and decision-makers (i1).
Another note was that building standards for construction projects utilizing reused materials are equivalent to those applied to projects incorporating newly manufactured components, requiring more effort for reuse projects (i2). Lastly, TU Delft faces stringent sustainability requirements imposed by the municipality in its construction projects. Legally compliant proposals are not automatically approved, as the government actively enforces and promotes higher sustainability standards. Consequently, this often results in significant additional costs for the university before construction can commence. In conclusion, getting environmental permits is getting more complicated (i2).

Standardization and digitalisation

It is important to note that the facilities department of TU Delft actively seeks innovative construction methods aimed at minimizing demolition and waste. Given the diverse range of disciplines and functional requirements across the campus, developing a standardized blueprint for future renovations presents a considerable challenge. Standardize circular construction within the university is therefore still at an early stage (i1, 2). Nevertheless, some progress has been made in developing material inventories and reuse strategies. TU Delft, for example, has introduced initiatives for:

- Reusing modular furniture and low-carbon concrete elements in campus development projects (i1).
- Establishing a centralized materials database to track reusable building components for new buildings (i1, 2).
- Reducing customization in new constructions to facilitate future disassembly and repurposing, like the Echo building (i1).

However, conflicts persist between the faculties' customization preferences and the necessity for standardized, interchangeable materials, with no immediate resolution in sight. While the standardization of lecture halls, leisure areas, and study spaces is widely recognized as beneficial, large-scale implementation remains challenging due to these competing interests (i1, 2).

Future-proofing and long-term adaptability

Both interviewees acknowledge that TUD now more than ever considers the long-term implications of non-circular construction, particularly concerning:

- The (intrinsically) changing mindset of employees and students.
- Image and claiming the position of being a frontrunner.
- Escalating market costs of raw materials due to resource scarcity.
- Stricter carbon taxation policies that will make traditional construction less financially viable.
- Legislative shifts favouring circularity, which may impose future compliance costs on non-circular buildings.

Although circular construction offers a promising approach to future-proofing university real estate, the challenge of quantifying its long-term financial benefits continues to hinder widespread adoption. Conducting thorough risk assessments to mitigate potential uncertainties and fostering a flexible approach toward new construction methods may help facilitating the integration of circular construction practices (i1).

Inter-university collaboration and resource sharing

Collaboration among Dutch universities in circular construction primarily focuses on knowledge exchange rather than the direct transfer of physical materials. Knowledge sharing slowly expanding, particularly in the areas of:

- External partner companies working on multiple university campuses in the Netherlands play a key role in sharing campus-specific knowledge. Their experience across diverse campus projects allows them to apply insights from one university to another, improving the effectiveness and adaptability of construction and renovation efforts (i2).
- Material-sharing initiatives through online platforms such as Insert is now coming up but rarely used (i1).
- Employee mobility between universities facilitates knowledge transfer, as staff moving from institutions like VU Amsterdam to TU Delft, or vice versa, bring valuable insights and best practices. This exchange strengthens collaboration, new ideas and promotes the adoption of circular construction practices across universities (i2).

Unfortunately, the direct exchange of physical building materials between universities remains yet underdeveloped, primarily due to (1) logistical and timing challenges in matching supply with demand, (i1), (2) regulatory constraints on material reuse, (3) competitive considerations, as universities sometimes function as market rivals. Universities are now starting to acknowledge that resource-sharing and integrating circular economy principles into university partnerships could yield significant benefits (i1, 2). And both interviewees acknowledge that although universities have started experimenting with shared spaces and external facility leasing (e.g., renting cinemas for lectures), the potential for more comprehensive space optimization remains underutilized. The main barriers therefore are (1) legal and financial restrictions on renting out university-owned spaces (although it is done on a small scale like at TUD sports complex X) (i2), (2) security and operational concerns associated with opening campuses to external users and (3) cultural resistance to shifting away from faculty-specific building allocations (i1, 2). What can also benefit from space-sharing strategies is reducing the environmental footprint of university constructions.

Furthermore, there is a pressing need for spatial efficiency within universities. The motivation for construction projects already has shifted from being user-driven to performance-driven. But the potential for more optimized space utilization and repurposing of existing facilities, for instance, through improved scheduling and multi-purpose infrastructure, could substantially reduce the demand for new buildings (i1).

5.3 CONCLUSION

TU Delft is advancing circular construction, but practical implementation over such a diverse spatial context remains challenging due to complex technical requirements, regulatory demands, and balancing standardization with faculty-specific needs. Following are the main 25 contributing and obstructing consideration for circular construction on this campus:

Driving considerations:

1. **Ambitious sustainability goals** and positioning as frontrunner in circularity.
2. **Intrinsic motivation** to build more circular among CRE staff.
3. **Growing preference for adaptive reuse** due to existing real estate portfolio.
4. **Policy and economic pressure** as external forces.
5. **Clear roles during RE development** amongst the CRE department.
6. **Market influence** on circular propositions on real estate through procurements.
7. **Evolving procurement strategies** rewarding circular solutions and performance-based criteria.
8. **Openness to innovative finance models**, like renting circular buildings (e.g., FLUX).
9. **Increasing focus on long-term adaptability** due to resource scarcity, carbon taxation, and changing legislation.
10. **Starting knowledge sharing network** among Dutch universities and external partners.

Obstructing considerations:

11. **Inconsistent engagement** with circularity across faculties.
12. **Lack of formal stakeholder engagement channels** for community-driven initiatives.
13. **Asbestos and traditional construction methods** limiting reuse in the existing portfolio.
14. **Specialized building requirements** (e.g., labs) obstructing flexible/circular designs.
15. **Underdeveloped circular supply chains** and procurement mismatches.
16. **Holding on to linear business models** dominating the construction industry.
17. **Financial and valuation challenges** as getting a proper business model including reused materials and their value over time.
18. **No direct legal obligations** to apply circular standards.
19. **Insurance challenges** for reuse and non-traditional materials.
20. **Equal building standards** for reused and new materials, making reuse harder.
21. **Stricter municipal sustainability demands** raising pre-construction costs.
22. **Lack of standardization** due to customization preferences.
23. **Difficulty quantifying long-term circular benefits** hinders broader adoption.
24. **Logistical, legal, and competitive barriers** to material exchange between universities.
25. **Underused space-sharing potential** due to legal, operational, and cultural barriers.

To accelerate progress, universities must strengthen stakeholder engagement, integrate more specific circularity demands into their procurements, and enhance collaboration between internal stakeholders as well as external supply partners. Standardized and digital material inventories, improved risk assessments, and optimized space utilization can further support circular construction integration on campus. By aligning economic, regulatory, and organisational incentives, TU Delft, but also other Dutch universities can drive a more structured and effective transition toward circular construction.

The organisational dynamics explored in SQ3 provide the lens through which the feasibility of applying strategies (SQ1) and overcoming barriers (SQ2) can be realistically assessed in university settings in SQ4.


Figure 21: Faculty of Architecture and the Built Environment (Braaksma en Roos, n.d.)

FINDINGS
EXPLORATIVE CASE STUDY

6 EXPLORATIVE CASE STUDY

6.1 APPROACH

This chapter describes the findings for sub-question 4: *How is remountability practically applied in Dutch university buildings?* Case study interviews were conducted between 10 March 2025 and 27 March 2025. The location varied from on site to online due to time constraints. All cases were visited on site, including inside tours. Two to four people were interviewed per case, resulting in nine participants in total. The interviewees were chosen based on their role in the project and being part of whether the demand or supply side. The length of the interviews ranged from 35 to 60 minutes. An overview of the interviews can be found in the following table.

	Codes	Role in project	Side	Date
SQ4	A1	Project manager	Demand	10-03-2025
	B1	Project manager	Supply	10-03-2025
	C1	Designing and coordinating constructor	Supply	11-03-2025
	A2	Manager real estate and maintenance	Demand	19-03-2025
	B2	Project manager	Supply	14-03-2025
	C2	Work planner	Supply	18-03-2025
	D2	Executer	Supply	19-03-2025
	A3	Asset manager	Demand	26-03-2025
	B3	Project manager / sales	Supply	27-03-2025

Table 15: Participant overview sub-question 4 (own table)

The demand side got 16 interview questions, for the supply side this was 17. All questions found their origin in the strategy findings of sub-question 1, found enablers and inhibitors of sub-question 2 and considerations of sub-question 3. Building on the approach of Davis et al. (2025, pp. 11–12), who structured their identified factors into a framework of themes and subthemes, a similar structure was developed for this research to categorize the findings. This framework is presented in table 16 on the next page.

For introducing the cases, a special case study booklet (CSB) is made entailing key facts, numbers and figures of the buildings. The main researcher advises to have a look at this booklet before diving into the remountability findings of sub-question 4 since it provides the necessary information to know about the cases. The CSB can be found in Appendix CSB.

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

Table 16: Emergent subthemes from factors out of literature review, used as deductive coding (own table)

6.2 TOTAL

Figure 22 gives a quantitative overview of the coded themes (left) in relation to the mentioned enablers and inhibitors (right). Shown at the left side, enablers and barriers in total were most frequently linked to culture (37%), followed by construction systems (27%) and building information (13%). Site was mentioned the least (5%). As shown on the right side, resulting from the interviews, the theme with most enabling factors is culture (41%), followed by construction systems (27%) and building information (12%). Whereas for inhibiting factors construction systems (27%) was most mentioned, followed by finance (20%) and culture (19%).

A more detailed overview is provided by figure 23 in the form of a bar chart. This chart is also inspired by the data display of Davis et al. (2025). In total (387), enablers (313) were discussed more often than inhibitors (74). Stimulating factors were most mentioned for team, mindset and execution. Financial feasibility, project plan and execution on the other hand were more inhibiting during the three circular construction processes.

The following sections contain a synthesis of the mentioned enablers and inhibitors by the participants of the case study, categorized by the themes, subthemes and factors following the structure of table 15. The subthemes are depicted in bold, italic text whereas the factors are in bold, underlined text.

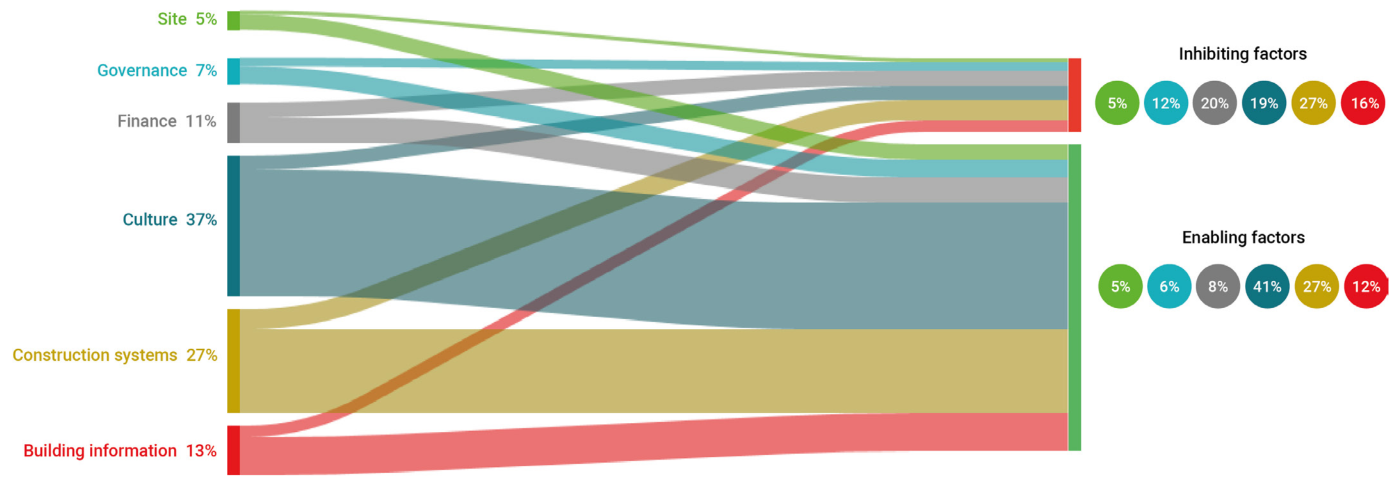


Figure 22: Co-occurrence Sankey Diagram illustrating the quantity and links of data related to subthemes (left) and enabling or inhibiting characters (right) (own illustration).

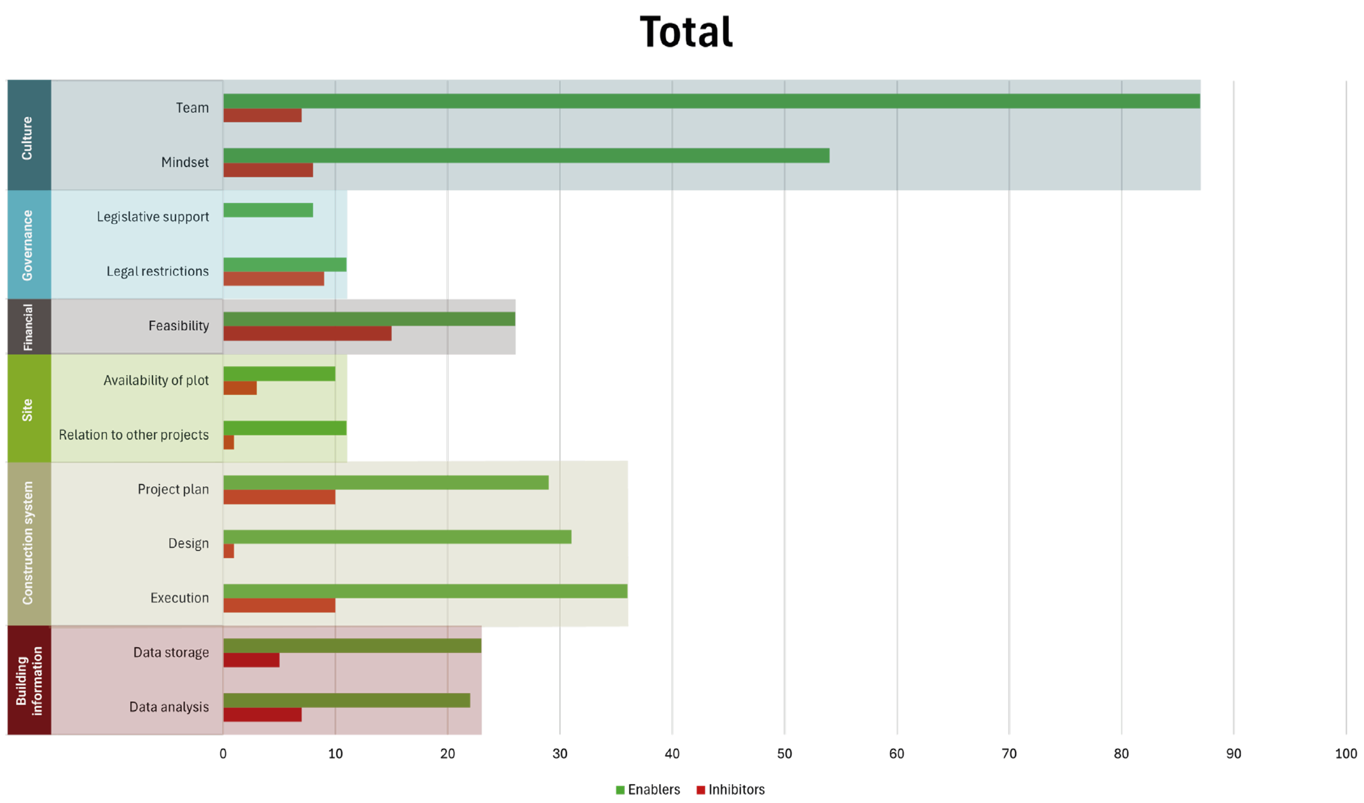


Figure 23: Bar chart of enablers and inhibitors per subtheme across all three cases (own illustration)

P-OLYMPOS

CASE I

Figure 24: P-Olympos(Continental Car Parks, n.d.)

6.3 P-OLYMPOS

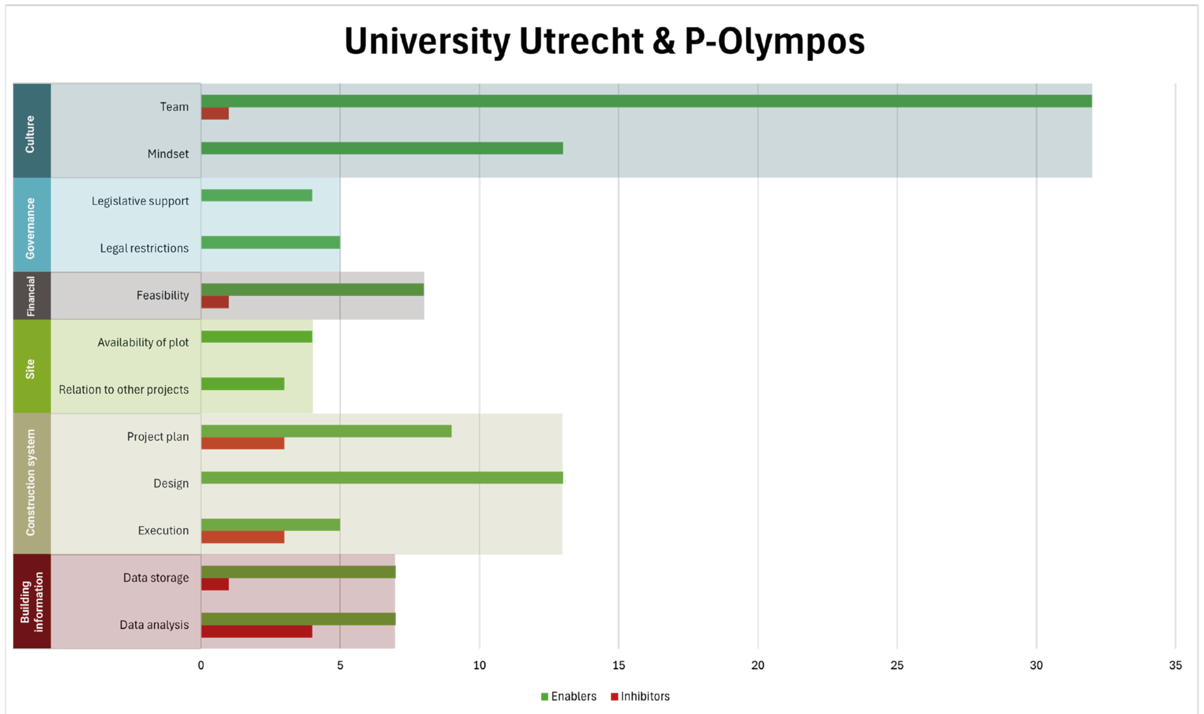


Figure 25: Bar chart case P-Olympos (own illustration)

6.3.1 Cultural

1A Team

Collaboration and ownership: The collaboration between the project developers and university went exceptionally smooth (A1, 2, 3). A main enabler according was that one party of the supply side had the lead and overall management of the construction (A2, 3) and different departments from the university came in when needed (A1, A3). Moreover, the developer has their standard partners with which they do projects in also the same procedures so there is also a proper base of trust (A3). Other enablers mentioned were efficient communication and meeting structures, so everyone knows to who to go with questions (A1, 3), a fair wage for all parties to keep them motivated and clear transfer moments to different phases (A3).
It is also remarkable that the university project manager revealed that students were also informed on the process of P-Olympos, which holds for every project on campus.

"When things go well, it usually comes from both sides." – Project manager

A critical note was given by the project manager, to work out contract more thoroughly to check whether everything is sufficient. This could have benefited the process.
Motivated and capable team: The project manager indicated that his/her company aspires to be a frontrunner in the field, which serves as a key motivation for undertaking circular projects and going the extra mile. He/she also expressed the view that client enthusiasm for submitted designs and corresponding budgets creates commitment. In the case of P-Olympos, the level of circularity ultimately exceeded the original design ambitions, driven by enthusiasm from both the client and supply side. Additional measures included the installation of extra solar panels and the reuse of materials from the Domtoren, as well as the incorporation of second-hand concrete in the façade (A2).

Interestingly, the coordinating constructor mentioned that they had not been fully aware that circularity was a major objective for P-Olympos until this interview. Nevertheless, they steadily work with steel joints and experiment with degrees of disassembly, indicating that they are actively engaging with circular practices in their own operations (A3).
Clear role campus manager: The role of the university's project manager was clearly defined from the beginning, as this was the specific function for which he/she was hired at the start of the P-Olympos project. The project manager's responsibilities, including managing the budget, schedule, risks, quality, and documenting progress, are consistent across all real estate projects on campus, providing a clear and structured task description. It was also noted during the interview, that carrying this responsibility fosters a certain degree of personal commitment and motivation to deliver high-quality outcomes.

The extent to which hierarchical approval is required varies by project and can sometimes lead to lengthy decision-making processes (figure 26) (University of Utrecht, 2021). In the case of P-Olympos, the university largely managed the project internally, owing to its extensive real estate portfolio, but supplemented the internal team by hiring two external advisors to address specific knowledge gaps, which ultimately strengthened the project's progression.

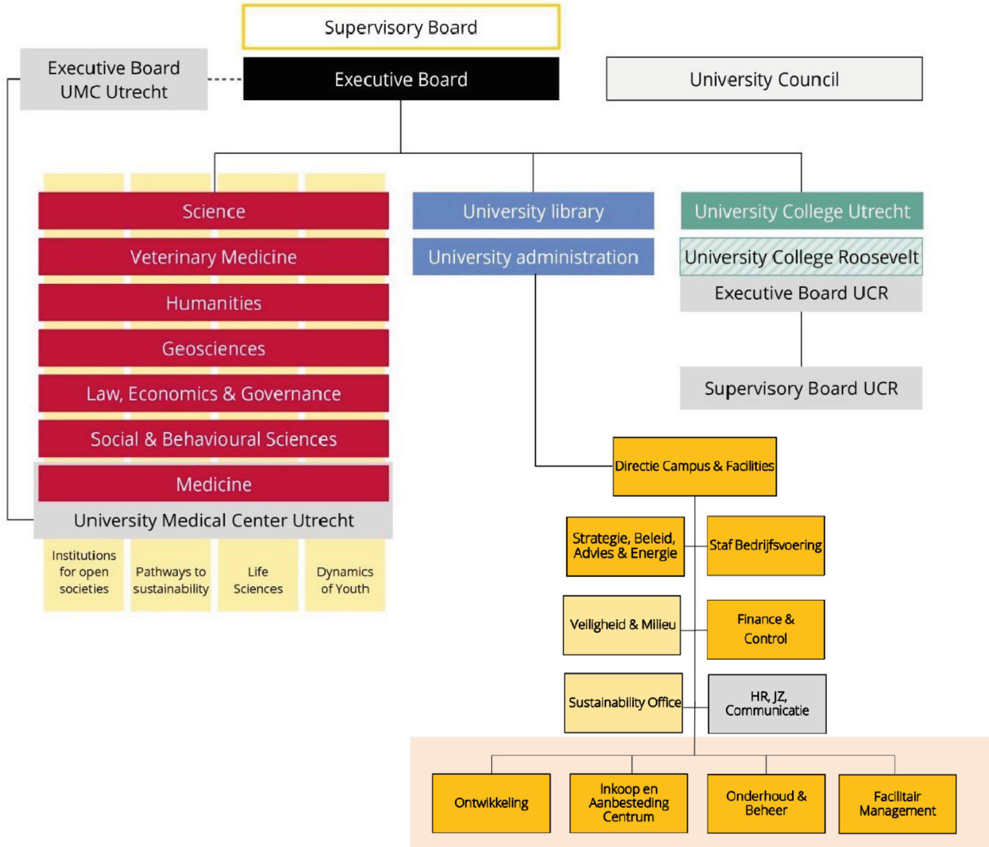


Figure 26: Organisational chart University of Utrecht (University of Utrecht, 2021)

Presence of expertise: All interviewees agreed that the project team encompassed all the necessary areas of expertise (A1, A2, A3). The project development company specialized in parking garages and has several standard blueprints that can be adapted to the specific requirements of specific cases, ensuring sufficient technical expertise on their part (A2). The construction company also emphasized its extensive experience with steel structures, contributing additional specialized knowledge to the project (A3). According to the constructor, a key enabler for successful collaboration was that each party had a clearly defined role and area of expertise, which fostered a sense of ownership and motivated participants to go the extra mile.
Conflicts between experts on campus: n/a

1B Mindset

Approach uncertainty with a flexible attitude: To reduce uncertainty, the technical drawings were made extra detailed to ensure that suppliers and contractors clearly understood the intended purpose (A2). The importance of such clear communication was emphasized by the constructor, who noted that this principle should already be applied at the initial tender stage, where project requirements must be specified in detail.
Innovative campus visions: The UU is increasingly integrating circular objectives and ambitions that are in line with the Paris Agreement, contributing to the circular transition. Circular construction is standard for every building project. For example, reuse is the first option for existing campus building, but it was stated that a lot of the existing real estate supply is from the 70s with complication, making reuse sometimes not a viable option. A current example of partly reuse is their veterinarian medicine building of which the concrete and steel structure is reused in the new building.

The university had high circularity requirements put in the tender and the design phase of P-Olympos, this required the project developing company, who was very experienced with parking garages, to think further and consider some new features, successfully ended (A1).
Raising awareness: During the project execution, P-Olympos evolved into a living lab for students, offering opportunities to conduct biodiversity research in relation to the built environment. This development arose after the university project manager became aware of a professor's initiative. Since then, students conduct biannual research into the presence of flora and fauna species and explore strategies to enhance biodiversity. Consequently, the project manager also incorporates biodiversity considerations into maintenance practices, such as refraining from mowing the grass around P-Olympos.

According to the constructor, increasing familiarity with circularity among both clients and suppliers in the real estate sector will contribute to making circular practices the standard within the construction industry.

"To promote circularity and reuse, we need to develop and share innovative solutions." - Constructor

The techniques applied in the P-Olympos project are now showcased to other clients as well, with the building serving as a successful reference project (A3).
Tendency to follow traditional paradigms: According to the constructor, a shift in vision within the building sector is crucial to stimulate circularity (A3). Within the university, a transition is happening from focusing on what is needed to considering what is available and reusable (A1). The university project manager emphasized that this necessary change in mindset extends beyond the campus and must influence the broader development sector.

"We need to take a serious look at how we can reuse buildings more intelligently, so that we require fewer new raw materials and ultimately emit less CO_2." - University project manager

6.3.2 Governance

2A Governance

Legal support: The municipality collaborated effectively throughout the project. The Environmental Permit was requested as soon as the design was finalized and was granted without complications (A1, A2, A3). The only governmental body that expressed scepticism was the fire brigade, which required the addition of extra safety facilities that had not been included in the original plans (A2). It was also stated that companies learn from working with different municipalities, as some demonstrate a clearer and more proactive vision on circularity than others (A3).
Legislative restrictions: In the municipality of Utrecht, temporary buildings are generally permitted for a maximum duration of ten years. The university's request for a fifteen-year permit was initially denied and required further negotiation before eventually being approved (A2). The university maintains frequent

contact with the municipality and collaborates closely on environmental permits and during execution phases, contributing to a strong and constructive working relationship.

6.3.3 Financial

3A Financial feasibility: The university's budget was established during the initiative phase, following the presentation of a detailed cost framework to the Board of Directors. This early financial clarity provided clear boundaries for the partnering companies. According to the university project manager, this was a major factor in ensuring that the project remained within budget. Discussions did occur, for example, when unforeseen additional work was required, but they were seen as positive moments that, in his/her words, "keep everyone sharp" (A1). Despite the significant socio-economic disruptions, such as the war in Ukraine, project costs were not heavily impacted, largely due to the strength of the agreements established early in the process (A2).

The project manager further explained that the financial feasibility study was based primarily on internal experience and expertise, without the need for additional external calculations. Sustainable and cost-effective choices were made, such as the use of bio-based wooden slats in the façade (A2). It was emphasized that as more experience is gained, the extra costs associated with circular construction are expected to decrease as it becomes more standard practice (A3).

"The experience we gain from projects like this parking garage shows us more and more that circular construction is possible with relatively little extra effort and costs. That is an important lesson: if it can be done with parking garages, it can probably be done with other buildings too." - Constructor

6.3.4 Site

4A Availability site: The site of P-Olympos was previously used as a parking lot with 100 spots. In line with the university's 2040-2050 vision to transition towards a car-free campus by relocating parking facilities to the campus edges, there was an initial intention to remove parking from this area. However, due to uncertainties regarding the future development of this part of the campus, a flexible solution was required. This led to the construction of the demountable P-Olympos parking structure, providing 320 parking spots.
4B Relations to other projects: Integrated above

6.3.5 Construction system

5A Project plan

Having a detailed project plan: Remountable construction is greatly facilitated when the project plan is detailed, the schedule is clearly defined, and the objectives are strongly articulated, as was the case with P-Olympos (A1, A3). Additionally, ensuring technical coherence in the design of joints was highlighted as an important enabler for P-Olympos (A3).
However, certain characteristics of university buildings can obstruct the integration of circular principles. Universities often have highly specific building and user requirements—for example, the specialized flooring needed for laboratories—which complicate the adoption of circular solutions (A1, A3). Moreover, the age of many campus buildings presents further challenges: structures built in the previous century were not designed with reuse in mind, making the disassembly and reassembly of components significantly more difficult.
Project having an informal character: Since the project had a strict program of requirement (in Dutch: Programma van Eisen), there was never an informal character (A1).

5B Design

Design based on available second-hand components: There was not spoken about adjusting the design specifically to available second-hand materials.
Overlap the phases beforehand: In the case of P-Olympos, the design and preparation phases overlapped,

resulting in an intense but relatively short overall process (A1). Although this overlap was not initially planned in the schedule, it occurred organically during project development (A2). Technical checks by the constructor began as soon as the first design sketches were completed. The constructor explained that their structural role was distributed across the phases: approximately 50% during the design phase, 20% during the preparation phase, and 30% during the execution phase, with continuous transfer and feedback between the phases.
Furthermore, subcontractors involved in the execution were engaged early on, immediately after the tender was awarded (A3).

5C Execution

Building and component characteristics: P-Olympos ultimately incorporated more reused materials than originally planned, as additional opportunities for circularity emerged during the project (A2). The majority of the building components were prefabricated in 3D, effectively creating a construction kit. This approach not only streamlined the assembly process but also significantly facilitates future disassembly and potential reassembly.
Tools to manage risks: No specific risk management tool was employed during the P-Olympos project. The relatively limited use of reused materials helped to minimize the risks involved. However, it is anticipated that greater risks may emerge in 10 to 15 years when the building is disassembled and reassembled (A2), as the reuse of materials at that stage will introduce additional uncertainties.
Technical complexity: During the execution phase, additional technical facilities were required, but these were not always clearly communicated, leading to some discussions over specific details (A2). The university project manager emphasized that the technical complexity of reusing campus buildings from the previous century is considerable, particularly when specific user and functional requirements must be met.
Another technical challenge also linked to P-Olympos, is the overloading of the university's electricity network, which struggles to accommodate the large volume of solar energy generated on campus (A1).

6.3.6 Building information

6A Data storage

Digital technologies on material tracking: The building was documented in Madaster by the project developer (A2). However, this platform is not the one used by the university, which meant that upon delivery, the university continued managing the building information within its own database. The project manager noted that it would be beneficial for all parties to work with the same software systems. This issue extends beyond the P-Olympos project to the broader construction sector; according to the project manager, if each party continues to use its own system, it limits collaboration and the efficient exchange of information (A2).
Lack of data and warranty on existing materials: N/a

6B Data analysis

Early information setting and sharing: The university project manager in this case played a key role in ensuring effective communication between the client and the supply side, which is crucial for an efficient and streamlined construction process. During the maintenance phase, he/she also maintained updated information and ensures that all parties are informed of relevant developments (A1). A notable insight from the interviews was that the constructing party was unaware that P-Olympos was intended as a circular project (A3).
The project developer maintains clear documentation structures that were familiar to all subcontractors, contributing to an efficient working process. Moreover, the use of clearly scheduled information transfer moments, accompanied by a status report for each project phase, was identified as an important enabler for a smooth construction process (A3).
At the delivery stage of P-Olympos, a final check was conducted to ensure that all documentation was up to date, combined with a feedback session to inform future projects. The constructor emphasized the importance of continuous improvement management to systematically identify and implement enhancements (A3).

"Many companies still keep their knowledge to themselves, while a shared database with successful applications in circular buildings would be very valuable." - Constructor

Bridge between theory and practice: Regarding knowledge sharing beyond the P-Olympos project, the university project manager explained that inter-university collaboration is now beginning to take shape. Lessons learned from completed projects, including P-Olympos, are among the key inputs for these exchanges (A1). For example, the project manager mentioned having several upcoming meetings with counterparts from other universities focused on topics such as CO_2 budgets.

TECHBANK

CASE II

Figure 27: Temprary Court Amsterdam(cepezed, n.d.-b)

6.4 TECHBANK

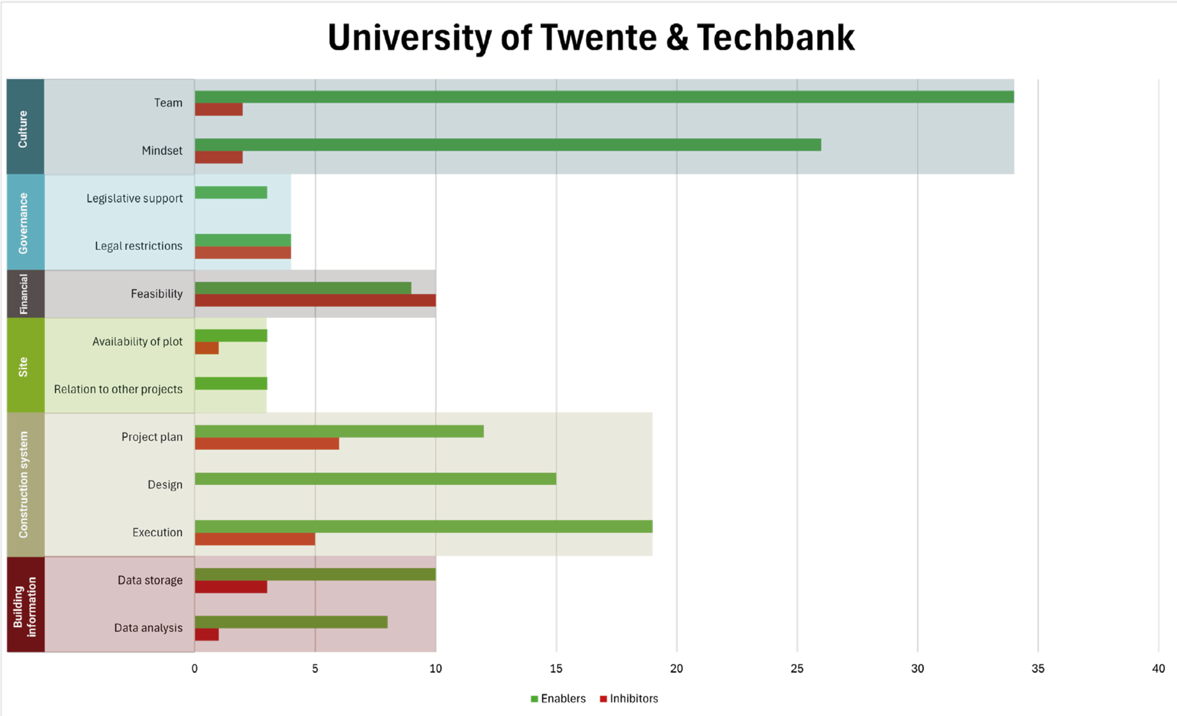


Figure 28: Bar chart case University of Twente and Techbank (own illustration)

Beforehand, it is important to state that the Techbank is, at the time of writing, being reassembled at Kennispark in Enschede which is located directly next to the campus. Kennispark is an affiliated entity of University of Twente (UT) and therefore has a link to the students, employees and campus landscape (figure 29). The University of Twente is therefore still interviewed on their views on circular construction on campus.

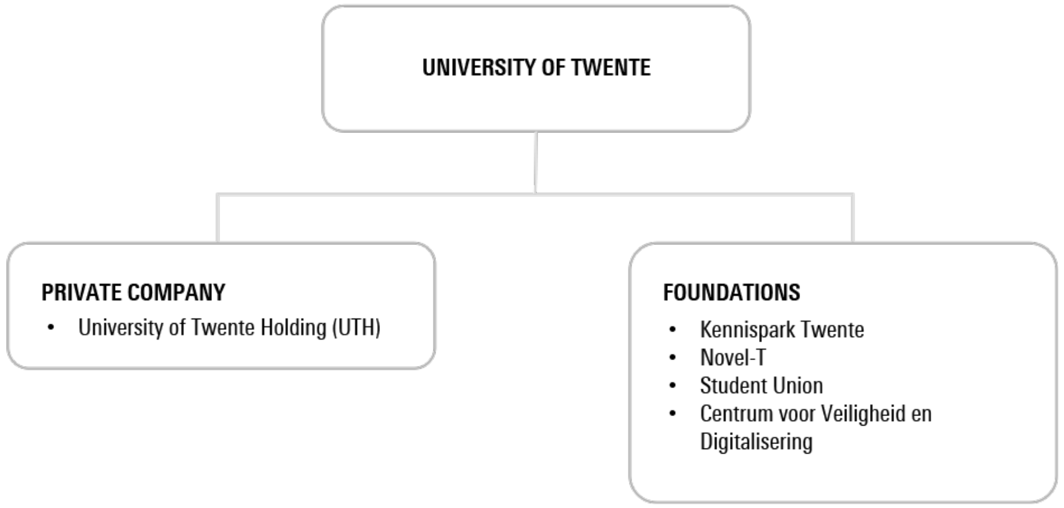


Figure 29: Group structure: affiliated entities University of Twente

6.4.1 Cultural

1A Team

Collaboration and ownership: All interviewees involved in the Temporary Court confirmed that collaboration went very well, with a shared vision and goals (B2, B3, B4). The client's decision to cooperate with multiple companies was seen as a key enabler. During the design phase, it became clear that broad collaboration was necessary, leading the design company to engage additional partners for the construction of this complex building (B2).

The project manager emphasized that minimizing changes in ownership enhances a building's reuse potential. Project success also increases when one party oversees the entire process, including disassembly and reassembly, ensuring effective decisions are made. Dividing responsibility can result in disassembly-focused solutions that ignore reassembly needs. Therefore, integrated responsibility is considered highly beneficial (B2).
Motivated and capable team: The client was highly motivated, demonstrated a positive attitude, and was willing to make concessions. According to the executor, this was a key enabling factor. It was noted that, in some other cases, clients still require persuasion to adopt circular solutions and must remain committed throughout the process which is something that needs to improve (B3). The executor emphasized that, beyond having the right expertise, motivation is critical; without it, a project like this is destined to fail.

"The most important lesson is that you really have to be driven to do it. You have to want to do it." - Executor

Additionally, the companies involved in the Temporary Court and Techbank have become increasingly enthusiastic about disassembly and reassembly and are now applying these principles more frequently in other projects (B2, B3, B4). As the executor stated:

"The circular train started driving and we wanted to join."

The project manager added:

"You shouldn't take 'no' too quickly or give up."

Clear role campus manager: The interviewed campus manager oversees three distinct teams, each responsible for new developments, renovations, and maintenance, respectively. This division clarifies the primary tasks, while the integrated supervisor is able to make decisions that consider the whole lifecycle. Depending on the decision, other departments of the organic structure must give approval (figure 30) (University of Twente, 2022). Project development is thus the responsibility of the project managers, who guide the entire process from the initial initiative through to delivery. This results in a task division that is "100%" clear from the outset (B1). For design and technical decisions, external expertise is brought in.

Presence of expertise: Having the right expertise during both the design and execution phases was essential for this project and for making effective decisions (B2, B3). This proved to be a key enabling factor. It was noted that, in this project, much of the knowledge was derived from practical experience while, there were also individuals who wanted to participate primarily to learn for their own development.
Conflicts between experts on campus: n/a

1B Mindset

Approach uncertainty with a flexible attitude: Another enabling factor in this project, as noted by the project manager, was the client's willingness to take risks and embrace uncertainties. Numerous uncertainties arose, given that this was a pilot project for both the client and the supply side. This situation demanded an open and flexible work approach, involving individuals prepared to go the extra mile (B3). The executor emphasized that complexity is essential, as it can serve as a stimulus for people to develop new solutions and foster creativity.
Innovative campus visions: In this case, the process began with an innovative tender issued by the client, which already expressed a preference for submissions emphasizing reuse over recycling.

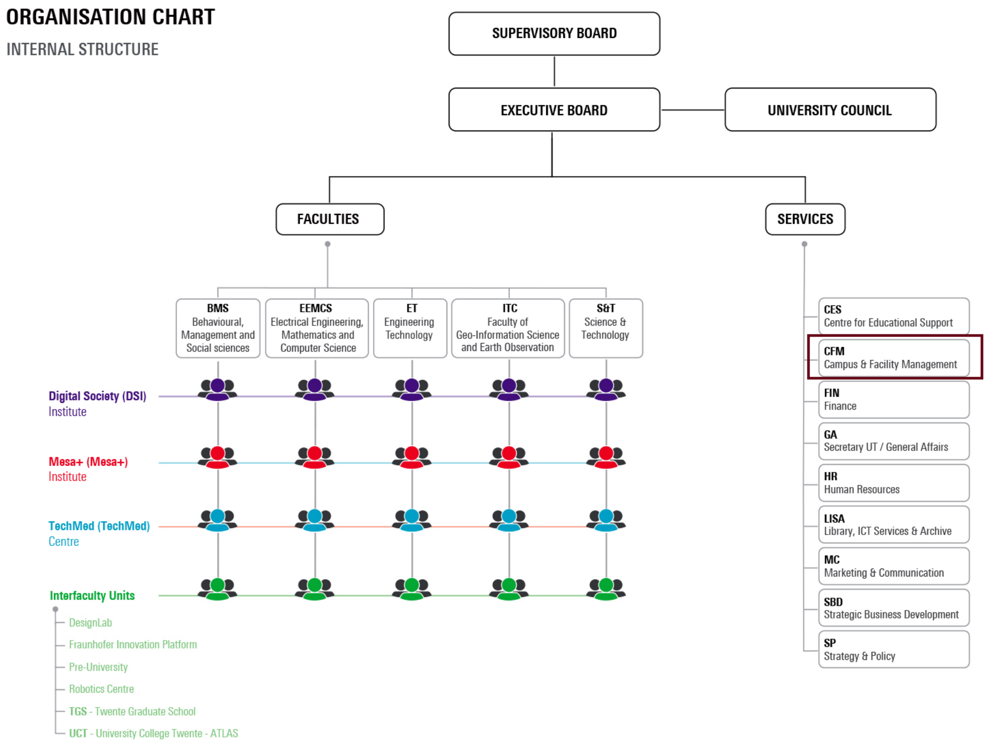


Figure 30: Organisational structure University of Twente (University of Twente, 2022)

Regarding the University of Twente, the real estate and maintenance manager confirmed that the campus vision is increasingly incorporating circularity and that ambitions in this area are steadily rising. Circularity is also becoming more embedded in the mindset of employees. The main drivers for circularity in campus real estate are the university's sustainability programs and the critical approach of the sustainability manager. Additionally, the university community, including both employees and students, was mentioned as a driving force, with a growing demand for a more circular environment.

As the real estate and maintenance manager stated:

"We often say: the greatest gain in terms of circularity is achieved by renovating a building. By retaining the shell, you save a huge amount of virgin materials. Reusing an existing building is therefore an important sustainability ambition for us."

Raising awareness: One of the client's objectives was to create broad support to prevent the building from being demolished after five years. By positioning the building as a frontrunning example, the project team and client hoped to motivate other clients to pursue circular construction as well (B3). Also, the RE and maintenance manager also confirms a growing awareness within the Real Estate department of the University of Twente. The project manager commented on the importance of raising awareness:

"We are now seeing that circular construction is becoming increasingly standard. This project has contributed to that, because by actively sharing the story of the circular court, other clients in the Netherlands have also started to engage with it. [Client] is a major client in the Netherlands, and because they were willing to experiment with this approach, it triggered the demand for circular construction in other projects as well. [...] Some clients have doubts: 'Is the market ready for it?' But if you prove it, those doubts disappear."

The current executor also observed growing interest in the reassembly process of the building, particularly from the University of Twente, whose representatives expressed a desire to visit the construction site and learn more about the process.

"If a project becomes a success, more companies will follow" – Executor

Tendency to follow traditional paradigms: According to the executor, a circular project must begin with a client who is willing to move away from traditional construction practices.

The work planner noted that certain aspects of the project were complex, requiring the team to *"invent the wheel."* This complexity occasionally still led to traditional choices being made to avoid potential discussions and delays (B2).
Throughout the process, it remained a challenge that many contractors continued to adhere to traditional construction methods and were unwilling to engage with the circular approach required for a project such as the Temporary Court.

"A project like this stands or falls with the cooperation of the client. They must be prepared to pioneer and realize that a circular, temporary building is not necessarily cheaper than a traditional building." – Project manager

6.4.2 Governance

2A Governance

Legal support: For the process in Amsterdam, the project team arranged an early involvement of the municipality, even before the tender was published. The team presented the concept in advance and discussed key points of attention with municipal officials to put in the tender. This was beneficial for the initial cooperation of the municipality (B2).
Legislative restrictions: Despite the early efforts to involve the municipality, the legal requirements surrounding a court building remained very specific and strict, which at times slowed down the process (B3). The plan required numerous approvals from different institutions, focusing more on the general building process than on the reassembly aspects. Moreover, the permits were oriented toward permanence rather than temporary use, largely due to uncertainty about the building's future transfer and thus remaining the possibility of permanence (B2). During the permit procedure, several environmental objections were filed, further delaying progress (B3).

Similarly, in Enschede, the municipality initially raised objections to the reconstruction of the Temporary Court, particularly concerning the reuse of materials and the assurance of their quality. Although these concerns were eventually resolved, general decision-making processes continued to slow down the overall construction timeline (B4).
In addition, the university's RE manager stressed that to make reassembly easier from a legal standpoint, governments should implement more flexible approval systems for reused components. This view was echoed by the project executer, who emphasized that in order to stimulate the use of second-hand materials, the legal framework must be more accommodating to reuse.

6.4.3 Financial

3A Financial feasibility:

"Sometimes the idea exists that reuse is automatically cheaper, but that is not always the case." - Project Manager

The project manager emphasizes the importance of managing client expectations: while circular buildings are often perceived as cheaper due to the use of second-hand materials, this is not necessarily the reality. It is essential to align these financial expectations early in the process. Higher labour costs, resulting from the disassembly and reassembly processes, can outweigh material savings (B2, B4). In the case of the Courthouse, the team incurred higher upfront costs compared to a traditional building. Nevertheless, the project proceeded, driven by the anticipated financial benefits during the reuse phase (B2). A predefined budget provided clear guidelines for exploring disassembly options. Although the tender was won based on the promise of residual value, the exact amount could not be guaranteed, and the client accepted the associated financial risk (B3). When asked about key lessons learned, the work planner stated:

“That circular construction does not necessarily have to be much more expensive and that it does not detract from the quality of a building. Thanks to CPZ, the aesthetic and functional requirements were high, but we were still able to realize a remountable building without extremely high additional costs.”

However, during reassembly, it became clear that long storage periods had negatively affected the technical installations. Reusing installations remains particularly challenging (B4).

At UT, similar barriers are experienced: although there is strong awareness and willingness to pursue circular ambitions, costs remain the largest inhibiting factor. Circular elements are often scaled back during tenders due to the expectation of additional expenses (B1).

“When it turns out that a circular project is more expensive, it sometimes disappears too quickly from the table. That is something we, as an organisation, can still improve.” – Real estate and maintenance manager

According to the RE and maintenance manager, clear budgeting from the outset, along with setting and monitoring explicit circular ambitions throughout all development phases, is crucial. Moreover, a shifting mindset among students and staff who increasingly expect sustainability from their environment, further motivates the university to firmly embed circularity within its real estate strategy (B1).

6.4.4 Site

4A Availability site: At the start of the project, several existing buildings on the site had to be demolished before construction of the Temporary Courthouse could begin.
Although it was clear from the outset that the building would eventually transfer to a second location, the exact destination had not yet been determined during the initial construction. This approach provided the flexibility to later select a suitable site and adapt the building’s new function accordingly (B2). Had the team committed to a specific second location during the design phase of the first life, the building would not have been suitable for its current use as office space in Enschede (B2).

When the time came to relocate the building, a suitable plot had become available in Enschede. The availability of both the site and the ready-to-use building components, combined with the search for a circular construction solution, made the reassembly in Enschede a logical and timely decision (B4).
Although the university does not own the Techbank, it sees the circular building as a fitting addition to the campus, matching the green, park-like landscape (B1).

4B Relations to other projects: The Temporary Courthouse was constructed specifically to accommodate the legal functions during the development of other new buildings on the site. Its use created the necessary space to allow the construction of the new permanent courthouse. Once the permanent courthouse was completed, the Temporary Courthouse could be dismantled and relocated. To make room for the Temporary Courthouse initially, several old buildings on the plot were demolished (B2).

6.4.5 Construction system

5A Project plan

Having a detailed project plan: The circular ambitions of the project were clearly articulated in the first client’s tender, which included a scoring system: the longer a material could be reused, the higher the awarded score. This emphasis also extended to the aesthetic dimension; strict requirements were set to ensure that the building would appear permanent. The architect responded by designing a structure aimed to last 30 years. Up until the definitive design approval, where the aesthetic, technical, functional, and circular requirements had to align, the integration of all demands remained a complex puzzle (B3).

In the case of the Techbank, inefficiencies in decision-making processes posed significant challenges. This was reflected, for instance, in poorly timed requests such as the desire to repurpose the former concrete cells into call booths, even though the cells had already been reused elsewhere, as they were not part of the second-life design plan. Such issues underline the importance of having a detailed project plan

established at the outset of the disassembly phase. As the executor put it:

“If you do not determine in advance what you are going to do with reused materials, and the reconstruction takes a few years longer than planned, this will have an impact on usability.”

The university’s RE and maintenance manager confirmed this point, emphasizing that the university’s tenders are highly specific so that companies clearly understand expectations. Particular attention is given to explicitly incorporating circularity requirements into tenders. At this stage, the university’s approach to circular construction has moved beyond the informal, experimental phase; it is now embedded in policy, as reflected by the fact that university budgets formally integrate circular ambitions.
Project having an informal character: The project was taken very seriously as the client really set strong demands in the tender and during the process. It was not seen as a trial-and-error experiment which was underlined by the consideration of the building as a permanent structure (B2).

5B Design

Design based on available second-hand components: According to the project manager, the integration of second-hand hollow core slaps for the temporary court was initially planned. But as it turned out, due to bad timing of the availability this circular initiative could not proceed.
Overlap the phases beforehand: For the Temporary Courthouse, a consortium was established in which the main contractor was integrated early in the process, resulting in a significant overlap between the design and execution phases (B2). This early integration triggered a snowball effect: the main contractor also involved subcontractors at an earlier stage, requiring them to make technical decisions sooner than usual. According to the work planner, early involvement of these parties is crucial, as their specific expertise is necessary for making practical and technically sound choices. The RE and maintenance manager of the university confirms this for circular projects.
In circular construction projects, it is not uncommon for the design phase to be extended, while the use of prefabricated components shortens the execution phase. Prefabrication often takes place simultaneously with site preparation activities. Therefore, detailed planning is essential to ensure that construction can commence immediately once the first prefabricated elements are ready.

For the building’s second life as the Techbank, the design, preparation, and execution phases were once again undertaken. This was primarily necessary because the building would serve a new function, namely office space, which required a different internal layout.

5C Execution

Building and component characteristics: Opting for a circular project within a fixed time schedule inevitably required making compromises (B2). As the project manager stated:

“You can’t achieve full circularity all at once. You have to make choices: ‘Choose your battles.’”

Although the majority of the Techbank’s components could be reused, the reassembly process in Enschede revealed that new materials are still needed, particularly for plaster, stucco elements, and technical installations. Given that the building was originally constructed in 2015, rapid technological advancements have made it impractical to reuse certain components. This is the case for every reassembly project (B3).

According to the executor, maintaining flexibility during reassembly is crucial. As the process unfolds, unforeseen issues continue to emerge, requiring the construction team to have the space and resources to develop solutions. For instance, the bolt connections in the Techbank can only be reassembled in one precise way, leaving no tolerance for variation. Had there been even a centimetre of flexibility, the reassembly process would have been significantly easier, potentially reducing contractors’ hesitation to participate in reuse projects (B3).
Tools to manage risks: The project team was well aware that undertaking this project would involve certain risks. Successfully delivering such an innovative project required both the client and the contractors to accept a degree of uncertainty (B2). Regular feedback sessions were held with the client to discuss planning updates and manage expectations.

"We calculated a certain residual value but were not 100% sure whether we could achieve it. However, we had the ambition to realize this building in this way, so we accepted that risk. The [client] also did not know exactly what they would get, but they were enthusiastic about the building and the idea behind it. Sometimes you just have to dare to take a leap of faith." Project manager

According to the project manager, two types of risks were distinguished: general risks, such as potential noise pollution for the surrounding neighbourhood, and technical risks, such as the feasibility of disassembly. Early involvement of the contractor helped to mitigate the risk of designing a building that would later prove too complex to dismantle — a notable difference compared to traditional construction projects. However, the requirement for full circularity significantly limited the pool of potential partners: four out of five contractors considered the project too complex. This limited choice can negatively affect price competitiveness and quality options, and the same challenge applies to sourcing prefabricated elements from factories (B2). As the executor put it:

"Often, a risk is considered a risk if it costs money. Risks are money-driven."

From the executor's perspective, every risk also presents an opportunity. This mindset guides their decision-making process, particularly in assessing whether something should truly be classified as a risk. Such evaluations often revolve around key factors like materials, time, residual value, finances, and safety (B4).

"If you have a risk of €10,000 but a chance of €20,000, is it still a risk?" Executor

Technical complexity: Designing the building to appear permanent in its aesthetic added a layer of complexity to the project. Instead of leaving steel joints visible, all elements had to be carefully and neatly finished. At the same time, ensuring that the structural components could be reused in the future required additional considerations, such as the method of labelling: numbers were pressed into the concrete rather than sprayed on, to enhance durability and legibility (B3).

Lessons learned from the Techbank project regarding complexity reduction, such as working with larger components instead of numerous smaller parts and simplifying construction methods, are now being applied to new projects (B2).

6.4.6 Building information

6A Data storage

Digital technologies on material tracking: The Temporary Court is digitally documented for the client on responsibility of the architect who also updated the model throughout the process and during the use. Yet, the digital documentation for the subcontractors laid with the main contractor. In 2015, BIM models were quite new, as a result of which the contractors were exploring multiple software programs, causing for a scattered documentation in the beginning (B3). In the end, the updated model of the architect was transferred to the owner of the building (B2).
In Enschede, they have the model of the architect which is not yet updated on the new or transferred components. At time of the interview with the executor, there were also no agreements on this updated model or to who the responsibility goes to update it (B4). To the question What would you do differently now? The answer of the executor was *"Make more documentations and more pictures"* which highlights the importance of recording as much as possible with circular construction projects. During the interview, the executer took it a step further by stating that software programs must communicate on a higher level to upscale the use available second-hand materials. By collecting all that is available on one platform, would significantly increase the efficiency of reuse (B4).
Lack of data and warranty on existing materials: The executor emphasizes that, in practice, obtaining warranties for reused materials is hard, as parties are generally unwilling to assume responsibility. As a consequence, when a component malfunctions, it is often replaced with a new one rather than being repaired.

6B Data analysis

Early information setting and sharing: The client was regularly updated on the status of construction and important notifications were shared. The presence of a frequently updated BIM model significantly supported the disassembly team by providing detailed insights into the materials used and their methods of assembly. This allowed for better technical preparation prior to disassembly. However, the main reason cited for the necessity of an updated BIM model was its role in stimulating the potential for reuse (B2, 4). Also, the UT is actively developing material passports to systematically document the materials present and identify those suitable for reuse on the market. They also aspire to assign unique identification codes to each material, thereby improving traceability (B1).
Furthermore, throughout the process, additional feedback moments were integrated to safeguard the reuse potential. Compared to traditional construction projects, significantly more verification and check-up points were implemented (B3).
Bridge between theory and practice: n/a

FLUX

CASE III

Figure 31: Flux (Broekbakema, n.d.)

6.5 Flux

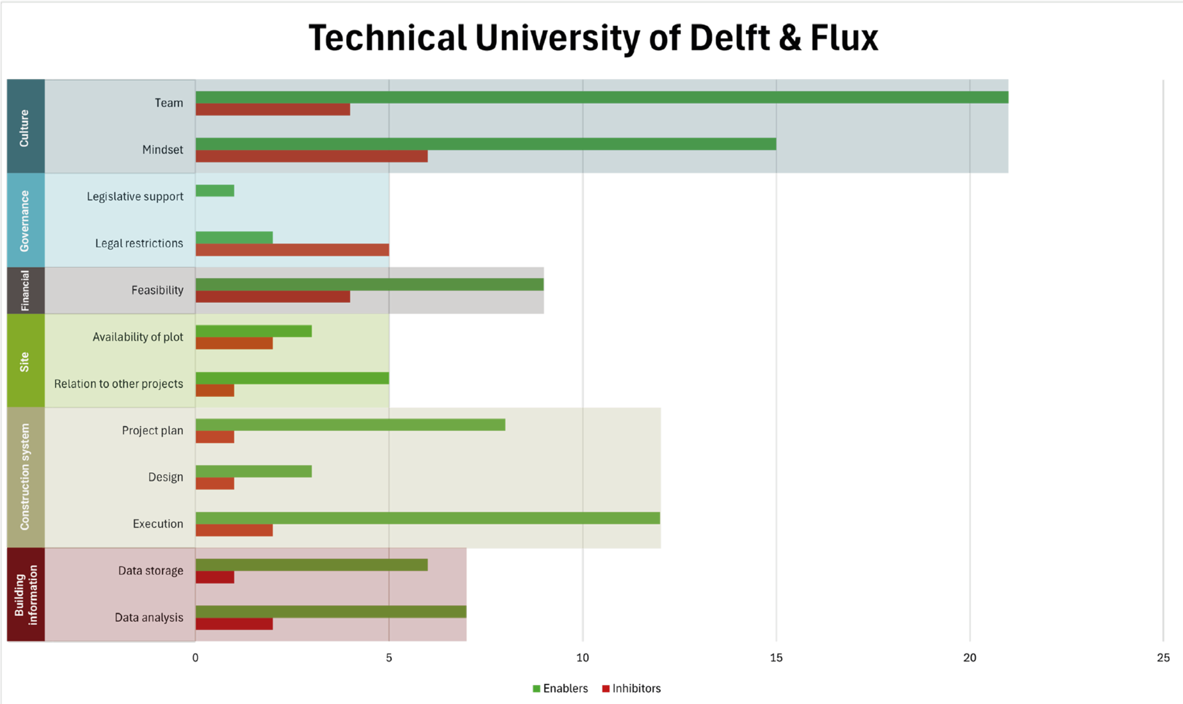


Figure 32: Bar chart case Flux (own illustration)

6.5.1 Cultural

1A Team

Collaboration and ownership: In the beginning, decision-making took too long to allow for a quick and efficient process. While the right mindset was present, involving a consultancy firm only added to the delays rather than speeding up the construction process.

"Every decision, drawing or change, they initially asked for 3 or 4 weeks to come to a decision. [...] That that won't work, because there are so many things that need to be decided on, it just has to be much faster." - Project manager

However, TU Delft recognized that the sluggish process would prevent them from meeting their own deadline. As a result, they adjusted their way of operating, which significantly accelerated progress and improved overall feasibility. According to the project manager, with this changed operation, the also the supply side got a boost, and all pulled in their extra weight.
Motivated and capable team: Following the project manager, the fact that there was a highly motivated client, both in circularity and time schedule, made this project a success. This motivation reflected on the external parties, because there was a clear objective: build fast.

"The speed stimulated this building project. This was a new way of construction. Therefore, everyone was focussed to gain results." - Asset manager

The asset manager claims that within the TU Delft real estate department, the motivation to build more circular buildings is coming more intrinsic. Yet, you need pioneers within your organisation who continue to actively push the circular agenda forward (A3).
To keep also the external project team motivated, the TU Delft team made a conscious effort to connect with the builders by regularly taking time for informal coffee chats and checking in on their mood. This approach was capped off with an opening party for all contributors to Flux, which was highly appreciated

(A3). On a more formal note, the cooperation towards a successful end project was stimulated by already circular motivated external partnerships who were willing to take that extra step and consult actively when there were issues, resulting in a cooperative solution.
The project manager mentioned one downside, which is that when the building sector has a shortage of staff, circular projects become harder to execute since it requires more consultation and cooperation this was the case with Flux concerning the installations.
Clear role campus manager: According to the asset manager of Flux who was closely involved in its construction, the roles within the TU Delft for this project were crystal clear, following the structure in the organisation (figure 33) (TU Delft, n.d.) . There were clear links between the external companies, the management organisation and the board which transferred to the maintenance phase. Additionally, TU Delft shifted responsibility for distributing real estate budgets from the faculties to a central level. This enabled a more objective allocation based on spatial needs aligned with the university's vision, rather than individual faculty preferences.

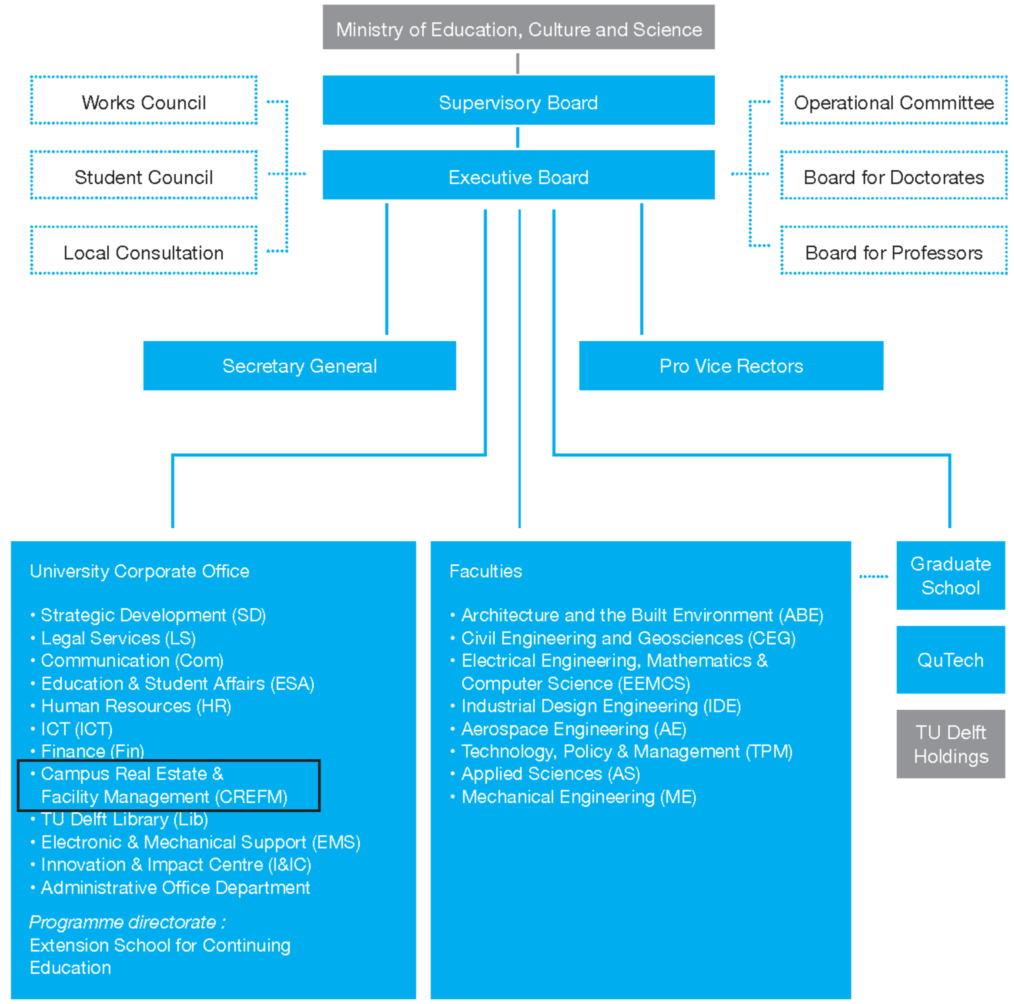


Figure 33: Organisational chart TU Delft (TU Delft, n.d.)

Presence of expertise: The interview laid out that from their establishment onwards, the contractor has had experience with disassembly and reassembly. Their core business of temporary structures has evolved in the last 85 years into solid remountable buildings. They a system entailing all components in supply. The contractor also gained expertise with educational buildings for another university. The fact that they implemented their own second-hand material for Flux, brought extra expertise into the construction process.
Furthermore, the interview revealed that in a circular process like this, having a company with the right expertise at the table significantly accelerated progress, as it allowed all questions to be addressed directly by an expert.
According to the project manager, it is not uncommon for architects to have a strong vision for a project and to be quite persistent in pursuing it. This requires the other executing parties to critically assess what is feasible and what is not.
Conflicts between experts on campus: n/a

1B Mindset

Approach uncertainty with a flexible attitude: According to the asset manager, the main reason the Flux project was initiated was the rising demand for on-campus study and lecture spaces following the Covid-19 pandemic. Additionally, the number of international students grew more rapidly than anticipated in the university's strategic plan which partly due to policy changes under U.S. President Trump and Brexit, which made the Netherlands a more attractive study destination. Another contributing factor was TU Delft's commitment to being an on-campus university, which further increased the need for student housing. The response to such unforeseen events was the need for a flexible building. However, since the pandemic, student behaviour has changed from being constantly physically present at university, from watching lectures or doing projects at home. Despite the university wanting to be an on-campus learning environment, the users of the institution approach education in other manners. According to the asset manager, this uncertainty should be considered in the real estate plans for the upcoming years.
Innovative campus visions: The interview showed that the TU Delft increasingly sees circular construction as logical and viable options to fulfil their real estate demand. The campus vision is *"110%"* circular according to the asset manager.

"There is no longer any assignment within CRFM – and I specifically mention CRFM. Because it is Campus Real State and Facility Management – that is not being addressed sustainably." - Asset manager

For all CRFM projects, sustainability is being addressed on topics as materials, mobility, transportation within a program that is published three years ago. He/she states that all circularity aspects or starting points are now slowly being integrated into the activities on campus. This was underlined by the following quote:

"And it is actually very simple, demountable construction is sustainable. We can move this building to another part of the campus. It is only sustainable if it is actually rebuilt." Asset manager

A sidenote with this circular vision was given through the mentioning of the dependency on budgets and technical feasibility.

"Of course, that [read: integrating circularity in campus projects] depends on budgets. What is technically possible, what is not possible, and so on. But the ambition is there. But the ambition is there, absolutely. That is now really being considered again and again. Where in the past it was said, oh we don't have the budget for that, we won't do anything with it, it is now the other way around." - Asset manager

Raising awareness: According to the project manager, an increasing number of components of their buildings are disassembled and reused directly, put in storage or put on second-hand market for building materials. The materials are offered to other market parties, trying to create more buildings with reused

materials. This contributes to a diminishing waste flow from their projects (B3).
Looking at the university, the interview revealed the following quote:

"Why wouldn't we always build like this on campus? And there are a number of reasons why you increasingly see that we would like to do that. One, the speed. Two, the concept of circular construction. In the past, we easily stepped over that. But nowadays, we have a responsibility. And why wouldn't we use old usable parts from other buildings? That does also apply to adjustments and transformations, because it is of course very strange that if you put new doors in one building and you throw away those old doors. While you might want new doors in another building a year later and you could have used those old doors." - Asset manager

Tendency to follow traditional paradigms: The project manager experienced an active vision from the TU Delft towards innovative, circular ideas rather than linear construction practices. Translating these ideas into practical actions, however, took the university some alterations in their mindset causing the process of Flux to be slowed down at the start which was resolved later.
For the company, the project manager states that Flux has changed their way of thinking about construction projects.

"Perhaps it has only become clearer that much is possible, and that we can do much too – but that there are always limits. We will not remain a traditional builder." – Project manager

Considering a new perspective, the interview with the university showed the following quote which underlines the acknowledgement of the need for change:

"[read: for construction projects we must be] looking from the supply instead of the demand. Well, that is another step we have to take." - Asset manager

6.5.2 Governance

2A Governance

Legal support: Flux currently has a permit for 10 years, but there is a sense that the municipality may grant an extension if TU Delft were to request one (A3).
Legislative restrictions: Requesting permits was a decisive moment and went rather smoothly (B3). The project did get a legal objection from a local resident, but the matter got resolved after consultation with the government. Also, the presence of bats in the adjacent trees proved to be quite a hold back. Both matters led to the design being revised twice, which prolonged the process (A3, B3).
Permit requests for circular projects take 14 weeks, which the project manager considers long when aiming to build efficient and quick. While permits for temporary buildings are subject to less stringent requirements, often resulting in fewer public objection, this also leads to lower building standards, which, according to the project manager, can undermine circular ambitions.

6.5.3 Financial

3A Financial feasibility: The university has to do with serious cutbacks which reflect on the available budget for campus real estate. For Flux, the financial aspect was not a main enabler, inhibitor or conflict (A3). Budget, however, seems to draw up boundaries to circular projects for both demand as supply side.

"But in a project, one must always search for a balance between budget, ambition and what is technically possible" - Asset manager

"If there was unlimited budget, choices are made differently. But that is a fantasy world. The challenge is being as circular as possible within the budget." - Project manager

6.5.4 Site

4A Availability site: The presence of the bats on next to the plot influenced the process negatively (A3). An enabling factor is the shift in mindset from owning to renting buildings, allowing the university to respond more flexibly to changing spatial needs. TU Delft provides the land, while external parties are responsible for constructing the buildings (A3).
4B Relations to other projects: The former function of the Flux' plot was parking. Before starting the construction of Flux, the adjacent parking garage needed to be finished to keep parking in this area possible. This transferred smoothly. Furthermore, piling was necessary, but the presence of nearby laboratories and exam halls made it crucial to carefully coordinate and agree on the piling schedule (A3).

6.5.5 Construction system

5A Project plan

Having a detailed project plan: The university did an extensive inventory in the market on what is possible and with whom. After this long period, a detailed tender was established. During the project, the phases overlapped which allowed for meetings with parties that in the execution needed to work together. This detailed project plan was crucial for the fast-paced timeline.

"The goal was building very fast." - Asset manager

Project having an informal character: The project was taken very seriously due to the time pressure of spatial needs on campus (A3).

5B Design

Design based on available second-hand components: The floors of the 2012 Olympic Games in London are used successfully in Flux. Other materials are manufactured new (B3). The university ideally sees a material flow of second-hand components between Dutch universities but perceives this as ambitious. It is already a win if that flow establishes within TU Delft itself. According to the asset manager, the idea of designing new buildings based on available materials is something that has not yet been enthusiastically received. Within the decision-making chain, this kind of reversible design thinking is still considered too risky (A3).
Overlap the phases beforehand: Design work had already begun in the initiative phase, as the university engaged an architectural firm to create several sketches of the proposed building to win time. Additionally, the preparatory phase also began during the initiative phase, as construction of the parking garage had already started (A3). Due to unforeseen events during the execution, the project team had to return to the design table several times to solve errors. For example, with the bats (B3).

5C Execution

Building and component characteristics: The floors, some roof components and part of the interior are reused from other contexts. And although the university was very open to using second-hand materials, most other building materials and components are fabricated new. The time pressure of the Flux project was perceived as too high to experiment with new materials and acoustic characteristics. Different choices would perhaps been made to if the deadline had not been as tight (B3).

"The installation world has shortages. As long as they are too busy, they have little room for innovation." - Project manager

What was new for the university was the installation of a heat pump. The asset manager did convey a progressive thought that he/she is asking to external parties when working on a building for TU Delft:

"What if we shop for materials first and then you design?" - Asset manager

Tools to manage risks: Several sustainable measures, as solar panels, the use of wood in the structure was familiar due to the recently delivered TU Delft Echo building. Apart from some components mentioned above, not many second-hand materials were used for the construction of Flux which did not increase risks. The large materials of the building structure that were reused, are professionally disassembled and transported by the same company that reassembled it for Flux, this decreased risks in terms of now being allowed to reuse (B3).
The delivery took from Monday to Friday entailing dozens of inspections and tests to guarantee no mistakes.
Technical complexity:

"Our quality levels for the tender [for Flux], we have set very high" - Asset manager

Especially the lecture halls had to be of a certain quality when it came to acoustics, sight lines and sustainability. This was new for some external parties which made it more technically complex (A3). During the delivery, there were certain acoustic features that proved too unpredictable in practice than was calculated beforehand, due to a new combination of shutters with aluminium material.

6.5.6 Building information

6A Data storage

Digital technologies on material tracking: The interview revealed that the TU Delft is working on establishing their own BIM department because they acknowledge the importance of digital building models, and they want to be able to compare buildings. This BIM department must also digitalize 'older' buildings as the Faculty of Architecture and Civil Engineering.
Lack of data and warranty on existing materials: The data and warranty were secured through the use of components that are owned, disassembled and reassembled by the same company.

6B Data analysis

Early information setting and sharing: In terms of information sharing, the communication was perceived as inefficient by external parties in times that a consultancy firm was involved as so-called "messenger". Regarding digital models, the existing BIM models are in hands of the contactor and by them updated when necessary. They have shared public documents with the TU Delft and if the TU Delft were to buy Flux at a certain point, the model is transferred to its new owner.
The asset manager explained that information sharing between Dutch universities on circular building construction, real estate management and ICT is nowadays happing at a passive level. This means that lectures and conferences are given as well as meeting are held between sustainability managers of different universities. Active levels of sharing consisting of material flows, are not occurring yet and according to the asset manager *"quite ambitious"*.
Bridge between theory and practice: Renting installations is twice as expensive as an owning them it is therefore not executed in Flux. In theory this renting system is more sustainable and flexible for future building adaptations, but in practice it is rarely done (B3). Also with fire safety, the project manager explains that the TU Delft made some (theoretical) demands, which required a shift from the executors.

6.6 CONCLUSION

The case studies make clear that circular construction is most successful when all parties truly commit to a collaborative attitude from the outset, practical expertise is involved from the start and establish a digital information model that is continuously updated throughout the building's first life cycle. Yet, a fundamental shift from traditional to circular thinking remains urgently needed on both the demand and supply sides. Without this critical change in mindset, circular construction projects are bound to fail.
The case study findings in SQ4 serve to validate and ground the theoretical insights from SQ1 to SQ3 by showing how strategies, barriers, and contextual conditions unfold in real projects. This forms the input for the needed improvements for integration in SQ5.

7 PROPOSAL

The objective of this research was to show how Dutch universities can integrate remountability in their construction to increase a long-term shift to more frontrunning circular construction. This chapter answers sub-question 5: *What needs be done to increase the integration of remountability in the construction process of future campus buildings?*
It consequently presents a process model with element to efficiently integrate remountable construction practices in campus developments. Hereafter, this research has led to the insight of the urgently needed cultural and mindset change in the building sector. That is why this research also entails a second deliverable in the form of a potential analysis. This revelation over time is explained in Chapters 7.3 and 7.4 whereas the implication of this change is further highlighted in the Discussion.
Creating both a process model and preliminary potential analysis contribute extensively to answering sub-question 5: What needs be done to increase the integration of remountability in the construction process of future campus buildings?

7.1 THE SMALL PRINT

During this research, certain key points have come up that that should be integrated into the construction process that stimulate efficient realisation of remountable campus buildings. Accumulating all findings of sub-questions 1, 2, 3 and 4 (figure 34) makes it possible to adjust the timeline of general construction from Chapter 3.4, to a remountable construction process. Findings, both theoretical and empirical, on remountability as a construction practice are combined with strategical considerations in the university campus context and lessons learned from three reference projects across the Netherlands.

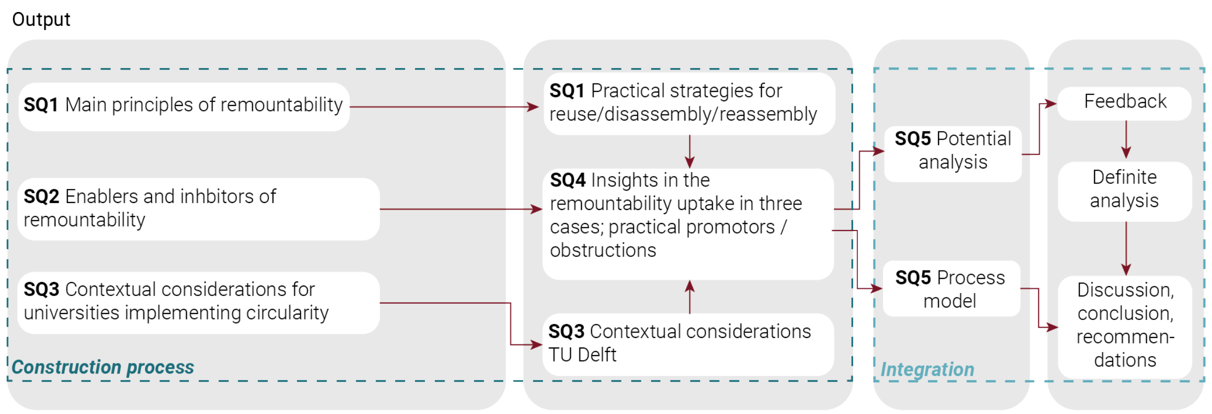


Figure 34: Output flow of this research (own illustration)

Let's start by stating it is impossible to create a standardized process guideline. A smooth strategy for one project can be the wrong move for another. The performed case studies show the variety of objectives and unforeseen events that occurred. This is why, when reading the process model, one should keep the following rules of thumb in mind, inspired by Hout (2021):

- The process model exhibits estimated duration of phases and points of attention during the process, but this gives no guarantee for an efficient or seamless process;
- Do not treat the model as an absolute truth: it is a guide, not a law of nature;
- Remain flexible as unexpected challenges or opportunities might require adjustments to the process.
- Deviations from the model are not failure as adapting to unique circumstances is inherent to project development.
- It must be transparent where decisive moments are during the process;
- It must be transparent where the bottlenecks are during the process;
- Use the model as a conversation starter, not a conversation ender. Critically discuss each phase.
- Validate the model against project-specific goals, since not all universities have the same objectives, priorities or constraints.
- Remember that the model simplifies reality: complex processes will always involve nuances that no theoretical model can fully capture.

7.2 TARGET GROUP

The target group of the process models are the main stakeholders in a university remountability process. Derived from chapter 3.4.2 Stakeholders, the key stakeholders considered are the following:

1. University CREFM department
2. Project developer
3. Architect
4. Contractor
5. Government

Within these groups there are different expertise such as installations expert, BIM specialists, investors etcetera.

The target groups can use the process model in multiple ways:

- For those already familiar with remountable construction, it serves as a reference tool to reinforce known practices and processes.
- For those with general reuse experience but public university settings, it acts as a translation tool, highlighting what sets heritage projects apart from standard adaptive reuse.
- For newcomers to both reuse and campuses, it functions as an orientation framework, helping them understand the phases and challenges they can expect throughout the process.

7.3 PROCESS MODELS

While we have learned that a circular construction process constitutes of similar phases as a traditional process, for an effective integration of remountability in university construction, adjusted phasing and specific key points are crucial. This paragraph explains the phases and its elements that belong to remountable construction process. A distinction is made between remountable construction for new-build and remountable construction for reuse, since both scenarios are possible starting points for contemporary campuses. Both models are also found in Appendix E with instructions on how to read them.

Both models contain different phases, key points and overall considerations that have appeared during the literature study and empirical research. The sequence of the model goes clockwise, starting at the top. Colours show an indication of the length of the phases that overlap in the fades. Perpendicular to the circle are the key points, specifically for remountable construction. It is important to note that 'regular' construction activities are not added to the key points.

7.3.1 Integrating remountability in new build processes

When remountable building construction starts from new build, the target audience can use the new-build model (figure 35). Following are the seven phases with an explanation of their adjacent actions.

Initiative
The initiative phase can be sparked by various drivers:

- Performance-based demand for additional campus space;
- The need to replace outdated or failing buildings;
- The ambition to establish a living lab project.

Currently, few existing campus buildings are designed with reuse in mind, which makes the safe reuse of structural elements challenging, if not impossible. To enable a reuse cycle that goes beyond interior elements like furniture, doors, or carpeting, new construction can be required. Such construction should employ prefabricated structural elements that are intentionally designed for multiple reuse cycles.

This phase is characterized by research, the identification of constraints, and the exploration of opportunities. Establishing clear operational boundaries early on is crucial to reduce uncertainty throughout the rest of the project. The feasibility study also narrows down the project plan. As options become more defined, the perceived complexity of the process tends to decrease. However, this phase probably still involves several revisions, especially if a current plan proves unfeasible. At that point, one must either explore alternative funding sources or adjust the proposal.

A motivated, committed and well-organized internal university team must be assembled in this phase, pushing both the initiative and ambitions. By aligning with the university's overarching circularity goals, this team sets a strong foundation and strategic direction for all subsequent project phases.

Briefing
In this phase, final decisions are made before the project is brought to market. Developing a detailed program of requirements, clearly outlining circularity criteria, enhances internal clarity and ensures alignment with broader campus development goals. The primary goal of the briefing phase is to establish a shared internal understanding of the project's ambitions, definitions and requirements. Achieving internal alignment on aspects such as remountable design ambitions and available budget, lays a solid foundation for structured and effective collaboration with external partners.

Procurement
The procurement forms the most formal phase of this process. Crucial for a remountable project is the extensive rewarding of circularity-aimed tenders of enthusiastic stakeholders who are not afraid of uncertainty.
UAV-GC contracts were mentioned as most suitable for remountable construction due to the integration of the contractor during the design phase. Involving the execution expertise leads to less design inconveniences appearing during execution.

Design
The design phase transforms circular ambitions into a detailed and actionable plan for a remountable new build on campus. This phase typically takes longer than in traditional processes due to the added complexity of designing for efficient reuse and anticipating next-life scenarios for building components.

A strong alignment with the university's long-term objectives is essential. Ideally, the design incorporates available components from the university's portfolio, alongside prefabricated and biobased elements to promote modularity and minimize environmental impact. Early collaboration with the contractor supports practical solutions for efficient disassembly and future reassembly. Once the design is finalized, fabrication of prefabricated elements can begin.

A university BIM department should already be in place during this phase to ensure digital models. Given the constraints of the Dutch electricity network, a comprehensive installations and electricity plan is required. Timely acquisition of permits, zoning approvals and securing insurance for circular components helps avoid delays. Finally, a formal transfer document must be prepared to clearly communicate all circular strategies, technical details, and responsibilities to the execution team.

Execution
The execution phase of a remountable project demands flexible planning and close coordination to ensure real-time progress updates. On university campuses, construction must be scheduled with consideration for noise and vibration, especially during exam periods. A detailed logistical plan for prefabricated elements must align with the readiness of the building site. During execution, it is essential to update BIM records and material passports to reflect the actual built situation, as this is when deviations or on-site changes occur, crucial for ensuring accurate documentation and future reuse potential.

Delivery
During the delivery of a remountable project, it is particularly important that the end-users, being students and employees test the building during a predefined period.
The client, contractor and architect should perform thorough handover checks to ensure the fulfilment of the circular ambitions, design and execution. But perhaps most importantly, when the BIM model is established by the architect or contractor, this informative document must be handed over to the BIM department of the university.

Maintenance and use
The final, and longest, phase of a remountable new-build process is the maintenance and use phase during which the evaluation and documentation of component performance is laid down. While the most significant reuse potential lies in the structural and skin layers of a building, the maintenance of other components can also greatly influence the overall level of reuse. This is particularly true for the space plan layer, such as interior walls, doors, staircases, and window frames, rather than the structural layer, which includes elements like hollow-core slabs, columns, and beams. Although maintenance strategies were not explicitly discussed during the case study, incorporating maintenance practices that facilitate future reuse and keeping relevant stakeholders up to date about this should be considered a deliberate and integral actions during this phase.

Sharing insights with other universities is essential to support broader adoption of remountable practices within these long-standing institutions. Ultimately, a decision must be made regarding the building's future: continuing in its current form, remaining in place without change, or preparing for relocation and reuse. Choosing the latter initiates the start of the reuse cycle.

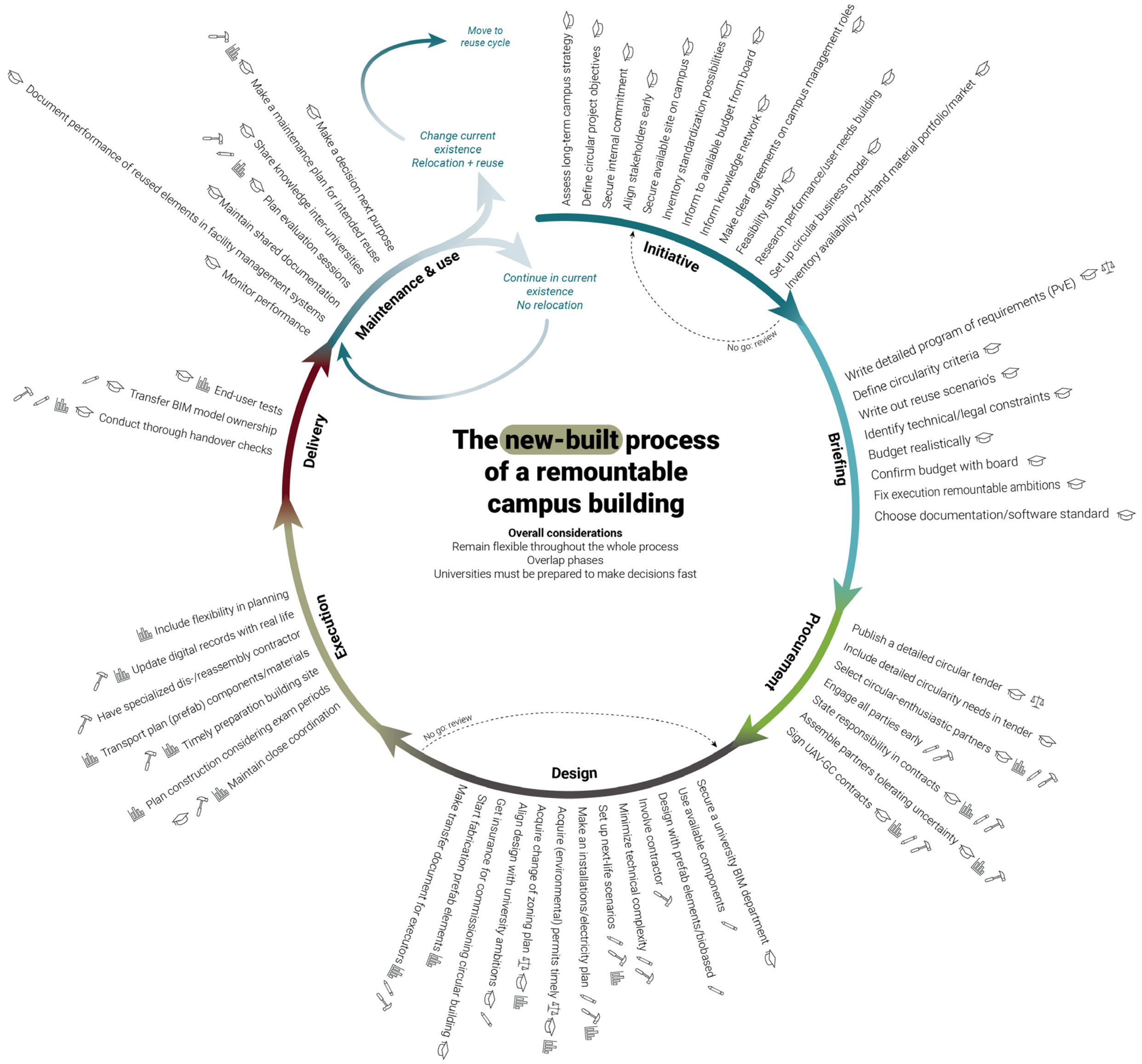


Figure 35: New build process model for remountability in campus buildings (own illustration)

7.3.2 Integrating remountability in reuse processes

When building components or an entire campus building is suitable for reuse, the construction process can follow the reuse process model (figure 36). This process shares actions with the new-build cycle, but due to working with existing components, new phases and action points are included in **green**. Specifically these green elements are discussed in this paragraph.

Initiative
In the reuse cycle, the initiative phase closely mirrors that of the new-build cycle, with the same focus on doing research and internal commitment. However, since dealing with an existing remountable building, the university's internal team must determine the new function and user needs, which will define the new building. Also, the condition of the to-be reused materials must be assessed.

Briefing
The briefing phase introduces several remountable-specific additions. By identifying available reusable materials early on, the university can define a well-substantiated reuse target percentage. This insight also enables the brief to incorporate design constraints based on the characteristics of the available components. Additionally, the university can update the residual value of the building, reflecting its potential for future reuse.
Procurement
Working with a second-hand building makes it even more beneficial to have a contractor with dis- and reassembly experience than with a new-build process.
During the procurement phase, special attention must be given to verifying warranties and clearly defining responsibilities related to reused components. Additionally, a new logistical and storage plan must be developed to ensure efficient handling and tracking of materials throughout the project.

Design
This design phase distinguishes from the former design phase by adapting the existing design to the new context and purpose. Unnecessary alterations must be avoided to simplify execution and maximize reuse potential. Available components must be mapped and matched to maximize the degree of reuse. Furthermore, a detailed disassembly and reassembly plan must be established considering extra flexibility for uncertainties.

Execution disassembly
The biggest difference between the new-build and reuse cycle are the execution phases. This phase is split up into parts, beginning with the disassembly.
Starting with a pre-disassembly inspection, followed by labelling and documenting all parts is the beginning. The digital documentation must be updated at all times. The disassembly must happen safe, without harming the components that are then stored appropriately.

Delivery disassembly
After storage, disassembled components must undergo re-testing. A risk assessment will determine whether each component is suitable for reuse or should be replaced. If a different party handles reassembly, all updated documentation must be transferred accordingly. This reassembly party is also responsible for coordinating the delivery schedule with the overall construction timeline.

Execution reassembly
The reassembly execution must be done precisely as planned with close collaboration among trades. The reused components must be tracked, and unforeseen issues must be flexibly addressed. Eventually, all reused and new elements must be documented in the university's facility management systems.

Maintenance and use
New insights gained during reassembly should be integrated into the knowledge network of Dutch universities. With a view to potential future reuse, reassembly records must be regularly updated and remain accessible for future projects. When working with reused materials already, it is crucial to define a proper maintenance plan that incorporates the care needed to allow for a new reuse cycle.

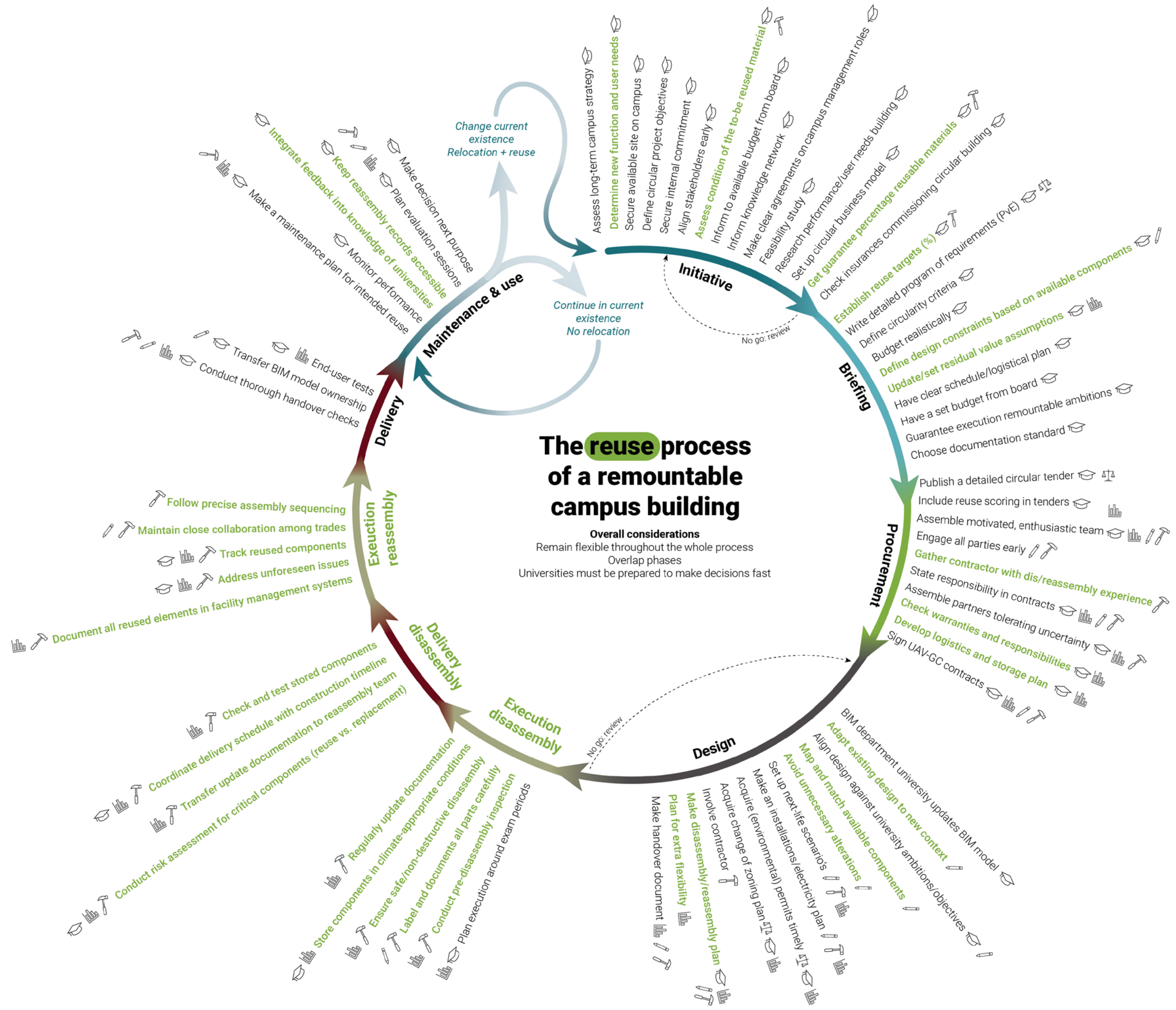


Figure 36: Reuse process model for remountability in campus buildings (own illustration)

7.4 DRIVERS OF CHANGE

The initial focus of this research was the development of a process model with key considerations for more effective integrating remountability into construction projects at Dutch universities. However, the empirical research revealed that a motivated mindset is the essential foundation of any circular project. Without collective enthusiasm from the start, the likelihood of achieving high-end circularity diminishes significantly. The interviews clearly demonstrated that shifting mindsets requires a parallel transformation of the sector's deeply rooted culture. This applies not only to university real estate developments, but also to the broader construction industry.

This insight, combined with several informal discussions, inspired the set up of a potential analysis. The point is to shift the perspective of universities and the supply side (*target audience*) from uncertainties, risks and financial barriers by highlighting the opportunities and potentials that are inherent in circular real estate. Interview participants responded with enthusiasm to this preliminary idea, which ultimately evolved into a robust secondary deliverable within this research, carrying substantial promise of its own. The next paragraphs tap into the creation of this analysis and its validation.

7.5 POTENTIAL ANALYSIS

After complementary desk research on opportunities in the circular built environment in academic literature and reports, a list of potentials could be developed. This original analysis (Appendix F) consists of seven columns, namely category, number, potentials, description, references, time horizon and scale. The time horizon indicates the amount of years it takes for the potential to have impact and is a proposed guess, drawn from reports. The column scale in the potential analysis provides a systematic indication of the level of circularity associated with each potential. It is based on the Scales to Aspects model developed by the Circular Built Environment (CBE) Hub at TU Delft (CBE, 2017). This model (figure 37) illustrates how circularity in the built environment operates across multiple spatial scales, ranging from individual materials and components to entire buildings, neighbourhoods, cities, and regions.

Figure 37: The scales to Aspects model by CBE (CBE, 2017)

To support a successful circular transition, the model emphasises the need to consider a range of interrelated factors. It highlights the interconnection between technical, social, and economic dimensions, which must all be addressed at each scale to achieve circularity. For the purposes of this research, the original CBE scales have been adapted to suit the university campus context:

- Material
- Component
- Building
- Campus (aligned with the CBE model's 'neighbourhood' scale)
- Network (aligned with the CBE model's 'region' scale)

Use and starting points

The PA can support a university CREFM department in two ways, shown in figure 38. First, it can be used internally to define organisational ambitions by setting clear norms, thresholds, and key performance indicators (KPIs) related to circularity. This helps a university to clarify their definitions and what they want to achieve on circular level. Second, the analysis can serve as a tool for external communication, allowing universities to translate their circular ambitions into concrete requirements for architects and contractors and thereby signalling clear expectations and encouraging alignment among project partners. Following are simplistic flow charts with three ways of how a PA can be established.

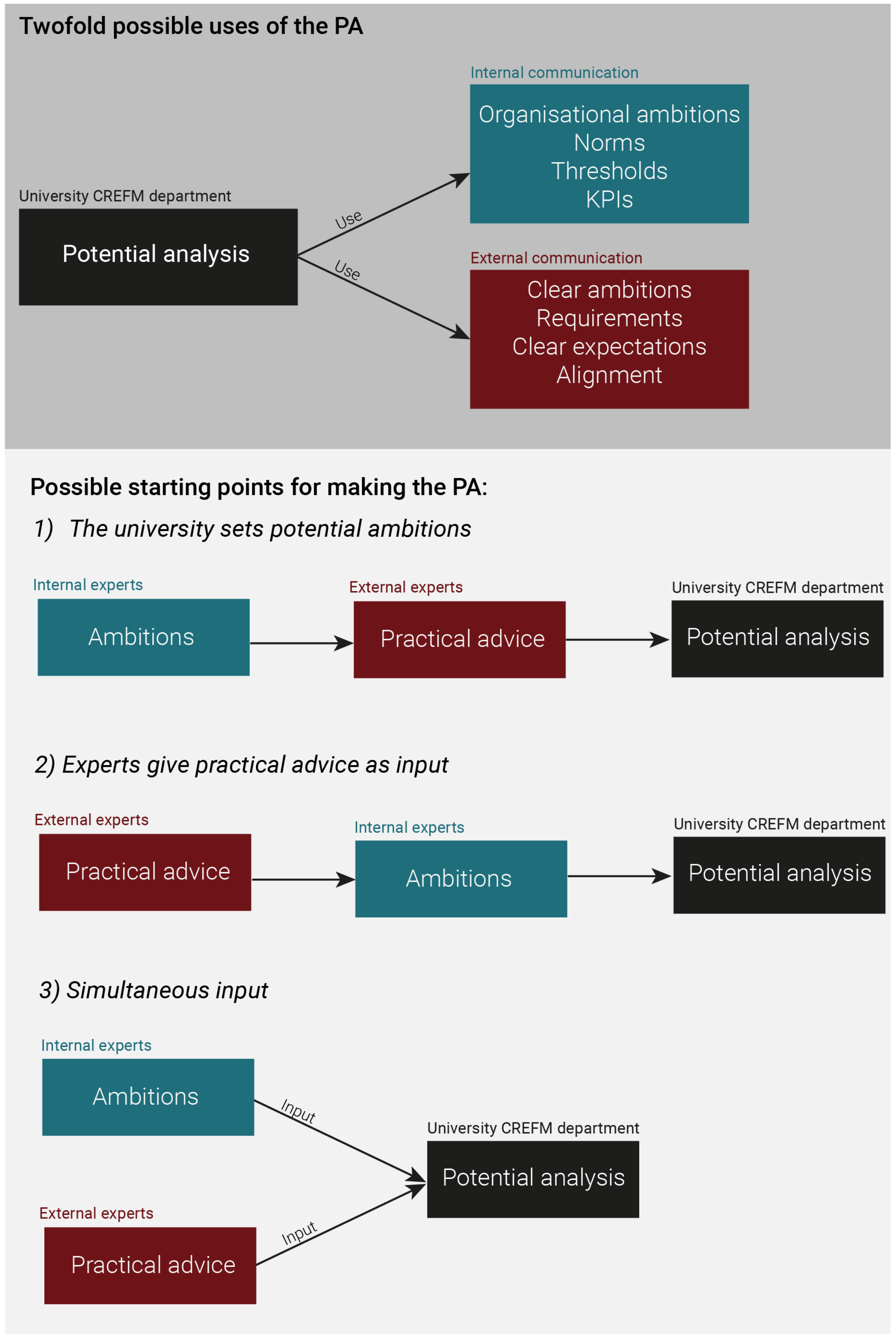


Figure 38: Twofold possible uses of the PA, followed by three possible ways the PA can be established

7.6 THE POTENTIAL OF THE POTENTIAL ANALYSIS

To validate the new findings of the potential analysis, an expert panel was set up on the 29th of April 2025. The expert panel consisted of three participants, with two being PhD candidates of a Dutch university with significant theoretical knowledge about the built environment, adaptive reuse and circular construction. The third expert has great practical knowledge on developments on Dutch campus and the contemporary drivers and obstacles that these institutions are dealing with. The panel was held physically at the cepezed office in Delft and took 90 minutes.

	Codes	Role in project	Date
SQ5	Validator 1	PhD candidate Built Environment	29-04-2025
	Validator 2	PhD candidate Adaptive Reuse	
	Validator 3	CRE developer of a Dutch university	

Table 17: Expert panel participants overview (own table)

The panel had the following agenda:

1. Background: informing the participants about the progress of this research at the time;
2. Identified potentials: reading through the identified potentials listed;
3. Discussion: group discussion on the rightful belonging, alteration, or additions to the listed potentials.
4. Scoring: giving the listed potentials a score on sense of importance for Dutch universities.

The latter two agenda points required active participation from the experts, as their input directly influenced the analysis. These points are therefore discussed in more detail in the following paragraphs.

7.6.1 Panel discussion

The panel discussion started with clarifications of certain descriptions. They proposed some small alterations and to make some potentials more specific by adding context. The implemented alterations and additions are in bold, red text. For example, potential one Availability materials in existing portfolios: material availability should not be bounded to campus buildings but also extend beyond university portfolios to create greater demand and supply. Validator 1 came up with a new potential that should be considered: The evolving market dynamics of supply and demand. As circular construction becomes more prevalent, the availability of second-hand materials is likely to increase. At the same time, growing awareness among clients, developers, architects, and contractors may stimulate demand for these materials, including biobased options. This shift could encourage a design approach that starts with available materials rather than predetermined needs.
If the whole panel agreed on a proposed alteration (including the main researcher), the alteration was implemented in the analysis.

7.6.2 Scoring importance

After the discussion, the panel was asked to score the listed potentials on importance and relevancy for universities to indicate the potential of the potential analysis. They answered the following question: How important is # for the realisation of circular construction on campus for Dutch universities?
The participants noted that some of the listed potentials focused more on the technical and practical implementation of circular construction, while others addressed its social and political dimensions. If the scorecard were solely centered on circular mindsets, it could lead to biased results, as the successful realization of circular construction also relies on practical drivers that enable action on the ground. The panel, including the main researcher, agreed that it would therefore be useful to leave the potentials focussed on the realisation in the analysis, rather than removing them. The distinction was therefore implemented by splitting the scoring column between a score for pushing circular realisation (R) and pushing a more circular culture/mindset (CM). Now, the panel had to score the potentials according to the following questions: How important is # for stimulating the realisation of circular construction on campus for Dutch universities? and How important is # for a promoting a cultural/mindset shift for decision-makers at Dutch universities?

The scores were individually assigned using a Likert scale, where 1 indicates lower importance and 5 indicates higher importance in relation to Dutch universities increasing their circularity uptake. Prior to scoring, participants were explicitly informed that a score of 1 does not imply that a potential is totally unimportant. Rather, it may play a less prominent role in the pursuit of more circular construction. Therefore, participants were encouraged to also assign scores of 1 where they found it suiting. Afterwards, the panel had another group discussion on why they assigned particularly high, low and diverging scores to some potentials and comparing these argumentations with each other. This discussion led to some remarks behind some scores.

The validated potential analysis can be found in Appendix G, whereas Appendix F contains the definite potential analysis that is meant for the target audience.

7.7 CONCLUSION

This proposal set out to explore how Dutch universities can effectively integrate remountability into their construction processes to promote long-term circularity. The process model presented in this chapter translates the insights from sub-questions 1 through 4 into a practical, phased approach for realizing remountable construction, tailored specifically to the campus context. However, the research also revealed that technical strategies alone are not sufficient. The need for a cultural and mindset shift in the building sector emerged as a critical precondition for success. Therefore, a second deliverable, a potential analysis, was developed to identify and prioritize drivers that can stimulate such a shift. Together, the process model and the potential analysis provide a comprehensive answer to sub-question 5, combining practical guidance with strategic vision to advance the integration of remountability in future campus developments.

8 DISCUSSION

Based on the findings, five key discussion points emerged. Notable critical views arose during research derived from insights from literature, interview responses and case study outcomes. Furthermore, the research process itself is critically reviewed in terms of methodological choices, reliability, and validity. Finally, the study acknowledges its limitations.

1. Scientific contribution
The first discussion point concerns the scientific contribution of this study. While the concepts of DfD, disassembly and reassembly have each received attention in academic literature, the overarching notion of remountability remains largely unexplored. Similarly, while '*losmaakbaarheid*' is a recurring topic in professional guidelines and policy reports, the equally (if not more) critical concept of '*vastmaakbaarheid*' is often overlooked. When looking critically, one could say that this research does not define new practical concepts within the construction sector. The added value of this study, indeed, does not lie in introducing entirely new principles, but in demonstrating how the strategic combination of the ones already existing can enable more meaningful and scalable reuse in construction practice.

2. Should universities even aim for remountable construction?
This research assumes remountability as a desirable objective, but should universities even pursue it?

As stated earlier, universities distinguish from commercial actors by operating for long-term spatial commitment, own their land and serve a public mission. These characteristics make them well-positioned to pioneer remountable construction, which benefits from continuity, stable ownership and trial-and-errors. Furthermore, embedding remountability in campus development aligns with university's strategic visions and frontrunning ambitions.

Yet, shifting toward remountability also brings complexity, upfront costs and organisational adjustments such as setting up a BIM department. If not embraced altogether, such ambitions risk becoming isolated pilots. Moreover, for certain buildings with fixed programs or heavy laboratories, remountability may offer limited added value.

Ultimately, universities should critically assess where remountability adds strategic, environmental or educational value and where it may not. The decision should follow from broader campus visions, not from circularity alone.

3. How do the key points have value?
While the identified key points and potentials offer valuable insights, their integration does not guarantee successful integration of remountable construction. External factors, such as economic crises or shifting political agendas, can still steer universities toward traditional choices or inaction. In the Netherlands, current political dynamics already pose challenges to advancing circular construction in the public sector.

Moreover, this study does not quantify the influence of each key point. As an exploratory study, the research aimed to identify relevant factors rather than measure their impact. The included key points are based on stakeholders' perceived relevance at the time of the interviews. As such, elements not mentioned by interviewees may be underrepresented in the established process model and potential analysis.
Therefore, while the deliverables offer a valuable foundation, they should be seen as a qualitative and perception-based framework rather than a weighted tool.

4. Are these deliverables applicable to other contexts?
An important reflection following the completion of this thesis concerns the extent to which the developed deliverables (process model and potential analysis) are specific to university real estate or transferable to other building types. Given that remountability and reuse are hot topics across the entire construction sector, as demonstrated in Chapters 3.1 and 3.2, it is important to consider the findings' broader relevance.

While the process model was enriched with university-specific insights from this study, its core elements are not inherently exclusive to academic buildings. From a technical perspective, a campus building contains standard components as beams, walls, installations, doors, that are also found in other public and private buildings. In this regard, the foundational principles embedded in the process model and potential analysis can practically be extended to other contexts.

However, the institutional context of universities introduces a number of enabling conditions that differentiate them from other actors. Their ownership of land allows them to bypass time-consuming acquisition procedures, and their long-term spatial commitments align well with the lifecycle thinking central to circular construction. Also, large portfolios and a public character position universities as effective demonstrators, helping to normalize remountable practices in the market.

While the technical process of remountability may be transferable, the institutional university context characteristics are more difficult to replicate. A clear distinction should be made between technical, practical strategies and context-specific conditions to assess applicability. This understanding can support the applicability of the model to other sectors, such as healthcare, municipalities, or commercial development, while acknowledging the particular advantages that allow universities to lead in this field.

5. What role does the persisting culture play in all this?
A key insight that emerged from this research is the urgent need to challenge and transform the prevailing mindset in the construction sector. The industry remains largely driven by risk avoidance, liability, and a focus on failure. When something goes wrong, such as a beam collapsing, the immediate question becomes: who is responsible, and who will cover the costs? This blame-oriented culture is deeply embedded in contractual agreements that prioritize fault over collaboration.

This mindset is established from early education onward. For instance, the TU Delft course *Building Law* – a core component of the MBE curriculum – trains students to identify liable parties in cases of construction error. Risk analysis is thus emphasized, but success is rarely incentivized. There are no systems in place that reward actors when things go right or when a structural element performs as intended, or when a circular solution effectively reduces CO_2 emissions.

In light of this, a potential analysis serves as a valuable counterbalance: rather than focusing on uncertainties and potential losses, it highlights opportunities, added value, and unrealized benefits of circular construction. Especially given the relatively uncharted nature of circular practices, such an approach can help reframe the narrative from one dominated by risk and hesitancy, to one oriented toward innovation, opportunity, and shared gain.

6. Who is responsible for this shift?
Circularity and green innovation have become core values within Dutch universities, which nowadays reflect to their real estate strategies. At the organisational level, embracing a forward-thinking identity and frontrunner mindset is crucial to driving this transition. However, while internal commitment sets the foundation, many argue that regulations and policies at governmental level and decisions on design level are equally important to enforce sustainable initiatives.

<u>Governments</u>
Although bottom-up initiatives play a key role in enabling reuse, the question arises: shouldn't governments also share responsibility for this transition for universities? The findings suggest that governmental actors can act as supportive and collaborative stakeholders. Yet, several participants noted that existing regulations often create resistance, particularly when permitting processes become too complex. This can discourage contractors and insurers who are open to circularity but lack experience. At the same time, cases such as P-Olympos show that governmental support and incentives can significantly accelerate progress. Clarifying the government's role and ensuring it enables rather than hinders circular construction, is vital to advancing this shift and engaging more stakeholders in the built environment.
Another important point of discussion concerns the minimum circular building requirements set by the government. Universities, and even more so commercial or private developers, still retain the option to skip circular construction altogether. By raising the baseline standards for circularity, the government can provide a strong, systemic push towards transition. When combined with a cooperative and facilitating approach, this regulatory pressure becomes a powerful mechanism to accelerate the shift toward circular construction.

Designers

At the same time, the question could be extended to explore the extent to which the supply side influences circularity. Architects and developers are responsible for delivering the design and can therefore make key decisions on circularity in the future building. While their choices are constrained by budgets and the program of requirements, they can, and arguably should, take that additional step towards circularity. Contractors also play a role in this design process to ensure executional efficiency. However, this sense of front-end responsibility is not inherent to architects and contractors. Moreover, in the absence of specific tender requirements, circular design is not always prioritized. Since the design phase lays the foundation for the end product, those involved in creating it must recognize the influence they hold in driving the transition towards circular construction. Yet, this designing push requires somewhat of intrinsic motivation as well.

On a last note, from the perspective of designers, circularity can also pose constraints to their craftsmanship due to the limitations in materials and joints they can use. Is that perhaps the sacrifice the construction sector has to make?

8.1 LIMITATIONS

Although this research aims to offer comprehensive and applicable insights, several limitations must be acknowledged.

First, the time-bounded nature of this study poses constraints. The construction sector is highly dynamic, influenced by shifting regulations, economic conditions, environmental focus, and societal trends. During the 2024–2025 research period, circularity was highly prominent, while Dutch universities faced financial pressure and on-campus activity increased. These contextual conditions may change rapidly, affecting the generalizability of findings.

Second, while efforts were made to capture diverse perspectives through semi-structured interviews, the data remains subject to personal bias. The selected participants represented different roles, but not the full spectrum of potential viewpoints. Also, the fact that three case studies were included means the findings are based on a limited range of examples. Including more cases could have enhanced the results.

Third, this thesis' developed process model combines theoretical insights and practical experiences. However, its value remains theoretical until tested in practice. Until universities apply and evaluate its use, it should be seen as a conceptual guide rather than a proven tool. Future research is needed to validate and refine the model's components.

Finally, a significant insight emerged in the later stages of this research: the cultural mindset within construction processes. This shift, from focusing on risks and liabilities toward opportunities and potentials, became increasingly prominent during final interviews. Although the initial thesis focus was not centered on this, a preliminary potential analysis was developed. Due to time constraints, this analysis is exploratory, but its emergence highlights the need for further research on how a cultural shift could support circular construction. In this sense, the limited time allocated to this theme also becomes a strong recommendation for future work.

9 CONCLUSION

This explorative research focused on the integration of remountability in the construction process of Dutch universities through the following question:

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

In order to answer this, five sub-questions supported the knowledge base, ranging from the characteristics, enablers and inhibitors, contextual considerations, in practice and increasing the uptake. Each sub-question is answered in the following section.

9.1 CONCLUSION SUB-QUESTIONS

SQ1: What strategies does a remountability process encompass in practice?
Remountability in practice is composed of three foundational principles: Design for Disassembly, disassembly and reassembly, all working toward the objective of enabling multiple reuse cycles of buildings and its components. These principles must be supported by clear strategies across the construction process, stretching from early design choices and standardization to digital documentation and overlapping of phases. The practical success of remountability depends on integrating both technical guidelines and process-oriented actions, such as storage planning, flexible planning, to overcome the gap between theoretical intend and physical reuse.

SQ2: What are enablers and inhibitors of remountability in the built environment?
The implementation of remountability is influenced by various enabling and inhibiting factors. Main enablers are: organisational commitment, having experts, aimed procurements, digital tracking methods and overlapping phases. On the other hand, the main inhibitors include lack of expertise, financial uncertainties, rigid regulations and traditional mindsets. These factors touch upon technical, financial, legal and cultural aspects, emphasizing the complexity of circularity in practice.

SQ3: What are contextual considerations for universities that influence the integration of circular construction processes to their building projects?
The TU Delft is increasingly committed to circular construction but still faces challenges in translating these ambitions into consistent project outcomes. Critical considerations are portfolio constraints, special building requirements, fragmented real estate interest across faculties, financial justifications related to public funding and insurance and permitting difficulties.
On the contrary, universities also possess strong enabling traits, like intrinsic motivation, high ambitions and land to test on, which do support the integration of circularity when they are on the same page and committed to.

SQ4: How is remountability practically applied in Dutch university buildings?
Practical application of remountability remains limited but growing, as evidenced by the cases P-Olympos, Techbank and Flux. These projects show that remountability is feasible when supported by clear collaboration, early involvement of executional expertise, consistent ownership and (semi-)organized BIM models. Succes grows by integrating reuse in tenders, keeping flexible plannings and maintaining enthusiasm among stakeholders. However, obstructions as unclear responsibilities, slow decision-making and legislative delays hinder wider application, especially during reassembly phases.

SQ5: What needs be done to increase the integration of remountability in the construction process of future campus buildings?
To increase the remountability uptake, universities must adopt a dual approach: technical integration through process restructuring and cultural shifts in decision-making. The process model of this thesis outlines key phases and actions tailored to new-build and reuse contexts, whereas the potential analysis shows the importance of mindset shifts, residual value recognition and cross-university knowledge sharing.

9.2 CONCLUSION MAIN QUESTION

The answer calling to the main question *How can Dutch universities integrate remountability in the construction processes of their campus buildings?* is given through the process models and its key points per phase. It depends on the building status which of the two process cycles to follow (Appendix E).
All the insights from the sub-questions are combined in these models. By performing the key points for remountable construction on top of regular construction activities, universities should, theoretically, be able to integrate remountability in their construction process.
Naturally, no remountable project is the same, which makes the form of the model adaptable to building type, time, stakeholders, internal team, economic and political climate. This process model functions as an inspirational guide for remountable projects.

An additional answer to how universities can integrate remountability, lies in the stimulation of a cultural mindset shift. Universities, but also architects, contractors and project developers, can try taking on a more opportunity-seeking mindset by exploring and applying the listed potentials in Appendix F in their benefit.
The identified potentials are slightly focussed on universities as organisations, but the potential analysis is not condemned for this institution. In fact, more (international) organisations can tailor the potential analysis to their context and answer the question *How can [we] integrate remountability in the construction processes of [our] buildings?* This outcome should stimulates organisation to explore their potentials.

In the end, the main things that should be taken from this thesis are the following:

1. Remountability is promising, yet an underdeveloped circular strategy
Remountability integrates disassembly and reassembly with the intent of enabling multiple reuse cycles. Unlike demountability, it emphasizes purposeful reassembly into new contexts.
Despite its potential, it remains conceptually vague in both literature and practice, with a notable lack of empirical integration in Dutch campus projects.
Dutch universities, with their unique organisational structures, innovation character, and long-term spatial commitment, offer an ideal living lab for remountable construction.

2. Operational strategies are key to implementation
Among the strategy types (passive, active, operational), operational strategies were most commonly identified as enablers in practice, these include clear communication, process documentation and flexible scheduling.
Design principles are the foundation of reuse, but without operational follow-through (e.g., digital documentation, flexibility and expertise), they will not make it to practical action.

3. Contextual complexity on campuses can both enable and inhibit circularity
Dutch university campuses present an enabling context: strong sustainability ambitions, public role, access to research networks, and long planning horizons. However, financial constraints, strict regulations and lack of standardization still hinder adoption.
The diversity of building functions and specific technical installations and requirements (e.g. no vibrations, heavy laboratory works) complicate standardization and reuse potential.

4. Mindset shifts are more urgent than technical innovation
In both interviews and case studies there is a reoccurring theme on the need to change from a risk-averse, cost-driven culture to one that embraces learning, experimentation and future value. This is especially important for public institutions like universities, where financial and material risks often weigh more heavily than long-term environmental gains.
The mindset shift must touch all stakeholders: real estate departments, boards, faculty heads, project developers, architects, contractors and even insurers.

5. Universities can and should lead in circular construction
Given their position as public landowners, knowledge hubs, and innovation leaders, Dutch universities are uniquely placed to pioneer remountable building strategies. However, leadership demands more than ambition. It requires structured procurement, knowledge sharing, and long-term alignment of campus development with circular goals.

9.3 RECOMMENDATIONS

The recommendations are drawn up in twofold: future research recommendations and practical recommendations for universities and other remountability actors.

For future research

- **Empirically test and evaluate the process model**
    - While this research presents a conceptual process model for remountable construction, future research should test the model in real university projects.
    - Longitudinal studies on multiple reuse cycles of circular buildings will help validate the findings in the process model over time.
- **Quantify the impact of the key points**
    - Future studies could investigate the weight or level of influence of the process model actions identified.
    - A weighted analysis could enhance the process model by prioritizing the actions for universities considering remountability.
- **Compare buildings beyond the (Dutch) university context**
    - As stated in the discussion, the investigation on integrating remountability does not have to stay within the boundaries of the specific context of this research. Comparing other clients, cultures, policy systems and economies where remountable buildings proved to be (un) viable, may identify global best enablers and inhibitors.
    - It is also worth looking into disassembly and reassembly options for 'heavier' buildings, such as laboratories or hospitals.

And last, but perhaps most importantly,

- **Dive into the potentials for mindset/cultural changes**
    - Build on the insight that culture and mindset are decisive for circular/remountable construction. Study attitudes, risk perceptions, financial business models and advocates for faith in light of organisational circular activities.
    - Conduct a policy analysis for the reform of building regulations, such as fast permits for reused materials or a systematic quality check for second-hand materials.
    - Study ways to restructure insurances to reduce hesitance of clients about non-traditional construction approaches.
    - Investigate management strategies, relevant for the construction sector that could enhance a shift from conventional to circular thinking.

For practice

- **Commit to circular construction in strategies and procurements:**
    - Buildings should only be developed or redeveloped when there is a clear, measurable reason, such as improved energy efficiency, structural performance or functional user demands that justifies the intervention.
    - Focus on what is already available within the campus portfolio in terms of buildings and materials.
    - Make circularity (incl. remountability), a fixed and specific criterion in all tenders and reward this heavily.
        - Give room for architects and contractors to take that extra step.
    - Develop and adopt campus-wide KPIs for reuse and circularity, to use in real estate portfolio evaluations.
- **Appoint a dedicated person within the CRE department responsible for the circular aspects of construction.**
    - For efficient remountability implementation, universities should secure clear roles and responsibilities within the campus real estate and facilities team;
    - Ensure that staff within the university's CRE department are responsible for developing and maintaining BIM models and material tracking systems to document, manage, and update inventories of reusable components

- **Integrally evaluate remountable reference projects:**
    - Use reference projects (like Flux and Techbank) to apply on your own process (applies to both universities and architects) and measure component performance over time.
    - Introduce reoccurring post-use and post-reassembly evaluations of campus buildings to capture learnings and embed them into subsequent projects.
    - Facilitate shared material databases between universities (beyond platforms like Insert), including timing-based matching tools for supply and demand in reused components.
    - Enable knowledge exchange on circular construction and procurement through regular knowledge-sharing events.
- **Push for legislative and financial reform:**
    - Advocate nationally for adjusted insurance models and simplified permit procedures for remountable or reused components.
- **Normalize the use of the potential analysis in early phases:**
    - Clients (universities) can use the potential analysis framework as a cultural tool to shift focus from risks to opportunities in circular construction for their hierarchical approval. But also, for setting minimum requirements of the building to developers, architects and contractors.

10 REFLECTION

From the first day on, the process of this master thesis has been a ride with ups and downs. In this reflection I will go in on different moments during this master thesis that were new, expected, surprising, fun and difficult. For my P2 report I established seven learning goals for myself on which I will also circle back during this chapter. The goals were:

- Coping with uncertainties and blanks;
- Coping with several sequential changes;
- Remaining flexible in approach and methods;
- Dealing with feedback from multiple experts and professionals;
- Develop my critical analytical skills further;
- Being able to integrate theoretical and practical knowledge in deliverables.
- I want to enhance my skills in writing a solid master graduation thesis.

After a bachelor at Wageningen University and studying in Norway I thought I knew the academic environment. Until I came in the TU Delft, where competition among studies and students, a we-they mentality and pulling all-nighters on Photoshop and InDesign for a simple poster is the starter pack. Luckily, by the time I started my master's I had developed a backbone strong enough to not join this unhealthy, competitive culture, especially present at the Architecture faculty. I discovered that Management in the Built Environment students maintained a better work-life balance compared to Architecture. But still, it made me think about my master thesis quite early before it was even time to think about it.

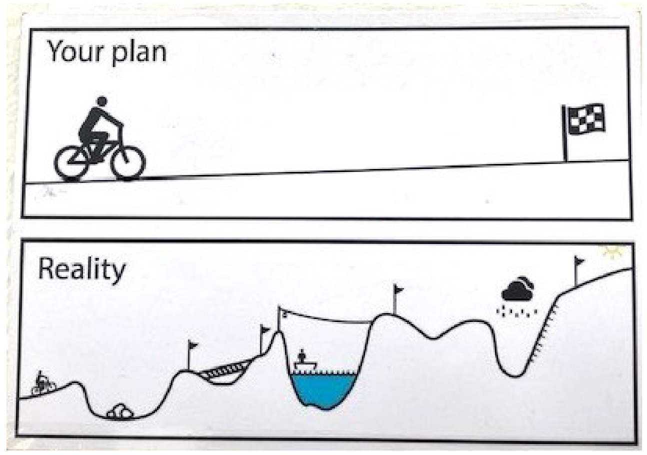
Starting with the first day of the MBE master thesis, I remember very well that I entered the lecture hall, seeing my second-year peers and Monique Arkestein being there. After choosing the adaptive reuse graduation lab, I started on my topic which back then was closing loops through demountability. What I found hard during the first couple months of this thesis was the lack of direction. Deciding as a young master student what the big academic world is neglecting and forgetting... Coping with these uncertainties and blanks is a learning goal that I established for myself which I really did not know if I did right. When I finally found my topic of remountability in the university context, still my research questions did not nail it down clear enough until 1,5 weeks before P2. After already a heavy year, December 2024 was also privately a heavy month for me. With that on the side, I think I have dealt quite well with uncertainties and blanks by not delaying any thesis and simultaneously finding the extensive time to process all that had happened. And I am very proud of myself for that.

Still, I had multiple days when I really struggled with this "research is never finished"-feeling. The second learning goal coping with several sequential changes did not go well. A large reason for that is due to myself for asking feedback from six of seven different persons. After a while I realized that, despite the well-meant suggestions, only receiving feedback from direct supervisors brought more clarity. So, dealing with the learning goal Dealing with feedback from multiple experts and professionals improved over time.

Eventually I setup a P2 of which my academic supervisors said, "It was never a question whether you were passing, only when your P4 and P5 are going to be". Being so caught up in my private life and feeling of never-good-enough research questions I did not expect that. It was after this realisation I think that I started losing up and finding joy in doing my thesis.

When the empirical study started, my supervisors advised me to not follow definite, pinpointed methods. Thinking back, that is quite sure what I would have done, since I like having a goal and a clear idea on how to get there. This anti-advice was therefore crucial for working on the goal of remaining flexible in approach and methods.
I had fun in doing the interviews. Getting out of the work environment, away from the screen and more important: seeing the building sector. Talking with project developers, contractors, executors and academics fascinated me. Their stories and links to other events and buildings made me want to see more. Doing this 'fieldwork' reassured me that MBE, or (re)development in the built environment is what I want to be occupied with in the coming years. This is maybe one of the most important lessons I draw away from doing this master thesis.

The period until P3 stands in contrast to the winter period. I had a minimal amount of meetings with Ad and Alexandra, and also at cepezedprojects I could proceed easily. Doing the interviews and gaining information went surprisingly smooth. During this time, remaining flexible in approach and methods and coping with uncertainties and blanks took a positive turn. That is, I think, why my analysis had a fast pace. Later, another graduate intern at cepezed gave me this roadmap card which really felt like my thesis journey where in the end there is sun.



Moving towards the deliverables, uncertainties became apparent again. I was not content with proceeding on my initial deliverable ideas. It felt like something was missing or unfinished and my thesis needed to be a spark of something else. This is when the conversation about the equally, if not more important, potential analysis rose. In the coffee corner at cepezed, there was, on a random Tuesday in April, a complaining architect talking about how very negative, capitalized and risk-oriented the building sector is and how refreshing it would be if someone would thank him for a good design that does its job. Then he got his coffee and went on. This casual moment was the spark that I needed for my research.

I find it remarkable that the social relevance for so much academic research is simply to be found by talking to the people doing the jobs. At that time, there was only one month left so I was forced to make choices. Especially since my supervisor said that a proper PA could be another master thesis on its own. But we all agreed that a PA would be a significant addition to my thesis with promising insights, letting us to decide at P3 to go on with a preliminary version of a PA. This prioritization helped with the learning goals develop my critical analytical skills further and being able to integrate theoretical and practical knowledge in deliverables. Discussing and developing the PA was interesting and taught me to widen my perspective, despite 8 months of specifying. Due to the sudden relevance of the PA, I decided to focus my expert panel on this instead of the process model. In the end, as you can see, I delivered both the PA and the process model. The reason for this was the boost I got from the PA and the enthusiastic expert panel, from which I decided "you know what, I do both".

Of course, working towards P4 came with stress, doubts and uncertainties. During the peak of my P4-stess a good friend of mine made me this drawing called 'future-Lynn in summer, calmy chilling on a boat in Greece' which is indeed one of my holiday plans. Different boat of course, but still, these talks with family or friends helped relieving the pressure.

Regarding the last learning goal I established in January 'I want to enhance my skills in writing a solid master graduation thesis'. At the time of writing, I am one week away from the P4 presentation, so whether or not the examination committee finds my skills and writing sufficient, is still open. As mentioned earlier, despite the challenges I faced this year, I believe I have succeeded in producing a solid master's thesis. While it may not be perfect, it demonstrates my ability to conduct research and write at an academic level, which is ultimately the purpose of a master's thesis. More importantly, this process confirmed that I have chosen the right sector to build my career in, which in itself is a highly valuable insight.

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APPENDICES

Appendix A	Interview questions SQ1 + 3
Appendix B	Consent form interviews
Appendix C	Consent form expert panel
Appendix D	Literature table
Appendix E	Process models
Appendix F	Potential analysis definite
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12 APPENDICES

APPENDIX A - INTERVIEW QUESTIONS SUB-QUESTIONS 1 + 3

Nederlands

Vragen interview SQ1 – aanbodzijde

Naam geïnterviewde:

Beroep:

Datum:

Interviewer: Lynn Kamphuis

Duur: 30 minuten

Definitie

1. Bent u bekend met het Engelse begrip remountability, of in het Nederland remonteerbaarheid?

2. Ja: Wat is uw mening over de definitie van remountability zoals ik die nu in mijn scriptie heb vastgesteld?

   *Definitie: [Het **ontwerpen** van een gebouw volgens de principes van Design for Disassembly, waarbij ruimte is voor meerdere **hergebruikmogelijkheden** waarbij **demontage** en **hermontage** in andere contexten mogelijk zijn.]*

3. Uit deze definitie kun je vier key points afleiden: meermaals hergebruik, een design dat op voorhand al rekening houdt met circulariteit, demontage en remontage.
   Welke praktische strategieën/stappen passen jullie toe voor …:

Meermaals hergebruik:
Ontwerpen voor hergebruik:
Demontage:
Remontage:

4. Wat zijn volgens u, belemmerende factoren voor het integreren van circulariteit in bouwprojecten?

5. Dit zijn zes belemmerende factoren uit de literatuur. Ervaart u dit ook? Waarin zit het precies?

Belemmerende factoren

IF1	Afwezigheid van expertise
IF2	Technische moeilijkheden met bouwproducten/materialen
IF3	Economische belemmeringen
IF4	De gewoonte om voor het traditionele pad te kiezen
IF5	Afwezigheid van data en garantie van tweedehands materialen Lack of data and warranty on old material
IF6	Wettelijke belemmeringen

Traditioneel vs. circulair bouwproces

6. Welke strategieën (van Q3) komen waar in de tijdlijn van het proces?

7. Waar verschilt volgens u een bouwproces waarbij remonteerbaarheid een rol speelt van een traditioneel bouwproces?

8. Wat merkt u aan de vraagzijde in de initiatieven om projecten remountable te ontwikkelen?
   a. Is er veel vraag naar circulaire, remountable projecten?
   b. Merkt u een verandering in de markt?

Remountability in de praktijk

9. In hoeverre merk u dat stimulatie vanaf de aanbodzijde nodig is voor van de ontwikkeling van een remontabel-project?

10. Hoe wordt de aanbestedings- en contracteringsfase beïnvloedt door remontage activiteiten in vergelijking met traditionele bouw?
    a. Zijn er specifieke contractmodellen die remountability aanmoedigen?

11. Is er een verschil tussen nieuwbouwprojecten en bestaande gebouwen [lees: ontwikkeling en herontwikkeling] bij het opzetten van een remountability-project? Zo ja, hoe ervaart u dit?

12. Hoe beïnvloeden projectfinanciering en -kosten de beslissing om remountability te integreren in het bouwproces?
    a. Zijn er financiële stimulansen of subsidiemogelijkheden die remountability ondersteunen?

13. Welke rol speelt digitale technologie (bijv. BIM, materialenpaspoorten) in het haalbaar maken van de strategieën binnen remountability?
    a. In hoeverre zijn de huidige digitale tools voldoende om gedemonteerde componenten te volgen en te beheren?

14. Welke regelgeving en bouwvoorschriften stimuleert of hindert circulaire bouwprojecten?

Stakeholders

15. Welke extra stakeholders komen volgens u kijken bij een remontabel project?

16. Wat zijn de grootste knowledge gaps in de markt met betrekking tot remountable bouwen?
    a. Hoe overbruggen stakeholders deze gaps momenteel?

17. Wat zijn de meest voorkomende misvattingen over remontabel bouwen die u in de praktijk tegenkomt? En hoe gaat u hiermee om?

Heeft u nog vragen voor mij?

Einde

Interviewvragen SQ3 – circulariteit bij campus bouwprojecten

Naam geïnterviewde:

Universiteit:

Datum:

Interviewer: Lynn Kamphuis

Duur: 30 minuten

Strategische en beleidsmatige overwegingen

1. In alle langetermijnvisies van universiteiten in Nederland staat duurzaamheid hoog in het vaandel. Maar hoe erg beïnvloeden deze universiteitsstrategieën de keuze voor circulaire bouwprojecten?

2. In hoeverre spelen nationale of Europese duurzaamheidsdoelstellingen een rol bij de besluitvorming over innovatieve bouwmethoden?

3. Wat motiveert, volgens u, universiteiten om te investeren in circulair bouwen?

4. Wat demotiveert, volgens u, universiteiten om te investeren in circulaire gebouwen?

5. Waarin verschilt deze motivatie van universiteiten nou van commerciële partijen of gemeentes?

Financiële en economische factoren

6. Welke financiële barrières of stimulansen beïnvloeden de implementatie van circulaire bouwprojecten op universiteitscampussen?

7. Hoe wegen universiteiten de kosten en baten van circulaire bouwprojecten af?

Technische en Infrastructuureisen

8. Hoe beïnvloed bestaande campusinfrastructuur en gebouwen de implementatie van circulaire bouwtechnieken?

Regelgeving

9. In hoeverre stimuleert of hindert regelgeving en bouwvoorschriften circulaire bouwprojecten op universiteitscampussen?

Organisatorische en Culturele Factoren

10. Hoe wordt circulariteit in bouwprocessen beïnvloed binnen de universitaire gemeenschap (bestuur, docenten, studenten)?

11. Hoe beïnvloeden interne organisatie en besluitvormingsprocessen de adoptie van circulaire bouwmethoden?

Samenwerkingen

12. Welke invloed hebben externe stakeholders (zoals bouwbedrijven, architecten, gemeenten en de industrie) op de implementatie van circulaire bouwprojecten op campussen?

13. In hoeverre werken universiteiten onderling ook samen in kennisdeling over circulaire projecten? Successen en falen?

Evaluatie en succes

14. In hoeverre wordt een circulair gebouw geëvalueerd voor toekomstige projecten op de campus?

Naar aanleiding van dit gesprek, zijn er personen die ik zeker nog moet spreken voor mijn onderzoek?

Heeft u nog vragen voor mij?

Einde

APPENDIX B - CONSENT FORMS INTERVIEWS

Delft University of Technology
HUMAN RESEARCH ETHICS
INFORMED CONSENT DOCUEMENT

Opening Statement

You are being invited to participate in a research study titled *Remountability on Campus*. This study is being done by L. Kamphuis from the TU Delft in collaboration with cepezedprojects.

The purpose of this research study is to promote a long-term shift from linear to circular construction practices for building developments on Dutch university campuses that align with their leading role as knowledge institutes where innovations are born. Participating will take you approximately 45 minutes to complete. The data will be used for establishing a process model on how to integrate remountability in a construction process, identify remountability strategies and getting insights into remountable campus building projects. We will be asking you to answer questions regarding characteristics of reuse, disassembly, reassembly and design practices.

Participating in this study involves giving information on the topic of remountability and/or circularity on Dutch university campuses and/or selected cases of L. Kamphuis, professional experiences, decisions, decision-making and opinions. This information will be pseudo-anonymized in the final report by the use of codes.
As with any participating activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by using pseudonymizing codes and storing your personal data (name, role, company) in a secured online storage of the TU Delft. The personal data is deleted as soon as the research is completed.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. The personal data will be deleted by the latest of 17-06-2025.

The responsible researcher of this study is Dr.ir. A. (Ad) Straub

Please fill in the consent point on the next pages.
Thank you for your participation.

Explicit Consent points

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [*DD/MM/YYYY*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: [*see points below*]	☐	☐
• *Informing about my profession.* • *When taking part in an interview for SQ4 (being informed about in e-mail): informing about the selected case.* • *The interview is being recorded on an external recording device.* • *The interview is being transcribed as text through the use of the computer program Atlas.TI.* • *The recording is destroyed at the latest of 17-06-2025.*		
4. I understand that I will not be compensated for my participation financially.	☐	☐
5. I understand that the complete research will end on 18-06-2025.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study involves the following risk: getting covid. This risk is mitigated by keeping 1,5m distance when meeting physically.	☐	☐
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) in the form of name and email and associated personally identifiable research data (PIRD) in the form of my profession, decisions, decision-making processes, and professional experiences are collected, with the potential risk of my identity being revealed.	☐	☐
8. I understand that some of this PIRD is considered as sensitive data within GDPR legislation, specifically the profession, decisions, decision-making processes, and professional experiences that are collected are sensitive data.	☐	☐
9. I understand that the following steps will be taken to minimise the threat of a data breach and protect my identity in the event of such a breach: *all data used in the final study is pseudonymized by using codes (pseudo-anonymisation), date is securely stored and only the L. Kamphuis and the responsible researcher have access.*	☐	☐
10. I understand that personal information collected about me that can identify me, such as name, email and company will not be shared beyond the study team.	☐	☐
11. I understand that the (identifiable) personal data I provide will be destroyed at latest on 17-06-2025.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
12. I understand that after the research study the de-identified information I provide will be used for the final thesis report.	☐	☐
13. I agree that my responses, experiences, opinions or other input can be quoted pseudo-anonymously in research outputs	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
14. I give permission for the de-identified data in the form of opinions, experiences or information that comes out of the interview that I provide and is used in the final thesis, is to be archived in the TU Delft repository so it can be used for future research and learning.	☐	☐
15. I understand that access to this repository is open to all internet-users.	☐	☐

Signatures

______________________ ______________________ ________

Name of participant [printed] Signature Date

[Add legal representative, and/or amend text for assent where participants cannot give consent as applicable]

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Lynn Kamphuis____________ [redacted] ________

Researcher name [printed] Signature Date

Study contact details for further information: L. Kamphuis

APPENDIX C - CONSENT FORM EXPERT PANEL

Delft University of Technology
HUMAN RESEARCH ETHICS
INFORMED CONSENT DOCUMENT

Opening Statement

You are being invited to participate in a research study titled *Remountability on Campus*. This study is being done by L. Kamphuis from the TU Delft with guidance of company cepezedprojects.

The purpose of this research study is to promote a long-term shift from linear to circular construction practices for building developments on Dutch university campuses that align with their leading role as knowledge institutes where innovations are born. Participating will take you approximately 1,5 hours in total. The data will be used for establishing a process model on how to integrate remountability in a construction process. We will be asking you to review the preliminary process model, established by L. Kamphuis, for integrating remountability in campus construction projects.

Participating in this study involves giving information on the topic of remountability and/or circularity on Dutch university campuses and/or selected cases of L. Kamphuis, professional experiences, decisions, decision-making and opinions. This information will be pseudo-anonymized in the final report by the use of codes.
As with any participating activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by using pseudonymizing codes and storing your personal data (name, role, company) in a secured online storage of the TU Delft. The personal data is deleted as soon as the research is completed.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. The personal data will be deleted by the latest of 17-06-2025.

The responsible researcher of this study is Dr.ir. A. (Ad) Straub

Please fill in the consent point on the next pages.
Thank you for your participation.

Explicit Consent points

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [*DD/MM/YYYY*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: [*see points below*]	☐	☐
• *Informing about my profession.* • *Giving my professional opinion on the process model.* • *The discussion in the panel is generally transcribed [meaning key words are noted]* • *The personal data is destroyed at the latest of 17-06-2025.*		
4. I understand that I will not be compensated for my participation financially.	☐	☐
5. I understand that the complete research will end on 18-06-2025.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study involves the following risk: getting covid. This risk is mitigated by keeping 1,5m distance when meeting physically.	☐	☐
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) in the form of name and email and associated personally identifiable research data (PIRD) in the form of my profession, decisions, decision-making processes, and professional experiences are collected, with the potential risk of my identity being revealed.	☐	☐
8. I understand that some of this PIRD is considered as sensitive data within GDPR legislation, specifically the profession, decisions, decision-making processes, and professional experiences that are collected are sensitive data.	☐	☐
9. I understand that the following steps will be taken to minimise the threat of a data breach and protect my identity in the event of such a breach: *all data used in the final study is pseudonymized by using codes (pseudo-anonymisation), date is securely stored and only the L. Kamphuis and the responsible researcher have access.*	☐	☐
10. I understand that personal information collected about me that can identify me, such as name, email and company will not be shared beyond the study team.	☐	☐
11. I understand that the (identifiable) personal data I provide will be destroyed at latest on 17-06-2025.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
12. I understand that after the research study the de-identified information, I provide will be used for the final thesis report.	☐	☐
13. I agree that my responses, experiences, opinions or other input can be quoted pseudo-anonymously in research outputs	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
14. I give permission for the de-identified data in the form of opinions, experiences or information that comes out of the interview that I provide and is used in the final thesis, is to be archived in the TU Delft repository so it can be used for future research and learning.	☐	☐
15. I understand that access to this repository is open to all internet-users.	☐	☐

Signatures

__________________________ _________________________ ________
Name of participant [printed] Signature Date

[Add legal representative, and/or amend text for assent where participants cannot give consent as applicable]

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Lynn Kamphuis___________ [redacted]_________ ________
Researcher name [printed] Signature Date

Study contact details for further information: L. Kamphuis

APPENDIX D - LITERATURE TABLE FOR SUB-QUESTION 2

Type	Tag	Factor	Source															
			Hamida et al. (2023	Du Preez et al. (2022)	Holzmann (2014)	Phillips & Bana e Costa (2007)	(Mankins, 2009)	Conceiçao et al. (2024)	Pichlmeier & Lindner (2024)	Yang et al. (2025)	Ness & Xing (2017)	Acharya et al. (2018)	Cai & Waldman n (2019)	Iyer-Raniga (2019)	Giorgi et al. (2019)	Eguchi et al. (2011)	Kanters (2020)	Frequency
Enabling	EF1	Building and component characteristics	x	x					x	x								4
	EF2	Collaboration and ownership	x							x	x	x	x	x	x		x	8
	EF3	Presence of a motivated and capable team/organisational commitment	x	x	x				x								x	5
	EF4	Economic viability	x							x								2
	EF5	Legislative support										x		x	x	x		4
	EF6	Digital technologies on material tracking								x	x		x	x	x	x		6
	EF7	Design based on available secondhand components						x										1
	EF8	Overlap the principles						x										1
	EF9	Early information setting and sharing		x				x	x								x	4
	EF10	Approach uncertainties with a flexible attitude		x				x									x	3
	EF11	Clear role for campus managers		x														1
	EF12	Innovative campus visions		x														1
	EF13	A bridge between theoretical research and practical know-how		x	x													2
	EF14	Availability of tools to manage perceived risks		x														1
	EF15	The availability of a suitable location and time on campus		x			x											2
	EF16	Raising awareness		x	x				x									3
Inhibiting	IF1	Lack of expertise	x									x		x	x	x		5
	IF2	Technical complexities with building products/materials	x											x	x			3
	IF3	Economic infeasibility of innovative strategies	x							x			x		x	x	x	6
	IF4	Tendency to follow traditional paradigms	x										x	x	x		x	5
	IF5	Lack of data and warranty on old material	x										x		x			3
	IF6	Legal and legislative restrictions	x										x		x	x	x	5
	IF7	Conflicting goals with other projects on campus		x		x												2
	IF8	Lacking a detailed project plan		x		x			x									3
	IF9	Conflicts between experts on campus		x		x												2
	IF10	The project having an informal character		x		x												2

APPENDIX E - PROCESS MODELS

Remountability projects are unique and different for every every real estate type. These process models form a guide on what Dutch universities - generally - have to consider during a remountable construction process. Two processes are depicted. The first one considers remountable construction starting from scratch. Meaning that the university wants to build for reuse but starts with new prefabricated elements. The second cycle considers remountable construction for a Dutch university campus from existing components. This can involve a building already meant for reuse and/or with individual second-hand components. Ideally, we find ourselves in the second cycle mostly: working with what is already these, rather than stating a promise to the future. Yet, institutions with a circular mindset happen to start with the first cycle quite often since most existing building components are not fit for safe reuse.

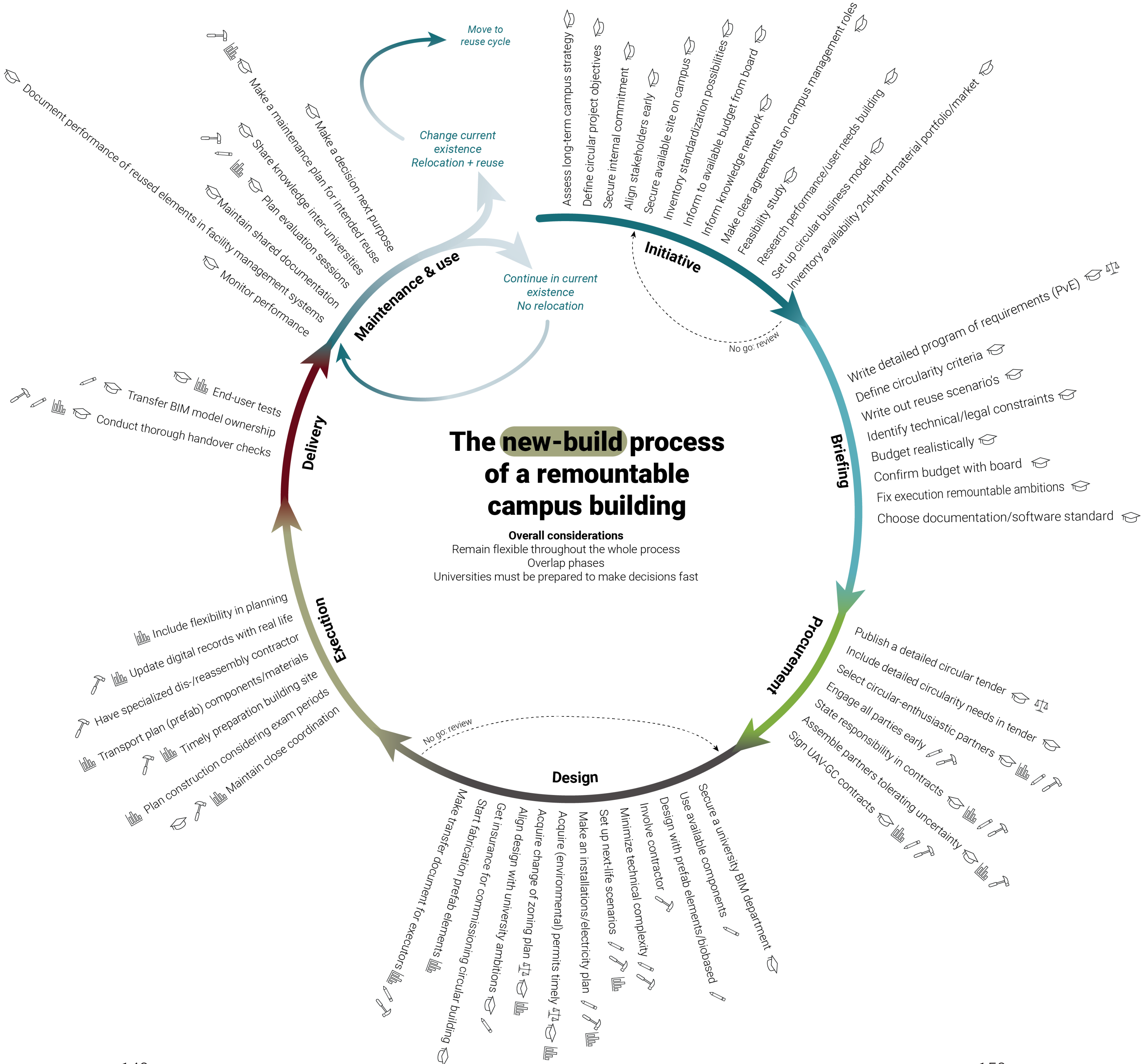
The models consist of different elements like phases, actions, stakeholders and flow. During the whole process there are certain overall considerations that are relevant during the entire process. All actions and overall considerations are derived from the three case studies, various interviews and literature reviews. The actions are bound to a phase in the process where they are deemed relevant. They are not prioritized since there is not one ultimate construction process. For you this means that the actions are fluid and in need of attention when the project goes along. Use the actions therefore efficient to get an effective outcome.

The objective of these models is to give universities, and especially their Campus Real Estate and Facility Management department, insight into a remountable process, but also for the stakeholders that they work with and are relevant to the project. With these models, you can promote a discussion to create a tailored process and get to a efficient remountable campus building.

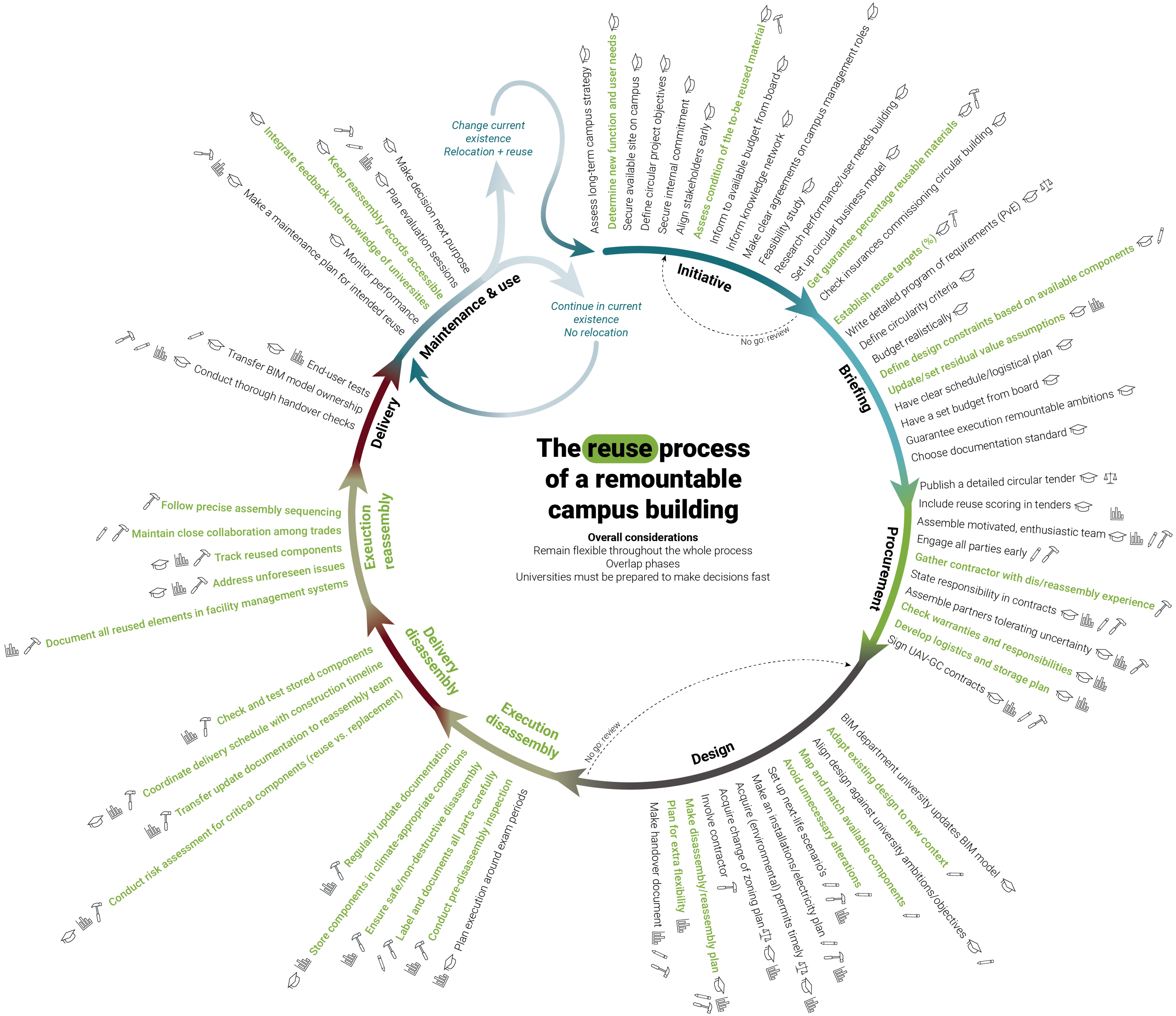
Start with the models during your initiating phase, talk it through, know what is coming and what to anticipate to. Discuss the model and its actions and make plans accordingly. Both models are to be read clockwise starting at the top.

Following is the legend of the models.

- Process phase
- Actions to do during the phase
- Go/No-go moment
- University CREFM department
- Government
- Project developer
- Architect
- Contractor



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
No go: review
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
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
Make a decision next purpose
Make a maintenance plan for intended reuse
Share knowledge inter-universities
Plan evaluation sessions
Maintain shared documentation
Maintain facility management systems
Monitor performance
Document performance of reused elements in facility management systems
Continue in current existence
No relocation
Change current existence
Relocation + reuse
Move to reuse cycle


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
Briefing
Procurement
Design
Execution disassembly
Delivery disassembly
Execution reassembly
Delivery
Maintenance & use
No go: review
No go: review
Change current existence
Relocation + reuse
Continue in current existence
No relocation
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
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
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
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
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
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
Document all reused elements in facility management systems
Address unforeseen issues
Track reused components
Maintain close collaboration among trades
Follow precise assembly sequencing
Conduct thorough handover checks
Transfer BIM model ownership
End-user tests
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

APPENDIX F - POTENTIAL ANALYSIS DEFINITE

Category	#	Potentials	Description	Time horizon	Scale
				Short (0-2y) middle (2-5 y) Long (5+ y)	*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

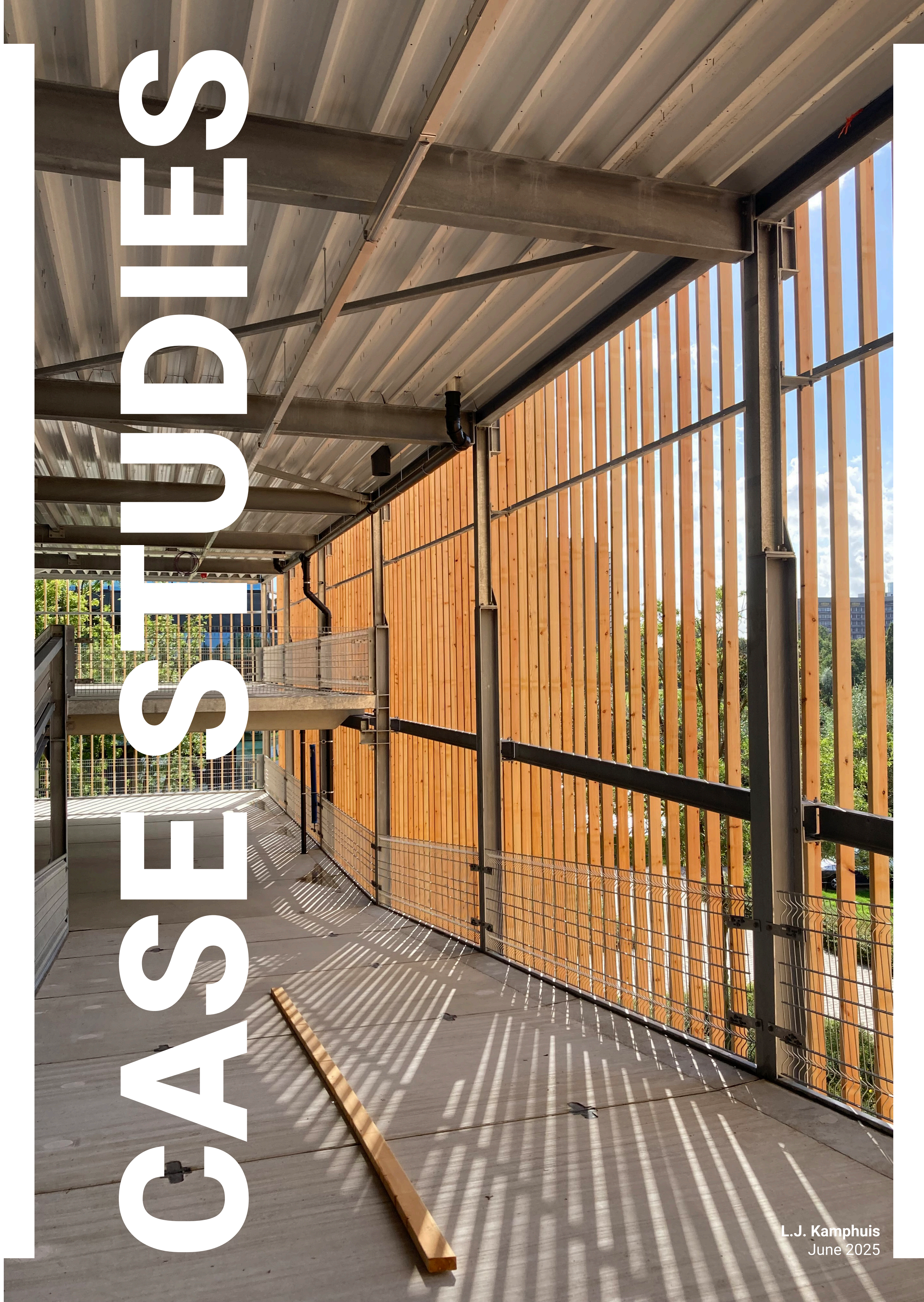
APPENDIX G - POTENTIAL ANALYSIS ORIGINAL

Category	#	Potentials	Description	References	Time horizon	Scale
					Short (0-2y) middle (2-5 y) Long (5+ y)	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.	*Interview 3.1, 3.2, 4.A1*	Short	Material / component / building / campus
	2	**Degree of disassembly**	Show how the materials and components are individually demountable for future adaptations.	*(Hamida et al., 2022; Het Nieuwe Normaal, 2024)*	Middle	Component / building
	3	**Degree of reassembly**	Show how the materials and components can be reused at the end of their lifecycle.	*(Het Nieuwe Normaal, 2024)*	Middle - long	Component
	4	**Standardization of campus buildings**	Constructing for disassembly and reassembly comes with standardized components which stimulates reuse.	*(Interview 3.1, 3.2, Geldermans, 2016; Hamida et al., 2022; HouseEurope!, 2025)*	Long	Building / campus
Environmental impact and circularity	5	**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).	*(Het Nieuwe Normaal, 2024)*	Short	Building / campus
	6	**Nitrogen emission reductions (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.	*(Het Nieuwe Normaal, 2024)*	Middle	Materials / component / building
	7	**Reduced dependency on global supply chain**	Reusing local building elements and using bio-based/recycled materials reduce dependence on imported materials.	*(Colloricchio et al., 2020; Ellen MacArthur Foundation, 2023; HouseEurope!, 2025)*	Middle	Network
	8	**Value retention**	Reusing building components and materials contributes to preserving existing material and immaterial value towards the future.	*(Interview 3.1, Eguchi et al., 2011; Ellen MacArthur Foundation, 2023; Het Nieuwe Normaal, 2024)*	Short	Component / building / campus
Value creation and economic potential	9	**Value creation**	When a building is able to adapt throughout its lifespan, it maximizes its value. Reusing building components and materials is also a strategy to add value to portfolio assets without generating waste.	*(Eguchi et al., 2011) (Hamida et al., 2022)*	Long	Building / campus
	10	**Branding and image enhancement**	Circular building can contribute positively to the image of an institution.	*(Interview 1.1, Kinnunen et al., 2022; RVO, 2025)*	Middle	Campus / network
	11	**Affordable living spaces**	Reusing existing buildings offers significant potential to create attractive and affordable living spaces and thus addresses current student housing challenges.	*(HouseEurope! 2025)*	Middle – long	Network
	12	**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	*Interview expert panel*	Short	Materials / component / building
	13	**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.	*(Interview, 1.1, 3.1, 3.2, 4.A1, 4.A2, 4.A3, Hamida et al., 2022; Het Nieuwe Normaal, 2024; HouseEurope!, 2025)*	Long	Building / campus
Innovative universities	14	**Knowledge sharing among universities**	Having a circular building allows for more knowledge sharing on circular construction amongst universities.	*Interview 3.1, 4.A1, 4.A3*	Middle	Campus / network
	15	**Material sharing among universities**	Having demounted building components allows for material sharing amongst universities or beyond.	*Interview 3.1, 3.2, 4.A1, 4.A3*	Middle	Materials / component / network
	16	**Engagement of faculties**	Adopting more disassembly and reassembly construction practices stimulates looking at available materials first, when designing a new building or renovation.	*Interview 3.1, 4.A3*	Short – middle	Campus / network

APPENDIX H - POTENTIAL ANALYSIS VALIDATION

Category	#	Potentials	Description	References	Time horizon	Scale	Validation: impact score						Expert panel: remarks
					Short (0-2y) middle (2-5 y) Long (5+ y)	Material, component, building, campus (= neighbourhoods), network (= region) (CBE, 2017)	R = How important is # for the realisation of circular construction on campus for Dutch universities? M = How important is # for a promoting a cultural/mindset shift for decision-makers at Dutch universities? (Likert scale: 1 = less important, 5 = more important)						
Red text = revised/added after expert panel							Validator 1		Validator 2		Validator 3		
							R	CM	R	CM	R	CM	
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.	*Interview 3.1, 3.2, 4.A1*	Short	Material / component / building / campus	5	3	5	4	5	3	One of the most important drivers for reuse for universities right now (V3).
	1a	**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.**	*Expert panel*	Long	Network / material / component	x	x	X	X	x	x	
	2	**Degree of disassembly**	Show how the materials and components are individually demountable for future adaptations.	*(Hamida et al., 2022; Het Nieuwe Normaal, 2024)*	Middle	Component / building	4	2	5	5	3	3	
	3	**Degree of reassembly**	Show how the materials and components can be reused at the end of their lifecycle.	*(Het Nieuwe Normaal, 2024)*	Middle - long	Component	4	2	5	5	3	3	
	4	**Standardization of campus buildings**	Constructing for disassembly and reassembly comes with standardized components which stimulates reuse.	*(Interview 3.1, 3.2, Geldermans, 2016; Hamida et al., 2022; HouseEurope!, 2025)*	Long	Building / campus	5	5	4	1	2	3	Modular design is well known (V2, 3), but in practice it does not work out, since users personalize their buildings and handle buildings according to their own needs (V3).
Environmental impact and circularity	5	**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).	*(Het Nieuwe Normaal, 2024)*	Short	Building / campus	4	4	5	4	4	5	Environmental impact is not as much a goal as it is a means (V2, 3).
	6	**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.	*(Het Nieuwe Normaal, 2024)*	Middle	Materials / component / building	5	5	5	4	4	5	
	7	**Reduced dependency on global supply chain**	Reusing local building elements and using bio-based/recycled materials reduce dependence on imported materials.	*(Colloricchio et al., 2020; Ellen MacArthur Foundation, 2023; HouseEurope!, 2025)*	Middle	Network	2	4	5	5	4	3	
	8	**Value retention (monetary – 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.**	*(Interview 3.1, Eguchi et al., 2011; Ellen MacArthur Foundation, 2023; Het Nieuwe Normaal, 2024)*	Short	Component / building / campus	4	5	5	5	3	3	
Value creation and economic potential	9	**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.**	*(Eguchi et al., 2011) (Hamida et al., 2022)*	Long	Building / campus	3	4	5	5	4	3	
	10	**Branding and image enhancement**	Circular buildings or components can contribute positively to the image/reputation of an institution.	*(Interview 1.1, Kinnunen et al., 2022; RVO, 2025)*	Middle	Campus / network	1	5	3	3	1	5	Less special today, publicity happens along the way (V1)
	11	**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.	*(HouseEurope! 2025)*	Middle – long	Network	3	3	5	1	2	4	
	12	**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	*Interview expert panel*	Short	Materials / component / building	5	5	5	5	4	4	
	13	**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.	*(Interview, 1.1, 3.1, 3.2, 4.A1, 4.A2, 4.A3, Hamida et al., 2022; Het Nieuwe Normaal, 2024; HouseEurope!, 2025)*	Long	Building / campus	4	3	5	5	3	3	Boards, and other high-end decision-makers, do not think long-term (as much as they should, that is why for mindset shifts of CvB's in NL, this potential would make less impact (V1).
Innovative universities	14	**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.**	*Interview 3.1, 4.A1, 4.A3*	Middle	Campus / network	5	4	5	5	1	3	Importance of this potential depends on the time horizon: educating new generation is really important (V1).
	15	**Material sharing among universities**	Having demounted building components allows for material sharing amongst universities or beyond.	*Interview 3.1, 3.2, 4.A1, 4.A3*	Middle	Materials / component / network	1	4	3	5	4	4	
	16	**Engagement of faculties**	Adopting more disassembly and reassembly construction practices stimulates looking at available materials first, when designing a new building or renovation.	*Interview 3.1, 4.A3*	Short – middle	Campus / network	2	4	5	5	2	4	

APPENDIX CSB - CASE STUDY BOOKLET



Cover picture: P-Olympos (personal communication with UU)

Case 1	**P-Olympos**	Utrecht	Parking garage
Case 2	**Techbank**	Enschede	Office/education
Case 2*	**Temporary Court**	Amsterdam	Court
Case 3	**Flux**	Delft	Education

Case study booklet

Dear reader, presented here is an extra product of my master thesis at TU Delft called Build to Be Back. In this research I investigated how Dutch universities can integrate remountability in the construction of their campus real estate.
To get practical insights into remountable campus buildings, I chose three cases. Two of them are to be remounted and one is already disassembled and is now being reassembled.
This booklet with information on these cases is an assembly of information from literature studies, notes and interviews with the universities in question and stakeholders of the supply side during the construction process.

This booklet serves as a case overview with a special focus on materials and circular strategies. It furthermore serves the purpose of portfolio with enough pictures to give you a feeling of the buildings and their construction processes.

Let this booklet be a reminder that it **is** possible to embrace circular construction strategies for real estate with varying functions. One can always come up with a critical note, but I urge you to look at circular opportunities that also the people from these universities and from the construction sector saw. In addition, these examples show how different types of universities – with a wide range of real estate units – looked at circularity in their real estate and how this has been expressed. As one of the project developers said:

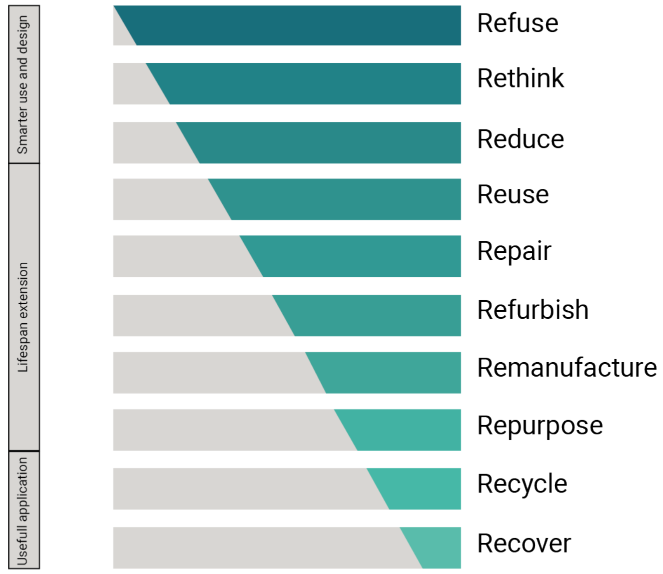
"We have proven that it is possible"

After reading this, I hope you too look differently at your own university or office building!

Kind regards,

Lynn Kamphuis

Circular card game (Galle, 2020)



R-ladder (own illustration)

Reading guide

Every case chapter contains the following elements:

- ***Background information***
- ***R-ladder:*** the two or three most outstanding R-strategies per case are highlighted. The choice of R-strategies is based on the interviews.
- ***Lets design out waste!-cards:*** the Vrije Universiteit Brussel has established a card game with circular design approaches, concepts and qualities. The cards are defined with the help of designers, researchers and organisations related to construction. The game's purpose is to get more insight in a building and what motivated the designers to make them (Galle, 2020). This game is also played for the cases of this research. The cards are chosen based on the gathered knowledge during this thesis.
- ***Six layers of Brand:*** per case, the materials and their expected lifespan is discussed. The materials are identified through the use of technical detail drawings and floorplans (which are not shared due to them being private documents). The expected lifespan is based on general information (Brand, 1994).

Important to note is that the buildings are documented in this booklet on basis of interviews, observations and public information. The information is as detailed as possible but there is a margin of error. Keep in mind that the projects can be altered since the moment of writing (June 2025).


Personal communication UU

P-Olympos

Building function:	Parking garage
Client:	University of Utrecht
Location:	Utrecht
Year:	2021

Relevance for this research
Applied remountability principle:
Design for disassembly

Continental Car Parks


Personal communication UU

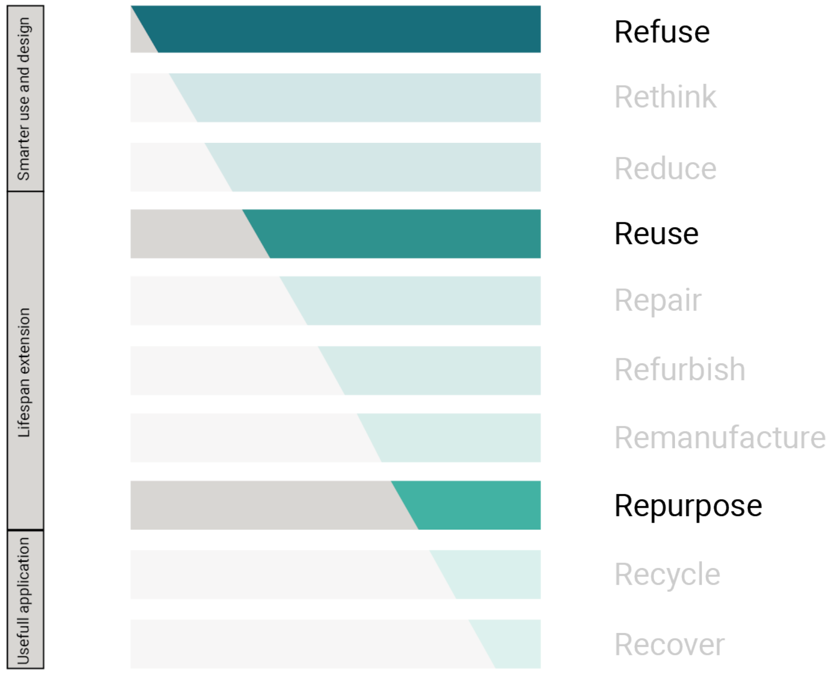
Information P-Olympos

Utrecht Science Park (USP) has 16 car parks of which P-Olympos is one. This above-ground parking garage of University of Utrecht (UU) has room for 320 vehicles, divided over four floors. Both regular and electrical parking spots form parallel rows alongside the walls of the building. The parking garage has a one-way traffic system for vehicles, designated walking paths for pedestrians and spacious, transparent stairwells. A broad lay-out is emphasized through the use of slim columns and by placing the ramps on the outer edge. The façade consists of gabions plinth and wooden slats requiring minimal maintenance. The gabions are filled with greenery which is part of a university course where students choose the plant and experiment with biodiversity.

The objective of the university was to build P-Olympos in a circular and modular way. Almost the entire building is demountable and remountable in its current form after 15 years (Utrecht University, n.d.). Regarding the RE strategy of UU, the ambitions are threefold: future-proof buildings, future-proof Utrecht Science Park and having a CO2-neutral energy supply (University of Utrecht, n.d.). P-Olympos being energy positive and remountable as one entity contributes to these ambitions. However, the remountability of P-Olympos is yet to be practically proved.

Being visible from the A28, P-Olympos is part of the sport complex Olympos of University of Utrecht. Olympos is mainly focussed on students and employees of the university but does not exclude external sportsmen and women. Sports enthusiasts can choose from 70 different sports, 65 group lessons or become member of one of the 31 sport associations (Olympos, n.d.). With this wide range causes the continuity of traffic flows beyond working days, only directed at sports. It is therefore not a random choice to place P-Olympos at the edge of USP. It is also a broader goal of the University of Utrecht to situate most of the parking needs around the borders of the USP to align with the ambition to make a car-free campus, stimulating cyclists and pedestrians (Utrecht University, n.d.).

R-ladder



R1 - Refuse
Refusal of permanence: opted for a temporary, demountable structure over permanent construction.

R4 - Reuse
Dom Tower parts were reused directly in the construction of the garage. Structural and façade components are designed for reuse after the temporary lifespan. The steel skeleton, concrete hollow floor slabs and wood slats can be remounted elsewhere.

R8 - Repurpose
Some façade materials, like the gabions also serve an educational function, repurposing an architectural element for biodiversity experiments.

Let's design out waste!

This building is designed with the intention of...

Approaches

To shift the built environment and construction sector towards a circular practice, designers and clients can take some basic approaches. Do you design for longevity, disassembly and reuse?

02 DESIGN FOR DISASSEMBLY AND DECONSTRUCTION

03 DESIGN FOR REUSE

Concepts

In past and present design practices, a variety of design concepts combine circular design qualities, tailored to a specific project context. Make yourself familiar with the most typical ones.

03 BUILDINGS AS MATERIAL BANKS

Qualities

Circular design qualities enable more effective reuse, recycling or renewal of buildings and building components. Walk through them and set your ambitions from the start of the project.

03 RENEWED
Use materials that are replenished continuously by responsible agriculture and forestry.

06 PURE
Prefer components that consist of a single material instead of a blend.

07 DURABLE
Use components that resist the wear and tear of use and reuse.

08 SIMPLE
Go for low-tech, legible solutions rather than complicated ones.

10 ACCESSIBLE
Integrate components so they can be reached and recovered without much effort or damage.

11 REVERSIBLE
Make it possible to undo connections without damage to the components they join.

12 INDEPENDENT
Assemble components so they are structurally, functionally and geometrically separated.

13 COMPATIBLE
Use building components that can be interchanged and (re)combined.

16 LOCATION AND SITE
Recognise and develop the qualities of a place responsibly.

Personal communication UU


Continental Car Parks

Site
50-100 years


Personal communication UU

Skin
20-50 years


own picture

Structure
50-100+ years


Personal communication UU

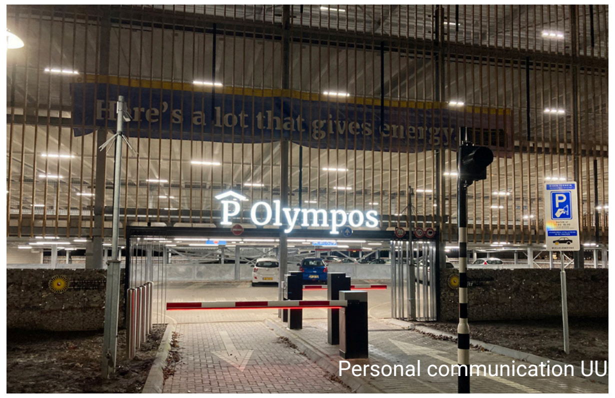
Services
7-15 years


Personal communication UU

Space plan
30-100 years


own picture

Stuff
8-10 years



Personal communication UU

Brand layers

Site: concrete pavers, soil and asphalt
The site used to be a parking lot as well, but on open ground level. On ground level, around the north and west side of P-Olympos is a small green strip of 1 meter (expected lifespan: eternal). Around this strip lies an asphalt cycling path for public use, leading to the bicycle parking spaces of sports complex Olympos (expected lifespan: 20-30 years). On the east and south side of the parking garage is a car road of concrete pavers with the entrance – of the same materials – to P-Olympos at the centre of the east side (lifespan: 50-100 years).

Skin: gabion plinth and wooden slats
The gabion plinth composes of steel fencing, filled with concrete waste chunks. The expected lifespan of a steel fence is 30 years.

From the top of the garage down to the first floor, the façade is clad with pinewood slats measuring 44 by 93 millimetres, spaced openly with no material in between. Pine wood, exposed to outside weather conditions has a life expectancy of 25 years. The wooden slats themselves are thermally preserved. They do not receive maintenance.

For visual effects, a few slats are placed in an aluminium construction of which further information is unknown for this research. Aluminium has a life expectancy of 20-50 years, depending on the environmental conditions and the finishing.
To resist different weather conditions, the material in the façade is required to have structural durability to be reusable on a new location.

Structure: steel
The garage's structure is made of steel. According to different sources, steel constructions are able to last 100 years with proper maintenance (Dev2021, 2022). Although newly fabricated steel is not considered a sustainable material, the reuse of the P-Olympos structure demonstrates durability, provided the university performs regular maintenance. However, given that P-Olympos is exposed to external weather conditions such as moisture, wind, and sub-zero temperatures, additional care is required throughout its 15-year use on this site.

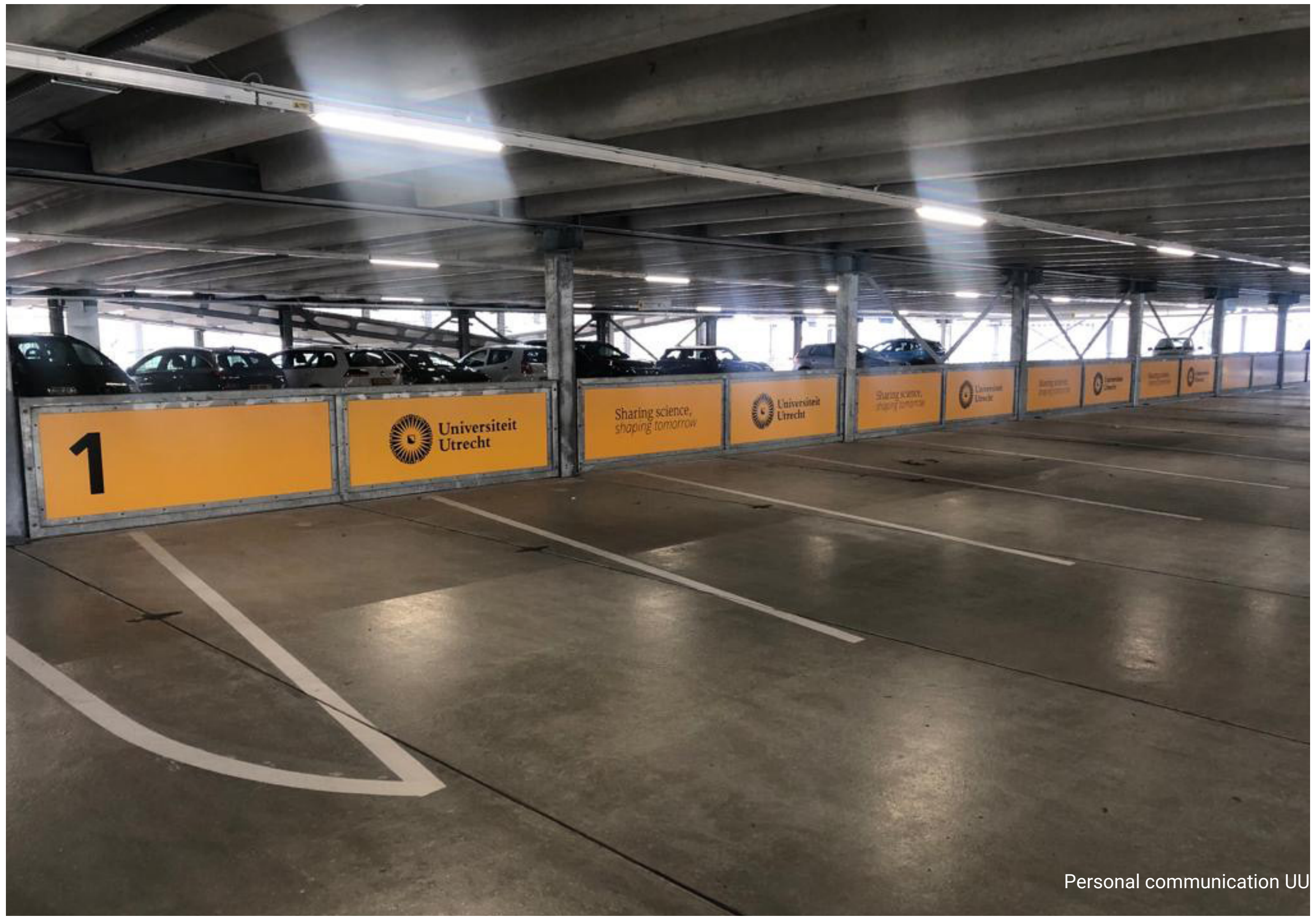
Services: LED lighting and elevator
As a parking garage with an open façade, the building requires relatively few installations. LED lighting has been incorporated, along with a single elevator powered by energy generated from the solar panels on the roof (expected lifespan: 7-15 years).

Space plan: prefabricated concrete TT floors and steel fences
In P-Olympos, concrete, prefab TT floor composes of the floors. The average lifespan of concrete can be 100 years with proper maintenance. However, since this concerns an open parking garage, road salt, freeze and moist will reduce the expected lifespan to 40 to 60 years (Haitsma Beton, n.d.).
The segregation of the one-way route are steel fences, like the gabion plinth (life expectancy: 30 years). These fences are easy to reassembly and change the space plan due to dry joints. However, in its current form and for current function, it is unlikely that the spatial lay-out needs severe alterations.

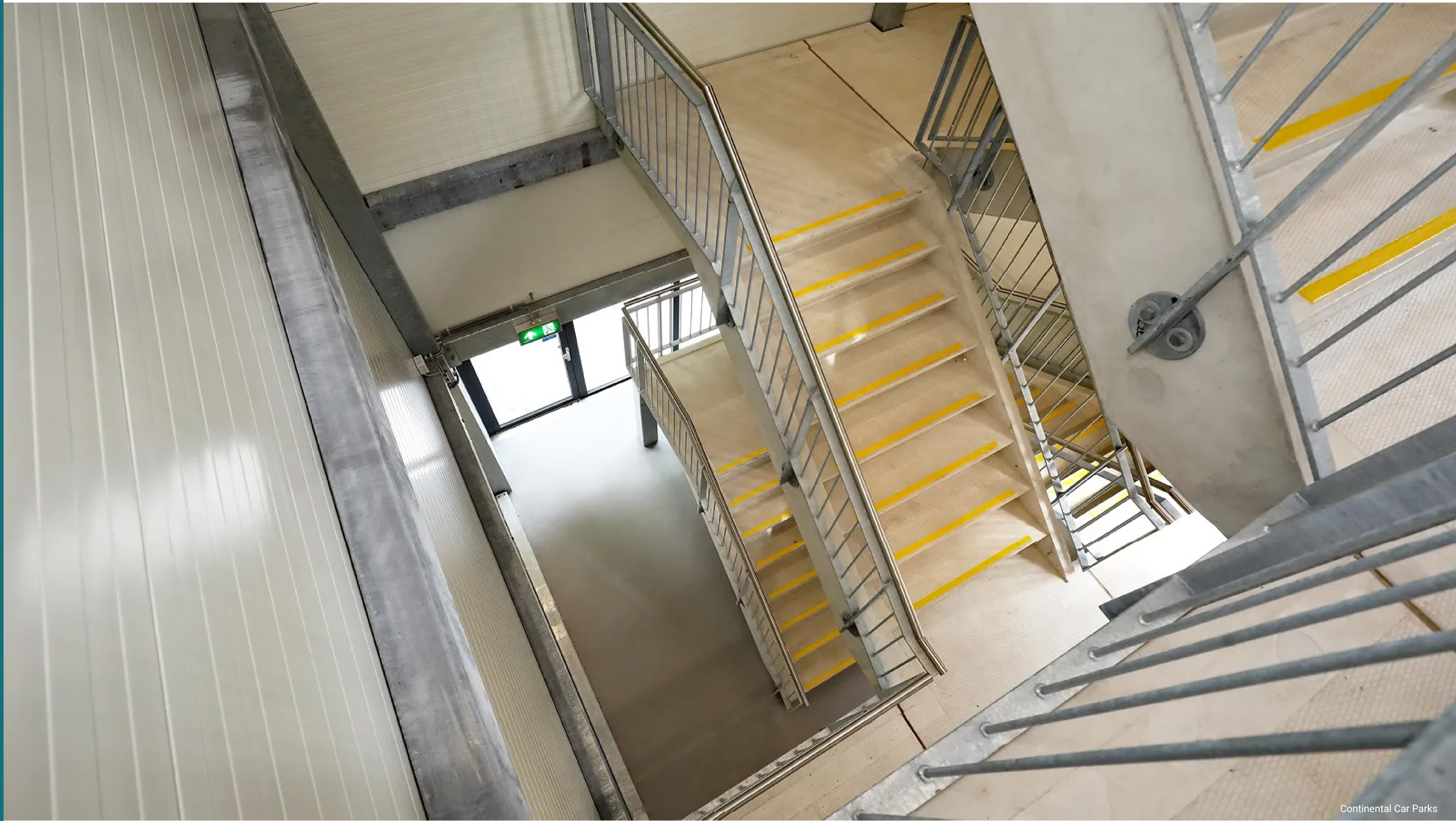
Stuff: parking machines and barriers
The only equipment installed within P-Olympos consists of parking meters and barrier systems located on the ground floor. These technological elements typically have an expected lifespan of 8 to 10 years, primarily due to wear and the rapid pace of technological advancements (Kredietaanvraag vervanging parkeerautomaten, 2023).

Personal communication UU

Personal communication UU



Personal communication UU



Continental Car Parks

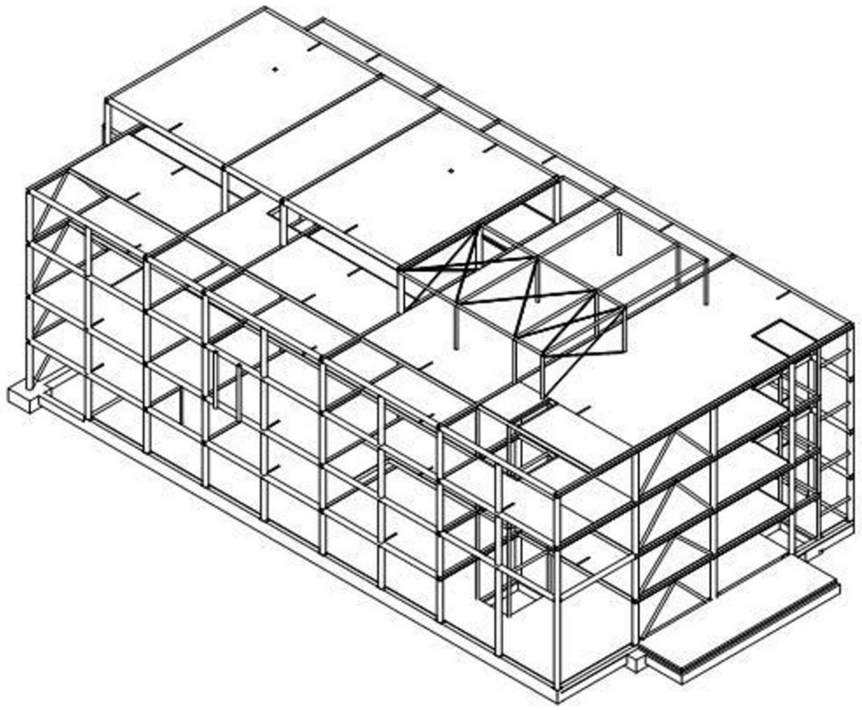

own picture

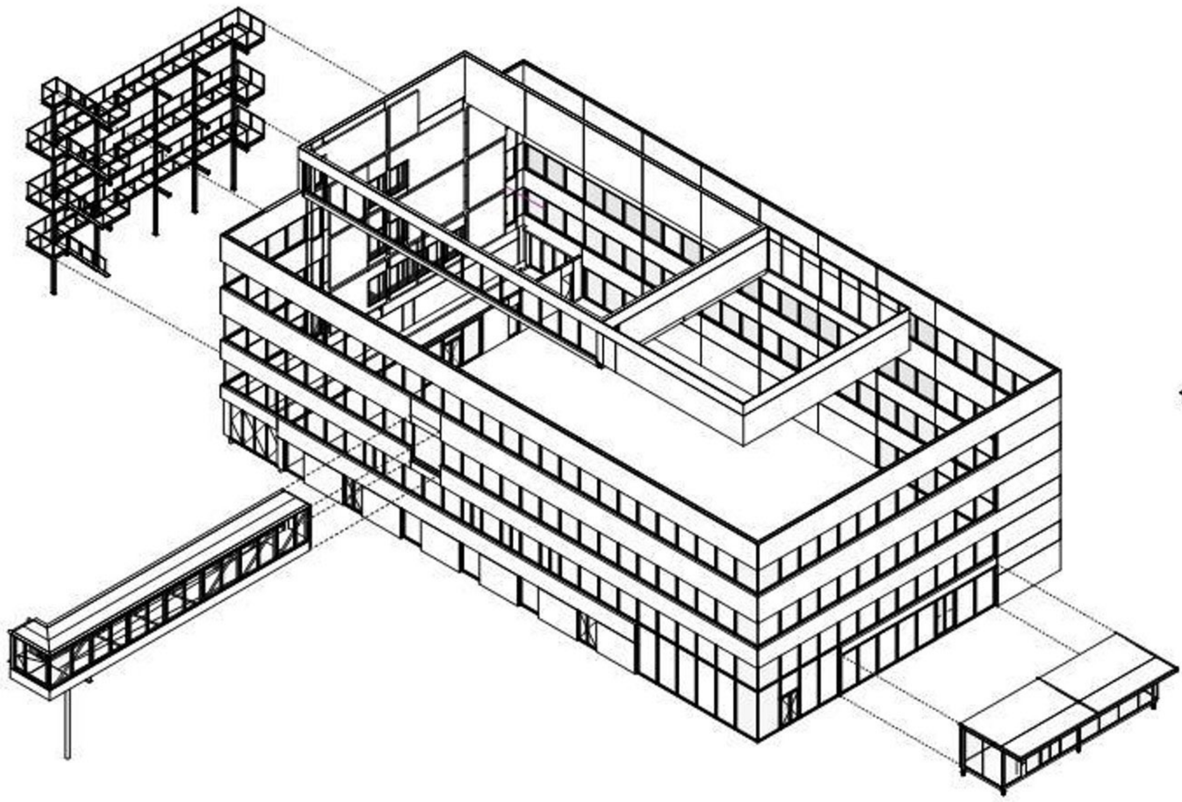
Techbank

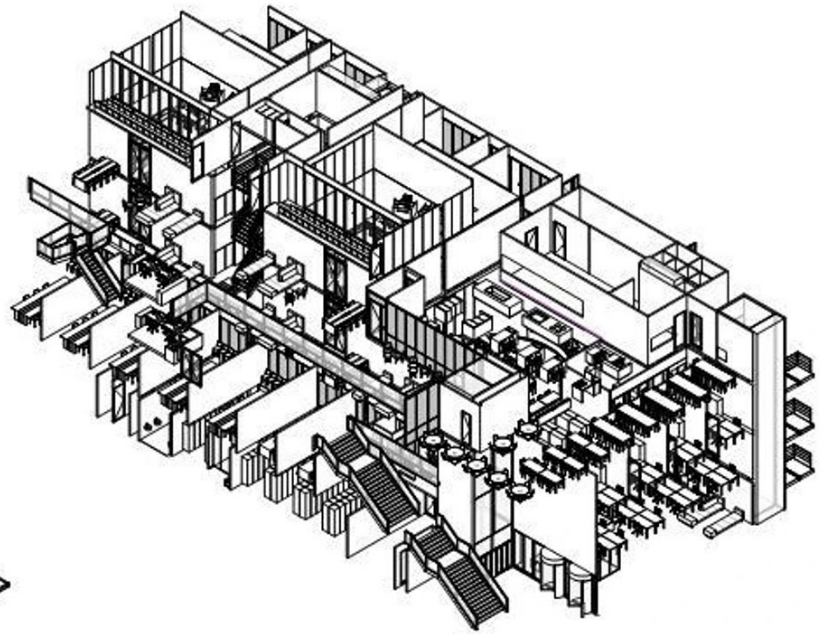
Building function:	Office and education
Client:	Kennispark
Location:	Enschede
Year:	2025

Relevance for this research
Applied remountability principles:
Design for disassembly, disassembly, reassembly

cepezed







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cepezed

own picture

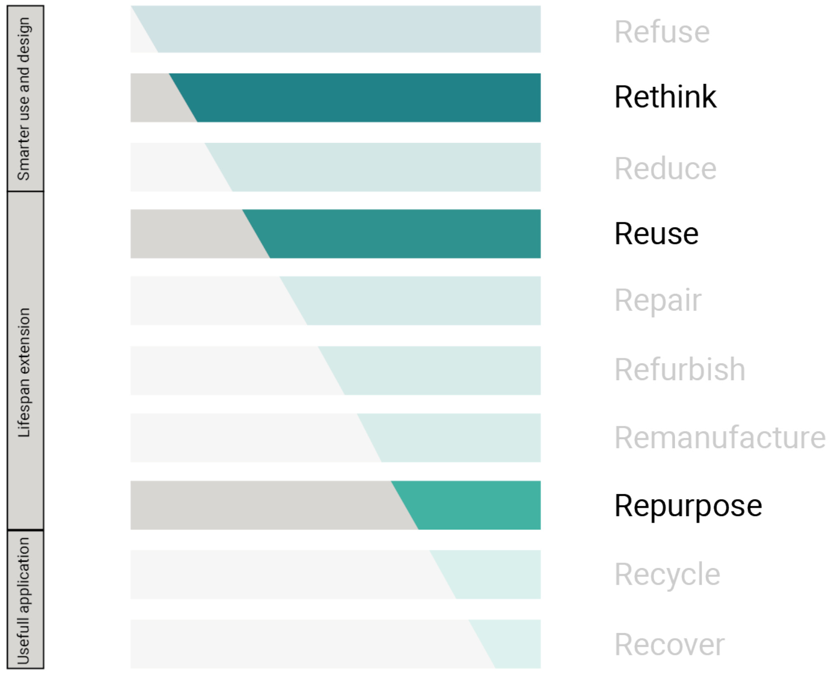
Information Techbank

The Techbank is a currently reassembled building on Kennispark in Enschede, originally constructed as the Temporary Courthouse of Amsterdam. This modular and remountable structure was designed to serve as a sustainable alternative during the renovation of the permanent court and has now found a second life as an office building focused on innovation and entrepreneurship. Situated in between train station Kennispark and University of Twente campus, Techbank offers workspace for start-ups, mature and research companies. The building retains its clean, industrial character with a visible steel frame and a light and open interior. The Techbank has a flexible layout and significant ceiling heights to ensure adaptability to different users.

The relocation of the Temporary Court to Enschede was driven by a desire to prove the feasibility of circular construction at building scale. The project emphasized how demountable buildings can be transported and reassembled without reducing architectural aesthetics or functional quality. Techbank thus directly contributes to circular building ambitions, aligning with broader sustainability goals of both the municipality and the University of Twente. While the original design was aimed a temporary legal function, its successful reuse will now support economic development within a regional innovation ecosystem. It is unclear for how long the Techbank will remain in Enschede, but another relocation, disassembly and reassembly are not ruled out (HMO, n.d.).

With its high visibility along the station area and proximity to both academic and entrepreneurial actors, Techbank plays a strategic role in Kennispark's ambition to become a dynamic innovation district. The building shows a shift toward more awareness of materials and construction and stands as a clear example of how reuse can contribute to sustainable area development.

R-ladder



R2 - Rethink
The design was reviewed on the ease of assembly for the components. On the urgent advice from the contractor, components (e.g. the staircase) were prefabricated and transported as a whole, instead of multiple individual parts.

R4 - Reuse
Entire structure (steel frame, floors, stairs, façades) was reused almost 1:1 in a new location.

R8 - Repurpose
The building's function changed from judicial (court) to educational (innovation hub), extending its useful life in a new way.

Let's design out waste!

This building is designed with the intention of...

Approaches

To shift the built environment and construction sector towards a circular practice, designers and clients can take some basic approaches. Do you design for longevity, disassembly and reuse?

02
DESIGN FOR DISASSEMBLY AND DECONSTRUCTION

03
DESIGN FOR REUSE

Concepts

In past and present design practices, a variety of design concepts combine circular design qualities, tailored to a specific project context. Make yourself familiar with the most typical ones.

02
KIT-OF-PARTS

Qualities

Circular design qualities enable more effective reuse, recycling or renewal of buildings and building components. Walk through them and set your ambitions from the start of the project.

01
REUSED
Use building parts and components already present on site or reclaimed elsewhere.

06
PURE
Prefer components that consist of a single material instead of a blend.

07
DURABLE
Use components that resist the wear and tear of use and reuse.

08
SIMPLE
Go for low-tech, legible solutions rather than complicated ones.

09
MANAGABLE
Design building components that can be grabbed, moved and handled easily.

10
ACCESSIBLE
Integrate components so they can be reached and recovered without much effort or damage.

11
REVERSIBLE
Make it possible to undo connections without damage to the components they join.

12
INDEPENDENT
Assemble components so they are structurally, functionally and geometrically separated.

13
COMPATIBLE
Use building components that can be interchanged and (re)combined.

14
MULTI-PURPOSE
Design buildings and spaces that support changing needs and requirements without alterations.

own picture

own picture

Site
50 -100 years

Skin
10-100 years

Structure
50-100 years

Services
15-25 years

Space plan
5-20 years

Stuff
8-10 years

Brand layers

Site: soil
The location of the Techbank used to be a grass lane in Enschede, repurposed as part of the university's tech campus.

Skin: sun blocking fabrics, prefab laminated veneer lumber and glass wool
The façade is mainly composed of specialized durable and recyclable solar blocking fabrics. The fabric by comes with a 10-year warranty, indicating its expected durability under normal conditions. This fabric is designed for outdoor weather as it is a woven polyester base cloth with a PVC coating and double-sided acrylic lacquer, which ensures dimensional stability and mechanical strength, contributing to its longevity.
While the warranty period is 10 years, actual lifespan can vary based on factors such as environmental conditions, installation quality, and maintenance practices. Regular cleaning and proper care can help maximize the fabric's service life. For detailed maintenance guidelines and to ensure optimal performance, it's advisable to consult the manufacturer's care instructions.
The glass wool has an expected lifespan of 55 years whereas the laminated veneer lumber is expected to last for 50-100 years, depending on its maintenance and protection.
All façade elements are easily demounted and reassembled.

Structure: steel with dry joints and prefab concrete hollow-core slabs
Composed of steel columns and beams (H-sections), all connected with mechanical bolts — no welding was used, to allow for disassembly (expected lifespan: 50-100 years with proper maintenance and protection e.g. against corrosion).
The floors were made from prefab concrete hollow-core slabs that were dry-mounted on the steel beams (i.e., no cast-in-place concrete). These slabs are reused in Enschede with some alterations to a few slabs for safe placement. The expected lifespan is 75-100 years, they need to be carefully disassembled, transported and reassembled for reuse.

Services: HVAC and lighting
Includes HVAC, basic lighting, and ventilation systems – typical for educational and office buildings. New systems are installed during remounting (expected lifespan: 15-25 years).

Space plan: lightweight wall system
Interior layout consists of modular partition walls, movable lightweight wall systems, and flexible floor plans. These are often adapted to suit the building's new tech/educational function and can be reconfigured as use changes (expected lifespan: 5-20 years)

Stuff: fixtures and furniture
The solid furniture is not reused, whereas the moveable furniture is also transported to Enschede.


cepezed

Neptunus

Flux

Building function:	Education
Client:	Technical University of Delft
Location:	Delft
Year:	2023

Relevance for this research
Applied remountability principle:
Design for disassembly


BroekBakema


Neptunus

Information Flux

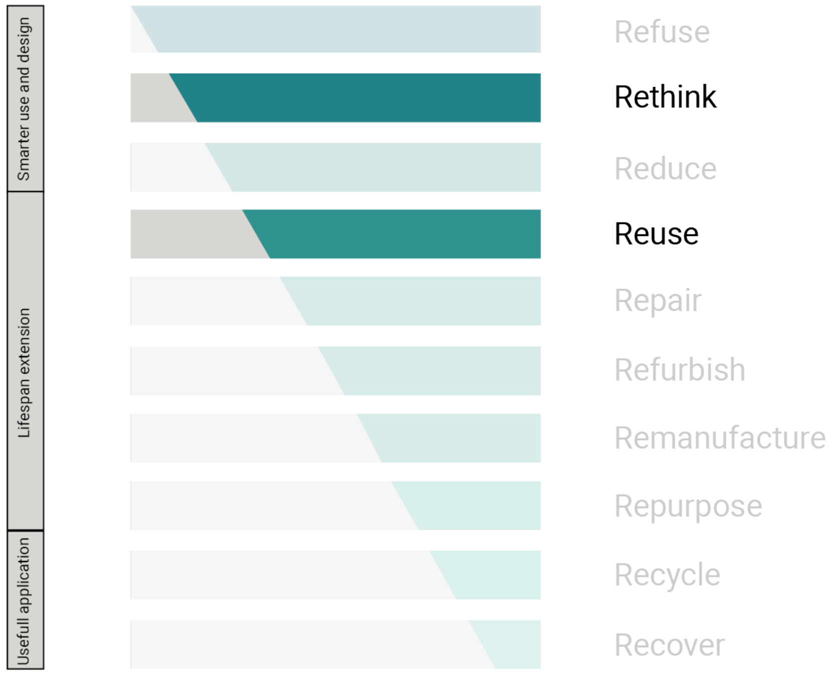
TU Delft Campus is home to various innovative educational and research facilities, one of which is the Flux building. Flux is developed as a temporary and fully remountable structure in response to an urgent need for educational spaces due to growing student numbers and an on-campus mentality. With this building, the university wanted to maintain flexibility for future campus development, which they embodied through for example leasing the building rather than the usual full ownership. Flux will remain at its current place for approximately 10 years. The second-life plan is not yet set.

On the site of a former parking lot, Flux comprises of four large lecture halls, each accommodating between 158 and 192 students. The design supports mixed didactics, allowing for both traditional lectures, exams and group work. The building's modular construction enables rapid assembly and future relocation, aligning with TU Delft's sustainability goals.
Sustainability is integral to Flux's design. The building features solar panels on the roof, a heat pump for climate control, and refurbished furniture. Notably, the floor panels were previously used during the 2012 London Olympics, exemplifying circular use of materials.

The building aligns with TU Delft's sustainability and circularity ambitions. As part of its Campus Vision for 2024, TU Delft aims for a future-proof and adaptive campus (Dorst, 2023). Flux is located centrally on campus, with its placement between key faculties and student hotspots ensures high accessibility. However, placed behind the EWI building does not accelerate its visibility.

Flux demonstrates how beneficial temporary buildings are for universities and how they can be (re)used and given a second life while complying with functional needs. When the promise of reusing this entire building is filled in, TU Delft not only reduces construction waste but also showcases a practical example of remountable architecture on campus environments.

R-ladder



R2 - Rethink
By opting to rent the building rather than own it, TU Delft has adopted a more flexible approach to real estate management.

R4 - Reuse
The design avoids use of permanent materials and cast-in-place components. The steel structure, façade panels, and modular units are all designed for reuse in another location after the current use period ends. Also, floors from the London Olympic games are reused in Flux. Finally, some furniture from other faculties of TU Delft are reused.

Let’s design out waste!

This building is designed with the intention of...


BroekBakema

Site
50-100 years

Skin
30-50 years

Structure
50-100+ years

Services
15-25 years

Space plan
5-20 years

Stuff
8-10 years

Brand layers

Site: concrete pavers and soil
The site on which Flux stands is a former parking garage and part of the ground is still covered with concrete pavers (explected lifespan 50-100 years). The building on site is intended for temporary use. As the building was constructed entirely above ground, without permanent foundations, the site remains fully reusable after removal. This reflects a conscious strategy of spatial flexibility, in which the land can easily return to its original function or be redeveloped in the future. Lifespan is permanent.

Skin: modular panels, glass, panels, aluminium frame
The skin of the building is made up of prefabricated modular façade elements, incorporating glass panels, aluminium frames and insulation. These elements were specifically chosen for their ease of installation and removability, aligning with the temporary and circular design of Flux. Some panels were newly produced, while others were reused from earlier projects. The materials used in the façade are expected to last 30 to 50 years, depending on maintenance and exposure to weather conditions.

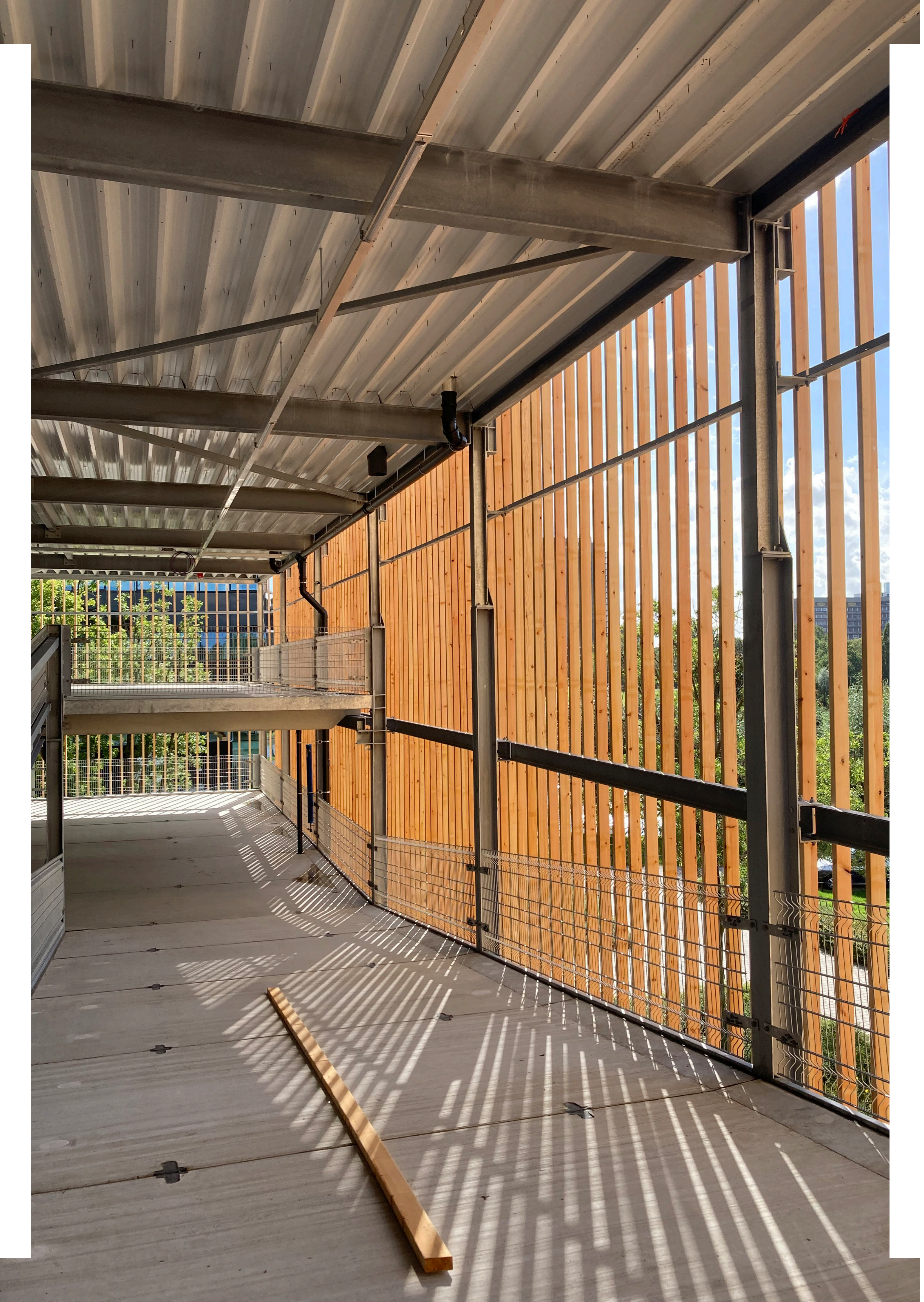
Structure: steel with dry joints
The structure of Flux consists of a lightweight steel skeleton with wooden beams, assembled using dry connections such as bolts and mechanical joints. This system was chosen to ensure the entire structural frame could be fully demounted and reused. Notably, part of the internal floor structure was reused from the temporary McDonald's pavilion at the London 2012 Olympics, highlighting a practical application of high-value reuse. The expected lifespan of the structural components, if properly maintained and protected against corrosion, ranges between 50 to 100 years.

Services: HVAC, solar panels, heat pump
The services within Flux are deliberately kept minimal, reflecting the building's temporary character. The HVAC system and lighting installations were newly added and tailored to the building's office and educational functions. These installations are not modular in themselves but were installed in such a way that they can be easily removed or replaced (expected lifespan: 15-25 years).
A large share of the electricity comes from solar panels on the roof (expected lifespan: 25 years with after 10 years reducing performances). The building is provided with heat from a heat pump. The type is not known in this research, but an average heat pump has an expected lifespan of 15-20 years. These sustainable service choices align with the TU Delft circular ambitions, but both need regular maintenance to upkeep the performance.

Space plan: modular interior
The space plan is open and flexible, designed to support various short- to medium-term uses. Interior partitions are non-load-bearing and modular, allowing rooms to be reconfigured or cleared out entirely depending on the changing needs of TU Delft. This adaptable layout supports both office use and educational activities, with an anticipated lifespan of 5 to 20 years.

Stuff: reused furniture and new audiovisual equipment
The lifespan of the stuff is varying. All furniture comes from other TUD buildings or external locations. The technical equipment in lecture halls as the audiovisual equipment need maintenance over time to keep it updated and durable. Overall, the expected lifespan is 8-10 years.

Neptunus



MASTER THESIS BUILD TO BE BACK LYNN KAMPHUIS JUNE 2025 TRACK MANAGEMENT IN THE BUILT ENVIRONMENT MBE TECHNICAL UNIVERSITY OF DELFT REMOUNTABILITY UNIVERSITY CAMPUSES MULTIPLE REUSE CYCLES DESIGN FOR DISASSEMBLY DISASSEMBLY REASSEMBLY