ENHANCING CIRCULARITY IN THE BUILDING INDUSTRY

A PROPOSAL FOR THE FACILITATION AND ORGANIZATION OF A SECOND-USE MARKET FOR BUILDING COMPONENTS

Nikolaos Tsolis
MSc. Construction Management and Engineering

23rd January 2017

-This page was intentionally left blank-

Preface

This report is the outcome of a 9-months research, conducted under the context of my graduation project for the Construction Management and Engineering master program at the Technical University of Delft. The main purpose of this thesis was to study the principles of Circular Economy in theory, and after the parallel examination of four targeted cases studies, to provide a holistic approach that would enhance circularity in the building industry. To practically achieve that goal I decided to focus on the development of an action plan that could lead to the facilitation and organization of a second-use market for building components. Key partner in that effort was Royal HaskoningDHV, an international engineering consultancy and project management company, which offered me a graduation position in Rotterdam, to run my research.

The path towards the completion of that project was not easy. Before I end up studying this topic, I spent one month and a half trying to find something that would totally gain my interest. That task turned out to be even harder, as I should also combine the university's requirement for a research of high academic value and the company's demand for the practical addressing of an existing problem. Although it took me some time before I found my pace and set a clear plan on how to proceed with the research, I finally enjoyed the whole process more than I was expecting to. During this 'research travel' I gained quite some knowledge on the area of CE, I met a number of really interesting people, I discussed with engineers, project managers, state representatives and fellow students, I exchanged ideas with experts from various backgrounds, I got inspired by some and I critically accepted the viewpoint of others, I enlarged my professional network, I made mistakes -especially time and process management mistakes towards my committee-, I get lectured on that, I tried to improve my weaknesses, partially I managed it, partially I didn't. There were moments that I thought of quitting, of postponing it for a couple of months later; there were moments that I felt really tired or it felt I was moving to a dead-end. But there were also moments that I was really happy and motivated from what I was doing; there were moments that I was feeling the satisfaction of doing something the right way and being credited for that; there were moments that I was thinking how nice it would be if I manage to implement my ideas in practice. And these moments were much more than pessimistic ones. So, at the end of the date, no matter how I look at it, I certainly gained a lot. Because through all these ups and downs, the tiredness and the excitement, the happiness and despair, I feel I became stronger; stronger in spirit, stronger in the way I manage unpleasant situations, stronger in turning a negative feeling into creative mood.

Apparently, as during this 'educational journey' I was not alone, there are quite a few people who stood by me and whom I really feel like thanking by heart. To start with, I should pay a huge thanks to **Ms**. **Marleen Hermans**, who offered right from the beginning to become the chairwoman of my committee, and who really helped me manage this research, not only with her interesting ideas and sharp commenting, but mainly with her warm and supportive attitude during all our meetings, even when I seemed to struggle with my progress. Moreover, I would like to address a special thanks to **Ms. Monica Chao-Duivis**, who accepted to be my first supervisor, without ever thinking it twice. Besides her always friendly and sincere approach towards me, her passion for work and eagerness to help, even when I was way out of schedule, was my biggest inspiration for not quitting during my hardest times -I will never forget the day of my green light meeting when I e-mailed the report at 2am and by 9am Monica had already read it, commented on it and waited for me to discuss it in the most friendly possible way-. Furthermore, I also owe a big thank to **Mr. Leon Hombergen**, , who despite his self-promise to keep a short list of students under his guidance, due to a full agenda, he accepted the invitation of joining my committee as my second academic supervisor. His fine manipulations during some crucial moments of crisis, and his off-the-record one-to-one lectures on people management, really helped me to reflect on

myself and try to improve some soft skills that I was clearly lacking. Last but not least, stands my company supervisor, **Mr. Thijs Huijsmans**. A person, who I can hopefully call friend, as the bond we developed after working together for more than a year, was more than the typical student-supervisor relationship. His discrete intervention to my work, his real interest on my progress, his inspiring ideas and valuable feedback, his continuous effort to help me broaden my network and meet more people, his willingness to share personal thoughts and experiences, relevant and non-relevant to the topic, as well as the freedom and flexibility in working time, space and methods he provided me with, are only some of the reasons that make me want to express him, my deepest and more sincere feelings of gratitude.

However, besides the people who stand on the first raw of thanking credits, there are a couple more, who also helped me complete this project, and whom I surely want to mention. Starting from my family that always support my choices and has the way to make me smile, I would like to thank both my **parents, Vasilis & Vaso,** and my two lovely **sisters, Maria & Dimitra**, for all the Skype love they provided me with all that time. Next to that, a big thank to my fellow CMErs, **Antonio, Marcos, Polina & Walid**, for the common hardships we experienced and the great time we had during this tough last year. A special thank has also to be appointed to my close friend, **Vasilis**, for his not always supportive, but definitely humoristic attitude towards my progress, as well as to another close friend of mine, **Dimitris**, for his talent to always cheer me up, even when my mood is not at its best. Closing, and hoping that I do not forget any of those who one way or another contributed actively to this result, I would like to address a sincere thanks to all RHDHV colleagues who offered to guide and discuss with me, all the interviewees who granted me some of their time and knowledge, and all the validation workshop's attendees, who eagerly offered to review my work and supply me valuable feedback.

Nikolaos Tsolis

Rotterdam, 23-January-2017

Summary

Living in a fast changing world, humans of today have a lot of serious challenges to deal with. One of the hardest relates to the prevailing way of production and consumption. Having based our whole progress on the triptych of make-use-waste, a point has been reached where thinking and acting irresponsible towards nature is not an option anymore. Through years, various sustainable theories have been developed, with the philosophy of circular economy -in short CE- being one of the most interesting and highly rated. However, despite its extended study in theory; in practice -at least with regards to the construction sector- not much have been achieved. Therefore, aspiring to enhance the concept of circularity within the building industry, the current research studies how the organization of a second-use market for building components can be practically achieved.

First step towards that goal is the investigation of the current organizational schemes, so that an insight on how building-related business and activities within linear economy are organized to be gained. According to the theory, two main aspects define -external- organization in the building industry: governance and legal. As far as governance is concerned, the cost, being the main driver for projects' development, sets two modes: market and hierarchy. Another mode however, the network, is also identified, as derives from the need of additional value's acquisition. With regards to the legal aspect, a great variety of contractual agreements does exist, and can be clustered in four basic "contract families": traditional contracts, early contractor involvement contracts, integrated contracts and partnerships/alliances contracts.

Next step is the better understanding of CE and its main principles. The relevant research shows that although CE is considered to be a sustainable philosophy, sustainability is not a precondition for that, but a highly desirable and welcomed feature, which should be pursued in any case. What actually matters for CE is circularity, and in order for that to happen, adaptability is the key. Adaptability, highlighting the capacity of a building to adjust itself into social or functional changes, reflects on many aspects. Next to that, the concept of shearing layers, referring to the classification of building components based on their technical life, sets another interesting theory for addressing buildings. These two aspects, if combined appropriately and mixed with the corresponding influential stakeholder -per case- do prove the importance of ownership in the feasibility of circular projects. Ownership issues do always involve and influence other aspects, such as legal and business, and consequently, the study of circular business models seems to be necessary. The latter, representing an organization's rationale for the creation, delivery and capturing of value with and within closed loops, can be classified in three main families: Circular Innovation Models, Circular Use Models and Circular Output Models. Each one of them, focusing on different production phases (development, use, after-use), applies different approaches in order to produce value, providing alongside different ownership and production alternatives.

After the insight acquired from literature, the examination of some circularly-oriented case studies is the logical step to follow. The first case to be -only theoretically- researched reflects on the automotive industry, as contrary to the building sector, its level of circularity is quite impressive. Using the afore-mentioned governance modes as a classification basis, a categorization of the actions and/or processes that facilitate circularity in the automotive industry is presented below.

Market	Hierarchy	Network
leasing and renting agreements are in force	invest around $100 billion ($1,200 per car) annually on R&D	invest on common modular family systems (CMF)
second-hand market for all types of vehicles and most of their components	think in products	allow for cross production to take place
physical and on-line marketplaces	design modular parts that fit more than one vehicle categories	
option of direct transaction between users	design modular parts that fit more than one vehicle categories	
option of repetitive transaction between users and official dealers	apply mass-production and highly standardized processes, reducing significantly the end costs	
financial incentives for recycling vehicles	develop takeback strategies	
regulations and high fees for out-of-date vehicles in terms of environmental pollution	invest on recycle systems and in-house remanufacturing processes	
car-sharing platforms are booming	implementation of European (or international) legislation (f.i. on ELV)	

Table 1: How automotive industry facilitates circularity within the different governance modes

Besides the automotive case, four additional case studies were examined:

- Recover-E®: a shared responsibility initiative which aims to optimize the value of ICT assets, generating alongside extra value for business, economy and society
- PARK4ALL: a flexible, demountable and fit-for-purpose parking concept which attempts to cover the need for semi-permanent parking spaces

- The temporary courthouse in Amsterdam: a project that was developed in order to support the operation of the city's main courthouse

- Alliander offices in Duiven: a completely renovated industrial building, being probably the best example of circular building in the Netherlands

The main goal for the selection of those cases was to reveal the applied organizational models, to study the developed relationships between the involved actors, to record the type of signed contracts and selected transaction forms, as well as to analyze the key actions that made the former to stand out of the crowd. Through the conduction of multiple interviews with project-related professionals, in-situ visits, extended document reading and internet research, all four cases analyzed under a common pattern. The first key point of that approach was the understanding of the circular organizational model that was implemented in each case, and its on-paper schematic representation. The second key point was the noting of the most interesting facts and thought-provoking observations that were related to the concept of circularity. Once all example cases were analyzed, a Table was created, summarizing the most important aspects per case: the most influential stakeholders, their initial role in the building industry, their (extended) role during -and after- the development of the corresponding projects, and the key actions that supported circularity (see Table 2, next page).

Using Table 2 as both inspiration and proof, a set of recommendations in certain "fields of intervention" to be realized by specific stakeholders, was developed. The appointment of the most suitable parties to implement these proposals, as well as the choice of the areas for those changes to happen, are not undisputable; they are the outcome of the author's line of reasoning based on the findings of this research and his personal interpretation. Under that context hereby, four main types of actors have being held appropriate to drive the necessary changes towards a circular market of building components: the developers, the collaborative schemes, the public sector and the private clients. With regards to the areas that action needs to be taken, nine fields have being distinguished as the key ground to start the changes from: business mind-set, planning strategy, project development approach, end-of-life care, communication management, circularity management, relationship management, process management and legal affairs (see Table 3, two pages after).

The recommended actions provide a holistic approach to the issue of building components circularity. However, the practical facilitation of a circular market requires "tangible" solutions and its overall organization is directly related to the aspect of time. Therefore, in order to proceed with the actions-time correlation, the experts' point of view was requested. Through a validation workshop, a group of professionals was asked to prioritize the proposed actions with regards to the essence of urgency that each one of them derives. Apparently, the collected feedback leads to an interesting result; **the path to the development of a second-use market for building components is a 4-step process** (see Figure 1, three pages after) that can sufficiently respond to the three circular-oriented questions, imposed on the following order: Why? How? What?

Case studies	Leading companies	Role in the industry	Extra role in the process	Key actions promoting circularity	
Choisy-le-Roi	Renault	Product developer, distributer & merchant	Product remanufacturer; recycler	1	Invest on materials innovation and demountable design
				2	Invest on reverse logistics through take-back strategies
				3	Strategic selection of recollection points
				4	Optimization of in-house remanufacture and recycling processes
				5	Centralization of recycling activities
Recover-E® Program	Recover-E® Foundation (Royal HaskoningDHV / SiSo)	Engineering & project management consultancy/ ICT solution and service provider	CE facilitator; product remanufacturer and seller	1	Development of a track and trace system for all registered products
				2	Development of a shared information platform accessed by all involved parties
				3	Facilitation of direct communication between the two sides of the cycle: product design and recover
				4	Remarketing of used products
				5	Remanufacturing of products and trading at lower prices
PARK4ALL	PARK4ALL BV	Product developer & service provider	(-)	1	Specific market target
				2	Invest on materials innovation and demountable design
				3	Standardization of building components and working processes
				4	Creating long-life, high quality elements for short-term solutions
				5	100% reuse of materials as no redundant parts are included
				6	Zero creation of waste as everything is screwed to each other
Temporary courthouse in Amsterdam	Cepezed Projects	Architect & project developer	Product remanufacturer and seller	1	Invest on materials innovation and demountable design
				2	Over-dimensioned building components to rise their field of applicability
				3	Standardization of building components
				4	High reuse % of building components and materials , minimizing alongside the introduction of new resources and the creation of waste
				5	Adjustment of the initial product to next user's requirements at a much lower cost for the company
Alliander offices in Duiven	RAU / Volker Wessels	Architect / Contractor	CE facilitators	1	Cooperate exclusively with CE oriented partners
				2	Implementation of smart and demountable design
				3	Reuse of existing buildings, building components and materials at a total of more than 80%
				4	Development of "material passport" for the tracing of all separate elements
				5	Remanufacturing of waste and transformation to new resources
				6	Highly reduce the need for new materials and transportation services
				7	Careful storage of non-able-to-reuse materials into 13 different waste streams
				8	Involvement of surrounding parties and local authorities to the promotion of a 'green' development for the whole area

Table 2: Summarized insight gained from the analysis of the theoretical and practical case studies

	Acting parties			
Field of intervention	**Developers**	**Collaborative schemes**	**Public sector**	**Private clients**
Business mind-set	think in products	think in CMF systems	think in services	think in long-term value
Planning strategy	invest more on R&D, new (bio-based) materials and new working methods	invest on common benefits, shared and integrated resources	create incentives for the development of circular buildings in terms of tendering, subsidies, tax concessions, permits, etc.	challenge usual practices and project delivery methods
Project development approach	design demountable, standardize components	work on cross design and/or production	ask for proof of circularity and waste minimization	ask for proof of residual value
End-of-life care	develop take-back strategies and apply reverse logistics	centralize and co-manage collection, remanufacture and recycle points	provide storage and showroom spaces for used buildings or building components	support actively the exchange of building components
Communication management	improve and expand current in-house sharing platforms	promote and integrate common network-sharing platforms	support the development of and participate in public-sharing platforms	exercise buildings management through on-line cloud-based platforms
Circularity management	full-scale development of material passports	development of common track and tracing systems and material databases	set directives and goals for large-scale circularity of building components and high value recycling construction waste	request and implement performance detection technologies
Relationship management	challenge manufacturers and suppliers in adjusting their working processes to CE directives	apply extra reward and exclusion provisions based on performance	create green alliances and promote "circularity within neighbourhoods" actions	co-work with circular-oriented parties and expand their projects' effects out of their physical borders
Process management	optimize in-house design and refurbish processes	optimize remanufacture and recycle processes	experiment and set example models of circular projects	co-lead processes of own projects
Legal affairs	expand contract terms beyond maintenance phase	develop standardized agreement forms for fair allocation of building components' residual value	implement EPR norms; detach buildings' function-location permit link; guarantee legal protection in case of changes in waste classification	(-)

Table 3: **Summary of the recommended actions that the most "powerful" actors of the building industry need to undertake in nine crucial areas**

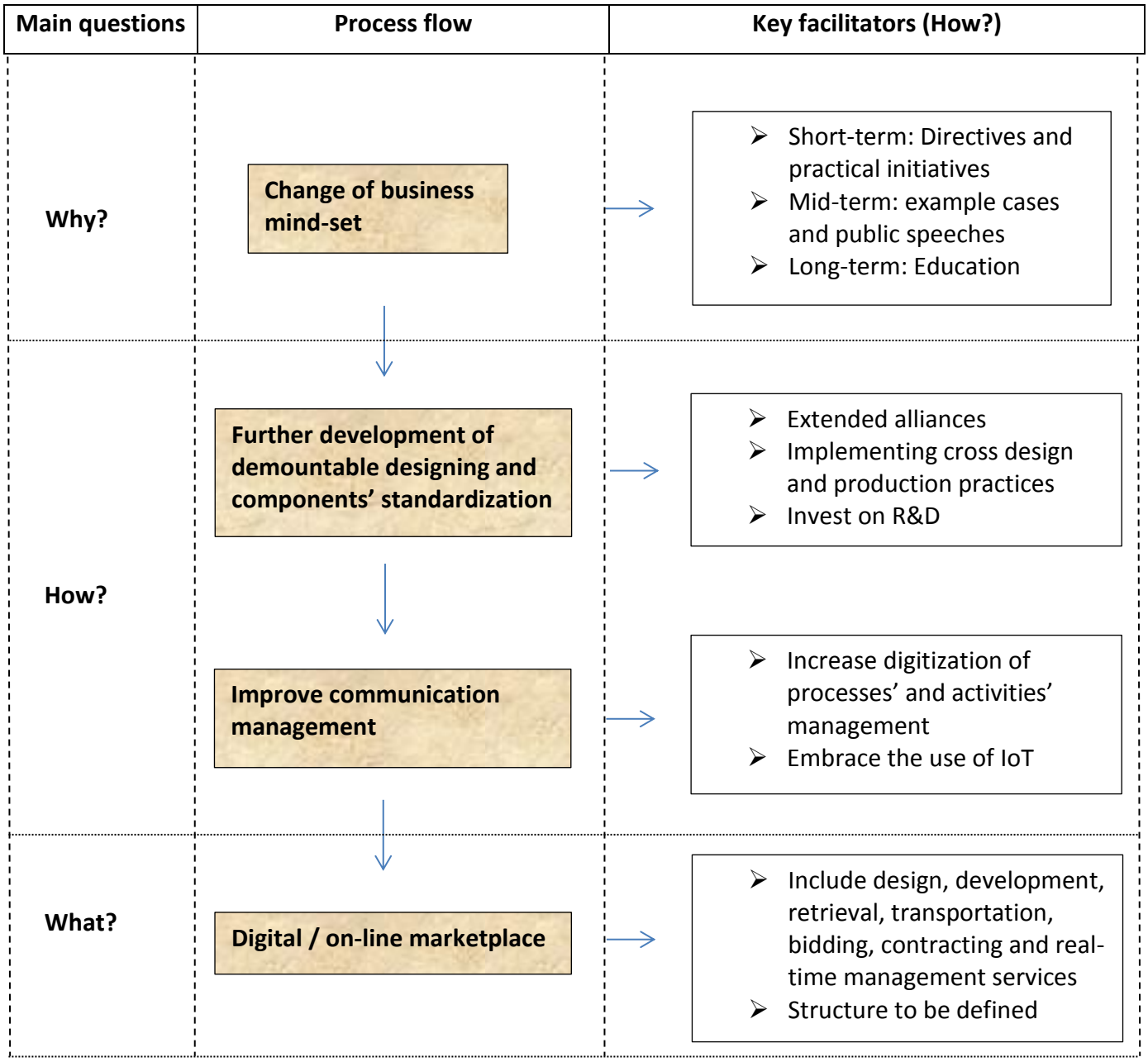

Figure 1: The 'path' towards a second-use marketplace for building components

Once 'Why' and 'How' have been properly addressed the 'what' can result in an on-line on-line marketplace that will support, facilitate and enhance the function of an actual market for second-use building components. In that sense, a digital space where all kind of services will be provided, including 3D designing and virtual reality representations, assembly and disassembly activities, transportation and storing possibilities, as well as legal consultation and bidding procedures, should be created. A draft example of such a platform and its hosted services, accompanied by the role that all potential stakeholders will need to play, is presented in the Figure below.

Online market-place

3D real-time depictions

Collaboration between architects and structural engineers with software developers and IT specialists

Free research possibility

Self-done by owners or appointed to professional engineers.

Evaluation services

Self-done by owners or appointed to professional engineers.

Record performances

Collaboration between different backgrounds' engineers, academic institutes, software developers, IT specialists and product developers.

Bidding process

Self-done by owners or appointed to professional engineers; enhanced roles for contract managers

Transportation and storage services

Empowerment of new actors: logistic and transportation companies; collaboration with engineers, software developers and IT specialists.

Figure 2: Representation of the way a digital marketplace for second-use building components is expected to function, through the depiction of its embedded services and copetent stakeholders

The prospect of a second-use market for building components is a topic which extends in many directions. Consequently, any study aspiring to fully include and sufficiently outline all its aspects can hardly be effective. Acknowledging that parameter and being also limited in time due to the nature of the current research - master thesis project-, the latter's scope was bounded in the field of organization and further limited in the steps, processes and activities that need to be implemented, in order circularity of building components to be facilitated in practice. A path towards the development of an on-line platform, that will serve as a combination of asset management tool and digital transaction center was presented, but obviously, the establishment of a suitable-to-fulfill-that-purpose marketplace requires the addressment of other factors as well. Hereby, taking that into consideration and based on the experience gained in the field of CE through that research, three topics, which according to the writer would be really interesting to further studied, are presented below.

1. *What would be the impact of collaborative schemes in the internal organization of participating actors?*

2. *What could be the impact of shifting to circular-driven project development methods on the aspects of cost, time and effort?*

3. *What would the introduction of –R (reuse, recycle) factor mean for the structure of currently used contracts?*

Table of Contents

1. Introduction

1.1 Need for change

Since the Industrial Revolution, humans follow a one-way linear model of production and consumption, in which raw materials are extracted from the ground, transformed into products, used for a certain time-period and then discarded or incinerated as valueless waste (Ellen MacArthur Foundation, 2014). According to the IPCC (2013), this highly unsustainable philosophy and way of living, which counts more than 200 years already, is to be blamed for a number of serious problems including feedstock scarcity, exhaustion of natural resources, global warming, ozone layer depletion, environmental pollution and climate change (Prins et al., 2015). In addition as emerging markets grow rapidly, the pressure on our planet's physical energy and material supplies keeps increasing (Cherim, 2016), while according to the World Bank's predictions for global waste generation, the amount of solid waste produced every day will continue rising within the next years, going double till 2025 (Lacy et al., 2013).

The construction industry is a strategically important sector for the global economy, but unfortunately it is inextricably linked to the (over)exploitation of natural resources. BAM reports of 2013, estimate that a notable percentage (almost 40%) of the total material that flow in the global economy is used in the manufacturing of building products and components (Prins et al., 2015). What is even more remarkable though, is the great disproportionality that exists between the waste production and the economic benefit resulting from the building activities. To give an example, Remøy (2013) states that the Dutch construction sector is responsible for 35% of the national waste generation, when it represents only 5,1% of the gross domestic product (Geraedts & Ruiterkamp, 2015). Apparently thus, for an industry with such statistics, it is more than obvious that a ground-breaking change in its business philosophy is urgently necessary, as the current production practices are far from serving sustainability and ensuring earth's longevity.

Over the years, various eco-friendly concepts were developed in order to address the alarming issues of unsustainable production, ecologic degradation and escalated climate change. One of the most interesting and popular theories among both academics and professionals, is that of Circular Economy -in short CE. Its concept is inspired by nature, in where the term 'waste' is absent, landfills do not exist and all elements are constantly flowing in circles, as after the end of their life-time they constitute the main ingredients for another life (ING, 2015). For the formation of its main principles CE was influenced by different theoretical disciplines, including cradle-to-cradle, blue economy, sustainable development, regenerative design, performance economy and industrial ecology (van

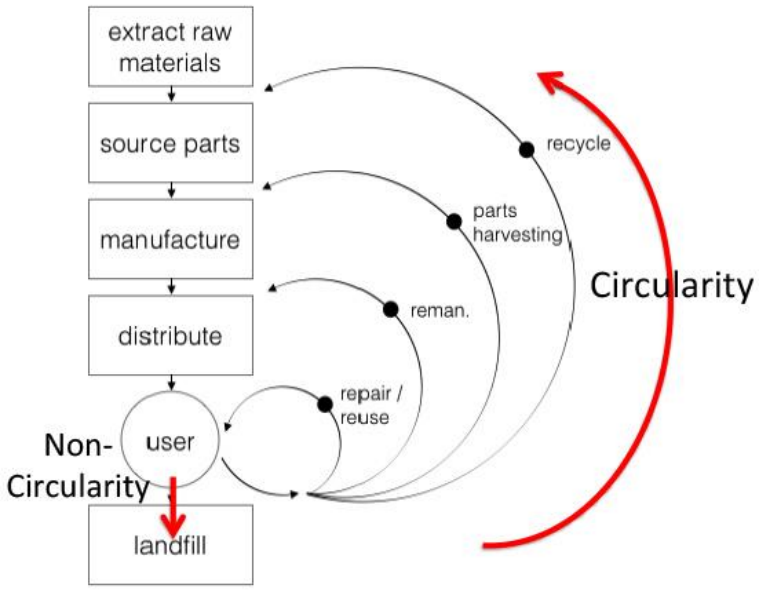

Figure 1.1: Turning linear economy to circular

Renswoude et al., 2015). Consequently, key principles such as design dispose-free, flexibility trough diversity, green energy, think in loops and act in cascades, have been derived from the aforementioned schools of thought and have formulated its core theory (Ellen MacArthur Foundation, 2014).

1.2 Problem context

As the need for change becomes more and more apparent, CE constitutes one of the hottest topics for research in the building sector. Consequently, a remarkable number of dissertations, academic articles, scientific papers and conference proceedings are presented every year, trying to address all the diverse challenges deriving from this philosophy. At the same time several initiatives are being undertaken by private institutions, governmental authorities and public-private joint actions, such as "The Circular Economy 100", initiated by Ellen MacArthur Foundation, the "Circular Economy Package", launched in December 2015 by the European Commission, and "The Green Deal", signed by more than 60 Dutch companies and local governments (Stigter 2016). However, as it emanates from the scientific work of Bom (2012) and Bakker et al. (2014), although some products are already partially aligned to CE principles through the development of modular pilot projects or the application of new business models, there is little material to be recorded with regards to the implementation of CE in the construction industry (van de Brink, 2016).

Based on the main obstacles presented by the research of Kok et al. (2013) and the outcome of three practical exercises –focusing on the aspects of ownership, finance and building components-, Stigter (2016) and van de Brink (2016) support that the main reason why the construction industry remains still far from applying CE practices in its core activities lays primarily on the **organizational aspect**, in where issues that concern the sharing of responsibilities, the allocation of liabilities and the configuration of ownership rights are included as well. The high fragmentation that always characterized building activities can actually enhance that argument. Hereby, when –almost- each construction project is addressed as a one-of-a-kind venture run by different stakeholders and having as key goal only the fulfilment of the clients' specific requirements, the nature of the prevailing business models within the construction sector seems to be quite different than these of the corresponding models of other manufacturing industries. In other words, the 'make-to-stock' mentality which is normally found in the manufacturing industries (van de Brink, 2016), is absent from the building sector, in where the short-term profit and temporary collaboration schemes are dominant instead.

Of course there is no doubt that financial burden and technological complexities play also an important role in the restricted adoption and embracement of CE principles, nor do that social and mental challenges impede an accelerated progress of that process (Kok et al., 2005). However, the addressment of these factors is highly dependent on the existing governance modes, and subsequently any future change demands the adaptation of current organizational models into new ones that will provide for, promote and facilitate circularity through their organizational framework.

Meantime, before we go further, a brief remark with regards to the essence of circularity needs to be done. Circularity should not be translated as the ability of making something possible to ride the cycles of reuse, remanufacture or recycle, but as the fact of reassuring and organizing the function of these cycles. Although the difference between these two notions seems quite clear, sometimes a misinterpretation occurs. Thus, the ability of making a product reusable for instance can be conceived in terms of providing flexibility and adaptability to its components and thus it should be addressed as a technical issue. On the other side, reassuring reuse of a product means –except from providing the

technical possibilities for that to happen- that there is an actual demand for that specific product, and subsequently an existing market in where this product can be offered and exchanged. Unfortunately that is lacking in the construction industry nowadays and it is more than obvious that more research on the organizational field of current design, production and consumption practices has to be done; otherwise all scientific work focused on providing adaptable structures and overcoming technical difficulties run the danger of remaining practically inapplicable in a wider level.

1.3 Research Objective, Scope & Goal

Identifying the most important challenge of CE's applicability in the field of organization, and acknowledging the current practical incapability of the building industry to successfully circulate building components in a large-scale, the main **objective** of this research is to explore how circularity can be realized in practice in the construction sector and what the consequences of a shift to circular building activities will be for the participating actors, by examining the organizational-related factors, and processing them accordingly towards the establishment of a second-use market for building components. As the aspect of organization is closely related to governmental, financial and legal issues, an investigation on the interaction of all these components is planned to be made.

With regards to the **scope** of the research, this will be limited in the survey of the factors that can influence and formulate the structural directives of future organizational models from a governance point of view, paying less attention to the addressment of definite financial frameworks or clear-cut legal provisions, and focusing mainly on what type of –organizational- arrangements can allow for building projects to flow in a second-use market, aligning thus with the dictates of CE. Next to that, the changes that a radical organizational rebuild of the construction sector will bring to the existing –and potentially new- stakeholders will be researched, but only as far as the role of the latter in a circular value chain is concerned. This means that no in-depth analysis will be made on the ways that an external organizational turn can influence the in-house structure of the participating actors. On the contrary, what will be studied is the new position that each party is expected to have in a CE-oriented production chain and the type of relationships that will be subsequently developed among the various stakeholders.

Following the previous, this project's field of interest can be deciphered in two main **goals**. The first one aims to provide a list of recommendations that will facilitate the establishment of a second-use market for building components and identify the steps to be taken for its practical and functional organization. The second goal aspires to foresee how these recommended actions will influence the role that the building industry's current and future stakeholders are called to undertake in a circular value chain, accompanied by a prediction with regards to how the in-between relations of the latter are expected to be affected and structured.

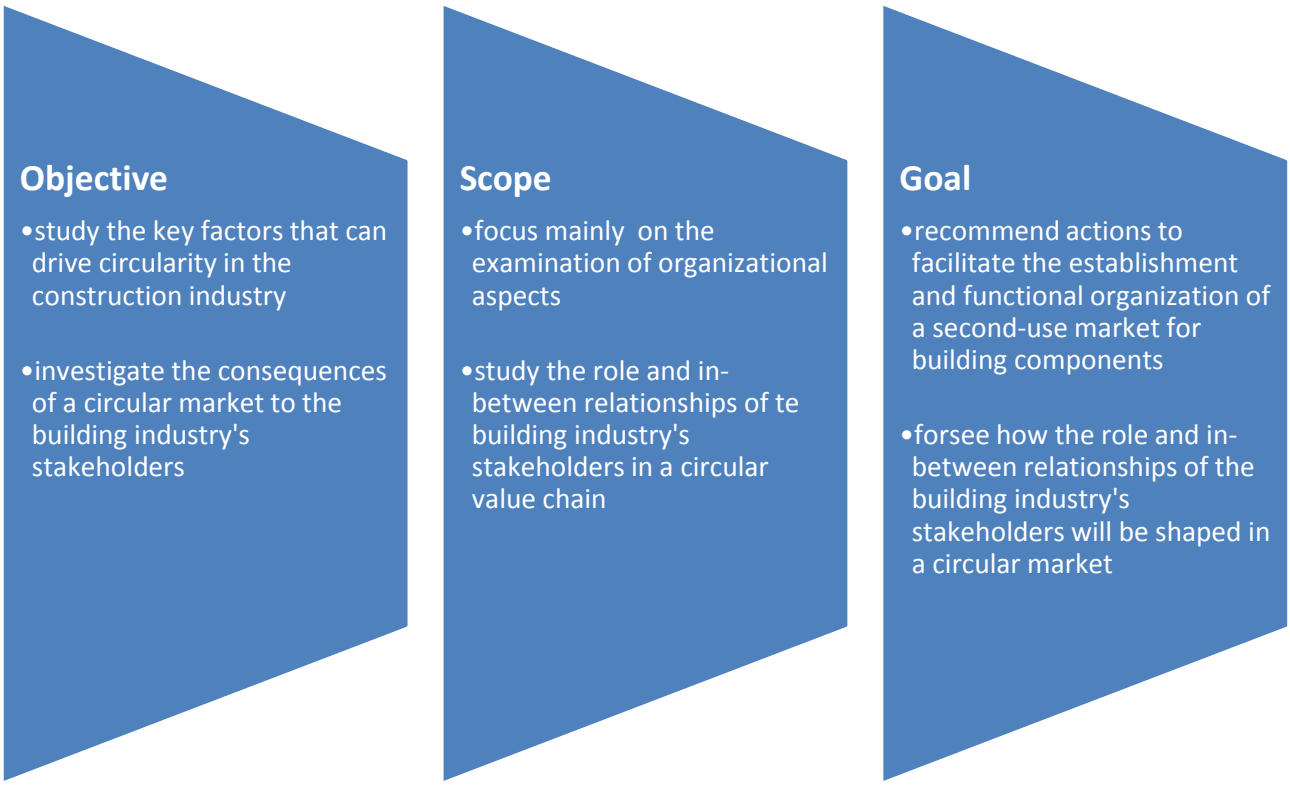

Figure 1.2: Schematic depiction of objective, scope and goal

1.4 Research Questions

In order to steer this project properly towards its goals, a set of research questions has been formulated and is presented below. For the smoother progress of the research, the central question has been subdivided into six sub-questions, attempting to study both the theoretical and practical data, and provide an insight on the different organizational schemes that can reassure the circulation of building components efficiently. This knowledge will enable the development of a general framework where different fit-for-purpose models will be placed, addressing thus the main inquiries of this project. However, taking into account the dynamic nature of a research and the various interesting or unpredictable aspects that can arise during a thesis, some of these inquiries may undergo changes, adjustments, replacement, elimination or augmentation.

CENTRAL RESEARCH QUESTION

How to holistically organize project delivery within the building industry in such a way that the establishment of a second-use market for building components can be practically realized, and what will be its impact on the role and in-between relationships of the key stakeholders?

RESEARCH SUB-QUESTIONS

1. *How are the projects in the construction industry being organized nowadays?*

First step will be the research of the current organizational schemes in the construction industry, as they are expressed primarily through the prevailing governance modes and secondarily through the most common contractual arrangements settled among participating actors in a linear economy. The way that projects are organized, materials flow in a 'first-use' market, energy is consumed and products' exchange takes place, will be investigated. Moreover, by examining how legal and governance aspects are linked in the context of a project, the role and developed relationships among stakeholders will also be recorded and analyzed.

2. *How CE is addressing the aspect of circularity in the construction industry in theory and what happens in practice?*

To answer this question a brief description of CE will initially be presented. A literature study on how circularity is pictured on a theoretical level and/or expected to be realized when it comes to permanent buildings will follow, while the extent that expectations match reality will be investigated as well. Through this study the most important aspects influencing the structure of a project's organization scheme will be examined and the main obstacles –as found by literature- will be demonstrated.

3. *What can be learned from building projects or other industries where CE principles are already applied with a certain level of success?*

Once presenting the incompatibilities between existing linear practices and wished circular procedures, a look at 'circularly' successful projects will follow. This subject will actually be addressed in two parts. Firstly, a literature research will precede focusing mainly on the automotive industry and its organizational models, which manage to incorporate some of the CE principles in its production processes, achieving high rates of materials reuse. After that, four case studies will be examined; one, lying on the field of IT services and another three lying on the area of temporary modular building projects. All case studies will be based on documents provided by the competent companies and supported by explanatory interviews. The main target of this step is to discover how the circularity of certain products is achieved in practice and which are the most important success factors regarding the organization of a second-hand market in various cases. Hopefully some interesting results will come out.

4. *Which organizational-related features can better serve the promotion of a second-use market?*

The answer to that question will be provided through the analysis and comparison of the aforementioned theoretical and practical examples, based on the findings of the existing organizational schemes and the proposed –by the literature- ways of organizing CE in the building environment. The outcome of this step will provide the most crucial features that can be drawn from different sources and will constitute the basis for the development of the desired organizational models.

5. *Based on the current findings which actions should be followed in order circularity of building components to be realized in practice, and how are the involved actors expected to be affected?*

Many factors can influence the promotion of circular building activities. Hereby, analyzing and processing all the gathered information, a number of actions that will need to be taken by different stakeholders

within multiple fields of interest, is expected to come up. Important part of this step will be the reference to the role and the developed relationships between the participating actors, which will be estimated based on the role that they are expected to play in a circular value chain.

6. *What is the experts' opinion on the proposed recommendations and their potential practical implementation?*

The last question aspires to get the experts' perspective on the feasibility of the proposed recommendations, and based on their feedback to display the starting points for the practical widespread of building components' circularity. Given the time of the thesis, as well as the nature and the extent of the proposed changes, some alterations and/or improvements may be incorporated in a revised version of recommended actions.

1.5 Research Approach & Strategy

Following the context of the aforementioned sub-questions and the brief explanatory of how they are planned to be addressed, it seems that the most suitable strategy to proceed with the current project is the use of the pragmatic approach, which can be expressed as the application of the best suited methods for the answering of the main research inquiries, avoiding thus the adhesion to a single research model. Consequently in that case, the mixture of three different approaches will be used.

For the addressment of the first two questions a **desk research** has taken place. Key point of that method is that no direct contact with the authors or the object of the previous research is required, as in its essence this method compares and reflects on existing material to offer an alternative perspective (Verschuren & Doorewaard, 2010). In addition, a second advantage lies on the possibility of processing large amounts of information with regards to existing theories, current practices, on-progress processes and future developments, while the close dependence from books, scientific articles and dissertations defines this approach mainly as a literature survey. A potential drawback can unfortunately be detected in one of its strong points –the indirect contact between the object and the author of the research-, as the latter can hinder important details on the configuration and application of a fit-for-purpose model -beyond those documented in literature-, while biased interpretation of data may also occur due to the subjective nature of the research.

With regards to the third and sixth sub-questions a different approach will be followed; the **qualitative research**. This method is about recording, analyzing and attempting to describe or interpret whatever is being researched, providing information in the form of words or visual representations. Qualitative approach tends to be inductive which means that the researcher develops a theory or looks for a pattern of meaning on the basis of the data that have been collected. This involves a move from the specific to the general and is sometimes called a bottom-up approach, although most research projects also involve a certain degree of deductive reasoning. An interesting point about qualitative research is that no pre-determined hypotheses are usually formulated. Nevertheless the researcher can clearly identify a problem or topic that wishes to explore and may be guided by a theoretical lens –a kind of overarching theory which provides a framework for the investigation. The approach of data collection and analysis is methodical but at the same time it allows enough room for flexibility. Interviews and case studies are common techniques for the collection of data, and they can be carried out in several stages rather than once and for all. Big advantage of this method is that the researcher can even adapt the process mid-

way, deciding to address additional issues or dropping questions which are not appropriate on the basis of what (s)he learns during the process.

Finally, as far as sub-questions four and five are concerned a third approach will be used, the **developmental research**. This type of research steps on existing knowledge and aspires to improve products and current technology or to introduce and develop something new. Although developmental research is a study focused on the progressive changes that occur as an organism develops, in that case it can be parallelized to the development of the necessary concepts for the design and creation of the desired actions to be taken.

1.6 Research Methodology

After presenting the selected research approach, the methodology deriving from that can follow, dividing the project's structure in five major phases:

- *The theoretical insight*. This constitutes the first stage of the research, including a literature study on three main fields: current organizational schemes in the construction industry, circularity of building components and key aspects of 'successfully' circulated example products. The data collection will be based on reports, technical papers, conferences' proceedings and internet searches.

- *The practical insight.* At this phase an investigation of real cases, in which circularity of specific products seems to work satisfactorily –at least to some extent- will follow, gathering information through documents, informal interviews and face-to-face meetings with appropriate colleagues of the supervising company (Royal HaskoningDHV) as well as via contacts with other companies' professionals (depends on the examined cases).

- *The decision-making phase.* Once a sufficient number of data, information, ideas and advices will have been obtained the process of combining and analyzing simultaneously the different knowledge sources will take place, aspiring to develop a set of recommended actions for the enhancement of building components' circularity. Each one of the appointed key parties will be held responsible for the undertaking of a specific action within the context of a specific field, where changes are considered necessary. This approach will be followed for as many actors and fields of interest seem more important to undergo some serious interventions.

- *The validation phase.* After the design phase, the recommended actions will be presented to experts for evaluation, either through the conduction of separate interviews or through the arrangement of a workshop where professionals will share their opinions on the feasibility of the project's deliverables. The positive and negative feedback will be processed and –if possible- changes and adjustments will subsequently take place.

- *The concluding phase*. In that final step, a couple of conclusions and recommendations will be provided, deploying the results of the current research and highlighting aspects that still need to be investigated from fellow students.

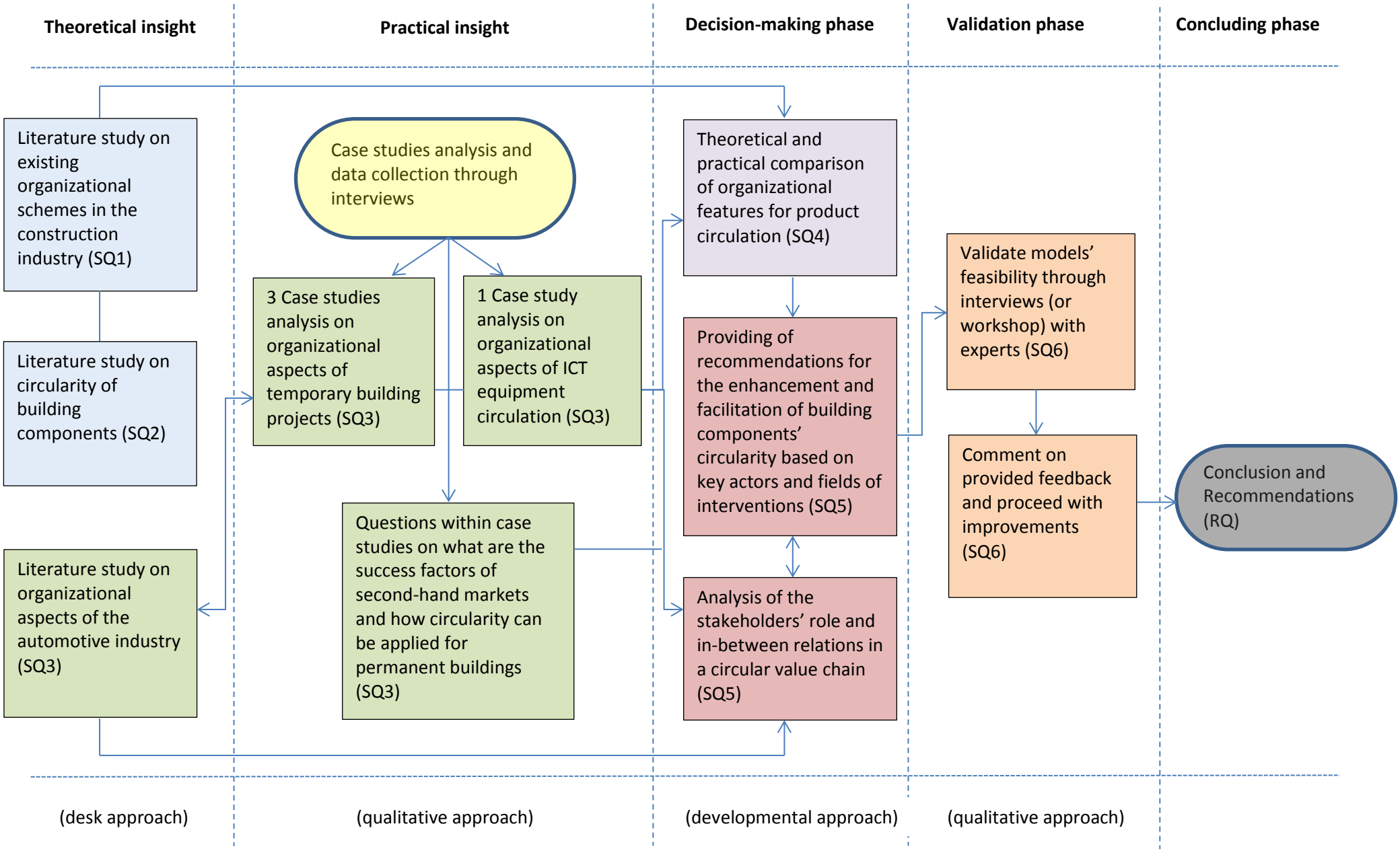

Figure 1.3: Schematic depiction of the selected research methodology

2. Current organizational models

The development of circular organizational models for the promotion and establishment of CE in a large scale demands adequate knowledge of the currently applied organizational schemes. The proper awareness of the ways that the construction industry is structured and managed nowadays is quite important both for the understanding of the way that projects are usually organized, materials flow and energy is consumed within the linear economy, but also for the comprehension of the relations that are developed between the involved stakeholders and the emerging discrepancies. Consequently, this chapter aspires to study and analyze the organizational models that are currently prevailing in the construction industry through the investigation of the existing governance modes and their linking to the most common contracting and ownership options.

2.1 Governance modes

Based on the needs and particularities of each era, the construction industry always tried to adjust and discover the most appropriate ways to provide its services at a reasonable price, time and quality. Although a simultaneous satisfaction of all these three aspects was rarely the case, it seems that the most important driver for the organization of the various parties involved in the building processes was mainly the price; or better to say the cost. Consequently, a transaction cost economics (TCE) analysis can provide a theoretical perspective for gaining a clearer understanding of organization and governance in construction (Reve & Levitt, 1984). Following this approach, construction governance modes can be classified in two main types: the "market" and the "hierarchy" (Ping Ho et al., 2009).

According to some other researchers however, "*governance structures can be conceptualized through different sets of decision-making, coordination mechanisms, incentives (Yin and Zajac 2004), and different levels of influence in controlling and coordinating the activities in a partnership (Gulati and Singh 1998)*" (Ping Ho et al., 2009). Although in the construction industry no project can substantially be undertaken by a single organization without some degree of outsourcing (Errasti et al., 2006) -making collaboration with other parties (subcontractors, manufacturers, suppliers, etc) seem as an unnegotiable necessity-, the term partnership is not limited only in that type of cooperation. Partnership mainly refers to the targeted organization of a collaborative structure between different companies –including even competitors- towards the realization of a specific goal. In that sense a "network" is being created and run quite differently than the governance schemes defined by TCE.

In the next paragraphs a brief description of the three governance structures will follow, as well as a reference to the corresponding developed relationships in the context of the construction industry. In addition, some examples will be provided, aiming to show in a clearer way the different working grounds of the aforementioned modes.

2.1.1 Market

The **market** model is highly based on an "as lower cost as possible" exchange model, although suppliers do also compete in other aspects, such as quality, aesthetics, sustainability, maintenance services and timely response to changes or new needs, and clients do also not always seek for the lower price. In a market environment there are no fixed or long-term relations between buyer and seller, as the transactions are usually one-time or project-oriented and based on bilateral deals (Klok, 2014). A simple

example can be derived from the relationship developed between a contractor (buyer) and a tile producer (seller) in the context of a specific project. Once a construction firm is in need of tiles, it can turn to the market for potential suppliers and choose freely the most satisfying bid, which meets the prescribed requirements.

Historically, this governance type has dominated the construction industry promoting the open competitiveness of suppliers and the unhindered will of clients to choose based on their personal preferences. However, relationships run clearly by market rules are often distrustful, competitive and poisoned by the fear that the other party may display high opportunistic or strategic behavior (Beach et al., 2005). As a consequence the participants are reluctant to share knowledge, information and resources, while instead act by the book and pursue higher profits just for themselves. Following this path though, what actually rise are the transaction costs, as the detailed definition of accountabilities and responsibilities through the preparation of fully comprehensive contractual agreements, the organization and operation of monitor mechanisms and the precise tendering process, demand a significant percentage of the project's budget (Beach et al., 2005).

2.1.2 Hierarchy

An alternative governance structure is the **hierarchy**. The hierarchical model, which can be also answered as vertical integration (VI), allows the principle organization to claim a better position in the market –with regards to its competitors- by expanding its operational control through targeted acquisition of key suppliers (Beach et al., 2005). As follows by the TCE analysis, through the rearrangement of ownership structure, hierarchy internalizes transactions under a common ownership shelter, making them subjected to bureaucratic rules within the limits of employment contracts, and eliminating thus the transaction costs that could occur by potential opportunistic behaviors or underlying opposing incentives (Reve & Levitt, 1984). Looking at the example that was used before, a clear shift from market governance to hierarchy will be conducted if the contractor decides instead of contracting the tile provider's services just for once, to buy the latter's company and incorporate it into the main construction firm, expanding thus its overall operational field. Moreover, VI can facilitate more efficient management and monitor systems through closer in-house communication and co-ordination of the necessary activities.

On the other side, hierarchy does not come with zero drawbacks. The VI can front much opposition varying over time, nation, industry, professionalization and education, and can easily be translated in disputes, conflicts or strategy and power games, both within and between organizations (Reve & Levitt, 1984). In addition it is not always possible for a company to keep up with the same economy of scale as its competitors –especially when the latter's expertise covers a smaller field of action-, neither it is easy for the former to maintain a core competence focus and be distinguished for that. At the same time, the more an organization is growing the more operationally inflexible it can turn into, while the less competition exits the hardest it gets for the former to raise motivation for excellency among its professionals (Beach et al., 2005).

2.1.3 Network

The **network** is a third governance model, which includes the strategic selection, the repeatedly collaboration and the patterned allocation of tasks and responsibilities between two or more autonomous parties, committed to common agendas and mutual benefits through collective action (Hay & Richards, 2000). The actors involved in such a partnership -which can have both a legally binding and a non-contractual form- are engaged in the creation of products or services based on implicit and open-

ended contracts, allowing room for environmental contingencies and promoting the coordination and safeguarding of internal exchanges (Jones et al., 1997). Consequently, through partnering, the members of a network can enjoy not only the closeness and co-ordination efficiencies of hierarchy, but also the service performance and unceasing progress benefits deriving from the traditional market trading (Beach et al., 2005). Moreover, the network governance can even balance the transaction costs, as from one hand there is no need for high capital investments -related to asset specificity and switching exchanges- while on the other hand there is no need for excessive tendering, negotiating and monitoring costs - compared to the market conditions (Jones et al., 1997).

Once a network is developed, a solid structure that facilitates the sharing of information, knowledge and resources between different organizations is provided. Taking a quick look at the previously discussed example, the contractor should seek for a partnership with the tile producer if they both think that this transaction will be in favor of their mutual benefits. The duration of such cooperation however does not have a single answer. Although a network does certainly not last forever, its lifespan has a finite end depending on the behavior, interests and communication between the involved parties. It wouldn't actually be strange to liken network governance with a "living mechanism" which can be changed, expanded, restricted, renewed or terminated in order to meet the relevant challenges of changing or completed goals, new members, innovative ideas, better performance, etc.

A network in the construction sector can be organized in different forms, based on a variety of aspects such as the way parties' relations are treated, responsibilities are shared, conflicts are handled, communication is achieved and goals are settled. After reviewing the existent literature, this study proposes the classification of construction networks in two main clusters: the **strategic partnerships** running by long-term co-operation agreements and the **project partnerships**, characterized by short-term (usually project-oriented) relationships and collaboration attitude. Adjusting Cheng's et al. (2001) network analysis in these two categories, the strategic partnership can be further separated in **formal partnership** (acting as a central operational unit between more joint parties and extended beyond a single project) and **informal alliance** (ruled by horizontal co-ordination and acting supplementing to the formal contractual agreements), while the project partnership can be divided in **contractual relationships** (run by bidding contracts between autonomous parties, hierarchical coordination and impersonal relations) and **project joint ventures** (act as a central coordination and management unit for the shake of a specific project). Key feature to this categorization is the combination of the term length - expressed through the co-operation perspective- of the developed partnership (Cheng et al., 2001), and the management level of the network's relationships (Cheng et al., 2004).

Once all different governance modes of the building industry have been analyzed, a Table outlining how each one of them addresses some key features is presented below.

Key features	Market	Hierarchy	Network
Business mindset	outsourcing	acquiring key suppliers	targeted partnerships
Communication basis	price	habitual	relational
Normative basis	explicit contracts	employment authority	sharing resources & co-operating mood
Relationship context	short-term	employment relationships	"living mechanism"
Degree of flexibility	high	low	medium
Commitment	low	medium to high	medium to high
Actor choices	free	dependent	co-dependent
Key driver	cost	cost	value

Table 2.1: Main differences between the governance modes of the building industry (own Table)

2.2 Contract families

The existence of different governance forms in the construction industry created an even greater variety of contract types and agreement forms, structured in such a way that they could serve better the needs and interests of the participating organizations. There is no single definition of a contract as the context of the latter can be attributed in multiple ways. Focusing mainly on the economic transactions f.i. Reve & Levitt (1984) state that a contract constitutes the explicit or implicit agreement on division of labor and profits, while according to Dutch Civil Code a contract is defined as the legally binding agreement between two or more parties from which specific obligations over one or more other parties originate (Chao-Duivis et al., 2013).

No matter the definition, contracts are inextricably connected to projects' organization as –almost always- they reflect the way that the latter are structured and run. The preferred governance mode, and therefore the way that project activities are managed and the relationships between stakeholders are regulated, are highly defined by the form of the selected contract. The latter not only describes the project's progress (sequence of works, milestones, delivery dates, quality tests, etc.) but it also details the sharing of accountabilities –through the allocation of risks and responsibilities-, the definition of payment methods and the form of the final product's ownership model.

Attempting to introduce the most characteristic examples of current construction contract types -and not to record the whole range of the latter- a targeted choice was made. Based on the insight provided

by different sources, four main families were reported: the traditional contracts, the design team contracts, the integrated contracts and the alliances or partnering contracts. In the next paragraphs a brief description of these contract families will follow, as well as a reference to their link with the corresponding governance modes of the construction sector.

2.2.1 Traditional contracts

The traditional contracts have dominated the construction sector through time and still remain the most commonly used method of procuring civil works in many industries, especially in the building. The main characteristic of the traditional contracts lay on their clear and rigid structure, which appoints explicit functions and obligations to each party (de Ridder, 2009), granting a highly **hierarchical** governance mode to the execution of the project's activities. Under the rule of traditional contracts, a quite 'classical' organizational model is usually settled. In this context, the client is the 'boss', asking for a tailor-made product, and the actors he is associated with are limited to architects, contractors and consultant engineers.

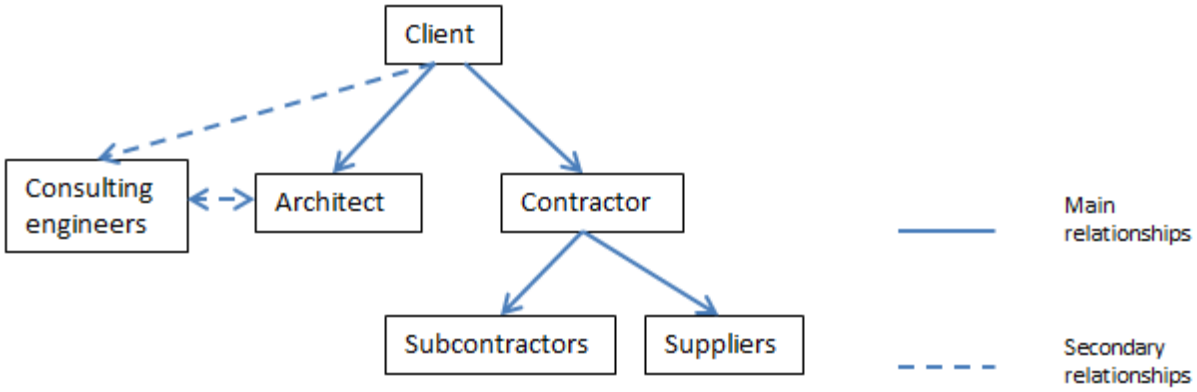

Figure 2.1: A usual organizational model of construction projects run by traditional contracts. The role of client in the development process is more than apparent.

The client first appoints architects –or/and consultants- to design the project in detail and then in collaboration with the latter prepare the necessary tender documentation, including drawings, work schedules and bills of quantities. Following that and depending on the nature of the project, either the client will select a specific contractor or more contractors will be invited to submit tenders (**market mechanism**) for the construction, usually on a single-stage, competitive basis. In case of a private client the decision of procuring a project is up to his personal preferences, but in case of a public client, attention has to be paid on the economical threshold of procurement regulations that stands for within or without the boundaries of a country (Chao-Duivis et al., 2013).

Regardless the tendering process when it comes to the flow of materials and / or ownership of construction products the situation is quite clear. The client pays for acquiring the ownership of the final product, while the contractor is responsible for the provision of all necessary resources to develop that product –including procurement of materials, availability of machinery and technical equipment, production energy, etc.- unless it is agreed differently (Chao-Duivis et al., 2013). Under these circumstances the contractor only cares about fulfilling the prescribed requirements within the lower costs, ignoring at the same time the potential value that the in-use materials can have in the long-term.

Consequently, only on the short-term –during construction phase- the contractor can be considered 'owner' of the building materials, as the ownership of the latter automatically passes to and stays with the employer -in form of a building- from the delivery of the final product till the end of its lifespan -as construction waste.

As far as the relationships among stakeholders are concerned, traditional contracts unfortunately come with a couple of noteworthy drawbacks. Fully developing the design before contracting it to a contractor gives the client certainty about design quality and cost estimations, but as a process it can be slower than other forms of contracting. In addition, as the contractor is appointed only once the design is complete he is neither able nor willing to help on the improvement of the buildability and packaging of proposals as they develop. Instead, in case the latter runs into design deficiencies he will try to make the most out of it, charging usually higher prices than the normal. As a consequence, if design information is incomplete at tender or if significant variations are required after the contractor has been appointed, the extra cost for the client can be significant. All these are not the exception but common practices, the addressment of which can cause friction between contractors and architects, or contractors and consulting engineers. Therefore the clear separation of design and construction supported by traditional contracts can be considered an adversarial approach.

2.2.2 Early contractor involvement

The early contract development model constitutes a partnership between different stakeholders of the building process, including the client, designers (architects, consulting engineers, cost estimators, structural engineers, etc.) and contractors for the execution of a project's design (Chao-Duivis et al., 2013). Each participating actor focuses on the set of activities that lays on his specific field of expertise in a coordinated manner, and if possible advices or assist the other parties involved. Although it seems as a clear network, the governance type that rules this contract family is more a **hybrid** between **hierarchy and alliance**. With the term alliance an informal rather than a formal relationship is attempted to be described (Cheng et al., 2004), while the hierarchical aspect of this partnership is attributed to the heading role that the client preserves and it is applied either through representation from one of the participating consultants or through an exterior third party (Chao-Duivis et al., 2013).

An important feature of the this contract model is the early involvement of a number of experts – including the contractor- in the design of the project. That way extra value can be derived from an early stage as design omissions or deficiencies can be reported and fixed, future cost overruns can be foreseen and avoided, increased quality can be achieved and more solutions may arise. Design and execution though are still separated and participation in the design team does not guarantee the work package to the contractor. However as the latter gets the advantage to be the first one to bid for the project, the incentive to contribute his best and convince the employer for his competencies is extremely high (Chao-Duivis et al., 2013).

Despite the development of a more co-operative environment among client and experts, the ownership model does not present any differences compared to that of traditional contracts. In an early contract development model, the focus is turn to the design process, aiming to raise and secure the value of proper planning; however during construction no change in working practices is observed. The selected contractor is again the temporary owner of construction products, searching once more in a 'first-hand' market of materials and building components, which once turned into the desirable building, they are set under the possession of the client.

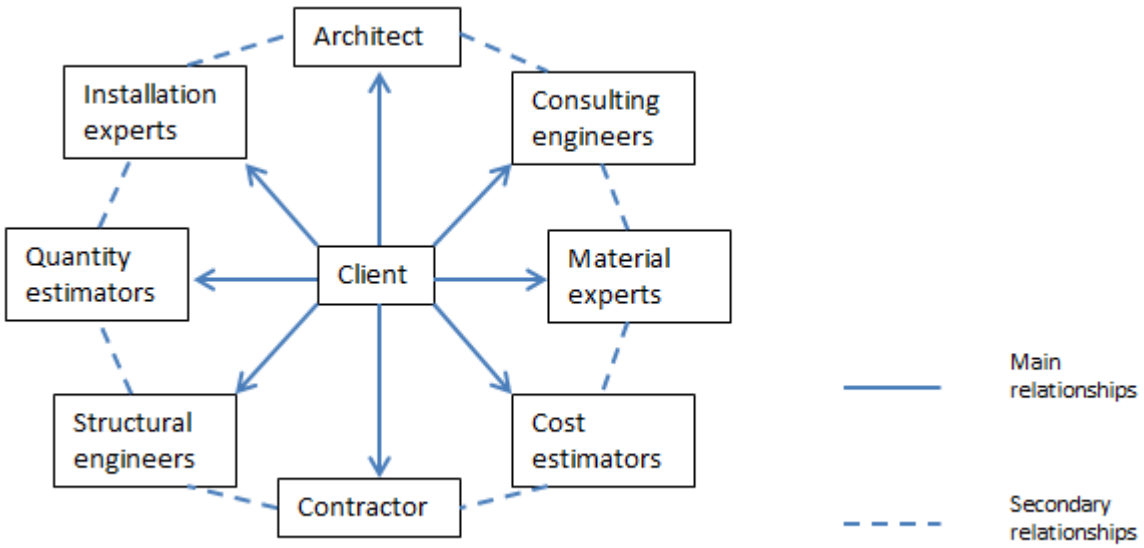

Figure 2.2: An example of the organization structure within a design team. The client is leading a network of professionals.

In such a cooperation scheme all the involved parties shall sign a coordination agreement to prove commitment on shake of the project and good will in their in-between relationships. The client shall also conclude different types of contracts with each one of the participants, using f.i. the New Rules 2011 or the FIDIC "White Book" for consultants and architects and the Standard Design Team Contract 1992, published by VGBouw for the contractors (Chao-Duivis et al., 2013). With regards to the liabilities that rise from this model, the blame of failure is not collective. Instead each party is accountable for the mistakes undergo in its area of expertise; even in case that the former just adopted an idea, advice or exhortation of another participating actor (Chao-Duivis et al., 2013). Apparently, the reasoning of the design team approach supports the development of trust and friendliness among its members, resulting in less conflicts and better final results. In case that an external contractor is selected though, the issues discussed within the family of traditional contracts are expected to emerge here as well.

2.2.3 Integrated contracts

The integrated contracts appeared in the construction industry in order to serve better a set of issues that the traditional contracts could not. Some of the most important reasons were the enhanced opportunities for innovation, creative solutions and closer coordination of a project's progress phases (Sebastian and Gelderen, 2007). Main feature of this contract family is that both design and execution of the construction works are gathering under a single point of reference (the contractor) in relation to the client, and consequently the pace of project completion speeds up, as the overlap between design and construction is managed in-house (GAO, 1999).

A great number of different contract forms can arise depending on the kind of responsibility transferred from the client to the contractor; to name a few Design and Build (D&B), Design-Build-Maintain (DBM), Design-Build-Finance-Maintain(DBFM), Design-Build-Finance-Maintain-Operate(DBFMO) and Design-Build-Operate-Transfer (DBOT) (Lenferink et al., 2013). In any case though, the presence of **hierarchy** is more than unambiguous, as each party has a clear set of obligations, responsibilities and liabilities to live with. The employer usually retains a passive role, transferring all risks to the contractor –for a higher

price compared to traditional contracts- which is not always wise as in case that the contractor misjudge the works to be done, miscalculate the necessary costs or –even worse- go bankrupt, the client will be forced to financially support the project again.

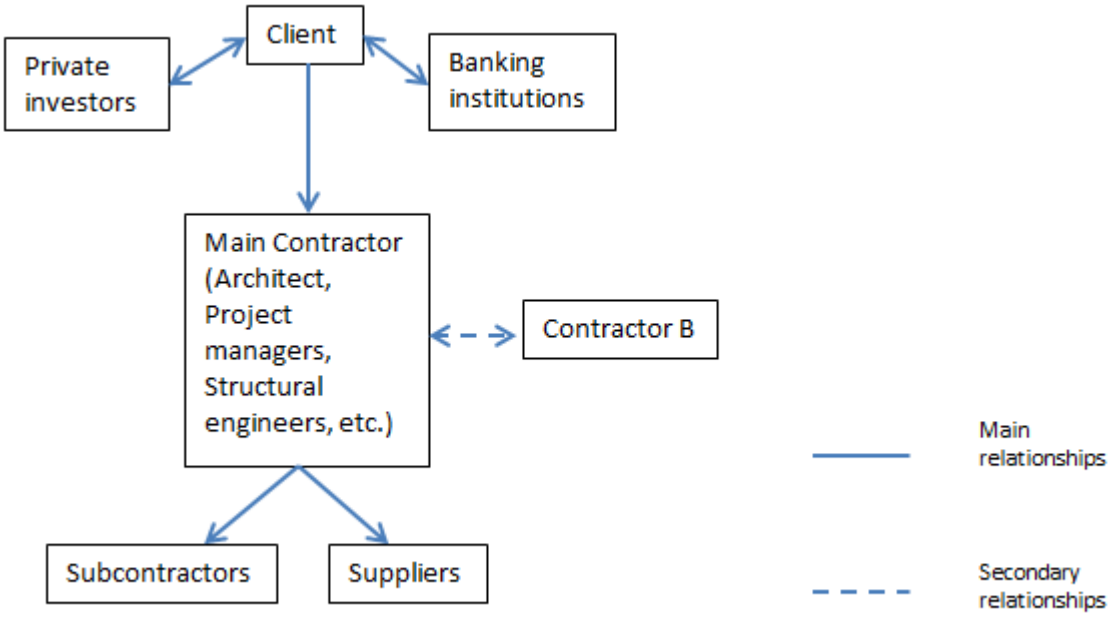

Figure 2.3: A common organizational model addressed in integrated contract family. The main contractor leads the development of the project, managing the allocation of works to all the rest professionals.

Speaking about money, another crucial factor that led to the introduction of integrated contracts was the need for a shift in the financing schemes of construction ventures. The development of large-scale projects –in terms of complexity, risks, costs, social impact, etc.- is not easy to be financially supported by a single stakeholder, even if the latter is a municipality, a province or a state. Consequently as new funding sources are necessary, banking institutions, big contractors and individual investors can participate in the financing of a project changing the rules of traditional ownerships models. Through the options of operation and lease for a considerable period of time (25 years f.i), the private investors can be compensated for their initial capital and achieve notable revenues. However, as after the end of the granting period the deliverables become client's property, the interest of the former is mainly restricted on the reassurance that the delivered product will be up to its standards for as long as it is managed by them. Apparently thus, the awareness of the contractors regarding materials' flow and processing is limited again on a short-term frame, as the exploitation period of 'materials' may be longer that time but still not enough to bond them with the future 'construction waste'.

In terms of stakeholders' relationships the client, as well as the financing participants, have limited contacts with and control over the contractor. As a consequence it is more common for these relationships to remain strictly professional rather than to be developed in closer tights. Obviously, the nature of integrated contracts allows all parties to be occupied with cautious trust and optimism for the final outcome, as the compliance with the predefined commitments is for the common interest of all the actors. On the other side the contractor acting as the leader of the project has a clearly structured and

close relationship with all the other professionals who can be either part of his company (architects, cost estimators, structural engineers, etc.) or external associates (subcontractors, suppliers, consultants, etc.). Apparently, under the same shelter confidence, reliability and inter-department co-operation are expected to be present; under difference shelters though the level of trust and commitment can vary, making the need of adequate management and controlling mechanisms necessary.

2.2.4 Alliances / partnering

Alliances or partnering represent the latest trend towards a more collaborative approach of delivering construction projects. They could be characterized unique in the sense that they require the involvement of owners, designers, builders, financers and key stakeholders on a project as early as possible, sometimes even at the conceptual stage. The essence of this collaboration is that detailed procedures are agreed upon with respect to mutual consultations. Consequently this contract type results in more transparency among all the parties involved on a construction project. Additionally, both risk and reward are shared by the involved parties resulting in greater integration of resources, processes, and expertise than would be possible under more traditional contract arrangements (de Ridder, 2009).

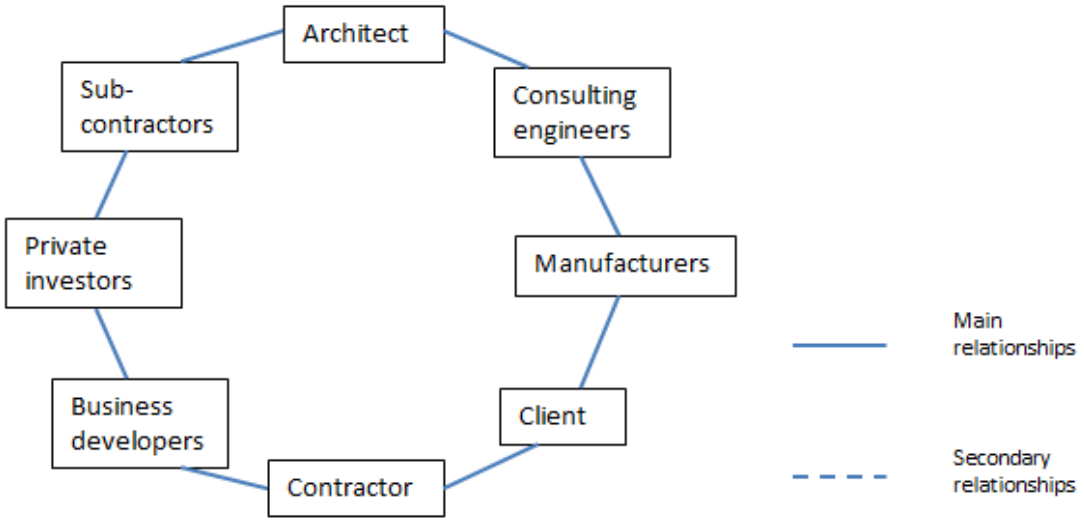

Figure 2.4: An example of alliance/partnering organizational model. All participating actors share equal responsibilities and benefits.

In this type of contracts the client becomes heavily engaged in the realization of the works. The hierarchical models of all previous contract families do not apply here as all parties are equal to each other, promoting a clear **network** governance mode. On the other hand, trust although necessary for such a model to function, takes time to be fully developed and even if that happens, inspection and monitoring costs will be quite higher than within integrated contracts. As alliance and partnering can take different forms –depending on the nature of the project, the goals of the parties and the level of the trust and communication that can be developed- a complete report of all potential agreement conditions is not advisable (de Ridder, 2009). The use of simpler contracts forms instead could raise the confidence of the participating actors over the good will of their fellow parties and contribute to the development of clan relationships, which is of high importance for such a partnership to succeed (Beach et al., 2005).

Unfortunately, despite the fact that this approach promotes the sharing of risks and profits, costs and values, and even ownership of the final product, the tactic that is followed when it comes to the building elements of a project does not differentiate from the previous cases. Materials and other components are still procured in the 'first-hand' market as the working practices remain the same and even in case of complete ownership by an alliance (through the introduction of an innovative concept f.i.) there is usually no plan for the resurrection of materials' value after the end of product's life.

2.3 Thought-provoking notions

What really needs to be mentioned is that within governance literature there is a strong current towards the creation of partnerships and alliances, including not only contractors, subcontractors, architects and consultants but also suppliers, manufacturers and even consumers. According to Hameri & Paatela (2005, p42) the value production for the client has turned into a highly joint effort, realized within corporate networks, where flexibility and quick response to demand changes are crucial for success and survival. Consequently, the higher the complexity of a project the more necessary the collaboration with suppliers and partners is. Moreover, Dubois & Gadde (2000, p214) state that variety in relationships is important, as customers can benefit from the diversity of skills and competencies of their suppliers, and deal differently with dissimilar interdependency issues. To add in that, pinpointing the criticality of relationships between customers and suppliers, several authors anticipate that it will not be long before competition will not be conducted among individual companies -as has been normally the case till now- but between global value chains (Errasti et al., 2006, p252).

3. Circularity in construction industry

3.1 Circular Economy: concept & definition

In the introductory chapter, a very brief notion on the philosophy of Circular Economy was made. However, as the context of this project is inextricably linked to that concept, some more details will be provided. So, what exactly is CE? According to Ellen MacArthur Foundation -one of the leading global organizations investing on the development and promotion of CE principles worldwide- it is a system which is restorative and regenerative by design, aiming to minimize the entrance of virgin materials into the production process, as well as to eliminate the corresponding created waste (van Renswoude et al., 2015). Ideally, CE attempts to deliberate human activities from the current "take-make-use-dispose" pattern and lead them into a new way of thinking, designing, producing and consuming where the terms 'circular material flow', 'reuse' and 'recycle' will have a dominant place. Hereby, it can be seen as a holistic approach that aspires to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological closed loops (van Renswoude et al., 2015).

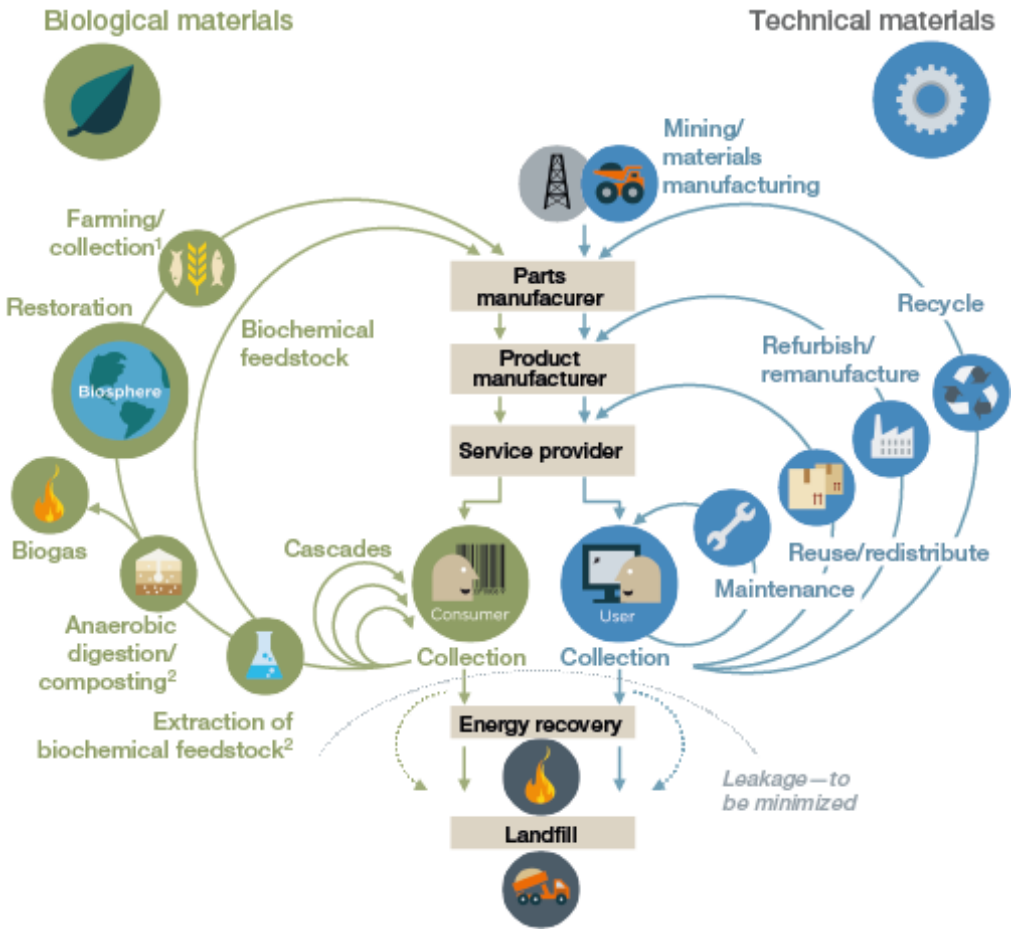

Figure 3.1: Simplified illustration of Circular Economy concept (Ellen MacArthur Foundation, 2012)

A ‘reading’ of Figure 3.1 can give a clear insight on the basic structure of this theory. Through a series of material circuits –represented by green and blue colours- CE aspires to create value by allowing products to ‘ride the cycle’, adapting them accordingly once they stop delivering the desired performance, instead of just sending them to trash (Stigter, 2016). Key motivators for that approach are the high prices and volatility of materials, which are expected to remain high and unpredictable in the near future –and probably go even higher and more unpredictable-, followed by a considerable population growth and the continuously increased needs of urbanization (Ellen MacArthur Foundation, 2014). Apparently in such a scenario, a system of endless resourcefulness sounds way more reasonable and lucrative than the current model of finite means and supplies. Moreover, looking at the different cyclical paths that a product can take after the end of its lifetime, there is a clear favouritism over the inner circles, as a ‘shorter’ route implies –at least in principle- less energy, costs and effort for restoring functionality or changing the operational scope of the circulated products.

Luckily, a short description of CE is more than enough for someone to get familiar with the main ideas that shape its philosophy. However, in case a more in-depth study of this concept is attempted, a lot of things are not so clear –or so well specified- anymore, including a unanimous definition. As the transition from linear to circular economy is expected to initially pass through a non-linear phase a lot of uncertainties and unknown factors remain to be determined (Mentink, 2014). Subsequently, a variety of different research approaches led to a number of –slightly different- definitions, each one of which is trying to attribute best the essence of the examined theory. Stigter (2016), after comparing, analysing and commenting some of these notions, is probably delivering one of the most complete by stating that:

> *“Circular economy is an economic system with cyclical material loops based on a financial incentive.”*

Although this definition seems easy-to-grasp, it is still worthy to decompose and explain it a little more. Herby -adjusting the terms provided by Business Dictionary accordingly-, the ***‘economic system’*** can be expressed as an organised set of regularly interacting or interdependent group of components that form a complex whole, and are directly related to the process of production, resource allocation, exchange and distribution of goods and services in a specific -geographic- area. Following, and based on Stigter’s interpretation, the ***‘cyclical material loops’*** attribute the predefined circular routes that allow for materials -a word capable of describing everything, from simple elements to advanced components and even complete products- to flow in recurrent loops, while the ***‘financial incentive’*** introduces the prospect of economic benefits, which actually drives most of the human activities.

Preliminary observations

Albeit in the beginning of this research, an early analysis of the terms that compound CE’s preferred definition –with a special focus on its organizational extensions- can provide a first insight on the necessary preconditions for the practical applicability of this theory in the construction industry. Hereby, some preliminary observations and rough parallelisms follow, the soundness of which may be rejected or confirmed depending on the findings that will come up later on.

Starting with the term “economic system”, the reference to ‘an organised set of regularly interacting or interdependent group of components’ can be interpreted as the need for a clearly structured organizational framework, where various stakeholders (components) will be able to communicate, work

and interact with each other by either forming close and frequent professionals relations or acting autonomously to a certain extent. Next to that, the notion to 'a complex whole' can attribute the high number of cooperation canals and interconnections among stakeholders, which are necessary for the development of a project and which subsequently create a mazy network of people and processes. Moreover, the inclusion of all the different 'processes of production, resource allocation, exchange and distribution' under the same context, should be addressed as a necessity to deviate from the fragmented use and management of project-related processes and move towards a more holistic approach that will examine and steer simultaneously the correlated issues deriving from all these procedures. In addition, the mention to 'a specific –geographic- area' can be seen as a notice that potentially limitations may arise with regards to the physical boundaries that a CE-driven model can be applied within in practice.

Furthermore, moving to the term "cyclical material loops", what can be derived from the CE definition is a clear need to enhance and promote circularity –in that case building components' circularity. Theoretically, that can happen through the design of routes that will allow for already used products to re-enter the production process. As linearity in consumption is not an option, each product has to be used more than once, and that demands the simultaneous co-ordination of two main aspects: the provision of advanced technical capabilities and the establishment of multilevel circular processes.

Finally, the expression 'based on a financial incentive' should be addressed with particular interest, as money is always a key factor for running business. Subsequently, although a preference to shorter circles has already been discussed, this may not always be the case. The proved quality or tested performance of specific building parts for example can be more valuable –from an economic point of view- for another industry (f.i structural steel beams offered on the shipbuilding market), skipping thus the stage of reuse for shake of a more lucrative remanufacturing or recycling processes. Consequently as the viability of CE is by definition dependent on financial incentives, the creation of economically attractive conditions for the building industry's stakeholders is crucial for a turn into CE practices to be achieved.

Setting aside the preliminary observations, the reason why the aforementioned statement is given the credits –by the current author- for being one of the most remarkable definitions lies mainly on the way that it approaches two key issues: sustainability and economy.

- Sustainability. Although environmental sustainability –which can be defined as the pursuit of natural resources' preservation and earth's longevity for the generations to come (Prins et al., 2015)- can be considered one of the principle currents that led to the procreation and development of CE's philosophy, there is no straight reference to that concept in the presented definition. Of course there is an underlying link through the notion of *'cyclical material loops'*, which includes the ideas of reuse, remanufacturing and recycling. However the main challenge in CE remains the ensuring of circularity, leaving all the other aspects of sustainability in second place of interest. In other words if the demand for used materials and their constant flow is not secured, the prospect of them being -just- environmentally harmless will not manage to eliminate resource overexploitation or material waste. Consequently, sustainability shouldn't be addressed as a key precondition for applying CE but more as a wished and welcomed consequence.

- Economy: The reference to *'financial incentive'* is the second reason that makes this definition to stand out from the crowd , as it clearly pinpoints the importance of the economical dimension for a new production and consumption philosophy to become dominant in modern societies.

Stigter (2016) supports that the financial motivation could constitute the main driver for both business and clients to adopt and invest on CE principles. Hereby, the prospect of spreader and higher profitably economy of scale can be a greater stimulator than the concept of sustainability for the interested stakeholders, and that is something that should be always taken into consideration in the planning of CE activities, processes or business models.

3.2 Circular building

After framing the concept of CE, it is interesting to see how the latter is applied in the field of the construction industry and what a circular building stands for. To begin with, a separation has to be made, with regards to two seemingly identical notions: circular building and circular buildings. The difference is detected on the meaning that the word 'building' can be labeled with, when used as a verb or noon. Once a noon, building is usually translated as a static physical object, but once a verb, it reflects on a series of activities, functions and processes which are constantly prone to change (Geldermans & Rosen Jacobson, 2015). Based on that approach and what CE "preaches", it seems more appropriate to address circular building the 'verb' perspective, being consequently, and according to Geldermans & Rosen Jacobson, a "*dynamic total of associated processes, materials and stakeholders, led by the owner/user*".

3.2.1 Shearing layers

The necessity to address buildings not as static and immovable objects, but as dynamic collections of multiple separate interrelated systems and components, has been shared within the industry for many years already. One of the people who adopted this line of thinking and strongly supported it through his work, Frank Duffy, provided the engineering world with an interesting approach on managing building space and its flexibility in use. What Duffy's theory states is that all buildings can be divided in layers, which experience different changes during -and based on- their different lifespan, and they should be hereby, addressed accordingly. He actually summarized this view in his phrase: "*Our basic argument is that there isn't any such thing as a building. A building properly conceived is several layers of longevity of built components*" (quoted in (Brand, 1994)). Therefore, he recognized four main shearing layer categories (Gyford, 2004):

- *Shell*: refers to the main structure; it lasts around 50 years in UK and 35 in US.
- *Services*: refer to means and equipment that supports the functionality of the building's purpose and guarantee the satisfaction of the users' needs like cabling, lifts, et.;, they can be replaced every 15ish years.
- *Scenery*: refers to add-ons that can grant practicability and general flexibility in any temporary use of space like partitions, dropped ceilings, etc.; they can be updated every 5-7 years.
- *Set*: refers to furniture, devices, technological equipment; stuff that can be replaced every 2-3 years, even more frequently.

Stepping on that concept, in 1994 Stewart Brand released a book named "How Buildings Learn: What Happens After They 're Built.", where he raised the number of shearing layers up to six, as a four-level division was not able to sufficiently address the different needs that more complex buildings usually deal with. The recommended classification, also known as "6S", and the characteristics he attributed to each layer follow below (Gyford, 2004):

- *Site*: states the geographical setting; it can –theoretically be unchanged- eternally.
- *Structure*: states the foundation and load bearing elements; it can be designed to stand for 30 to 300 years.

- *Skin*: Refers to the external part of a building, the façade; it performs properly up to 20 years – even more.
- *Services*: refer to means and equipment that supports the functionality of the building's purpose and guarantee the satisfaction of the users' needs like cabling, lifts, et.; they can be replaced every 7-15 years.
- *Space Plan*: describes the interior layout; it can stand from three (commercial) to 30 (domestic) years.
- *Stuff*: refers to furniture and belongings, which can be subjected to replacement at any time.

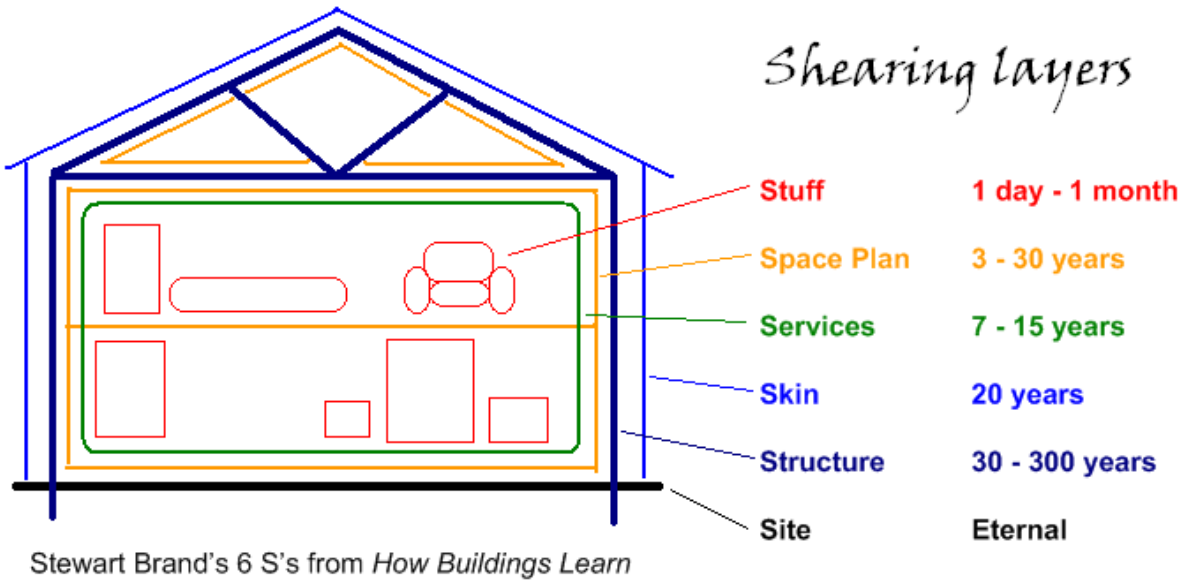

Figure 3.2: The six shearing layers of a building, as proposed by Steward Brand.

No matter what the number of layers a building should be divided in, the theory of shearing layers managed -at least on paper- to address the challenge of structures which are not designed to be changed, rearranged or relocated. Subsequently, a building's breakdown in systems and components, with different technical lifespans and provided functions, can be the first step for studying the CE's potentials within the construction sector, not only from an engineering point of view, but also from an economic, legal and logistic perspective (Geldermans & Rosen Jacobson, 2015).

3.2.2 Adaptable building

The prospect of 'de-structuring' existing and on-development buildings based on clearly-defined layers creates high expectations for the future flow of building materials, components and products. This prospect however, is strongly related to the aspect of adaptability and how buildings can efficiently address it. According to Geraedts (2015), adaptability outlines the capacity of a building to accommodate effectively the evolving demands of its context, either in social or in functional terms, maximizing thus its value through life. In order to make his statement more 'tangible', Geraedts created a list of indicators which are directly linked to the shearing layers, as presented by Edward Brand. Figure 3.3 includes some of the provided indicators, since not all of them are relevant to the issue of materials' and components' circularity (Geldermans & Rosen Jacobson, 2015).

STRUCTURE	Dimensioning system: modular coordination
	Dimensioning system: facade-grid
	Extension/Reuse of stairs and elevators
	Load bearing capacity of floors
	Load bearing floor systems
	Self bearing facade
	Geometry of Columns
	Use of fontanel constructions
	Fire resistance of load bearing structure
	Interruptions in structure
	Connection detailing of foundation en ground bound installations
	Building technology of load bearing structure
	Thermal and acoustic quality of floor insulation
SKIN	Demountable facades
	Reuse windows
	Daylight entry
	Thermal and acoustic quality of façade insulation
	Connection detailing of facade components
SERVICES	Over dimensioning shafts
	Over dimensioning the capacity of installations
	Over dimensioning the capacity of facilities
	The way installation components can be disassembled
SPACE PLAN	Inter-changeability of fit out components
	Movable separation walls
	Connection detailing of partition walls
	Individual fit out / finishing

Figure 3.3: Selection of Flex 2.0 indicators with direct relevance from material and product use (retrieved from Geldermans & Rosen Jacobson, 2015)

A lot of research has been done on the concept of adaptability and the study of Schmidt et al. (2009) provides one of the most interesting approaches on how to define it. Identifying six main areas, where building-related changes can take place (task, space, performance, function, size & location), a different aspect was selected to describe the main term's meaning in each case (adjustable, versatile, refitable, convertible, scalable & movable). The Figure 3.4 gives a clear picture of that classification.

Following that classification, some researchers from Loughborough University in UK, created a Table (see Table 3.1) to highlight the varying aspects of adaptable design and their relation to the shearing layers, outlining at the same time, the main influencing actors per case (Geldermans & Rosen Jacobson, 2015). The green color represents the extent of overlapping among all three variables -adaptable aspect, building layer and stakeholder- proving thus the importance of ownership aspect in the feasibility of circular projects. As

ADAPTIVE	BUILDING LAYERS: STUFF	SPACE	SERVICES	SKIN	STRUCTURE	SITE	DECISION-MAKING
ADJUSTABLE *(Change in task)*	■						USER
VERSATILE *(Change in space)*		■					USER
REFITABLE *(Change in performance)*	■	■	■				USER/INVESTOR
CONVERTIBLE *(Change in use)*		■	■				INVESTOR
SCALABLE *(Change in size)*		■	■	■	■		INVESTOR
MOVABLE *(Change in location)*						■	INVESTOR

Table 3.1: Adaptable aspects, building layers and decision-making (retrieved from Geldermans & Rosen Jacobson, 2015)

Geldermans & Rosen Jacobson, 2015, conclude "*a correct distinction between legal and economical ownership is evenly important, as in the Netherlands, for instance, a change in economic ownership is not always legally supported, making adaptability less efficient implementable*". Consequently, an adaptable building does not equal a circular building; it constitutes however a major precondition for the latter to be realized.

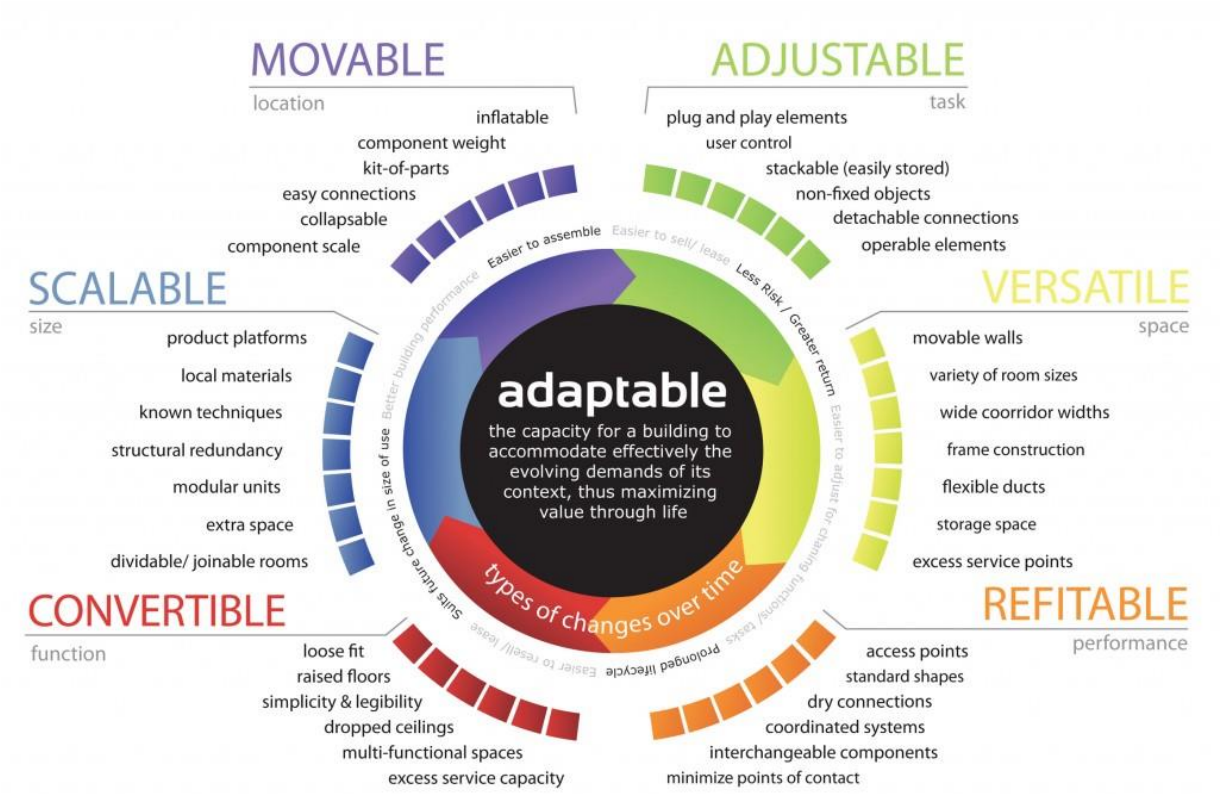

Figure 3.4: Adaptability classification and brief description of its aspects

3.3 Circular business models

The transition from linear to circular economy will definitely have an impact on business, as the latter can simply not support the challenges that circular concepts impose. Therefore, governments and companies are already looking for alternative approaches to follow, aspiring to achieve growth through a radical improve in resource productivity (Accenture, 2014). Business model innovation offers a potential approach to deliver the required change through re-conceptualizing the purpose of the companies and the value creating logic, while rethinking also perceptions of value (Bocken et al., 2014). According to FinanCE (2016) there are two basic changes taking place when shifting from linear to circular practices. The first one relates to the flow of products from materials to the final consumer, and vice versa, representing the necessary changes in design, technology and logistics. The second one reflects on the business models, including the way money flows and business' activities are organized.

But, what exactly is a business model? As Mentink (2014) simply puts it, "*it is the rationale of how an organization creates, delivers and captures value with and within closed material loops*". Apparently,

nowadays, 100% circular business models do not exist –at least in the building industry-, as zero waste creation is actually impossible to be achieved both du to physical and practical reasons (van Renswoude et al., 2015). However a circular business model do not necessarily needs to close the loop all by itself in order to meet its fundamental purpose. As part of a systems' network, a business model can add to other business models, co-creating thereby a closed loop system (Mentink, 2014).

A lot of research has already been done with regards to the necessary changes that current business models need to undergo in order to turn circular. Accenture (2014) presented an interesting model that links value chain optimization strategies to the relevant changes in business models. The outcome was the identification of four main areas of value creation, classified as:

- Lasting resources
- Liquid market / multiple users at the same time
- Linked value chains / next life opportunities of resources
- Longer lifecycles

According to Accenture's researchers the study of those areas can lead to the development of the following business models (Figure 3.5).

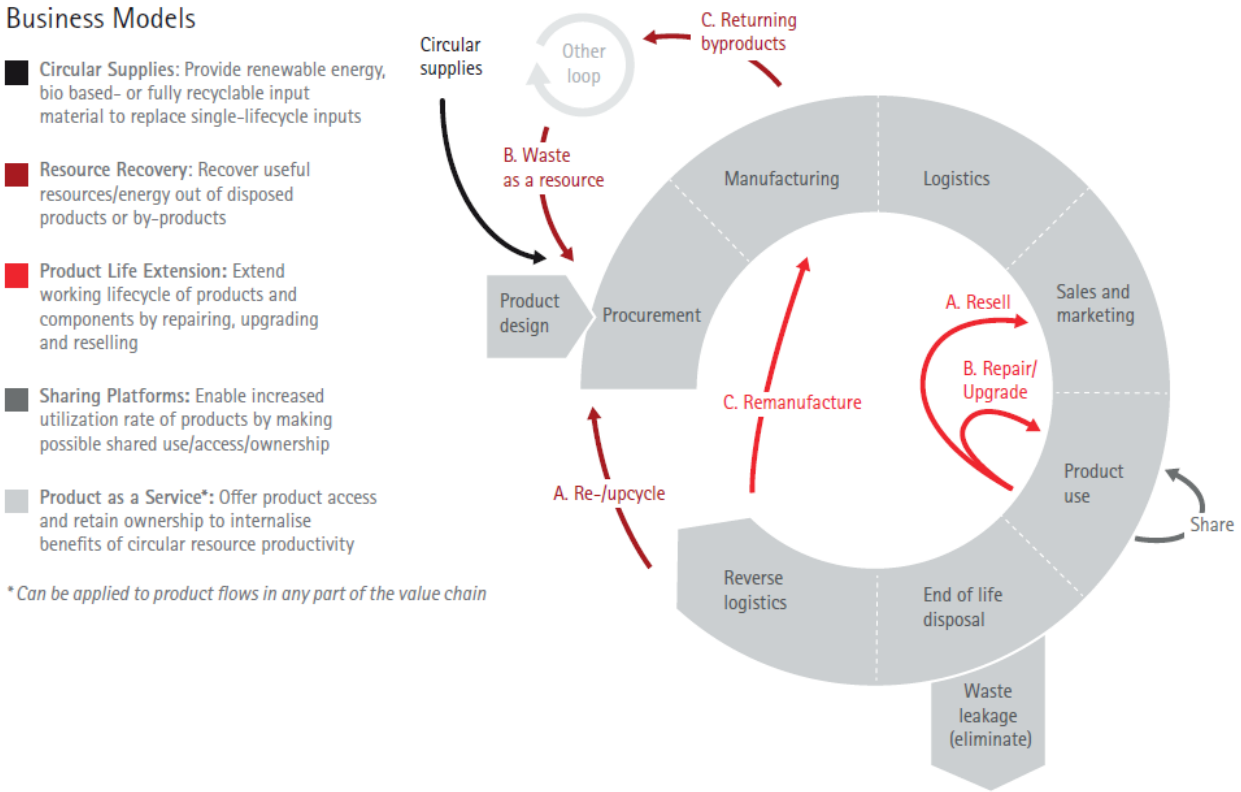

Figure 3.5: The five circular business models (retrieved from Accenture, 2014)

Following the research of Accenture, the working group FinanCE (2016) proceeded with the classification of circular business models in three main categories, based on the different phases of production:

- Circular Innovation Models (CIM): Having a primary focus on the development phase, the highest interest is paid on creating products which are less prone to the need of maintenance, repair, upgrade, refurbishment, remanufacture or recycle.

- Circular Use Models (CUM): Targeting mainly on the use phase, key goal is the optimization of product's use and its added value through time. In that case thus, retaining product's ownership is an option, but leasing and sharing can be also considered potential alternatives.
- Circular Output Models (COM): Being focused on the output and the residual value deriving from a product's after-use phase, the business interest lies on the remanufacturing and recycling processes, setting the aspect of reverse logistics in the center of attention.

The main characteristics of the three circular business model families are presented in the Table 3.2.

Circular Innovation Models (CIM)	Circular Use Models (CUM)	Circular Output Models (COM)
- **Product design:** Provides products that are *designed* to make them long and useful life and/or be easy to maintain, repair, upgrade, refurbish or remanufacture. - **Process design:** Develops processes that increase the reuse potential and recyclability of industrial and other products, by-products and waste streams. - **Circular Supplies:** Provides input materials such as renewable energy, bio-based, less resource-intensive or fully recyclable materials.	- **Product as a Service:** Delivers product performance rather than the product itself through a combination of product and services. Ownership of the product is retained by the service provider. Primary revenue stream from payments for performance delivered. - **Sell and Buy-back:** Sells a product ond the basis that it will be purchased back after a period of time. - **Sharing Platforms** (Access provider): Enables an increased utilization rate of products by enabling or offering shared use/access/ownership. - **Lifetime Extension:** Extends the useful life of products and components through repair, maintenance, or upgrade. - **Tracing facility:** Providing services to facilitate the tracing, the marketing and trade of secondary raw materials.	- **Recaptured material supplier:** Sells recaptured materials and components to be used instead of virgin or recycled material. - **Refurbish & Maintain:** Refurbishes and maintains used products in order to sell them. - **Recycling facility:** transforms waste into raw materials. Additional revenue can be created through pioneering work in recycling technology. - **Recovery provider:** Provides take-back systems and collection service to recover useful resources from disposed products or by-products - **Support lifecycle:** Sells consumables, spare parts and add-ons to support the life cycle of longlasting products.

Table 3.2: Main characteristics of circular business models, classified based on the different production and phase (retrieved from FinanCE, 2016)

4. The automotive industry

The automotive industry encompass all those companies and activities involved in the design, development, manufacturing, marketing and selling of motor vehicles, including the vast majority of their components, such as engines and bodies, but excluding tires, batteries and fuel (Britannica, 2014). Private passenger cars and light trucks -pickups, vans and sport utility vehicles included- are of the auto manufacturers' primary interest, while commercial vehicles, such as delivery and transport trucks, though important to the industry, do mainly have a secondary role (Britannica, 2014).

4.1 Mass production: the 'game' changer

The automobile industry may have a brief history compared to that of many others; however it is being studied with a remarkable interest due to its extensive impact on a wide range of social, economic and technologic changes that took place during its evolution (History, 2010). Although the automobile originated in the late 19th century, it managed to highly influence and stimulate progress in the fields of technology innovation, material science and energy consumption. One of its most outstanding contributions to the technological advance was the introduction of full-scale mass production; a process that managed to combine precision, standardization, interchangeability, synchronization and continuity (Britannica, 2014). The mass production was undoubtedly an American novelty, the development and standardization of which is considered to be work of Henry Ford (History, 2010). Although Ford was not the only one to anticipate the huge benefits that a shift to mass production would bring to the automotive industry, he was the one that leaded that shift, by introducing those methods and techniques that could achieve large-scale production at low costs and large-scale management of an industrial workforce (History, 2010). In order to do so, he initially developed a moving assembly line for the production of magnetos, which after further research and experimentation, was upgraded to a complete assembly-line for the mass manufacture of vehicles, being characterized by two key elements: the set-up of a conveyor system and the exclusive appointment of each worker to one single repetitive task (Britannica, 2014).

Figure 4.1:Mobile T, the most recognizable motor vehicle in history, created by Henry Ford, and between 1908 - 1927 managed to exceed 15 million sales (source: Britannica, 2014)

The implementation of mass production processes changed dramatically the correlations between the parties involved in the automotive industry. During its early stages, most of the producers were just assemblers, undertaking the integration of different components and parts that were manufactured by separate firms (Britannica, 2014). Apparently, after Ford's innovation that approach was not efficient anymore, as the productivity rate raised eightfold, while using less manpower (Sainoji, 2014). As the heavy in-front investment in plant, machinery and equipment that the assembly lines required, could only be made by large firms and organizations, the economically powerful early starters got benefited by a huge cost advantage that actually made it

extremely difficult –if not impossible- for smaller companies to compete them (Britannica, 2014). Hereby, it is not of a surprise that by 1930, 250 companies which were unable to invest on assembly lines got broke or simply disappeared (Sainoji, 2014).

In the modern era, which normally refers to the last 25 years, things have not changed much; especially as far as the role and power of the auto manufacturers are concerned. Of course there are a lot of technical and design aspects that strongly differentiate modern cars from antiques; the development of platform sharing services and computer-aided design systems for instance, allowed vehicle producers to fully unleash their creativity and experiment with new lines, shapes and concepts, while reducing at the same time development time and cost. However, although the automotive industry targets at a huge market -73.5 million passenger cars and 18.1 million commercial vehicles were manufactured globally in 2015 (acea, 2016)- the auto manufacturing companies worldwide still do not reach a 3-digid number in total. The fundamental cause of this trend is mass production, which, as already been mentioned, requires a heavy investment in equipment and tooling, and is therefore feasible only for a large organization. Although it is not easy to make a precise estimation about the optimum number of the vehicles that a plant should produce, the best calculations report 200,000 to 400,000 cars per year as the proper range (Britannica, 2014).

4.2 Developing a vehicle

The development procedure process and the procedure of introducing a car in the market follow a highly standardized set of actions. As it is depicted in the next Figure 4.2, seven major steps can be defined.

Figure 4.2: The steps of introducing a new car in the market (source: Tata technologies web site)

1. ***Prudent market definition and careful set-up of the best fitting product strategy.*** A thorough investigation of the customers' needs and wishes is initially taking place, followed by their translation in specific requirements and the subsequent development of new system concepts, capable to cover these needs adequately. Since there may be an interval of 3 to 5 years between the market survey and the vehicle's show-off at the dealers' gala, there is quite a risk of significant changes either in customers' wishes or in their willingness to pay (Britannica, 2014).

Because of the increasingly competitive and international nature of the industry, manufacturers have called various means to shorten the time from conception to production to less than three years in many cases. This has been done at GM, for example, by incorporating vehicle engineers, designers, manufacturing engineers, and marketing managers into a single team responsible for the design, engineering, and marketing launch of the new model (Britannica, 2014).

2. ***Concretization of the basic concept, configuration of the preferred styling features and selection of vehicle's architecture.*** At that phase, the outlines and framework conditions for the vehicle segments, technology, deadlines, costs and pricing are the subject of discussion –in conferences and internal meetings- among engineers, designers and executives. From a technical perspective, the drafting of a vehicle concept involves creating a package and safety concept, conducting a potential analysis, developing a body-in-white structure concept and aerodynamics values and defining the production technology (Porsche engineering, 2016). Styling designs are created based on an ideation process and a mock-up, on which alterations and improvements can be worked out later on.

   The selected strategies may substantially differ from those followed by other competitors, driven always however by the pursuit of the highest profits in terms of design, fabrication and delivery. The European automobile companies for example, being unable to copy the Japanese way of building cars –known as "just-in-time" method-, found their style in modular architecture (Suzuki, 2013). Modularization, a method pioneered in the automotive industry by Volkswagen, is a product design approach that divides vehicle architecture into modules that can be independently designed, developed and tested (Figure 4.3).

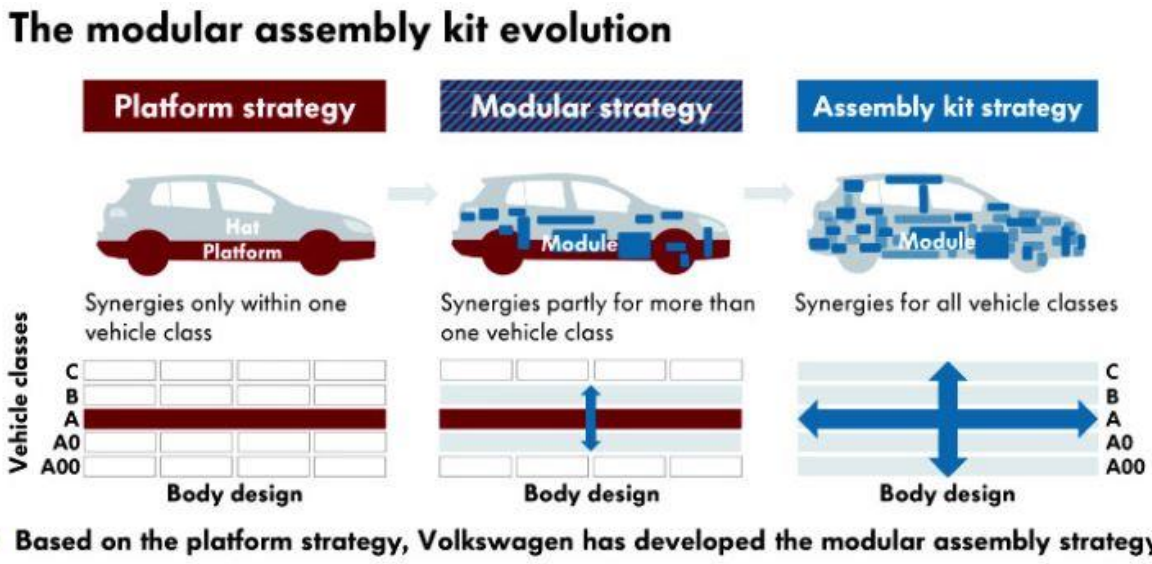

Figure 4.3: The development of VW's vehicle architecture strategies through time. From the platform strategy which allowed for parts and components interchange only within a specific vehicle class, to the assembly kit strategy which enables synergies with all vehicle classes (source: www.vwvortex.com)

3. ***Detailed engineering and design processes.*** The activities included in this phase, are the outcome of many years spent combined with too much effort and money on research and continuous experimentation. In order to be always in the front-line of technological advance, automakers are constantly trying to equip their products with high-tech innovations, placing

thousands of patents every year, through the investment of approximately $100 billion globally; an average of $1,200 for R&D per vehicle (autoalliance, 2016). Remarkably, and contrary to what happen in other industries, government support does not exceed 1% of that amount (autoalliance, 2016).

Once the final design proposal has been selected, it is time for precision work on the details that are crucially important to the series development process (BMW, 2012). Extremely close coordination between the designers, engineers and manufacturing specialists also constitutes part of this phase, aiming at the precise definition of each individual detail down to hundredths of millimetres (BMW, 2012). CAD systems and laser scanners are used to create detailed designs, which are used as templates for the production of initial prototypes and models (Porsche engineering, 2016). At the same time, various virtual technologies are specifically employed to optimize efficiency in the development process and ensure precision in execution. During that stage, the designers intensely turn their attention to those aspects which the eventual owner will experience when using the vehicle, and which will guarantee its enduring fascination, even after many years (BMW, 2012). In addition, the new developments are put through a variety of scenarios. This enables the calculation and simulation experts to optimize a variety of component and system developments early in the process and generate a cost-optimized and fully functional solution (Porsche engineering, 2016).

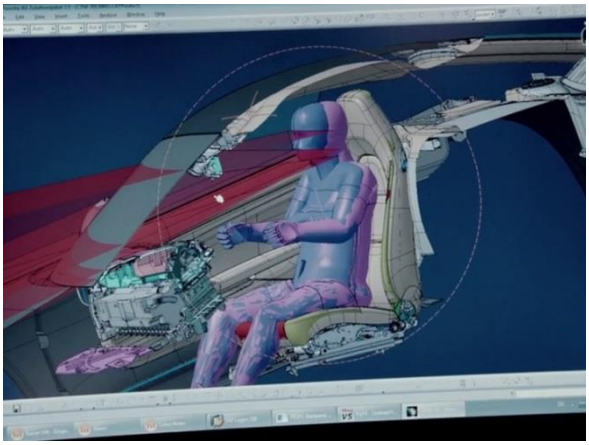

Figure 4.4: 3D-CAD systems facilitate the design precision and the integration of different experts' insight

Figure 4.5: Virtual reality tools aid engineers and designers to 'feel' the driving experience of the future owner

4. ***Manufacturing process and resource planning.*** The primary requisite of that process is the precisely controlled flow of materials into the assembly plants. Currently, three basic options are in automakers' disposal when it comes to the management and coordination of the necessary components, creating consequently three different structure types presented below (Suzuki, 2013):
    - Closed. The manufacturing parties that are responsible for the delivery of various separate components are subjected to a division or a group within an automobile firm.
    - Semi-closed. Some parts of the vehicle are being outsourced to a specific limited number of companies, in which the automotive firms usually own a percentage of their share.
    - Open. A vehicle's parts can be outsourced as an open bid.

Figure 4.6: Suzuki Maruti's diesel engine manufacturing plant at Manesar

Generally, the automotive firms are incapable of providing the economic resources or the physical space needed for the storage of all necessary parts throughout an extended manufacturing period, while any potential interruptions or deficiencies in the materials' flow can cause major troubles on the anticipated productivity (Britannica, 2014). The need for complete control over materials' flow is a driver for automotive companies to manufacture their own components, sometimes directly (closed structure) but more often through subsidiaries. Seats, tires, engines and batteries, but also front faces, cockpits and doors are being delivered pre-assembled to manufacturer assembly lines (semi-closed structure) (Fourcade and Midler, 2004). Automakers also involve component manufacturers in the design process to eliminate costly time-consuming reengineering in later stages, while the component maker is given usually full responsibility for the design and engineering of a part as well as for its manufacture (open structure) (Britannica, 2014).

Production of a new model also calls for elaborate tooling, and the larger the output, the more highly specialized the tools in which the manufacturer is willing to invest. For example, it is expensive to install a stamping press exclusively to make a single body panel for a single model, but, if the model runs reaches several hundred thousand, the cost is amply justified (Britannica, 2014). Therefore, there are three main reasons why the largest companies support outside suppliers even for items of in-house manufacture. Firstly, it may be more economical to buy externally than to provide additional internal facilities for the purpose; secondly, the supplier firm may have special equipment and capability, and thirdly, the outside supplier provides actually a "free" check on the costs of the in-house operation (Britannica, 2014).

5. ***Product and process validation.*** Before a new vehicle's model mass production gets launched, the development of some prototypes precedes. During that stage everything goes under numerous strict and detailed inspections, following a sequence of checks, which contribute in the evaluation, verification and improvements of all separate components' design quality (Sivaraman, 2014). Therefore, every development step, every component, be it the body, electrics/electronics, chassis, engine or the complete vehicle, is tested and optimized under realistic conditions (Porsche engineering, 2016).

   Depending on the context of the requested information, the testing trials can be classified in three main categories (Sivaraman, 2014):

   - *Function testing*. It run checks with regards to all functions of a vehicle, including the aspects of safety –impact safety, braking, strength, etc.- vehicle handling, quietness, etc.
   - *Vehicle testing*. It is held in order to reassure that emission performance will be in compliance with each nation's regulation, as well as to satisfactory address the

customer's driving pleasure for practicality, overall driving and environmental performances, durability, etc.

- *Powertrain testing*. It evaluates the performances, function, durability and reliability of engines, transmissions, driveline and electrical systems that support the vehicle driving performances.

.

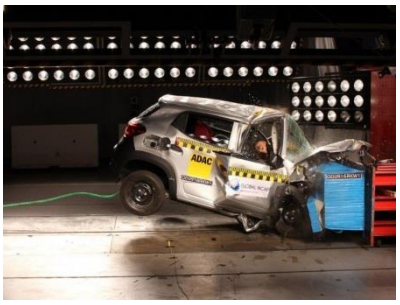

Figure 4.7: Prototype vehicle is getting tested against frontal collision (Function testing).

Figure 4.8: Laboratory testing is followed by outdoors testing, including drive circles, high-speed runs, diverse weather conditions, etc.

Figure 4.9: Manual transmission durability testing, supplemented by exhaustive testing i Milford and state-of-the-art laboratories in Pontiac, Michigan

Apparently, by applying all these check-and-control tests, the vehicle manufacturers guarantee high quality and optimum integration of all separate parts into a single unit, while at the same time, they can verify their suppliers' value and the quality of their deliverables

6. **Production readiness.** After the successful completion of the testing phase, the preparation of the production line constitutes the next set of actions to be taken. At that stage, the production engineering department takes over. Starting point is the careful planning and reviewing of the powertrain and vehicle production line, followed by the designing of all necessary production facilities, machines, tools and jigs, as well as the preparation of the production plant related documents and the practical support of the mass-production process (Sivaraman, 2014).

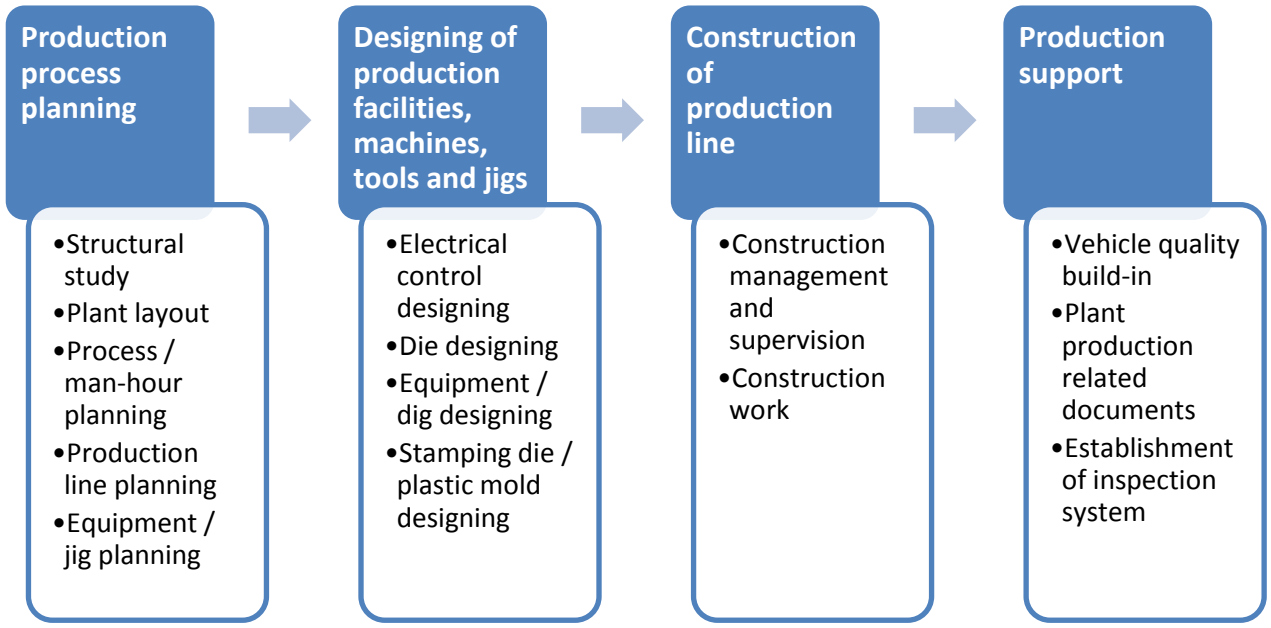

Figure 4.10: The four-step process of preparing the production line, schematized based on Sivaraman's (2014) recordings

Important feature throughout the progress of all the above presented activities is the continuous effort for power and energy conservation, which aim to minimize the final environmental impacts.

7. **Production launch and product strategy.** Final stage of a vehicle's development process is the industrialization of the delivered product. Once all major and minor design and manufacture details are clarified, the mass-production is ready to get launched. During that process, a number of diverse activities needs to be efficiently managed and coordinated, including the collection of all necessary up-to date data, the integrated application of assembly and production planning, the optimum collaboration with suppliers, and the effective communication of assembly instructions and technical illustrations to the competent personnel (Porsche engineering, 2016).

Figure 4.11: Capture of a typical vehicle production line

4.3 Performance drives innovation

The continuous progress of the automobile industry and the infinite advancement of technology, keep raising customers' needs and wishes, creating thus a constantly growing demanding market for innovation. Today's vehicles represent one of the most technological sophisticated products that are available to a vast mass of consumers worldwide, and automakers continuously try to provide the former with new high-tech add-ons. Thereby, from the early stages of planning, automakers design innovations into new vehicles, recognizing that technology provides many solutions to meet consumer needs (autoalliance, 2016).

In order to stay in line with the increased performance standards, asked for and set by their customers, automakers need insight, guidance and expertise from other industries. As not all technological breakthroughs can be developed and optimised by a single actor, the large automobile firms have no other choice than work closely enough with software developers, IT specialists and big-data analysts, as well as with material scientists and researchers from the academic community. In addition, being committed to ensure that a vehicle will constantly deliver high value to its user throughout its lifecycle, automobile producers constantly put more and more pressure on their suppliers, asking for smart systems, lifetime extension solutions and upgraded car parts (Circle Economy & ABN-AMRO, 2016).

The boost of smart systems can already be detected in a series of provided technologies, including lane departure and blind spot warnings, adaptive cruise control, automatic braking and telematics control (autoalliance, 2016). As progress is a never ending process though, new blow-minding innovations are almost ready to be launched. To give some examples, a lot of research is currently under progress regarding advanced sensors, intelligent navigation software and self-driving systems (Circle Economy & ABN-AMRO, 2016). At the same time, a number of large international companies, such as BMW, Bosch

and IBM, intensify the use of big data analytics and the internet of things, in order to enable sensor technologies to record performance data and proceed with predictive maintenance in vehicles, avoiding thus problems for occurring (Circle Economy & ABN-AMRO, 2016). Next to that, new materials, deriving from the field of nanoscience, are being tested and gradually introduced into production, aiming to make vehicles lighter, more fuel efficient and 'greener', while keeping them at the same if not at higher standards of power an stiffness (autoalliance, 2016).

Moreover, technological improvements in computer systems, smartphones, wireless communications and the cloud environment have converged, in order to improve safety and advance comfort for consumers (autoalliance, 2016). Connectivity software, portal devices and the internet are changing the world of autos, and more change is yet to come. What can it mean for the future? That maybe it will not be long before the differentiating source of supply and value in the automotive industry will not be the vehicle components but instead a network of software developers (Moazed, 2016). As car users crave for vehicles that can be constantly linked to their smartphones, the importance of computers systems in cars is rising, and that is no less the case for the electronic parts -like sensors and microprocessors-, which constitute the "backbone" of today's vehicles (autoalliance, 2016).As a consequence, the demand for software engineers and creative programmers is getting higher and higher within the automotive industry, creating more room for a relatively new category of experts, by giving them a significant role in vehicle design and operation (autoalliance, 2016).

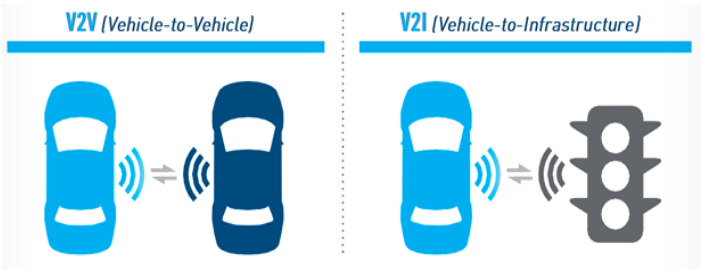

Figure 4.12: To advance safety and comfort, today's vehicles are getting equipped with systems for direct communication with other vehicles, and with the existing infrastructure as well (retrieved from autoalliance, 2016)

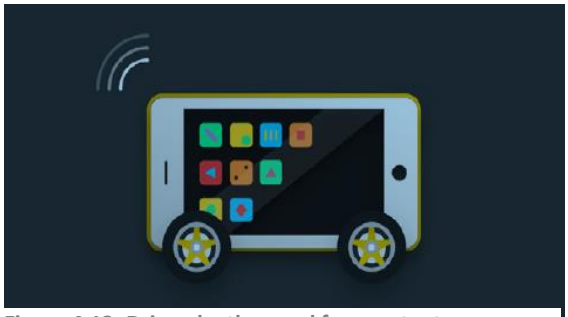

Figure 4.13: Driven by the need for constant connectivity, future's car will probably seem as a 'smartphone-on-wheels' vehicle (derived from Circle Economy &ABN-AMRO, 2016)

However, despite the increased interest of the large automotive firms towards software engineering, the future of automobiles maybe is not that rosy for them. The reason, is the upcoming trend, which sounds quite alluring, and is expected to revolutionize the whole industry; the autonomous car. No doubt that a world where people will not have to steer the wheel anymore -as the driving will be done by the vehicle itself- sounds as a science fiction scenario, but the introduction of the first fully autonomous cars on the market, maybe is closer than many people think. Apple for instance, is already moving to

Figure 4.14: Autonomous car -at least to some form- is almost unanimously anticipated to be the future of the automotive industry (autoalliance, 2016)

that direction as it intends to release its first own car by 2019, while Uber aspires to launch autonomous rides in Pittsburgh (Moazed, 2016). Apparently, as soon as autonomous vehicles become available at scale, the car will transform from just a mean of transportation into a new-age entertainment hub, where users will become constantly higher interested on the embedded software and the overall experience of the car (Moazed, 2016). Systems like self-parking, self-braking and staying in lanes without driver assistance are some of the features that fascinate users and are gradually becoming more and more widespread; after a couple of years however they will be nothing more than part of the 'standard' package (autoalliance, 2016).

4.4 Coopetition: a rising lucrative necessity

In a highly competing era, where the source of the biggest challenges is not restricted within the boundaries of the automotive industry, automakers have to innovate not only on a technical level but on a business level as well. Moving to that direction, Renault and Nissan, two traditional big competitors, impressively changed their approach on vehicle production, by deciding to invest on their in between cooperation. This synergy, proved to be more than successful, as it contributed in a revenue increase of 32.4% for the Renault-Nissan Alliance within a year -from €2.87 billion in 2013 to €3.80 billion in 2014- and is anticipated to boost even further, generating €4.3 billion by the end of 2016 (Green Car Congress, 2015).

The success of the Alliance lies on their new Common Module Family (CMF) architecture, which is estimated to generate an average 30%-40% reduction in entry cost per model and 20%-30% reduction in parts cost (Renault Group, 2016). CMF is not a platform based on the traditional structure of horizontal segmentation, but a cross-sector concept which accommodates the assembly of compatible big modules such as engine bay, cockpit, front and rear underbody, and electrical/ electronic architecture (ausauto, 2016). In other words, what CMF actually does, is facilitating both companies to develop a wider range of vehicles, from a smaller well of parts (Figure 4.16), while offering simultaneously more choices and better quality to their customers (Green Car Congress, 2015). The co-developed modules must be totally aligned with the requirements set by the Alliance Integrated Manufacturing System process, allowing thus the same product to be manufactured at several different sites, or different products at a single site, simplifying planning, enabling changes and modifications to meet global demand and scaling down entry costs (ausauto, 2016).

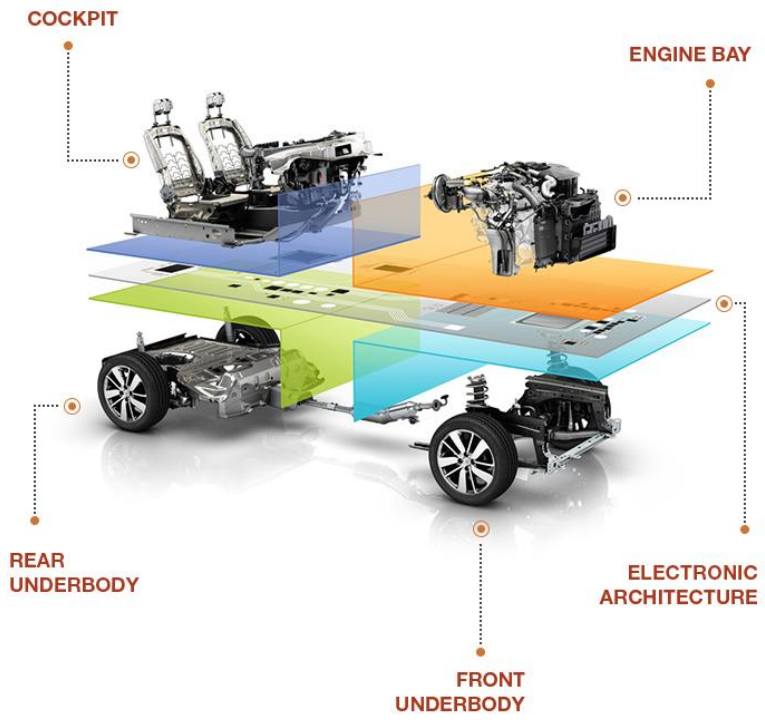

Figure 4.15: A 3D depiction of CMF architecture (derived from Renault Group, 2016)

The vehicles are sorted in three main clusters, depending on their size and functionality. The small ones are built following the CMF-A standards, the mid-size ones are aligned to CMF-B patterns, while the larger ones make use of CMF-C/D frames (Renault Group, 2016). According to the plan, by 2020, the Alliance will be able to build 70% of its vehicles following the CMF architecture (Green Car Congress, 2015), while also introducing its products into more than ten countries across all five inhabited continents. The first arrangement plans for global distribution of compact and large vehicle components, involve eleven Renault and three Nissan models, and count for around 1.6 million vehicles per year (ausauto, 2016).

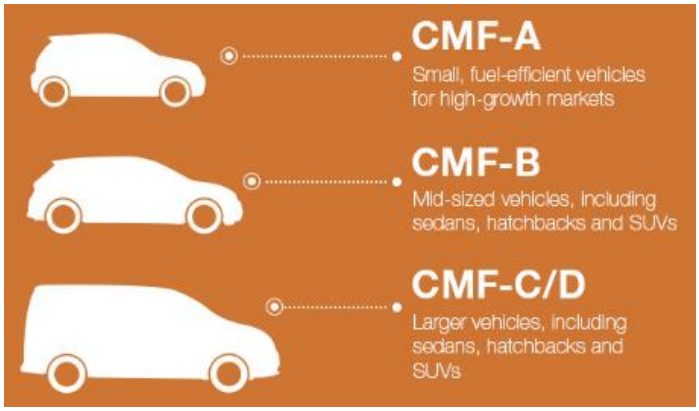

Figure 4.16: Clustering CMF based on size and functionality (Renault Group, 2016)

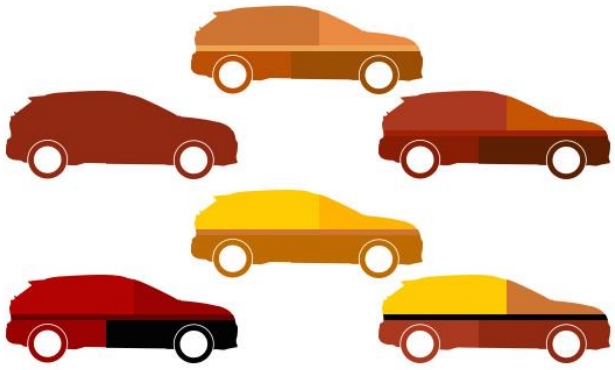

Figure 4.17: A wide range of vehicles can be developed, by designing and using efficiently a smaller well of standardized segments (derived by Renault Group, 2016)

The cross production of interchangeable modules was another significant driver for the establishment of the Renault-Nissan Alliance. Both companies actually, have already intensified their efforts in order to keep in line with the application of the Alliance Production Way (APW) at all their plants around the world (Green Car Congress, 2015). Thus, according to APW system, the best commonly designed manufacturing practices are being openly shared and introduced to all Alliance's production centers, enabling them to manage better their capacity, by facilitating the simultaneous production of both companies' vehicles (Green Car Congress, 2015).

Referring to the optimization of plants' operability, the rapid development of robotics is expected to widespread its influence on the automotive industry even more, declining further the costs, reducing production and delivery time, and minimizing manufacturing faults at the same time. The auto assembly line as it is currently structured, -a partly-human, partly-machine operating system-, will undergo some changes, reflecting simultaneously another form of coopetition; that between humans and machines. A new generation of smarter, smaller and gentler robots is ready to transform manufacturing again, this time however by working aside with their human colleagues and not separately (autoalliance, 2016). The collaborative robots -nicknamed 'cobots'-, gain day by day more ground on the factory floors, cooperating closely with engineers and technicians for the smoother realization of all necessary operations. Being designed to provide support in a number of activities, cobots can be useful in multiple ways, from transferring objects and improving safety conditions, to undertaking uninteresting tasks which can ameliorate the personnel's' health (autoalliance, 2016).

4.5 Organizing the production and delivery flow

The way automotive firms do business nowadays, does not only reflect on the relationships with their immediate partners and competitors, but it actually echoes to the whole supply and demand chain. At the current era, the large automotive producers, besides their central role in the development of vehicles, are also striving to expand their core activities in a wider spectrum of both sides of the market. To do so, they apply different tools and strategies according to each case, which at the end of the day need to be integrated under the context of a single, unified action plan. To give an example, when planning to minimize dependency on natural resources (main goal), automakers can play a key role in a twofold arena. They can turn for instance to their suppliers and partner manufacturers (supply side), asking for and co-participating in the development of improved products in terms of materials' after-life value, but they can also refer to customers (demand side), motivating them in the support of return-to-the-source schemes, and leading thus complete vehicles or vehicles' parts back to the manufacturing plants, for the providing of a renewed life-cycle.

4.5.1 Supply chain organization

The level of interference in the supply side, including the extent of responsibilities allocation to third parties, depends on the strategy that each automotive firm is willing to follow, as it has already been mentioned in the sub-chapter 4.2. The figure below depicts the typical configuration of the participating actors within the automobile industry, in a –mainly- linear economy. Based on their role and contribution to the market, the involved parties can be classified in four major clusters:

- Suppliers (raw materials, parts and systems)
- Manufacturers (Tier 2 & 1 suppliers and automotive firms)
- Dealers
- Consumers

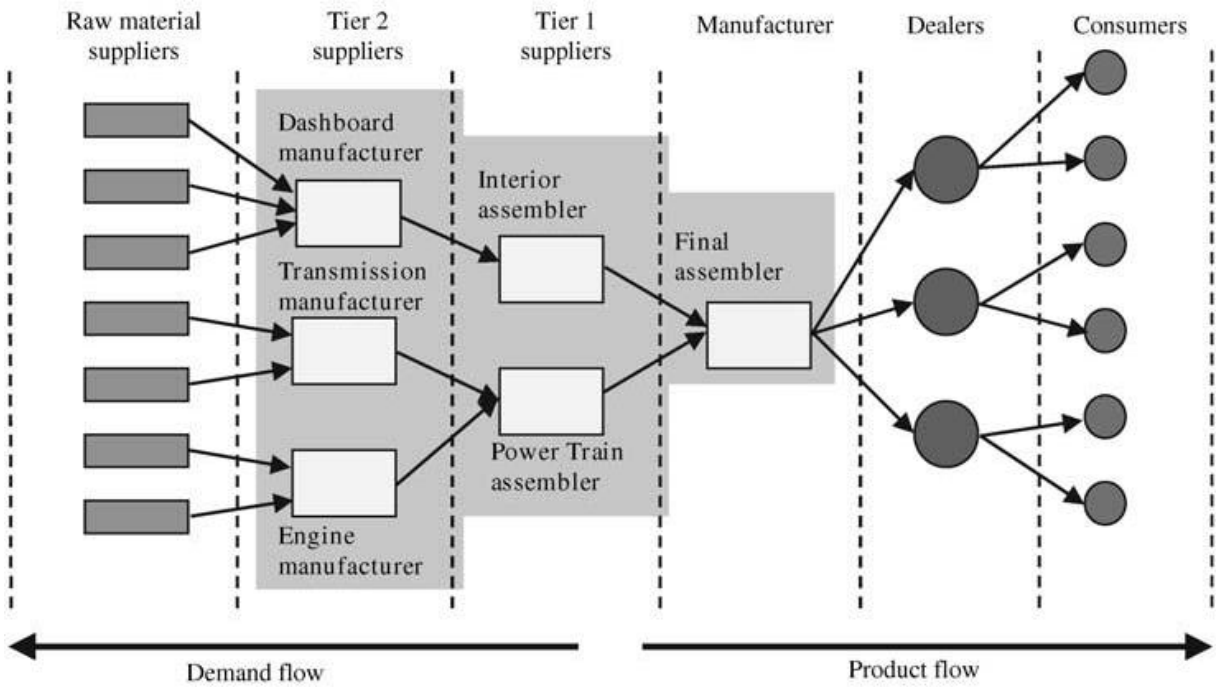

Figure 4.18: A generic automotive supply chain scheme (derived from Chandra & Kamrani, 2003)

The role of each actor in the supply chain is not necessarily one-dimensional, as with exception to the parties that are being involved in the lower level of the supply order, all the others do find themselves in more than one position.

- *Raw materials suppliers*: These parties, also known as third tier suppliers, are dealing with the delivery of basic materials -like rubber, glass, steel, plastic and aluminum- to the second tier suppliers, playing thus only a single part in the whole production process.

- *Second tier suppliers*: These companies are responsible for the manufacturing of various individual parts and subsystems -like dashboards and engines-, which afterwards deliver to the first tier suppliers and OEMs. In addition, they participate in a number of other activities, including designs' co-development, by the providing of own engineering resources for detailed drawings, as well as the delivery of welding, fabrication, shearing and bending services (Kumar et al, 2014).

- *First tier suppliers*: These actors are involved in the assembly of separate components into complete units -like seats and power trains-, as well as in the assembly of smaller systems into major systems -like brakes-axle-suspension and cockpits-, directly providing OEMs with sub-products that can be easily integrated into the final vehicle. They also have more freedom in undertaking their own designs and innovations, by making use of their own technology and expertise, in order to provide solutions which can better meet the automotive firms' requirements (Kumar et al, 2014). Moreover, next to the assembly tasks, they are usually responsible for the management and supervision of second-tier suppliers and the quality of their deliverables (Kumar et al, 2014).

- *Automakers or Original Equipment Manufacturers (OEMs)*: They are the key players of vehicles' production process as it has already been discussed in detail in sub-chapter 4.2. These are the parties to determine the basic configuration of the supply chain, as well as to set the optimum number of suppliers, plants and distribution centers to be kept under operation in order to increase their overall profits (Guhathakurta, 2014). To give an example, during the past couple of years, OEMs used to communicate with their first tier suppliers and only, avoiding hereby any direct contact with the parties found lower in the chain (Suzuki, 2014). That however, is no more the case, as automakers realized the extra benefits that can be gained by the expansion of their communication channels in a wider range, and they subsequently transformed the developed relationships from a linear to a more triangular-like formation.

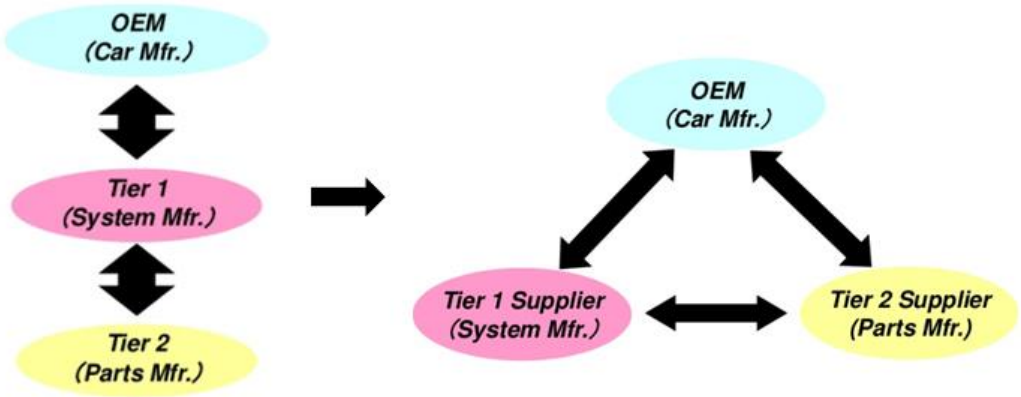

Figure 4.19: Automakers moving from traditional linear relationships with their suppliers to more cooperative ones (derived from Suzuki, 2014)

4.5.2 Demand-side organization

With regards to the demand side, there is a continuously rising interest from the automakers, to influence their end customers' actions and decisions even more than they currently do. Looking back at Figure 4.18, there are two main types of actors that complete the demand chain:

- *Dealers*: These parties constitute the middlemen between automobile companies and future consumers and they can be subdivided in two categories:
  - *Official distributers*: They are the only authorized distributers for a certain brand in a specific region, country or group of countries.
  - *Retailers*: They are usually distributing vehicles of one single brand, but depending on the case, they may host more than one brand in their facilities.

  Different distribution models can be applied by the automobile companies. In Japan for instance, Toyota divides its sales and marketing services into four main distribution channels, each one of which includes around 15 to 25 different models (Salameh, 2015). The reason behind this strategy is to make local dealers more capable of promoting not only the most profitable models, but the whole spectrum of vehicles that is assigned to them by the mother company (Salameh, 2015). Dealers are normally free to make their own independent decisions, being alongside supported by their automobile providers in terms of consulting and investment, but having though the obligation to stay in line with the latter's general guidelines and core values.

- Consumers: They are the final recipients of the delivered vehicles. Consumers' needs and habits do not remain unchangeable in time, but instead, they keep switching, following the trends and transitions of each era. Nowadays, although the traditional model of claiming ownership over a vehicle is still the most dominant way of transaction within the automotive industry, other options, including short-term and long-term leasing, temporary renting and vehicle or riding sharing, are becoming more and more popular among consumers. Thereby, in order to keep in line with their wishes, automakers have to offer not only high quality products, but also flexible ownership schemes to match their clients' requirements.

4.6 Going circular

Figure 4.18 provides a very clear representation of the actors, participating in the production and delivery processes of vehicles. However, there should be no misconception about the prevailing transaction environment, which is certainly not as linear as it is depicted in that scheme.

4.6.1 Manufacturers, consumers & recyclers

The principles of reuse, remanufacture and recycle do not constitute a novelty within the automotive industry, since many companies base their businesses on the delivery of spare parts and the providing of auxiliary services, both to automakers and final consumers, for years already. Thereby, alongside with the operations held and supported by the main automotive firms, several parties work on the fabrication of side-products, including tires, windshields and electronic equipment, the remanufacture and redistribution of spare parts, as well as the vehicles' life extension through the rearrangement of functional components from one vehicle to another. Maintenance, financing and repairing services can be hereby equally provided by common dealers and independent actors (Kumar et al, 2014), attributing consequently a significant sense of circularity within the industry.

Driving contributors to the performance of circular activities are the consumers. Moving mainly on the field of reuse, the vehicle owners actively participate in the rearrangement of spare components within the market, by being able to do sales and purchases in both physical and on-line second-hand marketplaces. In the physical markets, the basic providers of spare parts are the before-described authorized parties, who also trade complete used vehicles, letting thus the consumers to stand only on the demand side. In the digital marketplaces however, everyone can be a dealer, as no professional trading license is required. Of course in that case, the detailed check of on-sale components by certified car workshops is an option which is highly followed by potential buyers, as there is usually no official guarantee for the performance of the offered parts.

Another party that strongly supports circularity is the recycling companies, whom core businesses are directly linked to the aspect of recycle, and secondarily, to the activities of reuse and remanufacture. The recycling companies are the actors who prevent vehicles from ending up in the landfill, by collecting them for a very low price -usually subsidized by the government- and processing them in a way that the residual value can be derived from their structure. The processing activities include the removal of still functional parts and their redistribution to the market, but the main task lies on the production of raw materials, through a series of dismantling, heating, and sorting procedures.

4.6.2 Automakers

Besides the before-mentioned parties, the main actors of the industry, the auto manufacturers, constitute a key player in the support and implementation of circular practices. Being obliged to comply with the internationals rules and regulations, the high investments spent on R&D, allow the automakers to continuously improve the resource efficiency of their production processes and products. These investments, ranging from the reduction of production's phase carbon footprint to the design improvement of motor vehicles, facilitate the efficient repair of the delivered products, minimizing alongside the long-term costs (ACEA, 2015). In addition, for many years already, automakers are dealing with the remanufacturing of a wide variety of parts, including engines and gear-boxes. According to Renault's data, the remanufactured components have proven to reduce energy consumption during manufacturing by up to 80% when compared to new parts, while giving used components a new life also requires 88% less water and more than 90% less chemicals (Perella, 2014). Consequently this circular approach is capable of reducing overall waste by an impressive 70% (Perella, 2014).

The automobile industry does not only contribute to the circular economy by remanufacturing components or reducing waste, but also by prolonging the service life of the vehicles it produces. Manufactures believe that they have a responsibility to their customers to support the longevity of vehicles by ensuring that they can be serviced, repaired and maintained (ACEA, 2015). Extending the lifetime of a vehicle is essential to reducing costs for consumers, as well as conserving natural resources and energy. Moreover, manufacturers remain dedicated to further improving fuel efficiency and reducing CO_2 emissions, as the use phase of a vehicle still accounts for a large part of the total environmental impact that cars have. Because of the industry's commitment to the 'design for sustainability' concept, vehicles are built to be as sustainable as possible over their entire lifecycle. From prolonging the in-use phase of passenger cars and commercial vehicles to recyclability at the end of their life, the sector focusses its efforts on reducing the overall environmental impact in those areas that matter most (ACEA, 2015).

4.6.3 The Renault case

To better understand how automotive producers have incorporated to a great extent the principles of CE into their production practices, the example of Renault is presented. Renault's factory in Choisy-le-Roi has been pumping out remanufactured automobile parts since 1949 and has since, diversified into injection pumps, gearboxes, injectors and, most recently, turbo compressors (Perella, 2014). According to Laurent Claude, a Business Developer of Renault Environment, "*The parts destined for remanufacturing, called 'scraps', which can be used in 90% of cars in our range, are dropped-off to vehicles in-use /owned. By using reverse logistics of distribution of spare parts, the scraps are collected by the commercial network." (ellenmacarthur, 2013).*

Figure 2.20: The damaged parts (scraps) from vehicles in use are being collected through the commercial reverse logistic network.

Other than being 30-50% less expensive, the remanufactured parts have the same guarantee and are submitted to the same quality control tests as new parts *(ellenmacarthur, 2013).* By prolonging the life of the vehicles, retaining value and saving on energy whilst reducing waste, the factory in Choisy has created a comprehensive circular model. Moreover, this activity involved a skilled workforce and creates jobs locally, as in order to be economically alluring, remanufacturing has to be performed within the market in which vehicles are used; shipping engines abroad to be worked on, for example, would negate the savings *(ellenmacarthur, 2013).*

With regards to the figures, in terms of resources efficiency, the Choisy factory manages to impress. Based on its provided data, the factory sends nothing to landfill, as 43% of the carcasses are reusable and another 48% are recycled within the company's foundries for the production of new parts (Renault, 2014). The remaining 9% is valorized in treatment centers, turning the entire process into a waste-free activity (Renault, 2014).

4.6.4 The recycling process

Besides industry-led initiatives, automobile manufacturers also have to adhere to a wide range of existing legislation promoting sustainable production, more efficient vehicles and their proper dismantling (ACEA, 2015). Within Europe, the End-of-Life Vehicles Directive (ELV), for example, dictates 95% recyclability per vehicle per year (Perella, 2014). As a result of economic incentives, as well as existing legislation, the automotive industry has no other option, than make CE integral part of its DNA.

The end-of-life (ELV) management is anticipated from the design phase forward. Materials are therefore specially selected for their recycling potential, through a process that is in complete accordance with the principles of CE (Peugeot Citroen, 2014). The steps of that process are briefly described below.

1. End-of-life vehicle (ELV) collection at an authorized treatment facility
2. Issuing of a certificate of destruction for a guaranteed traceability
3. Depollution: battery / tires/ liquids (brake fluid, fuel, oil, coolant, washer fluid, refrigerant fluid) waste resulting from depollution is 100% recovered by accredited companies
4. Dismantling of parts for reuse
5. Reselling parts to private individuals or professionals
6. Compaction of the depolluted ELV
7. Transfer of the hulk to a shredder (shredder capacity up to 150 vehicles / hour)
8. Sorting of materials after shredding
9. Sorting of metallic materials (75% of a vehicle is metallic)
10. Sorting of plastic materials (20% of a vehicle is plastic)
11. Reselling of materials for recycling or energy recovery

4.6.5 The market's organizational form

The automotive industry is a sector where the level of materials', parts' and products' circularity is quite high. The way this feature is translated in terms of market organization and internal transaction relationships is quite interesting, as multiple transaction paths connect almost all involved parties directly. The Figure below represents a simplified version of how automotive industry's stakeholders are being positioned in the market of vehicles, depicting clearly the multiple channels of components' distribution and the different roles that each actor plays in the occurring transaction processes.

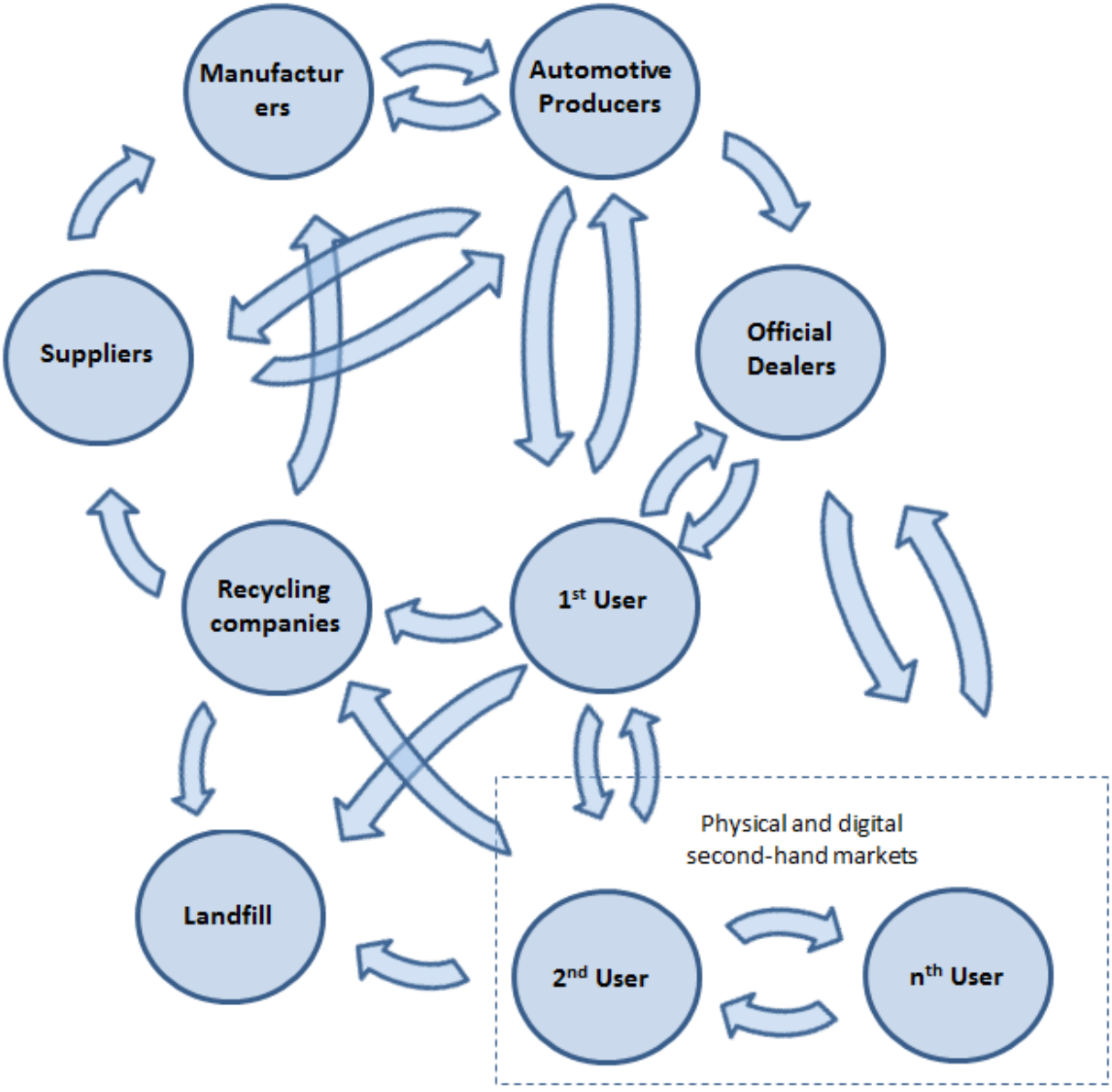

Figure 4.21: The organization model (simplified version) of the automotive industry.

5. Case studies

5.1 Selecting case studies

5.1.1 Key aspects

After examining how CE is addressed in theory, as well as in the automotive industry, it is time we take a look at the practical side of circularity. Unfortunately though, as literature does not provide yet enough insight with regards to circularity of long-term buildings or concrete solutions on the way the latter could be organized in practice, more focus was decided to be put on projects that have already managed to achieve a remarkable level of circularity -or they are close enough to make it-, both from the building and non-building industry. The goal is to reveal the organizational models applied in these cases, to study the developed relationships between the involved actors, to record the nature of signed contracts and selected transaction forms, as well as to analyze the key actions that made the former standout of the crowd and be used as examples. Hereby, besides circularity, the initial selection of projects was made based on three key aspects:

1. affinity with the engineering field
2. level of project's standardization and complexity
3. usage contracting period

In order to reach a more valuable comparison and to acquire a better picture of how these three aspects influence the level of circularity but also how they are being influenced by each other, the selected cases cover three different engineering fields, ranging from relatively simple to quite complex projects and having an operating lifetime that varies from a maximum of 3-5 years to more than 15. The list of the projects or products that will be studied in this thesis is presented below:

- The Recover-E® Program
- The PARK4ALL
- The temporary courthouse in Amsterdam
- The Alliander offices in Duiven

5.1.2 Interviewees' selection

The examination of these case studies was accompanied by the interviewing of targeted professionals. In each case, an effort was made to conduct interviews with at least two experts that have been participated in the development of the aforementioned projects. As the current research is mainly focused on the organization of circular-driven projects, the role of the interviewees was preferably lying on the fields of project, process or contract management, architecture and business development. In addition, people with more strategic approach on upcoming engineering opportunities, (such as standardization of building components and automation of the construction practices, increased use of 3D printing equipment, redesign of current production processes, etc.) were also been contacted, constituting a combined source of knowledge and inspiration.

A short version of the experts who were interviewed more thoroughly can be found in Appendices, coupled with the interview protocol that was created in order to gather as many and more valuable information as possible. It should be mentioned though that discussion with fellow colleagues on the topic of CE as well as on other circular and non-circular projects took place during the research period, adding on the better understanding of the examined cases and their more holistic analysis.

5.2 The Recover-E® Program

Recover-E® is a shared responsibility initiative which aims to optimize the value of ICT assets, generating alongside extra value for business, economy and society (recover-e, 2016). With a special focus on reuse, recover and recycle of existing and newly developed ICT equipment, the Recover-E Foundation attempts to extend the benefits of the latter through the application of a circular model, which allows ICT assets to ride all different cycles of utility and functionality, increasing thus their after-life value and minimizing the total produced waste. According to its initiators, Recover-E is a shared responsibility solution on the field of ICT which makes the client co-participant in the vision of circular economy, creating thus a feeling of accountability with regards to the management of his waste and transforming people's mindset on ownership practices.

Recover-E® Program is based on the belief that everyone –both private and business consumers- has some power in influencing and determining how products are purchased and treated throughout the value chain (recover-e, 2016). Under that context, the company provides its clients with the possibility of getting better and more control over their ICT assets through a transparent-based platform running by LogIT; an ingenious tracking and tracing system, which records and maintains accurate information on the ICT life cycle. Being the backbone of the Recover-E® program, LogIT ensures that every link in the chain works so that product and waste flows can be optimized (recover-e, 2016).

5.2.1 How it works

The concept of Recover-E® covers the whole spectrum of a product's utility life-cycle; from its purchase to its end-of-life. The first stage (see Figure 1) takes place after acquisition of the preferred hardware from an external provider / producer, when the client can get into a partnership agreement with the Recover-E Foundation. Typically, a service-providing contract is being signed, covering all new equipment that is being purchased during the term of the contract; meaning usually for a period of 3 to 5 years. Following, each devise gets discretely labeled, so that it can be identified within the system, ensuring thus that the contract is linked exclusively with a specific ICT hardware (recover-e, 2016). Through this partnership agreement, Recover-E® does not only provide extended maintenance services –most of the laptops for instance have only 1 to 2 years guarantee- but makes available to the client a number of other options including (recover-e, 2016):

- Real time asset management of all devices. The client can check and monitor the state of his hardware at any time in terms of working condition, spare hardware, location of equipment, etc.
- Registration of all ICT equipment movements using time-stamps. The client can register the activity of his hardware -for purposes of internal use, maintenance, recycling, etc.-, recording thus all its movement history.
- Project planning of on- and off-site services including logistics. The client can proceed autonomously with the addressing of various activities – equipment relocation, replacement, maintenance, etc.-, the planning of transportation and time-schedule, as well as the calculation of transaction costs and other expenses.
- Data-wipe of transferred equipment according to Blancco licenses. In case of equipment reuse, remanufacture or repair the client's hardware is being certified according to the internationally recognized standards of Blancco, so as no personal data will reach another client at a later stage.

Following the provisions of the signed contract, Recover-E® provides all the agreed services during the products' lifetime (second stage) and always in line with the client's specific requests on hardware reuse, recycling, innovation and donation (recover-e, 2016). Once the contract period is over, the client can

terminate the partnership or extend it and get benefited by the acquisition of a more advanced version of ICT equipment. As for his labelled assets that have been already disposed to Recover-E®, the client can check their path of processing all the way till the end of their life.

The third stage includes the flow of hardware from the client to Recover-E®. The reason to do so is based on a twofold concept. Firstly, it lies on the fact that the client after the time period of 3 to 5 years is willing to replace his existing hardware with new one, due to the nature of the products and the rapid development of ICT technology. Secondly, the client being sensitized on the issue of sustainability is already aware that his "old" equipment can be of value for another user, most probably with lower performance standards. Apparently thus, instead of sending the hardware to the land field, he prefers to dispose it to Recover-E® in exchange for a small profit –or in some cases even for free-, being solely responsible for its transportation to the offices of the company.

In the next stage (four) Recover-E® evaluates the condition of the received ICT equipment, and staying aligned with the 1st user's wishes, decides on their future fate. In case the previous owner requires for direct recycling or donation of his assets at the end of the contract, the hardware will follow one of the corresponding paths. Otherwise Recover-E® assesses the value of existing hardware and proceeds with their repair or refurbishment for reuse. Via LogIT the company is also able to manage better the obsolete equipment and subparts or materials that are getting dismantled from the initial hardware, while by using re-integration programs it can assemble new products from different initial sources (recover-e, 2016).

Following, Recover-E® applies redeployment practices through remarketing of the acquired and certified hardware to new clients. The latter can be anyone, from private customers or companies to employees of the 1st client –in case he is a business owner- willing to keep the discarded ICT equipment for their own private purposes (recover-e, 2016). Hereby, at this fifth stage the product –"mother-made", refurbished or "new"- flows to a 2nd user in a much lower price than its initial. The 2nd user enjoys exactly the same benefits as the 1st, while in addition he can select -to certain extent- the specifications of his new equipment. To say it differently, depending on the availability of spare parts within the company, the client is not limited to choose from a shell of premanufactured products but he can 'built' instead one, based on his personal preferences.

As the products are getting a second life and being contracted to a new client with the same terms and services offered to the initial owner, stages six (the contract period for the 2nd user), seven (the return of the ICT equipment back to Recover-E®) and eight (the evaluation process of products within Recover-E®) can be considered identical to stages two, three and four correspondingly. The greatest difference may lie in stage eight, where it is highly impossible for Recover-E® to manage a profitable repairing and reselling price for another reuse. Although in theory the reuse cycle could be ridden more than once, in practice it is way harder to do it, as most of the clients will use up their contract time, making the products after two consecutive 3- to 5-years periods functionally obsolete. So, in that case the necessary procedures for recycling take place, preparing the hardware to be disposed according to recyclers' requirements (stage 9). The recycling companies after acquisition of the electronic 'waste' proceed with its processing, which leads to the production of raw materials able to be used again from the ICT industry (stage 10). Based on the current business models of both recyclers and ICT producers the recycled materials are sold to the latter –leasing is not an option- (stage 11) before they turn them into new ICT products (stage 12). A graphic illustration of the whole organization process is being presented in the following Figure.

Recover-E®

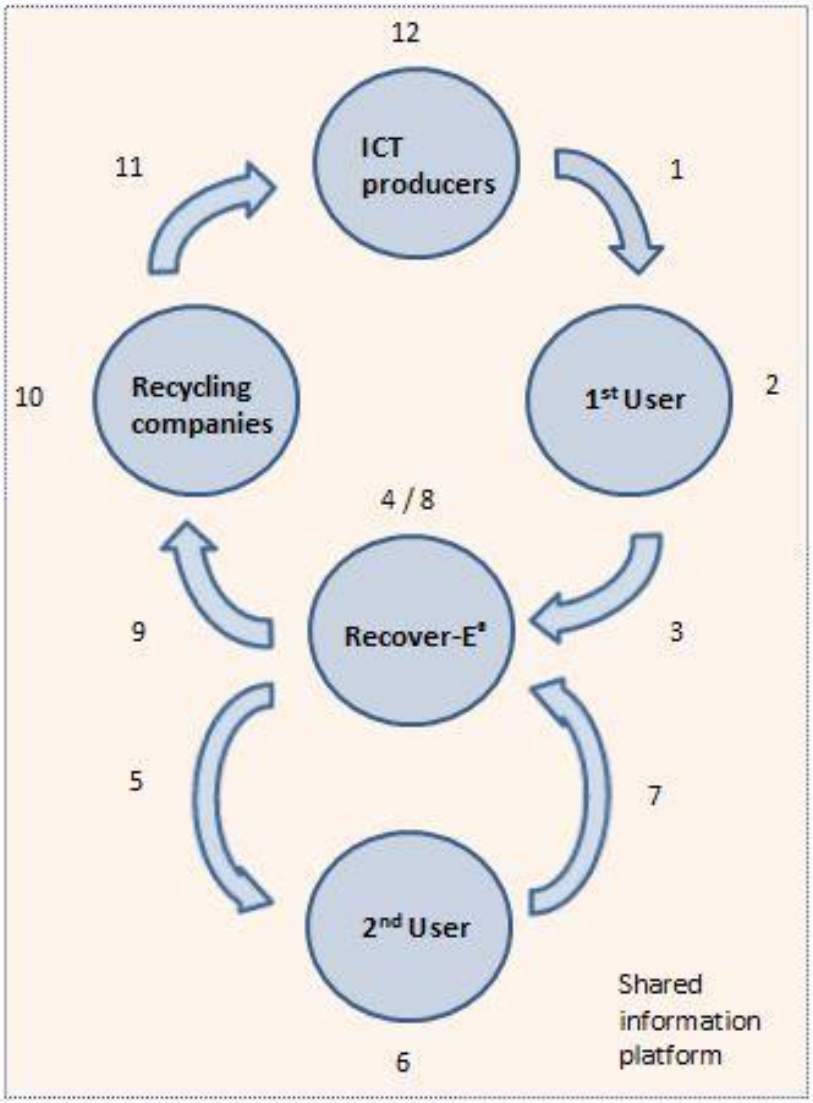

Figure 5.1: The Recover-E® organizational model (recover-e, 2016)

1. Partnership agreement between client and Recover-E® Foundation (3-5 years)
   - Sign contract
   - Register and label hardware to LogIT tracking and tracing system

2. ICT management by the client
   - Real time asset management of all equipment
   - Registration of ICT hardware movements through time stamps
   - Project planning on and off-site services including logistics
   - Data-wipe of transferred equipment according to international standards

3. Equipment flow from the 1st user to Recover-E®:
   - Transport of equipment at client's cost
   - Dispose hardware through selling or free of charge

4. Equipment assessment and products classification as directed for:
   - Repair and reuse
   - Refurbish and reuse
   - Donate to other parties
   - Recycle

5. Partnership agreement between client and Recover-E® Foundation (3-5 years)
   - Lower price than initial
   - Possibility to 'build' your own hardware –depends on selected specifications and spares availability
   - Same terms and benefits as in stage 1

6. ICT management by the client; same offered services as in stage 2

7. Equipment flow from the 2nd user to Recover-E® as in stage 3; hardware disposal mostly free of charge

8. Equipment assessment and product classification as in stage 4. Theoretically the cycle including the stages 4 ,5,6, 7 & 8 can be applied more than once; in practice though that is rarely the case

9. Preparation for recycle

10. Production of raw materials

11. Flow of raw materials from recyclers to ICT producers through traditional sell-buy agreements

12. Development of new ICT products

5.2.2 Additional remarks

Looking at the business case of Recover-E® Program there are a couple of interesting points that someone could stand at. Starting with the exchange relationships among the involved parties, it is worth to study how these are developed throughout the whole lifecycle of ICT hardware. What is really impressive at first sight is that only two types of economic transaction forms show up (Figure 2). What is even more impressing though is the extensive application of the free disposal option. The reason for that lies on the concept of 'shared responsibility' promoted by Recover-E®, which is based on all parties awareness on sustainability, as well as on their good will to offer their low value products free of charge, on the term that the latter can ride another cycle of reuse, remanufacture or recycle and not end up in the land field as valueless waste. In that context both users and Recover-E® may provide for free their assets to another party, taking seriously their role over society and environment. In addition, if one looks carefully on the transaction cycle, he will observe that although there is a high level of circularity driving this whole process, no leasing agreements are included, contrasting the continuous exhortations of literature on the importance of leasing materials as the basis for CE to be structured on.

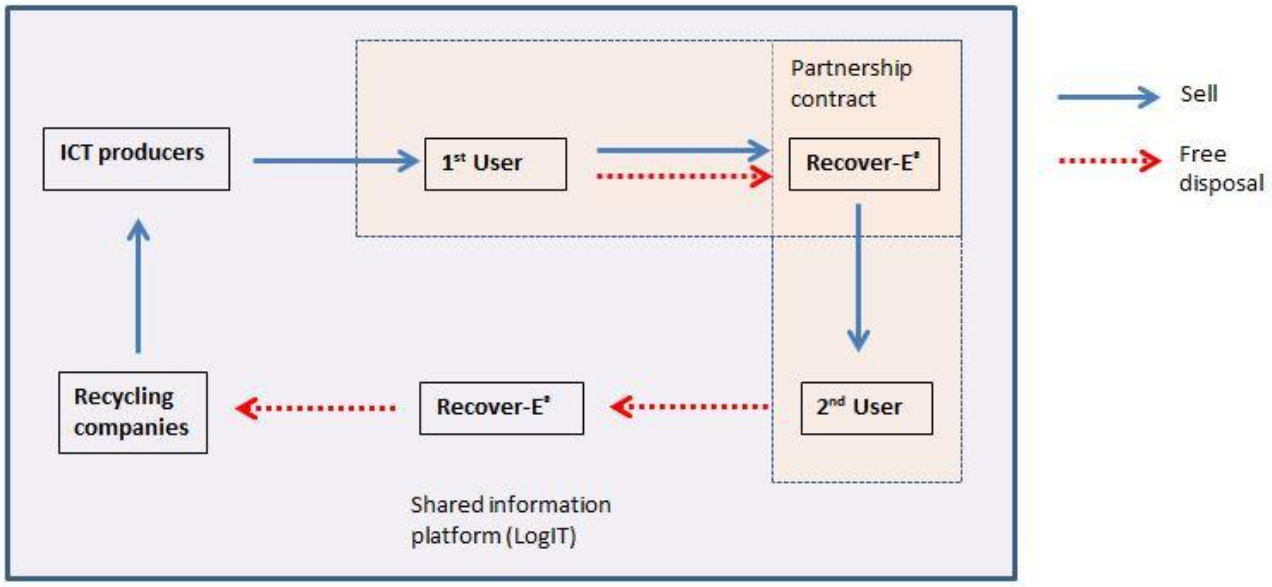

Figure 5.2: Options of economic transactions within Recover-E® case (own figure)

Moreover Recover-E® supports the objectives and solutions outlined in the WEEE Directive -Waste Electrical and Electronic Equipment (WEEE) is one of the fastest growing waste streams in Europe- (recover-e, 2016). The Recover-E® Program actively encourages and facilitates cooperation between ICT hardware producers and recyclers through the direct and transparent exchange of information, which is recorded in a single powerful database and can be accessed via an online platform; LogIT (recover-e, 2016). When coupled with innovative recycling processes, the experiences and insights derived from this information can enable both manufacturers and end-processors to objectively discuss product design optimization. Bridging the gap between product design on the manufacturing side, and recycling on the end-processing side, allows Recover-E® to implement optimal improvements on both sides of the chain (recover-e, 2016). Hereby, by bringing together all stakeholders of the ICT lifecycle chain and by providing tools for the maximization of products' reuse and recycling, Recover-E® manages a twofold objective: to keep valuable assets and materials in use for as much as possible on the side, and to create

a transparent, trustworthy environment in where all ICT stakeholders can identify themselves and willingly cooperate for their common benefit.

The change of Recover-E®'s role in the whole process provides us with another interesting remark. Starting as a service provider with benefits that far exceed the traditional maintenance services, Recover-E® can find itself in the position of owning products acquired in a fair low price -or never paid for- after the end of the contract period with its first clients. The in-house knowledge deriving by the expertise of the two initiating companies –Royal HaskoningDHV (an international engineering and project management consultancy) and SiSo (experts on providing services on surplus ICT equipment)- transform Recover-E® into a hybrid of product and service provider. Thus, next to the services included in the partnership agreement Recover-E® can now collect the used equipment, process it accordingly and feed a new market cycle through three different options:

1. by fixing malfunctioning hardware and selling it to another client at a lower price;
2. by retrieving functional parts from different products and proceeding subsequently with the development of 'new' properly operating hardware;
3. or by preparing and dispatching the economically valueless product parts directly to recycling

In addition in case of hardware's second life through refurbishment and re-integration, the 2nd user has a –limited- freedom to choose on the specifications of its new assets creating ICT equipment that can fit his needs better. What is impressive in that case is that this can happen at a total cost of around 10% its initial price.

At the end of the day, key goal of the company is to encourage 'shared responsibility' throughout the supply chain and circular economies through innovation in the entire ICT lifecycle; and that makes the Recover-E® Program more than just an end-of-life-cycle management initiative (recover-e, 2016).

Interesting Facts

1. All hardware get a specific registration number
2. All information is recorded in a single database (LogIT)
3. Database accessible by all ICT stakeholders via an on-line platform
4. Continuous track and real-time asset management of all ICT equipment
5. Only two types of economic transactions; sell and free disposal
6. A shared information platform promotes and facilitates cooperation between ICT manufacturers and recyclers, with the aim of 'designing for recycling'
7. The involvement of all ICT stakeholders maximizes the use of products and minimizes materials' waste

Thought-provoking Observations

1. Extended application of free disposal for the shake of sustainability and CE
2. High level of circularity without turning to the option of leasing at any stage
3. Optimal improvements on both sides of the chain -design and recover- thanks to a shared information platform
4. High transparency and increased willing for cooperation among ICT stakeholders
5. Recover-E® turns from service provider to a hybrid of product and service provider
6. Storage and logistics of hardware regulated within Recover-E®
7. 2nd user can 'build' his equipment based on his preferences –to a certain extent- at a way lower price than the 1st user

Tables 5.1 & 5.2: Interesting facts and though-provoking observations derived from Recover-E® Program

5.3 The PARK4ALL

PARK4ALL is a flexible, demountable and fit-for-purpose parking concept which attempts to cover the need for semi-permanent parking spaces. The idea of a solid but simultaneously easy to set-and-relocate parking facility was conceived by three experts in the fields of real estate (Marco Huibrechtse), steel construction (Bob Evers) and financial management (Hans Roerink), and it is realized by their commonly founded company; PARK4ALL BV (park4all, 2016). The latter is an independent legal entity, based on the Netherlands -but operating both in and outside Europe-, exclusively specialized on the construction and delivery of demountable car parks. According to its initiators the company's ambition is to manage a 25% share of the European market for temporary parking solutions (park4all, 2016).

The grandeur of PARK4ALL lies on its smart design. Consisted of small standardized parts with uniform dimensions and standard couplings, the layout of any offered solution can greatly vary, fitting perfectly on client's wishes and getting always adjusted to space and height restrictions. A PARK4ALL can cover an area from 50 to 5.000 spaces -available from stock- and it can be situated at any place due to its extremely light structure, which makes the provision for foundations completely unnecessary (park4all, 2016). In case of changes with regards to the client's requirements, the modular system allows for rapid expansion –or shrinkage-, both in space, where 5-meters sections can be added, and height, where the attachment of a full extra deck is also feasible (park4all, 2016). No matter its size, PARK4ALL can be assembled in a couple of weeks and disassembled the same as fast. In addition, any physical or technical obstacles that may be present on site can be easily integrated within the park, avoiding thus the need for extra civil works and optimizing the use of the existing space. Once it is not needed anymore, the building can be disassembled and relocated in another area, leaving no trace or waste behind (park4all, 2016).

5.3.1 How it works

PARK4ALL is a circular-oriented concept which has been developed to provide specific solutions to a specific problem: the demand for short-term parking facilities. To address that issue, PARK4ALL BV invested many years on running tests on different ideas, materials and building techniques, as well as on the certification of all its separate components, setting thus innovation as a cornerstone of its success (park4all, 2016). Hereby, at the first stage of that process, the company takes the lead by proceeding with the detailed design of all the necessary elements for a parking facility to be realized, while at the same time special focus is paid on the field of strategic marketing. Through the development of PARK4ALL, the company is actually introducing a new building product in the market, for the promotion of which potential clients have to be reached and become aware of the offered possibilities.

Once a client identifies the answer to his problem on the facet of PARK4ALL, the next stage (number two) comes in order. Client and providing company get into direct contact and discuss on the specific requirements of the former in terms of car parking capacity, plan layout, physical and technical particularities, etc. The aspect of ownership is also set at the table of negotiations, with options of sale and rent being both available. The fact that PARK4ALL is entitled under the article 17 of the Spatial Planning Act means that –at least in the Netherlands- it can remain in place for a maximum of 5 years, despite its flexibility, solidness and proven technical resistance for a minimum of 25 years (park4all, 2016). This legal restriction in combination with the usual demand of clients for semi-permanent parking services makes leasing a more alluring option. To add on that, in case of leasing no investment is necessary from the client's side as the latter is charged per parking space, while the cost of setting up the structure stays with the provider.

During the next stage (number three) the client makes use of the product, being –normally- the recipient of the service instead of the building's owner. A leasing contract includes not only the delivery of a functional parking facility but also its maintenance throughout the whole renting period. The same can happen with a purchase scheme, although in that case the maintenance period will probably be set to no more than 20-25 years -it has to be mentioned though that till now, no such offer has yet been done-. In both scenarios, the client can enjoy the benefit of a complete service which secures him against potential deficiencies or malfunctions, raising the value of the final product even more.

Once the contract is ended (stage four) –in case of a leasing agreement- the provider is responsible for the disassembly of the whole structure and the complete removal of all elements, leaving the site at the same state as it used to be before the parking intervention. That is not a hard task, bearing in mind that PARK4ALL is designed to the standards of Meccano (park4all, 2016), making its break down a simple reverse process of its initial erection. The costs of building's disassembly, transportation and storage go once more with PARK4ALL BV, while there is zero creation of waste during any of these steps.

After the parking facility is returned back to the company (stage five), the latter is in search of another client to dispose it –or parts of it- to. This is a process that usually happens way before a PARK4ALL is available (could be from six months up to a year), as the providing company is aware of that in advance, and can plan the building's next use on time, avoiding any extra costs of storage and structure's idleness. Apparently, when the next user is spotted, he is offered a contract based on the same terms and conditions as the ones presented before. From that point on so, a cyclical repeat of stages two to five takes place, with delivery, use, removal and remarketing processes being represented by stages six, seven, eight and nine accordingly, and being also able to get re-ride more than once. That means that a number of pure reuse cycles is possible, as no major refurbishment activities are needed due to the building's elements extended life expectancy.

Given the hypothesis that a PARK4ALL has exceeded its technical life cycle –note that there is no such case yet as the company runs for almost 7 years-, the providing company will assess the most profitable ways to treat all the separate components. Building parts that can still be used by the construction sector or get remanufactured and directed to other industries, like steel beams, staircases and façade elements, will most probably end up to material suppliers and manufacturers (stage ten) for the development of other projects (stage sixteen). On the other hand building components that is hard to decompose to their simplest elements -or it takes too much energy to do it-, like the glass-fiber containing decks and roadways, will be sent to the recyclers (stage eleven) certified with the processing of such stuff. These companies, having organized their business in different line streams for material production will proceed with the generation of recycled materials (stage twelve), which later on will be sold to suppliers and manufacturers (stage thirteen). The latter will either feed another project or industry, as has already been mentioned, or they will deal with the creation of new building components for another PARK4ALL to be built (stage fourteen). In case of the second scenario all specified materials and elements to be delivered to PARK4ALL BV will be either sold to the company, as it is currently done, or leased, as the product's developers are still anticipating for (stage fifteen).

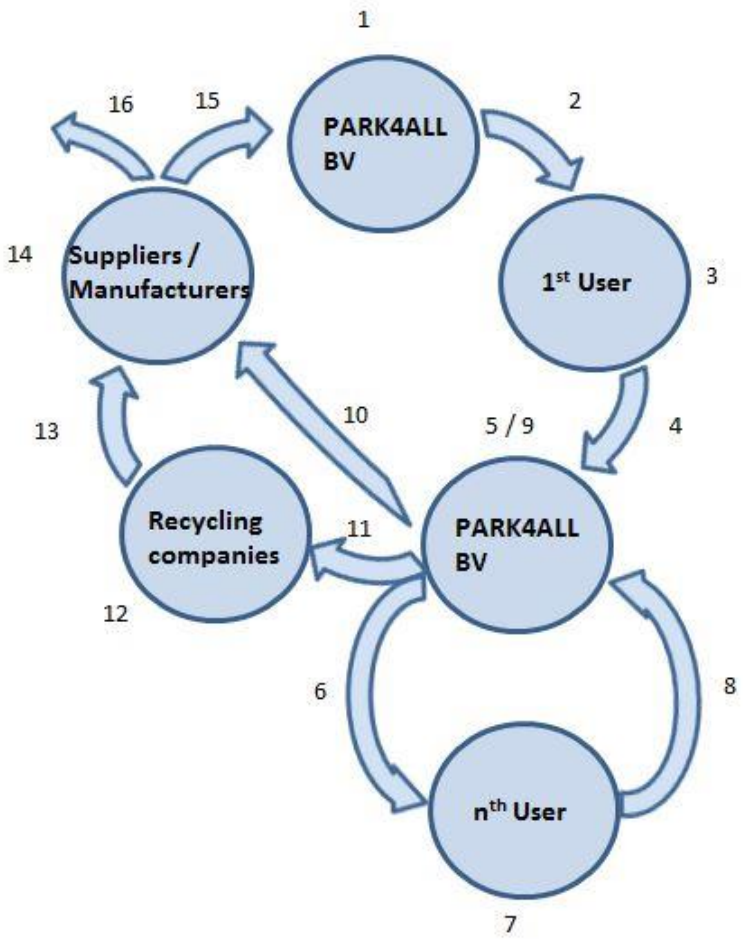

Figure 5.3: The PARK4ALL organizational model (own figure)

1. Detailed design of a parking facility concept to the standards of Meccano and strategic promotion of the developed product on the market

2. Specification of the client's requirements.
   Leasing agreement (3-7 years); special purchase schemes is also an option.
   Building assembly within a few weeks

3. Use of building's services by the client; maintenance is also included

4. Building disassembly and material retrieval:
   - All components go back to PARK4ALL BV
   - Disassembly, transportation and storage cost burden exclusively the providing company

5. Remarketing of the used PARK4ALL

6. Lease or sell of the parking facility to another user, following the same terms and conditions as in stage 2

7. Use of building's services by the second user, maintenance is included

8. Building removal and material retrieval as in stage 4

9. Beginning of another reuse cycle by repeating stages 5 to 8
   Assessment of all separate components' state of quality

10. Disposal of still functioning parts that are not up to PARK4ALL's requirements, to suppliers and manufacturers for their refurbishment and reuse in other projects; traditional sell-buy exchange

11. Disposal of hard-to-decompose or mixed components to recycling companies; sell-buy exchange or free disposal based on their remaining value

12. Recycling process; generation of raw materials

13. Flow of raw materials from recycling companies to suppliers / manufacturers through sell-buy agreements

14. Processing of materials according to client's specifications and needs

15. Provide PARK4ALL BV with new high quality building elements through sell-buy agreements (current practice) or leasing contracts (anticipated practice)

16. Feed another project or industry

5.3.2 Additional remarks

The further examination of PARK4ALL business case can provide us with a couple of interesting remarks. Starting point hereby can be the nature of the project, which really worth to be stated. Contrary to what is traditionally happening in the construction industry, in PARK4ALL case a group of professionals with different backgrounds managed to joint their forces and come up with a concept which can serve a very specific purpose. The way that concept is being developed classifies it more as a product, being closer to customized solutions offered in other engineering fields, like the automotive or ICT industries.

Apparently, this market approach influences also the relationship status between clients and parking provider, as the former do not lead the development process of a solution to their problem, but instead choose for one that is already available on the market and fits them the most. The idea of temporality lying behind PARK4ALL's service purpose seems to get fulfilled optimally when leasing agreements are on rule, mutating the clients from owners of property to owners of a service and increasing their level of confidence with regards to the received quality throughout the whole renting period. That is also beneficial for PARK4ALL BV, as the company being certain for the value state of its deliverables, can earn bigger profits in the long turn, by applying in practice a circular business model with no idle periods of product's use in between. Hereby, having their goals moving in parallel paths, both parties have proved to be less prone to disagreements and conflicts, co-operating instead in a more direct and trustful way.

When it comes to the relationship between PARK4ALL BV and its suppliers / manufacturers, comments can mainly made for the first steps of the development process, as the stages nine to sixteen have not yet taken place. Looking at the next figure, it can be observed that PARK4ALL BV is currently buying all the necessary materials and on-specific-demand components by third parties. However, even from the very beginning it was company's wish to introduce the option of materials' lasing, proposing, in a sense, its suppliers to become partners in that venture. Unfortunately that was hard to be accepted 7 years ago, when -according to the experts- the market was not yet ready for such a business organizational change. Even so, following the traditional transaction way of acquiring the required resources, PARK4ALL

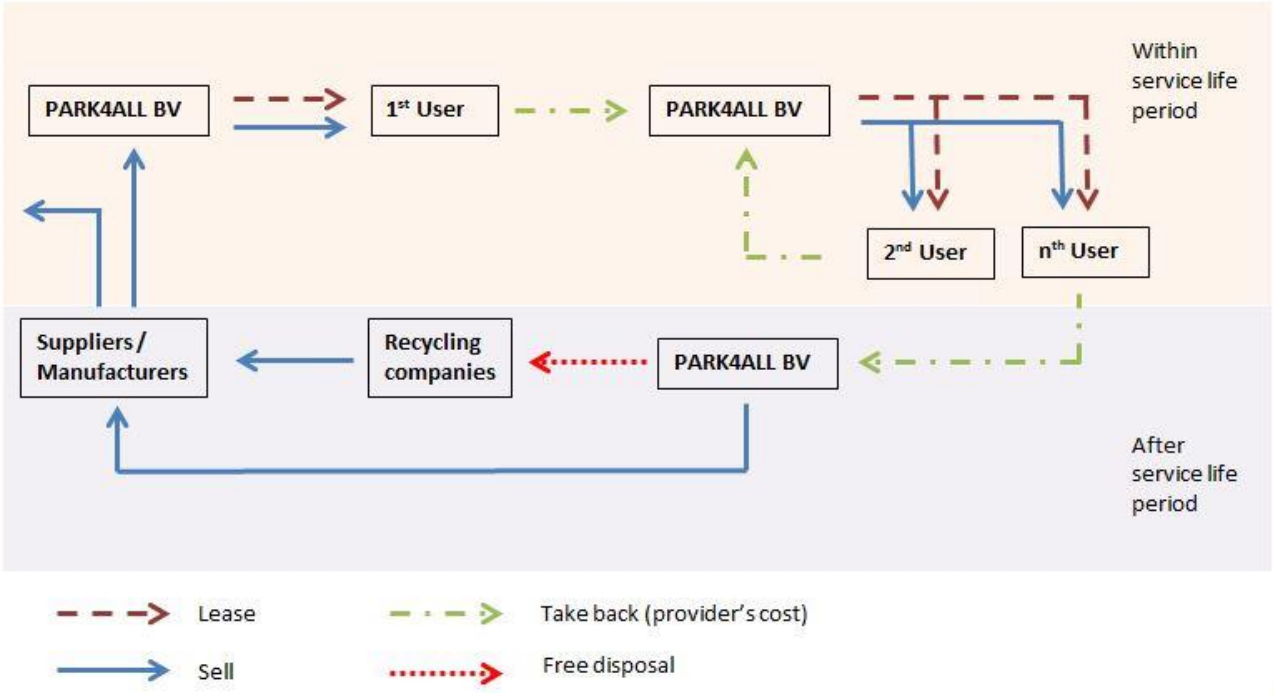

Figure 5.4: Options of economic transactions within PARK4ALL case (own figure)

has turned into a highly circular product. Hereby, it is anticipated that the certified quality of all its components and their easy decomposition to smaller parts will constitute a great lure for suppliers and recyclers to claim them once their technical life comes to an end.

In addition, a PARK4ALL facility, although based on the meticulously arranged assembly of a specific number of identically-patterned prefabricated components, can still match the client's personal style, through the space flexibility provided by its easy-to-play-with building parts and its tailor-made façade elements. The latter, being able to get covered with plants, landscape photographs or advertisement signs can aesthetically fit to any environment, while instead of parking space the roof can be used as an artificial grass sports pitch or roof garden (park4all, 2016), providing thus the building with a completely personalized tone. Next to that, extra options do exist with regards to the building's sustainability level, as low-energy LED lighting is being provided, while solar panels and total energy systems can also be added, reducing hereby the energy consumption even further (park4all, 2016).

Another interesting remark derives from the goal of PARK4ALL BV to set itself in charge of the one quarter of European market's temporary car parking facilities. Developing a building product which is driven by a specific need or problem bears high financial risks, as in case of limited acceptance by the clients, the initiating company can be even led to bankruptcy. On the other hand though, if a thorough market research has been preceded, followed by careful design–especially as an outcome of experts' insight from different professional backgrounds- and a strive for innovation, then the venture can turn into a complete success. And that is where the main advantages of PARK4ALL lay on; right feeling of the market's vibes, smart demountable design and integrated innovation within all building's components.

Interesting Facts

1. Short-term solution; designed however to cover long-term needs
2. One party does it all: design, construction, assembly, commissioning, maintenance, disassembly and retrieval
3. Fits on every plot (from a bank river to the top of another structure)
4. Super light structure; no need for foundation
5. Fully standardized components, but also tailor-made solution for the client
6. Fast and flexible mounting & demounting
7. Sustainable construction and disassembly; zero creation of waste
8. Full reuse of basic structure's materials; limited need for refurbishment or maintenance

Thought-provoking Observations

1. Change in traditional building roles; the building developer acts as a product seller while the client chooses for a complete, standardized solution that can only partially influence
2. High financial risks for the initiators of a building product
3. Success keys identified in:
   - deep understanding of market's needs,
   - smart demountable design
   - integrated innovation
4. The client –normally- turns from property owner to service beneficiary, being introduced unconsciously to the concept of CE
5. More fruitful relationships are developed between clients and car parking producers deriving from their parallel moving interests

9. Screw-based connections; no trace of the building after removal

10. Integration of sustainable systems is an option

11. In case of leasing, no investment neither front-end costs are required from the client's side

6. All design and construction data are recorded, processed and accessed exclusively by PARK4ALL BV

7. Leasing at the level of building provider – suppliers does not seem to direct influence the level of circularity

Tables 5.3 & 5.4: Interesting facts and though-provoking observations derived from PARK4ALL case

Before we move on to the next case study it would be also interesting to classify by shearing layers the key aspects -in terms of design decision, materials innovation and integrated technology- in order to make PARK4ALL a building product able to be located anywhere, covering almost any temporary or permanent need for parking spaces.

Shearing layers	Key aspects
Site	fits on every plot (from a bank river to the top of another structure); super-light structure; no foundation needed
Structure	high quality, extremely durable and innovative materials; standardized components; designed to be fast and easily assembled and disassembled; designed to be reused multiple times
Skin	tailor-made façade elements
Services	customized staircase systems; energy control systems; optional solar panels
Space plan	flexible layout of spaces; integration of obstacles; dynamic design of upper deck
Stuff	low-energy LED lighting

Table 5.5: Key aspects by shearing layer in the case of PARK4ALL

5.4 The temporary courthouse in Amsterdam

The temporary courthouse in Amsterdam is a project that was developed in order to support the operation of the city's main courthouse. When the latter -also known as the Parnas Complex- was regarded no more capable of serving adequately its purpose in terms of space availability and functionality, the need of a large-scale renovation came to the fore. For that to happen though, a number of specific particularities had to be taken into account.

Main wish of Rijksvastogoedbedrijf (National Real Estate Agency) and Rechtbank (High Court) of Amsterdam -the two decision-making authorities- was for the new facilities to be hosted at the same place as the current courthouse, without simultaneously any interruption of the latter's daily services and functions. Apparently thus, the intended new facilities would partially overlap the existing buildings, a considerable part of which should be demolished before the former's construction began. To deal with that challenge, the idea of a temporary building was promoted, the development of which should be aligned with several requirements. To name a few, all the established standards in the fields of space accessibility, safety and acoustics, as well as unabridged conditions with regards to equipment, complex logistics and comfort should be met, if not exceeded (Hendriks, 2015). In addition to that, the Amsterdam's courthouse being the largest in the Netherlands could not be reflected on an aesthetically low quality building –even as part of a short-term solution- but instead it should retain a highly professional and recognizable image to match the prestige of such an important organization (Rubbens, 2016; Oheler, 2016).

Under the context of all the aforementioned particularities, the competent authorities decided to tender a building project that would provide a temporary solution to cover the need for office workstations, courtrooms and corresponding annexed spaces, public waiting areas and other support spaces, as well as parking garages. The total space of the new facilities would be expanded in an area of approximately 5,400m^2 (cepezed, 2016).

5.4.1 Thinking sustainably, designing circular

The Amsterdam's temporary courthouse is clearly a case, where the project's principal –representing the Dutch government- tried to carry out its social role in sustainability (Hendriks, 2015). Top priorities to that direction were the minimization of the squandering of money, energy and resources, as well as the prevention of waste, under the context of a sophisticated design (cepezed, 2016). In addition, the building's value should be maximized, such a way that it could retain a high residual value to be proved by detailed documentation already within the tendering procedure.

Three consortiums bid for the project's development, coming up with three different suggestions in tackling its challenges. A really noteworthy fact is that despite their diverse ways of approach, all three contestants managed to achieve –or at least prove- high standards of materials reuse, to the impressive level of 60% or higher. The winning consortium DPCP, leaded by Cepezed & Cepezedinterieur and Du Prie bouw & Ontwikkeling, provided the selection committee with the most complete solution, being assigned thus a Design, Build Maintain & Remove (DBM-R) contract with 5-years duration. Other parties that got involved in the consortium were IMd consulting engineers advising on the structural design, Linssen installation consultants providing technical installation advice, LBP | Sight consultants advising on the fields of acoustics, fire safety and durability, Schoonderbeek installation and Putman installations undertaking the construction and maintenance of the equipment and Dijkstaal providing the steel structure (bouwenmetstaal, 2016).

The core of DPCP's proposal lies in the project's inherent circularity. By paying special attention to the triptych of 3R (Reduce, Reuse, Recycle), DPCP succeeded to convince the client for the soundness of its solution and guarantee the highest benefit during the whole lifecycle of the building (cepezed, 2016). The 3R were actually implemented on every scale of the development process and at all levels (building, building parts and building components), starting from the very beginning with the maximum use of donor materials, which helped to minimize both the total need in new resources and the up-front amount of disposed waste (Hendriks, 2015).

The circular design approach that was adopted by the consortium introduced also new materials and working techniques. To give an example, one of DCPC's main ambitions was to endow the old slabs with added value. Hereby, the idea of providing recycled channel plates from other buildings with a new drying mounting detail, in order to use them for the realization of the floor system, was investigated. The complete solution included the design of a special detachable coupling of the channel plates to the steel structure (bouwenmetstaal, 2016). As it is depicted in Figure 5.5, each one of the former is equipped with four steel rods which bear screw sockets on the ends. Two rods run horizontally, being connected to the supporting steel girder, while the other two bend down, being coupled to the steel structure, in order to ensure the rigidity of the floor (bouwenmetstaal, 2016). These anchors are removable and contribute to the easy and no damage-provoking dismantle of the plates, as the latter can just get lifted from the steel frame (bouwenmetstaal, 2016). That way the usual poured screed is replaced by a single compound floor which is also easy to be dismantled.

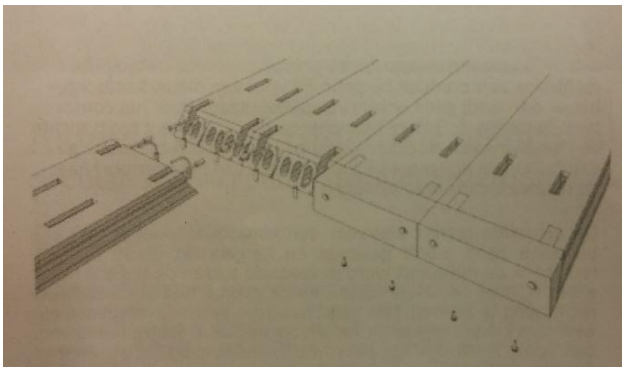

Figure 5.5: The floor system

Figure 5.6: Prefabricated parts

Besides the floor, the main structure is also easily demountable, as it is consisted of steel elements which are screwed to each other, avoiding thus any material loss during removal. In addition, almost all the other parts of the building are prefabricated, making the construction process faster, easier and quite standardized. That approach though was not a novelty for the designing team of DPCP. It was actually based on CENTRAL.AL, a previously developed concept of Cepezedprojects, which was aspiring to make temporary buildings suitable for different functions at different locations, coupled with alternative forms of financing (Hendriks, 2015). At CENTRAL.AL, the relationship between the building and its location is presented as non-existent, granting the former features of a product. Moving on that direction, Cepezed on collaboration with Du Prie decided to address the temporary courthouse on the same way. By over-dimensioning the spans, so that a lower number of columns would be needed, and by increasing the ceilings' heights in order more space to be available for installation or other

functions in the future, they provided a building that it can easily be transformed to a school, an office, a house or a laboratory (Rubbens, 2016).

5.4.2 Organizing circularity on a product level

Obviously, as the specific project is still on its infancy when it comes to its own circularity and reuse, no long-term project delivery model can be proven to be yet in force. However, based on the documentation that was provided to the tendering committee and the vision of the concept's initiators, an estimation of how the building is anticipated to flow into the market in the long run can be made (Figure xx). On the contrary, what can be stated with certainty is that once the contract period of the temporary courthouse is over, Cepezed and DU Prie will be responsible for the building's disassemble, as well as for the retrieval of all its materials, leaving no trace of construction waste on site. Being aware in advance about the exact date of that process, the project's developers will have enough time to confirm interest from a second user, and start working on the necessary changes for the building's new function.

As mentioned already, the project's initiators are mainly striving for the reintroduction of the building as a whole into the market, aiming thus at riding a cycle of reuse in the highest possible level; that of a complete product. Portraying the mindset of people in Cepezed, Menno Rubbens states that "*Within actual circular economy, you have to **think of buildings as products**; not to focus only on the floor slaps as a product for instance, but on the entire building instead and think of how you can reconfigure it in another location by reusing again all its components. That is much more efficient than trying to demount a structure and then redistribute all its separate building materials*".

In best case scenario thus, the dismantling of the courthouse will be followed by the direct relocation of the building in a new site. In a more moderate scenario, a refurbishment stage of the parts that need maintenance, enhancement or small-scale adjustments in order to align with the new requirements will have to take place first, before all separate components get transferred on site for assembly and installation. In worst case scenario -meaning that no interested client shows up or the re-design process is far from ending-, all building components will have to be stored in a warehouse for a significant period of time. Apparently, that will be an extra cost on the shoulders of the initiating companies, as they are the ones to pay for the materials' sheltering and maintenance when the latter are out of use.

To maximize their financial benefit, the project's developers wish for the reuse process to happen as many times as possible, as the cost of changes on a product level is much less comparing to the development of a new building from scratch. The technical life of the internal building components however, although being quite extended for the majority of them, it can always be a limiting factor to the number of reuse cycles. The same may happen with the changes of legislation regarding the material properties or the introduction of new materials and new technologies. Apparently thus, at some point in time, it can be expected that the still functional parts of the initial building will be incorporated in the development of other projects, while the building elements with some residual value left, will most probably end up to manufacturers and suppliers, in order to be their refurbished and promoted back to the market. The building parts which are not profitable for further reuse or remanufacture will most likely be disposed as valueless waste to appropriate recycling companies that will turn them into raw materials, before making them available to the building industry's supply chain (Figure xx).

Temporary courthouse in Amsterdam

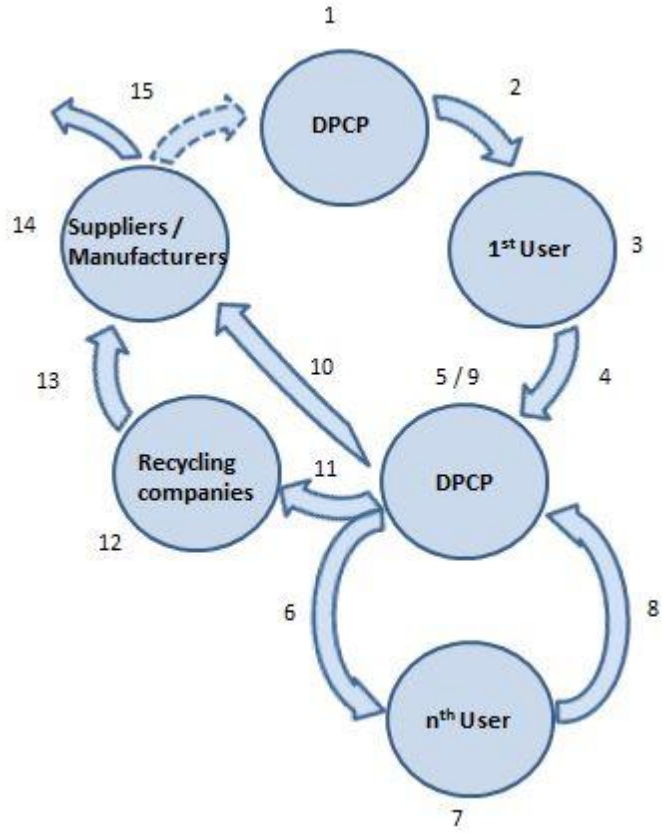

Figure 5.7: The 'expected' temporary courthouse's organizational model (own figure)

1. Bidding for a tender based on a building concept which can serve the current client's needs, but can also cover multiple functions in the future by applying small-scale changes in the building's basic configuration

2. Pre-fabrication, construction, assembly, installation and project commissioning under a DBM-R contract. DPCP leases the building to the client for a 5-years period

3. Use of the building's services by the client; shortly before the end of the contract the provider is in search of the second client

4. Building disassembly and retrieval:
   - All functional building components go back to DPCP retaining the properties of a compound product
   - Disassembly, transportation and storage cost burden exclusively the provider
   - Construction waste reaches a maximum of 30%

5. Application of the necessary refurbishment activities and/or changes in order the existing building to match the next user's specific needs and requirements

6. Construction, assembly, installation and project commissioning as in stage 2. The second client may choose for a different contracting period or ownership model than the first one

7. Use of the building services by the 2nd client; shortly before the end of the contract the provider is in search of the next client

8. In case of ownership retaining by DPCP, building disassembly and retrieval as in stage 4

9. Repetition of the activities conducted in stage 5. Once the in-house assessment shows that it is not profitable for the project's developers to reuse the building again as a whole, the latter will probably be disassembled in smaller parts with functional components being probably channeled in other projects

10. Disposal of individual building elements with some residual value to suppliers / manufacturers

11. Disposal of hard-to-decompose or valueless components to recycling companies

12. Recycling process; generation of raw materials

13. Flow of raw materials from recycling companies to suppliers / manufacturers

14. Processing of recycled materials according to the clients' needs

15. Feed DPCP's individual parties, another project or another industry

5.4.3 Additional remarks

Taking a more in-depth look at the temporary courthouse case, there are a couple of noteworthy points to highlight. Starting with the composition of the project development team, it is obvious that the high-standard requirements of such a project are hard to be addressed by a single actor, demanding thereby the insight of parties with different expertise for its realization. The product-oriented approach has to incorporate the design, development and operation of various systems, integrated in such a way that they can perform best as a consolidated unit. Technical difficulties, high initial investment costs, guarantees of long-term performance, financial risks of building's circularity and future reuse are only some of the issues that need to be tackled, in order to provide a solution which can be offered in a competitive price and is able to adjust into a multi-functional roleplay that will increase the building's turnover. It wouldn't be unreasonable thus to assume, that the uncertainty lied in many aspects of the temporary courthouse's development process, and the inability of a single party to arrange all risks, knowledge and resources by its own, made the composition of a consortium look as an imperative need.

Another interesting remark can pop up if one tries to challenge the product-like approach as implemented by DPCP. The project's developers choose to address reuse in product level, as that is more efficient than demounting a building and scattering then all its components to different projects. Although in theory this idea sounds undeniably reasonable, in practice it is not easy to be applied at its full extent. In the examined case, a declaration of proof for the circularity of materials in a level of 70% is definitely impressive, especially if it is taken into account the building's flexibility in use purposes. Still though, a significant 30% of materials will either have to be extensively refurbished or sent to recycle, asking for a considerable amount of energy before they are transformed again into valuable raw materials. To add on that, the delivery of a multi-functional building out of a single initial configuration sounds ideal and can apparently be realized if based on a smart, preventing design; however the need for small-scale changes will lead by definition to some material loss, as well as to a certain demand for new resources. In that sense thereby, there is still room for improvement when it comes to developing a project driven by a product-oriented mentality.

Moreover, another comment can be made with regards to the importance of the role that the client can play in the facilitation and realization of a circular concept. In the case of Amsterdam's temporary courthouse for instance, the idea of a demountable and easily adjustable to various needs building system pre-existed in the mind of its initiators way before the tender. However, no actual implementation could take place without a prior concrete interest from a client. The state's initiative to promote sustainability and favor a solution that would guarantee the highest level of materials' reuse constituted the best opportunity for Cepezed to present and test the value of its concept. The engagement of a governmental body was the push that the project's developers needed in order to do the next step and proceed with the practical development of their idea, taking alongside a higher initial risk for a higher future profit.

Furthermore, diving in the field of financial transactions (Figure xx), it can be seen that the traditional buy-sell agreements between suppliers / manufacturers and project developers are dominant. According to Menno Rubbens if we take as an example a steel company that keeps a claim on the steel structure of a building -designed in the context of a compound product-, once the leasing period is over the project initiators will be left with a nearly valueless asset, as there cannot be a building without a steel structure. Consequently thus, it can be said that if circularity starts at the level of materials supply, the situation may become extremely complicated and highly inefficient at the end of the contracting period. Thereby,

under building providers' initiative, the physical acquisition of all the necessary resources was preferred to leasing in the case of the temporary courthouse.

As far as the transactions between DPCP and its clients are concerned, although the first user asked for a short-term leasing contract, the options of long-term leasing or purchasing schemes can always be provided. Of course, as mentioned already, a sell-buy agreement can be the case if the client is interested in the delivered facility as a whole and not in its separate parts. Selling in parts, although it is early to be discussed, may be possible once a significant number of several building components are close to the end of their technical lifecycle, outdated or just incapable to match the criteria of future clients' requirements. In such a scenario the delivery of still valuable elements is expected to end-up to interested suppliers / manufacturers through selling exchanges, while the hard-to-gain-value-from components is estimated to be collected by recycling companies under free disposal.

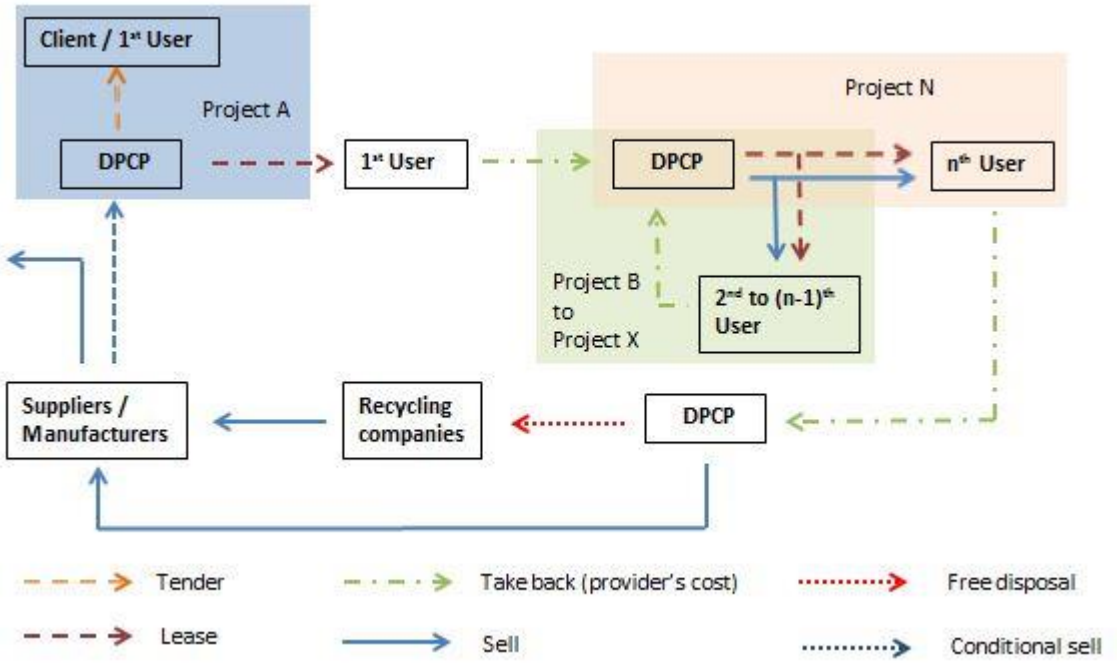

Figure 5.8: Options of economic transactions within Amsterdam's temporary courthouse case (own figure)

What also needs to be mentioned is that the tendering process followed by the competent authorities was structured in a way that managed to increase benefit for all sides; both the client and the providers. Driven by an innovative assessment method that would evaluate a number of aspects, known to the competing parties in advance, the solution space was broad enough for the latter to move around and table their own proposals. In addition, appointing the developers responsible for the dismantling, the financial incentive to maximize the residual value of the building was actually transferred to them. The advantage for the client is more than apparent as well; it is not necessary to pre-sort a specific solution, restricted to a very specific frame. By avoiding the definition of precise decision directions in an early stage, more room for innovation is allowed and better strategic choices can be made.

The above described win-win situation has undoubtedly a positive impact on the developed relationships between the client and the building providers. The latter do not only strive to perform their best in order to align with the agreed requirements, but also aspire to claim a positive reference at the end of the

contracting period. Being responsible for the design, construction, maintenance and 'guaranteed' reuse of the building, the contractor has no reason to deviate from the delivery of high-quality performance, increasing thus the feelings of honesty and trust towards its client. On the other side, the relationships between providers and supply chain parties seem to remain almost unchanged, as no major transformations take place in their in-between business. Perhaps the most noteworthy change can be detected in the undertaking of extra activities and responsibilities by the developing companies, in case that the manufacturers are unwilling to adjust their production process in the new requirements; the demountable floor system of Amsterdam's temporary courthouse and the role of Cepezed in its development is a clear example of that.

Interesting facts

1. Short-term solution with extended life expectancy
2. Focus on Reduce, Reuse, Recycle
3. Incorporation of donor materials in the construction phase
4. Invest on material innovation, demountable design and new construction techniques
5. Over-dimension of building elements in order to match easier the need for different future functions
6. Extended standardization of building components and prefabrication
7. Addressment of the whole building as a compound product, not as the sum of separate products
8. Under project developers' demand no leasing agreements are supported in a supplier / manufacturer level
9. Government's initiation promotes circular thinking and sustainable design
10. Enhanced relationships between project developers and clients, due to win-win situation
11. Hardly changed relationships between project developers and suppliers/manufacturers

Thought-provoking Observations

1. Serving an accommodation demand should be needs-driven, not place dependent; the disconnection of building-location should be considered
2. By developing multi-functional building products it is practical impossible to achieve full materials reuse. A certain % will always be 'wasted' and need to be replaced by new materials. The amount of necessary remanufacture/recycle energy should be taken into account
3. No single party has all the required knowledge, manpower, capital and resources to tackle with the uncertainties that follow a circular building; the need for collaboration is apparent
4. Interesting concepts already exist but in order to be put on the market there has to be prior confirmed interest by a client
5. No prototype was created
6. Client and user may differ
7. Public parties can stimulate circularity by contracting take-back temporary projects
8. A carefully designed tendering process can stimulate diversity, efficiency and innovation in the provided solutions
9. Adjustment of the initial building product to next user's requirements at a much lower cost for the developer

12. Increased business activities held by project developers due to manufacturers unwillingness of adjusting their working practices into new needs

10. Incapability in guaranteeing next user can set at serious risk the project's viability; costs of storage and maintenance are not to be neglected

11. Leasing agreements on a suppliers/manufacturers – developers level can create a highly problematic situation

12. Hybrid companies can raise their power and increase their market share, by undertaking part of the manufacturers business activity

Tables 5.5 & 5.6: Interesting facts and though-provoking observations derived from Amsterdam's temporary courthouse case

5.5 The Alliander offices in Duiven

On November 2015 Alliander opened a completely renovated industrial building in Duiven. Before that time, the site was nothing more than a collection of colorless 80s' buildings that could accommodate a total of 600 staff. Right after its renovation though, the whole place was transformed into an innovative, sustainable and positive energy complex of buildings, which can now accommodate around 1.550 people (Alliander news, 2015). What really worth to be mentioned is that for the first time the highest BREEAM Outstanding design sustainability certificate was granted to a project under renovation (Alliander news, 2015), and a key reason for that was the extended application of circular initiatives.

Unlike the usual practices in the development of office-complex, during the tendering procedure the client did not provide clearly defined specifications. Instead, the bidding parties were asked to come up with an overall concept for an ultra-durable housing, as Alliander commissioned the development of new premises based on the existing buildings and the following five aims:

- Creating a circular building and site in a circular construction process
- Making the location 'energy positive'
- Providing space for 1,550 people where they can work in an activity-oriented manner
- Stimulating interaction with the surrounding area
- Guaranteeing optimal coherence through an integral approach.

In addition, the development process should also include management and maintenance for a period of 15 years. Through 'co-creation' between the consortium and the employees, the final design was developed, leading to the expansion of the five existing buildings and their common sheltering by a "climate greenhouse" made of a floating roof (VWvastgoed, 2015).

The goal of the new building facilities was to raise awareness on the issues of sustainability and green energy, while adjusting the existing buildings in such a way that they would be economically, aesthetically, functionally and circularly satisfying (VWvastgoed, 2015). Under that context, 86% of the buildings were retained at their exact location, maximizing thus in practice the desire for reuse, while the prevailing concept was also driven by the reduction of necessary materials and resources, the remanufacturing of existing building components and furniture, as well as the minimization and the targeted separation of waste.

5.5.1 Implementing circularity

Classifying the development of a circular office-complex high on the list of goals to be achieved, a number of circular ideas were implemented. To begin with, 80% of all materials, building elements and complete products –like ceiling tiles, stelcon slabs and buildings- have been given a second life through remanufacturing and reuse, while all of them can still be reused in the future, as they have been linked to a special 'commodity passport' that verifies their place of origin and way of processing (Alliander, 2015). Hereby, the buildings' complex is actually one big commodity depot for construction projects in the future, as Alliander really strived to close the cycle. Moving on the same direction, 85% of the materials that were removed from the property were carefully sorted by waste stream. The elements that could not be reused immediately, such as metal and glass, were separated in 13 different waste streams and processed by the industry, so that they can be reused in another field at some point in the future(Alliander, 2015).

Moreover, in order the volume of the buildings to be expanded and get increased in size by one floor –so that more square meters of office space could be provided at the same location-, the concrete facades of

the pre-existing buildings were partially removed, pulverized on site and used both as granulate in the concrete floor of the atrium and as paving hardener. By doing so it was not necessary to obtain new gravel, saving thus on material, transport and CO_2 emissions. In addition,, the stelcon slabs used during the construction stage between the buildings for heavy-duty traffic, were recycled by being placed as basement floor in the car park area, after their initial purpose was fulfilled.

Another action of circular planning can be detected on the way that the external facades were treated, as all the latter were coated with timber cladding, deriving from recycled wood, which in any other case would have been incinerated. Hereby, the rough and unprocessed timber was collected from a nearby waste plant and sent to a woodworking factory[1] in order to be processed properly and turned into wooden façade sections. These sections were not permanently attached to the supporting structure, but they were instead designed and placed as puzzle parts, which can be easily removed or replaced if necessary. Moreover, insulation was incorporated into the rebuilt facades. For that process, overused workwear were sent to a textile factory, which converted them to fabric before transform them into insulation material. Thus, although in small scale –due to the low quality of the final product-, part of the insulation is now deriving from workers' clothing.

Furthermore, circularity was also applied on the roof of existing buildings, through various actions. All the ceiling tiles of the old structures were retained and recycled, by receiving a fresh coat of paint and being rehung in new ceiling grids. New ceiling systems have been also installed in all other areas, including the ceiling of the restaurant which was made exclusively by recycled timber, and the curved atrium roof, for the construction of which 800 tons of steel were used with a 90% of it being consisted of recycled materials. In the 'Bron' (Source) building the whole ceiling was reused, as in order for an extra floor to be added, the roof structure was temporarily removed and placed in the car park before returning to its initial place.

Other circular interventions include the reinstallation of existing toilet bowls and sinks -after getting cleaned-, the delivery of restaurant seats made from recycled PET bottles (Alliander, 2016), the remanufacturing of doors into furniture (VWvastgoed, 2015) and the reuse of deficient furniture after the necessary refurbishment.

5.5.2 Sustainability and clean energy

Besides the practical application of materials' circularity, the Alliander offices in Duiven follow closely all the dictates of circular economy. Special interest, for instance, has been set on the subject of sustainability. Under that context, several steps have been taken, with the application of smart design being on the top of the list. Through the latter, the new atrium, created by a wavy-shaped canopy, connects the five existing buildings in such a way that an energy efficient complex has been created. The shape of the roof, including its overhang and angle, was especially designed to take into account the position of the sun throughout the year, reducing thus the radiation during the summer months and increasing the solar benefits during winter. That way, the necessary energy demands, both for cooling and heating, are reduced, while the indoors' comfort rises (VWvastgoed, 2015). The micro-climate of the internal space becomes even more pleasant by the placement of 20.800 ivies and plants, which purify the air and partially control the temperature.

[1] An interesting fact is the social aspect of that initiative, as the timber collection was appointed to people facing long-term unemployment.

The goal of sustainability was further supported by the creation of an underground grey-water tank -with a capacity of 110m^3- for the collection and storage of the rainwater from the roof of the atrium and the carports, in order to water the green plants that decorate the 'Verbinding' (Connection) building, and to flush the toilets. At the same time, there is a seasonal thermal energy storage system, which collects and storages beneath surface the excessive heat generated during summer, using it in the winter to reduce the energy consumption. In addition, the low-energy climate control system (BaOpt Climattion) creates a pleasant climate in all buildings. The system operates on the basis of air pressure and chaotic air flows. This creates slow air displacement and avoids draughts or cold down-draughts near the windows. To end with, the atrium has underfloor heating throughout to ensure that the floor is heated in the winter and cooled in the summer through thermal energy generation.

Besides the reduction in energy consumption though, the aim of an 'energy positive' complex could only be successful if linked with the production of energy, at least to the point of serving the buildings' own needs. Apparently thus, the solution of generating electricity from solar power was promoted, resulting in the placement of more than 6.000 solar panels, which cover an area of almost 8.000m^2 on the roofs of the carports -in the parking area- and the warehouse. These PV panels can generate up to 1.500 MWh per year -way more than Alliander's needs-, while the placement of two wind turbines can contribute with a symbolic, annual energy supply of 18MWh as well.

In addition, the company's environment also got actively involved in the process from the beginning of the project. Alliander on collaboration with the surroundings businesses and the local government developed a 'Green Alliance'; an initiative for the promotion of sustainable thinking and clean energy. Moving in line with the wishes of the municipality of Duiven, a series of sustainable interventions were implemented. Some of them include (VWvastgoed, 2015):

- the construction of a cycle path to link the Rivierweg road directly to the business park, reducing the traveling time for cyclists from Westervoort Station by almost a third;
- the improvement of accessibility by public transport;
- the extension of carpooling among professionals of all surrounding companies;
- the introduction of smart parking –Alliander has already provided its complex with parking facilities that can host 250 ordinary and electric bicycles and scooters, containing 50 charging points for electric bikes, and another 500 car parking spaces, 32 of which are equipped with charging points for electric cars-;
- the application of flexible parking –as according to a recent survey, more car parking spaces will be necessary in the near future, Alliander increases its capacity temporarily through the hiring of one of the Ikea's multi-story car park floors-;
- the joint procurement of PV panels for companies and individuals resulting to approximately another 2.000MWh of extra power per year.

5.5.3 Organizational model

The project was contracted as DBM, and implemented by a consortium under the common leading of Volker Wessels and RAU architects; the winning group of the initial tendering process. In the formed consortium (Figure 5) a number of pioneering companies participated, including Fokkema & Partners (architects), Boele and Eesteren (construction work) Innax (installation consultants) KuiperCompagnons (landscape design), Aveco de Bondt (building physics, fire and BREEAM), Rossum Consulting Engineers (construction) and Turntoo (system innovation) (VWvastgoed, 2015).

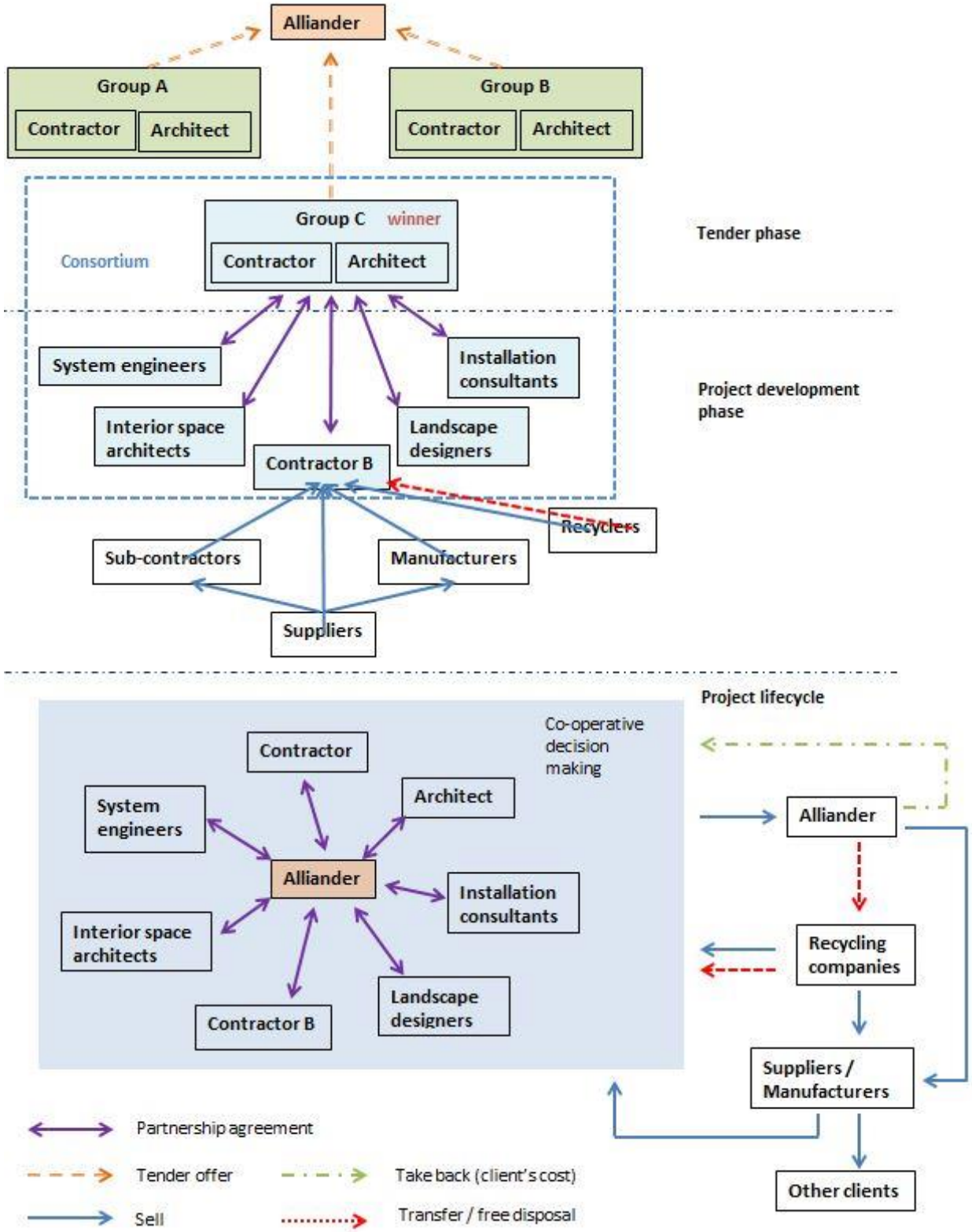

Figure 5.9: The organizational model of Alliander offices 'development in Duiven, coupled with the prevailing transaction forms

5.5.4 Additional remarks

The way Alliander chose to proceed with the renovation of its offices in Duiven is really remarkable. A more in-depth look at the overall set-up of the project can clearly outline the client's interesting approach on the issue of CE. Contrary to what usually happens, the latter decided to get the impact of its building activities out of the narrow boundaries of a project level, by trying to involve more actors in the development of a sustainable vision that would benefit everyone, including both its near-by neighbors and the local authorities. That way, hereby, circularity and sustainability were not attempted to be addressed individually, but as part of a wider 'green' initiative.

Analyzing the results of this strategy, many credits should be given to Alliander, for two basic reasons. Firstly for the holistic approach that it addressed its project with. Through the participation in the development and implementation of side-project sustainable interventions, a valuable point was made. Circular projects can function better if placed within a circular environment; and the creation of a circular environment demands the involvement of as many actors as possible -since the successful establishment of any market requires high numbers of participants in both the supply and demand sides. In addition, the savings in short-term storage and long-term transportation costs, which derive from those initiatives, are a proof that acting sustainably does not necessarily mean spending more. And the practical proof of a concept's financial viability is always a driver for people to embrace it and work on it.

The second reason why Alliander should be congratulated for, relates to the influence it had on people's attitude towards CE. The initiative for the creation of a 'green alliance' can motivate more parties to think different, especially when this is organized under the joint forces of "powerful" actors and local authorities. Feeling part of a large group that strives for the maximization of the common good, "smaller" players of the building industry may find the opportunity to join in, and present their own ideas, wishes and visions, being also willing to share their assets or resources.

Moreover, another interesting remark that derives from this case is that, perhaps, all buildings can turn circular if being appropriately addressed; the only thing needed, is the right incentive and willingness to succeed. The Alliander is a clear proof of that. The initially developed buildings were not designed to be neither particularly sustainable, nor circular. The incentive though of the company to set an example in the field of CE -in order to convince the world that the latter is not an utopia, but a goal that can be achieved through collective action and creative thinking-, lead to a remarkable transformation. The current facilities, being probably the most circular project of the Dutch building industry, costed more than a traditional approach would ask for. This comparison however is not fair. Trying to develop the most complete example case, in terms of all potential energy-production technologies, Alliander proceeded to the conduction of some disproportionate costly adjustments –the wind turbines, for instance. If the really functional solutions are only considered though, the difference in expenses is not that big, and in the long-term the circular approach is anticipated to be actually far cheaper.

Furthermore, a note should be made with regards to the issue of "material passports". Although in theory everyone seems to know what should be done, its practical implementation stands far from that. The interviewees' responses leave no room for question; material passports are currently underdeveloped, since they lack access to both quantitative and qualitative data, while their update is done manually, being, consequently, prone to unintentional human mistakes. The use of excel spreadsheets as the basis for their structure has many disadvantages, while the development of direct links with CAD software or BIM environment could probably upgrade their role in a faster and more valuable way.

As final remark, a reference to materials' trading options should be made. In Alliander's project, as also happened with all the other case studies, the option of materials' leasing was not used. Still though, the project is characterized by high sustainability and circularity scores, proving that leasing is probably not that important; it is just another financial model of temporarily acquiring resources. Its application is an approach that theory highly supports, as it sounds quite promising, but in practice it has not yet been implemented and its results remain unknown.

Interesting Facts

1. First time the highest BREEAM Outstanding design sustainability certificate was granted to a project under renovation

2. The development of 'Green Alliance' with the participation of parties from the surrounding area and local authorities

3. The users' opinion was taken into account

4. High level of circularity in all building levels
   - 86% of buildings reused
   - More than 80% of all materials were refurbished and reused
   - 90% of the necessary steel derives from recycled materials
   - Timber was collected by nearby recycling company
   - Clothing was used for insulation
   - Recycled PET bottles were transformed to restaurant seats

5. Waste minimization and reuse
   - 85% of materials not able to be reused separated in 13 different streams
   - concrete waste was reused as floor-basis for the parking space

6. No leasing terms included

7. The introduction of "material passport" provides information on the origin and previous use of materials

Thought-provoking Observations

12. Circularity is easier to be achieved if more parties get involved -especially the 'close neighbours''- as in that case high transportation and storage costs can be saved

13. The creation of 'green alliance' initiatives reduces parties' hesitation towards sharing of resources

14. Even not initially circular –oriented designed buildings can incorporate the principles of CE if there is an incentive to do so

15. "Material passport" systems are currently underdeveloped; link with CAD software or BIM could upgrade their role

16. Leasing is just another financial model of acquiring resources but not directly affecting circularity

Tables 5.7 & 5.8: Interesting facts and though-provoking observations derived from Alliander's offices case

5.6 Cases studies wrap-up

Taking into account the insight acquainted through literature, as well as the interesting facts and thought-provoking observations accompanying the examined case studies, Table 5.9 has been created. In that Table the key actions used by different actors in different industries for the enhancement and promotion of circularity are being summarized. Similarities and differences are easy to be spotted, as CE, although based in common principles, does not apply identically to all fields of human activity; it still encompass however some typical characteristics. What is really interesting in that case is the role change -or better to say role enhancement- for all leading stakeholders, since each one of those parties had to extend its business in order to meet circular projects' needs.

Case studies	Leading companies	Role in the industry	Extra role in the process	Key actions promoting circularity	
Choisy-le-Roi	Renault	Product developer, distributer & merchant	Product remanufacturer; recycler	1	Invest on materials innovation and demountable design
				2	Invest on reverse logistics through take-back strategies
				3	Strategic selection of recollection points
				4	Optimization of in-house remanufacture and recycling processes
				5	Centralization of recycling activities
Recover-E® Program	Recover-E® Foundation (Royal HaskoningDHV / SiSo)	Engineering & project management consultancy/ ICT solution and service provider	CE facilitator; product remanufacturer and seller	1	Development of a track and trace system for all registered products
				2	Development of a shared information platform accessed by all involved parties
				3	Facilitation of direct communication between the two sides of the cycle: product design and recover
				4	Remarketing of used products
				5	Remanufacturing of products and trading at lower prices
PARK4ALL	PARK4ALL BV	Product developer & service provider	(-)	1	Specific market target
				2	Invest on materials innovation and demountable design
				3	Standardization of building components and working processes
				4	Creating long-life, high quality elements for short-term solutions
				5	100% reuse of materials as no redundant parts are included
				6	Zero creation of waste as everything is screwed to each other
Temporary courthouse in Amsterdam	Cepezed Projects	Architect & project developer	Product remanufacturer and seller	1	Invest on materials innovation and demountable design
				2	Over-dimensioned building components to rise their field of applicability
				3	Standardization of building components
				4	High reuse % of building components and materials , minimizing alongside the introduction of new resources and the creation of waste
				5	Adjustment of the initial product to next user's requirements at a much lower cost for the company
Alliander offices in Duiven	RAU / Volker Wessels	Architect / Contractor	CE facilitators	1	Cooperate exclusively with CE oriented partners
				2	Implementation of smart and demountable design
				3	Reuse of existing buildings, building components and materials at a total of more than 80%
				4	Development of "material passport" for the tracing of all separate elements
				5	Remanufacturing of waste and transformation to new resources
				6	Highly reduce the need for new materials and transportation services
				7	Careful storage of non-able-to-reuse materials into 13 different waste streams
				8	Involvement of surrounding parties and local authorities to the promotion of a 'green' development for the whole area

Table 5.9: Summarized insight gained from the analysis of the theoretical and practical case studies

6. Recommended actions

Following the literature study on CE and some relevant to that theory concepts, as well as the individual and combinatorial analysis of the selected case studies, a set of recommendations in certain "fields of intervention" to be realized by specific stakeholders, is presented below. The appointment of the most suitable parties to implement these proposals, as well as the choice of the areas that changes should happen, are not undisputable; they are the outcome of the author's line of reasoning based on the findings of this research and his personal interpretation. Under that context hereby, four main types of actors have being held appropriate to drive the necessary changes towards a circular market for building components: the developers, the collaborative schemes, the public sector and the private clients. The main characteristics of these groups are briefly described below.

- **Developers:** The individual developers constitute the engine of the building industry, as they possess all the necessary knowledge, experience, expertise, manpower, means and equipment to apply in the development of buildings. Regardless their specific field of involvement – architecture, contracting and construction, engineering consultancy, or even a combination of all these-, their role in the promotion of CE's concept to their clients is crucial. Building developers may act autonomously, doing everything themselves, or they may choose to invest on project-based collaborations, sharing risks and profits with other parties.

- **Collaborative schemes:** The collaborative schemes refer to the strategic long-term alliance of two or more parties for the targeted development of building products. Although not yet applied in the building industry, it is highly recommended –through this research- to the building industry's stakeholders, to move towards that direction, as such schemes can turn out to be the driving forces of construction sector's future progress. Sadly, the cooperation between direct competitors -or potentially future competitors- is not common in the building industry, which is instead characterized by extreme project fragmentation, extended miscommunication, high level of competitiveness and a particular inclination to clashes, conflicting interests and hidden charges. Even in such an environment however, there is always room for change. The Nissan-Renault Alliance, a synergy which took place in an even more competitive industry where the number of key players globally is restricted to two digits, is an interesting case which can hopefully be seen as a useful example.

- **Public sector:** The importance of the public sector in the building industry is unequivocal and multidimensional. The governmental authorities not only set the national legislation and domestic laws, but they also participate in the co-development of international rules and directives, while at the same time constitute one of the main investors of large –but also smaller- infrastructure projects. In addition, the public sector has a significant educative role, an active participation in trial projects and a duty to support innovation, acting in favour of the common good. In that sense the public authorities can be a tutor and advisor to the private sector, a partner and co-initiator to ambitious concepts or an engaged supporter and promoter of start-ups and new technologies.

- **Private clients:** The private sector, being the biggest client for all kind of construction projects, is the cornerstone of the building industry. Its league includes all individual customers, private companies, financial entities, bank institutions and independent investors, who are willing to spend on real estate, either to cover their own needs in shelter or to get benefited from the providing of accommodation services to private and public parties.

With regards to the areas that action needs to be taken, nine fields have being distinguished as the key ground to start the changes from (Table 6.1). The reasons for their selection, as well as they type of the interventions to be undertaken by each party, follow in the next page.

	Acting parties			
Field of intervention	**Developers**	**Collaborative schemes**	**Public sector**	**Private clients**
Business mind-set	think in products	think in CMF systems	think in services	think in long-term value
Planning strategy	invest more on R&D, new (bio-based) materials and new working methods	invest on common benefits, shared and integrated resources	create incentives for the development of circular buildings in terms of tendering, subsidies, tax concessions, permits, etc.	challenge usual practices and project delivery methods
Project development approach	design demountable, standardize components	work on cross design and/or production	ask for proof of circularity and waste minimization	ask for proof of residual value
End-of-life care	develop take-back strategies and apply reverse logistics	centralize and co-manage collection, remanufacture and recycle points	provide storage and showroom spaces for used buildings or building components	support actively the exchange of building components
Communication management	improve and expand current in-house sharing platforms	promote and integrate common network-sharing platforms	support the development of and participate in public-sharing platforms	exercise buildings management through on-line cloud-based platforms
Circularity management	full-scale development of material passports	development of common track and tracing systems and material databases	set directives and goals for large-scale circularity of building components and high value recycling construction waste	request and implement performance detection technologies
Relationship management	challenge manufacturers and suppliers in adjusting their working processes to CE directives	apply extra reward and exclusion provisions based on performance	create green alliances and promote "circularity within neighbourhoods" actions	co-work with circular-oriented parties and expand their projects' effects out of their physical borders
Process management	optimize in-house design and refurbish processes	optimize remanufacture and recycle processes	experiment and set example models of circular projects	co-lead processes of own projects
Legal affairs	expand contract terms beyond maintenance phase	develop standardized agreement forms for fair allocation of building components' residual value	implement EPR norms; detach buildings' function-location permit link; guarantee legal protection in case of changes in waste classification	(-)

Table 6.1: Summary of the recommended actions that the most "powerful" actors of the building industry need to undertake in nine crucial areas

6.1 Business mind-set

The building industry as we currently know it cannot and will probably not stay unaltered in the years to come; on the contrary. Although even experts have a hard time to predict with accuracy the magnitude and speed of such a change, almost everyone anticipates that the nature of the building industry will be a lot different within the next 50 years. As the clients' needs and requirements increase in a fast pace, the complexity of today's projects keeps rising, asking thereby for solutions that can meet the standards of technological progress, while providing extra value to people's everyday life. In order to be aligned with those demands, addressing alongside the troubling issues of raw materials' scarcity and unsustainable consumption of building products, all involved stakeholders need to reconsider the way buildings are being developed, used and flow within the market. In other words, every single actor, no matter its place in the supply and demand chain, has a duty towards society to take a brave step and auto-reflect its actions, adjusting subsequently its mind-set to the values of CE and its driving principles.

- **Developers:** The stakeholders of the building industry, who belong in the developers' cluster as previously defined, is time to realize that a shift to CE should be accompanied by a redirection of their business philosophy to the product's development path. ***Thinking in products***, means thinking in specific user's problems, in complete solutions, in integrated technologies and –of course- in increased revenues for all parties. It also means fulfilling the clients' goals, understanding their biggest concerns and delivering the extra value that will make a difference at the end of the day.

  A building product has no boundaries. It can reach all levels of a structure, from its smaller elements –beams, columns and interior frames- to its bigger components –floor, walls and ceilings- and to the building as a whole. Hereby, it is up to the developers' perception to define the product level at which they want to focus on, while it is also at their hands to define its ground of development. In that sense, a building product may has a standard configuration that can be enriched with tailor-made features, like Park4All, or it is maybe based on a multifunctional frame, which can easily bear adjustments in order to comply with the requirements of different cases, like the Amsterdam's temporary courthouse.

  Regardless, the preferred approach, thinking in products will have a significant effect on developers' internal affairs, asking for important decisions on a top management level. A mind-set change of that magnitude demands the reshape of working practices not only in terms of process management and project development, but also in relation to in-house organization and communication management.

- **Collaborative schemes:** Under the rule of an alliance, the participating actors should start co-developing their ideas in terms of common modular family (CMF) structures. ***Thinking in CMF systems*** presupposes a clear mind-set change towards product-like building methods. The segmentation of buildings in shearling layers, based on time relevant criteria, or the grouping of different building types, based on functions and requirements that the latter may share with each other, could constitute two different approaches to that direction. Regardless the preferred path though, what is really crucial in all cases, is the wider collaboration of companies, coming both from the building and non-building industries. The more diverse the expertise included in such efforts, the more probable it is that all necessary provisions for current and future technological developments will be taken into consideration, leading to more complete and valuable solutions.

  Thinking in CMF systems does not mean developing similar dwellings under a specific number of building sub-products, but creating a platform that can optimize the manufacturing of systems and components, making them easily adaptable to different cases, while allowing enough room

for the realization of tailor-made interventions and the addendum of unique features. Looking at Amsterdam's temporary courthouse for instance, despite the excellent job that has been done in terms of building's multi-functionality, it would be even better if the over-dimensioning of its structural parts had been avoided. When setting as primary goal the minimization of materials loss, the existence of fit-for-purpose sub-products, could address the need of buildings' extended range of capabilities, far more efficiently.

- **Public sector:** Building developers cannot boost CE all by their own; the public sector has to play its role as well. Thereby, it is up to the competent authorities, to deviate from the traditional logic of explicit building requirements and detailed specifications, realizing that in a fast changing world the adhesion to old-school tendering, contracting and development practices can turn a rigid-in-requirements project obsolete in no time; and that is the main reason why the public authorities should undergo a mind-set aberration as well. ***Thinking in service*** thus, seems as the best fitting approach to an era where flexibility and agility are two essential features for any project to stay up-dated with the infinite new technologies. As a number of cases have proven it already, thinking in terms of functions and performances can satisfy the clients' needs with great success, while allowing simultaneously enough room for the engineers to innovate, present new ideas and add extra value to their final deliverables.

  So, does that mean that the public sector should adopt this mind-set towards all building-related development projects? Of course, not. Through the interviews it became clear that not all cases that the local or national authorities are involved in, can be assessed based on the same criteria. When designing a project for the Ministry of Defence for instance –like Kromhout Kazerne in Utrecht-, the demand for circularity cannot be client's main concern; other issues, like safety or flexibility of delivered spaces, are way more important. A location which has been selected strategically to accommodate the needs of the Ministry is unlikely to change even after 30 or 50 years, so no party can be motivated to foresee what will happen then, and act in terms of CE. Apparently thus, there will always be cases where the current working practices, requirements' specification methods and type of contracts will still be more suitable to be implemented than any CE-oriented concept. However, such projects will only constitute a minority, while for the resting majority a mind-set rewind is expected to be far more appropriate and beneficial.

- **Private clients:** The private clients constitute one of the building industry's cornerstones as they are the main funders of most building projects. Being an important part of the construction sector thereby, they also owe to realize the benefits and money-making possibilities deriving from CE. According to the interviewees, to do so, the private investors should initially step away from their most common mistake; the short-sighted addressment of buildings' usage and the way the latter are being related to the needs of their first users. To give an example, as more and more companies and start-ups are prone to change offices instead of renovating their in-use facilities after an average of 5-10 years, a high number of building owners find themselves in a precarious position, where their properties remain unoccupied and consequently valueless. ***Thinking in long-term value*** hereby, is what individual clients are recommended to do.

  A value-based approach includes an attentive and realistic estimation of a project's return of investment (ROI) in a timeframe that exceeds the decade. In that context, the clients should start taking into consideration not only the profits that they can be earned during the initial contracted period, but also the revenues that can be managed out of the mid- and long-term building's operation, as well as by its residual value at the end of its life-time.

6.2 Planning strategy

While all building industry's stakeholders have to undergo a radical mind-set transformation in terms of production, delivery and consumption habits, there is another relevant aspect that also needs to experience some big changes; the "planning for the future" parameter. Setting CE as a philosophy to be applied for the shake of the common good, the future planning strategy of all involved actors has to get aligned with its dictates, translating simultaneously the aforementioned mind-set shifts into practical steps for the enhancement of circularity. The role that each actor has to play however differs, as it depends on the type of power, influence or expertise that each one of them bears.

- **Developers:** The developers, being in the centre of all designing and production processes, are the most appropriate actors to be held responsible for the efficient integration of technology into their usual working practices. Throughout this research, it was made more than clear that R&D is a compulsory element for projects to stay in line with CE and its principles. Hereby, it comes as no surprise that in each examined case, at least some kind of material innovation, unprecedented production method or advanced remanufacturing process was developed. Unfortunately, R&D spending in construction lacks serious funding, running well behind that of other industries, such as automotive and IT sectors. And that needs urgently to change.

  It is on the developers' best interest to study the existing examples and realize the importance of ***investing more on innovation.*** As most of the interviewees have stated, ***new building materials***, such as auto-healing concrete, bio-based and nanomaterials, as well as ***innovative construction approaches***, including 3-D printing methods, preassembled techniques and plug-and-play modules, can lower costs and speed up construction, while improving safety and quality. At the same time, some of these "materials of the future" could redefine how projects are conceptualized, designed and executed, influencing alongside the ability of smaller and bigger building components to flow from structure to structure.

- **Collaborative schemes:** The establishment and wide-spreading of alliances can strongly enhance the field of R&D, since the collaborating parties will share the risks and expenses, while taking alongside common advantage of the individual knowledge, experience, equipment and workforce that each one of them is equipped with. The split of "innovation bill" in an industry where less than 1% of its revenues goes to R&D, could be an important incentive for those who wish to lead a turn to CE, but hesitate to bear all costs on their own. In addition, a guaranteed long-term corporate bonding between multiple actors can raise trust, confidence and commitment towards the achievement of common goals, appointing research as an essential feature of future building developers' business and not as a risky, unnecessary luxury.

  The Nissan-Renault Alliance case, although deriving from a different industry, is an interesting example to look at and seek for inspiration. The revenues' increase for both companies is a fact and it is already happening from the first years of their partial merge. Following this path thus, and adjusting the success factors of that synergy into construction sector's particularities, the building-related actors –both existing and newcomers- should work towards the direction of joined forces, *investing on* the prospect of increased ***common benefits and profits,*** as well as on the outstanding advantages of ***shared and integrated resources***.

- **Public sector:** The role of public authorities in the long-term planning strategy for the facilitation and promotion of CE is not primarily detected on their actual participation in ventures related to the development of new materials or the redefinition of the prevailing production methods. On the contrary, it is identified on their duty to ***create the right incentives*** for the building developers to proceed with those inventions and changes. Acting both as a key client and authoritative regulator, the public sector should provide the appropriate conditions for the

development of circular buildings, including the active support of ***circular-driven tendering procedures***, the rising offer of ***subsidies and tax concessions*** to circular-oriented projects, as well as the ***rearrangement of*** processes linked to ***permit acquisition and bureaucratic delays***.

Amsterdam's temporary courthouse is a clear proof of the central role that the public sector can play in the practical realization of circular projects, avoiding any imposition of strict rules and regulations. The careful conduction of a transparent and fairly-designed tendering process can provide enough guidance and room for innovative thinkers to move around, motivating them towards the acceptance of new challenges. Bearing that in mind and making use of the existing knowledge, it is up to the local and national authorities to undertake similar actions and stimulate the application of analogous ideas, ventures and products.

- **Private clients:** The private parties may not have any regulating power, but being the driving force of the building industry, they can certainly influence its future progress. To do so, the clients should not hesitate to ***challenge the usual practices and project delivery methods*** as presented by developers, asking thereby for solutions that will increase the value of their property both during and at the end of the projects' life-cycle. Taking the attitude of Alliander towards the usual remanufacturing methods of timber elements and ceiling components as an example, it is easy to prove that this approach had a two-sided positive effect. The client managed lower costs and higher sustainability scores, while at the same time, the willing-to-experiment manufacturers not only undertook the job but also got introduced into the high-promising filed of circular businesses.

  Of course, decisions like those are not easy to be made, as they normally have to be accompanied by internal organizational rearrangements, requiring alongside extra time and effort to be properly conducted. In that sense the clients cannot impose their will or vision. What they can actually do though, is motivate developers to think out of the box, asking for the embracement of new technologies including robotics, 3D-printing techniques and demountable fabrication systems. As the industry needs to radically change, moving beyond current methods to the next generation of techniques, the private clients have a duty to provide developers with a certain level of security and trust, which it will most likely be equally beneficial to everyone.

6.3 Project development approach

Another aspect that needs to go through great changes is reflected on the approach of building industry's stakeholders towards the usual philosophy of project development. The prevailing design and construction methods, which are applied to almost any project around the world, address buildings' location as a fixed variable, suppressing any thoughts for circularity from the very beginning. In addition to that, the most common building practices are still based on concrete purring and cast structures, in-situ fabrication of structural components, as well as low interest in terms of waste production, collection and processing. It goes without saying, that in a circular-driven environment such practices do not have a place and subsequently everyone needs to work on their reformation, according to its range of abilities.

- **Developers:** Basic demand from the side of building developers is the redefinition of the ways that they conceptualize and design buildings. All the examined case studies clearly depict that circular structures cannot coexist with glued-to-each-other elements; on the contrary the connection flexibility of separate components constitutes a key factor of the formers' subsistence. Not surprisingly thus, all interviewees pinpoint the high significance of bolted elements and screwed couplings, stressing alongside the idea of ***demountable design*** as a cornerstone of circular buildings. Designing in a demountable way, not only implies that a

structure is able to be removed from its settings and readily reassembled or repositioned to another site, but it also entails easy, fast and low cost assembly and disassembly processes.

Closely attached to the need for demountable design, stands the need for higher and more efficient ***standardization of building components***. The development of building parts that can be fabricated on the ground of specific patterns and quality standards, while being easily scalable and agile to improvements, changes and adjustments, should be of developers' main concern. Working towards the production of components that can easily flow within the same structure –covering even more than just one function-, or perform as 'Lego blocks' on the support of similar projects' development, would save a lot of fabrication costs and time. Starting point could be the basic structural elements –such as columns and beams- which by definition are more standardized, as they apply to specific regulations, while the focus on more complicated systems –such as floors and ceilings- could be the next step to take.

- **Collaborative schemes:** The extra value which can be added by an established synergy to its members lies on the augmented capacity of the group to contribute in both design and production procedures. As Lego-experts support, from a group of only 9 main block types, it is possible to create more than 6,000 different formations. Even if that number seems –or is- a bit exaggerated, it cannot be denied that a small group of basic elements can provide a great number of shape variation; a statement which is strongly supported by Lego's practice on hiring designers only to work on the creative conceptualization of new shapes and combinations. However, as the economy of scale between Lego blocks and building components is nothing to compare, the undertaking of that role by a single actor in the building industry does not seem feasible or realistic; and that is a burden that an alliance can minimize.

  The promotion of ***cross design***, as already applied in the automotive industry, can allow a team of experts with different backgrounds, to work on the development of integrated solutions within basic building components, thinking on their optimum use in a range of different projects. Under that context, a group of architects –or product designers- could be focused on the external retouching of these standard elements, attempting to grant them with a sense of uniqueness, which is highly appreciated and requested within the building industry. Moreover, moving to the same logic, the implementation of ***cross production*** processes could actively facilitate the outspread of standard components, as the demands in fabrication facilities, manufacturing equipment and specialised stuff would be significantly lower, and the margin for trial failures would be quite higher compared to a one-actor-does-it-all approach.

- **Public sector:** The public sector can highly influence the prevailing approaches on project development, especially when it carries out the role of the client. Once being in that position, it actually has the power to lead the relevant processes, by framing the boundaries of the practices to be followed and pushing thus the interested parties to comply with its vision. The innovative tendering method that was developed in Amsterdam's temporary courthouse for instance, clearly depicts how easy it can be for local authorities to trigger circular thinking within the building industry. By requesting potential bidders for ***proof of circularity*** -in terms of materials, building components or the structure as a whole-, and classifying ***waste minimization*** as top priority, the public sector can give credits to circular-oriented solutions, guiding the developers towards a more sustainable way of acting. Not to omit what Menno Rubbens –a project manager from Cepezed- thinks on that, as according to his sayings, concepts that can eliminate construction waste and promote circularity already exist within the mind-set of current developers; what is still lacking though is the opportunity for them to prove in practice the value of their ideas.

- **Private clients:** The private clients, being also on the demand side, can set their own project development frames, enjoying even more freedom in the means to do so, compared to the public sector. Thereby, based on how future owners identify value within a project, it is up to their personal perception to define the delivery methods to be applied, in order to maximize their final benefits. Alliander showed the way, by ***asking proof of residual value*** for the majority of the elements used during the renovation of its buildings. Setting as basic goals not only the suitability and functionality of all deliverables in their current state, but also the guarantee that the applied fabrication and remanufacturing practices will make the future use of all developed parts easily feasible, Alliander managed to ensure that the internal value of its buildings will last more than the contracted 15 years. What also needs to be mentioned is that the company's persistence towards circularity, led a traditional tile supplier to expand his spectrum of activities by including tile remanufacturing in his business, proving thus that a client's demand for long-term proof of product's value can be the spark for some parties to redefine their role within the industry.

6.4 End-of-life management

The determination of the most appropriate planning strategy, in combination with the preferred project development approach as defined by each individual actor of the building industry, can play with no doubt, a crucial role on a project's state, not only during but also at the end of its operational lifetime. Nowadays, the most common practices of managing buildings and building components after completion of their initial purpose are only satisfactory at a very low level, as only a small percentage of the latter are being processed properly, maximizing the use of their residual value. Acknowledging the benefits, but also the necessity that derives from the optimization of structures' end-of-life management, all parties should take action, striving for solutions that can resupply market from within, circulating the already existing valuable components form one project to another.

- **Developers:** In a CE environment, it is not enough for the developers to deal only with the design, construction and delivery of projects, as their share of responsibility can be extended after the hand-in to the client. Especially when the latter ask for temporary solutions or do not wish permanent ownership over building elements, the developers should be in place to get benefitted from their deliverables' residual value, by ***applying take-back strategies and reverse logistics practices***. The methods to do so can vary, being mainly dependent on the project development and delivery approaches that are being selected.

  In the automotive industry, where automakers are primarily interested in the recovery of specific vehicles' components such as engines and batteries, special incentives are provided to consumers as a reward for their willingness to help on that direction. Lower prices, extended product guarantee through the replace of 'old' parts with new ones, and better promised performances, are only some of those motives. Paralleling that to the building industry, if buildings are addressed in terms of shearing layers, allowing parts of them, like facades and ceilings, to get traded, something similar would be possible. On the other hand, in Park4All case, where the developing company is interested in the co-ordinated function of all structure's components as a single unit, the possibility of full building's recovery is presented as an extra feature, which adds more value to the final product and makes it even more attractive to the client's eyes.

- **Collaborative schemes:** In the field of project after-life management, synergies can once again be extremely helpful, as the large-scale organization of the afore-mentioned initiatives are a 'novelty' within the building industry, and the efficient coordination of such ventures can certainly be facilitated by the participation of multiple actors. Under the shelter of a

collaborative scheme, where the incurred costs for the collection, storage and redistribution of building components will burden all participated actors, it is easier -and probably more reasonable- to implement take-back practices that will be able to make use of common sources and increase the reuse options of the incoming parts. To achieve better results, the alliances should start thinking towards the ***centralization of collection, remanufacture and recycling points*** that will demand less space in production facilities and storage rooms, while offering better overview capabilities on spare parts and in-house logistics.

The ***co-management of all those services*** can be a tricky issue to handle, but as Renault has already proved through Choisy-le-Roi factory, the benefits of a strategically selected facility, in where all recovered parts are directed, can be multiple. The co-ordination of take-back processes will ask for high level of communication, and the shorter the distance between engineers, technicians, labourers and managers, the more efficient that communication will be. Besides, the leading of a network where all different kind of processes –like repair, refurbish, remanufacture and partial recycle- will probably take place, asks for high level of synchronization both between different parties and diverse activities, making thereby the co-sheltering of all these needs under a single roof sounds like a sound choice.

- **Public sector:** The public sector has the least direct involvement in buildings end-of-life management processes, but certainly one of the highest interests, due to their extensive environmental impacts. This interest thereby, should be translated in practical actions, by facilitating developers to manage the flow of existing building components. A simple –and probably inexpensive- way for local authorities to aid circular-driven parties is the ***providing of storage spaces for the temporary deposit of materials and building parts***. This accommodation should be offered free of charge, under one condition: all components hosted in such warehouses should be reused in future projects without being devaluated further. In other words, no option for these elements' recycling or low value reuse –as basement materials for road infrastructure for instance- could be permitted, as in that case the incentive of free deposition should be no longer valid.

  Moreover, the interest of public sector for the CE should be also expressed through actions that will help developers to trigger a high level of sympathy for reused building components to a wider range of clients. The local authorities hereby, should also mind about ***providing showroom spaces*** for the exhibition of retrieved building components, as the visible contact with products do always influence clients' perspective. In such places thus, the developers will have the opportunity to present parts of their work –from maquettes to 1on1 scaling models- and convince potential consumers on the high quality, functionality and aesthetics that is possible to be achieved.

- **Private clients:** The private clients may not have the luxury to provide all the knowledge, space, means and equipment that the implementation of take-back initiatives require, but they still have the power to influence the relevant processes. According to the findings of this research and contrary to what is usually supported when discussing about CE, the developers –and by extension the suppliers, the individual manufacturers, etc.- should not be bounded by any 'obligation' to take over the management of products they supplied, produced or assembled, when a project's operational life is ceased. By applying circular-oriented designing, fabrication and assembly methods, a structure has everything it takes to turn into a circular product, and its after-life addressment can be done equally responsible by the clients themselves. Thereby, what the latter should do is to ***actively support the exchange of building components*** acting in one of the following ways:
  - By keeping a more 'pathetic' attitude: This means that although they do realize the necessity and increased benefits deriving from circular buildings, they support the

implementation of relevant initiatives up to the point that they are not being hold responsible for the management of building products after the operational phase. Consequently, other parties may claim ownership on these deliverables alongside with the corresponding after-life management liability.

- By demonstrating a more 'aggressive' attitude: In that case the clients do not only care about take back schemes, but they also see an opportunity to make money out of that, either by cooperating with developers on the redistribution of their assets to the market, or by undertaking the role of seller/redistributor completely on their own –following the example of second use markets in the automotive industry-. Of course in order to so, the market needs to be organized in such a way that it will not be hard for the clients to promote directly their products to other potential buyers or users.

6.5 Communication management

Communication is one of the most crucial features for the success of any project, as the human factor is extensively involved in any building-related activity. Despite its great importance however, serious incidents of miscommunication constitute a sad reality not only in the developers-clients relationship but within the companies' structures as well. The main reason why this happens lies most probably on the fact that the construction industry has yet to adopt an integrated platform that spans project planning, design, construction, operation, maintenance and end-of-life management; instead, the industry still relies on bespoke software tools. Thereby, as there is a lot of room for improvement, especially with regards to digital communication, everyone should take the initiatives corresponding to their role and try to bring a change into their field of action.

- **Developers:** Being in the centre of project planning, the developers have a duty to reassure that the quality of communication in all levels remains as high as possible. The problem of poor communication can be even more intense in circular-oriented projects, where engineers try to develop their ideas while working on software platforms which are unable to store, process or present all the necessary data simultaneously. Seeking for a solution, both literature and interviews pinpointed the value that software like 3D BIM, and its anticipated expansion to 5D BIM, could have in the building industry. Despite the criticism on its true maximum capabilities, a BIM-like software that would take into consideration not only details like geometry, structural specifications and aesthetics, but also the developed relations between the building elements, as well as between the building and its direct environment, could be a helpful tool for engineers. Professor Hennes de Ridder, from TUDelft, has already done an extensive research on that topic and his academic work can be considered a source of great inspiration towards that direction.

  In addition, the example of automotive industry seems quite interesting, as extra benefits can be achieved through the introduction of virtual and augmented-reality technologies. The visual and intuitive nature of such innovations can enhance the experience of both clients and engineers, providing them with an "as close as you can get" representation of reality and identifying potential risks and flaws at an early stage. Apparently thus, what building developers should do, is ***invest on the improvement of*** their ***current in-house design and sharing information platforms***, trying to integrate all different software under the shelter of one, while alongside ***extend its range of capabilities***, by including features that will enhance project development, operation, maintenance and end-of-life management.

- **Collaborative schemes:** Moving at the same line as the individual developers, the collaborative schemes should focus on the establishment of common working platforms, guaranteeing that optimum communication and coordination between different departments and colleagues can be achieved. To do so, the cooperating parties need to agree on what may be the most

economically valuable, in-house knowledge-fitting, project-suitable software, which can be the basis on which everyone will have to adjust. Such an approach could be applied on a project level, identifying the most appropriate software tools based on the particular specifications of each individual case. However, it makes even more sense to create a permanent digital environment where the same rules will apply for all projects running under the 'jurisdiction' of the alliance.

Getting inspired by the Recover-E® case, it would be more efficient if all parties were able to communicate within the frames of one and single software, governed by clear, transparent and fair rules for all its members. As, often enough, even partners use different platforms, which do not properly synchronize with one another, causing thus multiple faults and delays, the formed alliances should attempt to ***integrate all their software tools into one*** and ***promote the development of network-sharing platforms*** that will connect all existing communication channels, providing real-time data, easy access and quick control over all kinds of side-information that may be necessary.

- **Public sector:** Driven by the need for circular activities' outspread in a larger scale, the public authorities should also work towards the enhancement of communication among building industry's stakeholders, even when the development of a project does not affect them directly. In other words, it is public sector's duty to promote the idea of circularity by encouraging initiatives that will raise awareness about currently or future available building products, facilitating alongside the necessary procedures for the transparent and credible flow of information to the interested actors. Under the context of an open source data centre, the public sector should strongly ***support the development of public-sharing information platforms***, which will inform clients and developers in real-time about the supply and demand requirements of the market. ***Participating actively in the establishment and expansion*** of such platforms by relating its own needs and activities to them, the public sector should lead the way for an easier and more direct exchange of information, emboldening more parties to do the same.

  As geographical distance highly influences the building components' tradability options, the creation of public-sharing information platforms could also play the role of regional on-line marketplaces –similar to the digital second-hand markets that one finds in automotive or IT industries-. Thereby, by motivating not only building-related actors, but also parties from other sectors, like logistics and transportation companies, to register and do business within such platforms, the local authorities could enhance the development of small beehives, specially focused on the circulation of building products. As a result, transportation costs and moving difficulties could be eliminated, making the establishment of a national second-use trading network sounds easier to be achieved in the near future.

- **Private clients:** The private clients can also get highly benefited by the introduction of common sharing information platforms, as it has already been proved in the Recover-E® case. Besides, the conceptualization of a building's residual value can only be achieved through the use of the proper tools that will allow for constant control over its components' functional state and that will provide the owners with real-time management possibilities; something that is currently lacking from the building industry. In addition, the poor communication between clients and developers is not only detected in the different type of platforms that they may use, but also in a notable lack of digitization, as the management of processes and deliverables is still highly based on paper. Striving for a more efficient administration of their assets thus, the private clients should ask the developers for advanced digital solutions that will grant them the ability to ***exercise the management of their buildings via on-line cloud-based platforms***.

The rapid growth of digital technology nowadays, has introduced the element of personalized accounts in any field people are involve in; from gaming and social networking to banking and trading. In that context, it is also about time for building owners to acquire their on-line real-estate property personal accounts. The latter, being uniquely connected to the assets that a client owns –a whole building, parts of a building or just a couple of specific materials- would provide him the possibility to manage in real-time but also trade his belongings, increasing consequently his interest towards the residual value of his assets and his willingness to turn into the development of circular buildings.

6.6 Circularity management

Crucial element for the implementation of CE is the practical guarantee that building materials, components, systems or complete structures will be able to flow within the market, following all different R-circles. The management of circular building products however, is still an unknown field for the majority of industry's stakeholders, and therefore, its addressment asks for practices that are not common yet, as the prevailing linear economy never expressed the same needs. The provided solutions may vary, ranging from tangible innovations to intangible actions. In that context thus, it is really critical for each party to identify its role within the field of circularity management and take the necessary steps to meet the corresponding challenges.

- **Developers:** The developers are probably the first who should be interested on that field and therefore, they should probably do some extra research on how a potential flow of building elements within the market can be organized, what will be the necessary tools to achieve that, what is already available and what needs to be developed. Nowadays, there is a lot of discussion about the value that material passports could bring to circular-oriented projects. Undoubtedly, the ability to know any material's properties, path of use, real-time performance scores, quality condition and design details would be of great help not only for the people who are responsible for the maintenance of a building, but also for developers who would like to incorporate these elements in their future designs. Surprisingly though, analysing one of the best circular-driven example projects in the Netherlands -the Alliander offices in Duiven-, it was revealed that material passports do not perform well yet. One of the main reasons is, according to Ms Schmull (ex-business developer of TurnToo), the lack of data on the 'history' of materials, as practically no company keeps records on their route once used in a project.

  To deal with that, developers should actually take several actions, aiming at a ***full-scale development of material passports***, meaning a complete system through which an automated identification of materials value at any stage of their life will become possible. An important step to that direction is the co-operation with software engineers and technology producers for the development of devices that will be able to evaluate the state of building components, even when the latter are already part of existing buildings. Looking at the automotive industry, such technological inventions may include, building-suitable thermal cameras, x-ray systems and advanced scanning machines, allowing thus the accurate "reading" of materials' performance and functional limits. The next step then should be the demand for software platforms that will be fully compatible and directly connected to that equipment. All retrieved measurements should be shared, automatically stored and properly classified within the system in real-time, eliminating any manual intervention and subsequently any human errors.

- **Collaborative schemes:** Working in cooperative groups, the developers have even greater opportunities to optimize the management of materials and building components circulation. Recover-E® is a successful functioning example on circular management of IT equipment, and by attempting to adjust its success key to the building industry the alliances should be triggered to

invest on the development of common track and tracing systems. These systems would allow the involved actors to gain complete control over the number and quality of the assets they manage, clear insight on their exact real-time location and availability, as well as constant up-dates in case of unpredictable situations.

Great aid to such an effort can be the rapid growth of Internet of Things (IoT); a reality which has already taken over many other industries. Examining the automotive sector for instance, the providing of sensors and wireless technologies to vehicles enables them to become "intelligent" as they are getting connected with one another. Correspondingly, on a construction site, the IoT would allow construction machinery, equipment, materials and structures to "talk" to a central data platform, capturing thus critical performance parameters. That way, sensors, radio-frequency identification devices (RFID) –which are already used in logistics, transportation and manufacturing environments- and other technologies could help the monitoring of assembly and disassembly processes, material collection and classification, as well as reliability of both stuff and assets. Through the extended use of IoT thus, the development of ***'smart' material databases*** would be also possible, allowing the latter to 'communicate' directly from the site with the competent engineers at the office.

- **Public sector:** When it comes to the public authorities, their main contribution to the facilitation of circularity management does not lie on the co-development of tools and software; that primarily constitutes part of the private sector's business and concern. Instead, the role of public representatives should basically lie on a supporting level, providing all the necessary guidance, consultation and motivation for the optimization and reinforcement of circular processes. Although in other industries, like automotive, most of the changes on that direction derives from norms and regulations imposed in national and international levels, the interviewees of this research almost unanimously agreed on the unsuitability of such practices in the construction sector. As it has been clearly stated, imposing stricter rules could be effective to a certain extent, but creating the proper conditions through the engagement of the public sector on long-term initiatives and reward schemes could be far more compelling to the industry.

  Thereafter, what the competent authorities should do –at least on a national level, if not on a higher one-, is to ***set mid-term and long-term goals*** that will strive ***for a large-scale circularity of building components***, while at the same time, ***directives with regards to the reuse and high value recycle of construction waste***, should be also established. The philosophy of these actions needs to be quite different from the ones that are currently applied in the building industry, where a number of directives and ambitious plans focused on the accomplishment of high recycling scores do also exist. Apparently, what should become absolutely clear is that material recycle is undoubtedly desirable, but only as the last acceptable option; and in that case, extra effort has to be put on the implementation of best practices which will increase its overall value as a process. The main principle of the new goals and directives however should mainly trigger developers to place the reuse of complete building components, parts and products in the centre of their attention, incentivizing them to integrate those elements in all their everyday design and production processes.

- **Private clients:** With regards to the actions that the private clients can take on that field, there are no many options to be discussed; however there is a lot of power within them, as the clients can provide the financial incentive to make them happen. Taking for granted that more and more building owners will sooner or later realize the extra benefits that can be acquired through the real-time management of their assets, that feature should be a basic requirement when communicating their needs to the developers. In that context, and being already "spoiled" from the use of corresponding technologies in other fields, like transportation and telecommunication, the clients should ***ask for the implementation of performance detection***

technologies both within existing and under development buildings, being willing to contract their projects to developers that do offer such services. Obviously, the higher the demand for performance measurement innovations, the more the market will turn to that direction.

6.7 Relationship management

In a circular-driven environment, the cooperation between experts from different backgrounds, productive powers from all levels of the building industry, companies from multiple sectors, stakeholders from both the supply and the demand sides, as well as national and international authorities, seems as a welcomed and desirable necessity. That does not mean however that competition is anticipated to extinct, especially in an industry which is strongly characterized by conflicting interests and high antagonistic attitude. On the contrary, competition will always be present and it will most probably get increased in the near future, being even more challenging, since the clients' requirements will keep rising. Consequently, some attention should be paid on how the new developed relationships can be best handled by each one of the involved stakeholders, how they can be evolved and how that progress may influence the transition to a more circular world.

- **Developers:** The way developers have been addressed at this chapter -noting the numerous actions, obligations and responsibilities that have been appointed to them-, may incorrectly create a false perception that these are the only parties of the building industry' supply chain to act, in order for CE to be realized. That is by no mean true though. The reason why so much emphasis has been placed on their role is because they are currently the leading parties of the supply chain, and as leaders, they have an extra duty to stimulate others by setting the proper examples. Flashing the attitude of "one party does it all" may have a certain success in some cases, but as a general rule, more actors governed by the same mind-set and approach on construction, are necessary in order to achieve better results. In other words, it is not only the developers that have to change, but the other parties of the supply side as well. In that sense it is to a certain extent the former's duty to ***challenge both suppliers and manufacturers in adjusting their working processes to CE principles***.

  The obvious way for developers to challenge those parties, is by cooperating –at least on project level- only with companies that show an increased interest to circular practices and are willing to innovate to that direction. Another way however, is to get these companies closer to the client by increasing the communication channels between them, so that the former can be better aware of the latter needs. In that case, the preferred suppliers and manufacturers should be in place to undertake the development of sub-products and solutions, for the quality and functionality of which they could also take full responsibility. The role of the developer would partially change from that of the classical contractor to an assembler of separate components, systems and technologies, undertaking alongside the role of guarantor for the overall operability and performance of the final deliverable.

- **Collaborative schemes:** Being part of a team comes with numerous advantages and benefits, but it denotes a lot of obligations and commitments as well; and that is something every party should take into consideration before siding with an alliance. In addition, reassuring that a diverse group of companies will always try its best for the common good of the team is a hard task, which requires transparent processes and equal rules for everyone. As the risk of conflicted interests and unpredictable disputes can always fire, fair terms of severance and protection of all sides' rights needs to be established in advance. However, starting an alliance by focusing too much on what can go wrong is not the wiser way to proceed. Instead, developing an incentive-driven set of internal norms can proved to be far more effective. Thereby, it would be smart for the collaborative schemes, to put more effort on the ***providing of alluring bonuses and extra***

rewards for the parties that contribute beyond the expected or settled agreements, trying constantly to be a step in front of the competitors. At the same time though, there should also be no hesitation in the drafting of ***excluding provisions***, functioning as a warning bell for those who underperform or not strive for excellence.

The performance-based evaluation of the participating companies should be conducted on the grounds of both alliance's best interests and clients' satisfaction. Regarding the first aspect, the issue of confidentiality can make the use of external auditors seem quite impossible, as the less is shared with 'outsiders' the better for the synergy's competitive advantage. However, it should not be omitted that in the automotive industry, allocating production activities to third parties is a strategy that is partially used for the free assessment of the automakers' in-house applied practices; and that is a well-functioning example that the building-oriented alliances should try to follow, adjusting it accordingly to their demands. With regards to the second aspect, multi-level assessment possibilities should be provided to the clients, allowing them to evaluate not only the overall performance of the final deliverable, but all the different building products, systems and services that are being developed and provided by the co-operating parties. That way, it will be easier for the alliance's internal auditors to get a more accurate picture on the clients' perspective and incorporate that feedback into the co-designed assessment procedures.

- **Public sector:** The contribution of the public sector in the field of relationship management can be quite important. The already formed ***'green alliances'***, which are established by the common participation of large companies and public authorities, show the philosophy that needs to prevail. The case study of Alliander in Duiven however, gives an extra dimension to that approach, highlighting the added value that can derive from the pursuit of wider collaborations in small-scale areas. Following that example thereby, and, in addition to the backing of synergies between the traditional parties of the supply chain, the local authorities should attempt to engage more potential contributors who lay in the close proximity of an imminent circular project. To do so, the public sector should ***organize and promote "circularity within neighbourhoods" actions*** that will be region specific –where a region may vary from a city's district to a whole municipality- and act as a mixture of guidance and driver force for any project's surrounding parties to aid in its circular development, both through the better exploitation of the region's current infrastructure and the flowing of existing resources. Such incentives, where the participation of private sector will constitute a necessity for their efficient implementation, would also increase the feeling of responsibility and awareness lying among the public, speeding consequently the process of min-set change towards the demand for more circular-designed projects.

- **Private clients:** Moving in a parallel line with the actions that can be taken by the public sector, the private clients have also great power in shaping the relationships with the developers and their proximate neighbours. As proven by the Alliander case, clients and/or investors can define the boundaries of the desired involvement allowed to third parties, deciding thus on the impact that their projects will have on a community level. Hereby, if willing to achieve the maximum potential sustainability and circularity footprints, the first step for the private sector to take, is the expression of a clear preference for exclusive ***cooperation with circular thinking-oriented parties***. That would constitute a definite statement to the whole supply chain that the current working practices are not acceptable anymore and urgently need to be reviewed, improved and adjusted to the new needs. The second step is the ***extension of each project's impact out of its physical boundaries***. This means that –in an ideal circular environment- a project should not be studied as a separate case of circular-oriented venture, but as part of a wider complex of building projects which are interconnected in a regional level and their in-between exchange of resources can add extra value to the whole hosting area.

6.8 Process management

The shift to CE requires the introduction of significant changes in a wide range of currently applied processes. As has already been discussed, those processes include not only the way projects are being conceptualized, designed and constructed, but also the corresponding delivery methods, maintenance practices and buildings' after-life management procedures. The adjustment of all the necessary activities -which have been shaped for the coverage of linear economy's needs-, to the requirements posed by the circular structures, cannot be instant, but instead, will have to go through multiple intermediate phases of experimentation and modification. Hereby, as different acting groups have different roles, goals and capabilities in the development, delivery and maintenance of building projects, it is recommended to each one of them that they pay more attention on those processes that can be of higher value to their specific interests.

- **Developers:** The benefits deriving from the adoption of demountable design and building components' standardization are not the only measures deserving the developers' attention. The construction, repairing and demolishing of buildings include numerous procedures, which are closely bounded to each other and apparently prone to chain reactions in case of changes to some of the prevailing designing and fabrication methods. The principles of CE highlight the need for reuse, which at first place can be achieved through smarter and more efficient design approaches, but at second place also ask for the update of the current repairing techniques. The redefinition of the latter should be in compliance with the demands for materials' circularity, sustainability and waste minimization, and therefore the developers should work simultaneously on the ***optimization of the in-house design and refurbish processes***.

  The accomplishment of the aforementioned recommendation requires the coordinated implementation of several actions, such as the introduction of innovative CAD software, the establishment of processes that will allow more experts to have a say during the design phase and the rearrangement of repairing methods. Hereby, the demountable design approach should not base its development on the current linear-oriented CAD software. Innovation in thinking needs to be applied in the designing software as well, incorporating methods that will be able not only to design in a parametric way, but also to 'read' the interrelations between building elements of previously developed similar projects, 'analyse' their behaviour and 'run' different alternative scenarios that can meet the clients' requirements. In addition the participation of engineers -beyond architects and designers- during all stages of design phase, is necessary, as the accumulative input deriving from different experts can provide solutions that will benefit simultaneously both design and refurbish activities.

- **Collaborative schemes:** With regards to the collaborative schemes, the advantage of common sources and sharing knowledge should lead the participating actors towards the ***optimization of the current remanufacturing and recycling processes***. As previously mentioned, although recycling belongs to the sphere of the desirable processes, it should still be the last acceptable option in a circular-driven environment. That is not only because of the energy amounts which are necessary in order to turn building components into raw materials, but also due to the inherent production time, effort and knowledge being lost along with the former, during that process. Under the shelter of an alliance however, higher investments on all levels can be made for upgrading the recycling techniques, aligning them to the new opportunities that demountable design and components' standardization can offer.

  The research for more efficient material detaching methods and recovery techniques would not only benefit the procedure of recycling, but that of remanufacturing as well. In a partnership where actors from different industries may join, ***the creation of an internal think-tank***, for the promotion of ideas that could make the 'waste' of one industry the 'resource' of another one, is

something that could boost materials' circularity. In addition, the progress of current remanufacturing procedures could be enhanced and accelerated, by the extended cooperation that an alliance can guarantee. In other words, the improvement of remanufacturing processes may not need to be the job of separate actors, but instead, it can be the common effort that derives from the experience and knowledge of multiple parties, blended by a mood of collaboration and innovation, and based on their common goal to make a difference.

- **Public sector:** When it comes to the public sector, its footprint in the field of process management should be primarily based on the creation of a trend, which will motivate both the private sector and the developing companies to embrace it and expand it. To do so, the competent authorities should not be afraid to ***experiment*** with new designing ideas, innovative procurement procedures or pilot building projects that will highlight the benefits of circular buildings in practice, ***setting*** thus ***example models*** for others to be inspired and follow. Of course experimentation and innovation cost money and needs actors who are ready to take some risks; hereby the cooperation with circular-driven parties is considered to be crucial.

  So, does that mean that the public sector will have to become a partner or spend high funds in circular projects? Not necessarily. Although collaboration is an option, the case of Amsterdam's temporary courthouse proves that other alternatives do also exist. The structure of innovative tendering processes for example, can activate the market, leading to economically sound solutions, which can meet the criteria of CE without lacking any functional or safety requirements. The success of such projects could be expanded on other cases as well, setting the tone for public sector's future policy and guaranteeing to the interested parties, that this approach is not a firework.

- **Private clients:** The transition from traditional to integrated contracts has signalled a transfer of responsibilities from the client to the developing parties. Part of those responsibilities are linked to the management of design activities and work supervision, since the contractors wished to have complete control over the final deliverables, and the clients accepted the option of less interference for lower accountability. However, as the examined case studies reveal, in circular-driven projects all alternatives can equally work. In the Park4All for example, the client participates neither in the design phase nor in the site supervision, having a say only in the definition of some details on the delivered product. On the other hand, the role of the client is more elevated in the Amsterdam's temporary courthouse case, where the public party sets the general boundaries of its requirements, leaving their interpretation, design, construction and end-of life management to the winning consortium. Finally, in the Alliander project, the client, in collaboration with the selected developers, took the lead in almost every procedure related to the reformation of the existing buildings, participating actively in the whole development process.

  Examining the nature of the aforementioned projects, it can be noted that in case of product-like buildings, it is reasonable for the client to interfere only partially, without complicating further the necessary development processes. For the non-product-like buildings however, the willingness of clients to leave their mark, can act positively in the final outcome, motivating others to change their business mind-set and consequently their working practices. Therefore, to the extent that this is possible, it is recommended that private clients will ***co-lead the development processes of their own projects***, setting the tone for the way that all involved parties should deal with their appointed tasks.

6.9 Legal affairs

Last but not least stands the area of legal affairs. The transition from linear to circular economy will, beyond any doubts, impact on the way building contracts are structured and construction legislation is fashioned. The contract types of today do not provide the necessary provisions regarding reuse, remanufacture or recycle of building components, while the current framework of rules and regulations that applies to the building industry sets sometimes major bureaucratic burdens to the expansion of circular projects. Hereby, the appointed actors, based on their field of action and their corresponding power to influence the legal aspects of CE, should work on the resolution of existing deficiencies and abnormalities, creating thus an alluring legal environment for the attraction of more circular initiatives.

- **Developers:** The role that developers can play in that area lies mainly on the field of contract design and administration. The aspect of building components' end-of-life management is currently absent from the most common contracting agreements, and the incorporation of the appropriate clauses to address that issue, is a necessity for the contracting of circular projects. Based on their approach regarding the ownership rights over raw materials, building elements or complete structures, the developers should work on the ***expansion of contract terms beyond the maintenance phase***. Why is that? Because maintenance can certainly guarantee the functionality and operability of a project under a reasonable price for a certain period of time, but it does not provide any 'waste' treatment care after that period is over; and that is a key issue for CE.

  So, does it mean that the current contract types should radically change? Of course not. A review of their existing provisions, accompanied by those adjustments that will cover the responsibility and accountability issues related to the management of building components at the end of a project's life, is what needs to be done. Such adjustments do not only refer to the obligations between contractors and clients, but they can be extended to the obligations of suppliers and individual manufacturers, in case the latter are willing to claim ownership over their deliverables. Apparently, in such a scenario, a contract's structure can become quite complex, while the more parties asking for future ownership rights the harder it may be to make a functional and appealing agreement. Hereby, keeping that in mind, the developers should act proactively by thinking in advance for clauses to simplify and group such demands, and by preparing also draft alternatives to be reviewed and accredited by the competent authorities.

- **Collaborative schemes:** When it comes to the collaborative schemes, the main focus of the participating companies should basically turn in the way ownership rights are being internally organized and distributed. As mentioned before, the involvement of multiple parties in the development of building products may lead different actors to claim ownership over their own deliverables, making the reaching of common agreement a hard task to be achieved. The arrangement of such wishes, demands the principal agreement of the production parties, and therefore it seems easier to be handled within the environment of an alliance, where all actors are committed to reach higher levels of consent in a variety of issues. Hereby, partnerships could constitute the best cradle for the ***development of standardized agreement forms, aiming at the fair allocation of building components' residual value*** based on the goals, offers and long-term planning of each party.

  The investment on standardized terms with regards to building components' long-term use, can also save time and money to the members of an alliance, especially during future negotiations with other parties that may ask to join the board, or even during usual dealings with external suppliers and clients. In addition to that, the input deriving from all participating parties may also be used by each actor strategically, when the latter do business with parties outside the

alliance, enhancing consequently their negotiation position and granting them with a competitive advantage on the fields of contract design and management.

- **Public sector:** The public sector, being the only body competent to make and enact laws, is certainly a party that can highly influence the transition to CE, through its official decisions, directives and actions. Its active participation in that effort though, should not be spent on the imposition of strict rules and compulsory regulations that would act punitively for those not complying with the imperative sustainability, waste minimization or circularity standards. As almost all interviewees clearly stated, the production parties should not feel threatened by an obligatory philosophy that they owe to follow, but instead, they should feel inspired and motivated to change, both for the common and their own good. Hereby, if the public authorities still wish to legally interfere in some way, it is highly recommended that they do it with carefulness and discreteness. To give an example of how this may happen, a process where ***different pilot measures are being applied, evaluated on their effectiveness and later on implemented on a broader scale***, could be a delicate approach to follow.

  Moreover, inspiration for extra actions to be taken can be also found on the successful examples of other industries. The concept of extended product responsibility (EPR), which is already promoted in a variety of products -from plastic bags to batteries and vehicle engines- should be studied further by the public authorities, in an attempt to define the most suitable ways for adjusting it to the particularities of the building industry. However, the ***implementation of EPR norms*** cannot work efficiently, if some practical obstacles, which impede the development of circular projects, do not get tackled at the same time.

  One of those obstacles -at least in the Netherlands-, lies on the field of building permits, and refers to the univocal link between the function of a building and its physical location. Apparently, such a legal clause complicates the processes of building products' flow -especially when that includes the transferring of a structure from one municipality to another- and discourages the private sector from investing on circular projects. Thereby, the central government, in collaboration with the local authorities, has a duty to work on that issue, legislating towards ***the detachment of the building permits' function-location bond***.

  Another problem that current developers are dealing with is the uncertainty with regards to the 'suitability' and sustainability standards of currently in-use materials. The possibility that some of them will be considered harmful for humans at some point in the future is always apparent, and this is a factor that restricts both clients and developers from setting long-term goals and estimating the building products' residual value. Once again the state has to interfere and undertake the necessary legal actions that will ***guarantee protection or compensation measures*** to the owners of such materials/building products ***in case of legal changes in waste classification***.

- **Private clients:** As far as the private clients are concerned, the area of legal affairs is probably the one that they can offer the least. The only way they could contribute is pushing for the including of provisions within the contracts, when negotiating with building developers, material suppliers and individual manufacturers, guaranteeing thus the quality state of the delivered products and their tradability at the end of the project's life.

6.10 Validation workshop

The composition, analysis and argumentation of the above presented recommendations are the product of a long-lasting research on both literature and practical case studies. As such, thereby, it is considered by the writer to be a valuable input for whoever interested on that topic. The produced outcome aspires to address circularity through a holistic approach, which lies on the actions that need to be taken by different parties, in a certain number of necessary-to-change areas. Therefore, being willing to test the soundness and validity of the proposed actions, a validation workshop supported by experts from the building industry, was decided to be held. This validation session, organized under the roof of Royal HaskoningDHV, hosted –unfortunately- only a small number of participants; seven in total, from whom only five actually managed to reply on the imposed questions. Besides the sample's insufficiency in number though, the educational background, level of experience, practical fracture with circular concepts and professional field of the attendees, were so rich and diverse that the derived results are still interesting and worth mentioning.

The main goal of that session was twofold. On the one side stood the feedback acquisition, regarding the applied research approach and the value of the corresponding findings, and on the other side stood the recording of the experts' perspective, with regards to the sequence that needs to be settled, in order for the proposed measures to speed up the practical activation of a circular market. Under that context, a short presentation was initially given, followed by an open discussion, where a lot of different opinions were expressed and commented. Special focus was appointed to the aspect of CMF systems and their potential contribution to circularity, as well as to the fields of digital innovation and end-of-life management. At the last stage of the workshop, all participants were asked to assess the proposed measures and prioritize them based on a time sequence. Using the grading scale 1-9, where 1 stands for the most urgent actions to be taken and 9 refers to the less critical ones, the experts had to classify the order of steps that each actor should primarily lay its focus on.

During the processing of the received answers, the 1-9 scale was evened to a 10-90 grading system, where 1 equals 90, and 9 equals 10. That way, an average estimation of each action's importance became possible, avoiding the existence of multiple decimal digits and allowing for a clearer depiction of the prioritization needs. The outcome of this classification is briefly analyzed below, while an overview of the actions' scaling performance can be seen in the next figure.

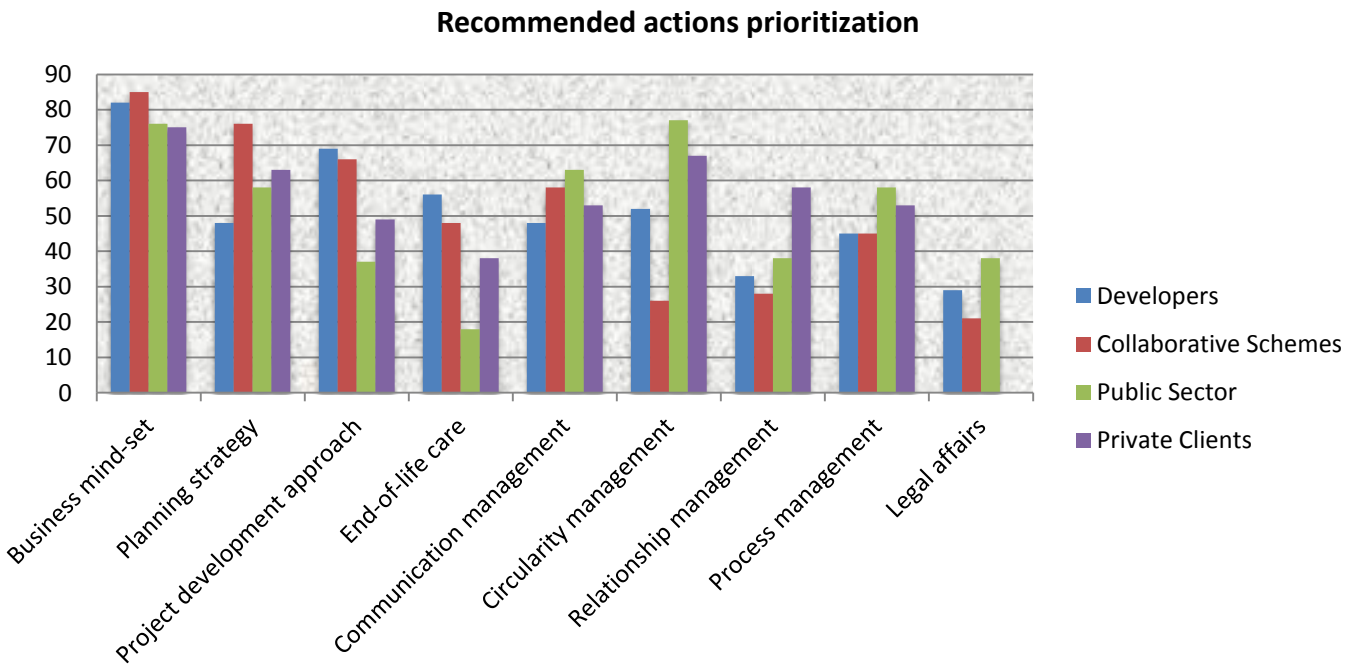

Figure 6.1: The prioritization of the recommended actions as derived from the answers of RHDHV's experts

Main observations

In order to make the prioritization order easier to understand, the above figure was sub-divided in three main clusters, based on the time factor:

- Short-term actions (graded from 60 to 90)
- Mid-term actions (graded from 30-60)
- Long-term actions (graded from 10-30)

As mentioned before, the validation's sample is not sufficient in number, although the respondents' professional prestige and achievements cannot be ignored. However, after assessing the latter's answers, the derived results were decided to be presented and commented for one extra reason: most of the aroused observations are totally in line with the perception that the writer has developed during the progress of this research and the multiple off-the-record contacts with various people from both supply and demand sides.

Short-term actions

Looking at the Figure below, it is more than clear that RHDHV colleagues detect the most critical factor in the field of business mind-set. That sounds quite reasonable, considering that the rationale lies behind all things humans do, and a transition to CE presupposes that all building industry's stakeholders will develop a circular-oriented attitude. Changing perception on how to produce, deliver and consume is not just a matter of short-term action though; it is an endless process that should start as soon as possible and escalate through time, both in number of followers and ways to be achieved.

Following, two other aspects have been highlighted of being equally important; the pursuit of broader common benefits, through the formation of wider alliances between the traditional and non-traditional parties of the construction sector, and the boost that the public sector can offer, through the setting of directives for better management of construction waste and the definition of goals for large-scale building components' circularity. The first aspect confirms the value of collaboration in a circular-driven environment and pinpoints the key role that multi-disciplinary alliances can play in the near future. The second identifies the beneficial role that the public authorities can undertake by engaging themselves in circular-oriented initiatives and motivating thus others to follow.

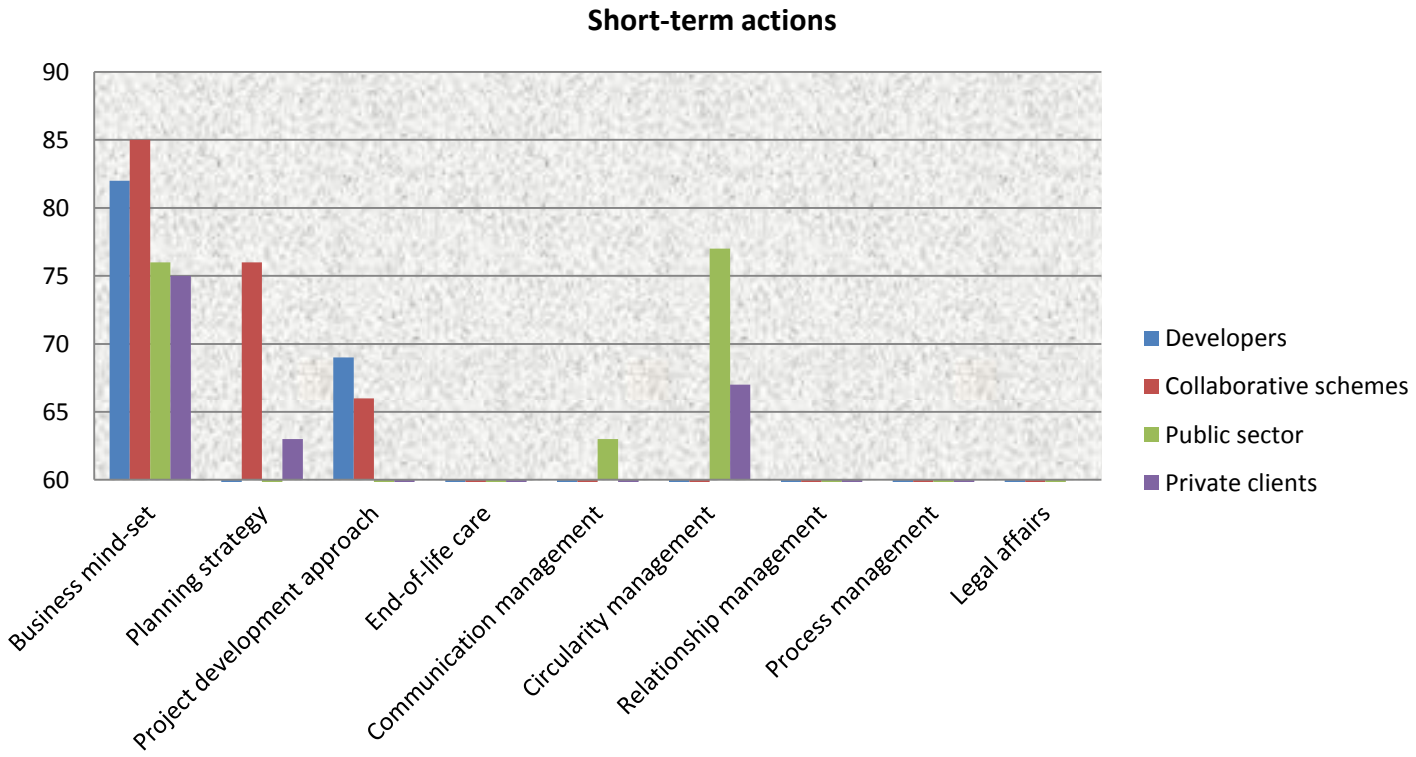

Figure 6.2: The first actions to be taken for the transition to a circular environment

Moreover, some extra aspects that rank high on the list of priorities are closely related to the design and production activities, including higher investment on demountable design and standardized building components' development, as well as further support, within an alliance environment, to the establishment of cross design and manufacturing processes. A reference to the public sector's influential power is once more made, through the active participation of the latter in open-to-public information sharing platforms and the promotion of those communication channels to as many private clients as possible.

Last but not least, with regards to the private clients' role, the experts' viewpoint mainly considers two fields of being particularly crucial. The first one is based on the challenge of the currently used construction practices and project delivery methods, which can lead the production powers of the industry to search for more efficient ways of working, and subsequently new solutions to align with clients' wishes. The second field refers to the request for advanced technological innovations that should be demanded by the clients, such as performance-recording devices, capable to be adjusted within all building products, both existing and newly developed ones.

Mid-term actions

Thinking of the mid-term actions, more than half of the proposed measures (19 out of 35), have been marked by the experts as such. Almost one fourth of them though (5 out of 19), lie closely to the borderline with the short-term initiatives, implying that perhaps more elements can be considered important enough to claim a place in the first cluster. What is really interesting regarding those five actions is that not only each one of them reflects to a different underperforming area, but they also require different parties to act in each case (see Figure 3).

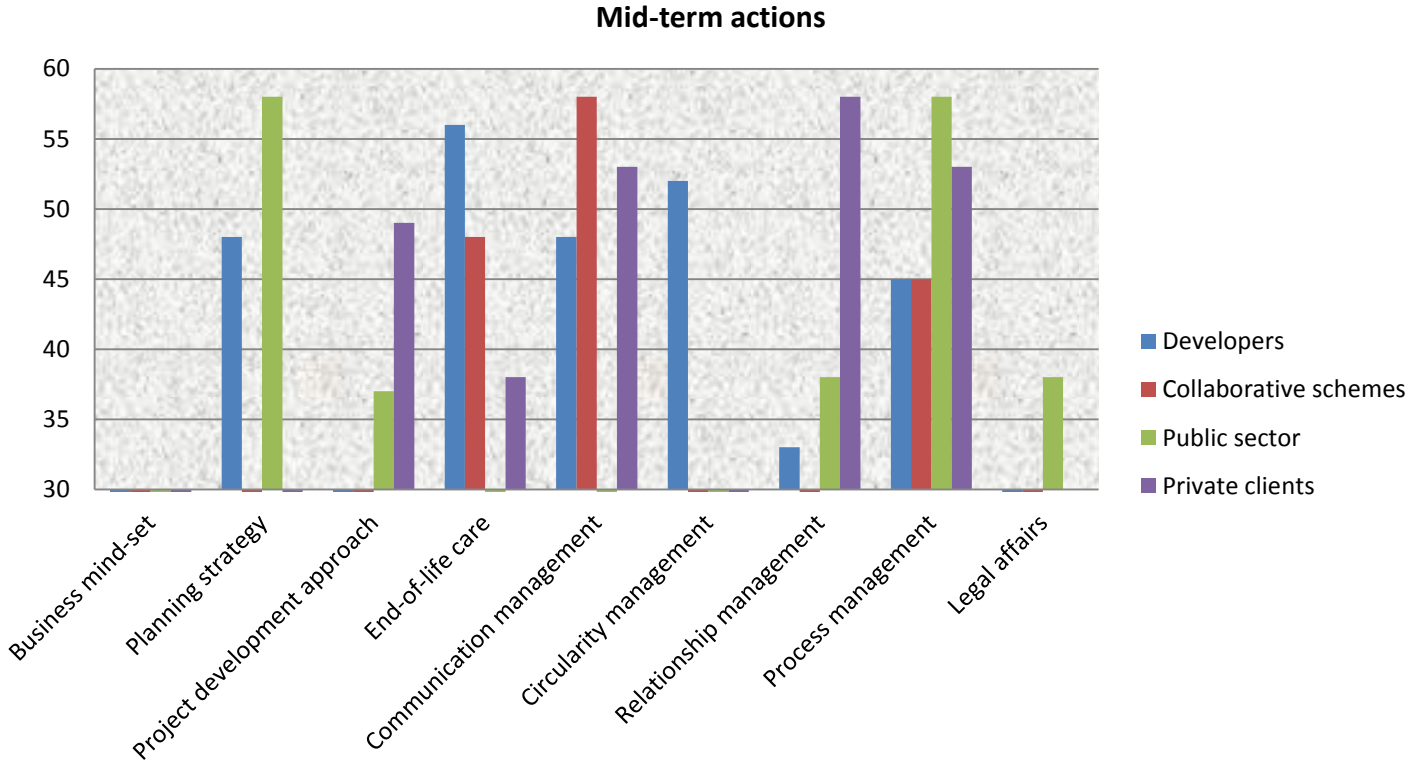

Figure 6.3: The mid-term actions to be taken for the transition to a circular environment

Examining the above Figure hereby, two of its highest ranked actions –getting actually the exact same grade- are credited to the public sector. One of them is linked to the push that the governmental

authorities can give to the industry through the creation of multiple incentives in a wide range of fields. Such incentives include the design of creative tendering procedures where proof of circularity will be asked, the providing of economic subsidies, the offering of tax concessions, and the facilitation of the necessary building permits' acquisition. The second action highlights the importance hiding behind the experimentation with innovative ideas, and the promotion of example cases, which can both act as models for others to follow.

In addition to that, the willingness of private clients to cooperate with parties striving for circularity, is regarded an important element, as besides the benefits that can derive from the guidelines, the example cases and the general attributed credits, the practical support of circular initiatives through investment is what can practically make the industry roll. Moreover, the ability of individual developers to design and apply take back schemes and reverse logistics practices -reclaiming thus the residual value of building products from ending up in the landfill-, constitutes another money-making source, which is also considered essential and quite imperative regarding its implementation.

Furthermore, special interest was appointed to the field of communication management. The "duty" of the alliances to connect and integrate more efficiently all the different platforms which can be found under their disposal, is one of the top rated mid-term actions, pinpointing that way the high importance of clear and sound exchange of information between experts from different backgrounds, disciplines and/or companies. What is also remarkable however is that the "family" of communication management, is the second most rated area in the prioritization scale, following only that of business mind-set. Obviously, this is something that certainly proves the role data and information management can play in the facilitation and implementation of a circular environment. Under that context thus, both clients and developers need to take some initiatives. The former through the demand for on-line cloud based platforms that will grant them the capability to manage their own assets in real-time, while the latter through the further improvement and capacity expansion of their current in-house information processing and sharing software.

As for the rest of the mid-term actions, it worth mentioning that the active participation of the client in the development of circular projects finds also great resonance among the experts' answers, since the co-leading of the necessary processes –as the Alliander case also proves- is expected to have a positive impact on the final deliverable. Quite high on the list –or else to say, urgent- is also the need for more advanced material passports. The full-scale evolution of the latter, accompanied by an appropriate system that will be able to trace and track their history, properties and latest performance, are thought to be features that the building industry should have already developed, applied and adopted in its working practices not too late from now.

On the other side, the aspect that is not stated as being a crucial factor is the intervention of the public sector trough the imposition of obligatory rules and strict regulations. Both the validation feedback and the insight acquired through the case studies' interviews clearly showed that most of the industry's professionals do not believe in legislation-driven changes, but instead, in the providing of practical support and multiple incentives. Contrary thus to what is happening in the automotive industry, where national and international regulations can define its evolution, in the building sector such provisions are not expected to be equally valuable. The legal aspect that could make a significant difference however, is the detachment of building location - building functionality restrictions. The proceeding of some adjustments in the current law provisions with regards to that relationship could eliminate the existing bureaucratic complexities, acting as a burden less for the private clients to seriously consider the solution of temporary demountable structures.

6.11 Towards a circular building components' marketplace

The nature of the recommended actions as well as the experts' validation feedback make clear that the transition to CE is a continuous process, requiring the introduction of smaller and bigger interventions, which may overlap one another, change or re-introduce themselves through the passing of time. All these steps however will not have the same impact on the final goal - the establishment of a circular market for building components- and subsequently will not take the same time, money and effort to be achieved.

Attempting to shape the sequence of that infinite process, and get a better picture on the importance of each action and their corresponding time to get effectively implemented, the approach of Simon Sinek seems to introduce an interesting perspective. Sinek's ideas about "the golden circle" and "start with why" concepts may seem simple in context, but at the same time they are so inspiring that certainly deserve some attention. Hereby, based on his perception –which was also followed by some of the validation respondents during the prioritization procedure-, three main questions can be posed before any decision is made; why, how and what.

Figure 6.4: The "Golden Circle" that should drive the leaders' mind-set as presented by Simon Sinek

Step 1

The 'why' constitutes the principle question. It reflects the purpose, cause or belief that inspires people and businesses to follow a specific path, question the prevailing route, challenge themselves or adjust to new demands. According to Sinek, the 'why' is not about the money or any monetary-related measurements, numbers and figures; it is about our contribution to impact society and serve others. Apparently thus, when examining the steps to be followed for the shift to CE, the 'why' corresponds to the perception people do have towards the prevailing consumption philosophy and the common production practices. And in that sense, the change of mind-set in terms of business rules comes first in the line of interventions for the establishment of a circular building components' marketplace.

As it has already been discussed, a business mind-set shift can be realized through different approaches, depending on the actors, the existing and rising needs, and the potential profit margins. Obviously such a change should start happening as soon as possible, but its broader outspreading is a process that needs time. Therefore, although some actors do think differently nowadays and already try to apply a circular philosophy into their projects, the transition to a circular environment is not a single man's job. Unfortunately, a few individual circular-oriented companies or circular-developed projects are not sufficient to bring the desired change; they can simply be the initiators or the 'bright' examples for a more sustainable world. On the other side though, a coordinated effort among all stakeholders of the building industry could have a far higher impact to society. Thus, that common effort is what needs to take place, translated in a series of actions, the application of which can vary through time.

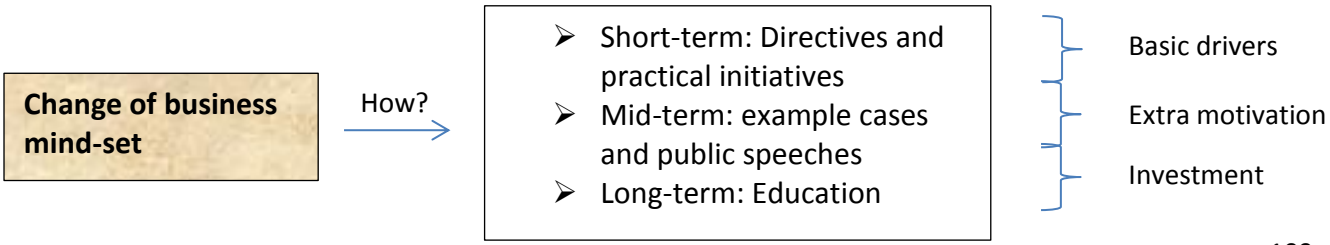

Figure 6.5: The 1st step towards a circular building components' marketplace and how to be achieved

Step 2

Once the 'why' is addressed it is time to ask the 'how' question. Sinek expounds "how" as organizations' or individuals' strengths, values and guiding principles. The 'how' thus can be translated in the processes and methods that need to be applied, in order the 'why' be properly answered and starts getting implemented. As the 'why' constitutes a long-lasting process, 'how' will also include procedures, steps and practices that can be applied in different time slots, varying from short-term interventions to long-term visions.

Briefing the research's outcome, the first group of actions with regards to 'how', should be focused on the further developments of demountable design and standard building components. As structures should be flexible in terms of offered spaces and services, the ability of easily assembled and disassembled building components, accompanied by a certain level of standardization, should constitute the field of core business for more and more companies in the years to come. Some of them may do it already, but as has already been said, it is the power of broader cooperations that can actually bring the desired change in a large scale. Hereby, the idea of extended alliances that will allow for higher investment on R&D, while sharing resources, equipment and knowledge, sounds as an alternative that deserves to be further examined.

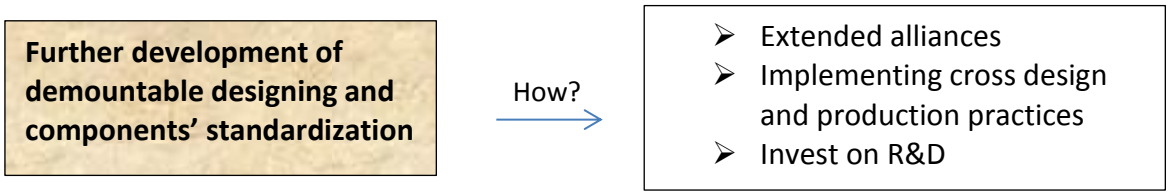

Figure 6.6: The 2nd step towards a circular building components' marketplace and how to be achieved

Step 3

The second group of 'why' actions, which can obviously start on parallel with step 2, should aim at the improvement of communication channels and their overall management. When almost all building projects are highly based on the human factor, the flow of information is a crucial aspect that asks for better and more complete solutions. Surprisingly, the field of communication, besides the significant progress that has been achieved the last couple of years in terms of computer software development, still has a lot of room for some quite important changes to take place. In that context, the increase of digitization with regards to processes and activities which are still being managed through paper-based methods, as well as the introduction of IoT, can highly aid the field of communication to expand its possibilities faster and further, contributing to a more direct and valuable exchange of information among all stakeholders.

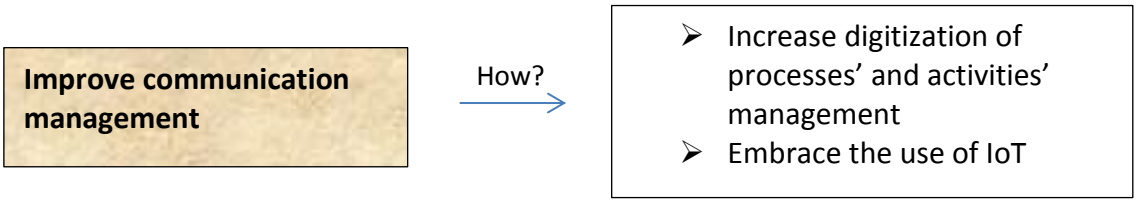

Figure 6.7: The 3rd step toward a circular building components' marketplace and how to be achieved

The turn to an era of extended digitization can be also translated into a more efficient integration of the various in-house software used by different companies, while the new horizons that the IoT opens to the building industry, can be reclaimed in practice through the development of performance measuring and

recording devices. All these cuts in technological progress are directly related to the 2nd step, as the collaboration among actors of both the building and non-building industry can facilitate their realization and practically support the optimization of the final deliverables.

At the same time, acting as facilitators, those technological novelties can aid to the full-scale development of material passports, through the real-time recording, storing and sharing of performance data. In addition, being equipped with applications that will provide a safe estimation for the 'path of use' that each material has been through, the assessing of materials which already constitute building elements of existing structures will be possible. Thereby, overcoming the shortages in ways and methods to retrieve information regarding the properties and the quality status of the currently in-use materials, the problem of insufficient data for the proper structure of material passports will belong to the past.

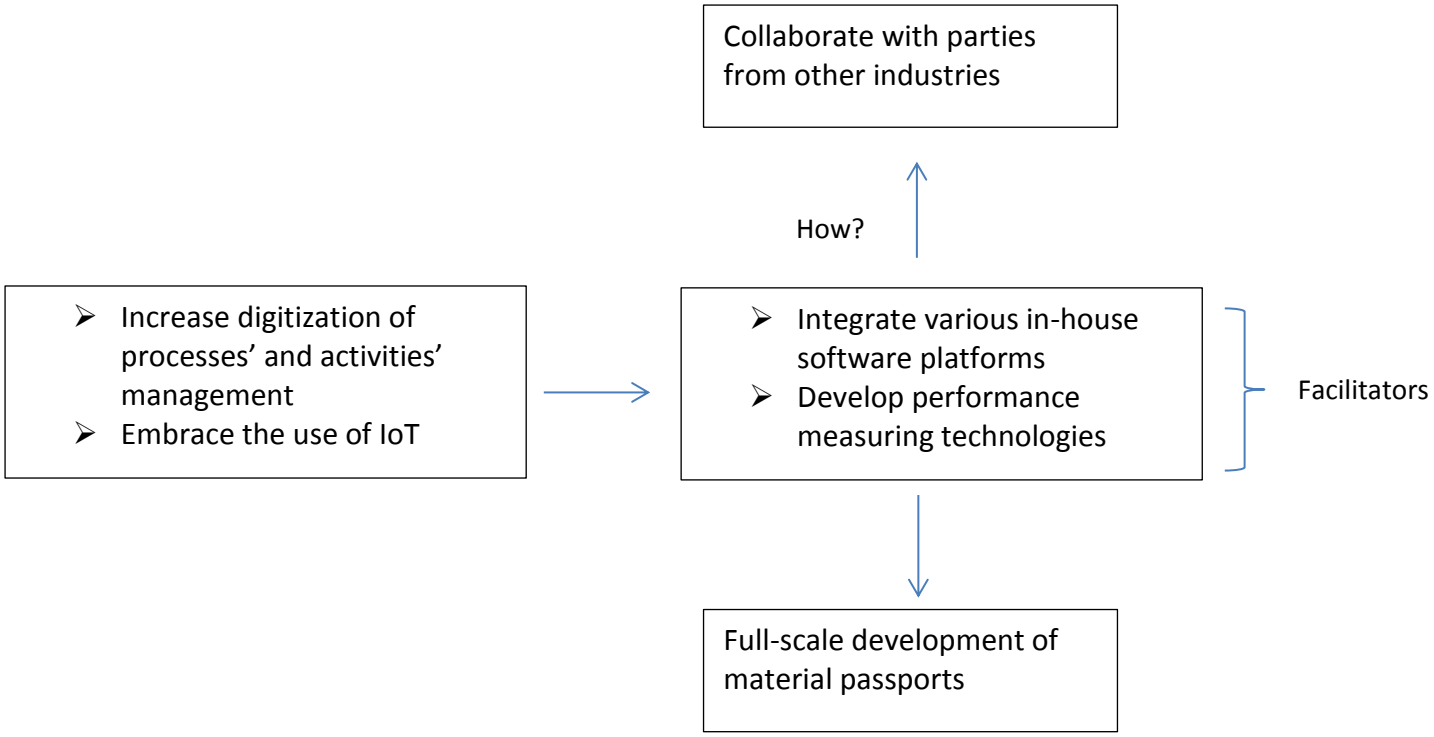

Figure 6.8: Increased digitization and IoT can thrive through alliances, answering issues which are currently hard to be managed

Step 4

Once 'why' and 'how' have been properly identified and answered, the 'what' remains to be addressed. That question corresponds either to the expected final deliverable or the means that need to be used for the desired outcome to be achieved. Looking thus into the current research's subject, the 'what' can be aligned with the providing of an on-line marketplace that will support, facilitate and enhance the function of an actual market for second-use building components. In that sense, a digital space where all kind of services will be provided, including 3D designing and virtual reality representations, assembly and disassembly activities, transportation and storing possibilities, as well as legal consultation and bidding procedures, should be created. A draft example of such a platform and its hosted services, accompanied by the role that all potential stakeholders will need to play, is presented in the figure below.

Online market-place

3D real-time depictions

Collaboration between architects and structural engineers with software developers and IT specialists

Free research possibility

Self-done by owners or appointed to professional engineers.

Evaluation services

Self-done by owners or appointed to professional engineers.

Record performances

Collaboration between different backgrounds' engineers, academic institutes, software developers, IT specialists and product developers.

Transportation and storage services

Empowerment of new actors: logistic and transportation companies; collaboration with engineers, software developers and IT specialists.

Bidding process

Self-done by owners or appointed to professional engineers; enhanced roles for contract managers

Figure 6.9: Representation of the way a digital marketplace for second-use building components is expected to function, through the depiction of its embedded services and copetent stakeholders

Process overview

Summarizing the process steps for reaching a second-use marketplace for building components the following table is drawn. Apparently, the most crucial actions should be able to answer the questions of why, how and what, and if addressed concisely, they could boost circularity in the near future. In the meanwhile, less critical factors, like the legal aspect, also need to be reviewed, with some premature thinking on their contribution and impact taking place or even being practically designed and implemented, as side-supporting steps.

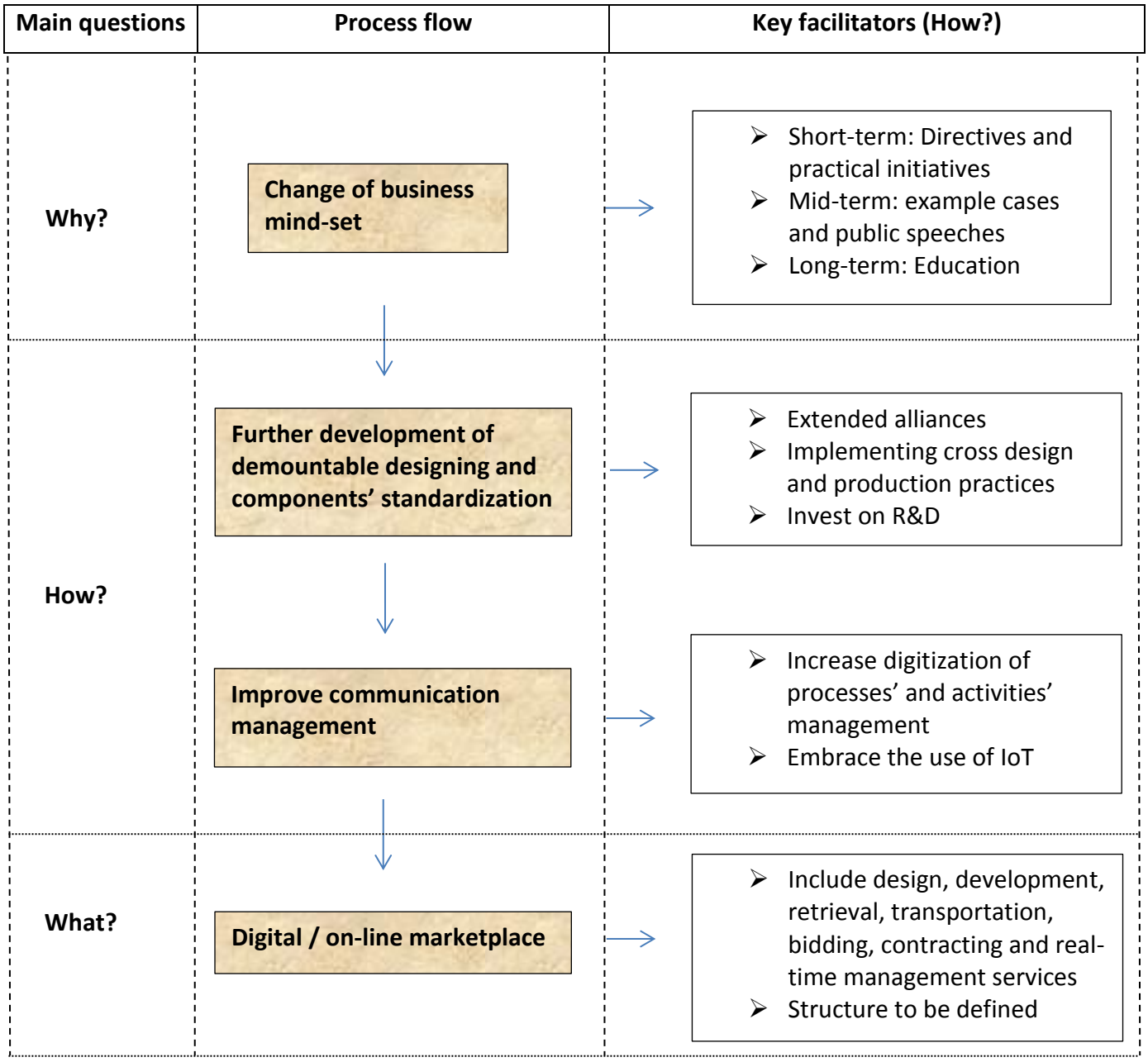

Figure 6.10: The 'path' towards a second-use marketplace for building components

7. Conclusions

The shift from linear to circular economy, although being discussed within both the academic community and the building industry for more than two decades, remains still a “hot” topic for researchers to work on, due to the anticipated high benefits that can bring to society. Unfortunately however, it also remains far from being vastly applied in the construction sector. As technological innovation is progressing rapidly though, the human capabilities in any field of business activity rise at a very fast speed, leaving us no more room for excuses when it comes to driving our production and consumption habits towards the direction of CE. Under that context, the principle goal of this research was to map the road towards the establishment of a second-use market for building components. Therefore, the setting of the main question was followed by five sub-questions, the answering of which would hopefully lead to a clear picture regarding what needs to be done. In this chapter thus, each minor question is briefly addressed, before the final answer to the basic inquiry is presented.

1. *How are the projects in the construction industry being organized nowadays?*

Once referring to the organization of projects within the construction industry, special attention needs to be paid on two main areas; the existing governance modes and the most common contract families. With cost being the key driver for the organization of building activities, the transaction cost economics (TCE) analysis classifies two main types of governance: market and hierarchy. However, other elements do also play a role in the arrangement of construction practices, and therefore a third category - the network - is also widely accepted. Interesting thing is that the last mode, contrary to the first two, does not base its philosophy on cost, but instead, on the concept of value, where the latter can actually reflect to more aspects than just monetary-related features.

With regards to the legal aspect, a wide variety of contractual agreements is currently applied within the construction sector. Based on the way that relationships among stakeholders are shaped, including the allocation of responsibilities and liabilities, the sharing of costs, risks and profits, the level of control by the client’s side and the type of cooperation between the contracted parties, four main contract families can be appointed: the traditional contracts, the early contractor involvement agreements, the integrated contracts and the partnerships / alliances. Each one of them comes with its own advantages and disadvantages, and it was developed to address specific demands of different eras and cases, as the complex and multidimensional nature of building projects cannot be covered by a single contract type.

2. *How CE is addressing the aspect of circularity in the construction industry in theory and what happens in practice?*

The principles of CE have been quite extendedly the subject of discussion, commenting and argumentation on a theoretical level. The need for the development of practices which aim at the retrieval of materials is crucial. However, as the majority of the buildings nowadays are not designed with a circular orientation, the value of flexibility and adaptability are highlighted as of major importance. Under that context, the concept of shearing layers can proved to be an interesting aspect to be taken under consideration. By dividing a building in layers, based on the average lifespan of its bigger components, the former can be addressed as the sum of different elements. When these elements are integrated all together they do function as a unit, but when they are no more useful to the client/user, they can easily stand autonomously and be renewed separately from their fellow

elements/components/layers. The concept of shearing layers hereby can change the common perception about buildings and how the latter should be developed, but till now only a small number of projects seem to have incorporated and express that approach.

In addition, what theory may not present in such a clear way is the difference between flexible and circular building. The first one refers to a structure that has the capability of being easily modified and adjusted to changes, both in terms of tangible and intangible requirements. Reflecting to the technical possibilities of making a building adaptable to dynamic situations thus, flexibility constitutes a precondition for a circular building to be realized. On the other hand, a circular structure needs to fulfill all necessary requirements for riding the 3R (Reuse, Remanufacture, Recycle) cycles, including the overall addressment of technical, organizational, economical and legal aspects. And nowadays that may happens in a few individual cases, but it is definitely far from happening in a large scale.

Finally, investigating the way value should be created, delivered and captured within a circular environment, three main types of circular business models have been identified; the Circular Innovation Models (CIM) focusing mainly on the development phase, the Circular Use Models (UCM) focusing on the use phase, and the Circular Output Models (COM) focusing on the after-use phase. The transition towards circular business models requires systematic change, because the current system does not allow for the required behavioral change to be applied.

3. *What can be learned from building projects or other industries where CE principles are already applied with a certain level of success?*

The automotive and IT industries are two of the most circular-oriented sectors, as various initiatives for the restreaming of used products in multiple channels are already applied. Although optimum use of material resources and energy may have not yet been achieved, the progress towards that direction is continuous and impressive. Thereby, example cases deriving from those fields can provide us with useful information on how to address products' circularity. The same can happen with the building industry as well, although in a smaller scale, as the currently circular developed projects are not high in number.

Studying the automotive industry, what makes the biggest impression, is the extremely high percentages of funds, spend on R&D. The investment on new materials and the implementation of demountable design and production processes help automakers to retain high quality of standards while creating vehicle parts that can easily flow in a second-use market, stretching thus the value of each component. In addition, the shift to reverse logistic practices and the large-scale retrieval of vehicle parts for refurbish, remanufacture and recycle purposes, enhances circularity and eventually attracts clients to become also part of this new 'reality'. The benefits that can be gained by the formation of coalitions with their traditional competitors are also under examination, as cross design and cross production methods seem to be quite lucrative for those who already apply them, embracing alongside more models for future development, under a specific group of basic common sub-products.

The IT industry on the other side introduce ways and methods to enhance circularity through what it does best; the development of software and hardware technologies, which facilitate the flow of data among all interested parties. Key aspect of Recover-E -an example used from the ICT sector- is the creation of a track and tracing system -the LogIT-, which registers all ICT equipment, recording in real-time their performances and quality status. Next to that, the development of a shared information platform accessed exclusively by the involved parties, grant the products' owners the ability to efficiently locate and manage their assets, optimizing thus their use. The platform's impact though does not stop

there, as at the same time it promotes the cooperation between ICT manufacturers and recyclers by introducing the concept of 'designing for recycling'. That way, the Recover-E Foundation, facilitates the direct communication between the two ends of the production and recovering cycle, while alongside it expands its own businesses in more fields, including not only maintenance and recovery services but also remanufacturing and remarketing options.

Finally, as far as the lessons that can be drawn from the building industry are concerned, the aspect of demountable design and material innovation stand once again from the crowd, coupled by some interesting observations with regards to ownership claims. Contrary to what is strongly proposed by the literature, the leasing of materials, especially in an early stage –meaning that the ownership is claimed by the suppliers-, was not the case in any of the examined projects; and still all of them can be characterized by a high level of circular behavior. Of course, leasing can be an option, but it should not be underestimated that some experts are cautious with regards to the decision-making freedom that such an option can provide them with. Moreover, although the 'one actor does it all' approach can achieve the desired results in a sufficient level, in the cases where bigger cooperative networks were developed the results are even more impressive, as the impact of the CE philosophy affected more actors and created new professional horizons to some of them.

4. *Based on the current findings what actions should be followed in order circularity of building components to be realized in practice, and how are the involved actors expected to be affected?*

The combined analysis of the literature and the examined case studies resulted in the identification of those parties that have the most power and/or highest influence to initiate changes within the building industry, as well as in the definition of the areas that a smaller or bigger change can constitute an important driver towards the shift to a circular environment. Under that context, a table consisting of 35 actions (see Table 6.1) was developed, anticipating to provide a holistic answering to the issue of building components' flow in all 3R circles. A detailed presentation of these actions is provided in chapter 6, introducing general and concrete ideas, and highlighting thus the path that building industry's actors need to follow.

With regards to the relationships among the industry's stakeholders some significant alterations are expected to take place. Following the impact that the aforementioned actions will have on a series of building-related processes, including development, delivery, recovery and reprocessing activities, the traditional contractors, architects and engineering consultants will probably no longer represent such a big part of the market compared to nowadays. The main reason for that lies on the expected rising of hybrid engineering companies that will be able to combine engineering knowledge, fabrication capabilities and investment capitals, being hereby able to proceed with the complete development of their own building products. Moving at the same line, the manufacturers and suppliers who are eligible-to-changes and willing to innovate are expected to improve their position into the market, as the demand for circular-oriented partners will be more and more intense. This trend, in combination with the continuously rising complexity of clients' needs, will also contribute in the flourishment of several start-ups that will be focused on the development of product-like solutions, with the latter being able to be used either as adjustments to other building products or as independent building side-products.

Besides the current actors of the building industry however, new parties are expected to claim a place in the circular market. As extra needs in transfer and storage of building components will occur, logistic, transportation and storing companies can turn into essential or even crucial stakeholders of the industry's spectrum. Companies from other sectors -especially IT and automotive- is quite possible to

enter the building market as well -some of them are already trying to do it-, but the feeling of this research is that the success of the former can only be realized if they attempt to create wider partnerships with the traditional actors of the construction sector. Through the establishment of such alliances the construction knowledge will be coupled with the expertise of digital services, resulting in more complete and optimized solutions.

Finally, as far as the local and governmental authorities are concerned, a double role is appointed to them; the guiding settler, meaning the party that consults and aids others on how to act circular, and the launching customer, motivating in practice the industry to start implementing the CE's principles into its projects.

5. *What is the experts' opinion on the proposed recommendations and their potential practical implementation?*

Through the organization of a validation session, the opportunity of recording and studying the experts' feedback on the conducted research was presented. After confirmation of the proposed actions' soundness, the experts were asked to make a prioritization of steps, based on the importance and urgency of the latter for a second-use market of building components to be implemented. The approach followed by some of the attendees in order to proceed with that request, was based on the ideas of Simon Sinek about the "Golden Circle" and "Start with Why" concepts.

The resulting input clearly depicted that the path towards a circular market is a long-lasting process, which should start with a shift in the business mind-set of all participating actors. That first step should address the 'why' question, attempting to identify the purpose and deeper meaning of the change that is required to happen. The second step can be detected in the further development of demountable design and standard building components, which partially responds to the 'how' question. The 'how', aiming at the identification of the methods to be applied in order 'why' to take shape, can be fully answered after the realization of the third step, which includes the upgrading of information sharing channels and the improvement of communication management. With 'why' and 'how' being already addressed, the last step for the establishment of a second-use market for building components, is the answering of 'what', which refers to the means that need to be used for the desired goal to be achieved, and can be realized through the co-development of a digital marketplace. The latter would be far more than a showroom or a warehouse to choose building components/materials from. It should be able to shelter under a common platform, all potential services that are necessary to guarantee a building component's performance, state of quality, untouched retrieval, transportation and storage, as well as bidding, contracting and real-time management options.

CENTRAL RESEARCH QUESTION

How to holistically organize project delivery within the building industry in such a way that the establishment of a second-use market for building components can be practically realized, and what will be its impact on the role and in-between relationships of the key stakeholders?

The findings of this research are quite optimistic with regards to the establishment of a second-use market for building components, as the collected data demonstrate that this vision is not a far-reaching dream, but a realistic goal that can be fulfilled in the near future. This optimism mainly derives from the fact that individual actors already manage high circularity scores on project level, setting thus the example for others to follow. However a holistic approach cannot be based on the distinctive initiatives of some circular-oriented unites; it requires the active participation of more actors, coming from both the supply and demand sides. Therefore, the organization of such a market presupposes the willingness of all involved stakeholders to change production, delivery and consumption habits, realizing the consequences that the current irresponsible and unsustainable way of living can bring to this planet.

Identifying the shift of people's mind-set as the leading factor for moving towards CE, a number of relevant interrelated areas need to undergo some significant changes. The current research classifies nine such fields, where interventions are necessary:

- business mind-set
- planning strategy
- project development approach
- end-of-life care
- communication management
- circularity management
- relationship management
- process management
- legal affairs

Apparently, the responsibility of action burdens every single stakeholder of the building industry. The grouping of the most 'powerful' actors, based on their common characteristics, as well as their current and future possibilities of progress, aspires to provide an overview of the path that the former needs to step on. Subsequently, a list of actions is proposed, for which each party is exhorted to think on critically and adjust to their business philosophy. As the transition to a circular market is a long-term process however, the implementation of these actions will not happen simultaneously. On the contrary, some steps will precede and others will follow, while the feature of overlapping will be apparent, since the recommended actions are closely related to each other.

Attempting to define a route to the establishment of a second-use market of building components, a 4-steps process has been drawn, prioritizing the actions of highest importance and impact. According to that proposal the final goal should be an on-line marketplace that will function as a supplementary-to-real-market, multi-tasking platform, hosting a number of services, which are necessary for the construction or dismantling of a building. These services will provide access to building development groups, supplying parties, storage and transportation companies, lawyer firms, auction houses and recycling centers, allowing all interested stakeholders to follow the market's availability in second-use building components and participate in the transaction of building products both as clients and providers.

The analysis of all aforementioned recommendations not only highlights the features that the different groups should focus on, but outlines also the kind of roles and relationships that are anticipated to be developed, as a result of a different approach in the whole development, use and management process of buildings. The examination of theory and case studies lead us to the conclusion that cooperation and business agility are the keys to a circular-driven environment. The role of the traditional production powers is slightly endangered, as the current clients' requirements for performance-oriented solutions, higher digitalization of provided services and better control of assets, challenges the current working

methods. In an era where technology is progressing at a fast speed and new ideas can find more way-outs to be developed, the perspective of joint forces, common sources and shared benefits under the shelter of collaborative schemes seems to match better CE's principles. Therefore, the actors who are eager to co-operate, slip off the mainstream state of things and adjust to the demands of completely different business reasoning are expected to prevail in a circular market. The introduction of 'new players' is not excluded, as product-oriented start-ups and IT-expertise companies are expected to claim a significant part of the market pie. It is strongly believed though, that such ventures can only be successful if partnerships with construction-expertise parties are pursued.

As a closing remark, it should be said that a holistic perspective on CE cannot be formed only through the review of our own actions in a wide spectrum of issues; the understanding and acknowledgment of other parties' role and responsibilities in the same processes are also required. Therefore, each actor should first and foremost reflect on the actions that lie on its own field of core business, knowledge and expertise, trying to optimize their implementation and maximize the total benefits. In addition however, all industry's stakeholders should also study the steps that need to be taken by their partners, competitors and clients. That way it will be even clearer to them what has to be expected by each party, which are the conflicting and merging points, who should take the initiative of certain actions or who can set some boundaries by guiding, consulting or leading the industry. No need to say that looking at the whole picture can help individuals to better identify their role in a circular building market, positioning themselves in the place where can fit them the most.

8. Recommendations for further research

The prospect of a second-use market for building components is a topic which extends in many directions. Consequently, any study aspiring to fully include and sufficiently outline all its aspects can hardly be effective. Acknowledging that parameter and being also limited in time due to the nature of the current research - master thesis project-, the latter's scope was bounded in the field of organization and further limited in the steps, processes and activities that need to be implemented, in order circularity of building components to be facilitated in practice. A path towards the development of an on-line platform, that will serve as a combination of asset management tool and digital transaction center was presented, but obviously, the establishment of a suitable-to-fulfill-that-purpose marketplace requires the addressment of other factors as well. Hereby, taking that into consideration and based on the experience gained in the field of CE through that research, a couple of topics, which according to the writer would be really interesting to further studied, are discussed below.

4. *What would be the impact of collaborative schemes in the internal organization of participating actors?*

   This research strongly supports the formation of long-term partnerships between stakeholders of the construction and non-construction sectors, traditional competitors, start-uppers and potential newcomers. Driven by the successful example taking place in the automotive industry, between Nissan and Renault, it is highly recommended that the production powers of the building industry will also try to apply relevant collaborative schemes, creating perhaps a type of alliance that does not yet exist. Hereby, as it always happens with something new, a number of subjects will need to be further researched before any actions are practically applied.

   One of the most interesting aspects to look at would probably be that of internal organization. As this study deals with the organization of a second-use market for building components, it focuses only on the role and responsibilities that each actor has with respect to the market and the relationships they develop with the rest stakeholders, leaving the in-house structure of all those actors out of the analysis. Apparently, a number of questions with regards to internal organization rise. What would it mean for a company to step in a circular-driven partnership in terms of personnel, knowledge and resources? Does investing in R&D require the creation of separate teams specialized on that field? Or should that happen on parallel with each project? How to communicate knowledge and expertise from partnership's projects to in-house activities? Hopefully, a combined study of the automotive and building industries, through the use of example cases where alliances have already been formed, could provide some useful data to collate, highlighting the arisen problems and potential ways to address them.

5. *What could be the impact of shifting to circular-driven project development methods on the aspects of cost, time and effort?*

   One of the issues that were not studied by this research is the financial aspect of shifting from linear to circular economy. Obviously, the economic parameter is of high importance for all human businesses, and any research focused on the implications of financial factor to the activities of building industry's stakeholders will be extremely useful. Being particularly

impressed by the case of tile-manufacturer in the Alliander project[2], a topic that really deserves to be studied is that of reforming or adjusting a company's usual working practices in order to meet CE's principles. Such an approach demands not only a brave change of mind-set, but also numerous interventions in processes, existing equipment, and even workforce, as maybe the necessary know-how is lacking. Thereby, the searching of relevant example cases, with a primary focus being spotted on the construction industry, would be quite interesting to take place.

Once more, several pertinent questions can be set. How easy is it in practice to change working methods? How is that translated in costs, time and effort? How is a company's workforce expected to react to such changes? Is it wise to invest on circular-oriented working practices before a remarkable demand for such services is apparent? By approaching different actors of the building industry, from suppliers and manufacturers to architects and contractors, some remarkable information is anticipated to be derived. The answers may vary based on the companies' size, average workforce age, core business or willingness to innovate, but their proper analysis and interpretation can provide the market with valuable information on what a transition to circular practices means in terms of cost, time and effort.

6. *What would the introduction of –R (reuse, recycle) factor mean for the structure of currently used contracts?*

The shift to CE can highly influence the status quo of property dominance in the building industry, introducing new schemes of ownerships, and requiring consequently new types of agreements. Under that context, an investigation on the implications that changes of that kind would bring in the structure of contracts, could be really useful. As all currently in-use contract forms do only cover the phases from design to maintenance, having no provisions for reuse or recycling options, it is more than clear that they are totally incapable of meeting sufficiently CE's contracting needs. Hereby, looking at the ways that the –R factor could be incorporated in the latter and how that would influence their structure, is a topic that needs to be further researched. The contact of parties which have already been involved in circular-oriented projects, such as Cepezed or Alliander, could give a first insight on what needs to be included in those agreements, how the current stakeholders address relevant issues and what the problems can be in case of ownership claiming by multiple actors. The analysis of this information can be the basis for the recommendation of specific clauses that will facilitate the negotiation process of circular-oriented projects.

[2] The company which undertook the job of remanufacturing the rooftops of Alliander buildings was not specialized in that task. However, despite the initial rejection and fear of complying with the client's wish, as that was asking for big changes in the way the company was used to do business, the latter finally decided to take the risk and proceed with the development of circular-oriented manufacturing processes, winning not only that contract but also the possibility to extend its core-business to a new level.

References

Accenture. (2014). *Circular Advantage.* Accenture.

ACEA. (2015, 09 01). *European Automobile Manufacturers Association*. Retrieved 08 07, 2016, from ACEA: http://www.acea.be/news/article/circular-economy

Beach, R., Webster, M., & Campbell, K. (2005). An evaluation of partnership development in the construction industry. *International Journal of Project Management*, 611-621.

Bocken, N. M., Bakker, C., & de Pauw, I. (2015). Product design and business model strategies for a circular economy. *Sustainable Design & Manufacturing Conference*, (pp. 1-12). Seville.

Bocken, N., Short, S., Rana, P., & Evans, S. (2014). *A literature and practice review to develop sustainable business model archetypes.*

Brand, S. (1994). *"How Buildings Learn"What Happens After They 're Built.* United States of America: Penguin Books.

Candace, J., William, H. S., & Stephen, B. P. (1997). A GENERAL THEORY OF NETWORK GOVERNANCE: EXCHANGE CONDITIONS AND SOCIAL MECHANISMS. *Academy of Management Review*, 911-945.

Chao-Duivis, M., Koning, A., & Ubink, A. (2013). *A Practical Guide to Dutch Building Contracts.* Den Haag: Instituut voor Bouwrecht.

Cheng, E. W., Li, H., Love, P. E., & Irani, Z. (2001). Network communication in the construction industry. *An International Journal*, 61-70.

Cheng, E. W., Li, H., Love, P. E., & Irani, Z. (2004). Strategic alliances: a model for establishing long-term commitment to inter-organizational relations in construction. *Building and Environment*, 459-468.

de Ridder, H. (2009). *Design and Construct in Civil Engineering.* Delft: Delft University of Technology.

Dubois, A., & Gadde, L.-E. (2000). Supply strategy and network effects - purchasing behaviour in the construction industry. *European Journal of Purchasing $ Supply Management*, 207-215.

Ellen MacArthur Foundation. (2014). *Towards the Circular Economy. Accelerating the scale-up across global supply chains.* Ellen MacArthur Foundation.

ellenmacarthur. (2013, July 24). *Ellen MacArthur Foundation*. Retrieved August 19, 2016, from https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram/the-circular-economy-applied-to-the-automotive-industry

Errasti, A., Beach, R., Oyarbide, A., & Santos, J. (2007). A process for developing partnerships with subcontractors in the construction industry: An empirical study. *International Journal of Project Management*, 250-256.

FinanCE. (2016). *Money makes the world go round (and will it help to make the economy circular as well?).* the Netherlands.

GAO. (1999). *Public-Private Partnerships, Terms Related to Building and Facility Partnerships.* United States General Accounting Office.

Geldermans, B., & Rosen Jacobson, L. (2015). *Circular material & product flows in buildings.* Rotterdam: Delft University of Technology.

Geraedts, R., & Prins, M. (2015). *The CE meter: An instrument to assess the circular economy capacity of buildings.* Delft: Delft University of Technology.

Geraedts, R., & Ruiterkamp, J. (2015). *A Business Case for Flexible Housing; The feasibility of implementing flexibility measures in the housing market.* Zurich: ETH Zurich.

Gyford, P. (2004, October 24). *Phil Gyford's website*. Retrieved June 27, 2016, from www.gyford.com: http://www.gyford.com/phil/writing/2004/10/24/how_buildings_le.php

Hameri, A.-P., & Paatela, A. (2005). Supply network dynamics as a source of new business. *International Journal Production Economics*, 41-55.

Hay, C., & Richards, D. (2000). The tangled webs of westminister and whitehall: the discourse, strategy and practice of networking within the British core executive. *Blackwell Publishers Ltd.*, 1-20.

Huijsmans, T., & Visscher, M. (2010). Te huur: oneindig herbruikbaar gebouw. *Duurzaam Gebouwd*, 40-43.

ING. (2015). *Rethinking finance in a circular economy. Financial implications of circular business models.* ING Economics Department.

Jones, C., Hesterly, W. S., & Borgatti, S. P. (1997). A general theory of network governance: exchange conditions and social mechanisms. *Academy of Management Review*, 911-945.

Lacy, P., Rosenberg, D., Drewell, Q., & Rutovist, J. (2013, April 24). *co.exist.* Retrieved May 10, 2016, from 5 Business Models That Are Driving The Circular Economy: http://www.fastcoexist.com/1681904/5-business-models-that-are-driving-the-circular-economy

Lenferink, S., Tillema, T., & Arts, J. (2013). Towards sustainable infrastructure development through integrated contracts: Experiences with inclusiveness in Dutch infrastructure projects. *International Journal of Project Management*, 615-627.

Mentink, B. (2014). *Circular Business Model Innovation. A process framework and a tool for business model innovation in a circular economy.* Delft: Delft University of Technology.

Perella, M. (2014, March 14). *the guardian*. Retrieved August 15, 2016, from https://www.theguardian.com/sustainable-business/renault-jaguar-nissan-toyota-sustainability-circular-economy

Ping Ho, S., Lin, Y.-H., Chu, W., & Wu, H.-L. (2009). Model for Organizational Governance Structure Choices in Construction Joint Ventures. *Journal of construction engineering and management*, 518-530.

Preston, F. (2012, March). *A Global Redesign? Shaping the Circular Economy.* London: Chatham House.

Prins, M., Mohammadi, S., & Slob, N. (2015). *Radical Circular Economy.* Delft: Delft University of Technology.

Renault, G. (2014). *Registration Document.* Groupe Renault.

Reve, T., & Raymond, L. E. (1984). Organization and governance in construction. *Project Management*, 17-25.

Schmidt, R., Deamer, J., & Austin, S. (2011). Understanding adaptability through layer dependencies. *ICED 11*.

Sebastian, R., & van Gelderen, K. A. (2007). Developing a model to support client's decision-making process on integrated contracts. *Second International Conference World of Construction Project Management.* TU Delft.

Stigter, R. (2016). *Suppliers going circular. An examination of the transition from product-based business models to a performance-based business model in the construction industry.* Delft: Delft University of Technology.

van den Brink, R. (2016). *At your service! Circular busiess model prototypes for a service provider in the construction industry.* Delft: Delft University of Technology.

van Renswoude, K., ten Wolde, A., & Jan Joustra, D. (2015). *Circular Business Models - Part 1: An introduction to IMSA's circular business model scan.* Amsterdam: IMSA.

van Renswoude, K., ten Wolde, A., & Jan Joustra, D. (2015). *Circular Business Models - Part1: An introduction to IMSA's circular business model scan.* Amsterdam: IMSA.

Appendices

1. Interview context

The context of the interviews was focused on the level that the examined projects do manage to align with the principles of circular economy, as well as on the practical steps that they take in order to achieve partial or total materials' circularity. Hereby, the questions were semi-structured in order to guide the interviewee on the topics that were more interested for the research, allowing him/her at the same time to expand his/her field of answering or to get more into details, depending on what each of the interviewees considered as the most valuable aspect to stand at. The interview was consisted of three main parts and it was intended to last for around one hour. Hopefully, at most cases the interviewees had both the time and the enthusiasm to stay longer, providing the researcher with better insight on their personal experiences or ideas.

With regards to the interview's structure, at first a short presentation of the researcher's identity was offered, followed by a brief and concise description of the examined project as presented below:
"*The objective of my research is mainly focused on the organization of a second-hand market for building components, which will not be restricted on the exchange of used raw materials (such as steel, stone and timber) but will expand on and allow for the circularity and trading of functional building products (such as complete walls, floors and ceilings). In order to record the current progress on that direction and get better familiar with the future challenges on that field, I would like to interview a number of professionals who have already got involved in the development of circularly-oriented projects from various industries.***"**

Following, a brief description of the interviewee's background was asked for. That move had a twofold purpose; to confirm the interviewee's experience and knowledge adequacy on the topic of CE at one hand and to provide the researcher with an accurate picture of the former's perspective at the other. Once the professional background of the interviewee was recorded, the second package of questions was coming into rule targeting at one or more specific projects that the former had actively involved in. Although before the arrangement of the interviews a common wall of questions was created for all the case studies, the asked questions were finally found themselves varying not only from project to project, but even with the same case from expert to expert or depending on the flow of the discussion. However, once enough information was collected for a specific project, more general questions were following, aiming to report the experts' point on view on the future of the building industry, the main burdens for applying CE, as well as the actions that need and can be taken within the construction sector in order CE to stop being an utopia.

2. Interview with Mr. Onno Dwars

Name: ***Onno Dwars***	Profession: ***Head acquisition and innovation***	Project: ***Alliander offices***
Group/ Department: ***Volker Wessels Vastgoed***	Years of Service: ***12***	Date: ***18-08-16***

General questions

1. *Could you please tell me a few things about your role and professional experience?*

I am working at the company from 2005 and for –almost- the last 2 years I am performing as head acquisition and innovation. As part of the management team I am responsible for the optimal use of existing and new manageable innovations and the acquisition within Volker Wessels Vastgoed. I have been also involved in logistics and hotel projects and I have dealt a lot with project development as well.

2. *Could you please explain me the nature of your company?*

We are the biggest building company in the Netherlands, even bigger than BAM –which remains the biggest internationally-. We do a lot of concrete and wood structures and we are also focusing on engineering development. In our company we focus on how to strain all our knowledge and technology towards the improvement of building components. At this moment we are developing different projects for which we also do the maintenance, the monitoring of installation and the KPI (key performance indicators) checks. Moreover, by October 2016 we will deliver a number of houses, made by bio-based materials, which will be very sustainable and completely energy independent.
We are also looking at what our next steps should be with regards to circular economy and what should be the processes in order to move more and more towards that direction. Sustainability on the contrary is not a goal for us because we think that building in a non-sustainable way shouldn't be allowed. So to our perception sustainability is not an issue, it is something that is considered to be just normal. There must be a belief actually on a positive energy balance and that is the way we try to make sustainable buildings, focusing simultaneously on the life quality of the user, or else to say on how the user will be able to enjoy his building the most. Apparently, when you focus on performances both for the client and the environment, then you can be sustainable.
However, the circular building is not as simple as we hoped, because there is a completely different business model behind it. You can save money by not using much energy, but making a circular building doesn't save you money. So we have to find new values to make such a concept attractive to clients and thus we have to spend a lot of time and energy in the design. I personally think that in circular economy the design is getting more and more important. Taking energy saving steps is also necessary from a financial perspective and I really believe that there should be norms about the sustainability level of materials. Nowadays although there are labels indicating the materials' eco-friendliness, it is still possible to use unsustainable resources and build, because there are no such norms with regards to the energy consumption of buildings that would make people build in a more sustainable way.

Project-related questions

1. *The building of Alliander in Duiven is mentioned as a circular building. How did you achieve that?*

We made a material passport for the building and we connected it with dbay; a platform for the data collection of materials that are used in the Netherlands. 90% of the materials are reusable and 40% of them have been received from other projects, like the ceiling for instance, some concrete and steel structures from nearby buildings, the clothes of workers –that were used as insulation- and the toilets; all the materials that we could possible reuse, we just did it. We also reused soft wood for the façade while the roof of the building was sent back to the factory in order to be remanufactured properly. All the materials that are in the building have a story.
Something that is also important to mention is that we tried to use as less resources as possible. So we did not only focus on the reuse of materials but also on the reduction of their quantities. We also did a lot of improvements from an ecologic point of view; we placed plants in the interior and we took care of the flora and fauna of the building's surroundings managing thus an even higher level of sustainability.

2. *Who is the owner of the project?*

The contract is DBMO and everything is owned by Alliander. We tried to disconnect the ownership of the materials from the building, but that is quite hard because there are a lot of regulations and other issues which make it quite impossible to finance the construction of a building while its materials are owned by different parties. It is hard in Holland to make financial agreements around a building's needs which people will invest on in exchange of just windows or installations for instance. So if you try to make a building more circular you should also try to transform the whole regulations and financial aspects that surround it.

3. *Which was the main goal of the client in that project? Was circularity at stake?*

The client wanted to develop a model concept that would show that a building cannot only be energy neutral but it can also deliver energy in the surrounding area; and it actually does. They wanted thus to make a showcase on sustainability showing simultaneously that it is possible to build a circular building. To my opinion that is mainly related to their business philosophy and image.

Circular Economy related questions

1. *What are the biggest burdens for implementing circularity?*

One of the main burdens is to get the proper information from the companies that deliver different components -like the façade for example - about the materials and their origin; unfortunately most of them don't have material passports for their products. You see, the middle companies that are working together for the development of a circular building usually don't possess the necessary information and it takes really a lot of time to collect all materials' data. As a company we tried to make a removable building in the context of being able to send the installation back to the installation firm for instance, but we had a lot of problems with the financing because in the Netherlands the rules makes it almost impossible to get a subsidy if you are not the owner of the materials.

In addition if you look at the financing aspects of materials technology, the focus of the companies is not extended in a timeframe longer than 5 years; no one is investing in materials that can be retrieved after 50 years and apparently there is no economic power to finance such materials. So, if we really want to reach circular economy we have to transform the way that companies are making new components, because that is how we can stay align with circular economy's theory of increased long-term materials' value. Hereby we need all types of companies to work together, focusing also on the life aspect of their products. When looking at the design or the technical aspects of a building I think there is a good possibility to make a circular building. The actual problems though lay with the materials' technology and recording, the regulations, the financing perspectives and the subsidies.

2. *Do you think there have to be standard material passports?*

I think there will be standardized material passports and all the building components will be connected with software like BIM or with some other type of software. Thus we will be able to connect the materials and with a design program we will be informed on their performance in real time. That could probably take some time, maybe 10 years, but most of the times technology is progressing faster than we expect. Maybe in 5 or 10 years all buildings will need to have material passports for all their components by law.

3. *Is the development of standard components (Legolization) a way to circular economy?*

Professor Hannes de Ridder supports this theory as applicable for the buildings. The buildings' specifications though can vary quite a lot and I feel that standardized elements of today will not be easily reused after 50 years for instance. I think that 15 or 25 years is already a long period to standardize elements and products. To my opinion there should be more emphasis on the reuse of materials for the development of new products. There are many examples of specifications that change with regards to facades, insulation performance or building aesthetics for instance. If you also take a look at cars, you will see that although there is a willing to reuse wheels –because most of the times they are not damaged despite their long-term use- the design changes so much in a time frame of 25 years that it just doesn't happen. And I think it is the same for buildings. So, what happens in the car industry nowadays is that most of the materials can be recycled and constitute a resource for new products.
In the future a lot of things will change in the building industry. Maybe we will make windows that will be able to produce energy; so we will not be able to reuse the current windows anymore. Of course, especially for the façade of a building we will be still able to reuse a lot of the current materials, and the same goes for other parts of the construction, like beams or doors could probably be reused a lot of times. I guess that this would be interesting from small scale projects but for high buildings, like skyscrapers it might be quite difficult to reuse such elements because everything is different and a lot of changes need to be made.

4. *How can we move to a more circular economy?*

We need norms; rules that will not only state what type of materials should be used but will also ask for circularity certification, compelling developers to prove the level of their products' sustainability. Then there is also the financial part that has to change so that everyone will be assimilated to new business models and the materials will flow back to the manufacturing companies easier. I think these are the fields we need to focus on: regulations, design and arrangement of new business models

5. *Should the government be more active in this process?*

I think that would really help. We can say the market has to change but there will be probably only few cases that this will be able to happen. Most of the buildings are not built by the contractors, so if we really want to change the market we need to change the regulations.

6. *Do you see any changes in the field of building industry's stakeholders?*

I think data of all kind, including material properties, circularity, quality of the building, performances, etc. will be a really interesting field. There will be a strong current towards the collection of data and their connection with the existing technology, the companies and the current working processes. All this information will make it possible to move into more circular buildings. You can see already within our company that there is a small group dealing with the collection of data and their processing.
Moreover, everyone is trying to create more and more sustainable materials so I guess there will also be start-ups focusing on the development of new materials, and even bio-products. Sometimes people say that companies like Tesla, Ikea or Google will enter the building industry but I think that is quite difficult to happen. The reason why it is not easy is because there is more than just making a building. Maybe they will deliver components to other companies or they will make improvements to certain issues, like the collection of solar energy during the summer, its storage and use during the winter. I think there will be more a combination of real estate investors but I don't think there will be any new type of building companies.

7. *How do you see the future of the building industry?*

I believe that there are going to be more concepts which will not remain restricted in the designing of a building but they will turn to the designing of products. Our approach is that we don't need a house designed just as a building but we want to see how we can improve the life of the users. So I guess in the future it will look more like industrial design than simply architecture. I also think that in this concept if you manage to get the right connections then you will deliver the best performances for a building, and that will be the biggest new step to be made; the fact that we don't just make volume of buildings but we create quality instead. There is already an example of 8 parties working together for a building company on the transformation of existing buildings into energy neutral structures. What they do is delivering this type of services where people after a certain period -5 years let's say- may ask for a new performance -a new house skin for instance- for which they pay a monthly fee. We are also working together with the University of Groningen on local hospitals trying to collect all the necessary information in order to improve the quality of the building environment. At the end, you have to do more than delivering just a building.

8. *In case of a second-hand market for building components, who do you think should run the quality tests?*

In the future there will be more and more thoughts about the quality of the products. TNO is doing a lot of research for example on the fatigue resistance of materials and there are already many companies that can run such tests, but I think also engineering firms will be able to test the building components

and provide products' or elements' certifications. It is important though that these parties stay not connected to a building, it is important that they are independent.

9. *Do you think that 3D printing can bring some serious changes?*

Yes, 3D printing and other additional tools can make a difference. At the end of the day I think technology is improving so fast that soon enough it will give as more freedom to make elements and improve our processes in order to provide better performances. I really think that technology will bring new steps in our working methods, helping us to build better life quality. The new materials that are already being designed or that will come in the future will probably have less impact on humans health, making them safer in use (bio-based nutrients will be very useful). In 2007 I started building more energy efficient structures and at the moment we have delivered several projects that produce energy, so I have a lot of hope in that issue and I believe that progress in that field goes faster than we have thought. So, I really hope that the introduction of new materials and the higher quality of new products will help us build better buildings.

3. Interview with Ms. Eugenie Knoop

Name: ***Eugenie Knoop*** Profession: ***Project manager*** Project: ***Alliander offices***

Group/ Department: ***Alliander*** Years of Service: **-** Date: ***05-09-16***

Project-related questions

1. *I was reading at the site that among other materials you even reused textile. Is that true?*

Yes, we did it in a small scale. The clothing of the colleagues who were working outside -like jackets and trousers- and that couldn't be used anymore due to wear, ended up in a factory which makes fabric, and this fabric was transformed into insulation material. However, we only use a small quantity–just for the center building- because the quality of the insulation was not good enough for our buildings. So, yes we used textiles as one of our goals was to be highly positive when it comes to energy balance, but not much as it was not qualitative capable to serve our needs.

2. *What were your requirements towards the designing team?*

First of all we run a European tender. We wrought our five main goals on paper briefly - the tendering document was only two sheets long- and then we put that document on the market, asking not really which specific company but which group of companies instead could help us create the building we wanted to. Our approach was that as far as we don't know exactly what we want -because we are not professionals on that field and apparently we lack the technical expertise-, we need the experts' insight

to guide us. RAU and Wolker Wessels thus, joined together and brought on board companies that think on the same way.

3. *Why did you go for the chosen offer?*

First of all I want to say that it was nice that there were three consortiums willing to design for us and help us make our five general goals more specific. They helped us for instance clarify what we really meant when we were asking for an energy positive project. Was the production of energy by solar panels what we were looking for or was the reduction of energy consumption our primary intention? And we actually set the usage of less energy as our first aim. Then circularity; what exactly is circularity? Or sustainability; what is sustainability and what does it mean for an architect or a building company? So these three consortiums helped us make clear what we want, what we are going to ask for, what is possible or what may be possible. And after those three parties made an offer we selected RAU and Wolker Wessels because of their innovative concepts -like the introduction of material passport- and their interesting ideas with regards to the surroundings.

4. *During the tendering process did you ask for a proof of the circularity of materials after the end of the project's lifecycle?*

No. We didn't ask for it. We didn't even know that it was possible. But RAU came with the idea, which they are still working on. The main idea is that there is a material passport which detects the materials that need to be removed, replaced or maintained and if over 15 years we don't need them anymore, we can downsize them, disassemble the buildings and deliver them to someone else that would be happy to acquire them, knowing already the state of these materials, where they have been used, what they can be reused for, etc.

5. *What was the contract form? Not a PPP right?*

No. And that is because we are not a 100% governmental organization, but more like a semi-public semi-private company. The contract that was selected was a DBM. The financing was done by Alliander and the operation is conducted by us as well. Volker Wessels is responsible for the maintenance.

6. *How was the dynamic between the involved parties? Did any problems come up?*

No, absolutely not, because for all parties this was a great opportunity to build beyond their usual boundaries. What I mean, is that normally when there is a question for a new building or the renovation of a building, the client writes down explicitly what the participant companies must do and what they are not allowed to do. What we did instead is that we stated our ignorance on our exact wishes, presenting only what we were standing for –our five main goals-, and thus providing the experts with the freedom of telling us what we really wanted and how to do it. And after that we made together a great plan, which it didn't happen to be expensive due to the developed openness.

7. *Do you think that at the end the application of a circular design turned out to be a more expensive solution?*

No; not at all. And that is because we incorporated the term of 15 years maintenance. So, we didn't only look for the price during the building phase but we calculated what the costs will be for the maintenance of our buildings within 15 years, and thus I think we managed to do better use of our financial resources. I think it is necessary as a client when you have a goal, and especially when you put new things or new opportunities on the table, to get the confidence that everything will be ok, everything can be maintained properly and stay intact for as long as planned. And we didn't only want to have a great design but the confidence that this design will stay in line with our goals for at least 15 years.

8. *The government parties are mainly cost-oriented instead of value-oriented. So how come you went for the second option?*

As I told you before, we are not exactly a governmental organization, but nevertheless we take our responsibility for the next generations which also have to live here; and if we keep using all the raw materials unwisely that will not be possible.

Circular Economy related questions

1. *Does the government seem to be more prone to move towards circular projects?*

Yeah, I think it does. It is a promise we have made as we have to be more energy independent. If you see, in Holland we don't really produce much of green energy. In Germany on the contrary they have a quite higher % of produced green energy than in the Netherlands, where it is only around 3%. In addition, our network is not designed -and subsequently not capable- to support the transportation of large energy quantities. So if every house within a city was equipped with solar panels, then during a sunny day we would have huge problems in the transportation of energy, as the needed cables should be three times the size of the current ones. And it is not possible for us to put on extra cables. So, we have to find ideas on how we can make that possible; how the communities will produce and provide their own energy. By developing this project what we actually tried to do is to create a showcase for our social environment in order to prove that if we need energy on site we are able to produce it, and actually produce it in a "green" way, being thus completely self-sufficient.

2. *So you wanted to make an example case for others to learn and follow?*

Yes. And that is also why I am here with you today; to share our story with you and to hope that you will do the same with your audience.

3. *How do you see the future of building industry? Is it going to be more puzzle-oriented?*

Yes, I think that this has already started and it is going to be asked more and more. The only difficulty I see is that the designs are going to be revolutionized, so something that now looks cool maybe in 10 years no one will be interested to have it or build it. In our case for example the façades are partially removable and reusable, but over 10 years I can't tell if a client will be still interested on those. So, I am very keen on the reuse of basic materials, like wood, which can be reused without any loss of material. I

think it is important during your building process to pay a lot of attention on the way you assemble all different parts together, without wasting anything.

4. *Does that mean that the design is the most important aspect?*

Yes, absolutely. If you design a façade in a smart way for example the raw material parts will be able to get reused, but I am afraid that for the whole façade that will still not be so easy to happen.

5. *How can we drive clients into a more circular-oriented mindset?*

By asking Thomas Rau to do some more presentations! I think awareness is a really important aspect but what could also be helpful is the setting of rules by the governments on the level of circularity that buildings should align with. What I realized through that project is that there are companies that really want to think in a more circular way and design based on reuse, but when there is no client asking for that, they have no incentive to do it and more important no money to develop their ideas.
If you look at our project for example, we asked from a ceiling company to reuse our own ceiling tiles. The company at first must thought "Oh my god, that is the end of my business; if my clients want to reuse the existing tiles, I am not delivering new ones anymore so that can literally be the end of my company". After the first shock however they realized that this could be an opportunity for them; they just had to jump in to that project in order to gradually change their providing services and not lose their company. And they did it! They are now offering the opportunity to take the paint off, refurbish the tiles and put them back. And that is very important. So, just a small party is now offering reused ceilings and the same is happening for our furniture as well.

6. *How easy do you think it is for companies to change their working practices in such a short time period?*

I don't know, and I don't know if it has to be in a short period, but I think it is necessary for all companies to start looking more carefully to the clients' purposes, understanding their main goals, and find ways to provide the required services while keeping the earth as intact as possible.

7. *Do you think we need any kind of initiator? Should the contractors make the first step?*

I think the clients are afraid as they are not really aware of the actual cost. They think that this approach is very expensive and their not willing to pay for that. But the concept of sustainability being too expensive is far from true. In addition, there are not a lot of example cases. If there were more, the clients would be more prone to try or copy something that has already been proved to work. **So I think that the problem is the client, not the contractor.** In my opinion if you ask a company the right questions everything can be done. You see, before 2011 we were thinking to build a new tower and we were considering all the old parts on site as waste; that was our first thought. But then when we thought again about sustainability, we realized that this was just not right. However we didn't know how to do this and that is why we asked the experts to help us design such way that -if possible- we could preserve everything we had already. **So I think that the first step is the client, the first step is the awareness of the possibility of reuse.**

8. *What do you think about penalties? Could they work?*

Yeah, I think that it is a very good idea because then you have a serious incentive; if you use the wrong materials it will get very expensive.

9. *Which are the main barriers for applying circularity?*

The fact that everything is new. To give you an example; for a façade made of tinder there are usually no specific reports on the flammability of its reused parts, and the person who is responsible to certify the fire security documents has no clue on what is happening with these components. Thus, any interested party has to make its own calculations and reports and that is definitely a barrier to choose for circular elements. To give you another example, in this project we didn't have any proof of the quality of the textile and clothing we used, so we couldn't be sure in advance that they would meet the necessary insulation requirements. Apparently so when you use materials which are not already applied in another building -where you can say if and how they have worked-, then the first time you have to spend a lot of time and effort on inventing everything.

10. *What about the financial aspect? Isn't that a key problem?*

No, I don't think so. I don't think that building circularly-driven is more expensive than building in the traditional way. It only requires a different designing thinking, which maybe takes more time than following the standard designing processes, but I guess it is normal when you dive more into details and discover new things, to take a little bit longer.

4. Interview with Mr. Menno Rubbens

Name: ***Menno Rubbens*** Profession: ***Director & project developer*** Project: ***Temp courthouse of Amst.***

Group/ Department: ***Cepezed Projects*** Years of Service: ***>10*** Date: ***10-08-16***

General questions

1. *Could you please tell me a few things about your role and professional experience?*

I am director of Cepezed Projects; a project development office which is attached to the architecture firm Cepezed. I am an architect as well. I studied architecture at the University of TU Delft. Before that, I also studied Economy in Rotterdam for a couple of years; although I never finished it. Later on, I worked for 10 years as an architect at several firms and gradually I chose to focus more on the initial stage of projects. Hereby, at a certain point I was working as a project developer and so, that is how I call myself now.

2. *Could you please explain me the nature of your company?*

As a company we are a bit of crossover between a contractor, an architect and a project developer, while sometimes we also finance parts of our projects. So we are actually a very hybrid kind of firm. The main number of people that work here, work as architects; the architectural firm employs about 50 people, while within the development company we are about 5. From an organization perspective, the projects for which we take the risks ourselves we always develop them with Cepezed Projects, while the standard architectural commissions are being overtaken by the architectural firm.
The ways we do business vary. We can come up with ideas for buildings and then search for places to develop them but we may also run into a place where we see the opportunity to do something and we invent on that, we come up with a building concept. So, partly we are creating our own concepts by looking for opportunities, designing our ideas and selling them to the clients, and partly we -the architectural firm better to say- also work a lot with the government and other companies for the development of offices, laboratories, houses etc.

Project-related questions

3. *Could you please tell me a few things about the project and your role in that?*

The client is planning to build a new courthouse in the city of Amsterdam. For the main functions of the current courthouse thus, like the courtrooms or the temporary prisons cells, he needs a temporary building. The latter should be very representative, as it is the biggest courthouse in Holland and apparently it is a matter of picture and prestige. So the client didn't want to have just a temporary building that he could choose out of a catalogue; instead he wished for a building that would look like it is not temporary, but at the same time without wasting -or at least reduce them as least as possible- any spare material or money. So what the client also asked for was a design or a proposal that could convince him that was based on the use of the least material. So, when we saw the tender we thought that if we could make a building that would stay there for 4-6 years and then we could pick it up and use it again in another place, then we would not have any material loss. And that is what we did.

4. *Why do you think the client asked for materials' reuse?*

I think because they were just aware about not wasting more material than necessary and respectively more money than necessary. What they really asked for was a temporary building. In the latest stage of the tendering procedure we were three companies. While the concepts of the other two companies looked more like a modular system with small modules or container-like building -which can be a really good approach by the way-, we thought about creating a building; not a temporary one but a real building that could be demounted and built up somewhere else. Actually that is very similar to a lot of projects that we do at Cepezed and to our way of thinking about designing. We always design something that can be prefabricated or demounted, like façade elements or floor elements for example which are not attached to the structure, as they are not welded together or purred with concrete, because in that case when the concrete dries you cannot do anything about it. This way of thinking is very deeply rooted in the design philosophy of Cepezed and luckily that came in handy with the concept of making a building which has to be representative but also easy to be demounted.

5. *During the design of that project did you already have in mind other projects where your building could be applied?*

We designed a building that could be used for different functions; so it can be used as a school, an office, a house or a laboratory. And that is mainly done by making the spans as big as possible so that no many columns are needed. That is actually one of the disadvantages of modular kind of building structures, where you need a lot of columns and smaller spans, as everything has to fit in the trucks. On the contrary, we designed big spans. In addition we made big heights for the ceiling so that in the future there will be more space for the addition of other installation or functions. We actually over dimensioned it so that it will be more flexible in the future. Obviously that costed us a little bit more, but since we will become the owners of the building when the courthouse leaves it, we decided to take the risk of investing more in the beginning, knowing that after 5 years we will have something with more value to us and then we will manage to get the invested money back.

6. *Do you plan to sell it in the form of materials or as a whole building?*

When discussing about the circular building, a lot of people support that we should lease its building's elements; the steel for example, it shouldn't be owned by us but by the steel company instead. We chose not to do that because then we wouldn't be the exclusive owners and we couldn't decide what to do with the building. To make it even clearer, we didn't want to have the steel contractor making a claim over the steel structure after five years, because apparently we don't have a building without a steel structure. That is maybe a different discussion but all this argumentation about leasing ownership in my opinion has nothing to do with circular economy; it is just another kind of business model, which can be very nice, but it doesn't related with circular buildings.
Looking at our concept, we designed a building that can be used with as much as the same configuration that it has now. We are not planning to bring the façade back to the factory for instance, we will use the façade in a new location, and the same goes for the steel structure or the floor slaps. This approach was also different from that of the two other contestants. Part of their concept was to bring back the façade for example, but in our experience when demounting a building, bringing the façade back to the factory, having it refurbished and then using it in another building, is almost always more expensive than making a new façade for a new building. This is mainly due to the transportation and the necessary material adjustments, including repainting and remanufacturing of their dimensions, but it can also be due to the different legislation with regards to material basics.
At Cepezed we think that within actual circular economy, you have to think of buildings as products; not to focus only on the floor slaps as a product for instance, but on the entire building instead and think of how you can reconfigure it in another location by reusing again all its components. That is much more efficient than trying to demount a structure and then redistribute all its separate building materials. This could only happen with materials that are very origin, of high quality and cheap in transport, while the cost and time of refurbishment should also be taken into account as an important variable. Thinking of a building as a product though, will make you add as much value as possible to the product itself.

7. *Is the storage of the non in-use materials an issue?*

Yes, this can be a problem. You really need to storage your materials somewhere and obviously that will cost you money because you usually have to rent a storage space somewhere. For the temporary courthouse however we know exactly when the client is going to leave the building, so we can use that

knowledge -let's say two years in advance- and sign a contract with the next user way before these building components become available. Still though there is a risk on that, which we apparently calculated and included in the price.

8. *Do you think you need to inform the next client for the fact that he will get a product made by 'used materials'?*

Yes, we could do it. However the thing is that the price does not refer mainly to the materials, but instead to the location and the function of the building. Also who do you think that really cares if you have a steel column that is used for five years? You don't say to the client that he will get a building cheaper because it is already used. If the delivered quality is still better than that of some new buildings then he will just pay the price that is right for it, and the price is more determined by the location and the function than by the materials.

Circular Economy related questions

10. *Are the clients nowadays getting more prone to ask for circular projects?*

Yes. At the moment we are working on three such projects. One of them is the temporary courthouse in Amsterdam. Another one is a pavilion in Utrecht; it is also temporary but it has to stay there for 15 years and after that period it will probably need to be relocated somewhere on the site, let's say between 200 and 500 meters away. The third one is a housing complex that we are developing for a client, who wants to use it on a site for 10 years under a temporary permit, and after that period he will probably has to remove it as well. There is still a chance for the building to remain there, but as the client doesn't know it yet, the building has to be flexible for all kind of different dwellings and house sizes.

11. *What is your business model for those projects?*

Our business model is a bit different for those projects because we mainly act as designers and advisors, but we are not the owners of the buildings.

12. *Is it feasible for most of the companies to be the owners of circular buildings?*

Yes, I think it is. You see, parties that are already involved in the building industry, they own buildings that remain attached to the ground and invest on them for a period of 10, 20 even 30 years in return for a renting income. Most of these buildings however have been developed after agreement with a tenant who only has a contract for no more than 5 to 10 years. In other words these buildings are designed with a cash flow in mind of 5 to 10 years, but no further think after the first contract ends. So, at a certain point when the occupants leave the building or the latter needs to get a different function, the owners start getting nervous because they doubt about the resting value of their property. Obviously so, they don't perceive a building as something that has value itself; and that is due to its immobility. If you build a permanent structure on a certain location where there is no demand for such a building after some time period, then the latter is worthless. Even if it has been built with the best materials or following the highest quality standards, no tenancy means no value. Apparently, this is one of the reasons why we need to make circular buildings.

13. What are the biggest burdens for implementing circularity?

Technically it doesn't seem that there are any serious barriers. Maybe there is only one, which can be translated as the invention of a very light floor system. What we did in the temporary courthouse was a new type of concrete floor, but apparently there is still room for that to be improved further and become even lighter. The current floor systems weight around 800 to 900 kilos per m^2 and we should go to a floor system of 100 to 200 kilos per m^2. At the same time though the provided span has to be around 7-10 meters and the floor system has to meet other requirements as well, like being fire resistant for an hour and sufficiently acoustic sounded. So, if someone manages to combine all that into a single system that would be also flexible, then this would constitute the Holy Grail of construction.
The housing buildings in Holland have the highest demands, because the units are relatively small -60 to $120m^2$- compared to the office buildings -500 to $2,000m^2$- and each one of them has to be fully separated in terms of acoustics, fire resistance, etc. Apparently thus if you can come up with a solution that meets the housing industry's standards then you can easily meet the requirements for the offices as well. What we are trying to do on that issue is to make our elements lighter, because that way we will also need no foundations. If we look at parking systems, there are already some structures for which you don't have to make foundations. Our goal is to make buildings that can be 4, 5, even 6 floors high with so light foundations, that we will be able to put them anywhere. Even if they start to tilt, by addressing something underneath the building, like a hydraulic pump which we could pump it up, it will be easy to stabilize the structure. Moreover, the way we now attach buildings to the ground, with large piles and large foundation, is also something that we should try to change and actually eliminate by using different kind of foundation systems.
From a **non-technical** point of view the main problem is probably convincing the banks and the investors not to focus only on the first –let's say 10- years but try to visualize what their building will really worth after that period -when it will be able to be relocated in another place-, because that is an entirely different concept. In Holland the real estate is called "vastgoed", which means immovable property, and in that case we discuss about moveable property, which is a completely different concept. Some people -mainly the investors- keep focusing on the location and this is usually one of the important factors which determine the rent. If the location is not fixed though, then there is a totally different way of thinking. As I said before, we have to see the building as a product, invest on it and use it in a place where we can make money out of it. If that is not the case after some point then we should be able to move it to another place, more profitable than the current one. That is an entire different business concept and way of looking at the real estate. So I think that is one of the biggest challenges; convincing the investors. What we do as a company is talking to real estate investors but also to product investors who are willing to take higher risks for higher revenue.
Another problem which is not much transparent is the legislation, as there are a lot of issues that are not clear based on the current rules. What happens for instance if we make a building today, locate it in a specific place for five years and then relocate it somewhere else -let's say in a different city-, can we still use the same building permit or not? Can we reuse the same building as it is if something changes in the legislation about the isolation values for instance? Right now a housing permit is fixed for a specific building in a specific location. You can have a temporary permit for 10 years, but still for a specific location. Temporary permit can never be longer than 10 years. So if you want something to stay there longer then you need a permanent permit. Otherwise you can also get a temporary permit for 10 years and after its expiration day you can renew it to a permanent one. But the thing is that no one knows what is going to happen after 10 years and answering these issues becomes very confusing for the cities and the municipalities as well.

14. What about the role of the government in all this process? Should more regulations be imposed?

I think the government should be more willing to experiment. But difficulties are still there because the laws are being made by the government, while the cities are the ones more prone to experiment and they should be able to do it. Actually it is possible to some extent, as you can already see some cities that are willing to take more risks and experiment with innovative projects, but it has to be done in a wider scale to realize how it works.
As for penalties I honestly don't think that they would work. In my opinion it would be better if in the building codes it was asked that buildings should be easily demountable or to think of ways that buildings should be demolished after 50 or 100 years, so that materials can be separated efficiently; that would be more useful I think. The reason why I don't believe so much in penalties is that people will look at the changes suspiciously, like something which is dangerous or evil, and they will only proceed with them because they will have to, because if they don't they will get fined.

15. How to trigger circular economy?

A circular building you have to see it as something that can bring you more money than a non-circular; it is a better business model that people should invest in because it is an investment in something that has much longer life and much more value in it; it is an investment in the product itself. You can certainly have a business model with temporary buildings, like tents, that you throw away at the end of their life time. It would be perfectly fine if it was profitable, but that would be very temporary and applicable in really few cases.
When we look at solid buildings however that could be used for all different kind of functions, we really have to go to more value-driven than cost-driven solutions. The building industry nowadays is mainly cost-driven, tending to calculate the actual cost of a product and the expected profit of the producer –as a percentage of the production cost-, before the final price is announced. That has nothing to do with the actual value of the building though, it only says something about its cost. If you buy an I-phone you are willing to pay 700 euros although the device only costs 200; in the building industry that is totally not happening. We maybe have really cheap buildings but they are not very efficient; buildings that are very efficiently-made will be apparently more expensive than the traditional ones. To really apply circular economy in the building industry we need to move more towards value-driven business models and unfortunately that is still far away from happening.

16. Could bringing the suppliers closer to the client be a solution to that?

I think the contractors have to invent more product-like solutions. Most of the office spaces for example that are being built are not so different from each other. The architects have usually their own 'signature' on each building, but for the contractors there is no difference; they just build a building. So, we have to treat them like products, like cars for example. And that is probably far away from the building industry now.

17. So should the contractors be the initiators?

There can be some contractors who can do that, but I think there can also be some engineering firms or architects who can do it as well; however there is no one that you can appoint and say 'he should definitely do it'. In my opinion there are going to be more hybrid companies which will be able to shift

between roles -from contractor to architect or to project developers-, overlooking thus the entire process, which should actually be: design something first and then sell it. On the contrary, what you see now in the building industry is that there is much more focus on selling a building first and then investing time on designing for it. The current approach thus is very different than the way the product market works and I think that the next step in the building industry will be more to think in terms of products; where building products will not be just a façade but a whole building instead.

18. How do you see the future of the building industry?

I think the distinction between architects, contractors and engineers will be much more fluent. There will be typical architects and typical contractors but there will also be companies which will not have that distinction anymore. The latter will have to be design-driven and they will manage to address buildings in a product-oriented way, like vacuum cleaners or cars. They will have some new ideas that will develop and then put on the market, like Tesla cars for example, which although I don't know exactly how many people wanted such a product before it was offered, seems to be a really good concept. Besides, if you compare a building with a car you will see that the former is much simpler than the latter. A car actually is much more complicated and a lot cheaper per m^2. And what is a building? It is just a complex of floors, walls and ceiling. The only thing that becomes more and more complicated within it is the electromechanical installations, but that is also the case in cars. The electronics in a car are getting more and more important. And I guess the same will also happen in the buildings; you will have the structure and then you will get the software that will turn the building into a classroom, a school, a laboratory or a house. That is way far from us; it is probably in the years to come though.

19. Is the leasing of all building components the key to circular buildings?

I don't see why someone would want to do that. If Philips has turned into leasing services, it is because that is a better business model for them, but leasing in the building industry is already very common. Everybody leases a building; someone can be the owner of the building's furniture but not of the entire building. Moreover leasing all the components has nothing to do with the client; the client doesn't care about it. If the façade is broken for example the client wants to contact one person to solve his problem; he doesn't like to call every time a different person depending on what the latter owns. So clients are apparently not interested in the ownership model; that is just the contractor's or the developer's business. If a contractor for example asks from the steel company to remain owner of the 20% of the steel structure, this is because the former will have to pay 20% less and that is probably interesting for him. But again this has nothing to do with circular economy; it is mainly a different business model. You can certainly make a circular building without that kind of things. Most probably is that if you own something you will also take better care of it.

5. Interview with Mr. Bart Hueben

Name: ***Bart Hueben*** Profession: ***Senior advisor*** Project: ***Kromhout Barracks***

Group/ Department: ***Royal HaskoningDHV / NSI*** Years of Service: ***17*** Date: ***08-08-16***

General questions

1. *Could you please tell me a few things about your role and professional experience?*

I have been in Royal HaskoningDHV for 17 years already. I have started as a consultant in real estate housing. If I go one step back, to my studies, I studied architecture and before my graduation I changed to management, so I actually achieved to combine both the technical and organizational insight. In RHDHV I started as a **consultant for housing companies** and I also worked as an **account manager**, representing our organization in the translation of the housing needs for large clients. My main focus was the financing world. I collaborated with all the large financing companies, making their housing plans and defining various projects till 2006-2008, when the financial crisis started and changed that market enormously.
This housing crisis was one of the reasons that I made a shift in my professional activities. A second reason was that by working closely with financial institutions I became more and more interested in financing projects and PPP, examining how bank institutes, engineers, contractors and public authorities can together create valuable projects. Starting with Kromhout –which was one of the first PPP projects in the Netherlands- I got involved in a lot of similar projects. Therefore my role changed more to these kinds of projects, while I also became more and more client-market oriented, doing apparently a lot of account management and **sales management**.
I have been also **responsible for emerging services** or in other words developing new services within the Buildings Business Line for the day after tomorrow, exploring thus what changes we should implement in order to keep being profitable in the next couple of years. After that I joined NSI (New Strategic Initiatives). So, now I am dealing with **contract management, risk management** and **project management** on a higher level, being mainly an **advisor of the financing companies**.

Project-related questions

1. *Could you please tell me a few things about the Kromhout Kazerne and your role in that project?*

In Kromhout Kazerne, RHDHV was the landlord's technical advisor. The landlord was a consortium of several companies, including banks that were financing the project –the total cost was around 500 million euro. The tendering procedure followed a couple of stages and already during the first phase the investors had to provide a number of calculations with regards to its financing aspects. In order to do so, they hired us to help them carry out the BAFO (Best and Final Offer), which constitutes the final bid of the consortium and includes elaborated financial calculations and risk provisions. After our consortium won the tender, a number of deals and contracts between all the involved parties -the financing institutions but also the state of the Netherlands, etc.- were signed.

From our side we made the final risk assessments and after that we were held in charge of monitoring the design and construction of the project. As a company we were not the actual designers; instead we were responsible for the conduction of the conceptual and preliminary designs -which later on had to be elaborated further- and we were also monitoring if the design is being developed as planned, trying to avoid for example any new changes that could be accompanied by higher risks. What we actually had to do was to challenge the detailed design in the context of involved risks and changes.
After construction the operational phase follows for a time period of 25 years, in which profit must be made for the involved parties, so another part of our role is to monitor the project's operation during that period and more specifically check for potential changes, irregularities, damages or discrepancies between actual performance and promised requirements. These checks were held at first every quarter, but now they are held every half a year.

2. *How were the relationships among the involved stakeholders?*

Kromhout is a PPP project and actually one of the first in the Netherlands. Before this, the usual relationships among the parties of the construction industry were quite traditional -like the one between a client and a contractor- and apparently that didn't always work satisfactorily. Within the years there were a lot of discussions about moving to more enhanced partnership schemes. And that is exactly what you can see in Kromhout. A serious investment was done in building and creating good working relationships between the client –the state of the Netherlands- and the contractors - the consortium-. However, not everything worked out fine. What you see in Kromhout is that although there is one consortium -the Komfort-, which is a SPV (special purpose vehicle) there is a clear division in two main sub-companies, one for the design and build of the project and another one for the operation and maintenance. Apparently thus, there is a big interface between design and construction in one hand and operation and maintenance on the other.
In other projects that followed Kromhout, these two parts are getting melted more and more into a common DBFMO organization. The sub-contractor or the company that is responsible for the maintenance for instance will be also present during the design process; something that was less the case in the kromhout, for which the distinction between development and operational phases is still apparent. Even after 2011 –when the operation started- a lot of issues remain unsolved or need to be clarified between these two companies. That is probably because the involved parties were used to a more traditional way of dividing risks, bringing thus over a lot of interface conflicts and risks' disputes. At the end of the date, what was managed to be done good in Kromhout was the partnering between the consortium and the client, but what lacked of success was the integration of design, build and maintenance.

3. *Which was the main goal of the client in that project? Was circularity at stake?*

What is really important in public projects is the aspect of flexibility. Any project should be characterized by a high level of flexibility and adaptability as the client's needs usually keep changing all the time. Moving on that direction, what happened with Kromhout was the development of a number of buildings with the same structure and materials, so that departments' rearrangement or changes in functions can be easily take place if necessary. In addition, within the contract there are provisions for the relocation of workplaces from one building to the other or changes in the security level; something that is already happening at the moment. So what the contractor did was the manufacturing of universal models, like furniture f.i. by using some kind of modular stamps, which make specific products interchangeable

within the same project, although still not designed and subsequently suitable to be used in another building project.
Circularity was not one of the project's goals; flexibility was. However it is hard to say that there was asked a certain level of flexibility. Each consortium had to come up with its own plan that could be profitable for both sides. At the end of the day some of the provided flexibility probably exceeds the client's wishes but as far as it serves best the interests of both sides, it is more than welcome. The high level of flexibility is one of the key benefits–in terms of operation- for the consortium as it is much easier for the latter to adapt the building to the wishes of any other potential clients.

4. *Was flexibility applied in the desired level?*

I think not. In this project the potential flexibility was not actually optimized, mainly due to the miscommunication between the two distinct parties of the consortium -D&B and operation groups. Although the selected type of partnership allows in theory more room for collaboration and solutions' integration from an early stage–for example a bit higher initial costs in favor of lower energy consumption, less maintenance needs or lower adjustment costs- this opportunity was not been exercised at its most.
In fact although there were mostly the same companies that participated in both stages, the people who were involved in the different phases were coming from different departments within the same companies, causing thus some miscommunication among them. It really matters that all participating professionals are able to work as one team; it is about the kind of involvement that is being promoted. You see for example in some projects that during the design phase the leading is being overtaken by the construction and design professionals, while the maintenance experts are being set aside. In other projects however the experts' involvement is much more integrated and f.i. no material decision is being made during the design phase without the approval or consent from a maintenance specialist.

5. *Who is the owner of the project?*

The consortium owns and operates the building for 25 years and after that the ownership will be fully transferred to the client under the specified state of conditions. In Kromhout –as it usually happens with other PPP projects- the client is not the owner of the building, at least for 20 to 30 years; he is more or less the owner of the performances for that period. What the client actually has is the guarantee that the building will perform according to a list of specified standards. The way that this is ensured -including the type of materials, the construction techniques, etc.- is up to the contractor. He is the one who practically owns the elements that deliver the performances.

6. *Any specific observations you would like to make regarding this project?*

First of all, the organizational structure is very important; and subsequently the way you manage to allocate risks to each party. If you succeed in aligning your goals with an earning model that is also profitable for the construction companies then everything should work fine. Otherwise, if the organizational structure does not assign risks and profits to the involved parties in the right way, people will act accordingly. Secondly, looking at Kromhout, the project started at 2008 and till 2006-2007 the client was still formulating his requirements. Of course, when you look at new trends in circularity or sustainability a lot of steps have been made since then. And that is one of the problems with this kind of projects; it takes a lot of time for the specifications to be made and then, when the operational phase

starts, a lot of changes maybe still needed. So, most probably the client will now require different things than he did ten years ago.

Circular Economy related questions

20. *Are the clients nowadays getting more prone to ask for circular projects?*

To be honest **I don't really see circularity to be asked for**; what I certainly do see though is an **increasing demand for performance based contracts (PBC)**. Kromhout was one of the first cases and the performance requirements that were asked for it were actually quite detailed. Nowadays, the trend is to move towards a less-detailed level.

21. *Can the change in demand requirements lead to circularity in the building industry?*

Personally I believe that when you ask for specific performances, like a certain room temperature or a certain level of lightning, instead of traditional building solutions, that is already a step towards circularity. To my opinion thus, circularity is not something that is being required directly from the client's side but it is mainly a solution or a way of thinking from a supplier's, contractor's or designer's perspective who tries to provide innovative and up-to-date solutions.
We are now working on the development of a hospital –running also under a 20 years contract- and one of the main concerns that lay on the client's mind is how to ensure that the hospital will remain up-to-date within that period. So, what you see more often in PBC is that clients require a manner or an approach or tools to ensure that their buildings will stay in line with the market. The current –traditional- way of doing so, is through the conduction of brainstorm sessions once or twice a year, where experts try to come up with new ideas. Apparently in case an interesting solution comes up they will make an offer to the client in return for certain compensation.
However it would be nice if we could ensure project's value and up-to-datedness in a different way. If for example we could go to the sub-contractors and say: you know best what you deliver, you know which are the latest trends in your field, so if there are any new options that could be interesting for us please bring them in. His reimbursement could remain the same by receiving a specific amount of money per year; however in case of an unsatisfactory level of service this cooperation could be terminated. That way I think the first step towards circular thinking can be made because even the sub-contractors, manufacturers or suppliers can anticipate for a long life cycle of the product.

22. *Hypothetically speaking, could a project like Kromhout be developed based on the leasing instead of the owning of materials?*

Leasing all materials for the development of a project like Kromhout is a bit strange, because these barracks are made to serve the client's needs for a long-term; the concept of leasing could only work if the client had no need of these after 25 years. Of course there is a slight possibility that after that period there will be no demand from the Ministry of Defense, but most likely there will still be or at least there will be another organization that will need to host 3,000 or even 5,000 people, so in that case nobody would be happy if some part of the buildings, like the columns or the walls have to go away.

23. *In circular-developed buildings how do you picture the material's retrieval?*

I think it is going to be done by the suppliers. Usually for a contractor this kind of things do not have any value, or at least do not have as much value as they could have for a supplier. Let's take the example of a car park. If the client has tendered a car park for 25 years which after 10 years he doesn't need anymore, unfortunately he will still have to pay for it and apparently an unpleasant situation will be developed. It could be a win-win situation for all parties if in exchange of a specific fee the car park could be removed. The client will save both space and money that otherwise he would have to pay for the next couple of years, while the supplier if disassemble it properly could still be benefited from the retrieval of the materials.

24. *Do current contracts support such agreements?*

I think that PBC is a good answer to such issues, at last when the latter have been anticipated in advance.

25. *How to trigger circular economy? Do we need an initiator?*

The experimentation with new circular ideas, concepts and models, as well as the development of corresponding projects can be driven by the pursuit of a better position or the acquisition of a business advantage in the market, despite the higher initial costs. I believe there probably has to be a party -maybe the contractor- with a vision on how to deliver flexibility and adaptability in a performance level over the years, and I think that this can only happen through subcontracting and easy adjusted-to-changes design. If we do not start thinking that way, it will remain hard to keep changing one single aspect without influencing or changing a thousand others.

26. *What about the role of the government in all this process? Should more regulations be imposed?*

I don't think regulations are the answer to trigger circularity. On the contrary, there is a learning curve on PBC and unfortunately it is really sad seeing that that PBC are not advancing with the same pace as they begun. I think thus that if we just pay attention to and learn from the PBC, circular economy will gradually come into practice.

27. *What is that lowering of pace in PBC development due to?*

PBC work best with long-term contracts and many industries don't have enough confidence to go with such a long-term planning. Public projects can probably fit easily in that context but there are a lot of building types that do not, making them unattractive for the application of PBC. So, the variable of long-term scope is one factor, while a second one has to do with the cost of the contracts. Although there is a discussion about the fact that PBC are more expensive for the client, I personally think that -as has already been proved in many cases- in the long-term, PBC are actually cheaper. To prove this though, a carful investigation of the project's particularities is needed, especially with regards to the expected profits, and that is unfortunately something that is not being done in many cases.

28. *Do you advice your clients towards PBC?*

Yeah! Actually I am a huge fan of PBC. Normally the client is not an expert; so our role is to sort all his wishes and requirements –specific or not-, and then to ask the market for solutions that can better answer these needs. As I have already mentioned, PBC can be the first step to the development of a circular mindset because thinking how to deliver performances in a more professional way, while looking at your competitors at the same time, will certainly lead to more developments. Look at the progress of the monitoring systems for example; the first system were based on the use of Excel sheets, while now on the press of a button any kind of performance can be visible in no time. There is already a lot of progress going on due to these contracts.

29. What are the biggest burdens for implementing circularity?

It is quite important to mention that in PBC the contractor has usually serious difficulties when subcontracting parts of the project, as the integrated risk that he would normally be responsible for is much less than the sum of all the individual risks that each supplier or sub-contractor may come up with, and apparently in that case the cost gets a lot higher for the former. So looking at circular economy, which actually aims at such level of cooperation, if the involved parties are unwilling to limit the number of their risks or accept a higher risk impact, it becomes impossible for the contractor to bear all risks himself. Apparently thus, this is one of the biggest current problems when it comes to making the step to circular economy.
From a money sense it is difficult to convince the client about the added value (with regards to risks). The case now in this project is that the price is already fixed for 25 years and every year you get an index and it is added to it, so the contractor knows what he gets and he has a lots of sub-contractors that he has to manage and I think the main focus now is on lowering this costs and one of the ways to do it is for the contractor to take over that risks and that risk is currently included in the total package right now. Of course partly there is some risks held to the suppliers, although the latter are surely not selected based on their circularly oriented thinking and of course if that was not the case (meaning if the selection was made taken into consideration the prospect of circularity of the provided products) then this would not happen.

30. Is the development of standard components (Legolization) a way to reduce these risks?

Yeah, I think so. But you need to go even further and integrate all the different systems into a single one. You actually have to start thinking of the building as a system from the design phase. It will probably be easier if a contractor or a designing team have already a concept in mind and then try to work towards the development of that concept with regards to the provided solutions that the latter can offer to a client.

31. How do you see the future of the building industry?

It is very difficult to answer that. One the one hand it is hard to imagine that it will not change very radically, especially if you think of this by that perspective –the extended application of PBC mindset-, but on the other hand it has always been this way; the architects for example always seem like they are a different part of the building industry. I think it is so old fashioned, especially if you compare it with the automobile industry, where the design is part of the production chain. In the building industry for instance you don't have a company that is specialized in building hospitals or -to frame it better- a company with a research and development department, supported by a group of architects and focused on the development of x different types of hospitals from which you could just select one and buy it.

Even if this did happen though it is difficult to think that it could work the same way for houses and schools. People just do not like it when everything looks the same.
In addition –with regards to circularity- it is totally different if you have products that you can disassemble and use them again as products or if you have products that you down-cycle enough or recycle them in order to reuse their initial materials for the development of a completely different product. The truth is that an effort is already being done to recycle some materials and gain back part of their end-of-life value instead of just throwing them away, but this is not happening due to some beforehand easy-to disassemble design concept; it just happens because there are companies that managed to come up with proper recycling process.

32. Could penalties on construction waste be an incentive for a shift to circular economy?

In the building industry there are a lot of SPVs that tend to disappear, so at the long term, after 30 years let's say, either no one is practically liable or it is really hard to find out who should be responsible for the demolishing of a building and the processing of the construction waste. Of course you can always appoint the owner of the building, but still the one who should pay for the demolishment may has gone broke and the corresponding liability stays somehow unclear. Hereby at the end no one is responsible. On the other hand you can certainly hold someone responsible during construction; I think LEED and BREEAM certificates already include provisions into reducing waste. In any case, in the Netherlands you have to pay for all your waste, so there is already some kind of pressure towards that direction. In addition, in order to get sustainability certificates you need to optimize your waste disposal process, so I think there are already movements within the building industry and perhaps no more regulations are needed at the time.

33. Do you think that a second-hand market of building components is practically feasible?

I think yes; an idea like that could work. Of course this should probably start in an alternative level and type of buildings and progressively expand to more traditional or complex projects. So, it could probably start with the exchange of furniture, doors or windows –stuff that people could more probably ask for and are not that costly to invest in- and it could be later on followed by other building products that need to be treated in a different way; a façade for example that fulfills its purpose no more or a building's structure -although for the latter the transportation will be a really hard task-. To make all these transfers feasible though, extra effort should be paid on the development of modular designs which can guarantee both easier future reuse of products and increased value of such a platform. As for the initiator of the latter I think it could be a private party that sees an opportunity for profit.

34. Would RHDHV be interested to get involved with building components transactions?

For RHDHV it will be probably difficult because we are mostly a knowledge company, and dealing with things that are mainly money-wise is quite different from our expertise. Thus an investment in tangible products like doors, walls or windows would be quite risky for us. As a quality inspector though –within a network of parties that would finance such a venture- it would be surely more interesting for us to get involved.
Actually, NSI already founds itself in such a dilemma at the moment. We are asking ourselves if we should move more towards the creation of products –meaning that we don't only advice, monitor and manage the development of a project but we are also partially the owners of some of its stuff, like materials or equipment- or if we should focus only in the field of knowledge which already constitutes

our core of expertise. The truth is that if we can guarantee our delivered performance then we will be more prone to a shifting towards business models which are closer to the development of products.

35. *What could be the impact of such solutions in the role of existing and potentially new stakeholders?*

When you start developing something like this, this kind of platforms for example, things will be developed themselves. If no one starts it, nothing will happen. If you think about current roles in a new business model maybe there is no space for them; you actually have to think from a completely different position. In the car industry for example there are no architects; there are instead research and development departments. So you really have to create that platform and find out what and how the new roles would be probably formed. I think it is really difficult now to picture with accuracy what the outcome is going to be. It would be definitely good for the economy to have up-cycles and down-cycles, and probably in the future we will keep moving more and more to that direction, which seems to me as a positive step. If I had to guess though what is in there for us as a company, I would say advising and consulting; and if participating in such a platform, it would probably not be from the suppliers' side.

36. *What could you do as a company to promote circular economy?*

When you look at C2C there are certified C2C products. So as a company we could probably say that we are going to design using such products and we could also set a target of using a certain % of C2C products in our design. The hard part though would still be to find clients that support this kind of design concepts and are willing to invest on these.

37. *How can we change clients' mindset then?*

We should pinpoint the advantages. What is in there for them? What does it matter the most? Is it money? Is it sustainability? Beside all the rest, we should also keep in mind that a building has to look appealing; aesthetics is always on stake.

6. Validation workshop – prioritization assessment

In chapter 6, a brief description of the validation workshop's arrangement processes was provided. As mentioned already, part of that meeting focused on the prioritization of the recommended actions, by the RHDHV's experts. Unfortunately, the attendees who managed to complete that task were only five in number, four out of whom prioritized the proposed actions as asked -through the 1 to 9 scale per column-, while one out of five, due to some misunderstanding, applied the 1 to 9 scale on the whole table, providing thus a different version of evaluation. Thus, in order to better assess the participants' responses, all their answers were added in a common table (see next page).

Recommended actions								
Field of intervention	**Acting parties**							
	Developers		**Collaborative schemes**		**Public sector**		**Private clients**	
Business mind-set	**1; 1; 1; 3**	think in products	**1; 1; 1; 2**	think in CMF systems	**1; 1; 5; 3; 2**	think in services	**1; 1; 5; 3; 5**	think in long-term value
	82		**85**		**76**		**75**	
Planning strategy	**6; 9; 3; 2**	invest more on R&D, new (bio-based) materials and new working methods	**3; 3; 2; 1**	invest on common benefits, shared and integrated resources	**5; 4; 7; 2; 1**	create incentives for the development of circular buildings in terms of tendering, subsidies, tax concessions, permits, etc.	**2; 8; 3; 2**	challenge usual practices and project delivery methods
	48		**76**		**58**		**63**	
Project development approach	**2; 2; 2; 6**	design demountable, standardize components	**4; 5; 3; 3; 4**	work on cross design and/or production	**6; 5; 8; 6**	ask for proof of circularity and waste minimization	**4; 3; 7; 6**	ask for proof of residual value
	69		**66**		**37**		**49**	
End-of-life care	**3; 4; 4; 7; 9**	develop take-back strategies and apply reverse logistics	**5; 4; 5; 7**	centralize and co-manage collection, remanufacture and recycle points	**8; 9; 9; 7**	provide storage and showroom spaces for used buildings or building components	**6; 7; 4; 8**	support actively the exchange of building components
	56		**48**		**18**		**38**	
Communication management	**4; 3; 6; 8**	improve and expand current in-house sharing platforms	**2; 2; 7; 6**	promote and integrate common network-sharing platforms	**3; 3; 3; 6**	support the development of and participate in public-sharing platforms	**8; 2; 2; 7**	exercise buildings management through on-line cloud-based platforms
	48		**58**		**63**		**53**	
Circularity management	**9; 6; 9; 1**	full-scale development of material passports	**9; 7; 9; 5; 6**	development of common track and tracing systems and material databases	**2; 7; 1; 1**	set directives and goals for large-scale circularity of building components and high value recycling construction waste	**7; 4; 1; 1**	request and implement performance detection technologies
	52		**26**		**77**		**67**	
Relationship management	**8; 7; 8; 4**	challenge manufacturers and suppliers in adjusting their working processes to CE directives	**8; 9; 4; 8**	apply extra reward and exclusion provisions based on performance	**7; 8; 6; 4**	create green alliances and promote "circularity within neighbourhoods" actions	**5; 5; 3; 5; 7**	co-work with circular-oriented parties and expand their projects' effects out of their physical borders
	33		**28**		**38**		**58**	
Process management	**7; 5; 5; 5**	optimize in-house design and refurbish processes	**7; 6; 6; 4; 8**	optimize remanufacture and recycle processes	**4; 6; 2; 5**	experiment and set example models of circular projects	**3; 6; 6; 4**	co-lead processes of own projects
	45		**45**		**58**		**53**	
Legal affairs	**5; 8; 7; 9; 3**	expand contract terms beyond maintenance phase	**6; 8; 8; 9**	develop standardized agreement forms for fair allocation of building components' residual value	**9; 2; 4; 9**	implement EPR norms; detach buildings' function-location permit link; guarantee legal protection in case of changes in waste classification	**(-)**	(-)
	29		**21**		**38**		**(-)**	

Figure 6.1: Summary table of the validation workshop's feedback on the prioritization of the recommended actions

The numbers in black reflect the responses of the 4 attendees, who followed the proposed directives, while the numbers in red represent the alternative prioritization approach. For each action an average score of the 4 first answers was calculated, adjusted to the final ranking by the addition of a the 5^{th} answer under the rule of a weighted factor. The final outcome for each action, which also defines the sequence that should be followed, can be found in the “one-number boxes”, right below the separate scores. Dark purple boxes represent the necessary short-term steps, medium-dark purple boxes reflect on the mid-term actions, while the light purple boxes outline the less urgent actions to be implemented.