

Within Case Analysis

Yin's (2009) approach was followed in this case study, using the procedure of multiple case studies (**Figure 1**).

1. Case 1 (C1): Transformation of a vacant office building to mixed-residential use in Den Haag

This adaptive reuse project was implemented to revitalise a vacant office building in Den Haag to a shorty-stay residential building, reducing its environmental impact. The archival research showed that different CBA-related strategies were implemented, including diversifying the function of spaces within the building, selectively dismantling of building material instead of demolition, using renewable energy systems to generate electricity, utilising dismountable building products, utilising reusable/recyclable and sustainable materials, and reusing existing components within the project as well as in another project through the demolition agency.

1.1 Motivation and driver for applying CBA-relates strategies

The interview indicated that CBA related strategies were considered and applied for four reasons from the perspective of the developer, namely:

- **Economic feasibility:** Using adaptability- and circularity-related strategies would provide economic savings through the time.
- **Ecological reason:** Circular and adaptable solutions are important at the end for the planet.
- **Emotional drivers by the real estate developing organisation:** Enabling future generations to inherit and use the building for different uses.
- **The desire to introduce innovation by the real estate developing organisation:** Providing the market with creative and effective solutions.

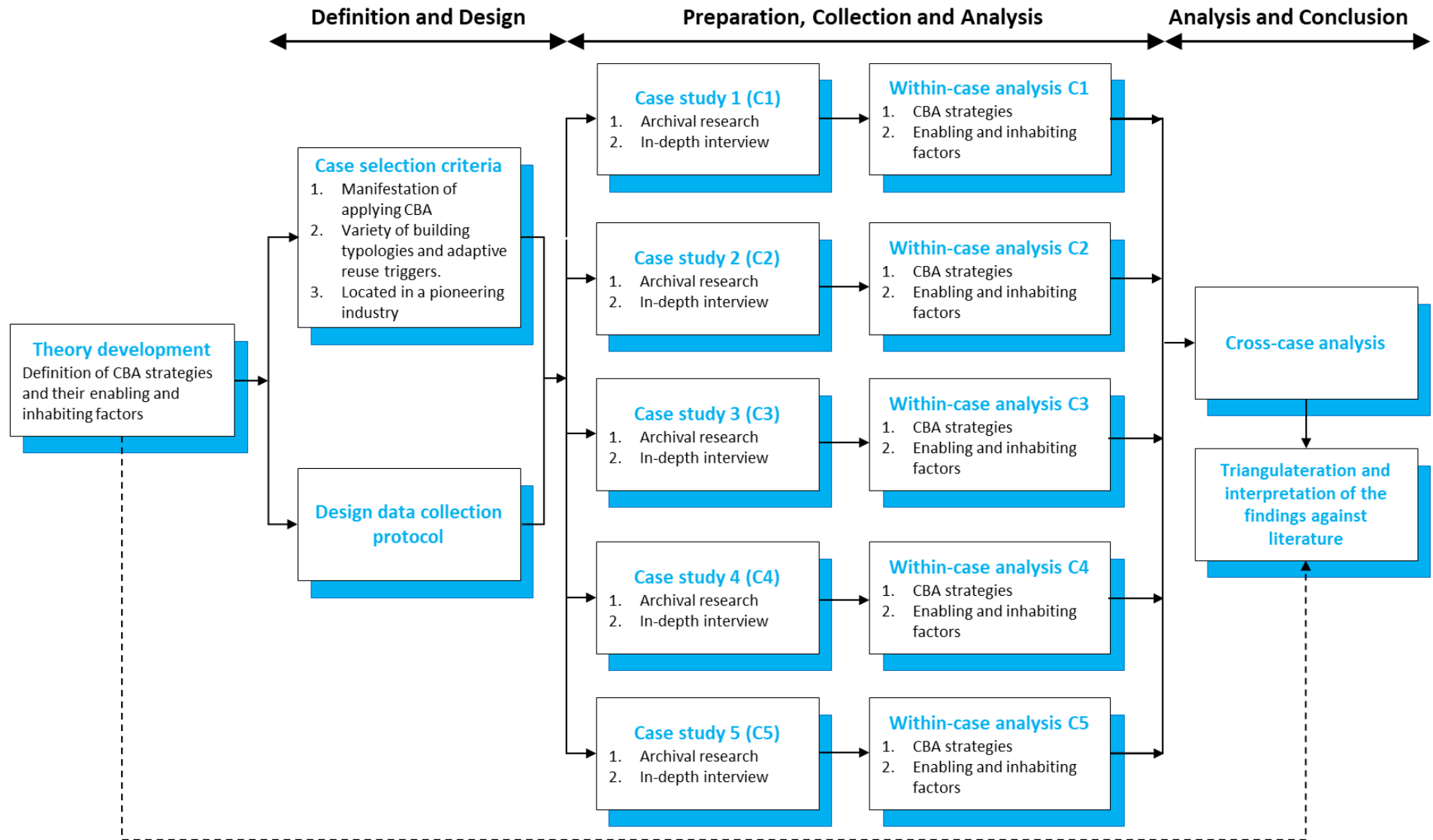


Figure 1: The followed procedure for multiple case study

*Adapted from Yin (2009)

1.2 The applied CBA strategies in relation to the CBA determinants

Nine out of ten of the CBA determinants were operationalised, using active, passive and operational strategies. Following is a description of the applied strategies corresponding to the relevant determinants:

- **Configuration Flexibility (D1):** Three strategies were applied to operationalize configuration flexibility, namely: using standardised building component, installing demountable products and separating the interior and exterior walls from the structure. The used standardized building components comprised different products and parts, including interior partitions, openings and other building products and stuff. These products are also demountable and independent, using dry connection. The interviewee stated: *“We decentralize the installations.”*. The interviewee explicitly indicated that the concept of “shearing layers” by Brand (1994) was adopted and followed in the configuration of the building products. The interior partitions are made from unitized panels. In this project, the façade was leased, in which it facilitates future changes like adding balconies. The interviewee stated: *“So in the building installations I mean building surfaces in the building surface layer, We look at the current use because the current use is always 10 to 15 years and then the building surfaces are recycled and new building services are added” and “we never used the facade as a structural, because we want to be adaptable in the future to put a balcony or change or put a window or something else.”*. The interviewee indicated that the use of flexible partitions was used as same as the second project (see section 2.2). However, special type of light weight wall panels was used in this project, due to the structural condition as stated by the interviewee: *“[name of the project] has a weak foundation, so we used [product name] that's micro concrete, that's a concrete with whole with a lot of air inside and fiberglass inside so it's really lightweight concrete panels. Your restrictions sometimes also influence the material choice”*.
- **Product Dismantlability (D2):** The use of demountable wall panels as well as other dismantlable building products besides the separation of the building layers – following the “shearing layers” concept of by Brand (1994) – were applied with the intention of facilitating dismantlability of the assets throughout the project use. The “shearing layers” concept was followed in the arrangement and configuration of all building products. The interviewee stated: *“We looked at the seven layers and see what we can use to make the building adaptable and which parts we have to change. Those part that we have to change, we get out and recycle or reuse. ”*
- **Asset Multi-Usability (D3):** Asset multi-usability was operationalised through adopting the principle of sharing the use of the provided assets. Two strategies were applied, namely the provision of sharable cars and social spaces: gym, offices and storage. The interviewee stated: *“Only uses short stay renting apartments offices in the ground floor and in the basement, storage in the basement, and fitness in the basement”, and “We also add sustainable cars in our projects. We add sustainable cars so to reduce parking places. Sharing cars. All sharing costs.”*.

- **Design Regularity (D4):** The regularity of the design was explicitly operationalised in this project through the achievement of the principles of the unity and standardisation. Two main strategies were applied, namely: installing standardised building products (wall panels) and standardizing the layout of spaces. The interviewee stated: *“The structure is the building is the same, it's the same, but the core is the same and the floors is the same. The staircases are the same. We changed the core a little bit because of fire regulations”*.
- **Functional Convertibility (D5):** Functional convertibility was deliberately and explicitly operationalised in this project, where the concepts of “function free building” and “shearing layers” were brought together adopted in the transformation of this project. The interviewee indicated that three interconnected strategies were applied – namely: the design for multifunctionality, the design for surplus capacity and decentralization of the building services, besides the design modularisation. First, the design for multifunctionality was harnessed during design by sorting out all possible functions that might be embodied in the future, and their legislative and technical requirements. The considered functions comprised commercial, apartment, hotel, healthcare and school building. Thus, the building configuration was aligned with all possible functions, with a particular relevance the current function for the first 3 interior layers: stuff, space plan and services. Second, and in this regard, the design for surplus capacity was harnessed by redesigning the other building layers – namely: skin, structure and site – against the maximum technical and legislative requirements across the possible functions that were pinpointed as possible use. The stated by the interviewee: *“We make a sheet of all the functions that we want to have in the building that we think that are needed in that location in the future, because in the future there's not going to be an energy central or something. It's not going to be a central station, so you understand you focus on what you think that is going to be for, what it is going to be used. Most of the time we look at hotel apartments, offices, healthcare, schools and retail. Those are the 5-6 functions that we try to embed. We both put those functions on the basis of the regulations beside each other, we try to choose the most heavy regulations. For instance, the façade is based on living because the noise of a hotel is much more low than the noise that is needed for a facade in the dwelling, because in a house you live permanently. In a hotel, you come and go, so the regulation is less. Although the building is short stay, we have put the regulation of apartments which is much higher. I think that's what we do, so we try to do that in every layer and in the space layer. That's the last layer space. We also look at the parking regulations for all the functions. And we can add or changed. Parking places and we also fix it when we cannot fix it like that we fix it with sustainable mobility”, “One important notice is that we don't make the installations in the way that it should, we cooperate with all the functions because if you have installation that can be a hotel, apartment, office, etc.”, “So in the building installations I mean building surfaces in the building surface layer, we look at the current use because the current use is always 10 to 15 years and then the building surfaces are recycled and new building surfaces are added” and “So in the first 3 layer – like the tables, this stuff and the space plan, the ceiling, the normal room walls and the surfaces, we look only at the first use. But from the skin the and*

structure, we look at the coming users in the future and spaces of course for parking”.

Third, the services of the building were decentralised by dividing them independent systems with their own floor holes “shafts”. Finally, the layout of the apartments was configured and in an alignment with the possible functions in a modular way, using unitised building products and components – e.g. standardized wall panels. The interviewee stated: *“In the structure, it is important to have awe don't believe in central building services, so what we do is we cut the building in the most into smallest parts, and that's most of the time hotel or healthcare because those units are 25 square meter. And every 25 square meter should be able to have its own building services”*, *“We decentralize the installations and the building services by making holes in the construction, so the construction should be able to facilitate a decentralized system through time.”* and *“If you have holes every 25 square meter, you can change the building through time”..*

- **Material Reversibility (D6):** Material reversibility was operationalized, applying 3 strategies. These strategies comprised: using reusable and recyclable building materials and products for the majority of the new products; sending back the discarded material for reuse and recycling; and selectively dismantling and reusing some of the old building products within the project. The interviewee stated: *“We start with [name of organization that released a CE model], so we try to reduce the use, reducing the use is the way you build the building façade and the way you design the total system of skin and surfaces, so we try to optimize, reducing the use and then adding sustainable resources”*, *“we used a circular composite that looks like, but it's circular”*.
- **Resource Recovery (D8):** Resource recovery was operationalised through the principle of using renewable energy systems to generate electricity and heat. PVT solar panels were used as a strategy for that. The interviewee stated: *“Yes, look you see the picture here, we use PVT panels photovoltaic so they are the most sustainable because they use the warmth and the rays of the sun to create energy neutral things via the warm the wall.”* *“We use photovoltaic panels as an innovation, because in [name of the project] we had not much roof area”* and *“In [name of the project], it is PVT, and the other one PV or solar panels”*. These panels were decentralised in their supply system, to feed the apartments independently, as stated by the interviewee: *“We have a really innovative installation system that is decentralized centralized, centralized PVT panels on the roof, but they decentralised for every apartment.”*.
- **Volume Scalability (D9):** Volume scalability was operationalized through three strategies to facilitate future spatial division and expansion. To facilitate spatial division, two strategies were applied, namely: using dismountable building components and separating the building layers. To facilitate spatial expansion afterwards, the leased facade enables for adding balconies and even merging some of the existing balconies to the building spaces, as stated by the interviewee: *“we never used the facade as a structural, because we want to be adaptable in the future to put a balcony or change or put a window or something else.”*.

- **Asset Refit-Ability (D10):** Asset refit-ability was seriously considered and operationalised in the transformation of this project. This was due to the aim of facilitating the fulfilment of requirements of future users was in mind of the developer and achieved through different passive, active and operational strategies. First, the design for surplus capacity in the site, structure and façade was applied for the sake of embodying the capacity to meet requirements of future functions or users. Second, the use of demountable building products – e.g. lightweight- dismantlable partitions – was applied to maintain such a quality. In addition, the leased façade enables for physical changes, also it can be replaced with new one. The interviewee stated: *and “we never used the facade as a structural, because we want to be adaptable in the future to put a balcony or change or put a window or something else.”* Finally, the applied design decentralisation of the building services and their holes would facilitate redistributing the system and adding new building systems and features through the time. The interviewee stated: *“We decentralize the installations and the building services by making holes in the construction, so the construction should be able to facilitate a decentralized system through time.”* and *“If you have holes every 25 square meter, you can change the building through time”*.

1.3 The experienced enabling factors that facilitated the application of CBA Strategies

The interviewee indicated some of the case-related enablers that facilitated the application of some of the applied CBA strategies in the project. First, the interviewee indicated that the presence of successful examples – e.g. previous projects – served as an enabler for convincing the clients on the effectiveness of the circular strategies in general, as the interviewee stated: *“Good examples, so if for example you are as best as your previous example, OK, so examples help to convince people, Your own people, but also other people to push farther to make better products”*. Second, the interviewee mentioned that partnership facilitated applying circular strategies, such as sending back the outdated building materials for recycling as well as leasing the façade. The interviewee stated: *“I think you need partners also partners that have the same ideology, or at least believe in your ideology. That’s also determinant”*. Third, the interviewee mentioned that entrepreneurship and creativity approaches that the developer organisation embraces has facilitated applying the innovative strategies that were carried out, such as façade leasing, the design for multifunctionality, design decentralization, provision of sharable car chargers, social spaces or installation of PVT panels. The interviewee stated: *“I think it is entrepreneurship and idealism, because you're entrepreneur and you take risks. You implement things that you believe in because of your idealism and they prove to be good, because [name of a real estate firm] bought it (the building), [name of second project] for instance, put it in the healthcare fund of 600 million of healthcare buildings and named this as the most circular healthcare building in their health care fund, And it has to be the example. So, you take risks you believe in your idealism, and then the market adapts it”*. Finally, the interviewer mentioned that the ability to make a floor shaft in building and separate the technical layers was “a main facilitators “ for applying a set of adaptability related strategies, such as design for multifunctionality, separation of walls from the structure, design for surplus

capacity and design decentralisation. The interviewee stated: *“To facilitate a decentralized system through time, so the flexibility most people think that the flexibility of building is building services, but it's the structure”*, *“If I'm not able to make holes in the floor because then the floor collapses, then we don't renovate the building.”*, and *“I call it technical and heretical adaptability. In technical adaptability you have the seven layers of Brand, you have the – 1st 3 layers space structure and skin, they have to adapt all kinds of functions and then you have the last layers they adapt the next function. Then you have the heretical part, that's where you choose for multi functions. That's what we discussed and every layer has its own restrictions or regulations or yeah.”*.

1.4 The experienced inhibiting factors that obstructed/challenged the application of CBA Strategies

The interviewee indicated some of the case-related obstacles that the developer faced at applying some of the CBA strategies, also other non-case-related obstacles that could hinder the application of CBA related strategies in adaptive reuse. First, the interviewee indicated that following the linear economy paradigm constituted an obstacle to the application of circularity in the project, without referring to a particular strategy. The interviewee stated: *“we're fighting for circular in a linear system”*, *“The linear obstacles when you are circular developing, because of the [name of a project in the Netherlands], lots of things like the tax regulation like the all kinds of stuff”*. Second, in the same context, the interviewee mentioned that “mono-functional thinking” in the market also constituted an obstacle to apply adaptability in the project, without articulating a certain adaptability-related strategy. The interviewee stated: *“I think in how we have 3 system flaws that [name of the developer organization] has encountered, one is monofunctional thinking”*. Third, the interviewee mentioned that the linear system of the regulations as well as the focus of the government on only reducing the CO2 emissions are general inhibitors for applying circularity in buildings. The interviewee stated *“The government only focuses on carbon dioxide to lower the carbon dioxide while we have much more bigger issues. Think about the transition of energy that we cannot pay for. It is too expensive. We cannot.”*. Finally, and similarly, the interviewee mentioned that the low-quality built areas represent an obstacle for applying circularity and adaptability in buildings, in general, as stated: *“Bad, ugly areas or areas that we put a lot of same people together and build low quality real estate at no quality in the environment.”*.

2. Case 2 (2): Transformation of obsolete and vacant office buildings to a care centre in Harderwijk

This adaptive reuse project was implemented to convert three obsolete and vacant office buildings located in Harderwijk to a care centre, preserving the old building while harvesting its materials. The archival research showed that different CBA-related strategies were implemented, including material reuse; installation of flexible partitions and energy neutrality by using of solar panels. Other social sustainability measures were incorporated, such as encouraging co-working and engagement of families.

2.1 Motivation and driver for applying CBA-related strategies

The interview of this case was the same participant from C1, as both cases were redeveloped by the same institution. Thus, the interviewee mentioned the same motivations for operationalizing the CBA-related strategies, namely:

- **Economic feasibility:** Using adaptability- and circularity-related strategies would provide economic savings through the time.
- **Ecological reason:** Circular and adaptable solutions are important at the end for the planet.
- **Emotional drivers by the real estate developing organisation:** Enabling future generations to inherit and use the building for different uses.
- **The desire to introduce innovation by the real estate developing organisation:** Providing the market with creative and effective solutions.

2.2 The applied CBA strategies in relation to the CBA determinants

Eight out of ten of the CBA determinants were operationalised, using active and passive strategies. Following is a description of the applied strategies corresponding to the relevant determinants:

- **Configuration Flexibility (D1):** Three strategies were applied to operationalize configuration flexibility, namely: using standardised building component, installing demountable products and separating the interior and exterior walls from the structure. The used standardized building components comprised different products and parts, including interior partitions, openings and other building products and stuff. Furthermore, the newly built recyclable brick façade was built using dry connections, meaning that it is dismantlable in case of any changes afterwards. All other building products are also demountable and independent, using dry connection in their installation, in which the interviewee explicitly indicated that the concept of “shearing layers” by Brand (1994) was adopted and followed in the configuration of the building products as same as C1. The interior partitions are made from unitized panels. Regarding the walls, the interviewee stated: *“It's the same as [name of the first project], no difference”* and *“Here is exactly the same, only the shape is a L, not a rectangular, so that's the only difference”*. Following is a quotation from one of the reviewed documents that has been published by the organisation *“Everything in the building is geared to future change, including the use of a flexible interior wall system.”*, which the interviewee has agreed with.
- **Product Dismantlability (D2):** The use of demountable wall panels as well as other dismantlable building products besides the separation of the building layers – following the “shearing layers” concept of by Brand (1994) – were applied with the intention of facilitating dismantlability of the assets throughout the project use. The “shearing layers” concept was followed in the arrangement and configuration of all building products. Dry connections were used in the newly built recyclable brick

façade. Following is a quotation from one of the reviewed documents that has been published by the organisation *“Everything in the building is geared to future change, including the use of a flexible interior wall system.”*, which the interviewee has agreed with. The interviewee indicated that wet connections were used as less as possible in this project to facilitate the product dismantlability, as stated *“Only the first layer on the floor you connect wetly, and then you go like Lego.”*.

- **Design Regularity (D4):** The regularity of the design was explicitly operationalised in this project through the achievement of the principle of the unity and standardisation. Two main strategies were applied, namely: installing standardised building products (wall panels) and standardizing the layout of spaces. Following is a quotation from one of the published archives on C2: *“But what turned out: precisely because of the use of prefab circular materials, modular shapes, prefab bathrooms, decentralised installations and the years of experience of building in modular forms, all problems can be easily solved and the entire design process is completed in less than 6 months. from structural design to construction agreement.”*.
- **Functional Convertibility (D5):** Functional convertibility has been embodied in this project as stated by the interviewee: *“We transformed it into what we call it functional free or dynamic building”*. To embody functional convertibility in this project, the exact approach followed in C1 was also adopted in this case, using the same strategies (see subsection 1.2). Thus, bringing the concepts of “function free building” and “shearing layers” together was carried in this project. The same three interconnected strategies were applied – design for multifunctionality, the design for surplus capacity and decentralization of the building services – were applied besides the design modularisation. Similarly, the design for multifunctionality was harnessed during design by listing all possible functions that might be included in the building afterwards, comprising their legislative and technical requirements. The building configuration was aligned with as well with pinpointed possible functions, with a direct relevance to the current function for the first 3 interior layers: stuff, space plan and services. Following that, the design for surplus capacity was harnessed in the same way by redesigning the other building layers – namely: skin, structure and site – against the maximum technical and legislative requirements across the possible functions. The services of the building were decentralised by dividing them independent systems and shafts. Finally, the layout of the spaces of the care centre was configured and in an alignment with the possible functions in a modular way, using unitised building products and components.
- **Material Reversibility (D6):** Material reversibility was operationalized, applying 3 strategies. These strategies comprised: using reusable and recyclable building materials and products for the majority of the new products; sending back the discarded material for reuse and recycling; and selectively dismantling and reusing some of the old building products within the project. In addition to that, some of the dismantled building materials from the façade were reprocessed, incorporated and reused in the new use in a form of flooring.

Regarding the dismantling, repurposing and reuse of old building materials, the interviewee stated: *“Yeah selected demounting. That's why I don't say demolish*

because we reduced a few materials and we recycled the rest.” and “We have reused, for instance, you see at the right part of the façade, this tiles, we use the tiles break it and incorporated it in the new floor and some kinds of buildings, so this one material we reused in another application in the building, but the rest of the building was so immensely poorly built”, Regarding sending back old materials, the interviewee give a brief explanation on how that strategy was applied: *“We recycled the materials with our partner [name of company]. A [name of the company] is our partner in demounting instead of demolishing”* and *“The demolishing costs were not much, so he incorporated in his price, the value of the material”*. Regarding the integration amongst circular strategies in project – reuse recycling and use of recyclable/reusable materials, the interviewee gave an example on the faced: *“We also, you saw it in the in the movie, 50% of the facade is reused, so we added materials to the existing facade to make it new again”, “one 4th, it's recycled stone, more or less, because that's regulated. The European regulation. They are not allowed to recycle more, and the [name of a brick product] can be recycled for 100%. So if you recycle the [name of a brick product] for 100%, 25% of it you can use in a new [name of a brick product]”, “Yes, every performance is better than a normal brick.”, “Yeah, connection and I'm against wet conditions” and “This is likely you go have a pin, or aluminium pin, you can put inside”*

- **Resource Recovery (D8):** Resource recovery was operationalised through the principle of using renewable energy systems to generate electricity. PV solar panels were used as a strategy for that. The interview stated: *“In [name of C1 project], it is PVT, and the other one PV or solar panels”* .
- **Volume Scalability (D9):** In this project, volume scalability was operationalized through two strategies to facilitate future spatial division. To facilitate spatial division, two strategies were applied, namely: using dismountable building components and separating the building layers as done in C1 (see subsection 1.2).
- **Asset Refit-Ability (D10):** Asset refit-ability was considered and operationalised in the transformation of this project, as the case of C1 (see subsection 1.2), as the interviewee stated: *“But they are exactly the same, they're decentralized”*. This was due to the aim of facilitating the fulfilment of requirements of future users was in mind of the developer and achieved through different passive and active strategies. First, the design for surplus capacity in the site, structure and façade was applied for the sake of embodying the capacity to meet requirements of future functions or users. Second, the use of demountable building products – e.g. lightweight- dismantlable partitions – was applied to maintain such a quality. In addition, the newly built recycled façade can be easily changed, as it was constructed using dry connections as a construction and assembly method. Finally, the applied design decentralisation of the building services and their shafts would facilitate redistributing the system and adding new building systems and features through the time.

2.3 The experienced enabling factors that facilitated the application of CBA Strategies

The interviewee mentioned the same the case-related enablers for both cases (see subsection 1.3). Thus, the presence of successful examples – e.g. previous projects – served as an enabler for convincing the clients on the effectiveness of the circular strategies in general. Second, partnership facilitated applying CE strategies, such as sending back the outdated building materials for recycling. Third, the entrepreneurship and creativity approaches that the developer organisation embraces has also facilitated applying the innovative strategies that were carried out, such as the design for multifunctionality, design decentralization, provision of sharable car chargers, and installation of PV panels. Finally, the ability to make a floor shaft in building and separate the technical layers was “a main facilitators “ for applying a set of adaptability related strategies, such as design for multifunctionality, separation of walls from the structure, design for surplus capacity and decentralization of design.

2.4 The experienced inhibiting factors that obstructed/challenged the application of CBA Strategies

The interviewee indicated same the case-related obstacles that the developer faced at applying some of the CBA strategies, also other non-case-related obstacles that could hinder the application of CBA related strategies in adaptive reuse. However, one strategy was completely hindered by the resistance of the client for change. This strategy was the provision of a smart and user-centred system for the elderly users of the building.

The other inhibitors were as same as C1 (see subsection 1.3). First, following the linear economy paradigm by the market constituted an obstacle to the application of circularity in the project, without referring to a particular strategy. Second, “mono-functional thinking” in the market also constituted an obstacle to apply adaptability in the project, without articulating a certain adaptability-related strategy. Third, the linear system of the regulations as well as the focus of the government on only reducing the CO2 emissions are general inhibitors for applying circularity in buildings. Finally, the low-quality built areas represent an obstacle for applying circularity and adaptability in buildings, in general.

The provision of user-centered smart system was hindered by the client resistance to change. Ther interviewee stated: *“In [name of the project], we wanted to make it the most smart healthcare building in the world, but you come to know that the health care organization is afraid of change to make it smart, they have their own system that they monitor elderly people and they didn't want to change that in a new smart system, so a lot of things that we want to do in innovation also touches the end user. And to change the end user to adapt your innovations, It's really difficult and a lot of time fails”*. The reuse of many of the old building materials was hindered by the poor construction and deterioration of the building. The interviewee stated: *“We have reused, for instance, you see at the right part of the façade, this tiles, we use the tiles break it and incorporated it in the new floor and some kinds of buildings, so this one material we reused in another application in the building, but the rest of the building was so immensely poorly built. It was, you can see it in the picture, it was really bad built so we could not.”*.

3. Case 3 (C3): Transformation of bank towers to mixed-use buildings in Amsterdam

This adaptive reuse project aims to convert a 10-towers corporate facility. The project was developed in the 1980s and used by a bank for more than 30 years. The corporate towers were bought by the municipality when the owner decided to relocate the corporate facility. The facility is a large-scale project, and the building has been listed as a monument by the municipality. Accordingly, the municipality decided to sell 7 towers to a developer who could redevelop the project in a circular way while preserving the monumental part. The municipality has decided to transform 3 towers to an international school to preserve the monument in a circular way. In the school project – 3 towers, different CBA-related strategies have been considered by the municipality, including repairing and reusing existing building products, selectively dismantling old materials and repurposing their use, and replacing the light system with a more energy-efficient system. In the other 7 towers, the developer has functioned the towers into a mixed-use towers and considered applying numerous CBA-related strategies, including embodying the multi-usability of assets through the inclusion of three functions in each tower – namely: restaurants/cafes in the first floor, offices and sharable spaces in the second floor, and apartments of different sizes in upper floors. Other strategies included repairing and reusing old lifts, facilitating the use of daylighting, preserving the monumental elements.

3.1 Motivation and driver for applying CBA-relates strategies

The interviewee indicated that the motivation and reasons for operationalising CBA related strategies in the transformation of this project are 3, namely:

- **Wish from the owner:** The owner is motivated to operationalise circularity in the building as it is a monument.
- **Obtainment of adequate consultancy from the installation company:** The installation institution provided an effective consultancy for the stakeholders.
- **Good physical condition:** The building was built with a high standard and quality in terms of design and construction, and if it is demolished that would be a loss.

3.2 The applied CBA strategies in relation to the CBA determinants

Overall, six out of ten of the CBA determinants were operationalised, using active and passive strategies. Following is a description of the applied strategies corresponding to the relevant determinants:

- **Configuration Flexibility (D1):** Configuration felaxabality was barely opreationalised in this project. Two strategies were applied to operationalize configuration felaxabality, namely: use of standardised building component and installation of demountable products. These strategies were mainly manifested in the walls, beside the use of some flexible A/C fittings – movable diffusers and flexible ducts in the 3-towrs schools. For the walls, the interviewee stated: “It's going to be no, it's only like walls metal” and “So that's not very future proof”. For the A/C fittings, the interviewee stated: “And I've learned it now. I showed you this panels I said. There are panels and there's installation in it and that's what I mean. So those long panels stored and there

are. Yeah. I don't know what the English word for this is. How do you call this? A fan of or something? [.....] OK, sure. Yeah, and that's what was like wrapped in blue paper and we keep it on the side and we reuse it."

- **Product Dismantlability (D2):** The use of demountable wall panels was applied. In the 3-school towers, the use of flexible A/C fittings was applied, *as indicated in the configuration flexibility*. Dry connections were used for the installation and reassembly of the walls.
- **Asset Multi-Usability (D3):** The multi-usability of the assets was operationalised in the 7-mixed-used towers. Co-working spaces and sharable conference rooms have been provided in second floor in each of the towers. Following is a quotation from one of the published archives on C3: *"[project name] combines living, working and meeting in one of the most unique monuments of Amsterdam. [project name] will feature catering, work and meeting spaces, inner gardens and even a cinema. In other words, all convenience under one roof."*
- **Material Reversibility (D6):** Material reversibility was operationalized by applying 3 strategies. These strategies comprised: using reusable and recyclable building materials and products for the majority of the new products; sending back the discarded material for reuse and recycling; and selectively dismantling and reusing some of the old building products within the project as well as in another project. For the second strategy, some of removed glass walls from the schools were sold to another project in Belgium. Regarding the third strategy, some of the old ceilings, walls, conduits and kitchen products were repaired and reused again. The interviewer stated: *"And they reused a lot of installations like 3 lift, 3 elevators" , "the ceilings they went to [name of recycling organisation]" and " In the interior, there were really, really nice office glass office walls. They went to Belgium to a party who is only building circular walls in circular buildings. So they have those connections and they were a very important partner for circularity in the renovation phase."*
- **Building Maintainability (D7):** Building maintainability was operationalised in this project for the sake of prolonging the use of the previous assets as well as maintaining the monumental elements of the project. In the 3-towrs schools, numerous building products has been repaired and reused, namely the ceiling tiles, conduits, and some of the interior walls. The interviewee elaborated on that and stated: *"The went to [name of company] and they got renovated and we got them back in boxes. It looks like brand new."* The lifts in the have been repaired and reused. The monumental parts were repaired and retained in the 10 towers. Following is a quotation from one of the published archives: *"All monumental parts that the building has to offer have of course been preserved and are cherished with care. It concerns the original tiled floor, slatted ceilings, lighting, ornaments and art, monumental office spaces and living areas and the gardens."*, which the interviewee has agreed with and stated: *"So there is a LED light instead of TL in it, so they refurbished the lighing."*
- **Resource Recovery (D8):** Resource recovery was operationalised through the principle of using renewable energy systems to general electricity, also through the replacement of existing systems with energy-efficient alternatives. PV solar panels were used as a strategy for that, and it has only been used for the 3-school towers but

not in the 7 mixed-use towers, as the interviewee stated: *“They're going to be solar panels on the roof.”*. The majority of old lighting fixtures were replaced with LED, as an energy efficient system. Following is a quotation from one of the published archives on C3: *“In some cases, this even reduced investment costs. This is the case with, for example, the existing old FLUORESCENT and PL fixtures from the [name of project]. A large part of this existing lighting, with largely reuse of the existing luminaire, has been converted into energy-efficient LED lighting by replacing the technology in the luminaire.”*.

3.3 The experienced enabling factors that facilitated the application of CBA Strategies

The interviewee indicated some of the case-related enablers that facilitated the application of some of the applied CBA strategies in the project. First, the interviewee mentioned that the existence of a motivated owner– the municipality – and shared vision for implementing circularity played a pivotal role in incorporating circularity in this project. The interviewee stated: *“The owner. Yeah, That's the most important facilitator”*. The interviewee described that as having the same goal and guiding perspective facilitated the determination of the circular solutions, as everyone knows the desired outcome and work on that. The interviewee stated: *“And they make things even better, because of a I don't know if it's it's, it's the whole team. We want to build circular and then and the all the people who work on this site, I don't know on other people of course, but on this site they are really they really think the same way and they have ideas themselves.”*.

Second, the collaboration amongst the stakeholders and existence of capable contractor are two enablers that facilitated the implementation of circular strategies in regard to reusing, repairing and retaining existing material and products. The interviewee stated: *“The constructors. They make things even better because of a, I don't know if, it's the whole team we want to build circular and then all the people who work for [name of the contractor] on the site they really think the same way and they ideas themselves”* The interviewee reflected on that by an example of the case of the deteriorated cement panels, where the contractor and architect came up with the solution of painting such panels as a solution to retain and reuse them in the new use instead of discarding or replacing them. Particularly, the interviewee emphasized the contribution of the contractor in figuring out and implementing all the technical solutions for circularity (e.g. reuse, repair and selective dismantling). The interviewee stated: *“For instance, I can give you an example. I'll show you. This is a cement plate, and this is an initiative the contractor suggested, because We asked to get rid of all those cement plates and put new ones on the wall again. And they said actually we are having trouble removing it. Because if you see this whole, in this hole, can I zoom in? Yeah, in this hole, it's like an oil product on the back. So why should you remove and make waste out of all those panels with all this oil on the back and put new oil and new panels? So we asked, we went to the architect and said is it okay if we leave everything with the damaged ones? Of course we are going to replace. The panels are available still available, so that's really important. In the same structure and then if you paint it, you will not see if it's a new one or an old one. We said, OK, that's good. Let's do that. So that's an initiative of the contractor [name of organisation].”*. In addition, the interviewee stated: *“Maybe this is a good idea and*

the architect. He's also a very good one. He's like looking at the solutions and not holding back and say no, we won't be and this is our idea. And so it's a good corporation.”.

3.4 The experienced inhibiting factors that obstructed/challenged the application of CBA Strategies

Similar to C1 and C2, the interviewee indicated some of the case-related obstacles that the developer faced at applying some of the CBA strategies, also other non-case-related obstacles that could hinder the application of CBA related strategies in adaptive reuse.

First, the lack of data and information on building installations in the building was a key obstacle faced in applying the strategies, as they could not figure out the appropriate solution for the materials and products without such records. The interviewee mentioned that they had to do a lot of research to overcome such an obstacle. The interviewee stated: *“The problem. Well, I can only say one thing, you have to do research, research, and research. Research what you have in your building. What is the state of your installation?”.* An example on that was the case of reusing plumbing fixtures and fittings, where the team expected that is possible, but after the investigation they found the pipes were deteriorated and their reuse is impossible. The interviewee stated: *“In [name of project] we have a problem with sanitary, because it looks very good. But it's all already 30 years there and I don't know if I've got a picture to show, but we have to replace a lot of toilets, unfortunately.”.*

Second, in the context of the same example, the deterioration of the building materials is an obstacle for their reuse. In this context, the reuse of the wooden ceiling was hindered by the deterioration of the sprinkler system. The interviewee indicated that they have to could not preserve that ceiling and had to remove it in order to repair the sprinkler system, in order to meet such a key safety requirement. The interviewee stated: *“We wanted to keep the wooden ceiling. But it was not possible because above the wooden ceiling There is a fire detection system now, a sprinkler. And in this wooden ceiling are, well, there's a log like wooden like doors in the ceiling there were. And they were on places they werelike taps, you know. So that was not the problem, but above that even higher there is this sprinkler system and that was the problem. We had to renovate the sprinkler system, but we couldn't do that without taking this wooden ceiling out of this, out of the hallway, unfortunately. So it was not possible to keep that wooden ceiling.”.*

The interviewee mentioned a series of inhibitors for CBA in general, but not directly related to this project. For instance, the taxation included on the 2nd hand material and low cost of unsustainable material – e.g. concert – represent key inhibitors for material circularity in the building industry (in general). The interviewee stated: *“Products has to go up, so it has to be more expensive so that you use and reuse materials. And it's also weird that if you have a building and you have a products out of this building. Then, you sell this products and you have to pay tax on the. Products you already pay tax, so it's twice text”.* In addition, the interviewee mentioned that not all experts in circularity and adaptability apply circular and adaptable strategies in the market, through this obstacle was not experienced in this project as well. The interviewee stated: *“Who say what they will do for you? Make circular building, but actually don't do what they say”* and *“They tell you what they will do that, but they tell you what they*

will do, but they don't do what they tell you, and that's a real big problem". In addition, the interviewee mentioned that the building industry is conservative, which constitute a barrier for circularity in buildings (in general), as stated: *"Yeah, there's a lot of work has to be done. It's gone. Note it's really slow, because of the, it's conservative".*

4. Case 4 (C4): Transformation of a disused gym to an office building in Bodegraven

The aim of this adaptive reuse project was to convert an underutilised gym in Bodegraven to an office building, while experimenting with circularity in building transformation in a form of living lab. The applied CBA-related strategies comprise embodying the regenerative capacity through installing solar panels, utilising secondary material, embodying the configuration flexibility through integrating and standardising different systems in the composition and configuration of the wall panels, and utilising lightweight materials.

4.1 Motivation and driver for applying CBA-relates strategies

CBA strategies were considered for three main reasons:

- **To implement theory into practice:** The project was mainly a graduation project, in which the interviewee and the organisation aimed to gain knowledge by implementing and experimenting theory, thus the project is a living lab.
- **To prolong the building:** Through circularity, prolonging the utilisation of the building is a possible as an imporent dimension in sustainability and circularity.
- **Adding value to the building:** Circular transformation can add value to the building by reusing the different materials in the building which can by itself add a value to the building for hundreds of years
- **Dutch requirements for energy production and climate change:** Circular building transformation that upgrades the environmental condition in the building according to the requirements of climate adaption will make the building in a high level of standard that is ready for the next 50 or 100 years: The building is ready for the future. Example was given about the reuse of the glass and frame inside the building.

4.2 The applied CBA strategies in relation to the CBA determinants

Eight out of ten of the CBA determinants were operationalised, using active and passive strategies. Following is a description of the applied strategies corresponding to the relevant determinants:

Configuration Flexibility (D1): Four strategies were applied to operationalize configuration felaxabality in the adaptively reused gym to office. These strategies comprise use of standardised building component, installation of demountable products, separation of walls from the structure, and open the floor plan. An innovative integration amongst the first three strategies was achieved in the interior wall panels. These panels are dismantlable, standardized, separated from the structure, and even flexibly embody the heating system. The lifts in the have been repaired and reused. The monumental parts were repaired and retained in the 10 towers. Following are quotations from one of the published archives: *"Progressive is*

the solution for the secondary wall on the inside of the outer façade. In addition, the thermal insulation, the acoustics, water-fed wall heating / cooling and the plinth are included in one integrated wall as a wall gutter for electricity and data. A solution that promotes the flexibility of the building. The interviewee has agreed with this information and stated: *“That's all the panel is basically detachable because it also uses gypsum, which is basically recyclable but also reusable, and there is also still some metal construction and stud inside.”* and *“And in the form of circularity, back again, regarding the forms that wall has multi functions. It uses materials for the acoustic functions to limit the sound echo in the building, but also inside we put in the heating pipes”*. To facilitate future changes within the office building, large part of floor plans kept open. The interviewee stated: *“But at the same time, it's also very flexible to have an open space”*. In addition, flexible writing techniques was incorporated throughout the building through flexible skirtings to facilitate extending wire supply for individual users as well as spaces in the future. Technically, the electrical cables are extended along detachable skirtings throughout the building. The following quotation is from one of the published archives *“For the partitions, we opted for a soft insulation material with perforations in the wall finish for good acoustics. The lower 2.5 meters is a hard insulation material with [product name] wall heating elements in which the water pipes run. With this water-fed wall heating, we prevent annoying radiators or cooling facilities from having to enter the room. The wall gutter with flexible places for electricity and data also prevents you from having to install sockets everywhere.”*. The interviewee also stated: *“And to add more into the flexibility, we have added a plint around the gym.”* and *“which actually inside the gym, which actually have all of the data and electricity connections”*.

- **Product Dismantlability (D2):** Product dismantlability was operationalised in a high level. The use of dismantlable building products (walls and skirtings) and the separation of the building layers were the key applied strategies for embodying the product dismantlability in the building. The interviewee stated: *“That's all the panel is basically detachable because it also uses gypsum, which is basically recyclable but also reusable, and there is also still some metal construction and stud inside.”* *“If you want and you can just screw it out”* and *“Yeah, so then yeah, it's really for flexibility and then to be adaptability in which that at the moment we don't really have room separations. We don't have like another walls inside. But in the future if there is another walls or the rooms are being separated further, then it will be easy to adjust”*.
- **Design Regularity (D4):** Design regularity was not explicitly applied through the spatial configuration of spaces, but rather through the through the newly provided products. The use of standardised products was applied through unitisation of the size and type of wall panels and skirtings throughout the building. The following quotation is from one of the published archives *“For the partitions, we opted for a soft insulation material with perforations in the wall finish for good acoustics. The lower 2.5 meters is a hard insulation material with [product name] wall heating elements in which the water pipes run. With this water-fed wall heating, we prevent annoying radiators or cooling facilities from having to enter the room. The wall gutter with flexible places for electricity and data also prevents you from having to install sockets everywhere.”*

- Material Reversibility (D6):** Material reversibility was operationalized by applying 4 strategies, using reusable and recyclable building materials and products for the majority of the new products; sending back the discarded material for reuse and recycling; selectively dismantling and reusing some of the old building products within the project as well as in another project; and use of second hand building material. First, many of the newly installed materials and products are reusable and made of recyclable material. For instance, the invented wall panels – that are standardized and dismantlable – are made of recyclable gypsum, as stated by the interviewee: *“That’s all the panel is basically detachable because it also uses gypsum, which is basically recyclable but also reusable, and there is also still some metal construction and stud inside.”*. In addition, the newly installed window frames are recyclable and reusable. Second, many of the old and outdated products were sent for reuse/recycling. For instance, some of the old glasses and frames were reused inside building where others were sent back for recycling. The following quotation is from one of the published archives on the project *“The old frames have been replaced by special recyclable plastic frames.”*. The interviewee stated: *“And the existing frame from the old building was sent back to the producer so that it can be reused, while the new ordered frames have been selected specifically so that 99% it can be further recycled in the future.”*. Third, some of the old materials and products were selectively dismantled and reused in the building for the same use or in another use. For instance, old heating pipes were reused in a form of stair railing. The following quotation is from one of the published archives on the project: *“Old heating pipes are incorporated into the stairs”*. The interviewee also stated: *“Yeah, and also the existing heating system back then was being reused inside.”* and *“Yeah, inside the trail for the stairs”*. Old HVAC ducts were reused for decoration, where the diffusers were reused again for the same purpose. The interviewee stated: *“The ventilation like the boosters that blow the air in, it was reused as well.”*. The old roof timbers were reused in the construction of extra as well as in some furniture items – e.g, meeting table. The interviewee stated: *“Yeah, and back then there was ceiling. There was a lower ceiling with isolation, isolation layer and we reused the isolation for the roof, while the ceiling itself the material is being reused for the extra floor. Than we have here and also to make the table this table”*. The old flooring of the gym hall was reused as it is, as the interviewee stated: *“Yeah, the floor of the gym itself is maintained”*. Finally, second hand building materials were reused. For instance, some of the floor insulations were brought from a previous project and installed in this project. The interviewee stated: *“The insulation of the floor under this building came from somewhere else”*.
- Building maintainability (D7):** Similar to C3, building maintainability was operationalised in this project for the sake of prolonging the use of the previous assets as well as maintaining the monumental elements of the project as the case of C3. In this project, the old flooring of the gym were retained besides other monumental parts – e.g. façade. The interviewee stated: *“The floor of the gym itself is maintained”*, *“yeah the walls and the constructions was still very good so that a lot of them almost about 80% has been reused”* and *“Yeah, so a lot of them are being maintained here or just being reused somewhere else.”*.

- **Resource Recovery (D8):** Resource recovery was operationalised through the principle of using renewable energy systems to generate electricity. PV solar panels were used as a strategy for that. The installed PV panels enabled for generating an amount of energy that is greater than the building demand, which facilitated the use of this extra renewable energy to supply other uses such as charging cars. The interviewee stated: *"We do have solar cells, solar panels, but that's of course more for the utilization phase and not really during, yeah, it's not really during the design phase, and we also have here electric charger for cars and that's basically make the usage of the building itself circular. Well, if you want to say it like that."* and *"We actually send electricity back to the grid. We actually produce more than we use"*.
- **Volume Scalability (D9):** Volume scalability was operationalised to enable for spatial division. Three interconnected strategies were applied, namely: use of demountable products, separation of the building layers and open the floor plans. The first two strategies were manifested in the utilized flexible wall panels, as stated by the interviewee: *"That's all the panel is basically detachable because it also uses gypsum, which is basically recyclable but also reusable, and there is also still some metal construction and stud inside"*. Regarding opening the floor plan to facilitate the spatial division, the interviewee stated: *"Yeah, so then yeah, it's really for flexibility and then to be adaptability in which that at the moment we don't really have room separations. We don't have like another walls inside. But in the future if there is another walls or the rooms are being separated further, then it will be easy to adjust"*.
- **Asset Refit-ability (D10):** Asset refit-ability was operationalised through the use of demountable building products, including the flexible walls and skirtings. Both solutions were provided with the intention of enabling for meeting new user requirements and accommodating new systems. The interviewee stated by the interviewee: *"And to add more into the flexibility, we have added a plint around the gym."*, *"which actually inside the gym, which actually have all of the data and electricity connections"* and *"Yeah, so then yeah, it's really for flexibility and then to be adaptability in which that at the moment we don't really have room separations. We don't have like another walls inside. But in the future if there is another walls or the rooms are being separated further, then it will be easy to adjust"*

4.3 The experienced enabling factors that facilitated the application of CBA Strategies

The interviewee mentioned some of the case-related and non-directly-case-related enablers for the application of the strategies. First, the interviewee referred to the building itself as a key enabler, where he referred to its physical, spatial and use condition as key enablers. The strength of the structure, quality of the components – e.g. the massive façade that is sound proofing, and the wideness of its dimensions – in terms of the high floor height – played a vital role in adaptively reusing the building and implementing circularity in general. In this context, he referred to the emptiness of the building as enabler as well. The interviewee stated *"Yeah, so the three things that have been mentioned that this is that the constructions the constructions was really good. The building was empty, but at the same time the construction is very strong. It can also holds lots of weight. And then the floor, the floor, you can just add extra floor"*. Second, the low cost of reusing the building material was a financial enabler for

applying the circular solutions pertaining to the reuse of building material and product, as stated by the interviewee: *“Financially, it's interesting, it's good to maintain to reuse the materials.”*. Third, the interviewee referred to the availability of ambitious team was also an enabler for problem-solution aspects, where the interviewee mentioned that having a team with the same goal for reusing the building brought the team together in situations when there is a problem. The interviewee interpreted that process as collaboration. The interviewee stated: *“And also that you have a team which has the same goal. A team the that basically wants to reuse the building”* and *“Yeah, so it's just like in general the team when they face, when they encounter a problem or obstacle, then they can work together to solve the problem.”*. Finally, the interviewee mentioned a market-oriented enabler, which is the availability of prefab materials and products, without mentioning a certain strategy, but in the context that relates to the standardized and innovative solutions that they implemented regarding the combined wall panels and flexible skirtings used in the project. The interviewee stated: *“Well, then, the availability of prefab materials which can yeah, like toilet or panels or such.”*.

4.4 The experienced inhibiting factors that obstructed/challenged the application of CBA Strategies

The interviewee indicated some of the case-related obstacles that the developer faced at applying some of the CBA strategies, also other non-case-related obstacles that could hindered the application of CBA related strategies in adaptive reuse. First, the high cost of readapting and reusing materials and products within the project in another application was perceived as an obstacle. An example was given on the railing that was made from old heating pipes in the building. The cost of adapting and reusing heating pipes in a form of stair railing was economically infeasible. The interviewee stated: *“One of it was the reuse of the heating piping, which was transformed into the railing, but apparently it's more costly to do that instead of buying new railing.”*. Second, the lack of warranty on the performance of second-hand materials obstructed their use in a large part of the project. The interviewee stated: *“Lots of lots of time it's related with the warranty of the materials performance. In which that if you release the material and use it in another constructions, then it's not always that the warranty stays.”*. Third, the project team could not separate the waste to facilitate its reuse owing to technical difficulties. The interviewee stated: *“Well, one of the things the separation of the waste, which back then some of the materials was not reused and it was considered to separate the waste and send it to certain stakeholders which will be able to reuse it. But that's actually difficult, proved to be difficult to do.”*. Finally, the lack of market emphasis on biobased material – during the time of the project – as well as the legislative requirements for fire safety hindered the use of biobased material in the project. The interviewee explained the last inhibitor in relation to the Butterfly Diagram model, where the project focused on the technical flow of material and overlooked the biological flow of material. The interviewee stated: *“And also another one, is that, another selection that we could have done back then is to implement biobased material which is at the moment at 2022 is a big thing. Yeah, for instance, instead of using metal for the extra floor that, we have where we can use wood.”* and *“It was too new at that moment that there are lots of other aspects relating to regulations that might be full of risk like the fire proofing and such things.”*.

5. Case 5 (C5): Transformation of a vacant office building to student housing in Rijswijk

This adaptive reuse project aims to convert a vacant office building in Rijswijk to student housing, as a means to overcome the shortage in student housing whilst coping with office oversupply. Numerous CBA-related strategies have been considered, including utilising secondary material, product exchange, preservation and repair of old plumbing systems, and installing lightweight wall panels.

5.1 Motivation and driver for applying CBA-related strategies

Following are the reasons and motivations for applying circular strategies in this project:

1. **Ambitious students who operate a nonprofit organisation:** As a new generation people working in a nonprofit organisation and have the ambition to make a change, they thought about the upcoming generation, and thus, approached circularity to the investor as an important aspect for the future.
2. **Circularity is an economically feasible action for temporary building transformation:** The team realised that the building will be transformed and used for a period of 10 years, and thus, using new material for this kind of projects would be wasteful. Applying circular strategies, such as using secondary materials and reusing existing materials, are feasible for such kind of short-span projects.

5.2 The applied CBA strategies in relation to the CBA determinants

Six out of ten of the CBA determinants were operationalised, using active and passive strategies. Following is a description of the applied strategies corresponding to the relevant determinants:

- **Configuration Flexibility (D1):** Configuration flexibility was barely operationalized in this project. The interviewee stated: *“So, the flexibility is only to say the scalable wall, and it's not that many and projects, yeah, I know our projects at the moment is not that flexible anymore.”*. It was mainly operationalised through the interior walls. Three strategies were incorporated, as lightweight, standardised and separated partitions have been provided. The interviewee stated: *“The walls that we are going to use for one office building I know are the standardized just bricks of saying, yeah, it's the standardized wall bricks that are used for almost everything”* and *“So in one building we're using the same walls that if you compare two over the different buildings”*. Some of the used interior partitions are scalable walls, as stated by the interviewee in the first quotation.
- **Product Dismantlability (D2):** Product dismantlability was barely operationalised as well. Similar to configuration flexibility, product dismantlability was operationalised through the use of lightweight, standardised and separated partitions, as the interviewee stated by: *“The walls that we are going to use for one office building I know are the standardized just bricks of saying, yeah, it's the standardized wall bricks that are used for almost everything”* and *“So when you take out all the walls you, are left with only the construction then you have an open floor plan.”*.

- **Asset Multi-Usability (D4):** Asset multi-usability was operationalised through the principle of sharing the use of the built assets. Different types of spaces have been provided in a sharable manner for the occupants, namely: kitchens, toilets and living rooms. The following quotation is from one of the published archives on the project: *“They will mostly be shared accommodation, in other words, homes in which students share a kitchen, bathroom and/or other amenities.”*.
- **Material Reversibility (D6):** Five strategies have been applied to operationalise material reversibility. These strategies comprise: use of second-hand building products, use of reusable building products, selective dismantling of old building components for reuse, send old building materials for recycling/reuse, and exchanging old building products with suppliers of second-hand building products. These circular strategies were centred and incorporated in the way of providing second-hand building products. Particularly, the interviewee indicated that most of the newly provided building products have been provided on the basis of second-hand. These products have been installed with the considering their recycling/reuse at the end of the projected life-span of this building use (10 years). The interviewee stated *“yeah, I’m not at the end of the life cycle, and 10 years is still a long time, but you can really make already make plan for how you want to detached the building in 10 years already.”* and *“Second reason I think is because our temporary transformations are for 10 years and building materials last longer than 10 years, mostly. So when you use new materials, it’s just a waste of material. Actually, because you use the material that could have been used for 25 years, but when you reuse or use circular materials, you can use it in another building, maybe not. Our project is another project that is also using them for a temporary time”*. However, the interviewee indicated that the team prioritised reusing the existing building products as much as possible, as stated: *“Because one of the most important actions we used to be circular as it is: in the design phase, we look at the floor plan as it was, and we try to fit in all the rooms like that most of the walls from – for example all the wet rooms like showers, kitchen toilets – can stay the same so you do not have to change. The walls that match the walls that are in the correct place can stay there. Some walls need to be removed.”*. The used second-hand products comprise some toilet fixates and fittings, doors and walls. The interviewee stated: *“We use reuse I think now the doors and toilets and that sort of modular stuff, mostly because that’s the easiest to adapt”*. Some of the old building products and material have been sent for reuse/recycling through the contractors, while others have been exchanged with the supplier of second-hand building products with a low price. The interviewee stated: *“I think it is that we are talking to a company and that the materials we don’t use that they can have it for free, and then order projects somewhere else and we can use their materials that they don’t use.”*. and *“Yeah, I think the biggest one is the one that we asked the contractor to take out the old ones for free or also low charges for demolish them in the place, and they reuse them and we get new materials from another partner.”*.
- **Volume Scalability (D9):** Volume scalability was operationalised through the use of lightweight partitions and some scalable walls that is separated from the structure. The interviewee indicated that these walls are removable, at which the openness of

the main floor plan facilitated their installation. The interviewee stated: *“The building already had an open floor plan because it's an office building, so it has already opened down there. Yeah, it is actually an open floor plan as it was so only the structural beams and columns are in there, but we are only putting small walls between them that are for all the rooms there.”*, *“Yeah, in this it's lightweight walls that are just for the noise.”* and *“So when you take out all the walls you, are left with only the construction then you have an open floor plan.”*.

- **Asset Refit-ability (D10):** Asset refit-ability has been barely operationalised in this project. As mentioned in the material reversibility, the interviewee indicated that the utilised second-hand building products have been selected and embodied in line with their projected lifespan. The interviewee stated: *“Second reason I think is because our temporary transformations are for 10 years and building materials last longer than 10 years, mostly. So when you use new materials, it's just a waste of material. Actually, because you use the material that could have been used for 25 years, but when you reuse or use circular materials, you can use it in another building, maybe not. Our project is another project that is also using them for a temporary time”*. Thereby, this could facilitate the accommodation of new products afterwards if need be. The use of lightweight walls was applied in this context as well, as mentioned in the volume scalability. The interviewee stated: *“So when you take out all the walls you, are left with only the construction then you have an open floor plan.”*

5.3 The experienced enabling factors that facilitated the application of CBA Strategies

The interviewee mentioned some of the case-related and non-directly-case-related enablers for the application of the strategies. First, the interviewee perceived the enthusiasm of the team who operates a nonprofit student housing as key enabler. The interviewee indicated that this the enthusiasm of the team to operationalise circularity has motivated them to approach the concept to the investor. The interviewee stated: *“I think the biggest one as I have experienced is the enthusiasm of our board, because we have five students, are doing very enthusiastic about the whole circular idea, and so we pitched it to the investor and they said as long as we do not lose profit, it's OK with us.”*.

Second, in this context, the interviewee indicated that the support the team received from the society – in terms of connect to a network of specialised parties who are willing to guide the team – has provided the team with the source and knowledge needed to apply circular strategies in the project. The interviewee stated: *“We get a lot of people who are willing to help us. Because of our nonprofit organization run by students, we get different contacts from people who could help us and we get to the right parties that are willing to help us for the best prices maybe even, because of the social skill of our project that we are having in. Because the companies want to be part of this social big nice student housing project, their willingness to help and think with us without costing money and just trying to help us the best way they could really helps us getting ahead with other companies”*.

The interviewee indicated other project-specific and strategies-oriented enablers during the interview.. The low cost of second-hand material facilitated their use in the project. The interview stated: *“So when you use new materials, it's just a waste of material. Actually, because you use the material that could have been used for 25 years, but when you reuse or use circular materials, you can use it in another building, maybe not. Our project is another project that is also using them for a temporary time.”*. The interviewee also stated: *“The low price of reusing the material is one of the factors”*. The building modularity and openness of the floor plan facilitated the standardisation of the wall configuration and the use multiple second-hand toilet products. As mentioned in the volume scalability, the interviewee stated: *“The building already had an open floor plan because it's an office building, so it has already opened down there. Yeah, it is actually an open floor plan as it was so only the structural beams and columns are in there, but we are only putting small walls between them that are for all the rooms there.”*.

5.4 The experienced inhibiting factors that obstructed/challenged the application of CBA Strategies

Different interrelated inhibiting factors have been indicated by the interviewee, including project related and non-project related inhibiting factors. First, the interviewee indicated that the monetary aspects constituted one of the key inhibiting factors for the strategies. The interviewee stated: *“I think we should start with the most important one, and that's money, and I think if you have the right company and right people you can just even it out as cheap as new materials. And maybe if everything is just going the best they, we can do it a bit cheaper, even circular, then everything needs to go all right. So yeah, money wise, that's the first problem.”*. Second, dimensional and spatial aspects constituted the second inhibiting factor which has been perceived as interrelated inhibitor with the first one. The interviewee stated: *“What I say here is what we talk about is no fixed measurements”*. The interviewer reflected on that and gave an example on the interconnection between the first two inhibitors, referring to the experience of using second-hand doors. Some of the bought second-hand doors had an initial cost that is less than the cost of new doors by 50%. The team experienced a difficulty to fit the doors out in the building, owing to the mismatch in the measurements (dimensions). Thus, the team had to pay a specialised carpenter to address this problem, resulting in a total product cost – cost of product and its installation – that made the use of second-hand doors economically infeasible strategy in comparison to the use of new doors. The interviewee stated: *“I think that is point, one contractor is pointing out that he's building with one building method – the building blocks, and when he wants to use the door, it doesn't fit the building measurements of his building method with the blocks, so he needs to hire a carpenter to fit those doors, but doors are actually cheaper for him to buy, like 50% cheaper, but then he has to pay carpenter to fit them and the carpenter at the moment is very expensive because there aren't that many carpenters around at the moment that are specialized to do such things. So there's no specialization within his company is holding him back from using the circular doors. I think for our project these are obstacles we're seeing at the moment”*.

The interviewee linked the financial inhibitor with another inhibiting factor, namely: the lack of knowledgeable expertise. Particularly, the interviewee mentioned that advanced circular strategies require experts which might be impossible for small organisations, reflecting on his experience in a nonprofit organisation. The interviewee stated: *“Contractor thinks it's a great idea because they already have other projects that they can use the materials from they have had some experience with reusing it. They already know what they're doing a bit and they. It's more yeah less risky for the big ones to use the circular approach, but with the small ones they have never used it in our life. They don't have someone who specialized in it, and it's just too much risk that something goes wrong because it's a bit more difficult than just setting up a whole new building with whole new walls. Yeah, what I've experienced is that for the smaller constructors, it's just way harder to apply. They can only really use the most easiest to use circular materials The smaller are still willing to use what they can. And then we're talking again about the doors and plumbing fixtures, but I think how bigger the company is, how more circular you can be.”*.