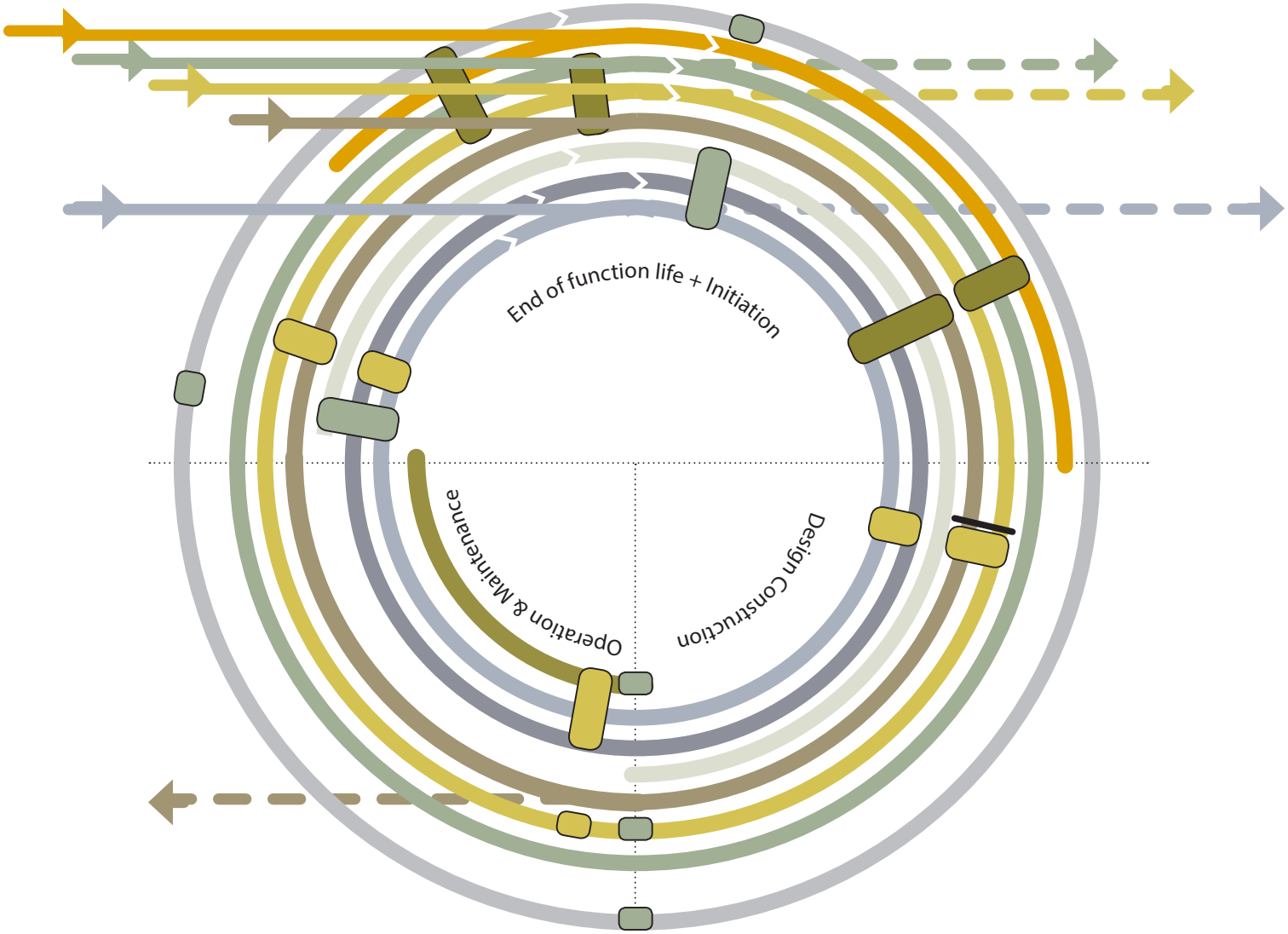

Investing in Circular Transformation

A shift in the role of investors in the circular construction industry

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FOREWORD:
August 2018, I started my Master thesis in the Management in the Built Environment Department at the Faculty of Architecture at the University of Technology at Delft. My research lies within the Real Estate Management sector and has been an offshoot of the study conducted by MOR team (The student team representing TU Delft at the Solar Decathlon competition 2019).

MOTIVATION:
The topic of research was introduced to me as part of my problem solving tasks for the MOR team. Being the student team leader for the Feasibility committee, responsible for building the business plan, I was confronted with how would the project be feasible. Personally I have been eager to understand how to integrate circular solutions within our everyday working because I believe strongly that it is the need of the hour. Having practiced as an architect I understand the amount of waste being generated by the construction sector and the importance of moving in a sustainable way with circular strategies being promising ones. Investigating this topic has increased my passion and am planning to take it further by making feasible circular concepts in construction, eventually with a goal of making a difference in the Real Estate sector. Eventually I would like to help developing countries create a roadmap to transform their existing construction sector to one with minimum waste generation and maximum output. The point of interest for me would be to understand how this concept adapts itself in different contexts in developing countries rather than imitating the western world.

VISION:
In 2015, the European commission has adopted an action plan to speeden Europe's transition towards a circular economy. With the vision to provide for the future generation the Netherlands Government launched a programme to have a fully circular economy by 2050. Which implies a circular built environment. My vision with this research is to develop a roadmap for this transition with a scheme which demonstrates the extent of circularity that can be achieved in transformation projects.

ACKNOWLEDGEMENT:
This dream of studying at TU Delft right from my first year of bachelors would have not been possible without the support and love from my family in India. A big thanks to my mother Rachna Asrani, sister Drishti Asrani for being my biggest pillar of strength in my first venture away from home. This journey seems far from complete without the direction from my Mentors. A big shout out to Hilde Remoy and Peter de Jong for challenging and removing the best out of me while having my back at every step of this amazing journey. Thank you Hilde, your constant support helped me reinforcing my faith in my work and myself. This one year has been a privilege to be able to learn so much from you. Peter, your motivation towards MOR helped me develop as a stronger individual and I cannot be grateful enough for that. Big thanks to Herman vande Putte and Monique Arkesteijn for being important influencer during my overall process at TU Delft.

I would like to thank my partner in crime for this thesis without whose shadow this journey would be incomplete Charitini. A big thanks to Abhas for dealing with all my tantrums and yet standing strong by my side. Thank you Fatima for being the constant in Delft. A big thanks to all my friends for making Delft so memorable. My constants Rajji, Dhiraj and Prajakta have been my strength through this amazing journey. I could not have been more grateful to the entire MOR team for the immense motivation. I am hoping to find an opportunity which facilitates for the execution of these ideas in practice.

I have enjoyed thoroughly and learned a lot during my research process, I hope you enjoy reading it!

ABSTRACT:
Context- Large proportion of the built environment needed to cater to the needs of the future already exists today. The scarcity of resources and constantly growing demand, makes it important to have a well thought of and sustainable method. Circular economy being proposed globally implied indefinite cycles of material usage. This translates in the construction sector as maximum reuse of material in different forms to reduce resource wastage.

Objective- The research aims to validate whether circular transformation of existing built stock could address the growing housing needs of the Dutch real estate market. The research extends to develop a roadmap which would help the investors validate the feasibility of moving in this direction.

Research Question- How would it be feasible for to invest in circular transformation for a future proof-built environment & what would be the roadmap for it?

Methodology- This research will be conducted using a hybrid method. Adopting both the empirical and operational method to understand, evaluate existing data and create a new structure for the construction sector. The process consists of an empirical literature study on the existing ways of working and the concept of circular economy and its implications in the built environment. An explorative study on the aspirations and extent of application and other related to the topic with different investment advisors was conducted. The gap in literature and the practical knowledge would be bridged through this research. Understanding the existing barriers in making this sustainable transformation and aim at finding solutions by revising the role of the stakeholders involved. Operationalize their expectations in a model to achieve the maximum return by investing within this new organizational framework. Analyse the cost of investment and the added value through environmental, socio-economics and financial returns in investment. Try to resolve the risks that exist in the way while making the required investments to realize the circular construction economy. Validate the working of the model in the pilot project of the MOR team.

Results- The circular transformation of underperforming office buildings is made by considering strategies such as Resource Recovery, Product Life Extension, Sharing Platform, Product as a service, Circular Supplies (Accenture, Lacy, 2014). The proposed organisation structure demonstrates a process and fully functioning business model the building owner would have to follow in order to conduct a circular transformation. Assumptions regarding the required infrastructure to support the transition have been made. The roles and relationships shared by different stakeholders have also been developed. The result demonstrates the financial, environmental and social viability in making this transition. Showcasing a feasible outcome specifically for building owners in moving towards circular transformation.

Conclusions- Moving towards circularity will not only have environmental but also social and financial benefits. Using existing under performing building stock strengthens the outcome with an overall better performance. Making it the most sustainable way to address the needs of the future. The implementation of circular business strategies helps make the investment feasible for all the stakeholders by maximizing transparency and profit sharing. In this study it has been demonstrated to be feasible for building owners. Scenarios demonstating the feasibility in different situations helps develop a possible roadmap towards circularity through transformation of existing built stock. However, realization of this business model is only possible with supportive infrastructure and regulations.

Keywords- Circular Economy, Transformation, Adaptive reuse, Financial feasibility, business model, investor, product as a service, roadmap, circular transition, stakeholders

MANAGEMENT SUMMARY

The chain reaction of rapid industrialization, urbanization and consequently globalization has changed the pace and face of development. The constantly growing demand as a result of increase in population has confronted us with the concern of the requirements of the future generations. It is estimated that the world population would be 9.8 billion in 2050 (United Nations, 2017) with 68% of the world population residing in urban areas (United Nations, 2018). Which means a 13% rise compare to the current day scenario. The current linear format of consumption has developed following the industrial revolution. The take-make-dispose model, forms the basis of the current day economy (Andrews, 2015). It is estimated that the global consumption of material resources could double to an annual of 186 billion tons in 2050 (R.Pardo, 2018). The calculated ecological footprint of the planet displays that the world is already exceeding the biocapacity usage by 60% (Network, 2019). "*Ecological Footprint measures the ecological assets that a given population requires to produce the natural resources it consumes (including plant-based food and fiber products, livestock and fish products, timber and other forest products, space for urban infrastructure) and to absorb its waste, especially carbon emissions.* (Network, 2017)."

The resources available today are insufficient to sustain this business in the future. The built environment is a resource intensive sector. It is estimated to contribute for 50% which equals to 250 million tons usage of the raw materials, 40% of total energy consumption, and 30% of total water consumption in the Netherlands alone (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016). Contributing to global warming: 32% of all primary energy is consumed by buildings, resulting in 19% of energy related GHG-emissions (IPCC, 2014). 95% of the waste generated is are being down cycled and eventually used as road fill (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016).

A Dutch government wide programme with an objective to reduce consumption of primary raw materials by 50% (minerals, metals and fossils) by 2030. The aim is that by 2050, the real estate sector and other infrastructure must be built, operated, maintained, re-used and demolished in a sustainable way. Built in a sustainable way they should also be energy neutral (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016). Thus, a circular construction sector by 2050.

Real Estate Issues:
Underperforming office stock
To combat the issue of environmental climate change, reduction of CO2 and to reach higher energy saving as defining during the Paris Agreement, the Netherlands has created a step by step plan. According to this plan all new buildings built at the end of 2020 must be near zero energy. This is the vision for all existing buildings by 2050 (JLL, 2018). According to the new Building Decree amendment, office stock with an energy label less than C cannot be used from 2023 (Bouwbesluit, 2012). It is estimated that 52% of the existing office stock, has a grade of D or lower (Dynamis, 2018). 34.6 million square meters of office is expected to be transformed (Hanff, 2018) In case these buildings owners fail to abide by the regulation, they will be considered as obsolete
(Dynamis, 2018). This has opened a large volume of office area to be transformed.

Housing requirement
Minister of Foreign Affairs Kajsa Ollongren suggested that the Netherlands will need a million new homes by 2030 (Jongeneel, 2018). The study conducted by PBL Netherland and Statistics Netherlands (CBS) predict a growth in households of 8% by 2030. This implies that there will be an increase from 640,000 to 8.4 million with an expected 12% in Amsterdam, 16% in Utrecht, 7% in Hague and 5% in Rotterdam (N.V., 2017). This makes housing a major concern to address the growing needs of the Dutch society.

Problem statement:
The current demand for affordable housing and the volume of underperforming office stock is well recognized. The vision of the Netherlands to have entire office stock above label C while addressing the larger goal of a circular economy makes this transition an important milestone. Adapting the existing stock in a circular way to fit the changing needs would not only demonstrate the viability but also contribute to a more sustainable and future proof-built environment. The method to be adopted and viability of this system is relatively unknown. Currently the Dutch construction sector is only developing and investing in new circular, sustainable projects.

The existing built stock will account for 87% of the built environment in 2050 (Hilde Remoy, 2018). This implies that in order to have a circular built environment all the existing built stock will also have to be upgraded. This stock accounts for a far more impactful outcome with lesser use of materials when transformed compare to a new project. Circular economy could be used for adaptive reuse of existing underperforming, vacant office buildings to combat the vision. Circular economy is an umbrella concept developed by clubbing different concepts and has been evolving since a long time. Due to the ambiguity of the concept definition, change

in conventional ways of working and unknown risks the construction sector has been extremely skeptical in transitioning into a circular economy.

The technical, operational, structural, financial, attitude, legislative barriers makes it difficult to determine a pathway to follow for the circular development let alone a circular transformation. The method to be adopted for circular transformations is relatively unknown. The infrastructure needed to support this transition has not been clearly identified. This increases the uncertainties by multiple folds. The feasibility of a circular business plan is unknown resulting in investors taking a backseat towards this transition. There has been no certain format to access the feasibility of a circular investment since the level of circularity amongst the Layers of Shear by Brand (1994) may differ.

Main Research Question:
As described above, no set organization structure exists for circular transformations to follow. Neither is there a set roadmap which can give a step by step plan, making the transition not very welcomed by investors today. The uncertainties and barriers prevent them from looking at the larger picture not even questioning whether the investments in circular transformations will be viable or not. Thus, the study conducted is focused on testing the feasibility of this concept with the main research question:

How would it be feasible to invest in circular transformation for a future proof-built environment and what would be the roadmap for it?

Sub Questions:
To answer the main question, clarity is needed for the supporting topics. The defined understanding of these topics will help develop the solution for the main research question.
What is circular economy in the built environment?
How would the new organization structure for a transformation process function?
Which stakeholders would be involved in the process and how would they interact?
What would be the process involved in reaching the ideal circular economy within the real estate sector and how would it impact financially for the investor?

Research Methodology
This research is a hybrid of empirical and operational outcomes. An exploratory approach was undertaken to conduct this study. An in-depth study of the existing researches and concepts were conducted. Understanding the current situation helped identifying the approaches and strategies to be adopted for the study. The literature study gave a comprehensive understanding of the work previously done and an understanding about the complexities the market is struggling with.
The conclusions and the unanswered questions from the literature study formed the basis of the qualitative research. Experts from the field were interviewed to understand the issues faced at ground level. The approach of the research conducted is demonstrated in the figure 1. The insights acquired from the interviews helped give direction to the final outcome. The process is demonstrated in the model proposed and the outcome of which will be reflected in the operational cash flow model.

Research Design
The research has been conducted in different phases as illustrated in figure 2. The first phase consisted of literature review to gain an understanding of the different topic and all its complexities. This also resulted in development of the conceptual model for the research. The information collected formed the basis of the second phase of the project which was the exploratory interviews with professionals. This gave a market perspective of the topics in discussion and helped develop an understanding of the scientific perspective while comparing it with the practical world. The third phase was developing the outcome from the study conducted and understanding the loop holes. To bridge in the missing links another set of interviews were conducted , which lead to the

Company Name	Typology	Name of Interviewee	Designation	Status
Bouwinvest	Long term investor	Dick van Hal	CEO	Conducted
Deloitte Real Estate	Advisory firm	Frank Ten Have	Partner	Conducted
Brink Groep	Advisory	Hans de Jonge	CEO	Conducted
ABN-AMRO Bank	Advisory	Casper Wolf	Analyst	Conducted
ING Bank	Advisory	Mayke Geradts	Vice Principal in	Conducted
Circle Economy	Advisory	Joost van Barneveld		Conducted

Table 1: Demonstrating participants for the research

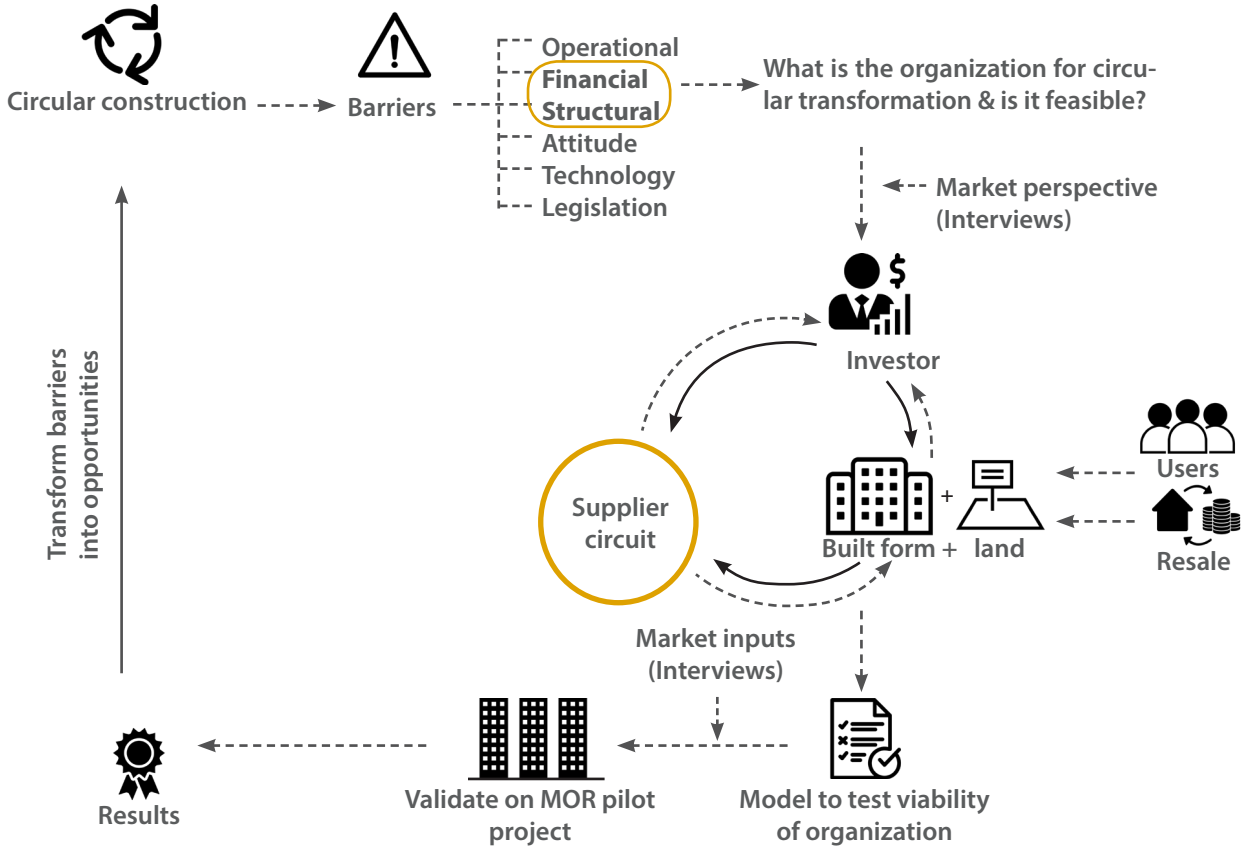

Figure 1: Research design

development of the final model in the 4th phase of the process. The research design may have been a linear one but the process of conducting the research was an iterative one, constantly moving back and forth. The additional information gained during the process made a well-structured argument and the outcome became clearer.

In the literature study conducted in chapter 3, an extensive amount of information was acquired. This information is a perspective of the different authors but does not clearly define the working of the cases in the study. It mentions the limitations and the barriers without throwing light on the complexities of the cases been studied. Thus, the study would be incomplete with only the scientific references. To bridge this gap in practical knowledge an explorative interview round was added.

The interviews are conducted with high stature professional of advisory firms. Companies which plan strategies and develop business models for investors. These companies develop the framework such as this one to help the investors reach his target and develop solutions for the barriers within the process and ways to mitigate the risks. A set of questions were sent out to the partners providing the material to them. The final set of interviews were made to developers from firms with different profiles to understand the mind set in the current market towards development of this kind and the rates for different functions.

Theoretical framework

The research addresses the topic of transformation of existing stock in a circular way. The aim of the research is to develop a circular vision of the existing built stock rather than focusing on new circular constructions. Confronted by multiple barriers, the financial and structural are the ones which form the starting point to address this problem. The implications of this proposal have been assessed against the current transformation processes. The shift in perception would be feasible under certain conditions which have been listed and considered for this study.

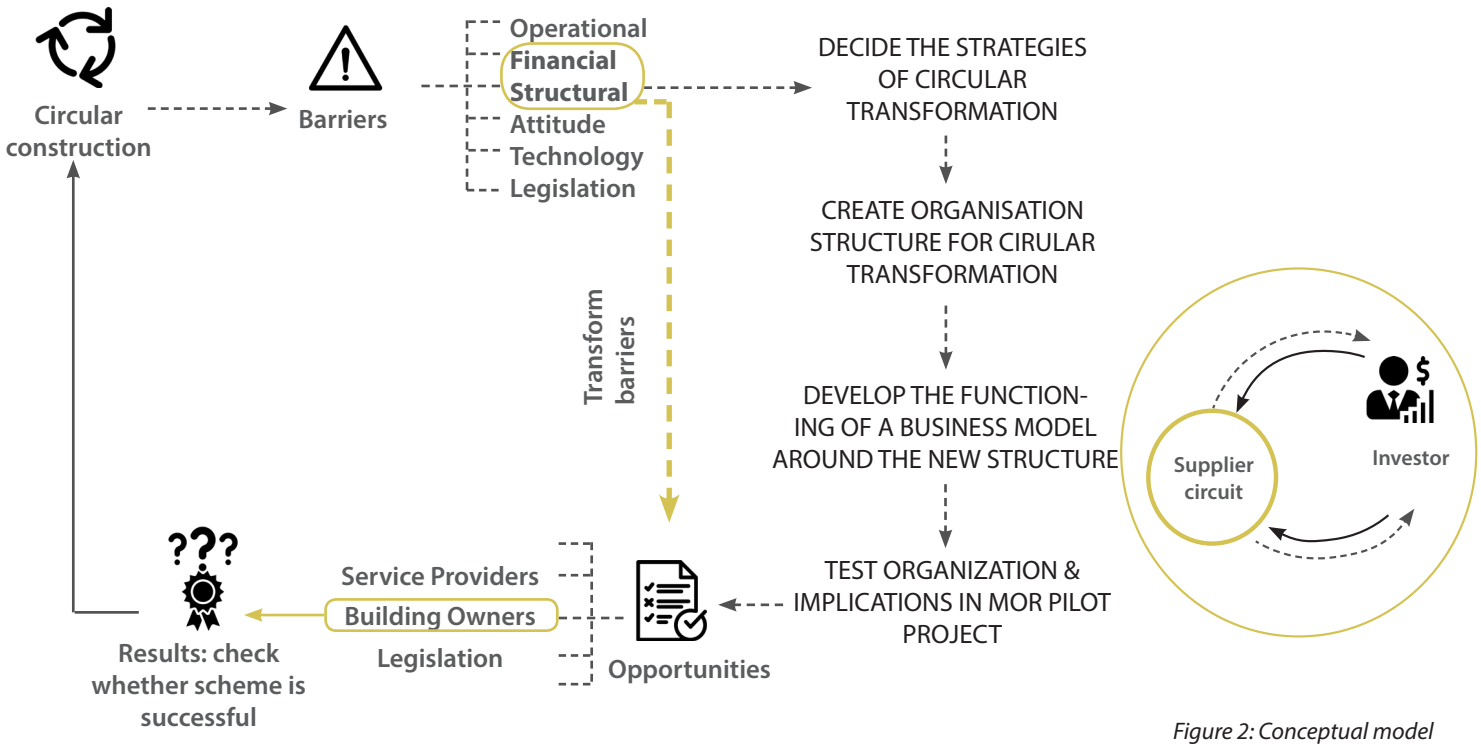

Figure 2: Conceptual model

Changing the pathway from linear to circular gives rise to multiple socio-economic, environmental and financial opportunities. Creating jobs to research and execute the working of the circular system, reusing and reducing waste production. Changing the traditional way of working and adopting sustainable ways to develop a future proof-built environment. The aim of this research is to create a pathway which could be adopted by different stakeholders and demonstrate to the existing building owners the feasibility of making a shift from linear to a circular approach.

Main research outcome
Literature review
Understanding the concept of circular economy was the backbone of this research. It was critical to understand the implications in general to streamline it towards the construction sector. Ellen MacArthur states, "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. This new economic model seeks to ultimately decouple global economic development from finite resource consumption." Implementation of this is translated in the value circle generated by Ellen MacArthur foundation in 2013. (Foundation, 2013)

Circularity is a concept which has evolved over a period of time and as adopted attributes from these varied concepts making it an umbrella concept. The complexities of this concept makes it difficult to focus on generating value in the construction sector. "*A building that is developed, used and reused without unnecessary resource depletion, environmental pollution and ecosystem degradation. It is constructed in an economically responsible way and contributes to the wellbeing of people and the biosphere. Here and there, now and later. Technical elements are demountable and reusable, and biological elements can also be brought back into the biological cycle.*" (Circle Economy, 2018) This is the definition of circularity in the built environment which is going to be considered.

The construction industry has characteristics different from the other sectors due to the varied lifespan of products within it. The implementation of this concept could be translated into the layers of Shear (Brand, 1994) to understand its outcome at the building level.

- Site: The geographical setting, the urban location, and the legally defined lot (eternal);
- Structure: The foundation and load bearing elements (30 – 300 years);
- Skin: Exterior surfaces (20 years);
- Services: Installations (7 – 15 years);
- Space plan: Walls, ceilings, floors, etc. (3 – 30 years);
- Stuff: Chairs, desks, lamps, etc. (< 1 year).

The larger vision is to address the circularity and sustainability goals by being responsible about production of waste, pollution, quality of space while getting rid of the notion that the building is one static product (Elma Durmisevic, 2006). The model of Shear layers of change is expressed in terms of the material/ component. Based on the assembly and the interdependencies of the layers. This can be translated into the impact the product has in relation to each other. The impact of 1 structure is made to skin, service, space planning and stuff. These layers have a direct impact on the amount spent on these layers and the hazardous environmental effects of it (Brand, 1994; P. A. Sattrup, & Schipull Krauschen, J., 2014).

The effects of going circular would not only impact the micro, meso, macro but the also the built environment and inturn the natural environment ((Pomponi & Moncaster, 2017). There are different strategies which have been developed for the adoption of circular economy. In 2014, Accenture Strategies developed 5 Innovative Business strategies with an aim to generate value by capitalising on the opportunities of circular economy. Unfortunately the method to evaluate the societal and environmental value has not been developed. The business models developed by Accenture are based on different themes which can be merged or used in isolation as per the nature of the business. The concepts in this model has been repeatedly used in multiple reports untill today.

The environmental feasibility could be assessed on the selection of the materials, its reusability and recyclability(Steinmann, Huijbregts, & Reijnders, 2019). Functionality of the component is dependent on the selection material and its properties. A research conducted by Ellen MacArthur & Granta (2015) calls this rating Material Circularity Index (MCI). This tool focuses on technical cycles & non-renewable materials as there is an effective outcome and better understanding of benefits of implementing it (Ellen MacArthur foundation, 2015). Quantifying the flow of materials its restoration and considering influencing factors like scarcity, toxicity, etc. According to this tool, the rating of a product is valued between 0 and 1 and the higher rating indicates better outcome of circularity.

The performance characteristics of the circular economy developed by Metabolic, is a wholistic impact driven tool, taking into account maximizing forms of value by use of energy, materials, water resources, along with positive impacts on health & well being, biodiversity, human culture and society (Circle Economy, 2017). A holistic assessment is possible by using Metabolic's performance characteristics of circularity
"Materials are incorporated into the economy in such a way that they can be cycled at continuous high value.
All energy is based on renewable sources.
Water is managed in a 100% circular fashion
Biodiversity is structurally supported and enhanced.
Human society and culture are preserved.
The health and wellbeing of humans and other species are structurally supported.
Human activities generate value in measures beyond just financial"

Renovation is not seen as a cradle-to-grave format, in which the materials have a single usage for a limited amount of time and is disposed of or recycled. Instead it could be looked at as a continuous circuit to upgrade the existing stock to extend its life span. Replacing the inefficient components and refurbishing to improve the overall performance and the life expectancy of the built form could be looked at as one of the main strategies of circularity. With 87% of the built environment required in 2050 in place (Hilde Remoy, 2018). This implies that more than 80% of the built form would be from earlier than 1980s (Pomponi & Moncaster, 2017). This makes it important to focus not only on the new but the existing built stock to create a difference.

Empirical data collection
The findings from this part of the research is that the concept of circular economy is well understood by the market in terms of reducing waste and emissions by making smart design decisions and reusing existing materials. Even though the strategies to implement that differ from company to company. The idea of circularity in built environment was limited to only new constructions for most of the interviewees. On being questioned about reusing an existing structure for circular projects, they found it difficult to comment on it and expected the complexities will be more and the project will not be completely circular. The concept according to them seemed to make adjustments to the current way of working. The newly proposed way would be filled with uncertainties and barriers which will resolve over time.

The stakeholder who would impact the process substantially are the investors, municipalities and users. The investors show interest in owning the real estate asset, municipality in setting the structure and giving direction and the users showing interests seem to be the stakeholders who could be responsible for a dramatic change in the current system. An interesting outcome discussed was of innovators and market disruptors, who have the ability to shake and remold the industry. The secondary resource suppliers and designers have a crucial role in deciding the pace of the transition. The interesting point made while discussing about the stakeholders and their involvement in the process, was the blurring of the role of the current developer. A common trend observed during the interviews was that the developer was never mentioned since their involvement was only short term which goes against the long term vision of circular economy. Understanding that the value chain will be different was evident across all the candidates. Infrastructure and a method to carry out the transaction while ensuring security and protection to all the stakeholders seems to be key issue being discussed. Online portals ensuring maximum security and transparency was looked at as a probable way ahead.

It was observed that the investments for circular and sustainable technology was estimated to be much higher than that of the ones used today. The feasibility of mass utilization is directly proportional to the product pricing. The preferred method for buildings owners is to reduce their investment and life cycle cost. An interesting observation made was that investors are willing to invest in sustainable and circular developments but the available stock is extremely limited. The investments need to be considering the long lasting impression of the investment but it is dependent on the kind of investor it is and their timeline being considered for the investment. Another important aspect is in being able to see the added value within the existing property while only considering the return on investment. The expected timeline for long term investors is expected to be from 15 to 20 years. It is expected that pension funds and long term investors along with financers such as banks happen to be the type of investors who will be willing to take the risk and be a frontrunner in circular investment. Corporate ventures could be developed to invest in the supply chain and depending on the kind of investors they may also be willing to take the risk of investing in a high return, high risk investment in the supply chain. The outcome on the role of an investor in the transition could be looked at as an important, the one who can trigger the transition and must be involved in the process from the very beginning.

Final Concept

The organization and roles of stakeholders are different in circular business model based on product as a service. This implies that the tasks they perform, their role in the process and relationship with other determine the success of the system. The new structure is essential to get the working of the circular in action. Stakeholders form an integral part of this process. Their roles and relationships determine the success of this new system. It is essential for all the stakeholders to be satisfied for the system to work. It is essential for them to collaborate and work with a common vision. The infrastructure provided plays a critical role as a stepping stone in this process. Thus making the Ministry and Municipality a critical stakeholder in designing the future of the cities and contributing to the circular transition in the built environment. Following assumptions are made for the working of the system they include: taxation, value of virgin materials, blockchain, adaptive land use plan, negative discounting, online platforms.

This model displays the different online platforms and shows the ways the stakeholders would interact with each other. Displaying the demand and supply side within the facilitating realm, this model is a graphical representation of all the online platforms mentioned.

To create a business model for a circular built environment it is important to analysis the full life cycle of the building within this new system. For this process to begin it is essential for the investor to initiate the process. Make a decision that something needs to be done to the underperforming existing structure.

The stages involved during a life cycle of circular transformation includes feasibility study as a pre-design phase. This would mark the end of the linear usage of the building and commence the circular transition. The initiation stage consists of a detailed feasibility study. Assessing the structural, technical and financial viability for conducting a transformation on the existing structure.
The financial implication of the above generated circular strategies were implemented in the 3 scenarios using the MOR pilot study. This project is a net positive, circular, mixed use, transformation project based on the Marconi towers in Rotterdam. Different levels of circular investments were testing in the financial models and the feasibility of conducting a circular transformation by the owner of

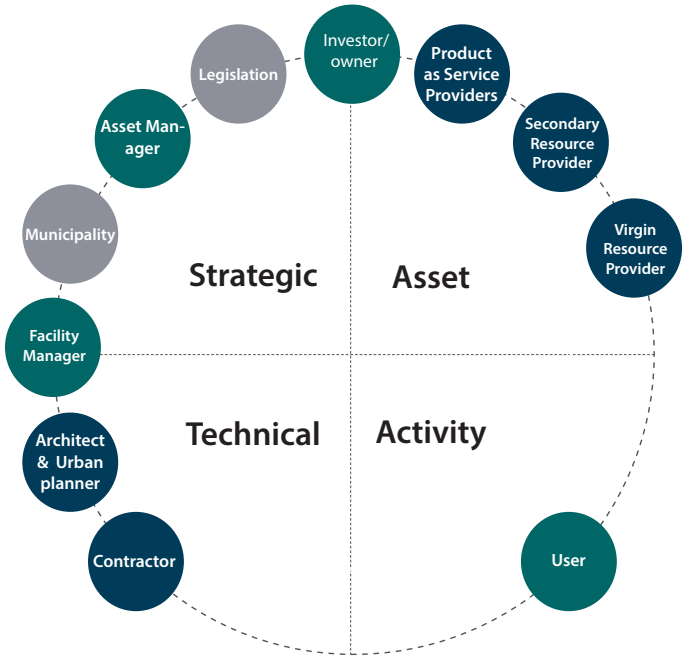

Figure 3: Stakeholders involved in the circular transformation

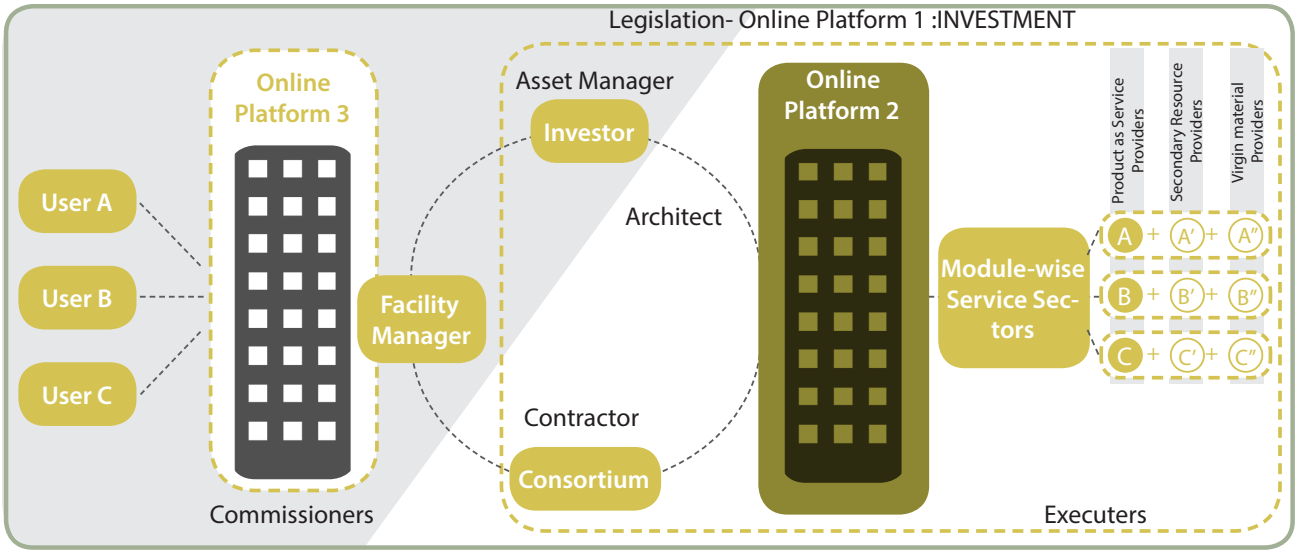

Figure 4: Proposed organization for circular transformation

the building was tested. Making the implementation of product as a service extremely profitable for investors.

Conclusion and Recommendations

The scheme developed shows that the level of profit rises when moved from a linear to a circular way of working. The investments and risks for the building owner reduce but the return received is higher. The model also displays the performance of the investment, making the building owners aware of the level of circularity of their asset at the time of decision making and planning.

The larger aim of this projects is to prove the feasibility for a future proof-built environment. This is by adaptive reuse of existing underperforming or vacant office buildings which are currently under the threat of being shut down by the Dutch government if not addressed. The buildings below energy label C, cannot be used as per the law in 2023 (Bouwbesluit, 2012). By transforming them into mixed functional spaces it increases the inclusive nature resulting in high social interaction, provides a better quality of life, etc. (Builders, 2017). The mixed-use adaptable development means the building can adjust to changing market conditions, reducing the time laps to address the real estate demand. Thus, avoiding the unnecessary rising in prices due to rise in demand.

The other important criteria is providing affordable housing to meet the demand of 1 million new homes by 2030. By adopting a circular way ahead, not only would we be safeguarding availability of materials for the future generations but also reducing emissions to combat the current issues of global warming. Circular economy would also facilitate economic benefits by creating jobs. The dismantling of modular components could help reduce the issue of unemployment in the Netherlands, thus reducing the pressure on the government. In a study conducted by TNO, the circular economy is considered to have a potential of generating 7.3 Billion Euros by creating 54,000 jobs in the Dutch context alone (Ton Bastein, 2013). The estimated global benefit by Ellen MacArthur Foundation is expected to be 1 trillion USD (Foundation, 2013). This would affect the economics and trade across the world. Every region will have to develop a sustainable loop to address their needs and issues locally, creating stronger communities.

Conducting circular transformations with affordable rent levels, demonstrates the feasibility for building owners to move in this direction. Making clear that this concept is could be adopted by every user type without finance being an issue. Giving an opportunity to all user groups to occupy sustainable spaces with high environmental and societal value. Adopting circular strategies not only helps reduce the investment costs for the building owner but extend the lifespan, reduces the maintenance expenditure and ensures material usage at the end of the life span. Making the users more conscious and the service providers active in the process. Thus, reducing the material wastage and incorporating a more conscious approach in utilizing raw materials. The method proposed demonstrates a change in the existing way of functioning which can impact the generations to come. This transition requires initial investments and infrastructure to facilitate it into being, but the most critical success factor is a change in mindset of the society. The feasibility needs to be calibrated juxtaposing the environmental, societal and financial benefits. The method proposed integrates the environmental and financial feasibility while providing better living conditions. Feasibility for all the user, building owners, service providers shows the potential of its implementation on a large scale.

Recommendations:

This research touches the financial and organizational aspect of circular transformation. Making the legal, social, economic aspects of this proposal topics for further research. The validation of the assumptions will demonstrate a stronger and more accurate result. These assumptions at policy level will aid implementing the concept in the built environment. The technical aspects needed to get the system running also need to be developed in detail. Designing for disassembly is essential which needs to be kept in mind while

designing. The research on use of the materials with minimum emissions needs to be developed further by the industry.

The effects of incentives and punishments in bringing circular economy into practice has be understood. This will also impact and will determine the taxation system to support this research. The model developed overlooks the financial implication and throws light on the environmental effects on making certain selections but the impact can be made more explicit. The social and economic effects can also be elaborated on. It should be possible to develop a way to quantify the impact of the decision taken in the impact area model by Metabolic.

The typology study of different building types could be conducted and based on the adaptive reuse of the typology a transformation proposal can be developed. This would create a catalog of the existing built form and help develop a system to address the complexities related to it.

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"Every issue we are facing today is long term in nature and requires systematic solutions. When we have political cycles which are short term in nature and investors who are short term in nature. So the question is who is going to address these issues. We look at everything through a microscope when we have to look at everything from a microscope and telescope."

-Indra Nooyi

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Content:

INTRODUCTION

1.1 Introduction

This chapter illustrates the background information which gives the contextual relevance of the research. The problem is then described and results in the research objective and problem statement. This further develops into the research question and concludes with the research design and eventually the expected results.

1.2 Background Research

The chain reaction of rapid industrialization, urbanization and consequently globalization has changed the pace and face of development. The constantly growing demand as a result of increase in population has confronted us with the concern of the requirements of the future generations. It is estimated that the world population would be 9.8 billion in 2050 (United Nations, 2017) with 68% of the world population residing in urban areas (United Nations, 2018). Which means a 13% rise compare to the current day scenario. The current linear format of consumption has developed following the industrial revolution. The take-make-dispose model, forms the basis of the current day economy (Andrews, 2015). The projected increase in population would increase the pressure on all lively needs. Besides the enormous economic contribution and improvements in human welfare (the circle economy, 2013). the population rise has resulted in the rapid consumption and has led to scarcity of materials and increase production of waste materials (Foundation, 2013).

Its is estimated that the global consumption of material resources could double to an annual of 186 billion tonnes in 2050 (R.Pardo, 2018). Exploiting resources carelessly, the last century has globally been responsible for 34 times more material demand, 12 times more fossil fuel consumption, 27 times the mineral consumption and 3.6 times the usage of biomass (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016). The concept of consumerism has been well rooted in society and found its footing ever since the industrial revolution. With a vision of manufacturing huge quantities at low prices and creating a demand by attaching social status with ownership. "Our enormously productive economy demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfactions, our ego satisfactions, in consumption. The measure of social status, of social acceptance, of prestige, is now to be found in our consumptive patterns ". (Victor Lebow, 1995).

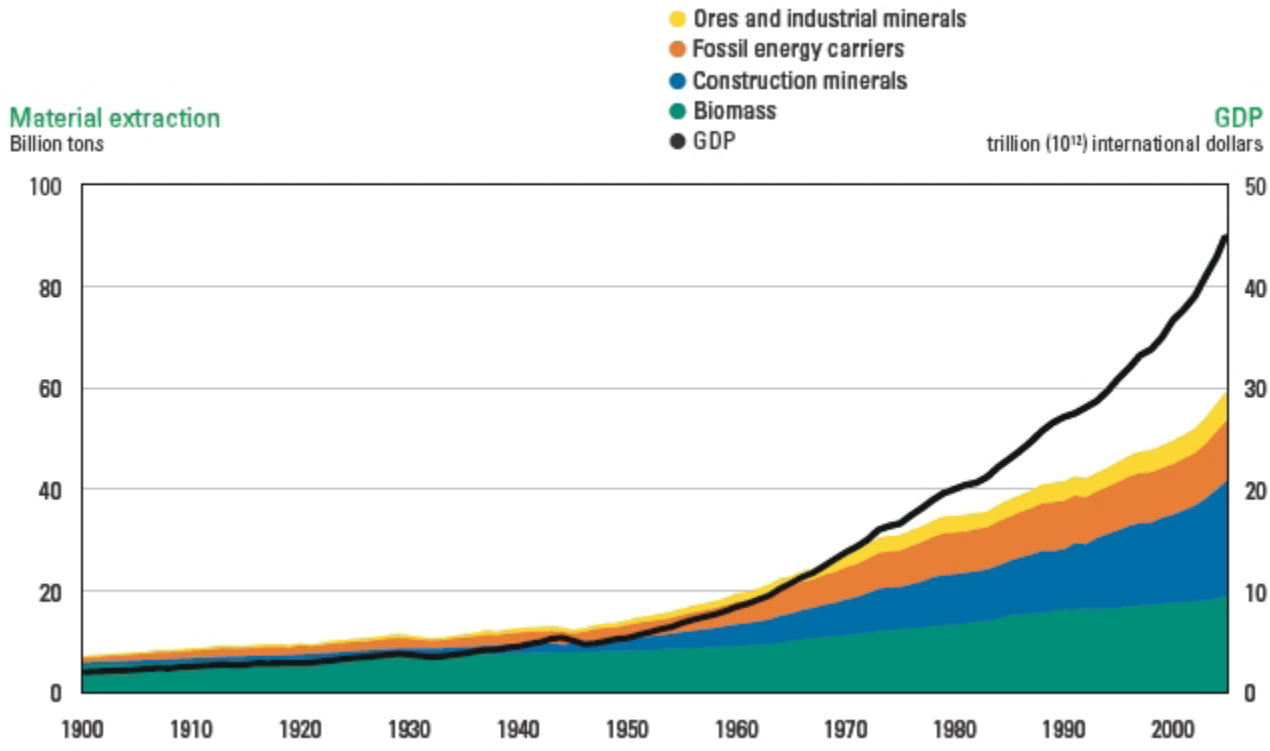


Figure 1: Global material extraction in billion, 1990-2005 Krausmann et al. (2009)

If we continue with the same rate of consumption, with the limited resources available, it will eventually result in extremely high rates of the everyday commodities. Which implies that the ill effects will not only reflect environmentally but also financially and socially. The steep curve in global material extraction unlit 2005 from 1900 in figure 1. displays the consumption patterns.

The future generation will face the consequences of our consumption habits. The issue is that linear business models are based on utilising non-renewable resources, prioritising sales of new products rather than conserving and reusing. These business patterns developed as a result of the industrial revolution, lacks the initiative to share knowledge or innovate and adapt for evolving market conditions (Circle Economy, 2018) all they care about is financial benefits. This mindset has to change to ensure availability of resources for future generations.

The calculated ecological footprint of the planet displays that the world is already exceeding the biocapacity usage by 60% (Network, 2017). "*Ecological Footprint measures the ecological assets that a given population requires to produce the natural resources it consumes (including plant-based food and fiber products, livestock and fish products, timber and other forest products, space for urban infrastructure) and to absorb its waste, especially carbon emissions*" (Network, 2019).

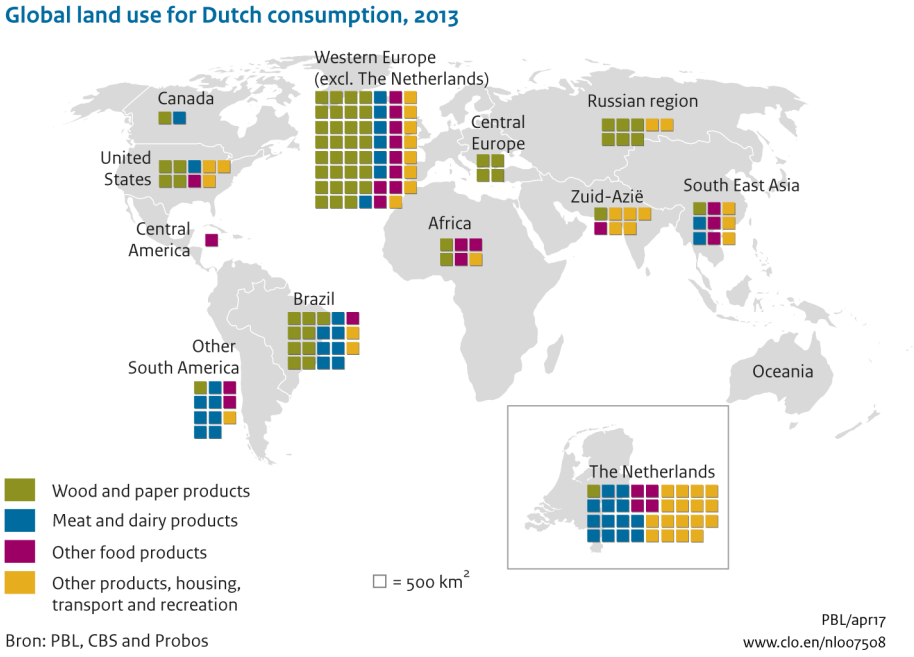


Figure 2: Global land use for Dutch consumption
PBL, CBS & Probos

1.3 Impact of linear economy: Construction sector

1.3.1 Global level

In EU alone, the production of waste in the demolition and construction sector accounts for 450 million tonnes (Osmani, 2011). With the ongoing trend of population growth, increase wealth levels and continuous migration to the cities, would increase the energy use and its resultant emissions by double or even triple by 2050 (Shell International BV, 2011). The different sectors and in particular the real estate sector are increasingly gaining awareness of the ill effects being caused and their importance to reduce the environmental effects (Stern, 2007). There is a need to take a responsive step to minimize wastage of resources. Being completely dependent on the product and service sectors, it is important for the construction industry to find alternatives which are future proof. The role of the construction sector was originally to create durable products with a long-life span. The current trend of demolishing buildings that have years remaining of their service life causes immense loss of embodied energy (Sheila Conejos, 2013). According to the shearing layers of change by Brand 1994, the components in a building could be distinguished based on their probable lifespan. Making the structure, as a component having a life range between 30-300 years. Structures must be designed to be resource efficient, sustainable, adaptable, resilient, fit for purpose and improve the whole life value while also being attractive (Jonathan Goslinga, 2013; Sheila Conejos, 2013). These strategies would impact the future operation, maintenance and disposal of the building and other activities associated with the building (Jonathan Goslinga, 2013). Over the years this approach of a long-term asset has been transformed into a short-term return producing commodity. Resulting in deterioration in quality and character of the built environment.

The resources available today are insufficient to sustain this business in the future. Currently only 3 to 4% of material from non-residential and residential built form are given a second life. A major part of the current materials is downcycled which ends up as rubble beneath roads or as feed into biogas plants. Its is estimated that at least 50% of the buildings can be given a second life(Circle Economy, 2017; A. A. Circle Economy, 2017). Thus, it is the need of the hour to critically evaluate the practice, understand the magnitude of the damage done and act responsibly.

1.3.2 Dutch Level:

The built environment is a resource intensive sector. It is estimated to contribute for 50% which equals to 250 million tons usage of the raw materials, 40% of total energy consumption, and 30% of total water consumption in the Netherlands alone (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016). Contributing to global warming: 32% of all primary energy is consumed by buildings, resulting in 19% of energy related GHG-emissions (IPCC, 2014). 95% of the waste generated is are being down cycled and eventually used as roadfill (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016).

1.4 Combating the problem: Visions

1.4.1 EU level

According to the European Union, construction and demolition waste has been identified as a stream of priority waste. According to the waste framework directive, article 11.2 "Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17.05.04 in the List of Wastes shall be prepared for re-use, recycled or undergo other material recovery" (including backfilling operations using waste to substitute other materials) (European Commission, 2018). The transition towards a circular economy could be seen as an opportunity to reduce ecological footprint of Europe (R.Pardo, 2018) and intern the global footprint. Minimizing resource consumption and wastage by reusing and recycling materials and products, forms the basis of circular economy. This concept could play an important role in achieving the objectives of the Paris Climate Agreement. While considering the environmental benefits at a global level, an annual economic advantage of 2 billion is estimate (UNEP, 2017). The estimated benefits of this circular vision at the EU level of creating 1.2 to 3 million jobs, reduce demand of raw materials by 70 to 184 Mt (excluding fossil fuels and energy carriers) and by 80 to 154 Mt of greenhouse gasses, this means 56% reduction of emission by 2050 (R.Pardo, 2018).

1.4.2 Dutch Level

A government wide programme with an objective to reduce consumption of primary raw materials by 50% (minerals, metals and fossils) by 2030. The aim is that by 2050, the real estate sector and other infrastructure must be built, operated, maintained, re-used and demolished in a sustainable way. Built in a sustainable way they should also be energy neutral(Netherlands, nd). Thus a circular construction sector by 2050. Which leaves the construction sector with 12 years or so to be redesigned and built in a way to reuse the existing construction materials or biomass. This goal is quite extensive with a lot of planning and work to be done by the sector (A. A. Circle Economy, 2017).

This leads to the following vision by the Dutch Government:
"*By 2050, the construction industry will be organized in such a way, with respect to the design, development, operation, management, and disassembly of buildings, as to ensure the sustainable construction, use, reuse, maintenance, and dismantling of these objects. Sustainable materials will be used in the construction process, and designs will be geared to the dynamic wishes of the users. The aim is for the built-up environment to be energy-neutral by 2050, in keeping with the European agreements. Buildings will utilize ecosystem services wherever possible (natural capital, such as the water storage capacity of the sub-soil*" (The Ministry of Infrastructure and the Environment and the Ministry of Economic Aff airs, 2016).

1.5 Real Estate Market

1.5.1 Underperforming office stock

To combat the issue of environmental climate change, reduction of CO2 and to reach higher energy saving as defining during the Paris Agreement, the Netherlands has created a step by step plan. According to this plan all new buildings built at the end of 2020 must be near zero energy. This is the vision for all existing buildings by 2050 (JLL, 2018). According to the European Energy Efficiency Directive, 75% of the existing built stock is energy inefficient and 35% of these buildings are older than 50 years (EU, 2018). According to the new Building Decree (Bouwbesluit, 2012) amendment, office stock with an energy label less than C cannot be used from 2023.

It is estimated that 52% of the existing office stock, has a grade of D or lower (Dynamis, 2018). 34.6 million square meters of office is expected to be transformed (Hanff, 2018). In case these buildings owners fail to abide by the regulation, they will be considered as obsolete (Dynamis, 2018). This has opened a large volume of office area to be transformed.

1.5.2 Housing requirement

Minister of Foreign Affairs Kajsa Ollongren suggested that the Netherlands will need a million new homes by 2030 (Jongeneel, 2018). The study conducted by PBL Netherland and Statistics Netherlands (CBS) predict a growth in households of 8% by 2030. This implies that there will be an increase from 640,000 to 8.4 million with an expected 12% in Amsterdam, 16% in Utrecht, 7% in Hague and 5% in Rotterdam (N.V., 2017). This makes housing a major concern to address the growing needs of the Dutch society.

1.5.3 The way ahead?

The industry seems to be ignoring the existing built stock while speaking about this transition. 75-90% of the existing built stock in the Northern hemisphere will be standing in 2050. Which implies that more than 80% of the built form would be from earlier than 1980s (Pomponi & Moncaster, 2017). "*Buildings can be constructed in a modular way. The flexibility of multifunctional buildings ensures that buildings have a longer life span despite the varying demands of residents and users. This underlines the role of architects and property developers in the design of buildings that are suitable for redevelopment. Modular construction can contribute to rapid and cost effective adaptation of different building functions, reducing vacancy and optimising unused building space." Vision of circular construction (Gemeente Amsterdam, nd). Statements like the one stated above, clearly indicate that either a n*ew or a tabula rasa approach or only new construction could be the way ahead to implement circular construction. Most reports leave the term "re-development" ambiguous, not mentioning whether it is based on refurbishment of existing stock or based on demotion and building a new project. A convenient way to acknowledge its presence but avoid going into details to address the way ahead.

The reason the industry chooses to stay away due to the complexities and uncertainties that come with transformation. Redevelopment is an easier option since all the details and function of the building and in case of the circular construction the future use could be kept in mind while designing. With the vision of the Netherlands and the existing built stock we are confronted with a major issue since at the end of the day it all comes down to whether transformation is feasible.

METHODOLOGY

The previous chapter, explains the context of the research, throwing light on the magnitude of the issues both at global and national level for the Netherlands. Responses planned to combat these issues in the long run along with the ongoing real estate issues being faced by the Dutch government. The method for solving these issues within the construction sector is relatively unknown which results in the following problem statement.

2.1 Problem Statement

The current demand for affordable housing and the volume of underperforming office stock is well recognised. The vision of the Netherlands to have entire office stock above label C while while addressing the larger goal of a circular economy makes this transition an important milestone. Adapting the existing stock in a circular way to fit the changing needs would not only demonstrate the viability but also contribute to a more sustainable and future proof built environment. The method to be adopted and viability of this system is relatively unknown.

The current office building owners are ignoring the requirement and delaying the decision making process to transform or redevelop their underperforming assets. The government can develop an action plan which helps in achieving the vision in the long run. There are multiple unanswered questions which makes it difficult to put this vision to action which include technological, financial, structural, organizational, legislative and attitude act as barriers (Ritzen & Sandstrom ,2017, Oghazi and Mostaghel, 2018, World Economic Forum, 2018).

The roadmap planned for this transition, takes into account more new developments than transformation projects. With 2/3rd of the built form required in 2050 already in place, the authorities are only touching the surface of the water rather than planning a dynamic change. The current planning is also extremely vague and the direction is unclear. The return on investments, possibility of subsides, unnecessary mandate, current demands for circularity makes it convenient for investors to avoid considering circularity as a topic to consider for their portfolios. Leaving users ignorant of the possibilities that could exist. The solution in hand related to technology and innovation have not been considered for upscaling since there is no demand for it. This creates just like sustainability a vicious cycle for circularity.

2.1.1 Circular Transformations

Circular Economy as a concept is a result of development of multiple ideas over a period of time. Making it an umbrella concept without a fixed definition. Applying circular concepts in transformations makes it important to identify the level at which it can be applied. There are multiple models in the market to validate the performance of the design (KPIs- key performance indicators) but a standardized model is lacking. The financial implications is critical for the widespread implication of this concept. The transformation has be feasible for the existing owner to consider this as an option.

2.2 Research Questions

The objective of this research is to derive an answer for which organization structure would facilitate circular transformation in the built environment. What needs would be satisfied through this system. The roles different stakeholders would play and the effects it would have on the entire industry. It would help in investigating whether the investments could be profitable for the investors. The business model and the organization would be designed to address the challenges which are being faced in practice. With an aim to maximize transparency which is lacking in the current way of working. The aim on one hand would be to optimise the output of the services being provided by the suppliers while minimizing costs for the end users. So experimenting with the structure in which all these stakeholders would interact. Point out the critical trigger factors which would aid this transition. Explaining the
Satisfying the needs of the different stakeholders and making the investments feasible would attract investors to move in this direction and would help close the loop to achieve a circular built environment.

2.2.1 Main Research Question:

How would it be feasible to invest in circular transformation for a future proof-built environment & what would be the roadmap for it?

2.2.2 Sub Questions:

What is circular economy in the built environment?
How would the new organisation structure for a transformation process function?
Which stakeholders would be involved in the process and how would they interact?
What would be the process involved in reaching the ideal circular economy within the real estate sector and how would it impact financially for the investor.

2.3 Methodology

2.3.1 Project Scope:

Functioning in a circular method remain relatively blur for most of the stakeholders since the pathway and scope remains unknown. The research aims to clarify the system and put light on the process that would help reach the required results.
The research includes:
Proposing a system for transformation, which would define which stakeholders would be actively involved and to what their roles would be. The kind of infrastructure needed to support working in a circular way in the real estate sector.
The study aims to demonstrate the feasibility for a investor to transform his existing asset in a circular way. The study is centric to transformation due to the existing volumes which need to be addressed. The outcome however could be applied to different typologies based on the properties they possess.
Using building circularity index developed by Ellen MacArthur foundation & Granta(2015) in the layers proposed by Brand (1994) to demonstrate the extent to which the existing structure could be made circular. This process would help the investors with the decision making process and assess the impact on the profit being made in transforming the asset in the method proposed.

2.3.2 Research Methodology

This research is a hybrid of empirical and operational outcomes. An exploratory approach was taken to conduct this study. An in depth study of the existing studies and ideas available. Understanding the current situation and identifying the approaches and strategies to be adopted for the study. The literature study gave a comprehensive understanding of the work previously done and an understanding about the complexities the market is struggling with.

The conclusions and the unanswered questions from the literature study formed the basis of the qualitative research. Qualified professionals from the field were interviewed to understand the issues faced at ground level. The approach of the research conducted is demonstrated in the table 1. The insights acquired would be demonstrated in the model proposed and the outcome of which will be reflected in the operational cash flow model.

2.3.3 Literature Review

The literature study was conducted to gain an understanding of the situation in hand and the existing studies conducted. This also throws light on the probable solutions the market has proposed and their complexities. The study conducted covers the following topics:

Understanding the concept of circular economy.
Historical development of the concept of circular economy.
Effects of implementing of circular economy in the built environment.
The area the strategies are expected to impact.
Study the proposed strategies and the business models proposed by the industry and understand their complexities.
Comparison between new circular buildings and transformation of existing built stock in a circular way and understanding the effect of it. Also assessing the impact of focussing on either of the topics.

The study helps define the concepts in discussion like that of circular economy. By identifying the key topics to be addressed the focus could shift to the aspects related to implementing it. The literature study reflects on the existing barriers in moving towards a circular economy in the built environment. Which helped narrow down and developing the scope of the research.

The business model concepts and strategies for implementation are investigated in the the literature study. The effect of while is reflected in the layers by Brand (1994). This helps give the transformation a certain value. Which helps the overall functioning of the system.

2.3.4 Ex-ante

Financial model is about proposing a change in the existing situation for an improvement for the future. (Barendse et al., 2012). The proposed outcomes are tested in a pilot case study, a way to validate the outcomes. The operational outcome gives the market the relevant to assess the results and to understand the its limitations and strengths. For the purpose of this research the MOR pilot

study has been selected as a case to test the outcomes.

2.3.5 Pilot Study

Figure 3: Proposed design MOR team

The MOR team is representing the TU Delft in the competition of Solar Decathlon 2019, which is to be held in Hungary. The competition is focused on design and creating the most energy sustainable home for the future. This already builds a very high goal of being positive for the 5 elements which include: Air, Water, Energy, Biomass, Material. The core principle defined by the team is to create affordable, mixed function transformation using the existing vacant office building of the Marconi Towers in Rotterdam. The tower and its 2 other identical towers which stand besides form the well known corporate landmark for the area and the city. The overall aim is to have a future proof-built environment which has the ability to adapt to the future requirement. The study targets the existing buildings which forms the larger proportion of the built environment in the future.

The building complex with the 3 identical buildings have a typical 80's floor plan with a central core and open floor plate surrounding it. This typology is seen across the globe which makes it a large number of similar building. The building into consideration happens to remain vacant while planning for its transformation. This building is just an example of the multiple underperforming unoccupied buildings in the large cities of the Netherlands. This will not only result in losses for the owners but also for the cities. The team has adopted for circular transformation as a method to address this issue while creating affordable homes which are in deficit for the starter group in the housing market. The target occupiers are the young professionals who have recently stepped into their professional work life and are unable to deal with the expensive housing the city has to provide. The leased based housing is proposed as a solution for this target audience within the MOR concept.

Being a pilot study, without any restrictions in policies makes it a good platform to test the results of this research. Material/ service supplier (partners) are willing to share and contribute to this experiment which makes it easier to access information and validate its extent of circularity. Giving the freedom to explore probable options to adopt this kind of transformation.

2.4 Project Design

2.4.1 Research Design

The research has been conducted in different phases as illustrated in figure 4. The first phase consisted of literature review to gain an understanding of the different topic and all its complexities. This also resulted in development of the conceptual model for the research. The information collected formed the basis of the second phase of the project which was the exploratory interviews with professionals. While gave the market perspective on the information collected. This helped develop an understanding of the scientific perspective while comparing it with the practical world. The third phase was developing the outcome from the study conducted and understanding the missing data. To fill in the missing links another set of interviews were conducted. Which lead to the development of the final model in the 4th phase of the project. The research design may have been a linear one but the process of conducting the research was constantly moving back and forth. The outcome that evolved as information got clearer during the process.

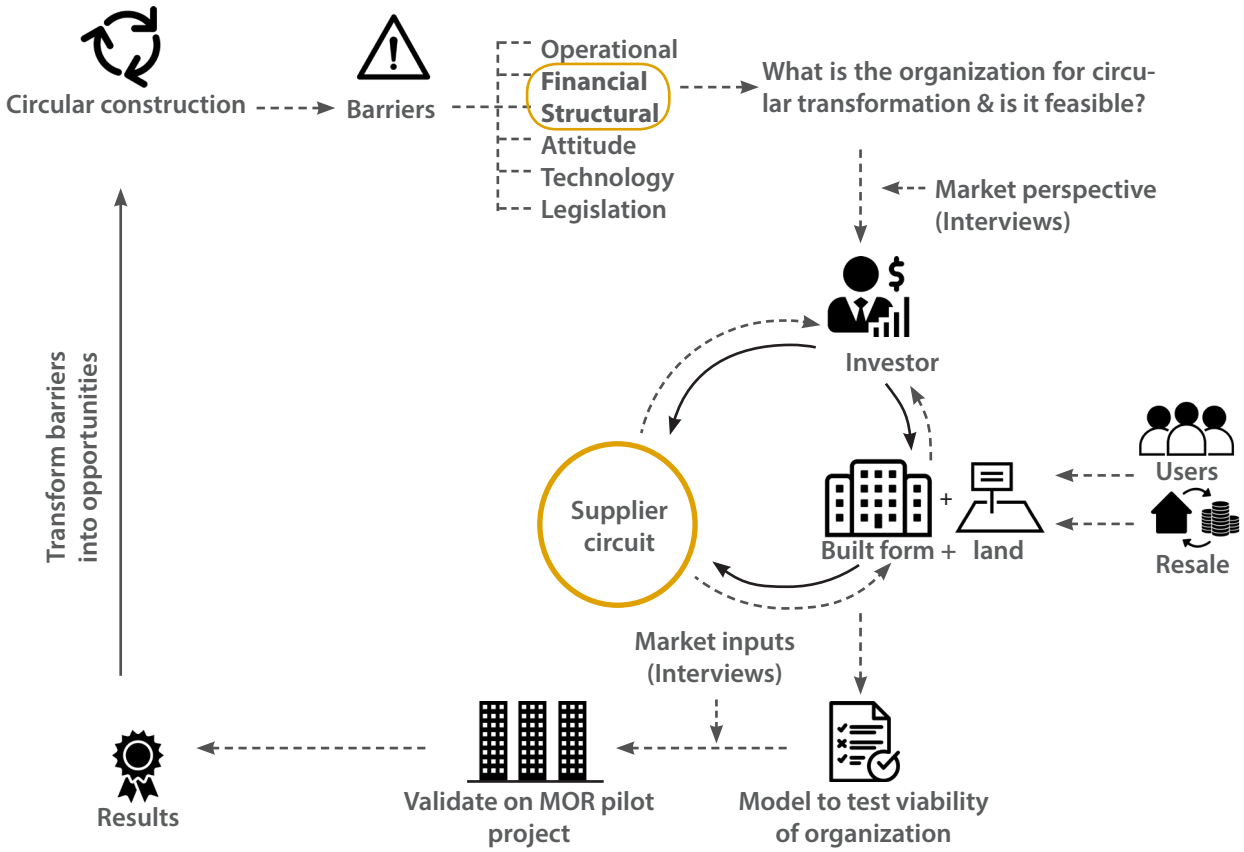


Figure 4: Research design

Company Name	Typology	Name of Interviewee	Designation	Status
Bouwinvest	Long term investor	Dick van Hal	CEO	Conducted
Deloitte Real Estate	Advisory firm	Frank Ten Have	Partner	Conducted
Brink Groep	Advisory	Hans de Jonge	CEO	Conducted
ABN-AMRO Bank	Advisory	Casper Wolf	Analyst	Conducted
ING Bank	Advisory	Mayke Geradts	Vice Principal in	Conducted
Circle Economy	Advisory	Joost van Barneveld		Conducted

Table 1: Participants for the research

In the literature study conducted in chapter 3, an extensive amount of information was acquired. This information is a perspective of the different authors but does not clearly define the working of the cases in the study. It mentions the limitations and the barriers without giving all details of the cases been studied. Thus the study would be incomplete with only the scientific references. To bridge this gap in practical knowledge an explorative interview round was added.

The interviews are conducted with high personels of advisory firms who plan strategies and develop business models for investors. These companies develop the framework such as this one to help the investors reach his target and develop solutions for the barriers within the process. A set of questions were sent out to the partners providing the materials to the team. The final set of interviews were made to developers from different types of companies to understand the mind set in the current market towards development of this kind and the rates for different functions.

2.4.2 Theoretical framework

Conceptual model:

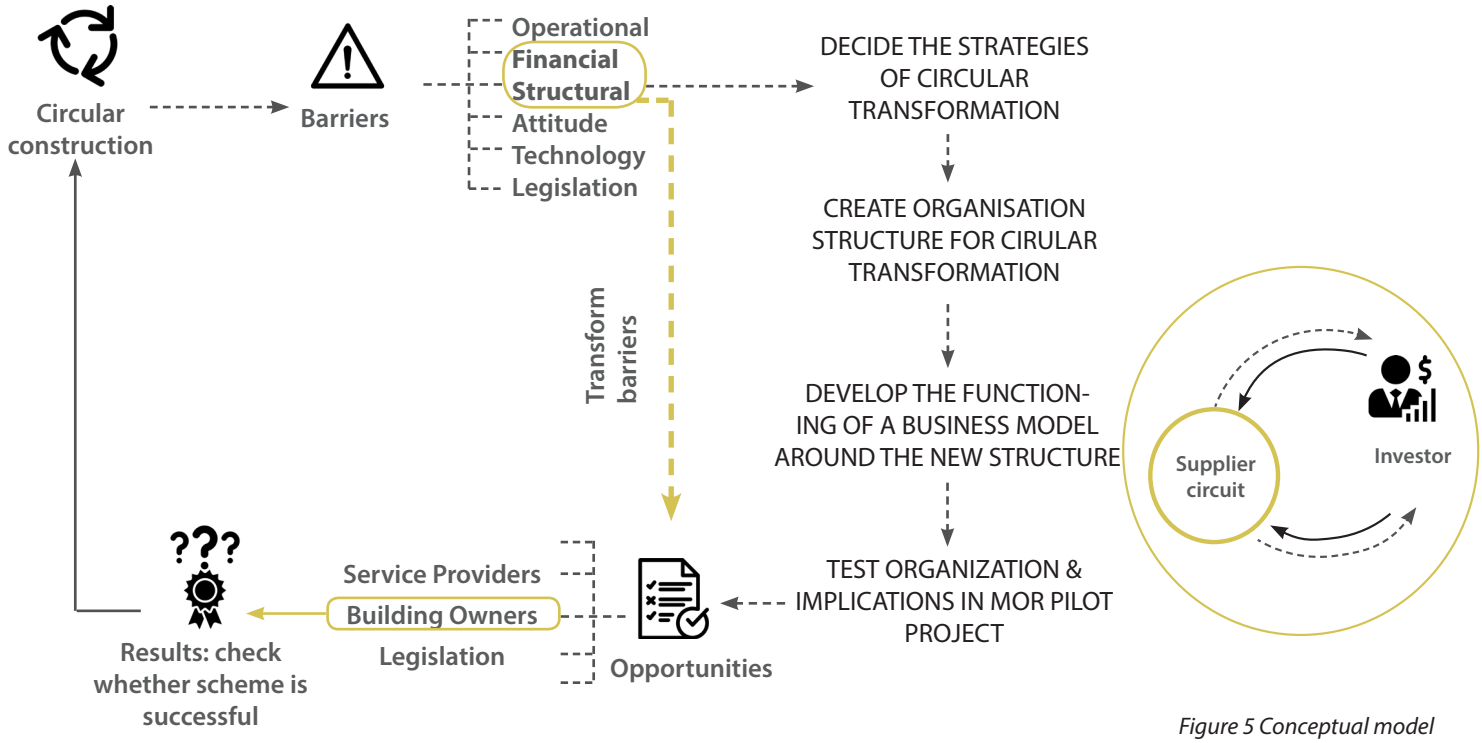


Figure 5 Conceptual model

The research addresses the topic of transformation of existing stock in a circular way. The aim of the research is to develop a circular vision of the existing built stock rather than focussing on on new circular constructions. Confronted by multiple barriers, the financial and structural ones formed the starting point to address this problem.The implications of the proposal have been assessed against the current, process of transforming and the fully functional circular system. The shift in perception would be feasible under certain conditions which have been listed and considered for this study.

Changing the pathway from linear to circular gives rise to multiple socio-economic, environmental and financial opportunities. Creating jobs to research and the execute the working of the circular system, reusing and reducing waste production. Change the traditional way of working and adopt ways sustainable for the development of a future proof built environment. The aim of this research is to create a pathway which could be taken up by different stakeholders and demonstrate to asset owners the feasibility of making a shift from linear to a circular way of thinking.

2.5 Expected Results

The research aims to develop a roadmap for transforming underperforming existing built stock from a linear to circular transformation projects. This is done by addressing the issue of upgrading the energy inefficient office stock by transforming rather than demolition thus realizing the vision of circular construction sector. To bring the circular transformation into practice a business model has to

be feasible for all the stakeholders. A detailed scheme of the roles the different stakeholders would play in the process of circular transformation has been developed. This further translates into the organization of the different stakeholder within the transition model towards a circular construction sector and a fully functional construction sector. For this a set of assumptions have been considered which are based on facilitating infrastructure or incentive or punishment.

The organisation of the same project under the different scenarios (i.e. process and fully developed circular construction sector) helps develop the financial model demonstrating the feasibility from the investor perspective. Thus showing the feasibility of moving towards an environmentally, socially and financially better performing way of working. The model developed is keeping in mind the complexities of the particular case but can be adjusted to adjust to fit other transformations.

2.5.1 Deliverables

This graduation started in August 2018 and is expected to be concluded by July 2019. The research is divided in 5 phases, each of which ends with a progress report handin and a presentation about the findings. A research planning illustrating the different phases could be found at the end of the chapter.

Time schedule:
Phase 1 - Exploration
Phase 1 marked the start of the research with selection of the topic in the field of interest. The topic is strengthened with academic literature and reports as references. This phase ends with a presentation demonstrating the field of interest and the relevant goals with the research.

Phase 2 - Theoretical + empirical method
Phase 2 is about gathering the relevant data about the topic of study and defining the scope of the research. The literature study is conducted using scientific literature, company reports and published articles to strengthen and articulate the argument. This phase results in a designing the conceptual model, deciding on the method to be adopted for the next phases which will help answer the main questions. In the case of this research the interview protocol had been created and 3 interviews have been conducted.

Phase 3 - Empirical + theoretical methods
Phase 3 is a continuation of phase 2 where the interviews with the remaining participants would be conducted. The empirical and scientific literature would be analysed and the gaps in literature would be identified. The theories based on the interviews would be looked into to strengthen the research. Phase 3 should end with ideas to develop the business model. This would be in terms of the organization structure of the business model.

Phase 4 - Cash Flows & Development of the business model
Phase 4 would be about developing the business model based on the selected organisational structure. Study its implications, restrictions and the reaction on the urban fabric. Conduct another round of interviews to fill in the existing gaps in order to create a functioning business model.

Phase 5 - Conclusion

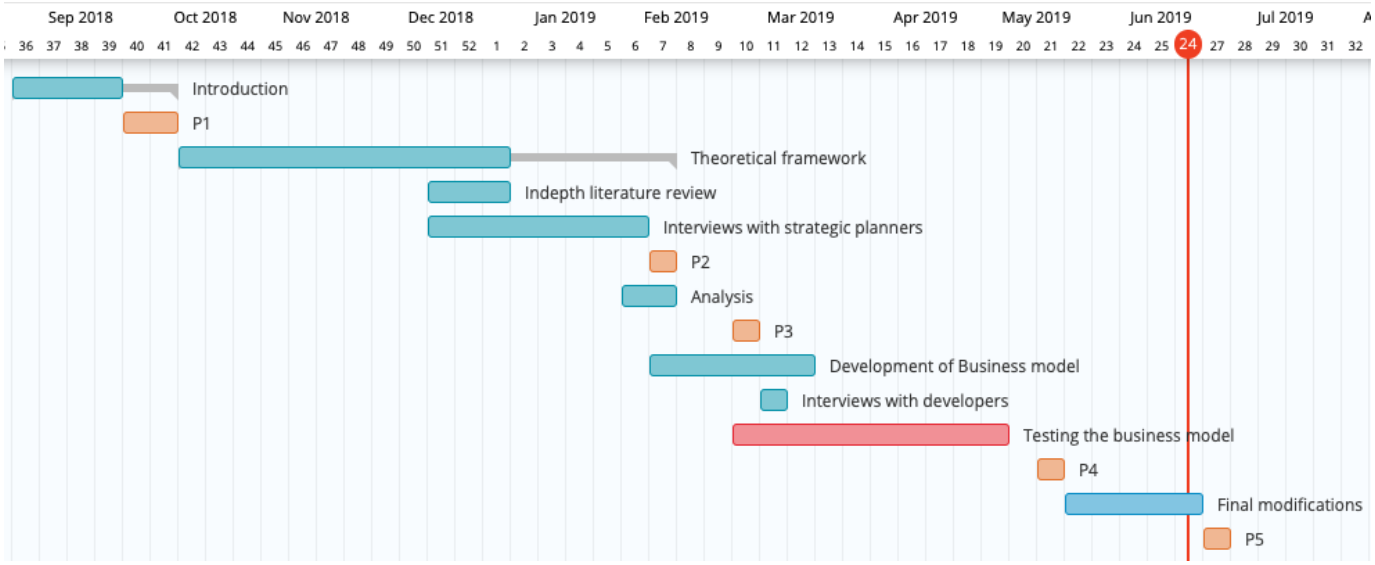


Figure 6: Timeline for the research

LITERATURE STUDY

Based on the introduction of the issues of linear consumption and the vision of combating it at a global at Dutch level in chapter 1, the literature study elaborates on the concept of circular economy. The evolution of multiple theories over the years which lead to the development of the concept of circular economy. The implications of the concept when translated into the built environment. The probable results that are expected as a result of implementing this new responsible way of working. Finally, the ways in which this concept could be included in the construction sector and how would it impact the overall real estate sector.

3.1 Circular Economy

Circular economy could be referred to as a restorative or regenerative industrial economy by intention and through design (Foundation, 2013). The adoption of which offers environmental quality, social equity and economic prosperity(Kirchherr, Reike, & Hekkert, 2017). It suggests to replace the predominant linear value method which is based on take-use-waste with a closed circuit where materials are infinitely used (Stahel, 2012, 2016). An economy in which the commodities are designed for maximum reuse using human labour, skill and knowledge(Stahel, 2012). A study conducted by Kirchherr et al (2017) shows the issues the industry is facing to just evolve to a single definition. This is due to the different aspects that this topic covers. With an idea to create a substantial future the Circular Economy impacts the roots of the industry the effects of which are experienced all across. For the purpose of this study the definition by Ellen Mac Arthur Foundation, 2013 will be referred, which is, "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. This new economic model seeks to ultimately decouple global economic development from finite resource consumption." The figure generated by Ellen MacArthur foundation is well known as the Butterfly Diagram,

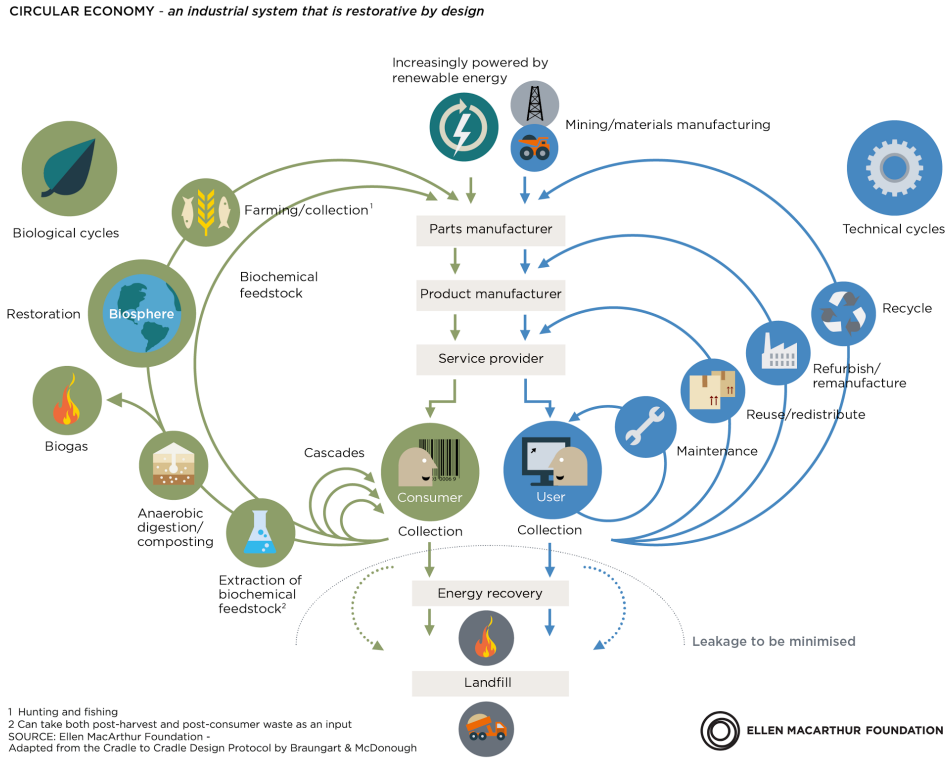


Figure 7: Butterfly model (Ellen MacArthur Foundation, 2013)

This model is a visual representation of the circular economy by the Ellen MacArthur foundation. The diagram showcases the careful flow of materials in order to close the loops maintain the the value. Comprising of both the biological and technological cycle. The biological cycle is where the residues are directed back into the biosphere in order to build future natural capital. The blue technological cycle is the one where the material residues of all non-bio materials are designed to be transformed and reused without entering into the biosphere. The 5 main principles on which circularity is based on according to Ellen MacArthur foundation is designing out of waste, building resilience through diversity, Shift to renewable energy source, system thinking and Cascade thinking (Foundation, 2013). To understand this multilayer concept it is important to understand its historical evolution.

3.2 Historical development

This section explains the concepts which have developed into the concept of CE. Underlining the vision of these concepts which come together to create the imagined vision of CE. The table below mentions the year of evolution of the concept. A detailed description of the concept and the vision of the creators. A comparison is drawn with the associations with CE. The focal point of the vision is mentioned in the last column. This study is important to gain an overview of the development and understand the importance of the different concepts that come together to create the concept of circular economy and eventually conjecture what its future would look like. Circular Economy is an umbrella concept, bridging gaps within the previously developed concepts which may not have been directly related but work come together and pay attention on particular or shared characteristics that these concepts have (Blomsma & Brennan, 2017). The idea of biomimicry which is imitating concepts from nature in solving modern day engineering problems, forms the basis of the circular economy. The study of the historical developments is essential to predict the future of the concept.

Table 2: Historical development of CE Source: World Economic Forum, 2018 pg. 8,9, , CIRAIG (2015), Kate Raworth (2013-18) (OWN TABLE)

Year	Concept	Description	Association with circular economy	Relevance
1960 LCT is environmental Life Cycle Assessment (LCA), which started in the 1960s, as partial LCAs. Guinee et al. (2010) split the development of LCA in three main stages:1) Conception (1970-1990); 2 Standardization (1990-2000); 3) Elaboration (2000-present).	Life cycle thinking (LCT)	Focus on reducing environmental impact by incorporating Life cycle assessment (LCA) and life cycle management (LCM). The ISO benchmarking considers eco-efficiency method in all the stages to reduce the environmental impacts to the minimum.	LCT include- LCA & LCM, the focus is to minimize resource consumption and pollution while maximizing value, while CE looks at absolute sustainable solutions.	Considers the method involved in the overall process. Focus on process outputs
1970 (John T. Lyle according to Ellen MacArthur Foundation (2013)	Regenerative Design(RD)	RD is focused value of living within the limits of available renewable resources without environmental degradation, in a regenerative way.	The idea of the organising all systems in a regenerative way could be a link between CE and RD.	Does not mention the process only the output. Focus on regeneration- closed loop.
1987 (Gro Harlem Brundtland's Report for the World Commission on Environment and Development (WCED), Our Common Future)	Sustainable development (SD)	SD is a dynamic yet a holistic combination of development that includes development in the economic , environmental and social dimension.	The environmental and economic aspects could be the major link between SD and CE. Development of corporate social responsibility and the concept of sustainability made its way within corporate business plans.	Does not mention the method only highlights the topics which need to be addressed. Focus on topic definition
1986 Walter R.Stahel, Focused on the function, or Performance, of goods and services.	Performance economy (PE)	One of the important foundation concepts of CE. Also known as functional economy. New business model based on the selling services instead of products with retained ownership. Innovative ideas and providing incentives for closing the consumption loop.	Focusing on the longevity and reduction of waste through management backed by innovative business models, making PE an important contributor towards the economic model.	Well organised structure of execution base of CE. Focus on business operation
1989 Exist since at least the 1940s, the official birth of the "industrial ecology" concept can be related to a 1989 scientific article by Robert Frosch and Nicholas Gallopoulos	Industrial ecology (IE)	Creating a closed-loop industrial ecologies. Aims at optimising energy and material usage through minimum pollution and waste in an economically viable waste utilising way. Ultimate goal to copy ecosystems for industrial production.	Application of industries within a particular ecosystem. System approach of resource efficiency in terms of CE part of IE.	Focusses on system efficiency by replicating natural ecosystems within a production sector.
1990 1990s developed by William McDonough and Michael Braungart	Cradle-to-cradle thinking (C2C)	Cradle-to-cradle thinking focuses on eco-effectiveness instead of eco-efficiency which means use of materials which cause less harm to the environment and are upcycled to cater to a function. Ingredient optimization,	C2C concept which is part of CE. Product designed for recycling with environmentally safe and healthy material usage. CE could be optimised by including this concept. Use of product as a service.	Focuses on materials in the product and its eco-effectiveness. Healthy material metabolis
1992 Thoma Lindhqvist	Extended producer responsibility (EPR)	The damage produced by the producer through the life cycle are to be taken care of by them. Shift of Environmental responsibility from municipalities to the producers. It is mostly enabled after the first life cycle and end of life management.	Responsibility of producer of product from initial production to end of life within the same company. First attempt to create a closed loop system. CE incorporates the idea of design out of waste to create closed loop.	Focusses on producer responsibility as a result of product life cycle and end of life.

992 Thoma Lindhqvist	Extended producer responsibility (EPR)	The damage produced by the producer through the life cycle are to be taken care of by them. Shift of Environmental responsibility from municipalities to the producers. It is mostly enabled after the first life cycle and end of life management.	Responsibility of producer of product from initial production to end of life within the same company. First attempt to create a closed loop system. CE incorporates the idea of design out of waste to create closed loop.	Focusses on producer responsibility as a result of product life cycle and end of life.
2006	Ecodesign or Biomimicry	Integrating environmental aspects into product development. Ecodesign used as a tool to implement LCA results or as set of guideline, to access the eco-efficiency-based product development process.	Covers 80% of CE concepts. Ecodesign is a tool that aims to implement environmental considerations into product design and is often used in conjunction with LCA.	Focus on Eco-efficiency and impacts Reduction into the design process
2011 Harvard Business School professors and strategy authorities Michael E. Porter and Mark R. Kramer.	Shared value (SV)	SV strives to reconcile capitalism with societal needs. Framework to create value by addressing social and environmental needs. Redefining value chains by producing products for community development clusters.	Evaluates approaches and business strategies to achieve the optimal output. Both need to consider consumers and their environments and its factors to thrive for better results. CE needs it to be more widespread compare to SV.	Focusses on value creation through larger influencing factors.
2012 UN General Assembly,	Green economy (GE)	Focussing on environmental concerns through a set of complex policies created by the UN, which is incorporated into national governments & through NGOs.	Providing leverage on economic activities in order to achieve the laid down outputs.	Guidelines mentioned and rewards given- formation of framework Focus on guidelines to be included
2013 2013- UN General Assembly	Circular Economy (CE)	Designed for regenerating or restoring the value of the material by reusing or recycling. With a larger goal to create a impact on the society, environment, finances and overall economies of working. Closing the loop by increasing the material circularity index an increasing the use of bio based materials.	Is the concept	Aims to have an optimal solution to all societal, environmental, economic problems
2017 2017- Kate Raworth	Donut Economy (DE)	DE strives to meet the challenges faced by the 21st century humanity by ensuring no shortfalls of essentials needed for life.	Demonstrates a specific list of impact area for both ecological and social aspects	Considered as a more detailed and specific model to work with, however method not mentioned
2020 0nwards Circular Economy Realized	Circular economy realised (CE)	Focuses on the real time possibilities rather than a optimistic solution for the issues being faced.	Realized version, understanding the limitations of certain material usage and deciding on 1 definition for the industry to work	A realistic achievable solution after having experimented with the possibilities

3.3 Principles and working of CE

The issue of the current linear model is the large amount waste it produces which also creates relationships between input of new unused virgin materials and economic development (Ellen MacArthur foundation, 2015). The warnings of limited resources has been are seen through rapidly increasing prices and the irrational demand to cater to the needs of the growing population (Ellen MacArthur foundation, 2015).

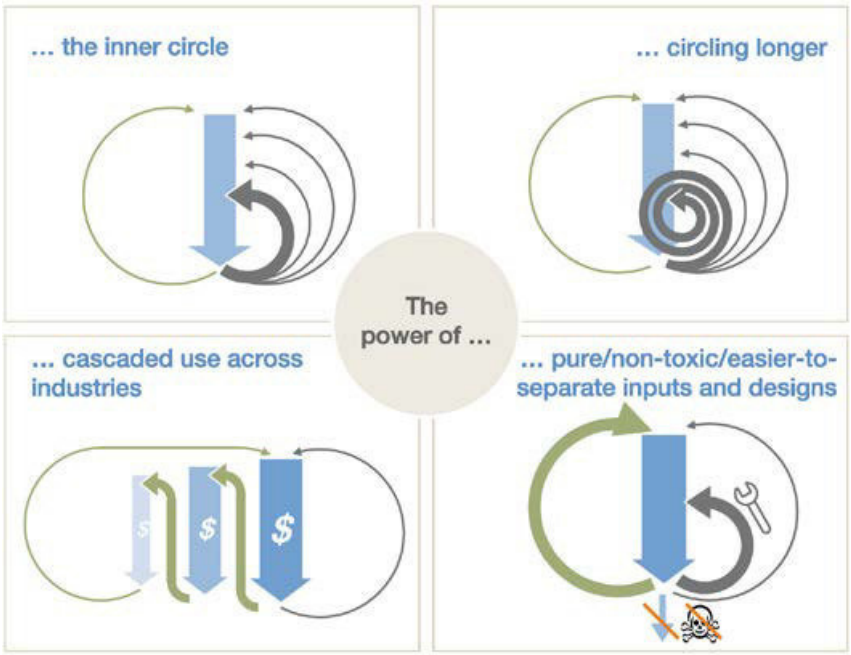


Figure 8: Generating value (Ellen MacArthur Foundation, 2015)

3.3.1 Generating Value:

Ellen MacArthur Foundation has described 4 mediums to create value in a circular economy.

The top left quadrant displays the potential of the inner circle. The inner circle is based on the idea that the goods are the most efficient when they retain their original purpose and can be directly reused. Direct reuse of goods reduces the consumption of resources, so it is important to design products to be able to serve its desired purpose for the longest possible duration. The components must be easy to maintain and operate and replace in another product of the same function, incase its original product is not functional any longer.

The second source is to create value is by extending the use of product by maximising the life cycles which is replicated in the top right quadrant of the figure… Keeping the use of all the parts longer within the circular economy. This includes the products, components and materials invested within the product. By designing for longer lifespans there will be lesser material consumption and energy spent to create new products.

While extending the use of the products, the lower left quadrant describes the use of product parts across different value chain. By using a discarding material and creating value of it in a different product inflow by replacing the use of a virgin material. It is crucial to keep in mind that the process of reusing in a different chain does not spend more energy or resources that the use of the virgin material.

The bottom left quadrant describes increasing the lifespan of the components within the product by designing them to be able to disassemble the pure materials easily. Retaining the original composition of the material without using toxic coatings so they can be reused with minimal processing.

3.4 Barriers

As mentioned above the concept is known for its positive impact on the environment and the society but it yet seems far from execution. The following table explains the barriers which are being faced today.

BARRIERS

Topics	Challenges	Description
Technology	Technological barriers	Lack of methods for handling life cycle of products data. Limited availability and quality of recycling materials. Technological limitations for recycling, product design, and other processes have been identified as major barriers for CBM adoption (1)
	Product Category Restrictions	Product category restrictions would be a barrier. Lack of resources for designing products adopted for reuse, repair and remanufacture (1)
	Certification of reused product	there is very little information on where the product has come from and its length of use in a particular application. (2)
	Time for disassembly and packaging	the length of time needed to deconstruct can be unappealing where extra costs are incurred through having a building, or loss of revenue on a replacement building owing to an extended scheduling of works. (2)
	Building technology	a mixture of traditional and rapidly changing techniques both can cause challenges in further reuse (2)
Attitude	Customer Type Restrictions	Customers want to have ownership, particularly in B2C area. Customer is careless when leasing. Lack of customers' knowledge on origins of products (1)
	Fashion Vulnerability	Since CBM strives to slow down or close the life cycle of materials and products, fashion could be a barrier for high quality products (1)
	Risk of Cannibalization	Risk of cannibalization similar to fashion vulnerability hinders production of long-lasting high quality products (1)
	Confidentiality for individual firms	Information exchange between all actors in CE can conflict with confidentiality and related competitive position of an individual firm (1)
Financial	Financial and economic barriers	Major up-front investment costs, recycled materials are often still more expensive in CBM rather than in linear business models. Different skills and resources can be more expensive (1)
	Mutual benefits for all partners	Mutual benefits among all stakeholders are necessary for collaboration. Misaligned profit sharing along supply chain would hinder CBM adoption (1)
	Product Pricing	Determining the cost of the product based on the life cycle analysis of every material and the profit made based on the leasing of different material is complex (3)
Structural	Organizational barriers	Change is difficult for organizations and individuals. Restructuring is costly and risky, resistance among managers benefiting the current structure might rule out the expected benefits for the firm and the environment (1)
	Cultural barriers	Fear of the unknown is a barrier for organizations (1)
	Lack of channel control	Lack of channel control and conflict of interest within firms are barriers to CBM adoption (1)
	Trust among partners	CBM is based on collaboration, and that requires trust between parties (1)
Operational	Lack of Supporting Regulation	Lack of supporting regulations, complexity and inconsistency of regulations(1)
	Return Flow Challenges	Exchange of materials is limited by capacity of reverse logistics. Return flow challenges are barriers to CBM adoption (1)
	Increase of dependency to partners	Partners work closely and increase dependency on each other which is considered a risk that must be controlled (1)
	Higher risks for CBM	Validation is not achievable without later sales and that risk of resource exposal grows during the validation (1)
Legislative	Lack of Supporting Regulation	Lack of clear and consistent policy, and the existence of hindering regulations. (4)
	Non-virgin materials	Legislation preventing construction players from certifying non-virgin inputs and using some associated machinery

Table 3 (own): Table showing barrier in transforming to circular economy1- Ritzen & Sandstrom (2017), 2- Oghazi and Mostaghel (2018), 3- World Economic Forum (2018) 4- CiSCA (2019)

3.5 Circular economy in the built environment

3.5.1 Interdependencies

The role of the construction sector was originally to create durable products with a long-life span. Over the years this approach of a long-term asset has been transformed into a short-term commodity due to the narrow-minded visions to earn maximum revenue and consumerism. The focus has to be shifted back to adding value by holding onto the commodity (Sante, 2017). The main focus for the built environment within a circular economy is centric to the building level rather than the current macro level (Pomponi & Moncaster, 2017). Thus development at the smaller scales will shape the output at an urban level which will reflect on the overall built environment and eventually on the natural environment.

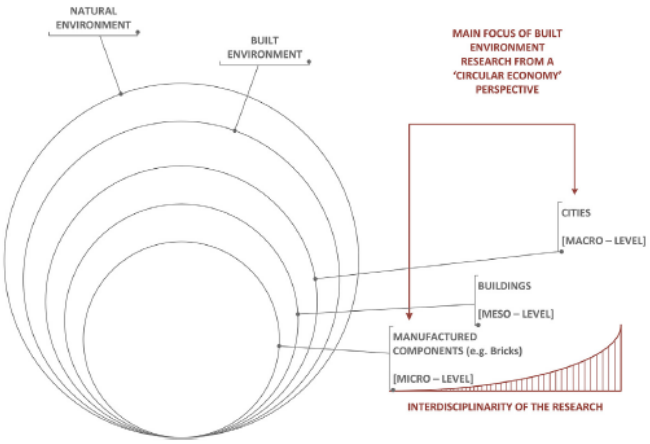


Figure 9: Framing of built environment research Source: (Pomponi F. et Moncaster A., 2017)

The construction industry has characteristics different from the other sectors due to the varied lifespan of products within it. The surrounding and site have the inherent ability to be continuously used, adapted and reused. The structure must be designed to be durable and adaptable. As architect Bob Van Reeth mentioned that the building should be designed for a use of 400 years, the current user must be seen as an alibi while designing the building. This mindset will change to creating maximum value with minimum wastage. Buildings are considered as dynamic structures subjected to environmental, functional, technical changes through their lifespan and they need to be able to adapt constantly (Novem, 2007; Pieter Beurskens, 2015). Being conscious about the materials, the service and their life span will help build awareness and create a larger demand for the same. The construction sector has been rightfully divided into different layers by Brand in 1994. He decomposes the building into its components and evaluates their life span in the building.

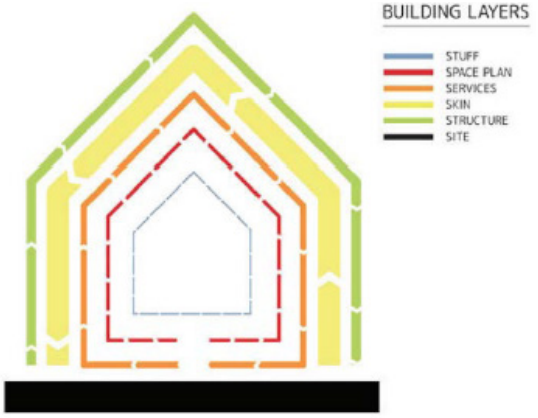


Figure 10: Model shearing layers (Brand, 1994)

Site: The geographical setting, the urban location, and the legally defined lot (eternal);
- Structure: The foundation and load bearing elements (30 – 300 years);
- Skin: Exterior surfaces (20 years);
- Services: Installations (7 – 15 years);
- Space plan: Walls, ceilings, floors, etc. (3 – 30 years);
- Stuff: Chairs, desks, lamps, etc. (< 1 year).

These decomposed layers each have a life span which could be divided into the following as per Senter Novem, 2007.
Technical lifespan: The tenure where the structure meets its technical requirements

Aesthetic Lifespan: The tenure of the structure where its appearance meets the required or planned one.
Functional Lifespan: The tenure of the structure which is suitable for its overall functioning.
Economic Lifespan: The tenure where operating the structure in its present state is no longer viable economically.
The hierarchy of material levels

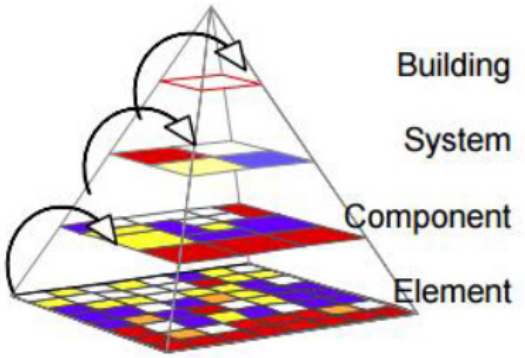


Figure 11: Hierarchy of material levels (Durmisevic & Brouwer, 2006)

Every material going into the building is a well thought of and integrated into the system based on its technical and functional life cycles. The material division made by Durmisevic & Brouwer (2006) could be divided into 3 main divisions (Durmisevis, 2006; Verberne, 2016)

"Building level represents the composition of systems which are carriers of main building functions (load-bearing, enclosure, partitioning, servicing);
System level represents the composition of components which are carriers of the system functions (bearing, finishing, insulation, reflecting, distributing);
Component level represents the layered or frame assembly of component functions which are allocated through the elements and materials at the lowest level of building assembly. "
The larger vision is to address the circularity and sustainability goals by being responsible about production of waste, pollution, quality of space while getting rid of the notion that the building is one static product (Durmisevis, 2006).

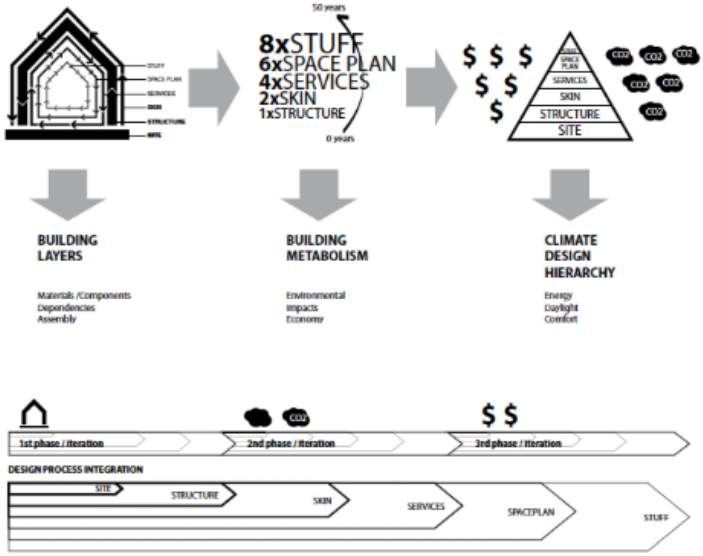


Figure 12: Shearing layers of change (Brand, 1994 & Sattup et Kauschen, 2014)

The model Shear layers of change is expressed in terms of the material/ component. Based on the assembly and the interdependencies of the layers. This can be translated into the impact the product has in relation to each other. The impact of 1 structure is made to skin, service, space planning and stuff. These layers have a direct impact on the amount spent on these layers and the hazardous environmental effects of it (Brand, 1994; P. A. S. K. C. Sattrup, Jan, 2014).

3.5.2 Defining CE in the built environment

The definition of Circular Economy in the built environment is well stated by Circular Economy et al., 2018.
"A building that is developed, used and reused without unnecessary resource depletion, environmental pollution and ecosystem degradation. It is constructed in an economically responsible way and contributes to the wellbeing of people and the biosphere. Here and there, now and later. Technical elements are demountable and reusable, and biological elements can also be brought back into the biological cycle."

3.5.3 EU level and vision for circularity

The circular transition will not only help in safeguarding the planet for the future generations, but the estimated tangible societal and environmental value of the circular built environment in EU is $300 billion saving compared to the current path towards 2030

(ING, 2018). Thus circularity would be a key player in stabilizing rates of materials which fluctuate based on material availability and create a nuisance in the economic sector(Ellen MacArthur foundation, 2015). Circular economy would play an important role in keeping the increase in temperature below 2 degrees above pre-industrial levels by reduced usage of raw materials(R.Pardo, 2018). It is expected that societal and environmental justice would form the core of circularity, generating employment within different sectors, very likely to reduce the disparity within the society. According to the vision of the EU, the future of goods will be satisfied by combining private needs with delivery of public goods (R.Pardo, 2018).

3.6 Accessing Circular Economy within the built environment

Circular Economy is based on the selection of the materials, its reusability & recyclability(Steinmann et al., 2019). Functionality 37 Investment in Circular Transformation
of the component is dependent on the selection material and its properties. A research conducted by Ellen MacArthur & Granta (2015) calls this rating Material Circularity Index (MCI). This tool developed by Ellen MacArthur Foundation nd Granta Design (2015) focusing on technical cycles & non-renewable materials as there is an effective outcome and better understanding of benefits of implementing it.

Quantifying the flow of materials its restoration and considering influencing factors like scarcity, toxicity,etc. According to this tool, the rating of a product is valued between 0 and 1 and the higher rating indicates better outcome of circularity. This tool takes into account input in production process, utility during use phase, destination after use, efficiency of recycling based on the detailed bill of materials. The limitations of this method is that the materials lost as waste during the process of production is not taken into account(Leising, 2017). This makes the calculations complex. This success factor of this tool is directly dependent on time as an indicator (Leising, 2017).

The process begins with calculating the linear flow Index (LFI), which consists of the virgin feedstock and unrecoverable waste. The LFI and MCI together are determined by the Utility factor for each of the systems. The figure demonstrates the flow of the materials and the process needed to close the loop. The source of material flow however could come from a either the manufacturers or an open source (Ellen MacArthur foundation, 2015; Leising, 2017). The following list of abbreviations are used within the formula to calculate the circularity level of the product. This is based on the production process and not the designed process. (Ellen MacArthur foundation, 2015). This process is a combination of namely 3 product characteristics the utility factor (X) which accounts for the duration and the intensity of the usage, mass (W) which is unrecoverable waste and mass (V) of virgin raw materials used during

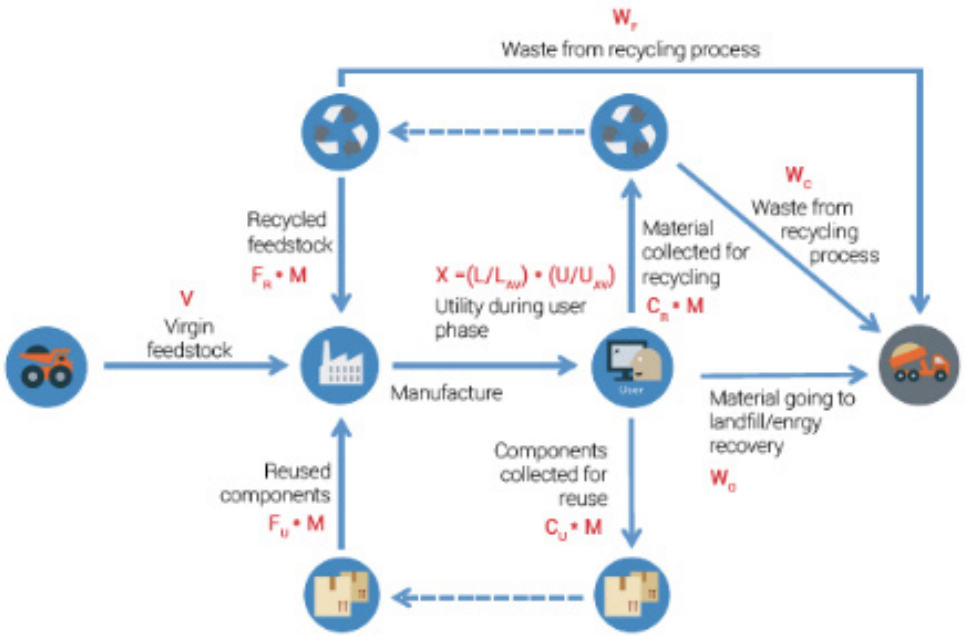


Figure 13: Diagrammatic representation of material flow (EMF, 2015)

manufacturing.

Table of Symbol (Ellen MacArthur foundation, 2015)

Symbol	Definition
M	Mass of a product
FR	Fraction of mass of a product's feedstock from recycled sources
Fu	Fraction of mass of a product's feedstock from reused sources
V	Mass of virgin feedstock used in a product
CR	Fraction of mass of a product being collected to go into a recycling process
CU	Fraction of mass of a product going into component reuse
EC	Efficiency of the recycling process used for the portion of a product collected for recycling
EF	Efficiency of the recycling process used to produce recycled feedstock for a product
W	Mass of unrecoverable waste associated with a product
W0	Mass of unrecoverable waste through a product's material going into landfill, waste to energy and any other type of process where the materials are no longer recoverable
WC	Mass of unrecoverable waste generated in the process of recycling parts of a product
WF	Mass of unrecoverable waste generated when producing recycled feedstock for a product
LFI	Linear Flow Index
F(X)	Utility factor built as a function of the utility X of a product
X	Utility of a product
L	Actual average lifetime of a product
Lav	Actual average lifetime of an industry-average product of the same type
U	Actual average number of functional units achieved during the use phase of a product
Uav	Actual average number of functional units achieved during the use phase of an industry-average product of the same type
MCI	Material Circularity Indicator of a product

3.7 Strategies for implementing circular economy

In 2014, Accenture Strategies developed 5 Innovative Business strategies with an aim to generate value by capitalising on the opportunities of circular economy. Unfortunately the method to evaluate the societal and environmental value has not been developed. The business models developed by Accenture are based on different themes which can be merged or used in isolation as per the nature of the business. The concepts in this model has been repeatedly used in multiple report till today. The different isolated strategies have been explained by Circle Economy et al. (2018) in A Framework for circular buildings. These business models were disintegrated into the possible strategies and is displayed in the diagram in this report.

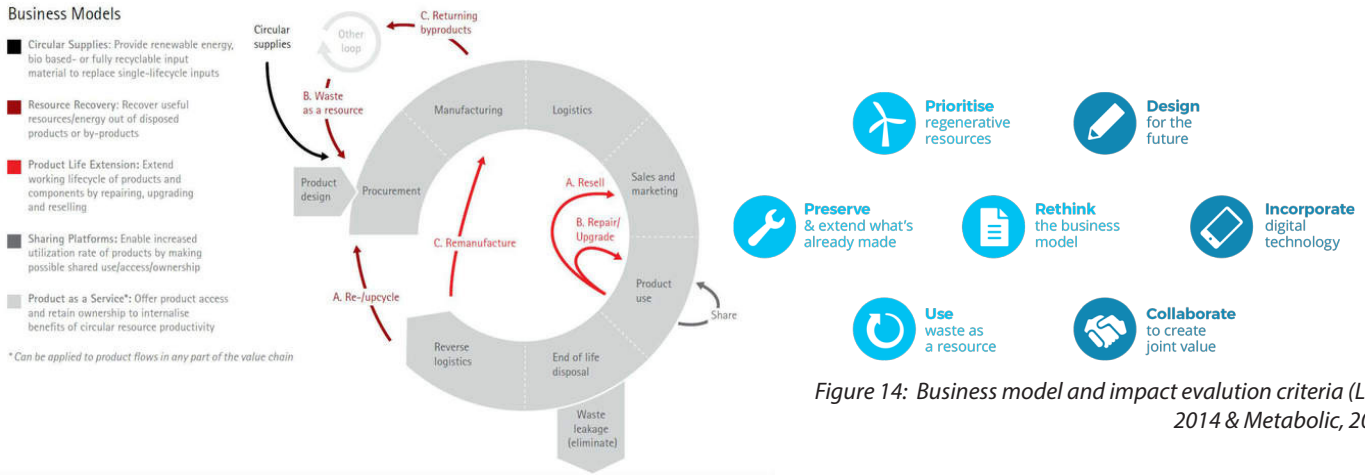


Figure 14: Business model and impact evalution criteria (Lacy, 2014 & Metabolic, 2017)

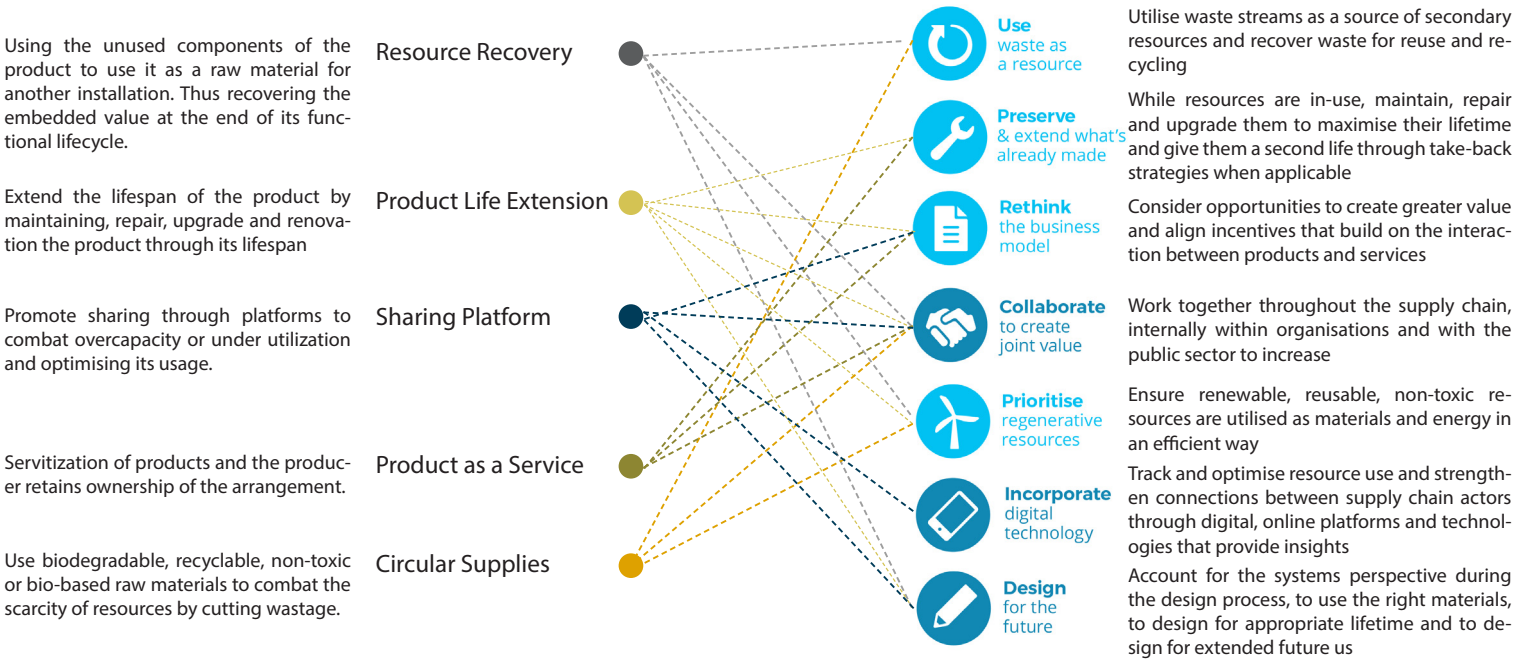


Figure 15: Consolidation of Business model idea published by Accenture and Metabolic (Lacy, 2014 & Metabolic, 2017) own diagram

3.8 New business models

There are multiple business models being developed independently by different market players to be a front runner in the transition. A business model essentially comprises of different components ranging from the means of earning revenues, the stakeholders involved and their organization (Carlos Dasilva, 2013; Clauß, 2017; Ranta, Aarikka-Stenroos, & Mäkinen, 2018). Business model could be also understood as the firm's ability to generate revenues by connecting to the customer value in the venture (Osterwalder, Pigneur, & Tucci, 2005). A business model within a circular economy would simultaneously generate economic and environmental benefits by being critical of the material usage. By adopting 3R framework which would be centric about reducing overall resource wastage by modifying the production and consumption through improved technologies (Biwei Sua, 2013; Feng Zhijun, 2007). and infrastructure to support the refurbishment and reuse of them but does not take into account the environmental and societal effects. It is important for a business model based in a circular economy to consider the use of the material after its first life span. Understand and create infrastructure required for the material to retain its original value or through refurbishment or downcycle the material through recycling. To create a business model it is important to to understand what forms one. According to Osterwalder et al. (2005) a business model consists of strategy implementation within an organization with supporting ICT.

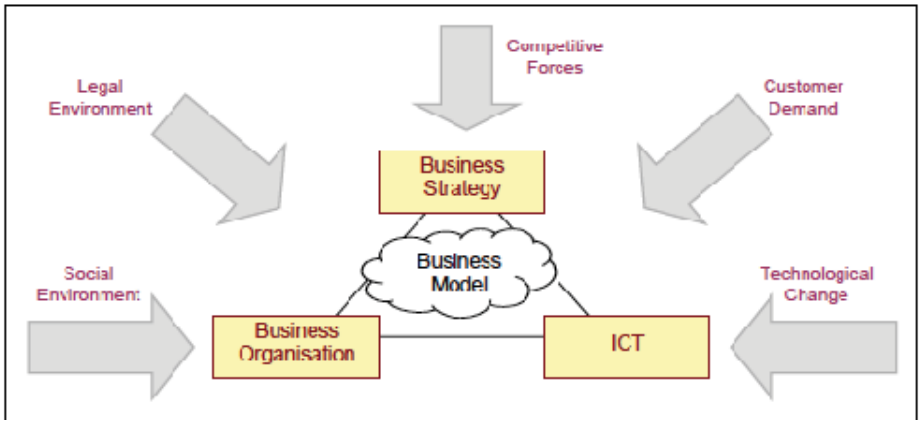


Figure 16: The Business Modle's Place in the Firm (Osterwalder et al. 2005)

Business model [noun]
"COMMERCE, FINANCE a description of the different parts of a business or organization showing how they will work together successfully to make money."(Press, 2019). Many different strategies could be developed taking into account different kind of collaborations of different players involved. Multiple studies have been conducted to underline the working and the shortfalls of the current developed models. The strategies adopted must be reflected in the evaluation criteria and the organization structure to receive the desired output. Adopting the circular concepts within the economy would directly impact the structure and way of working. The distinction between business process models and business models as mentioned by Osterwalder et al. (2005) would be the same during this transition. To develop the transition model it is important to understand the steps involved in the life cycle of a building. The life cycle model developed by Ghisellini et al. (2018) explains the linear process of a building.

3.9 Impact Area

The performance characteristics of the circular economy developed by Metabolic, is a wholistic impact driven tool, taking into account maximizing forms of value by use of energy, materials, water resources, along with positive impacts on health & well being, biodiversity, human culture and society (A. A. Circle Economy, 2017) A holistic assessment is possible by using Metabolic's performance characteristics of circularity
Materials are incorporated into the economy in such a way that they can be cycled at continuous high value.
All energy is based on renewable sources.
Water is managed in a 100% circular fashion
Biodiversity is structurally supported and enhanced.
Human society and culture are preserved.
The health and wellbeing of humans and other species are structurally supported.
Human activities generate value in measures beyond just financial.

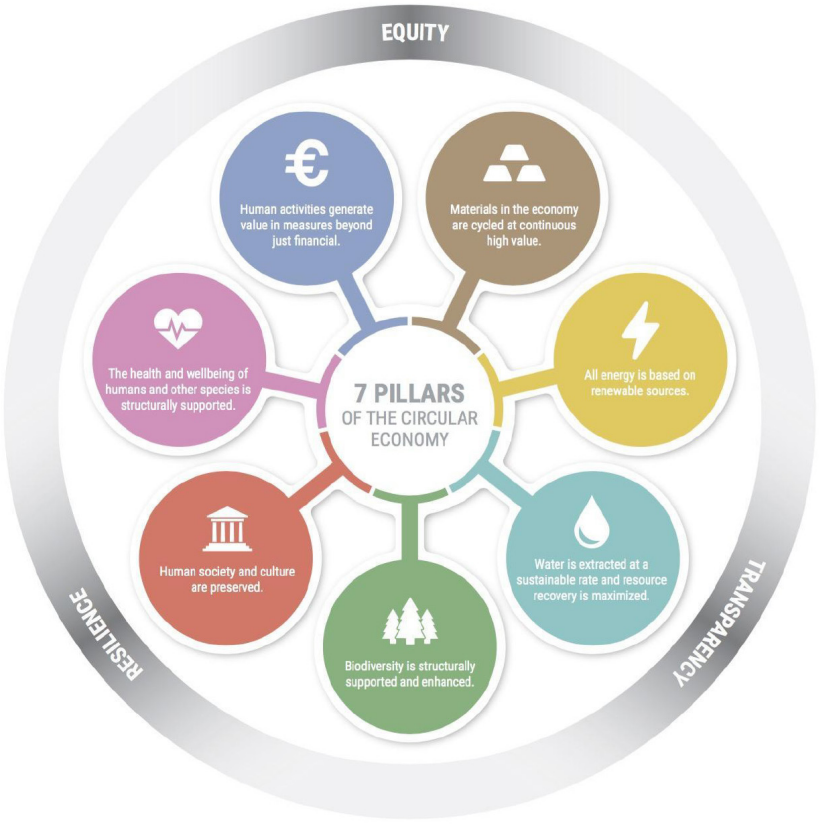


Figure 18: 7 pillars of the circular economy Metabolic, 2018

3.10 Transformation or New Circular building

Renovation is not seen as a cradle-to-grave format, in which the materials have a single usage for a limited amount of time and is disposed of or recycled. Instead it could be looked at as a continuous circuit to upgrade the existing stock to extend its life span. Replacing the inefficient components and refurbishing to improve the overall performance and the life expectancy of the built form could be looked at as one of the main strategies of circularity (A. A. Circle Economy, 2017; Circle Economy, 2018; Juan Francisco Azcarate-Aguerre, 2018). The prevailing system of the linear economy is majorly based on commercial interests to maximize profits, while being insensitive to the built and overall environment. Renovation or transformation could be looked at the conflicted interest

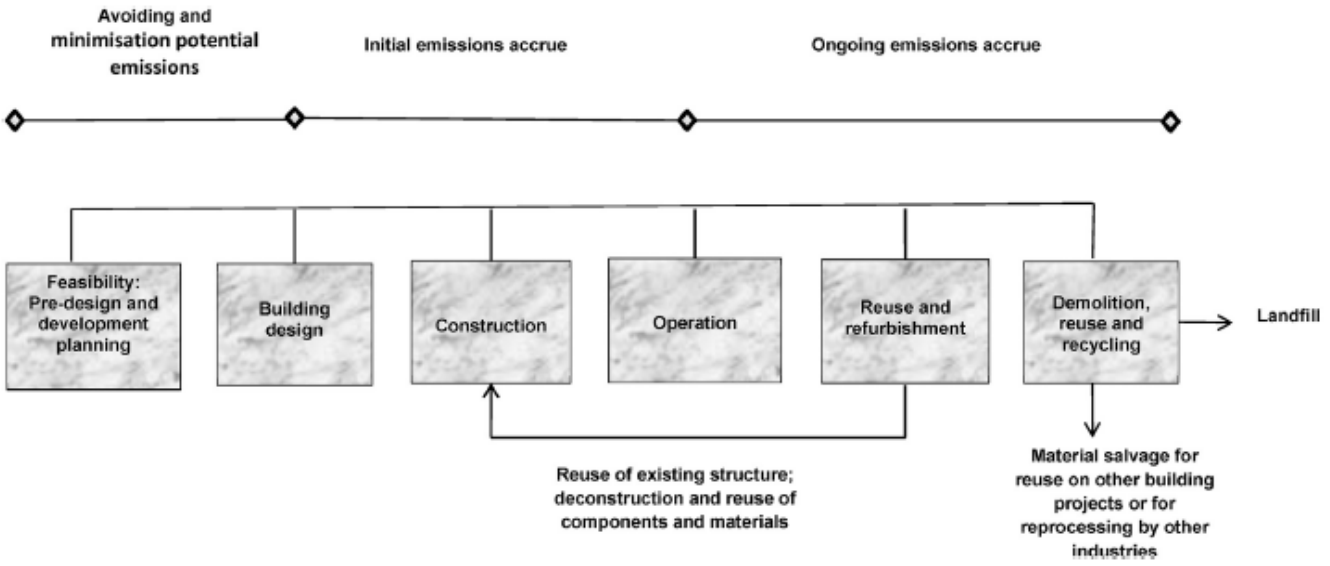


Figure 19: Full life cycle of a building (Ghisellini et al., 2018)

of different market parties.
The circular built environment is expected to benefit from primary resource by $60 billion and an estimated 3% increase in resource productivity(ING, 2018). The developer & production companies are responsible to create keeping in mind the long-term performance of the building. Rather what is seen is based on primary requirement of the user or revenues in a short term. At a product level many producers focus only on one-time sale and not the performance and quality on the long-term cause that will reduce the sale of the new products (Circle Economy, 2018). The technologies and facilities incorporated in the built form are also selected with no direct interest in long term performance which is eventually disposed while handing over the project at the end of its service life creating a relatively poor built stock lacking quality.

The complexity is not limited to the economic models and narrow vision of the current stakeholders but according to IEA (2014) The existing built stock will account for 87% of the built environment in 2050 (Hilde Remoy, 2018). This implies that more than 80% of the built form would be from earlier than 1980s(Pomponi & Moncaster, 2017). This makes it important to focus not only on the new but the existing built stock to create a difference. According to the European parliament all new building need to have near zero energy consumption by 2021, this could be used as a stepping stone to incorporate for near zero wastage of material by incorporating circular components within the building design. The major renovation projects post 2021 have to be done keeping near zero energy consumption post 2021 (European Commission, 2018).

In the Netherlands, all Dutch office stock has to have a minimum of label C for it to be available for use post 2023. According to Hanff (2018) currently 34.6 million square meter which is equal to 44% of the total stock needs refurbishment. Which makes this a great opportunity to upgrade the buildings in a circular way. The built environment has to ability to evolve into a unique product by using the same components which emphasis on the role of the designer in the circular built environment. The effects of a circular built environment would need the support and its effects would be visible at a micro, meso and macro level (Pomponi & Moncaster, 2017). It is also important to critically evaluate the condition of the building in terms of its design, its ability to adapt to different functions before investing in extending in life (RIVM, 2015). Extending the lifespan of existing stock is accompanied with multiple uncurtaining (Hilde Remoy, 2018) but it results in higher levels of sustainability (de Jonge, 1990) and circularity within the built environment. It is possible to upgrade the existing stock by reusing its structure and using reused materials as infills. The flexibility of the building determines the probable functions within the building during its lifespan (Hilde Remoy, 2018) .

The new circular construction should follow the 3R principles of Reduce, Reuse and Recycle proposed by the Ellen MacArthur Foundation. According to the Ministry of Infrastructure and the Environment this translates into number of parameters that should be considered when a project is being designed in a circular way. This includes the following," Low-material design, Modular Design, Design for deconstruction, Design for recycling/ Cradle to Cradle, Recycle for (circular) design, material passport"(RIVM, 2015)

EMPIRICAL STUDY

This chapter elaborates on the input from practice which helped provide additional information and clarify ideas which lead to the development of the research outcome.

4.1 Method

The concept of circular economy is widely spoken and researched topic. With a lot of pilot studies being conducted in this field. As a result no new research has been published recently. The literature available is also mostly repetition of what has been already been spoken about making very little new information relevant. In order to gain a better understanding of the topics relevant for the research, expert interviews were conducted. Conducted in 3 parts the first set of interviews were conducted with experts from advisory firms, giving advice to investors for their investments in real estate. This was conducted to gain an understanding of the market opinion on the topic of circular economy, their visions for the organisation needed to get the concept into action. Along with probable strategies for the business model. The second round of interaction was in the form of a questionnaire that was sent by the MOR team to the suppliers who were partners within the team. The third part of market interaction was with interviews with developers and current owner of one of the 3 towers Egeria and the other developer was one well known to carry out circular transformation projects. This was specifically to determine the insights of how developments commence and the ideas they have in mind while initiating a project.

4.2 Structure & interviews

The interview conducted with the investment advisory firms was divided into 3 parts, background information, Structure and organization and business model. The Study below shows the findings and my interpretation of the information obtained. The scientific research conducted with different companies was critical in shaping the output of the research. The participants were carefully selected knowing their expertise and visionary status. The participants were people with strong ideas across varied age groups making it a good mix of perspectives. Resulting in neither a very conservative nor a very ambitious outcome. The participants belonged to different positions in the companies ranging from CEOs and founding Partners to head of departments and general employees. Thus, gathering an idea not only at a conceptual level but also discussing the implementation and functioning of the systems at ground level. The visions and interpretation of different participants was important to add richness to the output. It helped me question ideas, clarify concepts, add another dimension of viewing the topic while rationalize to develop a concrete outcome.

Data collected from the interviewee

Interpretation of data

What according to you is the meaning circular economy in the built environment?

Circular Economy is changing the concept of the current linear economy with an idea that nothing is waste. Trying to minimize the use of materials and add value through material selection. This is all done with the vision to reduce emissions and resource wastage. With different strategies being used to support this concept this concept a few of the ones discussed and supported by the participants were: Butterfly model by Ellen MacArthur foundation, 5 points of accenture: product as a service, sharing platforms, life extension, resource recovery, circular supplies, 9R model. Circularity in the built environment is successfully implemented by making the investments financially, environmentally, socially feasible.

The concept of circular economy is relatively known. Its implementation in the built environment is generally mixed with extremely general concepts or borrowing ideas and examples from other sectors like manufacturing which do not always work for the built environment. The implementation of some strategies in the construction sector were questioned in the process, the strategy developed was not flexible enough to adapt to the needs of the built environment. Making it difficult to clarify the meaning of circular economy within the built environment specifically.

Would that (circular economy in the built environment) be the same as circular construction?

Circular Built environment: Broader vision of considering the entire built environment. Circular construction is a part of circular built environment. Looking at the existing and possible new stock which could be adaptable, flexible spaces, re/ demountable, using less virgin materials- use all materials in existing buildings. Circular Built environment includes real estate and built infrastructure taking into account longer durations and extensive usage.
Circular Construction: Circular construction is about the functioning of the product. It is focused on real estate only. With an idea to be movable based on requirements of the product (circular construction as a product) in a place. Ability to reuse the product, in different places with same or different functions. This could reduce investment in the long run, both financial & material.This is only possible with smart design and construction methods. With a conscious focus on end of life while designing the circular construction. This could be done by considering the 7 layers of the building (Brand's layers of shear) while considering designing in the initial stage.

Circular construction is only considered for a new project. Circular construction is expected to have a long life span because of its circular design approaches. The ability to dismantle and transport it post its current usage gives it added value, but this is limited to new projects according to the market players. Questioning the idea of transformation and the notion of reducing material wastage if the existing built stock cannot be transformed into circular construction but could be part of the circular built environment.

In your opinion how could it be implemented within project? Do you see a larger implementation in transformation projects or new developments? (Please give reasoning)

The maximum advantages are expected in new construction projects. The implementation of circular concepts is also observed majorly in new projects which is limited to a very small fraction of the new stock. Since the project can be designed keeping in mind its usage life, it is difficult to comprehend them in a transformation project. The complexities with transformation projects remain unknown. The potential results are not as satisfying as a new project for the market players.

Circularity in new construction is observed because it is easier to execute and is gaining more attention from the market players. More advantages are observed with new projects, more information is available, it is easier to plan and design for future use like junctions and connections, etc.
Old Transformations: Needs more attention since there is a large stock of existing buildings. The process is more complex using cosco is a possible way. Transformation is expected to be more expensive than new projects since the risks are relatively unknown. The steps to transform in a circular way remain to be unknown. The notion of market players loosing out on subsidies and privileges if they take an active step to circular way of working. Thus, making it a Wait game since the objectives of the city with respect to implementing circular economy in the built environment remain unclear.

What are the reasons in your opinion, that the concept of circular economy within the built environment has not picked up the required momentum?

The construction industry is relatively traditional in its approach and is averse to changes. The feasibility of adopting this change and its financially, structurally, technically, legally and socially effects remain unknown. The market has too much work currently to find ways of incorporating this new way of working.

Multiple different reasons surfaced while discussing this issue. The vision is known but the roadmap remains unknown for the market players. Making them work in pockets to design solutions rather than coming together as an industry. The legal aspects remain unknown which makes it difficult for this multi-stakeholder sector to function. The urgency of moving to a circular way of working is not propagated by the legislation. The construction sector being reactive rather than proactive chooses to acknowledge the concept while ignoring to act upon it actively.

Which stakeholders would you directly involve in process of circular construction?

Innovators and disruptors together would be able to bring about a change in the current way of working. This will help the conservative sector to move from its current comfort zone. Change in mindset and policies are important to adopt circular concepts. Implementing circularity in the construction sector could trigger multiple changes or even evaporate roles of stakeholders in the current value chain. Stakeholders with a long term vision will play an important role in this system. Making law makers, municipalities, investors and financers important stakeholders in realising this transition.

Innovators and disruptors do not have to be ground breaking to uproot the current way of working but a steady trendsetter resulting in the transition within each company can create a far impactful. A collaborative process with the experienced and the young blood could trigger the transition with a well thought of outcome. Every stakeholder is critical in this transition, this is because of the changed roles they would have to address.

Who are the key players in the circular construction and what would be the role they played?

Policies play an important role in directing the transition so Legislation and Municipalities are critical. Developing a roadmap and providing incentives could help the transition. The political decisions can steer the process and decide the pace of transition towards a circular economy. Investors can channelize funds towards sustainable projects making them a key player. Owners with a long term vision who can understand the value addition in investing in such projects play an important role in being trendsetters. The users create a demand and can determine the success through a successful response.

Every stakeholder has a critical role to play to avoid the vicious cycle of blame. The demand and supply along with the facilitators have a critical role to play in bringing this new economy into practice. The facilitators have the ability to create favourable situations for the functioning of the system. Provide incentives and create guidelines to help the transition by making the vision, roadmap clear for all stakeholders. The role is important since all the stakeholders are going to be skeptical to this change. The demand which includes the users are critical in the process but they lack the knowledge and are unaware of the importance of implementing this system. The supply side lacks the finance for upfront investment and the demand to bring this system into practice.

What according to you would be the organization structure of the construction industry? How would it differ from the traditional /current way of working? (Please elaborate with an example)

The short term vision will have to be replaced with a long term vision for all the stakeholders in the value chain. This means that municipalities would have to ensure more public attention and active engagement in circularity and sustainability. The supply chain would have to retain ownership for the products to allow for quality in the long run. This will be supported with more direct interaction between stakeholders and would avoid the people in between.

The mindset of all the stakeholders needs to move from the current short term to a long term one. This requires suppliers to be accountable for their products. The municipalities play a critical role in implementing this system. Cutting the chain short the direct interaction would allow for direct interaction, better understanding and smooth functioning and services with lower costs in this system.

What medium of interaction do you expect between the stakeholder?

More direct interaction amongst stakeholders through online platforms. Which would help organise, coordinate, manage contracts and maintain transparency amongst stakeholders.

The virtual world would help connect different stakeholders directly, erasing the middle men in practice. Creating an online platform to plan, organise, design and execute the work while helping maintaining and operating the processes would replace the current with a more transparent way of working. With maximum transparency the accountability of different stakeholders will increase.

According to you, what should the business plan of circularity in the built environment look like? Would it be an own or leased based contract? How would it function?

The critical point is to make the outcome feasible for the end user. If it is too expensive the users will not be able to afford it.
Investors will need- Incentive or punishment based to aid the transition for transformation. It needs to yield value in the long run for investors, if they are willing to make an investment which is circular and sustainable in nature. If thought about strategically well it could have a lot of added value in the future. Owner wants user to have maximum tenure of the contract. While the user would want flexibility and short contracts. Monitoring the financial returns of suppliers is essential. Ownership however is tough to deal with in this case.
For the supplier of different layers of the building how do you evaluate them and put a price on them needs to be worked on. How do you analyse product cost after its first usage is important.

It is important for the system to be financially feasible for all to be executed. There are multiple complexities which every stakeholder will have to respond to. The system for ownership and leasing are completely different and will have to be responded independently. The negotiation discussing the requirements of different stakeholders is critical for the development of the business model.

What are the critical success factors of this business plan?

Different external influencing factors like labour costs, technology & adaptable futuristic designs to address the needs of the future. Being able to reuse the products is essential for the success factor. Managing the circular way of working is extremely complex. The risks of adopting product as a service like suppliers going bankrupt need a proper legal system to safeguard the interests of involved stakeholders. The way the system is marketed to the users is important to create a demand for it.

The relatively new concept needs the entire system to be developed for the smooth functioning of the system. This makes every topic essential during the initial phase of the project. This will change once the system starts setting up and more information is made available.

What according to you is the role of an investor in circular construction? Which point in the process according to you would investors get involved in the process?

Generate returns by investing in low risk and high return transactions, investing in sustainability and circularity is extremely important for maintaining the value of the real estate. They want to diminish their future risks to the minimal.
There is availability of too much money and very few green projects to invest in. To generate higher rates for pension funds- the availability of money needs to be reduced. Their accountability is not only to the private but also beneficiaries. They have the power to shape the future by steering the investment.
Depending on whether a pension fund investor or a bank as a financer, the priorities and ways of working are different. The purpose of the investor determines his interest and thus the kind of investment he makes. The level of intervening also varies based on the kind of investor.

The role of an investor varies as per the nature of his investment. With the idea to maximize returns it is important for the investor to be guided by some regulations which will help them make decisions in a certain direction. For transformation, which the larger investors do not cater to need to be incentivized for the required results.

What are the risks for you as an investor (or for your client) in investing in a circular project?

Transformation has additional risks since not everything is known about the process. The risk of being able to see the added value of transforming the asset is important to convince the investors. The constant conflict between the long term or short term interest of the investor determines the possible future usage of the project. Also, determining the future value of the project is difficult with a circular project. Circular economy works with different stakeholders collaborating to achieve the required outcome, this could also be difficult with multiple stakeholders. It would be difficult to evaluate the investment costs versus the returns incurred by different stakeholders. This could result in unfair returns on investments.

Circular economy being a new way of working brings multiple uncertainties. Issues related to the structure and functioning remain the main topics of discussions followed by the legality of the implementation. Safeguarding the interests of every stakeholder in the process is essential while it also happens to be the biggest risk.

What kind of returns would you expect by investing within a circular project? (Consider the case of a commercial transformation project while answering)

An expected return of 2 to 6% is required to be achieved in 10 to 15 years. The societal and environmental impacts must also be included in the evaluation. There should be incentives like discounted mortgages for such investments.
The return must not only be earned by the investor but the people working to construct it, the operating crew and everyone involved.

A new way to evaluate the environmental and societal benefits needs to be developed to support this economy. The expected return on investment is conjectured comparing the linear way of investing, this could vary drastically from the circular way of investing.

In your opinion which are the major barriers you foresee within this transition towards Circular construction?

The current regulations do not support the circular way of working, policies safeguarding the interests of all stakeholders needs to be developed. The vision is clearly defined by the government, but the roadmap remains relatively unknown. This will help steer a lot of developments. Giving the investors incentives to make such investments. This will help scale up the progress of implementation of this concept. Societal awareness will help create a demand and trigger the process. The technical, functional and financial feasibility for the suppliers is also important barrier which stands in the way. The way the sector would function remains unknown which forms a major barrier.

Financial, legal, structural, technical, organizational and societal barriers need to be addressed which currently stand as barriers in the way. It is important to understand the perspective of all stakeholders while addressing these barriers.

Drivers

Standardization is seen a way to get this system functioning. Investors who make a conscious decision and choose to set an example would be the market drivers. This is because competition is a good way to develop a trend.
Connecting the mortgage to the land instead of owner. This will help owners conduct the circular transformation and have to pay for it only till they are using it.

The drivers could be in the form of incentives or punishments. This would trigger a chain reaction if the right infrastructure is provided.

What kind of investors according to you, would be willing to take on these risks and take the place of the front runners in this transition towards circular construction?

Pension funds and social investors, housing association, parties who are secure themselves, investors who have a strong societal agenda

Parties with long term interest and vision are the ones who will be the front runner in this transition. Pension funds seem promising but they do not invest in transformation or renovation projects. This is a major setback. Also the projects they do are only on a large scale, so the smaller projects will not have a strong investment flow.

What are the opportunities or added value for you (as a client) in implementing this concept? How would you give value to them?

The effect it has to the company's reputation and its value on the globe market increases. Project possessing societal and environmental value not only financial value has a higher return in different market conditions and is a more safer and stable investment. The building attracts a certain type of user. Different levels of opportunities could be seen like Subsidy in mortgage, business opportunities, government as a supporter, society with better living and working conditions so people can benefit.

The opportunities and added value cannot be evaluated or accounted for in the beginning of the project but the effects are seen once the project is in use. Once acknowledged an additional price can be charged for it.

Would you be able to change premiums for them? If yes, on what basis?

No scientific data for this, there could be a premium but it is a different economic way of thinking. Premium will be visible in the long run. Premiums should be accounted for the societal and environmental impacts the project has and evaluate it financially. Added value to society will yield the best return at the end. People are willing to pay for that. If the building is not in isolation but interacts with its surroundings then it has a possibility to generate more value and charge a premium for it.

It is important to look beyond the finances into designing and take into account the environmental and social aspects to make it an interactive object rather than a static one to be able to display the performance of the building.

Would investors be willing to invest in the supply chain as a result of lesser upfront investment towards land property (land & built form)?

The investor type determines the kind of investment being made. Generally real estate investors choose investments with lower risks. Investing in the supply chain could be a high-risk oriented investment.

Depending on the interest of the investor he would be willing to invest in the supply chain.

What according to you would be the timeline (tenure) to be considered within a circular project in the business model?

10-20 years with an average of 15 years

Which point in time, in your opinion, would it be profitable for investors to invest in a circular project?

Once the system is working the investment costs may reduce.

4.3 Objective

This data collected helped understand the prevailing situation in practice. There are multiple perspectives for the same topic. With every interview another layer of complexity was added in this multidimensional problem. The objective was to analyse the reasoning why the market has not been able to take a step ahead. Also understand the mindset and limitations of the current set up which is hindering the transition. The experts were also a good source of insights of how the system may function.

Questionnaire: MOR team Data

The next set of data collected was from the MOR team, the written questionnaire was sent by the feasibility committee to the partners who were supplying materials in order to get the relevant rates within the business plan. The data was essential to get the service provider's perspective and create a realistic understanding of the services that go into making the building components. Understanding their willingness to participate in the product leasing setup. Check with them the rates they would charge for annual maintenance of the product. The minimum profit they would require in order to make this method feasible for them. Also, the lifespan of the product and the value of the material at the end of its first life usage. Understand the cost of maintenance of the product. This data was critical to insert in the business model developed create the roadmap of the transition.

Interview with developers:

The last set of interviews was conducted with developers within the industry. Developers with different ideologies were selected for this round of interviews. This was done intentionally to understand the vision of the current developers in the market. The outcomes were very different but gave an understanding how sustainable developments can generate more value in the long run. The information regarding current investments and project costing were derived from this set of interviews.

4.4 Outcome:

An important learning from this process was that the market perceives the same topic in different ways. This makes it important to spell out the specifics to an extensive level for this topic to be adopted by the market. The interviews helped gain awareness of various topics which were not given too much focus in scientific literature. The practicality of the strategies was not discussed in the scientific data. Thus, the process helped open up new dimension for further research and questioning. The cumulative results from these interviews along with the literature study helped design the Output for the study. Helped generate the business model and the roles and relationships of different stakeholders in the progress. The details are found in the next chapter.

SKETCHING THE FUTURE OF THE BUILT ENVIRONMENT

Real estate market has different cycles. This affects the demand and supply and the prices of commodities. The case for real estate also stands the same. The prices are directly proportionate to the demand and supply of real estate. By facilitating mixed function usage, the required function can be places in the unused space. This will positively affect the owners of the building to avoid losses. Also, the mixed function space can facilitate better social integration and higher convenience for users. This will also allow for flow of materials within the area.

Strategies being adopted within the circular economy in the built environment

The strategies adopted in this circular way of working are the ones mentioned by Accenture in 2014, which include Product as a service, Resource Recovery, Product Life Extension, Sharing Platforms, Circular Supplies. These have been explained in chapter 3 section 3.7.

5.1 Roles of Stakeholders

The organization and roles of stakeholders are different in circular business model based as a result of adopting the strategies mentioned above. This implies that the tasks they perform, the roles they play in the process and relationship with others determine the success of the system. The tasks of the stakeholders would vary significantly compare to the traditional linear way of working. For this it is essential to understand which stakeholders contributes to which sector. For the purpose of this study they are categorized in 3 main divisions being: Commissioners, Executer and Facilitators. These three divisions in roles will be considered for the convenience of the study. The roles are further interpreted in the 4 quadrants of stakeholders depending on the roles they play, diving them into Strategic, Asset, Technical and Use (A.C Den Heijer, 2006). In the model proposed by Den Heijer, helps decipher the underline purpose of the role while giving them a new role to play.

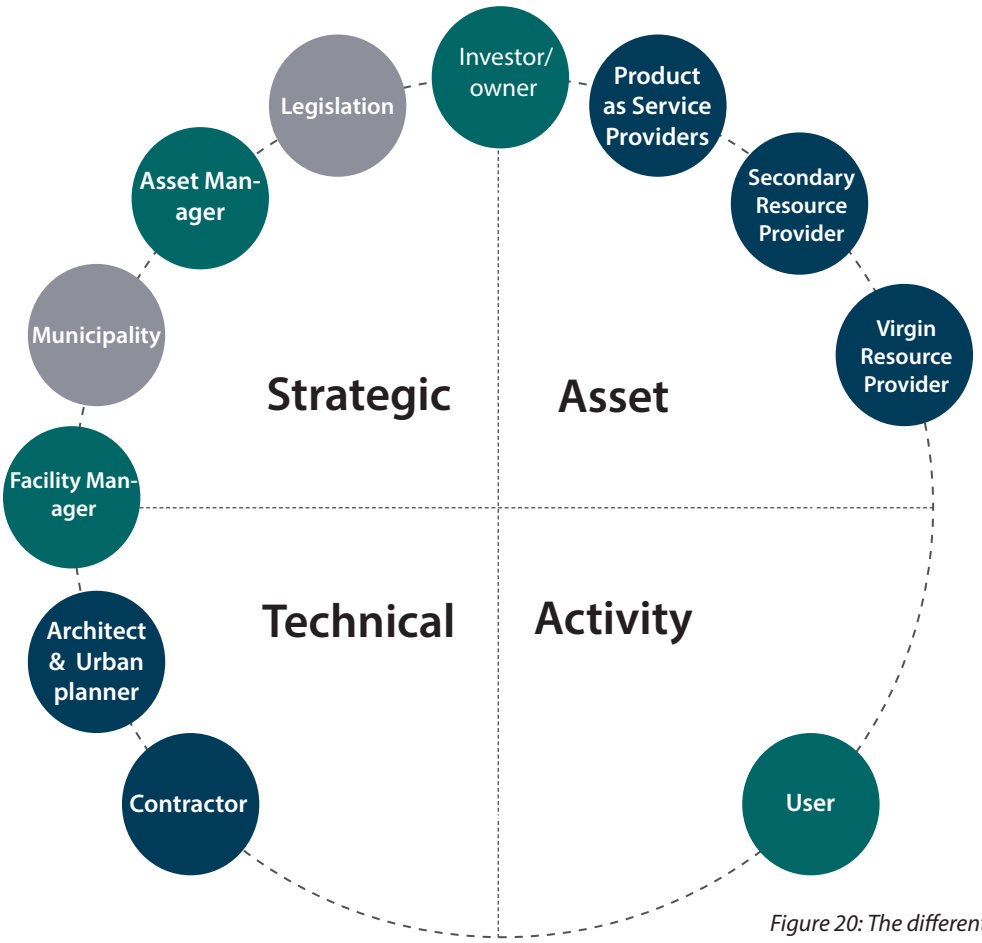


Figure 20: The different stakeholders involved in circular transformation

The commissioners: They are the stakeholders who create a demand and are ready to pay for the services they are looking for.
The executers: They are the stakeholders who respond to the needs of the commissioners with services and charge for it.
The facilitators: They are the stakeholders who create the infrastructure and the medium of interaction between the commissioners and the executers. Creating the right supporting system for the overall functioning.

Table 4: Stakeholder in circular economy





	Stakeholders	Traditional role	Role in circular economy	Result in implementing CE	Interactions with stakeholders
EXECUTER	Service providers	Supplies products	Supplier move from suppliers to service providers, responsible for the life cycle and maintenance of the product along with the materials at the end of its use life.	Responsible for the quality and output of the services provided. Shareholders in the profit sharing	Project manager, facility manager, users, municipality, owner
EXECUTER	Service providers	Supplies products	Supplier move from suppliers to service providers, responsible for the life cycle and maintenance of the product along with the materials at the end of its use life.	Responsible for the quality and output of the services provided. Shareholders in the profit sharing	Project manager, facility manager, users, municipality, owner
EXECUTER	Architect & engineers	Design with virgin materials for single usage. Access new designs	Access the existing structure and materials and responsible to design with the existing materials and design for adaptive reuse of the spaces	Environmentally and financially more responsible	Project manager, contractor
EXECUTER	Contractor	Development based on design with fixed single use connections	Make detachable connections during the construction phase and coordinate with the different service providers	Evolution of new details for construction, Critical for future use of the services being installed in the building	Service providers, project manager, architect
EXECUTER	Secondary resource provider	Sort materials for recycling	Supplier of resources to manufacturers and contractors	Active and critical role in the construction process	Product as a service, contractors, engineers, architects
EXECUTER	virgin material providers	Suppliers of all materials	Suppliers of materials which are not available or cannot be reused	Increase in value of materials being provided but a diminished role in the overall process	Product as a service, contractors, engineers, architects





	Stakeholders	Traditional role	Role in circular economy	Result in implementing CE	Interactions with stakeholders
COMMISSIONER	Owner	Defining the strategy to achieve the required results, User satisfaction, Receive maximum income by maintaining optimum occupancy	Strategically plan the desired outcome and monitor the project, Responsible to initiate the process, Build the team for the project, Make service provider selections based on desired rents	Increase in market value of the company and attracts certain user group. Reduced in liability of ownership (handed over to suppliers) Better returns with lesser risk	Asset manager, facility manager, architect.
COMMISSIONER	Asset Manager	Give owner advice when investor plans on investing	Plan changes based on market conditions to maximize profit	Maximum benefits due to monitoring based on market conditions	Investor, municipality
COMMISSIONER	Project manager	Monitor the process on the investor's behalf	Monitor the process on the investor's behalf	Better coordinated outcome of the building	Investor, asset manager, facility manager, architect, contractor.
COMMISSIONER	Facility Manager	Plans the facilities in the initial stage and involvement once the project is functioning	Responsible for the operation of the project and plan for the next cycle of use. Coordinates between the user, service providers and the investor. Monitors material selection in order to change the function quickly.	Less vacancy due to quick change in functions, smooth functioning of the building. Share holders in profit sharing	Investor, architect, facility manager
COMMISSIONER	User	Pay and utilize services, expect cheap rents along with standard of living	Pay and utilize services, expect cheap rents along with standard of living, while being responsible to the environment	Better living & working environment, lifestyle/ attract certain kind of customers, Enjoy the functions and services provided.	Facility manager and service provider's maintenance team
FACILITATOR	Ministry	Setting policies	Setting policies and implementing changes to facilitate the functioning of the system	Strategically plan considering the future of the building sector and set the required	Municipality
FACILITATOR	Municipality	Vision for the area	Act as a facilitator and provide the necessary infrastructure	Monitor the execution and implications of the projects being carried out	Project manager

Table 4: different stakeholders involved with their roles

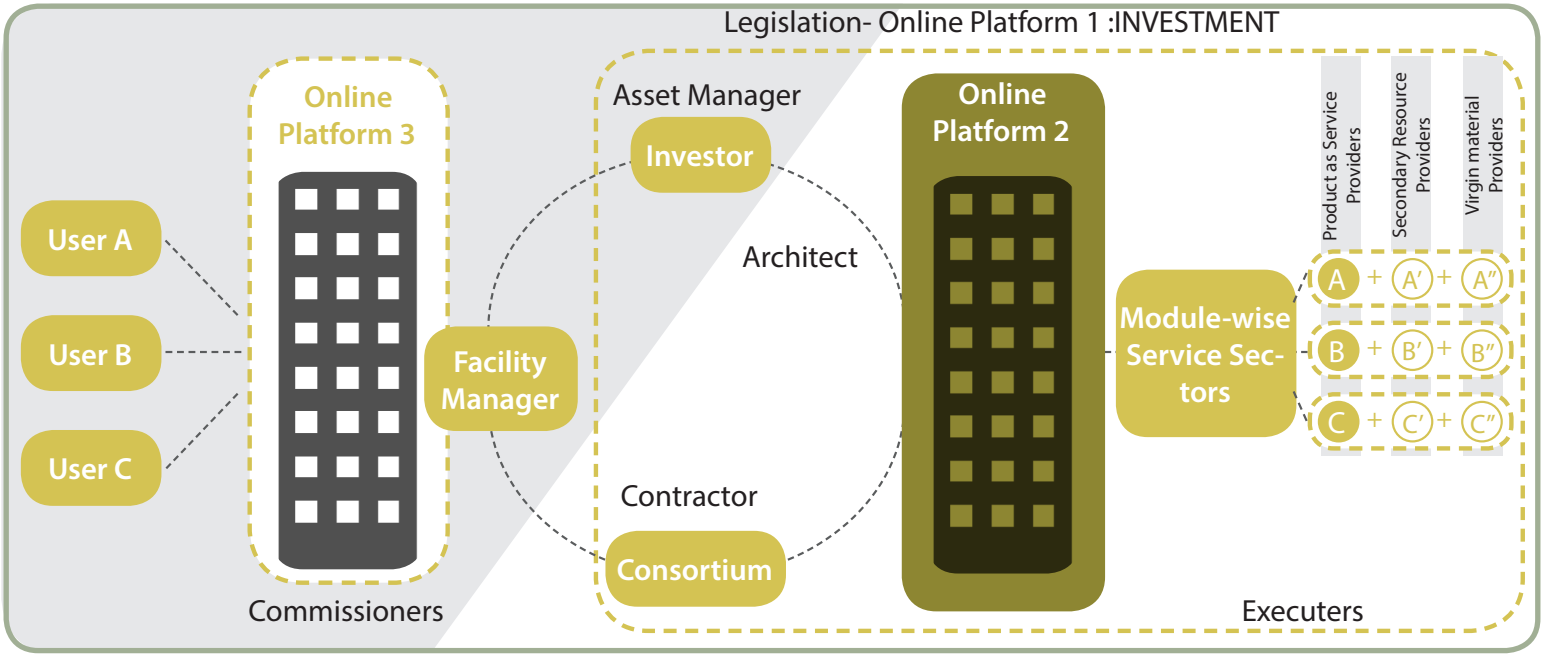


Figure 21: Organisation of different stakeholder and working of the new structure

5.2 Working of the New organization structure

This model displays the functioning of the new system. Integrating different strategies of circular economy with the transformed roles of the stakeholders, a new framework of working is created. The 3 typologies of stakeholders are displayed clearly. The commissioning stakeholders are to the left in the grey shaded area. The right side us the executer group. Both these groups of stakeholders are monitored by the facilitator group.
The users of the building are connected to all the facilities in the building through an online platform monitored by the facility manager of the building. The facility manager is connected to the consortium and building owner and interacts with them for the smooth operations and maintenance of the building. The service providers in the consortium are part of the service sector online platform and have been selected during the initiation process for the project. For the smooth functioning all the online portals are monitored by the facilitators could be the ministry at a large scale and municipalities at a small scale. The municipality have a portal which displays the availability of units and plots for transformation for the commissioner group and the ongoing and expected market trends for the executer group to increase transparency.

5.3 Assumptions

The current legislations do not abide for circular projects, making it difficult to approach this process. For the purpose of this research few assumptions have been made. Based on the document published by the Ministry of Infrastructure and Water Management, on behalf of the Ministries of Economy and Climate, the Interior and Kingdom Relations, Agriculture, Nature and Food Quality and Foreign Trade and Development on implementing circular economy 2019-2023, Stahel W R (2012), Pardo R. et Schweitzer J.P (2018), Circle Economy et al.(n.d) the following assumptions have been created for the implementation of circular economy in the construction sector. They could be characterized as incentive or punishment based.

5. 3 .1 Taxation

Actors: Municipality, owners, service providers, users
Product: Incentive to users of circular buildings
For Users: To generate a demand amongst the users which will intern generate pressure on the market by demanding to move towards a circular way. The municipality can offer an annual rebate in taxation to the middle- and lower-income occupiers of circular homes. This scheme can be launched for an initial period to set the system rolling. Thus, giving financial support to contribute to environmental benefits.

Limitations- Marketing plays an important role in creating a trend or selling the idea of circular lifestyle which will help create a demand. A budget would have to be developed by the municipality for this tax rebate.
Product: Incentive to service providers moving towards circularity
For Service providers: Not taxing human labourers will incentivize more unemployed population into the labourer industry. Reduced VAT levels on value preservation would promote the reusing of materials. Reduction of prices is also a great way to attract more service providers to reduce the cost of the product while making higher profits. Rewarding carbon credits not only for their

reduction but also for the prevention of GHG emissions could get more service providers to rethink their production methods.
Limitation: New method of evaluation for taxation needs to be created

5. 3 .2 Virgin materials

Actors: Service providers, designers, secondary resource providers
Product: Virgin Material consumption
For Manufacturers & designers: Cost of virgin materials will have to be monitored by law to enforce reuse of existing material. This would put pressure on designers to consider available products components or materials while designing. Secondary resource managers at the end of the life cycle, gain an important position in this system compare to their current role. Their role would have to deal with the reuse/ refurbish/ recycling process of the used components within the products. Conducting research to increase the durability and strength of the material before it is reused. Thus, increasing job availability within this sector. The reuse process would need to be complemented with online sharing to make aware of availability of reusable supplies.
Limitation: System for monitoring virgin material consumption needs to be developed.

5. 3 .3 Blockchain

Actors: Service providers, municipality, investors
Product: Investing into sector-based supply chain
Blockchain in supply chain: To produce modular, demountable supplies to cater to the demand of circularity within the built environment, the suppliers face a major barrier of upfront investment. Investments are needed for the research and designing phase and then in developing technology to support this modular way of production. Which will finally translate into the production of demountable products.
To get this circular research started it would be better to divide the construction sector based on the product to reduce investment cost. Blockchain could be seen as a good way of investing into technological development without immediate pressure of performing. This will help the users and investors to contribute and earn returns and have ownership for a sustainable investment. The system however would have to be monitored by all the participating sectors.
Limitations: The structure of the construction sector would have to develop based on sector of work. This means there will have to be transparency in the systems. Not sure how the structure of the supply chain would work. The returns made with this system would have to evaluated as well to get investors to invest in this venture.

5. 3 .4 Adaptable Land Use

Actors: Investors, municipality
Product: Reward with adaptable land use
Adaptable land use for plot: With the idea that waste is food (Ellen MacArthur Foundation, 2013) the structure at the end of its lifespan could be looked at as an asset. Buildings being multifunctional ensures flexibility and adapts to the needs of different users. A well-planned adaptation of the building for various functions could reduce vacancy which in turn will be optimum use of spaces (Gemeente Amsterdam, nd). The possibility to transform the land use from single use to adaptable use while conducting a circular transformation. The function of the plot would be determined within by a framework developed by the municipality as a vision of the area. During the transformation, the function of the building could be changed as per the market needs monitored by the municipality.
This would be displayed on the Online Platform developed and monitored by the municipality for the investors and the planning of the city. The adaptable title helps increase the land value of the plot thus intensifying the investors to transform in a circular way. The possibility to convert into an adaptable plot could be an incentive given for a stipulated period to the frontrunners. Making it possible for the municipality to monitor the area development.
Limitation: May create nuisance within the area and deter investors from investing due near a mixed function land use due to the possible function change.

5. 3 .5 Negative Discounting

Actors: Investor, Municipality
Product: Transforming into circular structure
Moving towards circular transformation: The municipalities could enforce for transformations only in a circular way. Incase investors did not want to take up the task of conducting this transformation, then the land could be bought by the municipality for a discounted rate and auctioned. The municipality gets to plan for the functions within the building based on the market requirement and the investor investing in the project needs to abide by it. This would insert pressure on the investors to move towards circular transformation.

5. 3 .6 Online Platforms

Actors: All stakeholders
Products: 3 online platforms could facilitate the working of this new system.

The online platforms help increase the transparency in the system and avoid monopoly within the market. It gives the users utmost variety within their regional zone which reduces a major issue of pollution caused by simply transporting materials from one place to another. It helps the projects commissioners and users gain knowledge about the functioning, output and environmental effects of the product. All the platforms are created and monitored by the municipality to ensure safeguarding the interest of the stakeholders involved in the process.

Online platform 1:

It is an online platform monitored by the facilitator, this could be a municipality or even a city level. It is a platform which all the stakeholders in the process can access it for their own interest. This platform displays the availability of new plots or buildings available for sale. The probable own can get all the information about the asset. Including size, location, probable function, current sale price, etc. Which will be useful for investors and building owners. For users this platform can be used by different user types to understand the availability of units in the area. Get information about their rent levels, unit size and circularity rating, etc. This platform is useful for the supply chain to understand the current market trend in terms of utility of products. From housing to work spaces to commercial and retail spaces. The service providers get a better understanding of the market from the demographics and trends provided by the municipality. This platform helps the municipality have an overview of the system, without interviewing in it. This is important for the stakeholders to gain faith in the new system and if backed and promoted by the government, this system will be a bigger success.

Municipality/ Investors- Investors	Available buildings and their location, level of circularity, current suppliers, probable function as per market needs, cost
Municipality - Users	Availability of unit, tenure of contract, rent per month, level of circularity (for tax discounting),
Municipality - Supplier	Requirement of module types- based on market condition

Table 5 : Online Platform 1

Online Platform 2:

It is the platform which displays the services available to choose from. The suppliers are divided into sectors as per the layers of Shearing of Brand (1994). This clusters the service providers into their sector and is easier for the functioning of the sector. The secondary resource suppliers, product leasing service providers and raw material providers for each sector can collaborate through this online platform. The designers and architects can see the available services on this platform to propose the larger design. The architect and building owners can choose the product as a service based on the number of pieces available, the time of its availability, its performance, its circularity index, monthly rental cost, aesthetics, current location, etc. This helps designers get introduced to newer products and the building owners to maintain the performance standard of the building and the required rent levels. This is created by the government to safeguard the rights service providers while it is operated and maintained by the sectors.

Supplier- (Investor + Designers)	Performance of product, time of availability, price, number of units, current location
Supplier- secondary resource suppliers	Requirement of material, component or products
Secondary resource suppliers - Supplier	Availability of components or materials at the end of the lifespan

Table 6: Online Platfrom 2

investor(facility manager) - supplier	User type and units required, maintenance & operation
investor(facility manager) - user	Availability of shared facilities, cost based on usage
Investor - supplier	Profit sharing

Table 7: Online Platform3

Online Platform 3:

It is the online platform for the inhabitants of the building. Maintained and operated by the facility manager, this platform facilitate the use of amenities and services within the building for all the users. The users can see the shared amenities available in the building and book a slot while connecting with like-minded people within the building. The users can keep a check of the usage of all utilities on this platform and it will give you a comparison with the relative consumption in the building. This will help users get aware and use them in a sustainable way. The users can lodge complains, check for the maintenance and repair for the services on this platform. For the building owner this displays the take-up of spaces within the building. Which helps evaluate the rent generated with the project at a particular time. The facility manager can coordinate maintenance and address demands with the service providers to optimize user satisfaction.

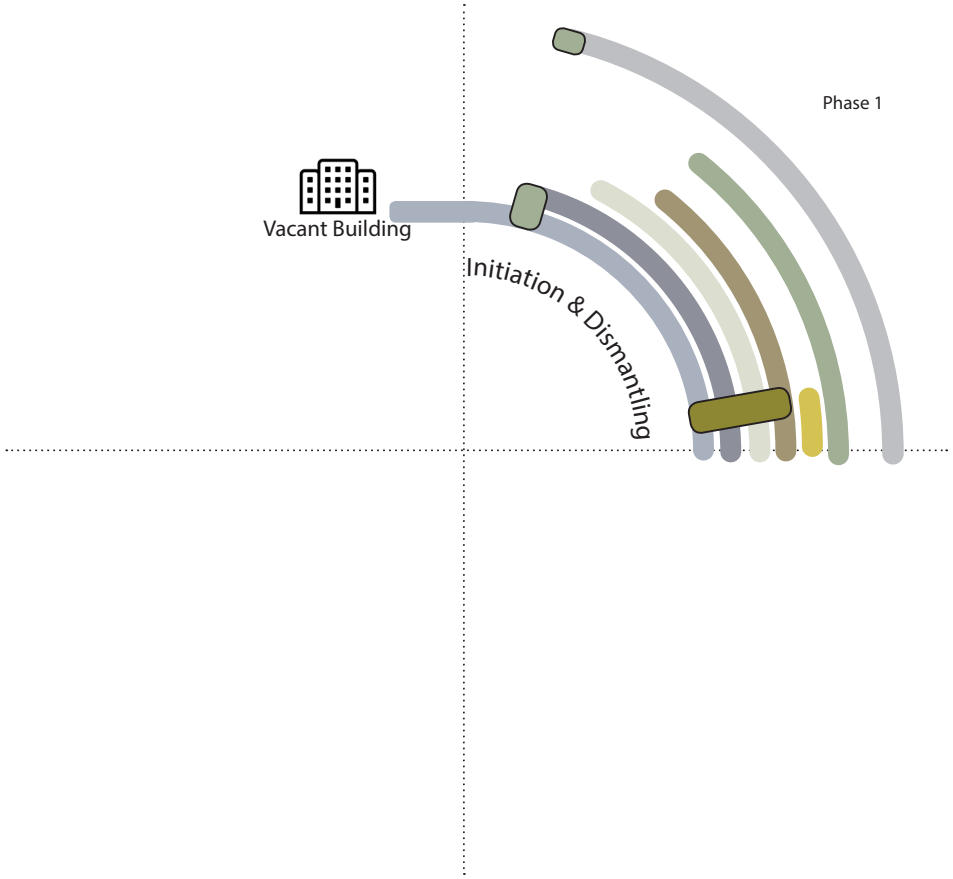
5.4 Phase wise execution of circular transformation:

To create a business model for a circular built environment it is important to analysis the full life cycle of the building within this new system. For this process to begin it is essential for the investor to initiate the process. The reason this is critical because this will change their current perspective of owning an asset for a set period and selling it once it has generated its required revenue and when repairs need to be conducted. With investors initiating this process they will be more involved in the process making them aware of the added value the asset could generate with minimum investment. This will push them to retain assets and upgrade the services provided by service providers rather than selling the asset. Making them liable for a longer period thus accountable for the asset.

The process starts with them making a decision that something needs to be done to the underperforming existing structure in a circular way. The stages involved during a life cycle of circular transformation includes feasibility study as a pre-design phase. This would mark the end of the linear usage of the building and commence the circular transition.

The initiation stage consists of a detailed feasibility study. Assessing the structural, technical and financial viability for conducting a transformation on the existing structure. Once the decision of conducting a circular transformation is made the following step by step plan commences:

Initiation & Dismantling Phase



Owner appoints an asset manager to plan for the next life of the project. The probable functions and target audience are decided as per the market requirements. The online platform 1 helps the asset manager understand the market needs and probable competitors. The engineer is commissioned to assess the structural quality followed by the architect to develop a proposal for the transformation of the existing building. A contractor is appointed to extract the resources not going to be used within the building during transformation. The secondary resource manager can use these resources by testing its strength and providing it to the service manufacturers (suppliers). The online platform 2 helps investor, architects and facility manager choose for the modules to be inserted during transformation. This would be based on the performance, leasing amount, availability, number of modules available. This results in the final proposal for execution.

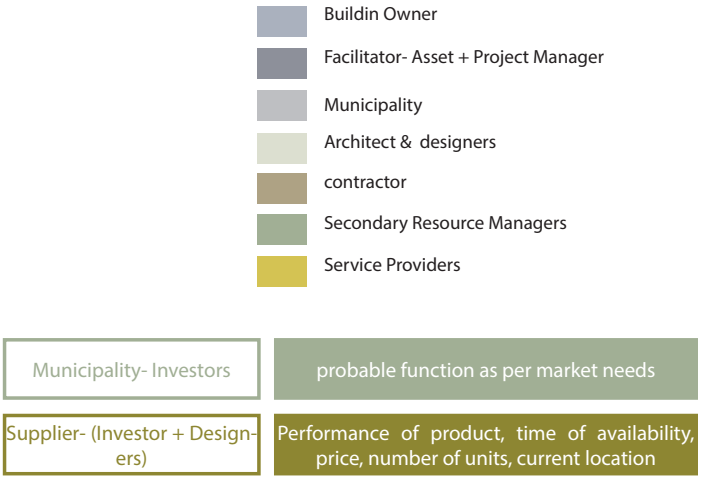
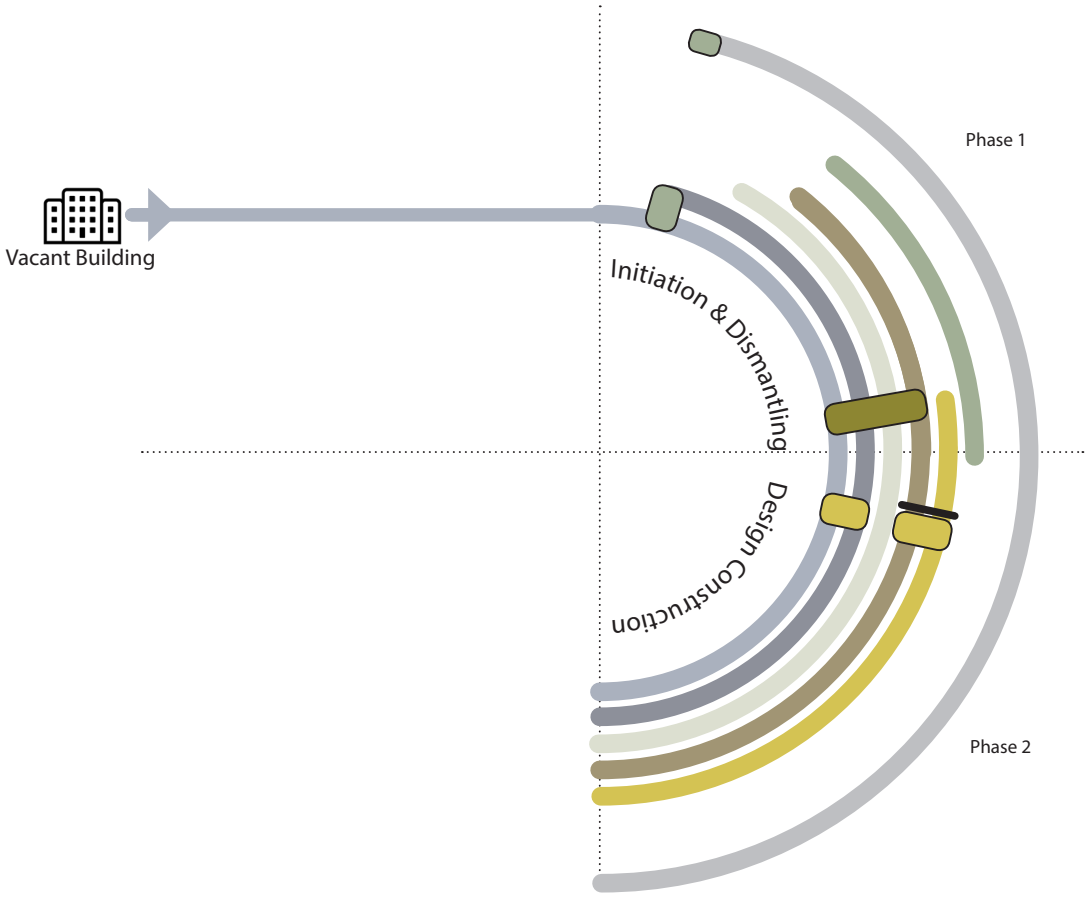


Figure 22: the initiation and dismantling phase

Design & construction Phase



The service providers of the selected products by the building owner, project manager, facility manager, architect & engineers and the contractor come together to create a coalition. The service providers and facility manager are in the project based on profit sharing. This ensures the quality check at all times. A consortium is developed between the service providers and the contractor, building owner and facility manager to insert the products into the building using a demountable method. The consortium is in an agreement with the owner of the building for a fixed tenure. The service providers are responsible for the maintenance and operation of the modules. The facility manager coordinates the working of the entire system through the online platform 3.

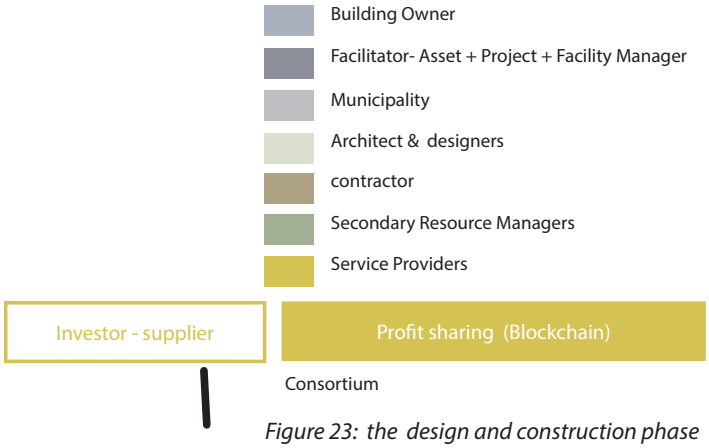
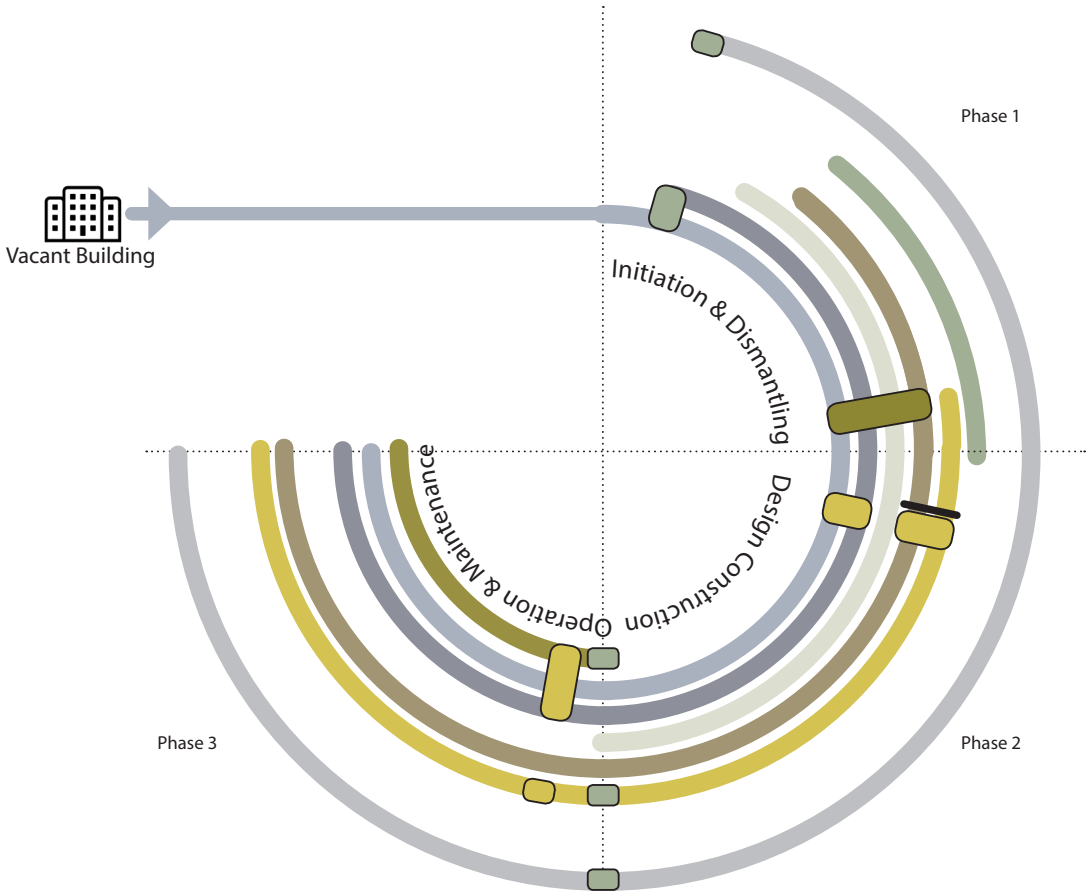


Figure 23: the design and construction phase

Operation & Maintenance Phase



The user goes over the online platform 1 which displays the availability of homes and office spaces within the area. It also displays the size of the units, tenure if contract, level of circularity for tax reduction, etc. The users occupying the building get access into the online platform 3 displaying the whereabouts and functioning of the building. The service providers maintain the units along with the facility manager. The users pay for the services as per their usage in addition to the basic rent level. The profit generated is divided on profit sharing bases between the facility manager, building owner and service providers to ensure smooth functioning and active processing to maximize profits for all.

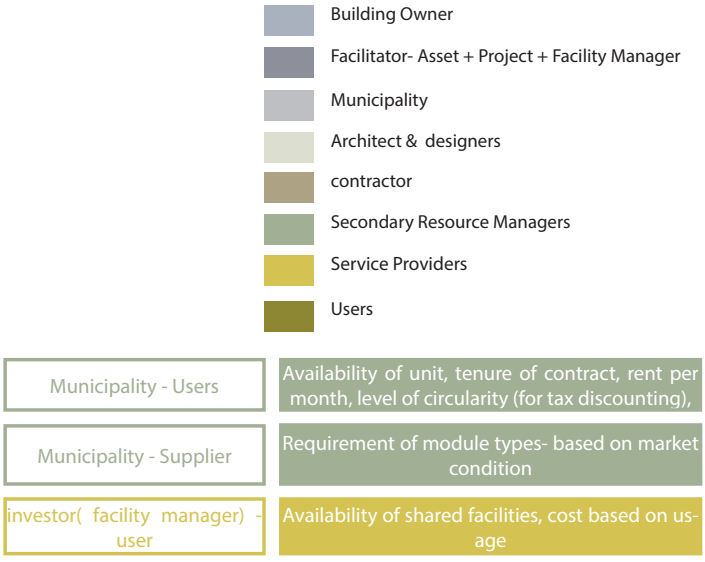
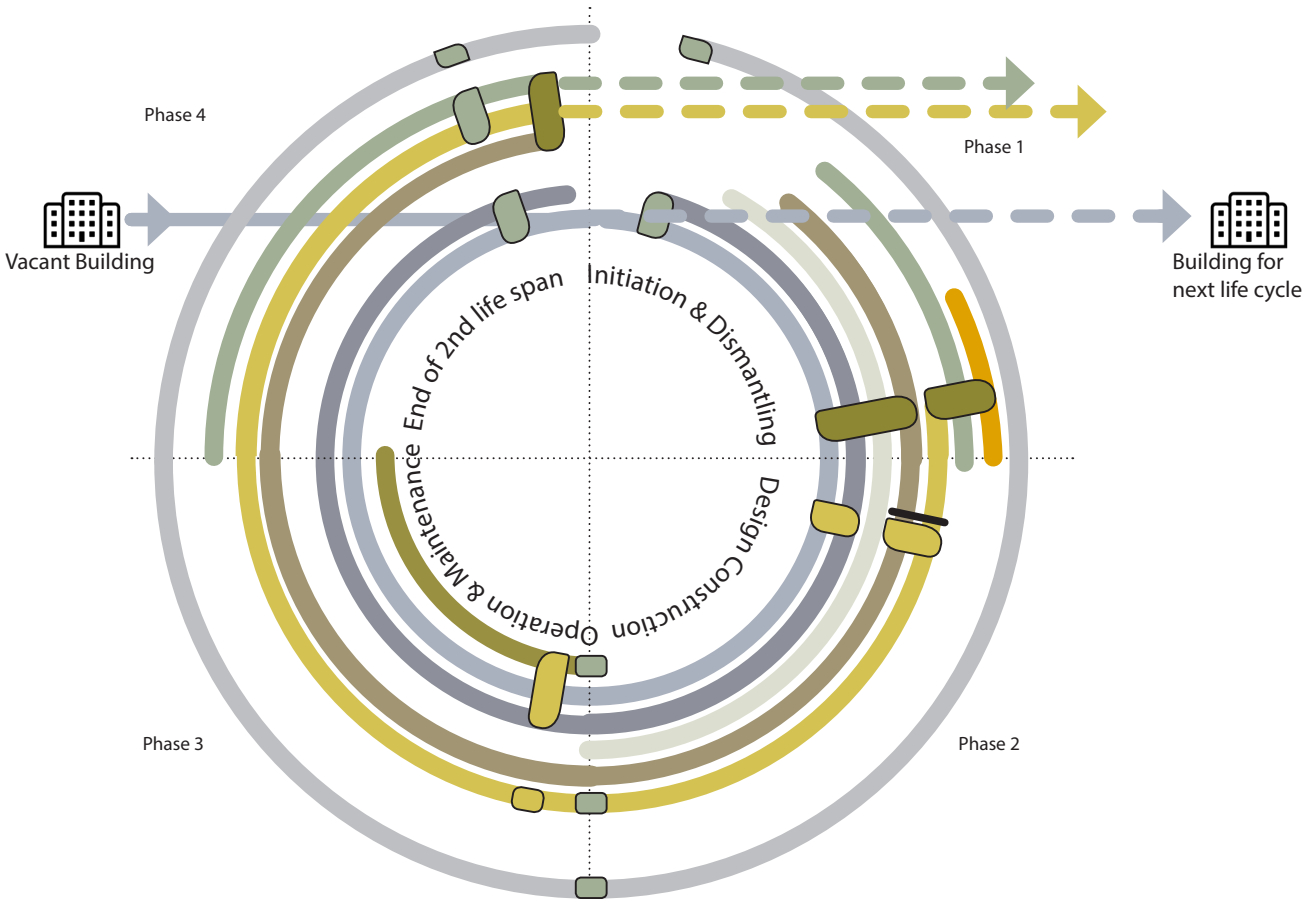


Figure 24: use and maintenance phase

End of 2nd life and initiation of next life



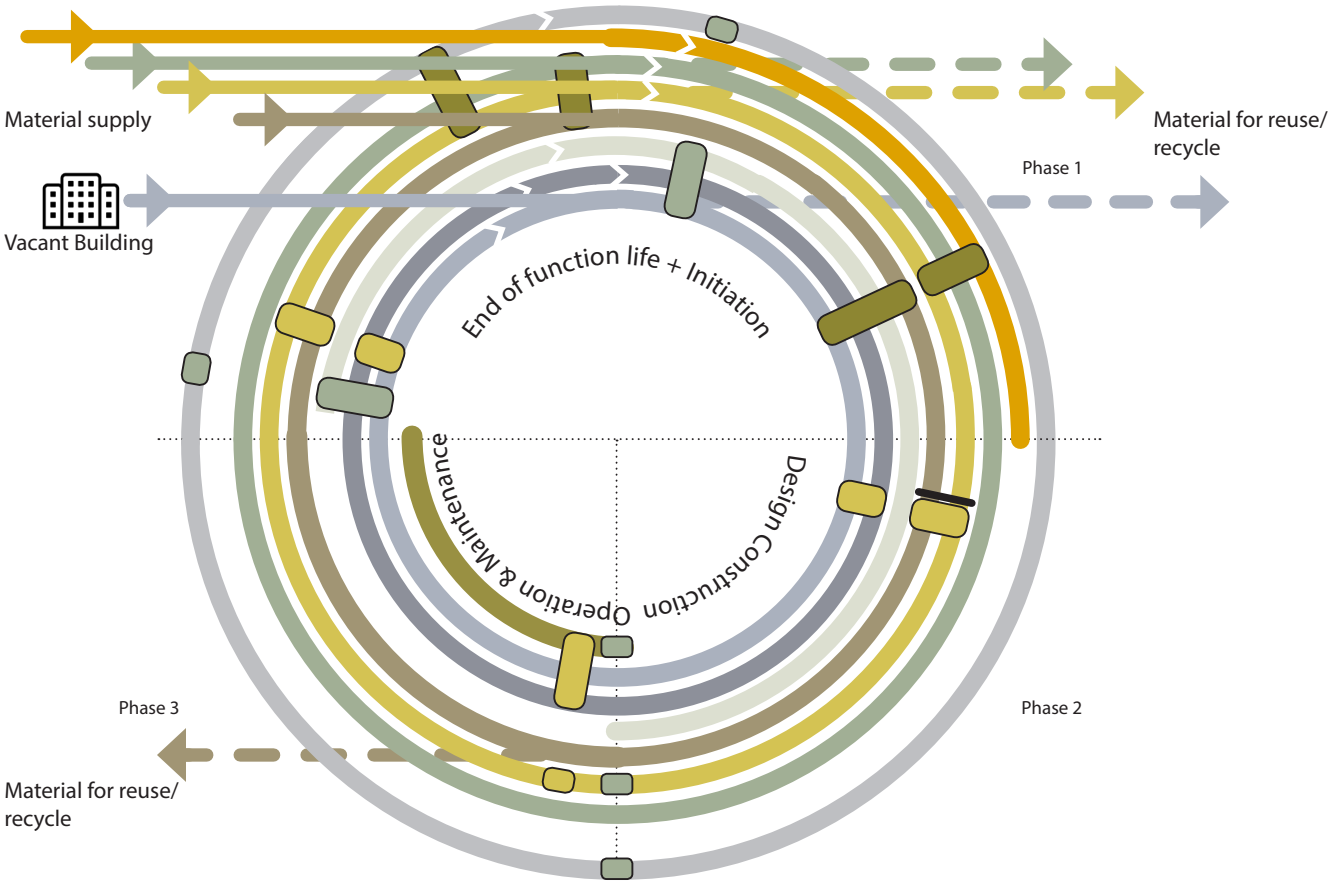
Near the end of the contractual tenure of the consortium, the building owner with the asset manager access the asset and plan for the next life span of the building. If the building owner want to end transfer the ownership, he can show the property details to interested buyers on the online platform 1. In case he is interested in retaining the property and is happy with the services and the functioning of the building, he could propose the service providers for an extension of consortium. In case the building owner decides to retain the asset but would like to create a new consortium, the asset managers with the architect can plan for the next use phase. While the existing consortium operates till the specified date after which the service providers disassemble and take their suppliers. The contractor helps during the disassembly and the managers helps coordinate the process. Following which the new consortium starts the process for the next use phase.

Building Owner
Facilitator- Asset Manager + Facility Manager
Municipality
Architect & designers
contractor
Secondary Resource Managers
Service Providers
Users
Raw Material supplier

Municipality/ Investors- Investors	Available buildings and their location, level of circularity, current suppliers, probable function as per market needs, cost
Secondary resource suppliers - Supplier	Availability of components or materials at the end of the lifespan

Figure 25: end of 2nd life phase

End of 2nd life and initiation of next life



If the building owner is satisfied with the products in the building and the service providers maintain and upgrade them constantly, then this cyclic process could be conducted till the end of the structural lifespan of the building. Maximizing the usage of the materials invested in the existing buildings. The process will result in materials removed from the products in the buildings. This could be either reused in the product post refurbishment or given to the secondary resource supplier for recycling. This prevents the materials from ending at the landfills and ensure resource usage to the best of its ability. The difference in the initial step and this step is that the building needs to be adapted to a circular way of working. This includes use of dismantlable products and services. Changed mindset and changed system to adjust to, which will be a well-established system during the next use life of the building.

Figure 27: the end of life and initation of next life

5.5 Assessing the risks

While understanding the convivence of this new way of working in the construction sector, it is important to understand the risks which accompany the process. The risks are discussed further in a SWOT analysis conducted.

SWOT Analysis	
Strength	Higher benefits for all stakeholders comparing to the current way of working Higher environmental, societal and financial benefits More transparency in the system of working and all stakeholders aware about the sustainability level of the product Can address the issues in new as well as existing real estate optimizing material usage. Implementing this system as a has a long term
Weakness	Higher investment being made by all stakeholders- which may be difficult to achieve currently, the returns to which are not very clear. A lot of new investments need to be made in all fields- research, designing of products, manufacturing, distribution, maintenance, operation, refurbishment and end of life or downcycling. The impact of implementing this system is not known in terms of CO2 emissions, etc. High number of incentives need to be provided by the government The construction sector is extremely orthodox and averse to changes, so this system will be confronted with opposition.
Opportunity	High chance for new innovations due to the prerequisites for standardizations and modular designs. Fair chance for all stakeholders in the new transparent way of working The system prevents accumulation of wealth in the hands of a few and promotes employment Higher possibility to upgrade products in use Environmental and societal effects have a financial implication, which helps putting a price on it. Use of more recyclable materials being introduced into production, thinking about the next use life.
Threat	Possibility for the system failing since many new changes needed to the current system to incorporate for the required changes. Change in legislations are needed to bring this system into being Change in mindset is needed to adopt this new structure Everyone will have to adopt this system for it to be a success Standardization will play a key role in implementing this process

Table 8: Showing a SWOT analysis of the scheme developed

PILOT STUDY AND FEASIBILITY

This chapter explains the pilot study being used as a case and the effect of conducting the circular transformation. The implications of conducting the circular transformation are compared in 3 scenarios, where the format of the investment for the investor varies. This helps determine the roadmap to a circular built environment and shows the feasibility of conducting circular transformations for investors.

6.1 MOR pilot case (project details from MOR project manual)

The MOR team is a student team representing TU Delft at the Solar Decathlon Europe 2019. MOR stands for Modular Office Renovation. It is a joint effort of students, professors and market experts with a common vision of making the built environment future proof. The MOR design aims to give back to the more than what it consumes to its surroundings. The strategy developed has proposed a solution to two major problems encountered by the real estate sector in the Netherlands. One transforming the under performing vacant office stock into mixed function transformation, thus addressing the growing demand of housing. The starter group and others faces the ruth of shortage of affordable housing in the Netherlands. The transformation proposed is net positive, circular, mixed function and affordable to address this problem.

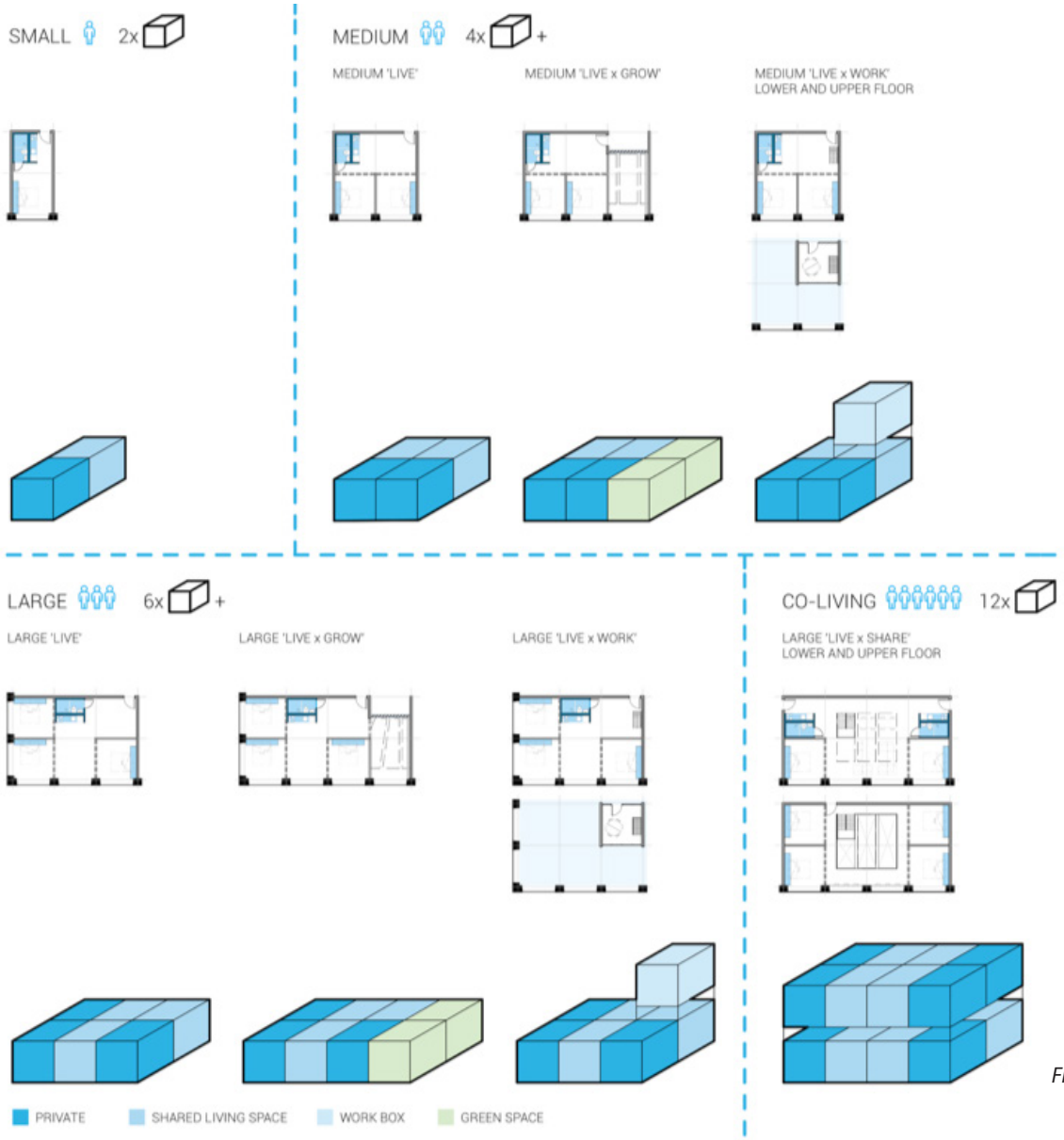
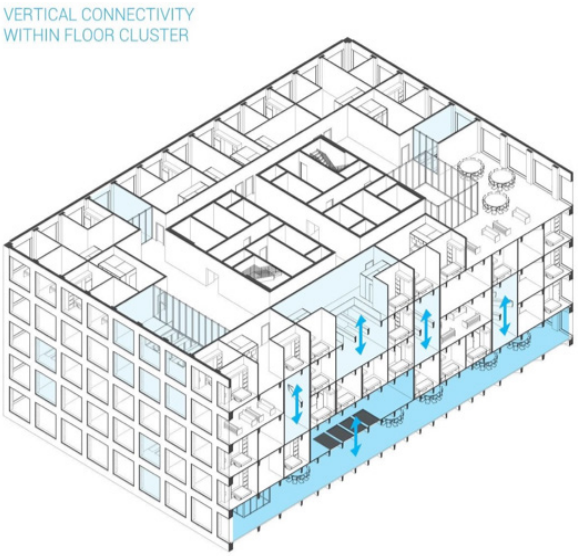


Figure 28: MOR team typologies (MOR, 2019)

The layout of the building is that of a typical office building from the mid 70s, with a central core and an open floor layout. This set of 3 buildings has been replicated 6 times across the globe by the same architect SOM. The typology is well known and the solution proposed can be modified contextually and adopted across the globe. The concept is to use demountable modular units to create the space. The modularity is seen in most of the component such as the facade, kitchen and bathroom module, the bedroom module and the different kind of wall modules. Designed to be highly sustainable and circular these modules can easily be demounted and reused in other spaces. The units are of different typologies. Given maximum flexibility to adjust as per user needs if there is an availability. The sizes of the typologies vary between 25, 50, 62.5, 75, 87.5,100, 150 meter square.

The 22 level building is divided into 5 clusters, the lower cluster with 2 levels and the 4 above with 5 levels each. Each of the 4 larger clusters has one office level and 4 residential levels. The smaller cluster consists of retail spaces on the ground level and commercial activities on the level above. Inserting modular demountable spatial features makes it possible to adjust the area into the functions required by the market. Thus easily adjustable from offices to dwelling and back, as and when needed. Thus adaptive reuse of the existing building and optimizing its usage by designing for functional flexibility and material circularity while being affordable.

The MOR pilot case has been used to test the different scenarios created in the study. Using the modular components designed along with their costs, lifespan and residual value to test the feasibility for investors to move towards circular transformation projects rather than only focusing on new circular construction projects.



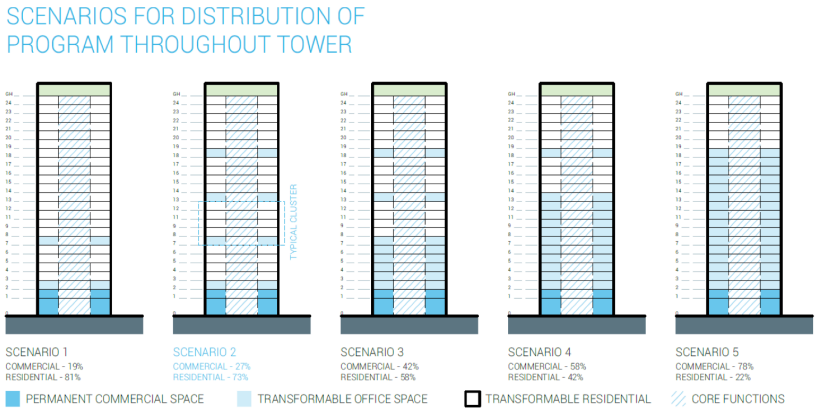


Figure 29: MOR team cluster(MOR, 2019). Figure 30: Scenario study (Mor, 2019)

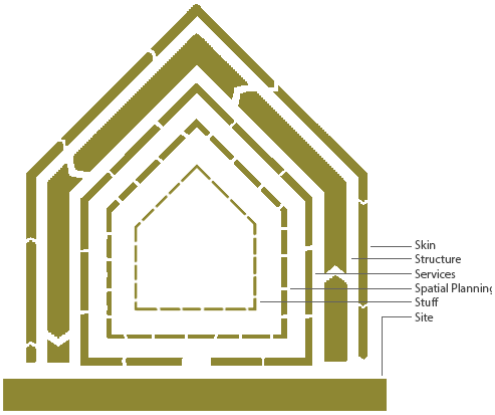
6.2 Feasibility of Circular Transformation

6.2.1 Financial Feasibility for investors

The MOR pilot case of circular, net positive transformation project has been tested under 3 scenarios to check the feasibility for investors to move in a circular way. These scenarios are based on the varied percentage of investments being made in the project by the owner of the building and the service providers. This is based on the data collected by the service providers for the MOR project. Their willingness to provide their products in a product as a service format.

While implementing product as a service, the service providers take a larger risk of ownership through the product life span thus expecting a higher return. The calculations considered for the products in product as a service includes the cost of the product, the expected profit and maintenance at an inflation based on the lifespan of the product. At the end the residual material value mentioned by the service providers is subtracted. This helps create the basis for the products.

Moving towards product as a service eases the investment burden from the building owner and distributes it to the service providers. Introducing product as a service is based on increasing the liability, tenure of ownership but also the profit earned by the service providers. The more the product as a service strategy is adopted the more the investment pressure will move towards the service providers from the building owners. Thus making them a critical stakeholder in this process. By reducing the investment of the building owner the process seems for feasible for them, but the level of feasibility has to be evaluated. This is done by developing scenarios where different investment opportunities are considered by the building owner and the service providers based on the products being considered as service. The feasibility for the investor has been tested in different scenarios.



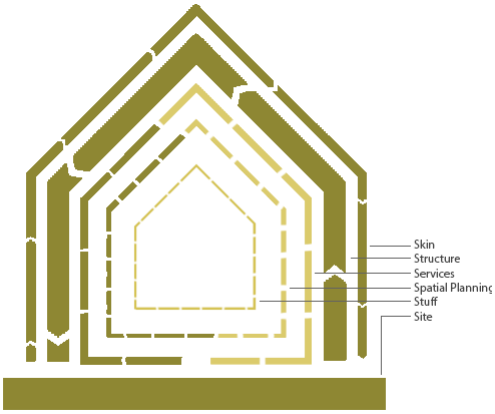
Scenario 1

Owner: Site + structure + skin + service + spatial planning + stuff

Service Providers:

The scenario 1 is the current day scenario. Where the concept of product as a service is not widely used. It also happens to not be very feasible for suppliers to currently move towards this business model. The investment being made would be fully funded by the owner of the building. By taking the initiative and appointing the asset and project manager. Making the required investment decisions based on expert opinions and developed plans. This reduces the developer's fee from the investment while incurring the cost for investing in the relatively more expensive circular products. The investment in the project based on the high quality of circular and sustainable products based on the proposed MOR design will be 101,663,474.89 Euros With an estimated return on the overall investment to be 7.91%.

Owner's investment



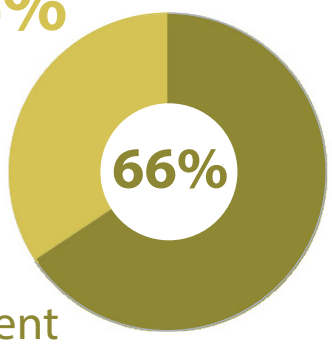
Scenario 2

Owner: Site + structure + skin + service + spatial planning

Service Providers: Service + Spatial planning + stuff

This scenario demonstrates the process business model which demonstrates partial implementation of product as a service. A point in time where the infrastructure needed would be established. The regulations and framework for working would be set in place and product service providers would have an established investment for upfront investments. This would give them the opportunity to participate in this system as a service provider. This scenario is where the building owner invests in the site, structure and the facade along with planning for the building, while the service providers take care of the products comprising of the spatial planning, part of the services and the stuff within the building. The sharing of profits is determined by the percentage of investment in the building. The rent charged to the users is a cumulative one and is then divided based on the investment of the shareholder. The investment for the owner of the building in the project based on the high quality of circular and sustainable products based on the proposed MOR design will be Euros 57,512,884.00 with a return on investment of 8.49%. The facility manager would also be part of the profit sharing since he manages the project to optimize its functioning.

Service provider's investment **34%**



Owner's investment

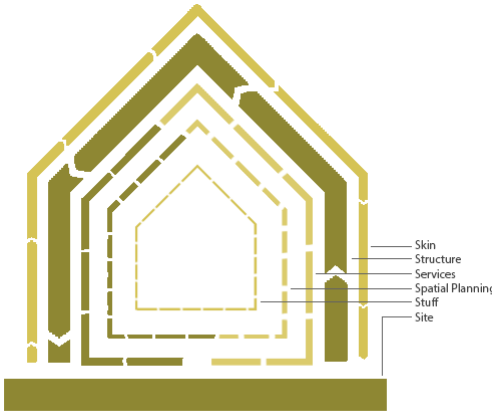


Figure 31 & 32 & 33: Showing ownership of investor and service provider in scenario1, 2 & 3 respectively.

Scenario 3

Owner: Site + structure + service + spatial planning

Service Provider: Skin + Service + Spatial planning + stuff

In this scenario the investment of the owner is limited to the site and the structure and part of the services which could be used by all the years to come. Thus leaving the investments related to the skin, most of the services, spatial planning and stuff in the hands of the service providers. This scenario is where the building owner invests in the site, structure along with planning for the building, while the service providers take care of the products comprising of the spatial planning, part of the services, skin and the stuff within the building. The sharing of profits is determined by the percentage of investment in the building. The rent charged to the users is a cumulative one and is then divided based on the investment of the shareholder. The investment for the owner of the building in the project based on the high quality of circular and sustainable products based on the proposed MOR design will be Euros 31,426,780.00 with a return on investment of 12.1% The facility manager would also be part of the profit sharing since he manages the project to optimize its functioning.

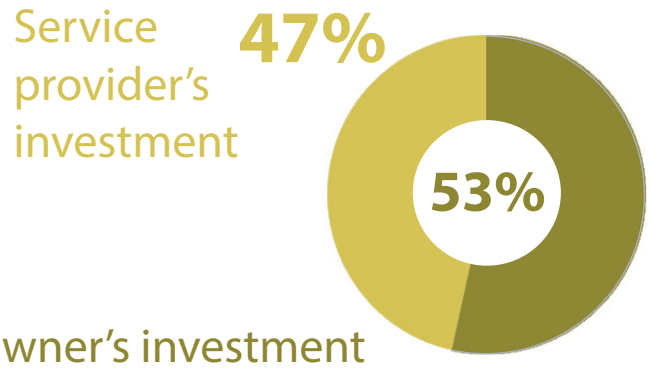


Figure34, 35, 36 : Showing investment of investor and service provider in sceario1, 2 & 3 respectively.

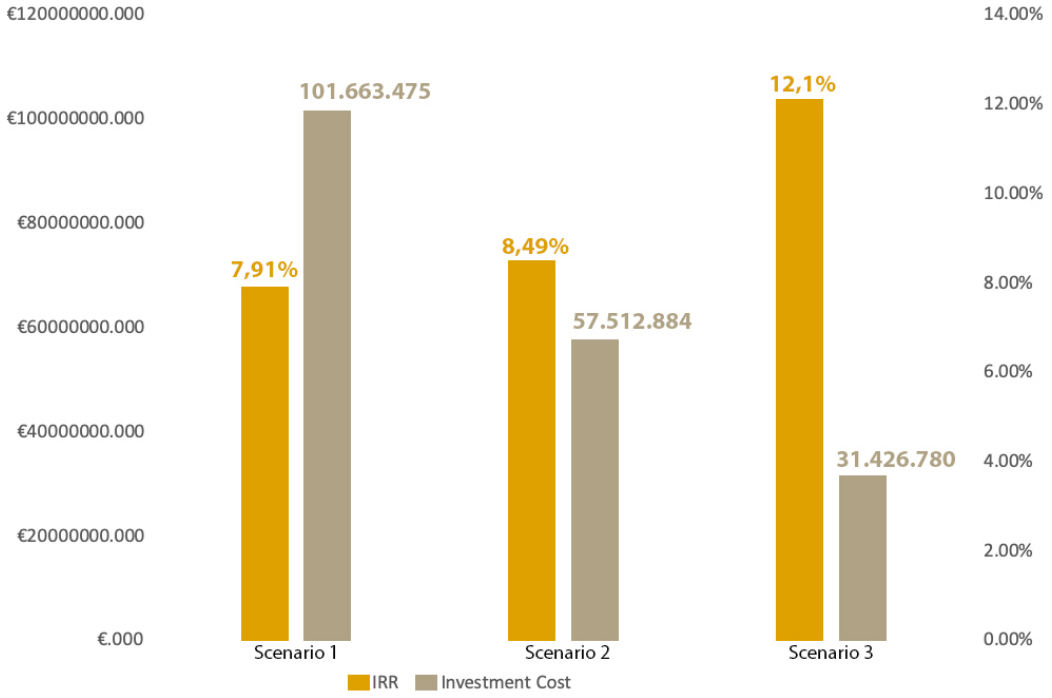


Figure 37: The IRR and investment is of the building owner in the project in the 3 scenarios

6.2.2 Environmental Feasibility

In order to incorporate environmental feasibility into the system a method to evaluate the environmental effects of the components incorporated into the building is important. The impact of the product on the environment in terms of material scarcity, its local availability, toxicity, energy consumption,etc. (Ellen MacArthur & Granta Design, 2015). Based on the assessment methods available today, the Ellen MacArthur's Material Circularity Index could be used to access the degree of circularity of the materials being used. The production and demolition process is considered, however the context is not considered. Details of this method to calculate the MCI are explained in chapter 3.6. This calculation will help the owner of the building access the level of circularity which making a selection of the required products during the initial process. This will impact the rent level for the users in the building and also determine the kind of lifestyle the owner wants to sell.

There are multiple rating systems like BREEAM, LEED, etc. but this rating will add the circular dimension to the assessment. The level of circularity of the project can also determine the value of the project at its point of transfer of ownership. Making the investment and the value of the transformation higher.

6.2.3 Social Feasibility

For the part of social feasibility, the rent levels per person considered for all the scenarios falls in the affordable range. Making this project viable for all the users types without hurting their pockets. The concept can also be adapted to the needs of different user groups, thus making it flexible for incremental growth within the building.

The modules being demountable during transformation to address market conditions, makes its a labour intensive job, thus giving rise to more employment opportunities for the socially backward and unemployed population within the country.

6.3 Scheme developed

Transformation is made feasible when the structure is physically strong, and the layout is flexible enough which allows for adaptive reuse of the existing building. Different typologies of buildings based on their layout could follow the transformation process specific to their typology. This implies that if the layout allows for maximum flexibility, the design for transformation should allow for that. In case the existing layout is less flexible, then the layers which allow for change must be addressed with maximum flexibility the rest must be designed to complement the layout.

The process begins by testing the structural strength and planning for the repairs. The requirement of functions within the land use plan/ area vision planned by the municipality. The adaptive capacity along with the area vision will help determine the function of the building post transformation.
The spatial planning must take into account maximum flexibility. The transformation should be designed to address changing functional needs and should be easily adaptable. The spatial planning and design proposed should follow the idea of "function follows flexibility".

Once the design for transformation is created, the service providers must be selected. The options available amongst the different layers of Shearing (Brand,1994). More the circular strategies are adopted across the layers the higher is the expected outcome of the process.
This will be more relevant when the system of working is adopted by the construction sector.
It could begin with the site, structure being reused. The spatial planning allows for extensive use of the transformed structure, by incorporating modular partitions and easily dismantlable walls, doors, etc. the spatial planning comes under the circular label, which allow for change in the future.
The next layers to move towards the circular transition is critical. The services should be designed to take into account the needs of the future functions within the building. The connections must be demountable incase a part needs to be replaced the entire system does not have to be taken out. The maintenance handled by the service provider will ensure smooth function of the service for a longer period of time with a clear understanding of the issues being encountered.
The skin of the building would have to adjust to the building type. This makes the façade an important component since it can not only affect the image of the building but also the outcome and affects the overall performance.
The stuff in the building has the shortest lifespan and methods of sharing established helps the functioning.
By incorporating the scheme based on the layers of shear by Brand, the high the circular the components the more the circularity in the building and a larger impact in the overall built environment.
A consortium of the different service providers along with the building owner will allow for and aid for the transition to a circular system.

The more layers of Shear (Brand,1994) with circular products the higher is the level of circularity. This makes transformation projects the highest level of circularity since the projects retain the existing structure and giving it a second life instead of demolishing it. Following transformation projects, reusing materials in new projects makes the project more circular than using virgin material products. The rating systems of the building must reflect this and incentivize steps to move towards circular economy in construction sector.

6.4 Types of investors

The long term investors would be expected to continue their on going role in investing in the asset for a long duration preferability a longer duration would make the system more efficient. The investment would be limited to the land and the structure along with the smaller investments in services, design and management of the building. The risk level in the investment would reduce so would the amount invested decrease compared to the current day scenario. The building owners would probably have larger portfolios since lesser amount of investments would be made. The short term investors who are unwilling to invest for a long time period could invest into the supplier's market (blockchain). With a higher return on investment but with relatively higher risks.

DISCUSSIONS & LIMITATIONS

This chapter explains the topics that have emerged as a result of the research. Topics to be discussed which could influence the research results in the long run, along with the limitations. The limitation of the research are the unresolved topics which will define the overall feasibility of the project.

7.1 Discussions

7.1.1 Architectural typology & image of the city

The conceptual scheme developed demonstrates the feasibility of circular investment for the building owner and the service providers. The circular scheme developed works well for the transformation of the typical 70's office building with a central core and an open floor plan. This is a typology commonly seen across the globe. The typology could be recognized for its adaptive capacity and flexibility, capable to adjust to different functions with minimum interventions.
The scheme developed is relevant to any building of this typologies across the globe. With the base idea being that the same the scheme could be adjusted to fit the requirements of different typologies. The typologies of buildings could be categorized based on design (form), planned function, materials, sizes etc. This analysis would help evaluate whether the architectural typology is fit for adaptive reuse by circular transformation. "Revive the meaning in architecture through typologies of the past" (Daniel Koch, 2014) It would also help understand how the scheme would adapt based on the typology and what would be best suited adjustments to be made for the transformation.

If we take the example of the Marconi Tower from the MOR case, the proposed transformation is an initiative of the owner of the building. This could be a completely different picture if the layout of the building was different. It would not be able to account for functional flexibility for instance. Thus, distinguishing the typologies of form from use (Markus T., 1993). The earlier buildings were designed for function, rather than immediate use. Example the Marconi tower was not designed for a particular commercial office but as a common one which any commercial office was free to use. Thus focusing on the functional type of architecture (Daniel Koch, 2014). Planning and labelling rooms with functions is a postmodernist phenomena this is seen widely in the works of architects like OMA, BIG, Rafi Segal, etc. (Daniel Koch, 2014).

If we consider the building typologies before the modernist era, the site and structure of existing stock can also be considered as product as a service. Making the current investors also part of the supply chain rather than viewing him on the demand side. It could be a possibility that the service provider of the land and structure leases the site from the municipality. Changing the role of the stakeholders on the commissioning, executing and facilitating side to be completely different. Increasing the value & role of managers in the facilitatory role is a result of this new system. Handing the vision of urban and area planning to the city in this case the facilitators. This will not only affect the construction sector but will address the questions related to architectural typologies, their adaptable nature and their impact on human life.

7.1.2 Marketing circularity

Another critical point is how circular economy within the livelihood sector is changing the marketing strategy. The only approach we have been introduced to is "New is Good" from the industrial revolution period. With the impression that is clean, healthy, of a better quality, better for life. This mindset has been ingrained into the generation which is important to address for the success of circular economy. The current generation consumers is could not have been in a better position of been influenced by branding that surrounds them (A. A. Circle Economy, 2017).

Giving circularity a status symbol will be essential to create a demand for it. Its is important to understand and address the human psyche while introducing this topic. This is because everyone is aware of the global climatic issues but choose to ignore it. They are aware about their life span and believe in momentary pleasure without looking at the larger picture. Thus its is important for brands to educate their consumers explaining about effectively redesigning and improve consumer relationships along with generating value (A. A. Circle Economy, 2017).

Lauren Phipps (2018) in her article acknowledges communication to be the key in explaining circular strategies and describing the products and services being offered. Explaining them the story is important but explicitly stating their benefits is equally important for convincing your end users.

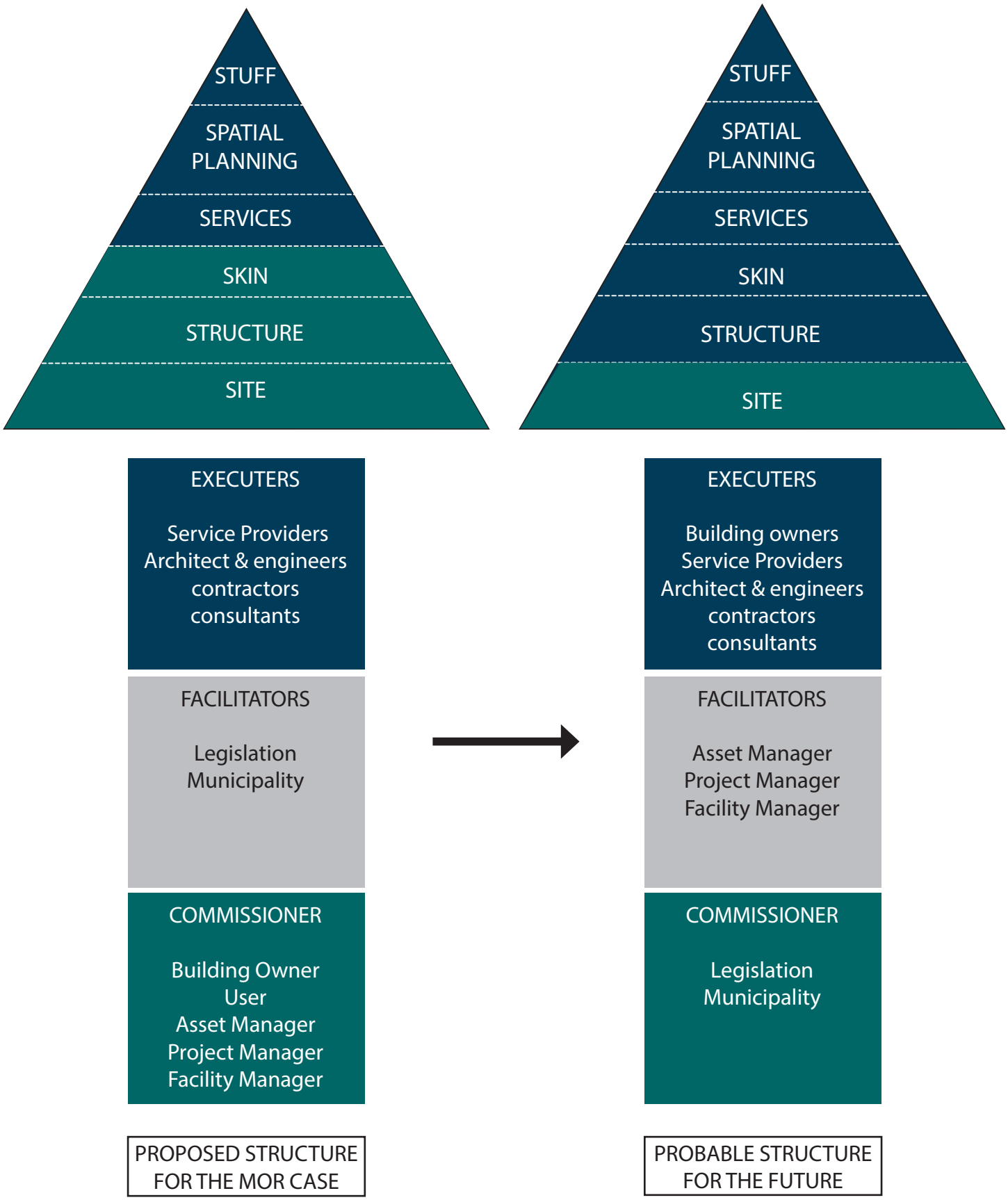


Figure38: Showing curently proposed scenario and the possible future scenario

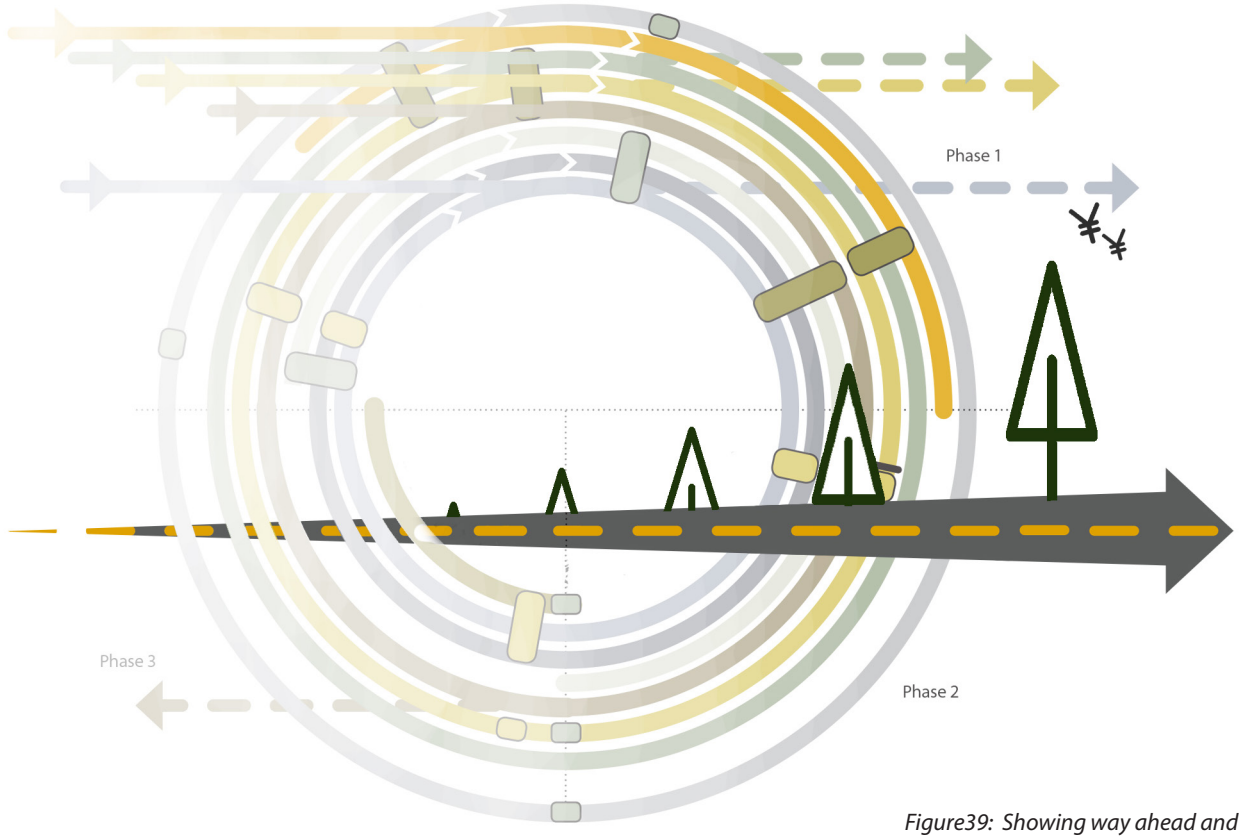


Figure39: Showing way ahead and impact of circularity

7.1.3 Change in mindset

The construction sector is a combination of multiple sectoral divisions coming together. This implies that all these divisions look only at their requirements neglecting the larger picture and its impact to the real estate at large. Construction as a sector lacks a common vision to bind all the stakeholders to work towards it. This results in fragmented and individualistic approaches. The current mindset amongst the suppliers is only about generating revenues, not considering the impact on the environment and society at large. With extreme convenience the environmentally hazardous products are imported from developing countries trying to waver off the liabilities of developed nations but are actually cause even more disasters globally. It is important for this to be discussed and addressed critically.

The construction sector should function with a common vision adopting a converging approach. It is important to develop principals to follow globally to avoid exploitation and atrocities across the world. Thus, bringing integrity to all contributing to the construction sector and global real estate at large. The approach has to be inclusive and considerate all the different stakeholders and user groups.

7.1.4 Changed Roles of Stakeholders

One of the striking findings of the research was the change in roles of stakeholders. According to the empirical research conducted, the role of the developer seems to be modified greatly to fit within the asset and project manager along with the contractor. This is a rather major shift from the current way of functioning, where the developer takes the initiative and the risk of planning and developing the project and handing over the completed product to the building owner.

The current situation where investors cannot conduct renovations under their company's name makes their stand even stronger in the Dutch market (in sources). "In the construction industry, a developer is usually considered to be a person who develops land through construction and who, to this end, becomes an owner of the developed land. The developer seeks a profit from development of the land, either by selling a development, such as a tract of residential homes, a shopping mall, or an office building, or by holding the developed property to reap a return on the investment." (Reuters, 2019). The holding of the property post completion for a is for a short duration. Thus, making their vision extremely short sighted for a circular development.

7.1.5 Concept of ownership

The proposed concept is for leasing of space only. If this is implemented, it will change the landscape of land ownership all together. The concept of product as a service makes the idea of ownership questionable. The concept of a home with personally owned

products will turn into a scarce phenomenon. This concept will work in areas with high density but may not produce the required results in remote locations or in villages or with informal dwellings. A new system to support the rural areas will have to be created.

7.2 Limitation

Based on the technology, financial, structural, attitude, operational, legislative barriers mentioned in chapter 3, the following barriers create the limitations for the success of this research. The following references have been used to focus on the limitations. Ritzen & Sandstrom (2017), Oghazi and Mostaghel (2018), World Economic Forum (2018), CiSCA (2019).

7.2.1 Rules and regulations

The method proposed overlooks the existing regulations and laws, since they are made to support the traditional linear way of working and not the circular way. Issues related to ownership within a building while incorporating product as a service is essential to determine the clauses of the contract and solve any dispute related to it. The regulations will also be a binding factor for all stakeholders to move in a circular way. The added incentives and penalties can only be justified by law. There are a few assumptions made in the chapter 5 based on the probable regulations proposed by Ministry of Infrastructure and Water Management, on behalf of the Ministries of Economy and Climate, the Interior and Kingdom Relations, Agriculture, Nature and Food Quality and Foreign Trade and Development on implementing circular economy 2019-2023, Stahel W R (2012), Pardo R. et Schweitzer J.P (2018), Circle Economy et al.(nd). These need to be reviewed and put into action to allow for future development.

7.2.2 Infrastructure needed

The scheme proposed is a relatively futuristic, where the policies and regulations have been adjusted to allow for the functioning of the circular system. In order to ensure quality of products, the system must have transparency and equality. The infrastructure proposed could be developed by the ministry to set a structure for the system to work in. Not interfering but more in a facilitating role to avoid any discrepancies in the future. The infrastructure needed could be the online platforms where different stakeholders could interact in order to get on board for the project. This would be clearly based on availability and quality since the resources available would be limited. Making the online platform an important component to avoid monopoly of materials in the hands of a few.

7.2.3 Consortium fails

The proposed scheme functions by developing a consortium between the service providers, the contractor and the owner of the building. In case any of the stakeholders go bankrupt the system will collapse. Thus, it is important to address the required legal issues within the contract to safeguard the project and the resources coming together in the form of services. Making the sector of the product liable rather than the consortium.

7.2.4 Stakeholder engagement

Stakeholder engagement is important for the stakeholders involved in the process, especially the shareholders in the building are engaged in the process for smooth functioning of the building. The success of the project is proportionate to the involvement of the stakeholders since they all are important contributors to the process. This management tool is critical for a multi-stakeholder project (Winch, 2010).

7.2.5 New ways of working

The attitude of companies to take the plunge and set up a circular business model is equally important as it is to develop technologies which are circular. Unless the mindset of the business owners does not change, it is going to be impossible to get the system running. They need to have confidence in their business to convince their customers about what they have to offer. This is how the users will develop trust. There are multiple risks involved but the most of them are related to external factors and can be dealt with. However, the internal factors and personal mindset is difficult to alter.

7.2.6 Financial Barriers

Finance is important to get the circular setups running. For service providers to move circular, the industries on the supply side, have to transform their existing businesses to accommodate circular ways of working. This implies investments in research related to product design. Investments for the proposed design manufacturing and eventually mass production of the product before marketing the circular product to the users. This is going to affect the entire manufacturing industry. For this to be conducted a lot of upfront investment is needed with a well-defined return on investment. Uncertainties of this nature makes it difficult to move towards circularity. Financers are willing to invest if the business plan proposed are promising but the entire industry is not willing

to move out of their comfort zone in order to take the risk, since there is not a lot of demand currently.

7.2.7 Evaluation system does not consider environmental and social issues and is only weighed financially

The current method of evaluating an impact is inefficient since it only lays focus on the financial outcomes. The impact on the environment needs to be given a spot in the evaluation process to access the outcome of the product/ service. Another critical factor is the societal impact of the product. It is important that the product generates employment thus reducing the disparity, inequality and maintaining a minimum amount of quality of life.

CONCLUSIONS

This chapter elaborates on a circular business plan for the investor and the overall roadmap of moving towards a circular real estate sector. A concise answer to the research questions are given in this chapter.

How would it be feasible for to invest in circular transformation for a future proof-built environment & what would be the roadmap for it?

Considering the global reaction to rapid urbanization, globalization and the constant upward trend in population has confronted us with concerns to meet the increased requirements of the generations to come. With a predicted 186 billion tonnes of material resources needed to feed the global consumption in 2050, which happens to be twice the rate compare to the current day consumption (R. Pardo et J.P. Schweitzer, 2018).

In order to comply with the 'Paris agreement' to limit global warming below 2°C, the built environment will have to make many adjustment. As it is caters to approx 45% of global Greenhouse Gas Emissions (GGE) and is a consumer of 40% of the global materials produced (DGBC, 2013; Remoy et de Jonge,2018). It was critical to address these complex issues which lead to the development of multiple concepts leading to the development of the concept of circular economy by Ellen MacArthur Foundation in 2013. Circular economy could be referred as a restorative or a regenerative design with an aim to maintain the value of the product by minimizing waste production and downcycling of materials (Ellen MacArthur Foundation, 2013). It suggests closing the linear take-use-waste with a closed infinitely used circuit (Stahel, 2016).

The current challenges being faced by the built environment is the upgrading of office building below the label C by 2023, this accounts for 55% of all the office buildings in the Netherlands (MOR, 2019). Also 1 million new affordable houses will be needed to address the needs of the Dutch population by 2030 (MOR, 2019). With 87% of the built stock needed to cater to the needs of the built environment in 2050 already in place transforming the existing stock could result in large amounts of carbon saving (Remoy et de Jong, 2018). Transforming implies retaining the structure and changing the infill to be more sustainable and easily reusable. Thus addressing environmental effects by reducing demolition waste, maximizing material usage. Social aspects by increasing job opportunities and increasing the quality of well being in all built environment. Financial aspect by extending the lifespan of

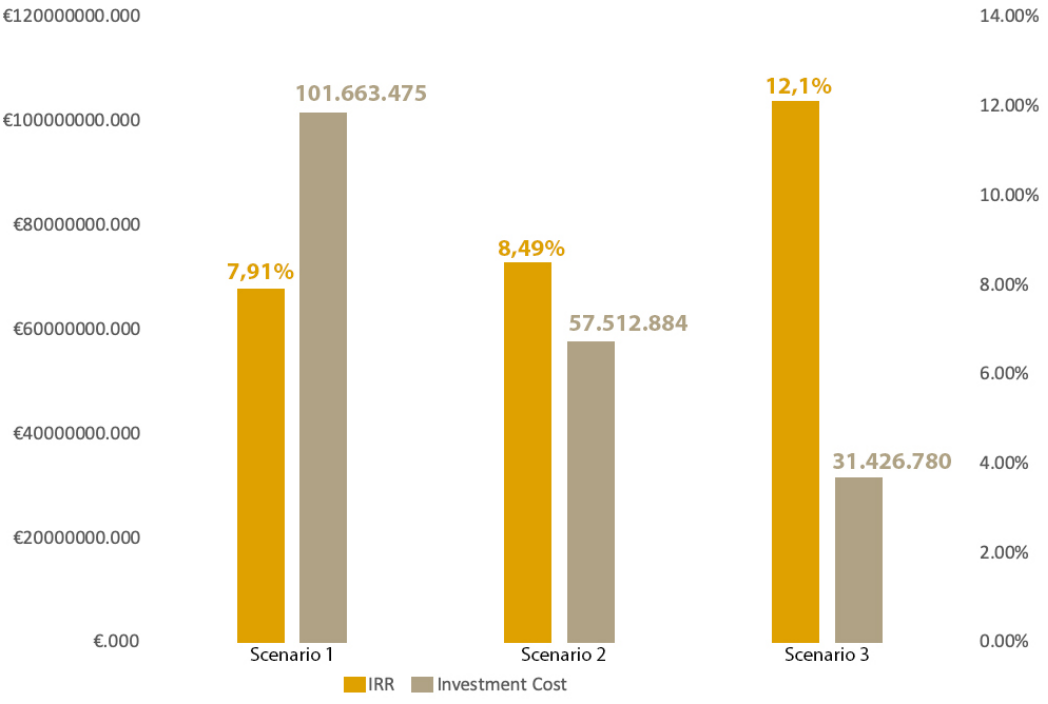


Figure 40 : The IRR and Investment is of the building owner in the circular project in sceario1, scenario 2 & scenario 3 respectively.

the product and reusing the material. Socio-economic by maintaining transparency and profit sharing thus reducing the existing inequality.

Different strategies were adopted to make the overall investment environmentally, socially and financially feasible, such as product life extension, sharing platform, product as a service, circular supplies and resource recovery (Accenture Lacy, 2014). The developed scheme demonstrates the transition to circular transformation from the current traditional way of working. The circular working model shows the involvement of different stakeholders in a step by step format to ensure smooth functioning, product upgrading and circular usage of materials.The developed organization structure proposed increases the transparency and reduces the burden of investment from one stakeholder (building owner) and spreads it to all the participants in the form of shareholding. This increases risk and profit sharing, it reduces the investment cost for building owner but managed to yield a high return on investment even in the case of affordable housing. Proving all the strategies adopted to be profitable for the building owner.

The outcome of the different scenario studies developed using the MOR case shows that this system proves to be profitable for all. The scenarios considered are not the final pathway ahead but as an instrument to demonstrate the feasibility in moving towards circularity. The MCI calculation works as a supportive tool to maximize the use of circular products through a rating system which would help in material selection in the initial stage which will intern affect the rent levels and the overall performance of the building. The reduction in taxation would help create a high demand for this circular spaces.

Research Relevance

Societal Relevance

The larger aim of this projects is to prove the feasibility for a future proof-built environment. This is by adaptive reuse of existing underperforming or vacant office buildings which are currently under the threat of being shut down by the Dutch government if not addressed. The buildings below energy label C, cannot be used as per the law in 2023 (Bouwbesluit, 2012). By transforming them into mixed functional spaces it increases the inclusive nature resulting in high social interaction, provides a better quality of life, etc. (Builders, 2017). The mixed-use adaptable development means the building can adjust to changing market conditions, reducing the time laps to address the real estate demand. Thus, avoiding the unnecessary rising in prices due to rise in demand.

The other important criteria is providing affordable housing to meet the demand of 1 million new homes by 2030. By adopting a circular way ahead, not only would we be safeguarding availability of materials for the future generations but also reducing emissions to combat the current issues of global warming. Circular economy would also facilitate economic benefits by creating jobs. The dismantling of modular components could help reduce the issue of unemployment in the Netherlands, thus reducing the pressure on the government. In a study conducted by TNO, the circular economy is considered to have a potential of generating 7.3 Billion Euros by creating 54,000 jobs in the Dutch context alone (Ton Bastein, 2013). The estimated global benefit by Ellen MacArthur Foundation is expected to be 1 trillion USD (Foundation, 2013). This would affect the economics and trade across the world. Every region will have to develop a sustainable loop to address their needs and issues locally, creating stronger communities.

Conducting circular transformations with affordable rent levels, demonstrates the feasibility for building owners to move in this direction. Making clear that this concept is could be adopted by every user type without finance being an issue. Giving an opportunity to all user groups to occupy sustainable spaces with high environmental and societal value. Adopting circular strategies not only helps reduce the investment costs for the building owner but extend the lifespan, reduces the maintenance expenditure and ensures material usage at the end of the life span. Making the users more conscious and the service providers active in the process. Thus, reducing the material wastage and incorporating a more conscious approach in utilizing raw materials. The method proposed demonstrates a change in the existing way of functioning which can impact the generations to come. This transition requires initial investments and infrastructure to facilitate it into being, but the most critical success factor is a change in mindset of the society. The feasibility needs to be calibrated juxtaposing the environmental, societal and financial benefits. The method proposed integrates the environmental and financial feasibility while providing better living conditions. Feasibility for all the user, building owners, service providers shows the potential of its implementation on a large scale.

Scientific Relevance

The research published on circular economy is limited with a lot of rephasing and writing on the same topic, making multiple researches waste of published information. The topic of feasibility is something which is not addressed by the researches conducted. The market parties are in the stages of conducting their pilot studies and choose to work in isolation, so the information and the background research for this is not made available. The visions published in order to develop the roadmap by different government bodies are extremely abstract and do not share the right information that will help the market to move in a certain direction. The general trend observed as a result of vague roadmaps is the waiting game by the market. The initiative and the strive fizzles down just awaiting the direction. Thus the objective of this research was to transform the financial and structural barriers into opportunity. By developing an organisation structure for the stakeholders to function in, with all the required infrastructure to support it. Then demonstrating the feasibility for the building owner to adopt circular transformation to conduct the renovations. Making the results

available to trigger discussions and further research and develop a roadmap in a collaborative and feasible way for all. This helps develop a scheme which can be adopted for circular adaptive reuse/ transformation projects across the globe. Following the simple steps of analysing the building typologies. Conducting the circular transformation to the layers that the typology permit thus creating an archieve of the steps to be followed while conducting circular transformation of most building typologies.

The financial feasibility of conducting the transformation makes the proposition favourable for the building owner thus helping develop a roadmap for the future which reduces the direct risk of transformation from the building owner and spreads it to the service providers. This research proposes a possible direction to move the circular transition and shows the feasibility for the building owners.

Future Research

This research touches a the financial and organizational aspect of circular transformation. Making the legal, social, economic aspects of this proposal. The validification of the assumptions will demonstrate a stronger and more accurate result. The technical concepts needed to get the system running also need to be developed in more detail. Designing for demounting is essential which needs to be designed. The research on future use of the materials with minimum emissions needs to be developed.

The effects of incentives and punishments in bringing circular economy into practice has be understood. This will also impact and will determine the taxation system to support this research. The model developed overlooks the financial implication and throws light on the environmental effects on making certain selections but the impact can be made more explicit. The social and economic pictures can also be elaborated on. It should be possible to develop a way to quantify the impact of the decision taken ib the impact area model by Metabolic. The implication of the assessment into practice is something that can be focussed on further.

A study of architectural typologies of building types could be conducted. This would form the basis of the adaptive reuse strategies to be implemented and the transformation proposal can be developed. This would create a catalog of the existing built form and help develop a system to address the complexities related to it. Thus promoting maximum reuse of existing materials.

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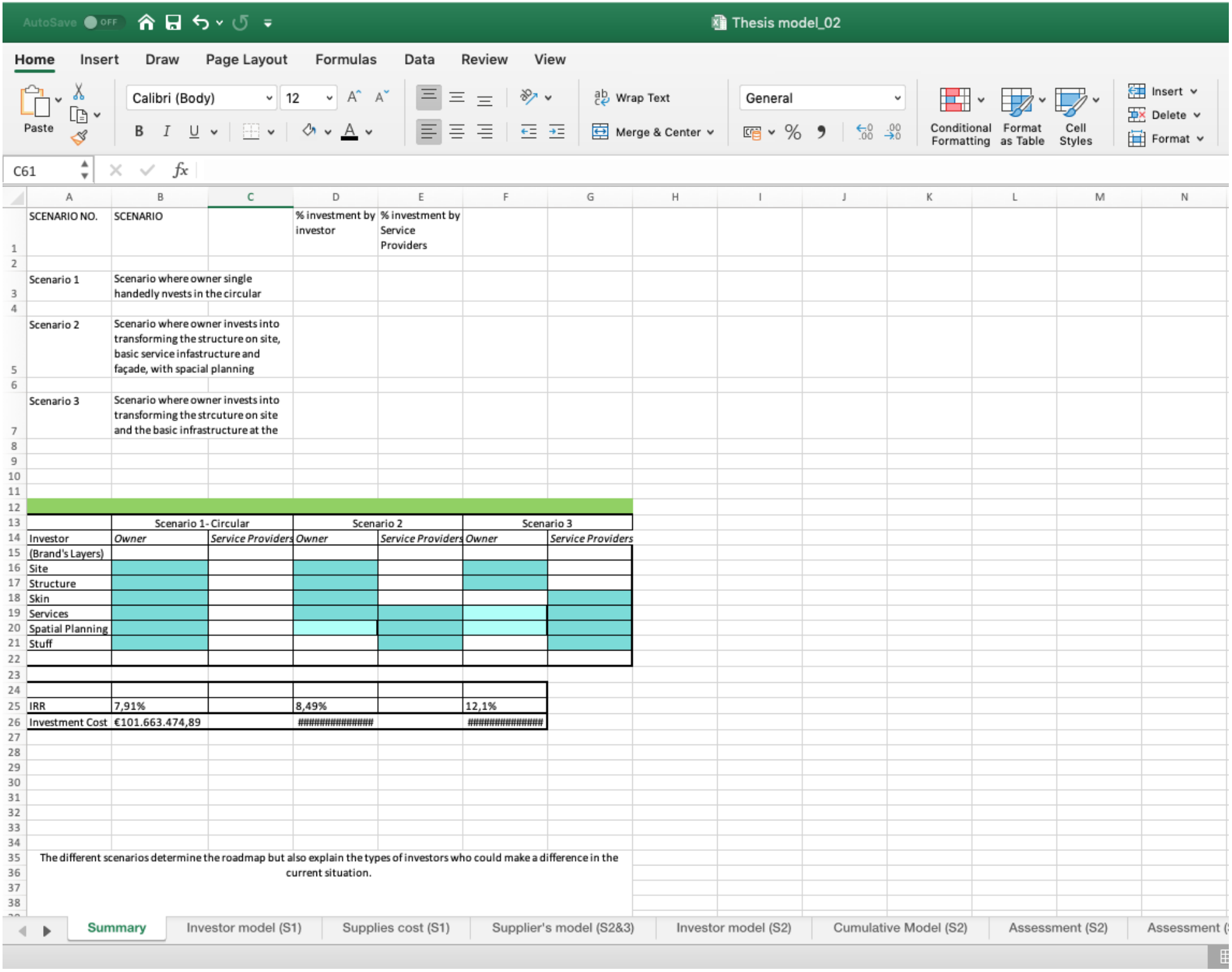

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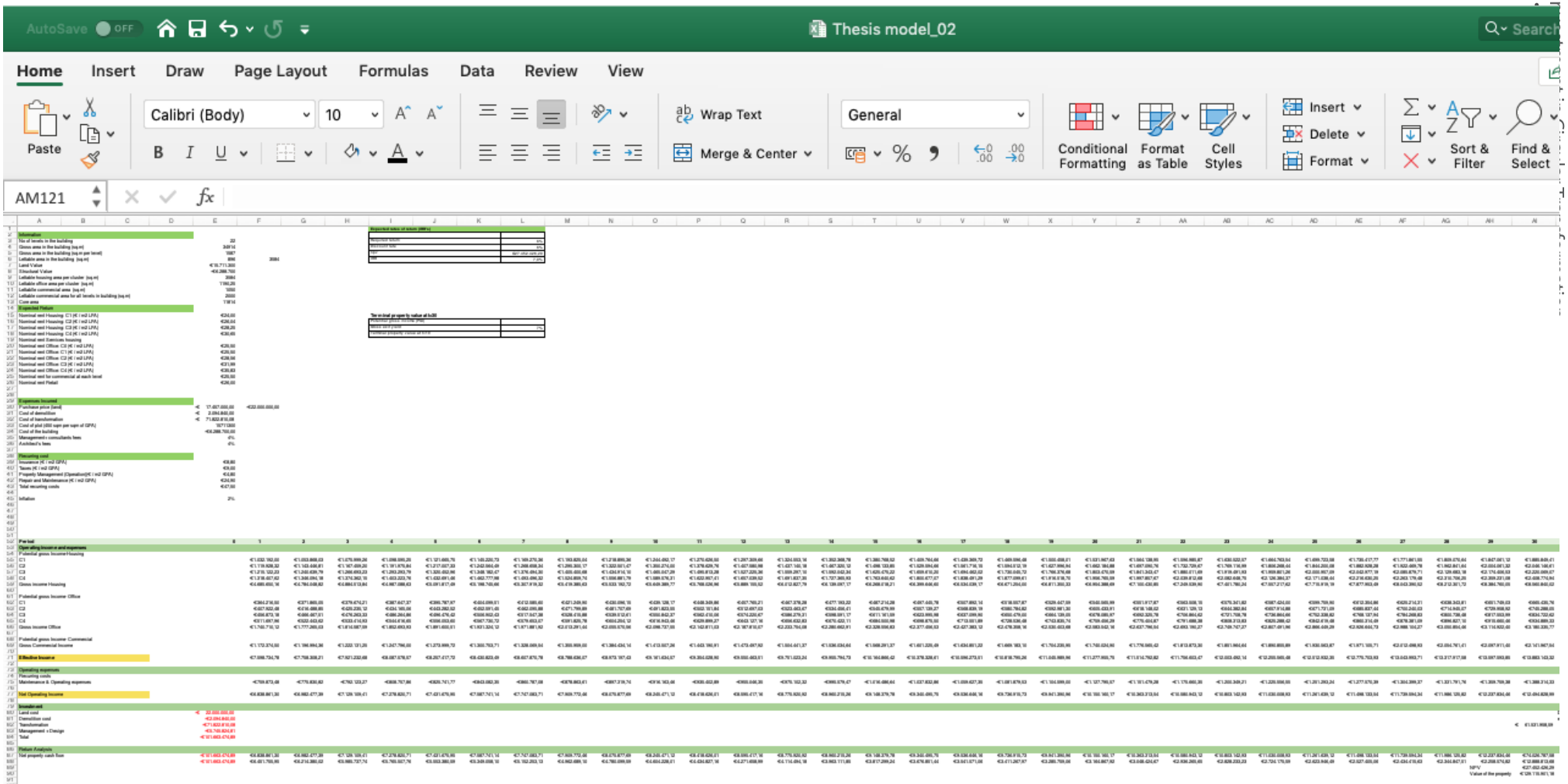
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	SCENARIO NO.	SCENARIO		% investment by investor	% investment by Service Providers									
2														
3	Scenario 1	Scenario where owner single handedly nvests in the circular												
4														
5	Scenario 2	Scenario where owner invests into transforming the structure on site, basic service infastructure and façade, with spacial planning												
6														
7	Scenario 3	Scenario where owner invests into transforming the strcuture on site and the basic infrastructure at the												
8														
9														
10														
11														
12														
13		Scenario 1- Circular		Scenario 2		Scenario 3								
14	Investor	*Owner*	*Service Providers*	*Owner*	*Service Providers*	*Owner*	*Service Providers*							
15	(Brand's Layers)													
16	Site													
17	Structure													
18	Skin													
19	Services													
20	Spatial Planning													
21	Stuff													
22														
23														
24														
25	IRR	7,91%		8,49%		12,1%								
26	Investment Cost	€101.663.474,89		################		################								
27														
28														
29														
30														
31														
32														
33														
34														
35	The different scenarios determine the roadmap but also explain the types of investors who could make a difference in the current situation.													
36														
37														
38														

Summary | Investor model (S1) | Supplies cost (S1) | Supplier's model (S2&3) | Investor model (S2) | Cumulative Model (S2) | Assessment (S2) | Assessment (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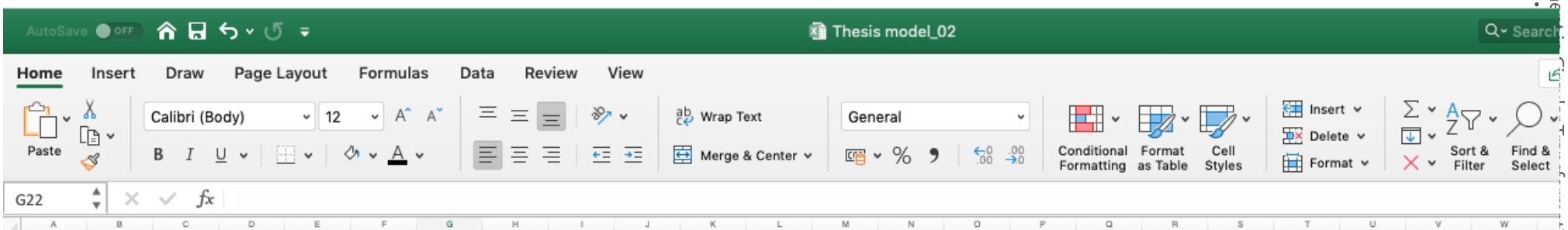

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	BASE DATA FOR DIFFERENT UNIT TYPOLOGIES																						
2			Dwelling	Offices		Commercial	Retail	S	M (living)	M (living + grow	M (living + work	L (living)	L (living + grow)	L (living + work)	Sharing	Office	Com Each Leve	C0 retail level					
3			Price per sq.m	Price per sq.m		Price per sq.m	Price per sq.m	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M					
4								25	50	75	62,5	75	100	87,5	150	1190,25	70	1190,25					
5		RENT C0				€25,00																	
6		RENT C1	€24,00	€25,50		€26,00		€660,00	€1.200,00	€1.800,00	€1.518,75	€1.800,00	€2.400,00	€2.118,75	€3.600,00	€0,44	€1.820,00							
7		RENT C2	€26,04	€28,56		€26,00		€716,10	€1.302,00	€2.000,00	€1.659,00	€1.953,00	€2.604,00	€2.310,00	€3.906,00	€0,49	€1.820,00							
8		RENT C3	€28,25	€31,99		€26,00		€776,97	€1.553,94	€2.330,91	€1.965,76	€2.330,91	€3.107,87	€2.752,06	€4.661,81	€0,55	€1.820,00							
9		RENT C4	€30,65	€35,83		€26,00		€766,37	€1.532,75	€1.791,28	€0,00	€1.300,00	€0,00	€38.318,67	€76.637,35	€0,61	€1.820,00							
10																							
11	PRODUCT AS SERVICE PRICE AND REQUIREMENT CALCULATION																						
12	Different modules		Price per module	Cost per module	Maintenance			No. of different modules required for different typologies															
13																							
14		Façade	€15.086,08					1	2	3	2	5	6	5	8	44		44					
15	al Walls (Between corridor and ir		€3.500,00					5	6	6	8	5	5	7	16			25					
16		Folding garden partitions	€5.000,00							1			1										
17		Internal partitions	€2.000,00						1	3	3	2	3	4	4	20	4						
18		Bedroom partition	€3.000,00						2	2	3	3	3	3	6								
19		Green Wall	€4.000,00							1			1										
20		Flooring	€3.450,00					2	4	6	5	6	8	7	12	84	84						
21		Ceiling island	€590,00					2	4	5	5	6	7	7	12	84	6	84					
22		Kitchen and Bathroom Module	€7.000,00					1	1	1	1	1	1	1	2	6							
23		Bedroom Module	€3.500,00					1	2	2	2	3	3	3	6								
24		Chair and Table	€1.800,00													210							
25		Locker	€200,00													210							
26		Other furniture	€700,00													20	17						
27		Services	€43.664,99																				
28																							
29	SUPPLIER'S COST																						
30	Different modules							Costing of the services provided by product as a service providers															
31																							
32		Façade						€15.086,08	€30.172,16	€45.258,24	€30.172,16	€75.430,40	€90.516,48	€75.430,40	€120.688,64	€663.787,52	€0,00	€663.787,52					
33	xternal Walls (Between corridor and interi							€17.500,00	€21.000,00	€21.000,00	€28.000,00	€17.500,00	€17.500,00	€24.500,00	€56.000,00	€0,00	€0,00	€87.500,00					
34		Folding garden partitions						€0,00	€0,00	€5.000,00	€0,00	€0,00	€5.000,00	€0,00	€0,00	€0,00	€0,00						
35		Internal partitions						€0,00	€2.000,00	€6.000,00	€6.000,00	€4.000,00	€6.000,00	€8.000,00	€8.000,00	€40.000,00	€60.344,32						
36		Bedroom partition						€0,00	€6.000,00	€6.000,00	€9.000,00	€9.000,00	€9.000,00	€9.000,00	€18.000,00	€0,00	€0,00						
37		Green Wall						€0,00	€0,00	€4.000,00	€0,00	€0,00	€4.000,00	€0,00	€0,00	€0,00	€0,00						
38		Flooring						€6.900,00	€13.800,00	€20.700,00	€17.250,00	€20.700,00	€27.600,00	€24.150,00	€41.400,00	€0,00	€1.267.230,72						
39		Ceiling island						€1.180,00	€2.360,00	€2.950,00	€2.950,00	€3.540,00	€4.130,00	€4.130,00	€7.080,00	€49.560,00	€90.516,48	€49.560,00					
40		Kitchen and Bathroom Module						€7.000,00	€7.000,00	€7.000,00	€7.000,00	€7.000,00	€7.000,00	€7.000,00	€14.000,00	€42.000,00	€0,00						
41		Bedroom Module						€3.500,00	€7.000,00	€7.000,00	€7.000,00	€10.500,00	€10.500,00	€10.500,00	€21.000,00	€0,00	€0,00						
42		Chair and Table														€378.000,00	€0,00						
43		Locker														€42.000,00	€0,00						
44		Other furniture														€14.000,00	€256.463,36						
45																							
46	TOTAL SUPPLIERS COST							€51.166,08	€89.332,16	€124.908,24	€107.372,16	€147.670,40	€181.246,48	€162.710,40	€286.168,64	€1.229.347,52	€1.674.554,88	€800.847,52					
47																							
48	INVESTOR'S MODEL																						
49																							
50								S	M (living)	M (living + grow	M (living + work	L (living)	L (living + grow)	L (living + work)	Sharing	Office	Com Each Leve	Com bottom 2 levels					
51								0	0	0	0	0	0	0	0	0	100	0					
52	Each cluster							24	11	6	8	4	4	8	2								
53	No in building							96	44	24	32	16	16	32	8	5	22	1					
54	Cost per module							€51.166,08	€89.332,16	€124.908,24	€107.372,16	€147.670,40	€181.246,48	€162.710,40	€286.168,64	€1.229.347,52	€1.674.554,88	€800.847,52					
55	Cost for the building							€4.911.943,68	€3.930.615,04	€2.997.797,76	€3.435.909,12	€2.362.726,40	€2.899.943,68	€5.206.732,80	€2.289.349,12	€6.146.737,60	€36.840.207,36	€800.847,52					
56	Total investment							€71.822.810															
57																							
58																							
59	Core cost					11814	1700	20083800															
60								€91.906.610,08															
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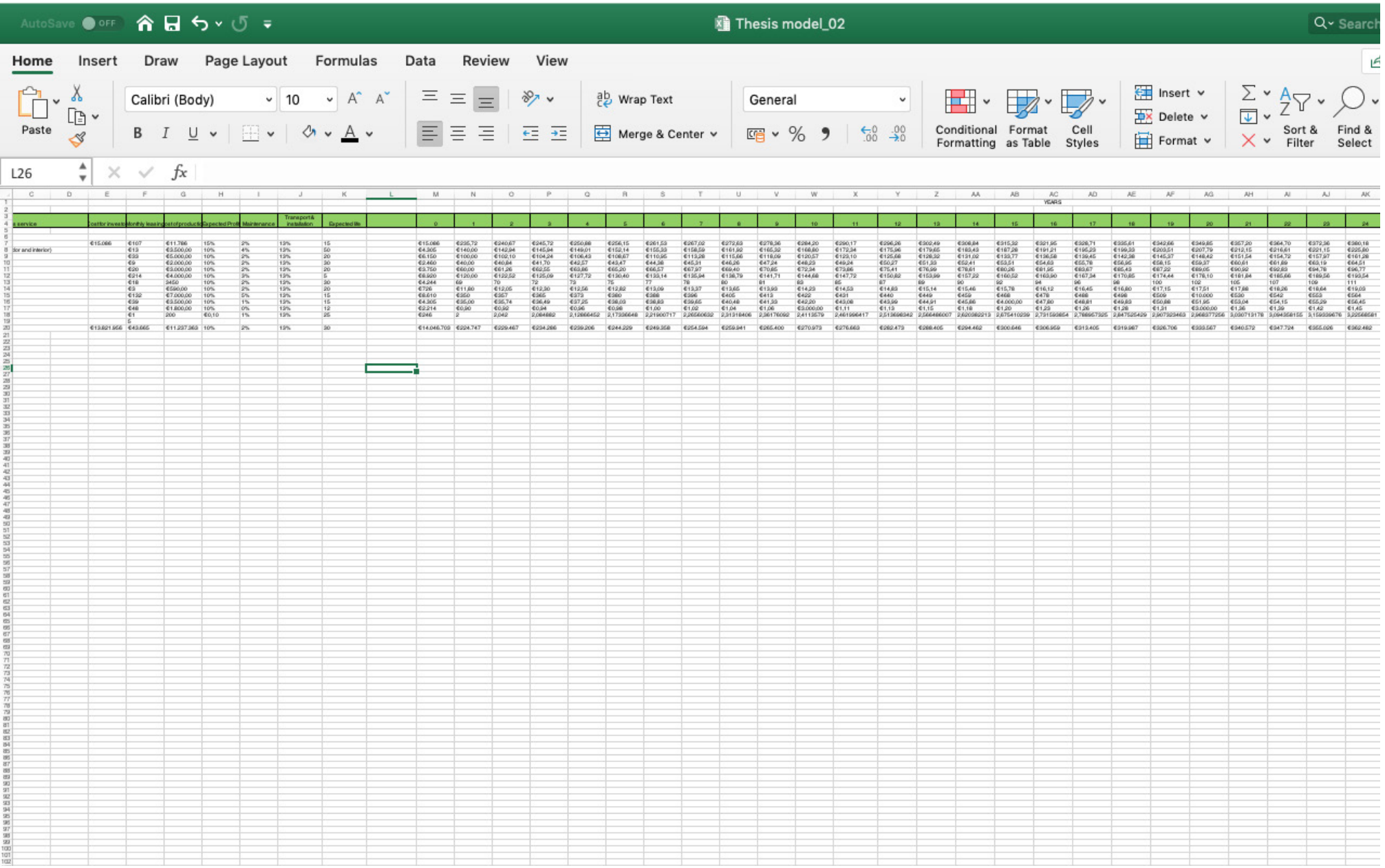
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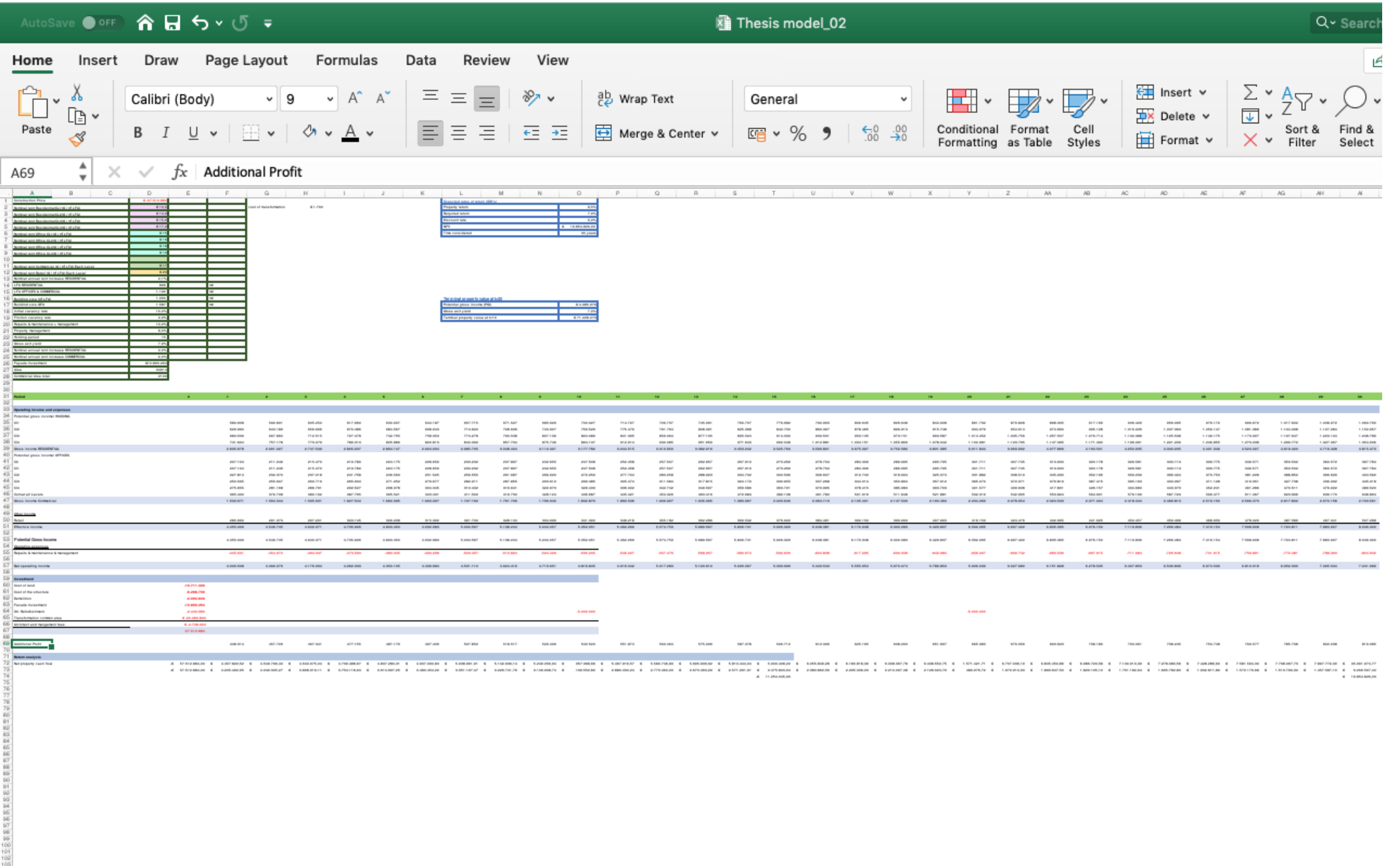
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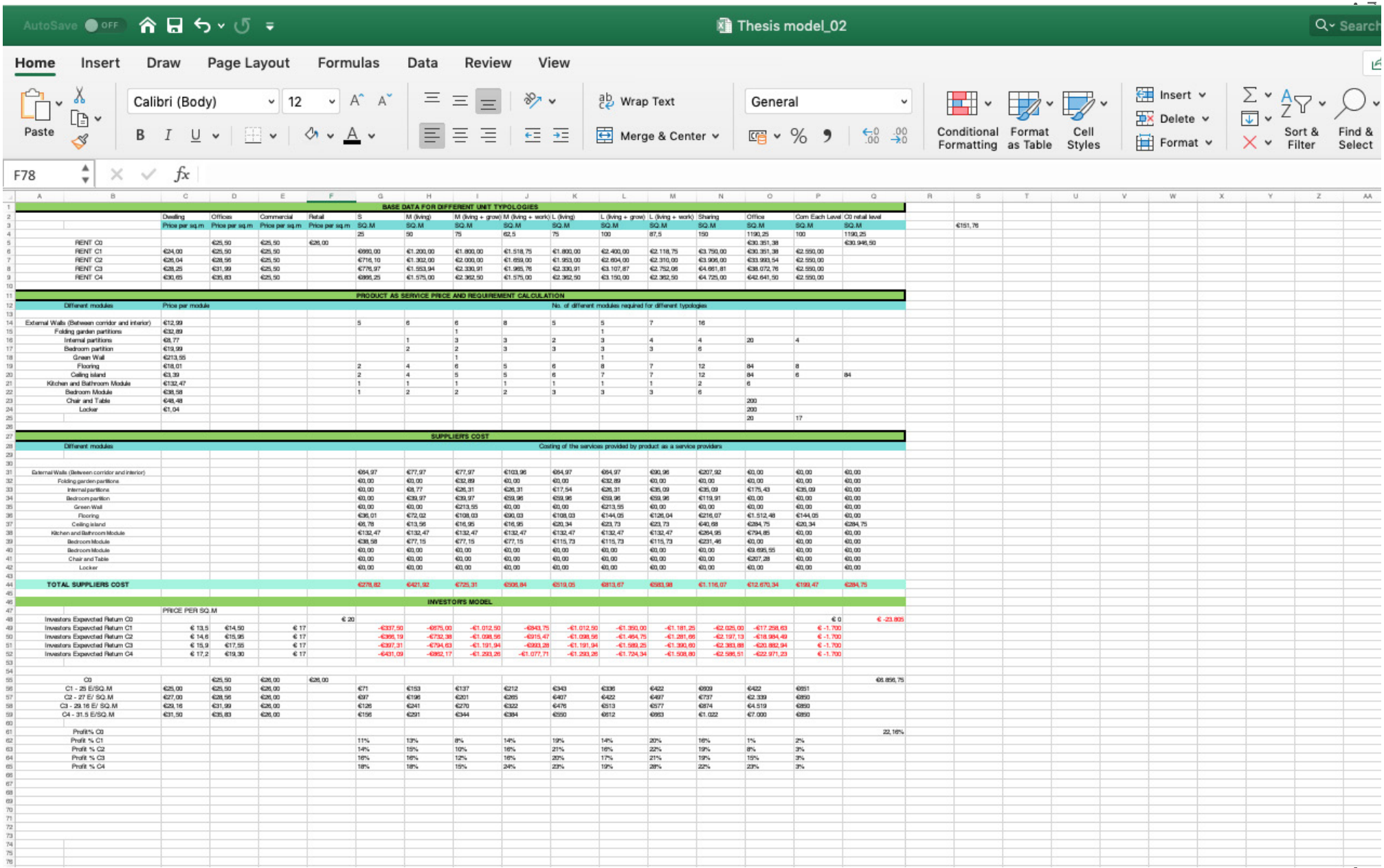
Additional Profit



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BASE DATA FOR DIFFERENT UNIT TYPOLOGIES

	Dwelling	Offices	Commercial	Retail	S	M (living)	M (living + grow)	M (living + work)	L (living)	L (living + grow)	L (living + work)	Sharing	Office	Com Each Level	C0 retail level
	Price per sq.m	Price per sq.m	Price per sq.m	Price per sq.m	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M	SQ.M
					25	50	75	62,5	75	100	87,5	150	1190,25	100	1190,25
RENT C0		€25,50	€25,50	€26,00									€30.351,38		€30.946,50
RENT C1	€24,00	€25,50	€25,50		€990,00	€1.200,00	€1.800,00	€1.518,75	€1.800,00	€2.400,00	€2.118,75	€3.750,00	€30.351,38	€2.550,00	
RENT C2	€26,04	€28,56	€25,50		€716,10	€1.302,00	€2.000,00	€1.659,00	€1.953,00	€2.604,00	€2.310,00	€3.906,00	€33.993,54	€2.550,00	
RENT C3	€28,25	€31,99	€25,50		€776,97	€1.553,94	€2.330,91	€1.965,76	€2.330,91	€3.107,87	€2.752,06	€4.661,81	€38.072,76	€2.550,00	
RENT C4	€30,65	€35,83	€25,50		€896,25	€1.575,00	€2.362,50	€1.575,00	€2.362,50	€3.150,00	€2.362,50	€4.725,00	€42.641,50	€2.550,00	

PRODUCT AS SERVICE PRICE AND REQUIREMENT CALCULATION

Different modules	Price per module	No. of different modules required for different typologies												
External Walls (Between corridor and interior)	€12,99	5	6	6	8	5	5	7	16					
Folding garden partitions	€32,89			1			1							
Internal partitions	€8,77		1	3	3	2	3	4	4	20	4			
Bedroom partition	€19,99		2	2	3	3	3	3	6					
Green Wall	€213,55			1			1							
Flooring	€18,01	2	4	6	5	6	8	7	12	84	8			
Ceiling island	€3,39	2	4	5	5	6	7	7	12	84	6	84		
Kitchen and Bathroom Module	€1132,47	1	1	1	1	1	1	1	2	6				
Bedroom Module	€38,58	1	2	2	2	3	3	3	6					
Chair and Table	€48,48									200				
Locker	€1,04									200				
										20	17			

SUPPLIER'S COST

Different modules	Costing of the services provided by product as a service providers													
External Walls (Between corridor and interior)		€64,97	€77,97	€77,97	€103,96	€64,97	€64,97	€90,96	€207,92	€0,00	€0,00	€0,00		
Folding garden partitions		€0,00	€0,00	€32,89	€0,00	€0,00	€32,89	€0,00	€0,00	€0,00	€0,00	€0,00		
Internal partitions		€0,00	€8,77	€26,31	€26,31	€17,54	€26,31	€35,09	€35,09	€175,43	€35,09	€0,00		
Bedroom partition		€0,00	€39,97	€39,97	€59,96	€59,96	€59,96	€59,96	€119,91	€0,00	€0,00	€0,00		
Green Wall		€0,00	€0,00	€213,55	€0,00	€0,00	€213,55	€0,00	€0,00	€0,00	€0,00	€0,00		
Flooring		€36,01	€72,02	€108,03	€90,03	€108,03	€144,05	€126,04	€216,07	€1.512,48	€144,05	€0,00		
Ceiling island		€6,78	€13,56	€16,95	€16,95	€20,34	€23,73	€23,73	€40,68	€284,75	€20,34	€284,75		
Kitchen and Bathroom Module		€132,47	€132,47	€132,47	€132,47	€132,47	€132,47	€132,47	€264,95	€794,85	€0,00	€0,00		
Bedroom Module		€38,58	€77,15	€77,15	€77,15	€115,73	€115,73	€115,73	€231,46	€0,00	€0,00	€0,00		
Bedroom Module		€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€3.695,55	€0,00	€0,00		
Chair and Table		€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€207,28	€0,00	€0,00		
Locker		€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00	€0,00		
TOTAL SUPPLIERS COST		€278,82	€421,92	€725,31	€908,84	€519,05	€813,67	€883,98	€1.116,07	€12.670,34	€199,47	€284,75		

INVESTOR'S MODEL

	PRICE PER SQ.M													
Investors Expavcted Return C0				€ 20									€ 0	€ -23.805
Investors Expavcted Return C1	€ 13,5	€14,50	€ 17		-€337,50	-€675,00	-€1.012,50	-€843,75	-€1.012,50	-€1.350,00	-€1.181,25	-€2.025,00	-€17.258,63	€ -1.700	
Investors Expavcted Return C2	€ 14,6	€15,95	€ 17		-€395,19	-€732,38	-€1.098,56	-€915,47	-€1.098,56	-€1.464,75	-€1.281,66	-€2.197,13	-€18.984,49	€ -1.700	
Investors Expavcted Return C3	€ 15,9	€17,55	€ 17		-€397,31	-€794,63	-€1.191,94	-€993,28	-€1.191,94	-€1.589,25	-€1.390,60	-€2.383,88	-€20.882,94	€ -1.700	
Investors Expavcted Return C4	€ 17,2	€19,30	€ 17		-€431,09	-€862,17	-€1.293,26	-€1.077,71	-€1.293,26	-€1.724,34	-€1.508,80	-€2.586,51	-€22.971,23	€ -1.700	
C0		€25,50	€26,00	€26,00											€6.896,75
C1 - 25 E/SQ.M	€25,00	€25,50	€26,00		€71	€153	€137	€212	€343	€336	€422	€939	€422	€851	
C2 - 27 E/ SQ.M	€27,00	€28,56	€26,00		€97	€196	€201	€265	€407	€422	€497	€737	€2.339	€850	
C3 - 29.16 E/ SQ.M	€29,16	€31,99	€26,00		€126	€241	€270	€322	€476	€513	€577	€874	€4.519	€850	
C4 - 31.5 E/SQ.M	€31,50	€35,83	€26,00		€156	€291	€344	€384	€550	€612	€693	€1.022	€7.000	€850	
Profit% C0															22,18%
Profit % C1					11%	13%	8%	14%	19%	14%	20%	16%	1%	2%	
Profit % C2					14%	15%	10%	16%	21%	16%	22%	19%	8%	3%	
Profit % C3					16%	16%	12%	16%	20%	17%	21%	19%	15%	3%	
Profit % C4					18%	18%	15%	24%	23%	19%	28%	22%	23%	3%	

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K81

Overall monthly assessment of Product as a service with investor making investment income structure and lease infrastructure

	S	M (living)	M (living + grow	M (living + work	L (living)	L (living + grow)	L (living + work)	Sharing	Office	Com Each Level	Com bottom 2 levels
	25	50	75	62,5	75	100	87,5	150	1190,25	100	1190,25
Each cluster	24	11	6	8	4	4	8	2			
No in building	96	44	24	32	16	16	32	8		22	
Cost	279	422	725	507	519	814	584	1116	12670	199	

Income

Residential

RENT C0												
RENT C1	24	17424	13200	10800	12150	7200	9600	16950	7500			
RENT C2	26	18905	14322	12000	13272	7812	10416	18460	7812			
RENT C3	28	20512	17099	13995	15726	9324	12431	22016	9324			
RENT C4	31	22869	17325	14175	12600	9450	12600	16900	9450			
TOTAL		79710	61946	50970	53748	33786	45047	76346	34086			435624

Commercial

RENT C0	26									56100	30351,375	
RENT C1	26								30351			
RENT C2	29								30351			
RENT C3	32								33994			
RENT C4	36								38073			
TOTAL									132769	56100	30351	219220

Retail

RENT C0	26										30946,5	30946,5
												665791

Owner's Share

Residential

RENT C0												
RENT C1	15	8700	7975	6525	7250	4350	5800	10150	4350			
RENT C2	16	9570	8773	7178	7975	4785	6380	11165	4785			
RENT C3	18	10627	9650	7895	8773	5264	7018	12282	5264			
RENT C4	19	11580	10615	8685	9650	5790	7720	13510	5790			
TOTAL		40477	37012	30283	33647	20188	26918	47106	20188			255718

Commercial

RENT C com	14									30800		
RENT C0	13										16663,5	
RENT C1	13								14878			
RENT C2	14								14878			
RENT C3	15								16366			
RENT C4	17								18009			
TOTAL									64125	30800	16664	111589

Retail

RENT C0	14										16663,5	16663,5
												388741

Service Provider's Share

Residential

RENT C0												
RENT C1		6692	4641	4352	4055	2076	3255	4672	2232			
RENT C2		6692	4641	4352	4055	2076	3255	4672	2232			
RENT C3		6692	4641	4352	4055	2076	3255	4672	2232			
RENT C4		6692	4641	4352	4055	2076	3255	4672	2232			
TOTAL		26766	18566	17407	16219	8305	13019	18687	8929			127897

Commercial

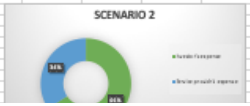
RENT C com										4368,352479		
RENT C0											12670	
RENT C1									12670			
RENT C2									12670			
RENT C3									12670			
RENT C4									12670			
TOTAL									50681	4368	12670	67740

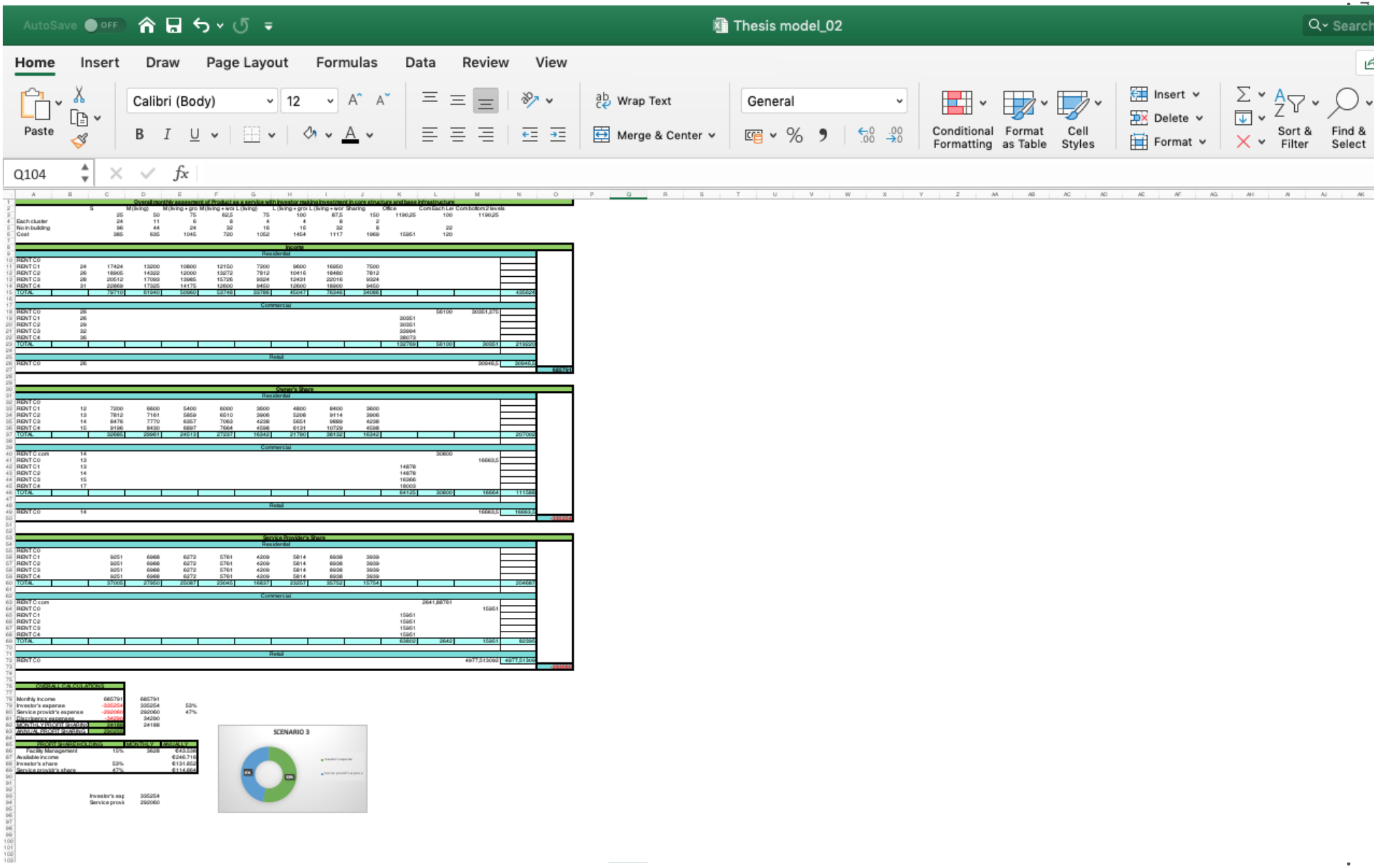
Retail

RENT C0											4977,513092	4977,513092
												200614

OVERALL CALCULATIONS		
Monthly income	665791	
Investor's expense	383971	65,68%
Service providr's expense	200614	34,32%
Insurances expenses	84290	
MONTHLY PROFIT SHARING	66918	
ANNUAL PROFIT SHARING	802996	

PROFIT SHAREHOLDING		MONTHLY	ANNUALLY
Facility Management	15%	10037	€120.449
Available income			€682.546
Investor's share	66%		€448.314

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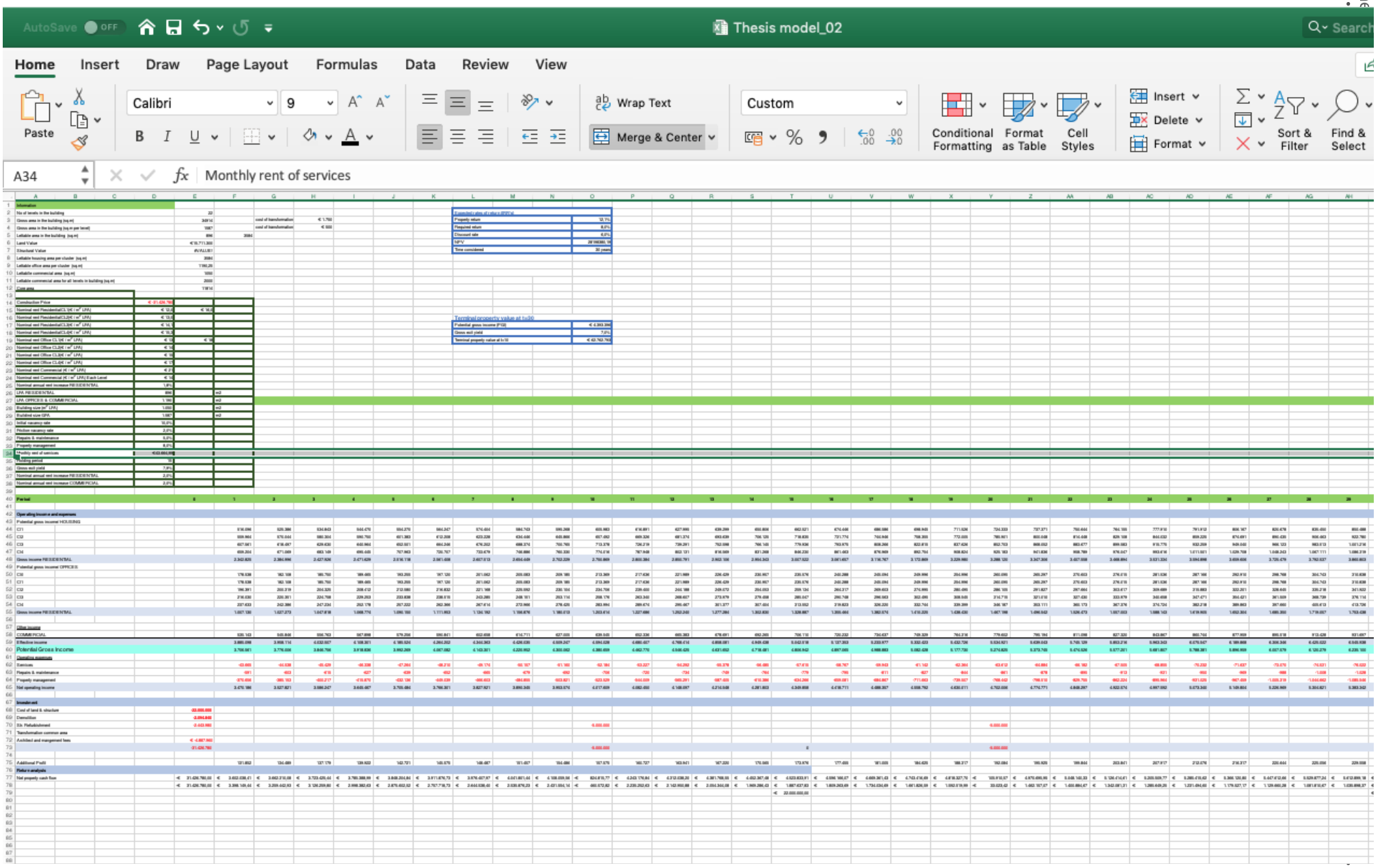
Q104
Overall monthly assessment of Product as a service with investor making investment in core structure and base infrastructure
Income
Residential
Commercial
Retail
Owner's Share
Residential
Commercial
Retail
Service Provider's Share
Residential
Commercial
Retail
SCENARIO 3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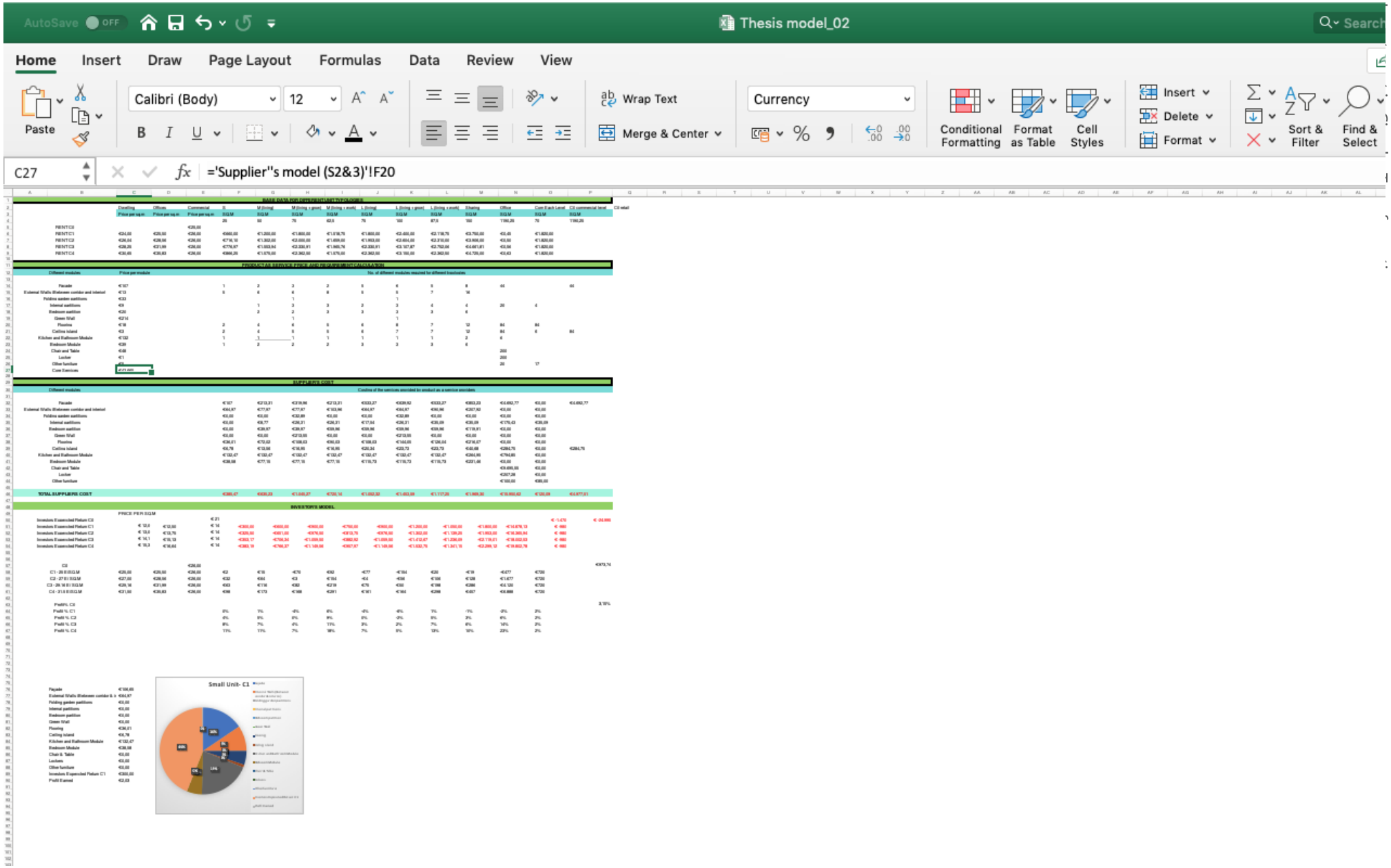
A34
Monthly rent of services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C27
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Small Unit- C1