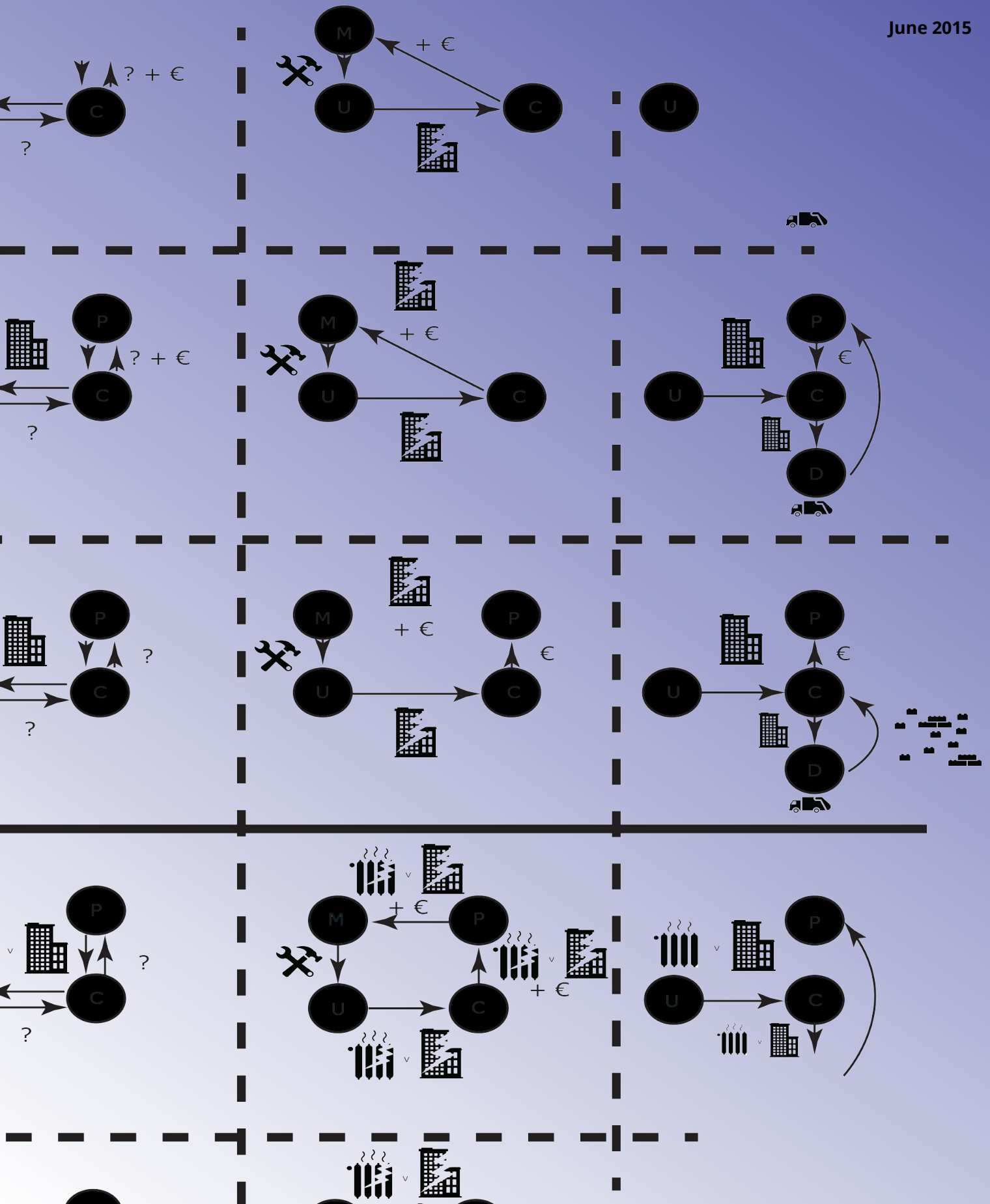


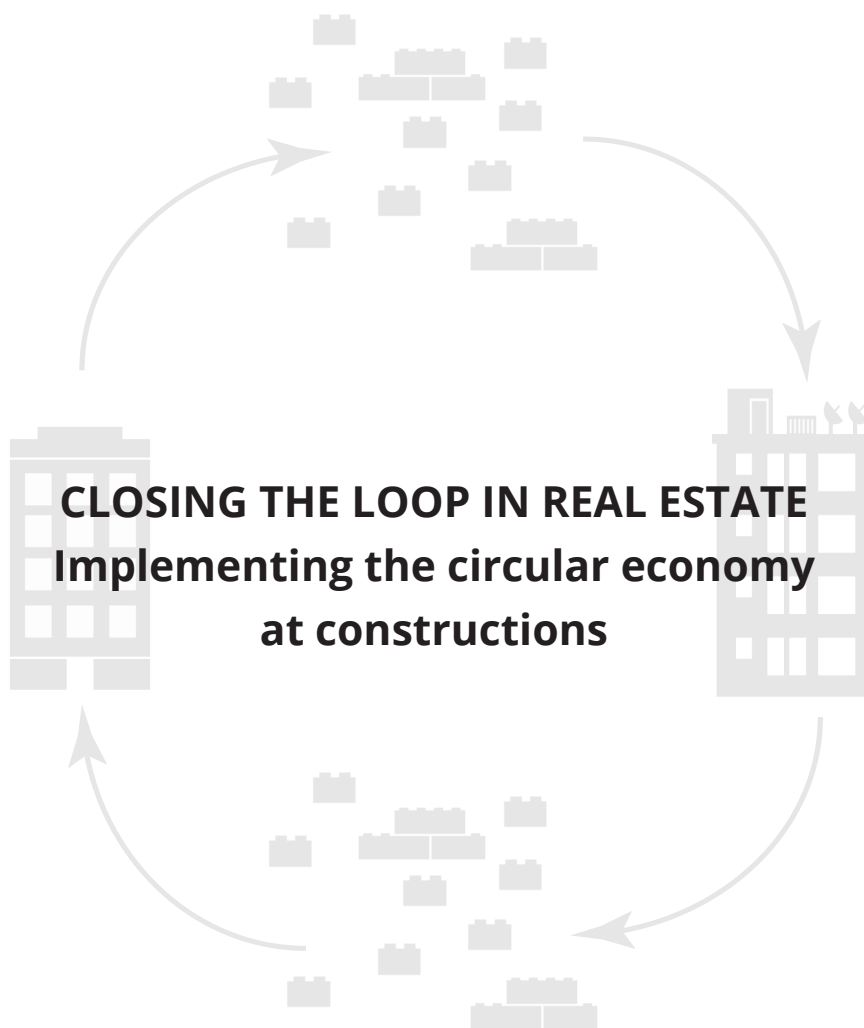
CLOSING THE LOOP IN REAL ESTATE

Implementing the Circular Economy at constructions

Master thesis - David de Grauw

June 2015





"The costumer wants the service, the performance rather than the product."

Ken Webster, A new dynamic; effective business in a circular economy (2013)

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Sustainability within the real estate and construction sector has always interested me. Finally, at this graduation project I can fill my need to study this subject of sustainability more thoroughly. My study focusses on the Circular Economy within the construction sector. This study is part of the Master 'Real Estate and Housing' at the Delft University of Technology. The report presented before you will elaborate on the methodology and will outline my findings regarding the Circular Economy.

Discussions about sustainability and the upcoming issues regarding depletion of natural resources and devastation of natural conditions have been there for decades. The concept of Circular Economy tries to give an solution towards these issues. My main subject will be the implementation of the Circular Economy in the Dutch construction industry. There is an urgency in the commercial sector to implement the Circular Economy. One example is the 'Green deal Circulair bouwen' which is be signed by a lot of companies in the real estate and construction sector in the Netherlands. Therefore I hope that this study will contribute in gaining knowledge about the Circular Economy.

The subject of the Circular Economy crossed my way during the first phases of graduating and it attracted my fascination. By doing a literature review and by talking to experts about this subject my research design was finally completed, as can be seen in this report. This report will show the obtained results.

The results are obtained by doing interviews with employees in the educational real estate and experts of the Circular Economy. The results are reflected and evaluated in the Performance-Service System. At last, a conclusion and recommendations will be made .

I couldn't obtain this result without any help and support. So I would like to thank the following persons who have been a support during this graduation project. First of all my two main mentors Matthijs Prins and Alexandra den Heijer. We had a lot of discussions, such as the enthousiasm for this subject versus the realism regarding Circular Economy. Furthermore I would like to thank Niel Slob, Saman Mohammadi, and Raouf Jarmo. I learned a lot of how it is done in practice.

At last, I would like to thank my ex-roommate Niels for all relaxing moments we had during the years. My family who has supported me throughout all these years. And my girlfriend Rachel for all the love she gives me.



David de Grauw

Delft, June 30th 2015

Introduction

Five issues are considered to be general acknowledged. First of all, the world faces depletion of natural resources. Secondly, we devastate natural conditions all over the world. Thirdly, people have an ongoing increasing standard of living. Fourthly, there is the trend of ageing of the world population, especially in industrialized countries. And finally, last years there was the financial crisis that affected a lot of societies. All issues have there affect on the construction sector.

Because of those issues there is an urgency to implement principles of the Circular Economy in the construction sector. The concept of the Circular Economy tries to counterpart these issues. Unfortunately, there is no step-by-step plan on how to make a transition towards the Circular Economy. There is a lack of, but also a need for, data, information, and knowledge regarding the Circular Economy within the construction sector. In order to address this problem the following research question is developed:

How to develop and implement a Performance-Service System in constructions of the educational sector regarding operations, organisation and financial schemes?

The expected result of this graduation project is a Performance-Service System. The use of this system should implement principles of the Circular Economy in the current construction sector. By developing this system awareness and insights will be given in the Circular Economy and Performance-Service Systems.

Therefore, the expected result is twofold, namely practical and scientific. Practically it should give clients an advice on how to implement the Performance-Service System. Secondly, scientifically this thesis must acquire more insights regarding the trend of Circular Economy. Definitions have been operationalized in order to implement the Circular Economy into practice.

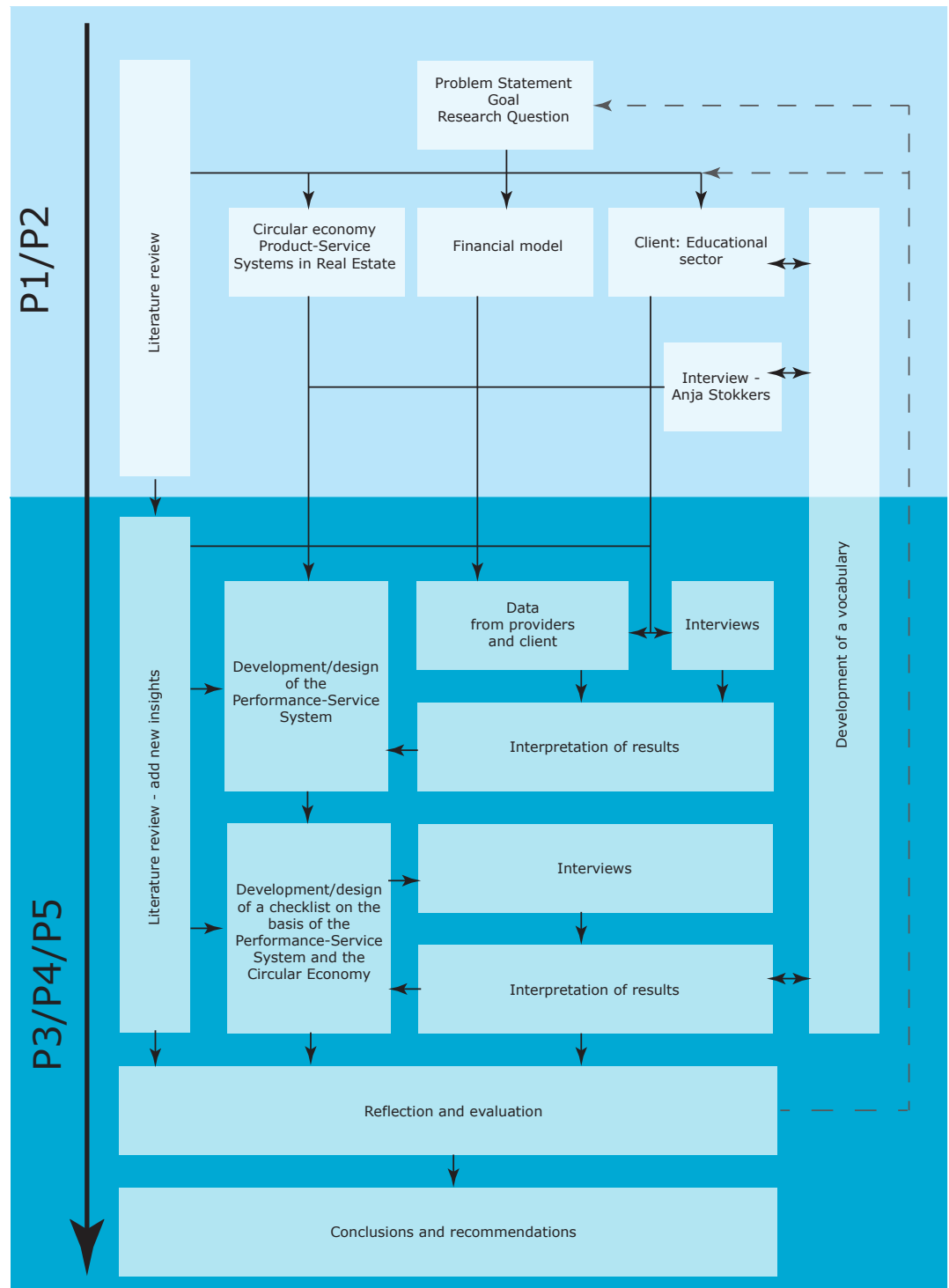
In order to achieve this result a graduation plan has been made as can be seen in figure a. During phases 3 and 4 this model is being designed, reflected and evaluated. The results are used to improve the model. Besides the development of the model, financial models are developed, interviews are carried out, and test cases have been conducted in order to get a better grip and an in depth understanding of the model.

Furthermore, this study focuses on the construction sector. Real estate is a unique kind of asset. In comparison with other assets it can be defined as an immovable, but very costly asset. Due to all the aspects of real estate it is a very unique market within our current system. Because real estate is an asset that is developed for a long horizon one should keep different obsolescence's in mind.

The Circular Economy

The Circular Economy is a new way of thinking and reshaping the world. There are a lot of different opinions on how to implement this system. All relate to the model made by the Ellen MacArthur Foundation, see figure b. Due to its foundations in different sustainability theories a lot of principles can be applied within our current system. In order to implement the Circular Economy in construction sector a selection is made from these principles. Furthermore, these principles have been translated into three categories. The three categories are the 'organisation', 'operations', and 'finance'.

Figure a: Research design



Principles Circular Economy applicable in the construction sector:

Operations

- Replace fossil-fuel-based mechanisms with passive and natural systems where possible;
- Design reversible, adaptable, demountable and/or biodegradable systems;
- Compensate for past design decisions and their environmental impacts;
- Reduce total resource flows over a building's life cycle;
- Design out waste;
- Rely on energy from renewable sources;
- Reducing consumption of non-renewable resources;

- Efficient use of energy, materials and natural capital;
- Replacing non-renewable with renewable resources;
- Creating an energy supply based on renewable energies.

Organisation

- Continued ownership is cost efficient; reuse, repair and remanufacture without a change of ownership saves double transaction costs;
- The customer wants the service, the performance rather than the product;
- All parts of the circuit count and the key to vitality lies in rapid, robust, thorough circulation of money, goods, services etc. to all stakeholders.

Finance

- The smaller the loop (activity-wise and geographically), the more profitable and resource efficient it is;
- Loops have no beginning and no end; value maintained replaces value added.

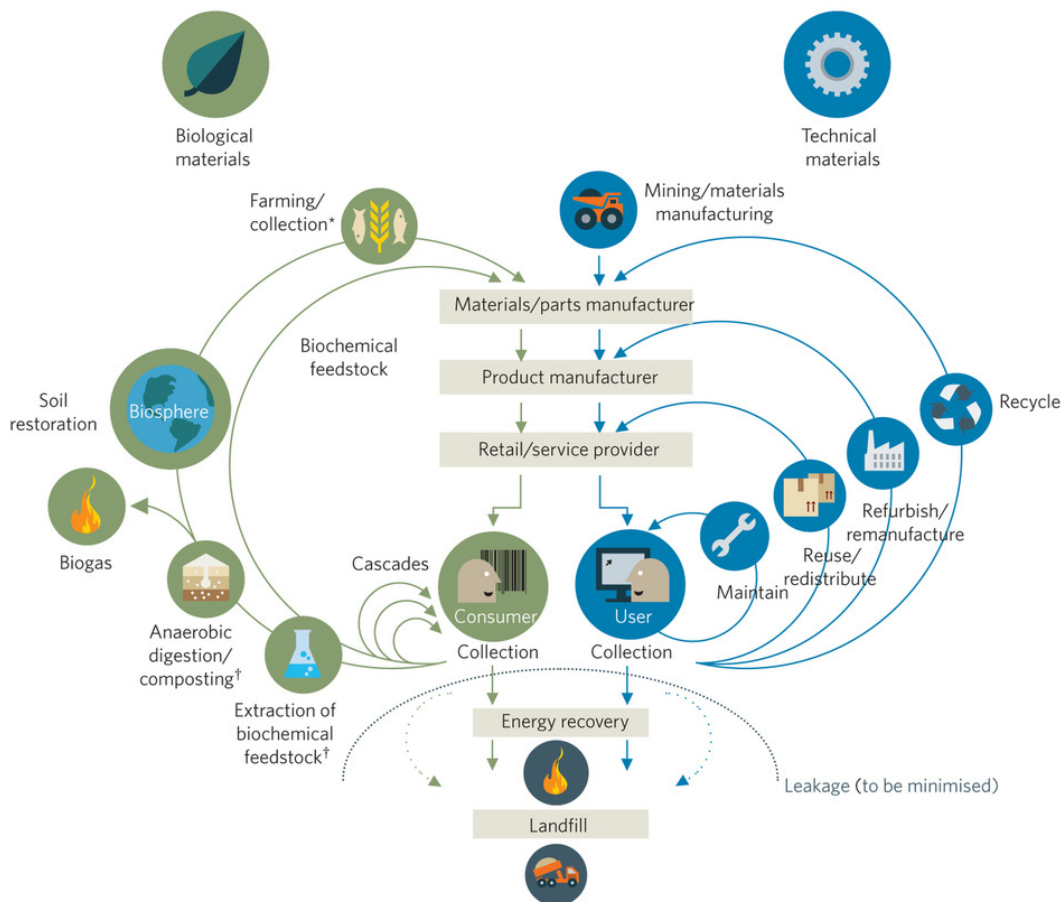


Figure b: The Circular Economy (Ellen MacArthur Foundation, 2012)

All reports written about the Circular Economy are opportunistic about this system. During the literature review it became clear that there are still a lot of obstacles to overcome:

Obstacles Circular Economy

- The Circular Economy is in its infancy;
- There is a knowledge obstacle. In order to overcome this training skills and competences must be applied at the working population;
- Behaviour of both the client and provider must change in order to implement the Circular Economy;

- Obstacles regarding the design of components. It is believed that the techniques in order to apply components that inhabit the principles of the Circular economy, but there is a lack of finance opportunities in order to apply these techniques;
- At last, calculations must be made not only about the residual value of materials, but also the demolition costs. An opportunity lies in broadening Life-Cycle Costing calculations.

Product-Service Systems and Performance-Service Systems

The Performance-Service System is based on the Circular Economy and Product-Service Systems. Goedkoop et al. (1999) give a definition of the Product-Service System. They state that the Product-Service System is “a marketable set of products and services capable of jointly fulfilling a user’s need”. Aurich et al. (2006) add that “the manufacturing service enterprise no longer distinguishes between products and services but rather provides its customers with highly individualized solutions.” Meaning that the product is not a goal in itself. Furthermore, Mont (2002) describes a few approaches and trends towards the development of the Product-Service System:

- the sale of the use of the product instead of the product itself;
- the change to a ‘leasing society’;
- the substitution of goods by means of service machines;
- a repair-society instead of throw-away society;
- the change in consumer attitudes from sales to service orientation.

However, Product-Service Systems do not correspond perfectly with the Circular Economy. Therefore a Performance-Service System must be developed. This system combines principles of the Circular Economy and uses parts of Product-Service Systems. If one should compare the Performance-Service System with Product-Service Systems than it corresponds mostly with the Result-Oriented Product-Service System explained by Deckmyn et al. (2014). Keeping all principles and theories in mind the following definition will be applied for the Performance-Service System:

The Performance-Service System is a marketable and sustainable set of performances and services capable of jointly fulfilling a user’s need.

Whereas a performance is an agreed action of performing that results in an utility, goal, function, or commitment whereby a product is not a goal in itself, but subordinate to the performance. Secondly, the service is mainly a non-physical action or operation whereby the performance is maintained, extended or optimized over time. The service cannot be produced or consumed in itself and is subordinate to the performance. And at last, the system is an integrated mix of performances, and the subordinate services and components needed. Furthermore the system includes the communication required between client and provider.

Developing the Performance-Service System

The first models of the Performance-Service System were made by doing the literature review and by designing. The following model was used during interviews with employees of FMVG Delft University of Technology, as can be seen in figure c. First the stakeholders mentioned in the model will be described:

Client

The client represents an organisation and the users within this organisation. In most cases the client will also be an user itself. This stakeholder is in close contact with all other stakeholders involved. The client is responsible for any errors that occur due to missuse of the performance by both the client and the users.

User

This stakeholder will use the performance. First of all, there is a need for a certain performance from the user perspective. The user will pass this on towards the client, who in turn will tender this in the market. The user will only use the performance and is probably not responsible for any errors in the components.

Provider

This stakeholder delivers the performance towards the client. Between the client and provider agreements will be established regarding the performance, the payments, and the maintenance needed.

Maintenance provider

Works on behalf of the provider. This stakeholder will provide the maintenance needed in order to keep the performance on the agreed level. The client is responsible for reporting errors that occur during the usage phase.

Dismantler

The dismantler is responsible for the disassembly of the components used. The components or materials should be brought back into the system. This can be done by bringing it back to the provider of the performances. The provider is probably in close contact with the other stakeholders within the production chain. Furthermore, the dismantler should besides bringing back the components and materials also give feedback on the design of the components. This must be done in order to stimulate innovations regarding the components used.

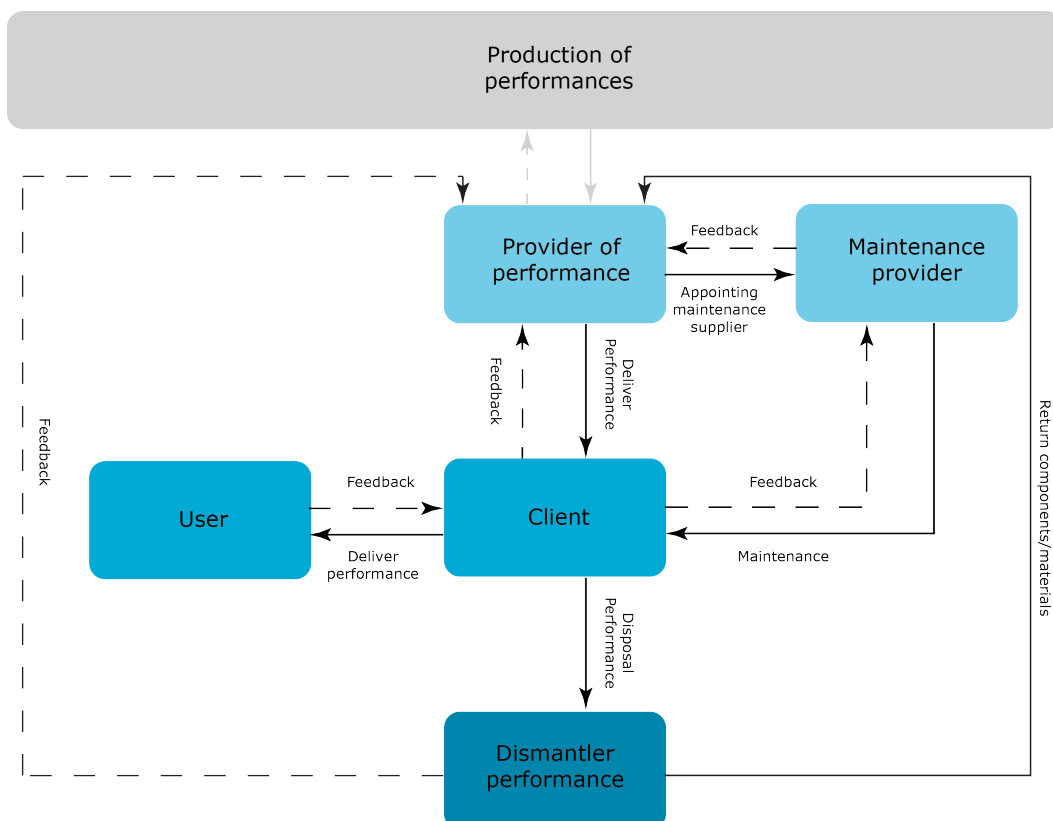


Figure c: Performance-Service System - model 1

Financier

This stakeholder is the one who will provide the necessary financial means in order to develop Circular Economical components that will provide the performance.

The model was discussed during the interviews and some conclusions could be drawn from these interviews. The following can be concluded about this model:

- A lot is uncertain about the content of the model. Take for instance the loops that take components or the materials back into the system. A lot of questions were raised when discussing this part of the model. How do you monitor this aspect? Who is responsible for bringing back components into a system?
- Furthermore all agree, when applying this model at the Delft University of technology, that there should be a change in the organisation towards contract management. Although not all interviewees agree on the fact that this will happen within the FMVG (Facilitair Management en Vastgoed; Facility Management and Real Estate).

Above all the interviews made clear that the model was still insufficient, incomplete and inconsequent.

- The model is too static. It lacks flexibility regarding the client. Discussions showed that this scheme does not apply to all clients and providers in the market.
- It lacks to show different periods in time. It tries to capture all different time periods in one static model. For example, when looking at the different operations in the model one could see a discrepancy. At the top of the model it is stated that the provider delivers the performance to the client. At the same time there is an operation going on at the right side of the model that states that the components/materials for this performance are returned to the provider. Using common sense one can conclude that this stage in the model occurs in a later period, however it still leaves a lot of questions.

Redevelopment of the Performance-Service System

After discussions with mentors, experts, and students it became clear that the model of the Ellen MacArthur Foundation (see figure b) creates some confusions. First of all, they show different stakeholders, such as the manufacturer, the supplier, and a provider. The model implies that these are all different stakeholders. But this is not necessarily true within our current system. One company can be a manufacturer, supplier of materials, and a provider at the same time. In theory it is possible that this stakeholder is its own user of the performance, as is illustrated in figure d. Therefore the model of the Ellen MacArthur Foundation can be considered as one of

Figure d: Simplification principles Circular Economy

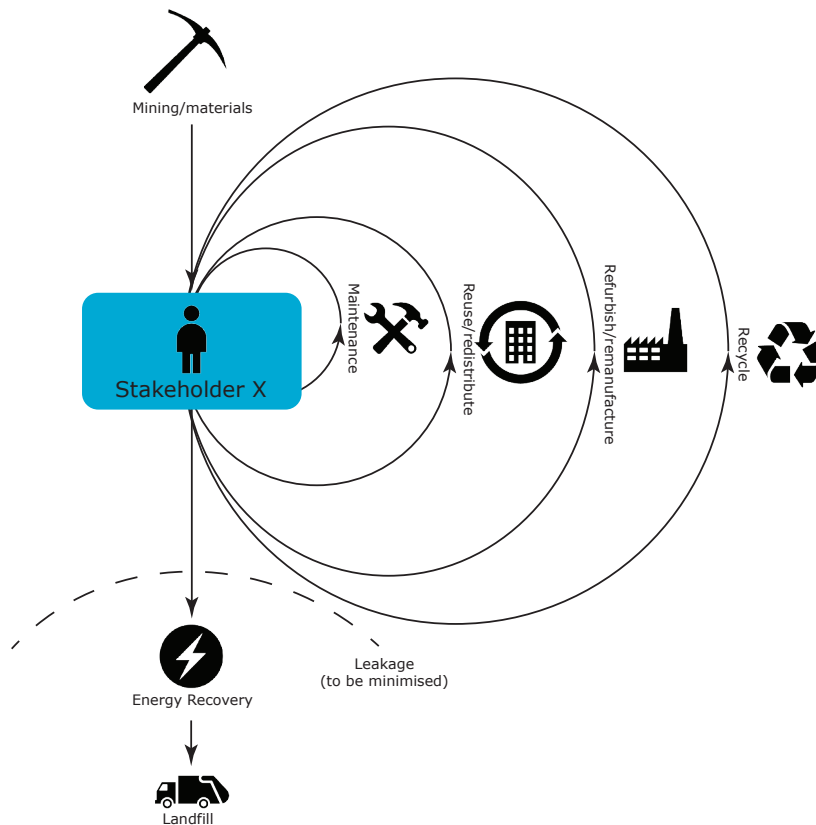
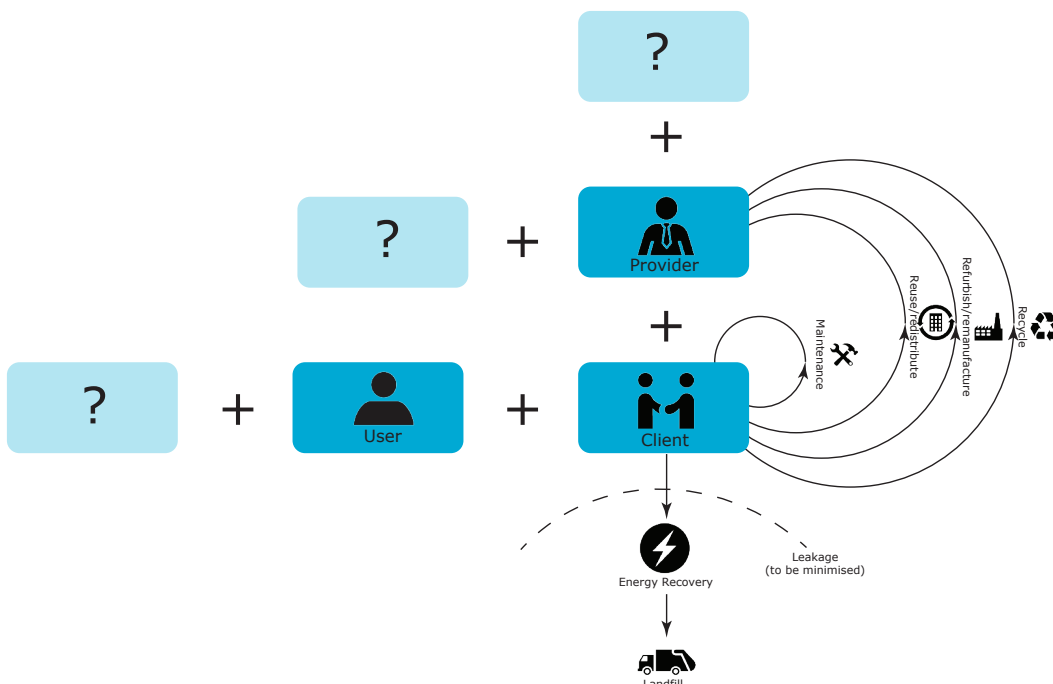


Figure e: Expansion simplification model Circular Economy



the possible scenarios.

The model should be adaptable regarding the wishes and requirements of a client. It should not state where a certain stakeholder is located in the model. Furthermore it must neither state where the loops back should be in the model. It depends on the agreements between the client and the provider how processes will go and how performances will be provided.

The Performance-Service System cannot be explained by one model. First of all, from a client perspective, there are three phases that need to be taken into account. These phases are the initiative, usage, and the end of loop phase. Short descriptions of those phases are given below:

Initiative

The client and/or user have new requirements regarding facilities. The client will write these requirements down and it will be tendered towards the market.

Usage

During this phase the user and the client will use the performance or product provided. The provider or maintenance provider should sustain the required level of performance.

End of Loop

The performance is no longer needed or components must be replaced in order to fulfil new requirements. The components used will be brought back into a system.

Looking at figure b, one sees different strategies a client can take regarding tendering of facilities. Differentiation is made between linear economy strategies and Circular strategies. Within the linear and Circular Economical strategy a differentiation is made between 'buy', 'buy-buy back', 'financial lease', 'Operational net lease', and 'Operational gross lease'.

Conclusion

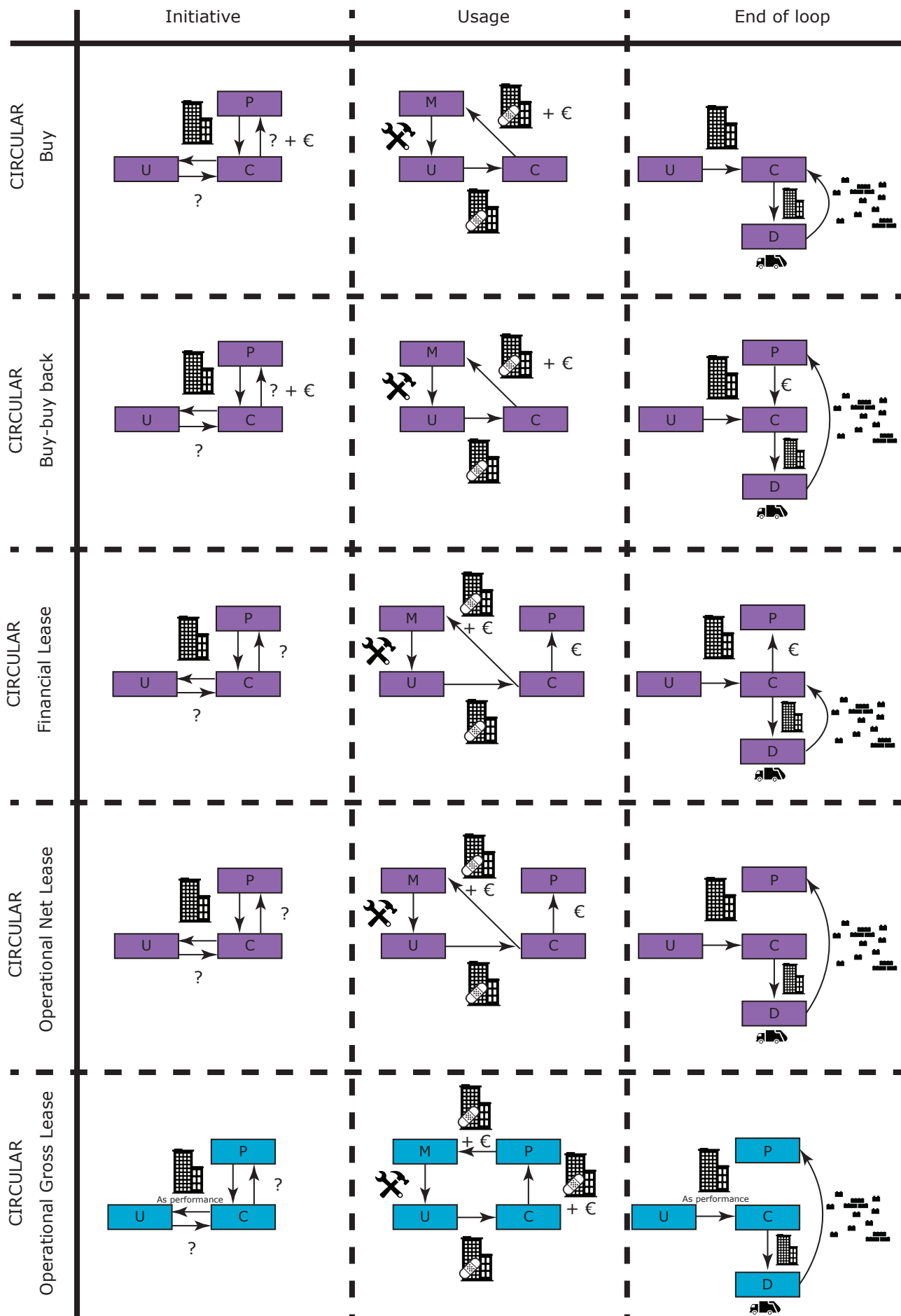
There is no simple answer to the above mentioned research question. How to implement the Performance-Service System depends on a few variables, such as principles of the Circular Economy, context of the client, the operations, organisation and financial schemes. Therefore every aspect of this research question will be briefly discussed:

According the principles of the Circular Economy the best strategy would be to use an Operational Gross Lease (Circular Economy). However, it depends on the clients wishes and requirements if this strategy fits the needs best.

The test case was conducted at the Delft University of Technology. The university has a major ambition with respect to sustainability, but at this moment this only includes the reduction of carbon emissions. In addition to the ambition regarding sustainability Delft University of Technology develops and manages its own real estate. If Delft University of Technology wants to alter towards the Circular Economy by implementing Performance-Service Systems than the following aspects should be taken in mind:

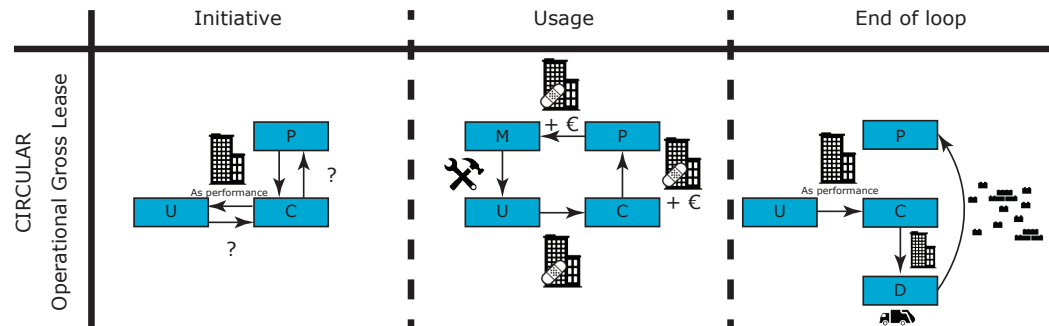
- Change within the organisation towards contract management
- Decreasing ownership of components

Figure f: Strategies
(Circular Economy)



Furthermore, the client has a responsibility towards the provider when using the required performance. Users have a lot of requirements and wishes, but they also need a change in their mind-set regarding Circular Economy. This means that there is a probability that users must be educated in their behaviour regarding performances.

Figure g: The Performance-Service System - Operational gross lease (Circular Economy)



Is the model implementable in the educational construction sector?

As a final conclusion, the model will not support decisions in its current state. There are several options to optimize this model:

- Add advantage and disadvantage list per strategy. According to Koopmans this list could help to base your decisions on.
- The development of other models that support this model. One can think of a decision tree or multi-criteria-models.

It can be said, due to the model the discussion about the Circular Economy is stimulated. It gives, by using relatively simple figures, a good illustration of what the Circular Economy is all about. Although it does not support decisions in its current state, the model gives a lot of different insights of the Circular Economy in the Dutch educational sector.

As a final step of this graduation project a checklist is developed. This checklist was tested at Gilde Opleidingen. It can be concluded that the checklist is a good first attempt to operationalize the Circular Economy in practice. Therefore this study is a first attempt to stimulate research relating to this subject. Hopefully, this study can serve as a base for future researches.

Introductie

Er zijn op dit moment vijf problemen die in de gehele wereld algemeen erkend worden. Als eerste hebben we te maken met uitputting van natuurlijke bronnen. Ten tweede zijn we als maatschappij bezig met het afbreken van de natuur. Daarnaast hebben we te maken met een verhoogde welvaartsstandaard, die leidt tot nog meer uitputting van natuurlijke bronnen en een verder afbreken van de natuur. In vele delen van de wereld neemt de vergrijzing toe. Als laatste hebben we afgelopen jaren ook te maken gehad met het omvallen van ons financiële systeem. Langzamerhand komen we uit de economische depressie. Onze constructiesector heeft te maken met alle bovengenoemde problemen.

Vanwege al deze kwesties is er urgentie om principes van de Circulaire Economie te implementeren in onze constructie-industrie. Het concept van de Circulaire Economie probeert een antwoord te geven op alle bovengenoemde problemen. Helaas bestaat er geen blauwdruk hoe wij als maatschappij de transitie naar de Circulaire Economie moeten maken. Er is een gebrek, maar ook een behoefte aan data, informatie, en kennis in relatie tot de Circulaire Economie in de constructiesector. Om een oplossing te zoeken voor dit probleem is de volgende onderzoeksvraag opgesteld:

Hoe ontwikkel en implementeer je een Prestatie-Dienst Systeem dat gebruikt kan worden voor constructies, kijkend naar de factoren: handelingen, organisatie en financiële schema's?

Het verwachte eindresultaat van dit afstudeeronderzoek is een Prestatie-Dienst Systeem. Dit systeem kan worden gebruikt om principes van de Circulaire Economie te implementeren in de constructie sector. Dit systeem zal meer aandacht met betrekking tot de Circulaire Economie genereren en zal dit model inzichten verwerven over hoe we de transitie naar de Circulaire Economie kunnen versnellen.

Het verwachte eindresultaat is tweeledig, namelijk praktisch en wetenschappelijk. Praktisch gezien moet het afnemers een advies geven over de uitvoering van het Prestatie-Dienst Systeem. Wetenschappelijk gezien zal dit onderzoek meer inzicht verwerven in de nieuwe trend van de Circulaire Economie. Definities zijn geoperationaliseerd met het oog op de uitvoering van de Circulaire Economie in de praktijk.

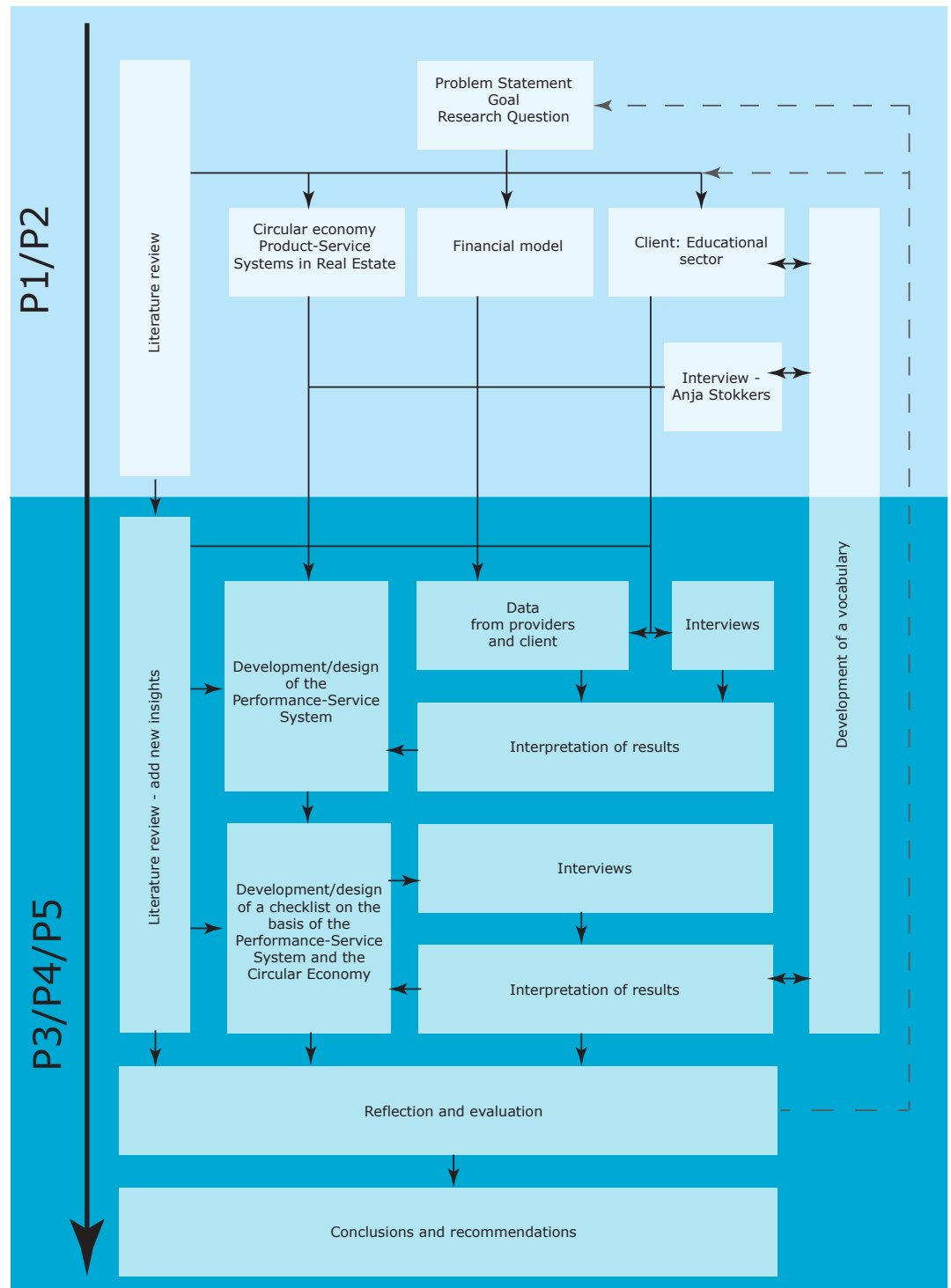
Er is een afstudeerplan gemaakt, zoals te zien is in figuur a. Tijdens fase 3 en 4 is het Prestatie-Dienst Systeem ontworpen en ontwikkeld. Het model is vervolgens geëvalueerd. De resultaten worden gebruikt om het model te verbeteren. Naast de ontwikkeling van het model, zijn financiële modellen gemaakt en interviews afgenomen om een beter en diepgaander begrip te krijgen.

Bovendien is deze studie gericht op de bouwsector. Vastgoed is een unieke vorm van activa. In vergelijking met andere activa kan vastgoed worden gedefinieerd als een onroerend, maar zeer kostbaar bezit. Door alle aspecten van onroerend goed heeft het een zeer unieke marktpositie binnen ons huidige systeem. Vastgoed wordt ontwikkeld voor een lange periode, daarom moet men verschillende verouderingsvormen in het achterhoofd houden.

De Circulaire Economie

De Circulaire Economie is een nieuwe manier van denken. Er zijn veel verschillende meningen over hoe dit systeem geïmplementeerd kan worden. In essentie zijn vele ideeën van de Circulaire

Figure a: Afstudeerplan



Economie te herleiden uit het model van de Ellen MacArthur Foundation. De Circulaire Economie is gebaseerd op een aantal duurzaamheidstheorieën. Deze theorieën brengen vele principes met zich mee. Met het oog op de uitvoering van de Circulaire Economie in de bouwsector is er een selectie gemaakt van deze principes. Bovendien zijn deze uitgangspunten vertaald in drie categorieën. De drie categorieën zijn de 'organisatie', 'handelingen' en 'financiën'.

De volgende principes zullen worden gehanteerd:

Handelingen

- Vervang op fossiele brandstoffen gebaseerde mechanismen met passieve en natuurlijke systemen waar mogelijk;
- Ontwerp omkeerbaar, aanpasbaar, afneembare en / of biologisch afbreekbare systemen;
- Compenseer voor toegepaste ontwerpbeslissingen en hun milieueffecten;
- Verminder de totale materiaal stromen over de gehele levenscyclus van een gebouw;
- Reductie van afval;
- Vertrouw op energie uit hernieuwbare bronnen;
- Verminder de consumptie van niet-hernieuwbare hulpbronnen;
- Efficiënt gebruik maken van energie, materialen en kapitaal;
- Vervang huidige energiebronnen met hernieuwbare bronnen;
- Creëer een energievoorziening op basis van hernieuwbare energie.

Organisatie

- Doorlopend eigendomschap is kostenefficiënt; hergebruik, reparatie en herfabricage zonder verandering van eigenaar bespaart dubbele transactiekosten;
- De consument wil liever de prestatie, prestatiekenmerken in plaats van het product;
- Alle delen van het circuit te tellen mee en de sleutel tot vitaliteit ligt in een snelle, robuuste, grondige circulatie van geld, goederen, diensten voor alle belanghebbenden.

Financiële

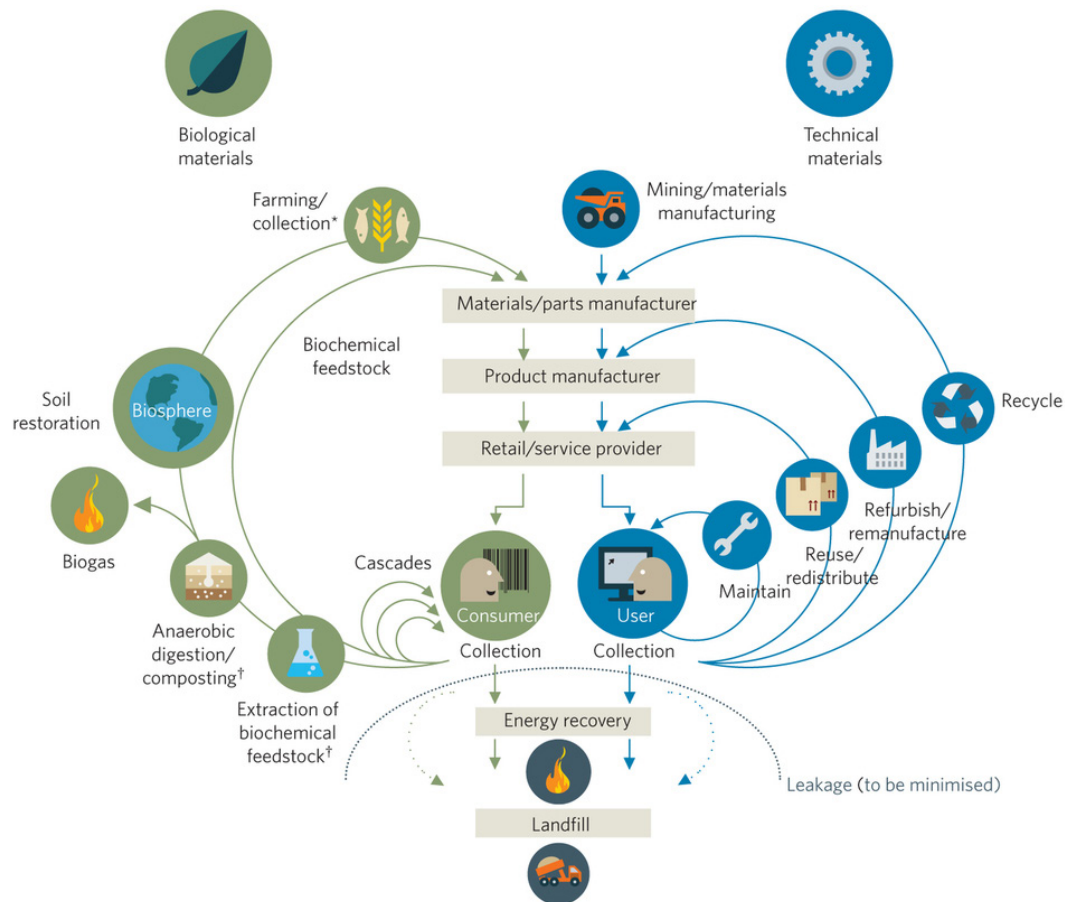
- Hoe kleiner de lus (activiteit-wijs en geografisch), hoe meer winstgevend en zuinig het is;
- Lussen hebben geen begin en geen einde; toegevoegde waarde wordt vervangen door gehandhaafde waarde.

Rapporten die geschreven zijn over de Circulaire Economie zijn positief over dit systeem. Uit de literatuurstudie werd duidelijk dat er nog veel obstakels overwonnen moeten worden:

Knelpunten Circulaire Economie

- De Circulaire Economie staat in haar kinderschoenen;
- Er is een knelpunt met betrekking tot kennis. Om deze te overwinnen zijn trainingen voor vaardigheden en competenties nodig;
- Gedrag van zowel de opdrachtgever en leverancier moet veranderen om de transitie naar een Circulaire Economie plaats te laten vinden;
- Knelpunten met betrekking tot het ontwerp van componenten. Technieken om componenten die de beginselen van de circulaire economie toe te passen bestaan, maar er ontbreken financiële mogelijkheden om deze technieken toe te passen;
- Uiteindelijk moeten er berekeningen worden gemaakt, niet alleen over de restwaarde van de materialen, maar ook over de sloopkosten. Een kans ligt in het verbreden van Life-Cycle Costing berekeningen.

Figure b: De Circulaire Economie
(Ellen MacArthur Foundation, 2012)



Product-dienst Systemen and Prestatie-Dienst Systemen

Het Prestatie-Dienst Systeem is gebaseerd op de Circulaire Economie en product-dienst systemen. Goedkoop et al. (1999) geeft een definitie van een product-dienst systeem. Zij stellen dat het product-dienst systeem een verkoopbare set van producten en diensten is die gezamenlijk de behoefte van de gebruiker vervullen. Aurich et al. (2006) voegen hieraan toe dat de dienstverlenende producent niet langer een onderscheid maakt tussen producten en diensten, maar biedt haar klanten sterk geïndividualiseerde oplossingen. Dit betekent dat het product geen doel op zich is. Bovendien, Mont (2002) beschrijft een paar benaderingen en trends in de richting van de ontwikkeling van het product-dienst systeem:

- De verkoop van het gebruik van een product in plaats van producten zelf;
- De overgang naar een lease-maatschappij;
- De vervanging van goederen door middel van dienstmachines;
- Een reparatie-samenleving in plaats van wegwerp maatschappij;
- De verandering in de houding van de consument met betrekking tot de verkoop aan servicegerichtheid.

Echter, product-dienst systemen komen niet perfect overeen met de Circulaire Economie. Daarom moet een Prestatie-Dienst Systeem worden ontwikkeld. Dit systeem combineert de principes van de Circulaire Economie met delen van product-dienst systemen. Als men het Prestatie-Dienst Systeem moet vergelijken met product-dienst systemen dan komt dit meestal overeen met de resultaatgerichte product-dienst systeem van Deckmyn et al. (2014). Met alle definities en theorie in het achterhoofd, zal de volgende definitie voor Prestatie-Dienst Systeem worden toegepast:

Het Prestatie-Dienst Systeem is een handelbaar en duurzame reeks van prestaties en diensten die gezamenlijk de behoefte van de gebruiker vervullen.

De prestatie is een overeengekomen actie van presteren dat resulteert in het gebruik, een doel, een functie of een verbintenis waarbij het product geen doel op zich is, maar ondergeschikt is aan de prestaties. Ten tweede, de dienst is voornamelijk een niet-fysieke actie of operatie waarbij de prestatie wordt gehandhaafd, uitgebreid of geoptimaliseerd in de tijd. De dienst kan niet worden geproduceerd of geconsumeerd op zichzelf en is ondergeschikt aan de prestaties. Het systeem is een mix van prestaties, de ondergeschikte diensten en componenten. Verder omvat het systeem de communicatie die nodig is tussen aanbieder en afnemer.

Ontwikkeling van de Performance-Service System

Met behulp van deze literatuurstudie en door middel van ontwerpen werden de eerste modellen van het Prestatie-Dienst Systeem gemaakt. Het model, zoals te zien is in figuur c, werd gebruikt tijdens de interviews met medewerkers van FMVG (Facilitair Management & Vastgoed) TU Delft. Hieronder zullen de verschillende stakeholders worden toegelicht.

Afnemer

De afnemer staat voor een organisatie en de gebruikers binnen deze organisatie. In de meeste gevallen zal de afnemer ook de gebruiker zelf zijn. Deze belanghebbende heeft een intensieve relatie met alle andere betrokkenen. De afnemer is verantwoordelijk voor eventuele fouten die het gevolg zijn van misbruik van de prestatie door zowel de opdrachtgever en de gebruikers.

Gebruiker

Deze belanghebbende zal de prestaties gaan gebruiken. Allereerst zal de gebruiker een bepaalde behoefte hebben. De gebruiker zal deze behoefte doorgeven aan de afnemer, die op zijn beurt dit zal aanbesteden in de markt. De gebruiker zal alleen gebruik maken van de prestaties en is waarschijnlijk niet verantwoordelijk voor eventuele fouten in de componenten.

Aanbieder

De aanbieder levert de prestaties aan de afnemer. Tussen deze partijen zullen afspraken worden vastgesteld ten aanzien van de prestaties, de betalingen en het onderhoud dat nodig is.

Onderhoudsaanbieder

Werkt namens de aanbieder. Deze belanghebbende zal het onderhoud, om de prestaties op het afgesproken niveau te houden, verrichten. De klant is verantwoordelijk voor het melden van eventuele fouten die optreden tijdens de gebruiksfase.

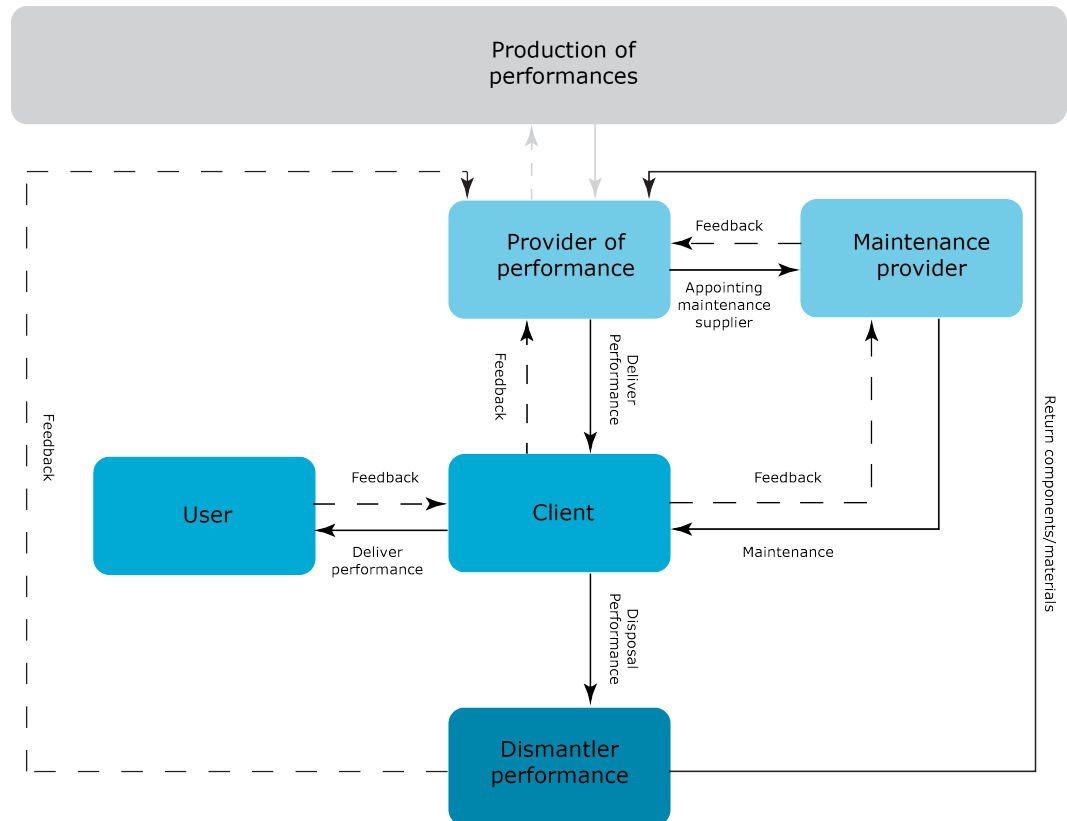
Demonteur

De demonteur is verantwoordelijk voor de demontage van de gebruikte componenten. Deze componenten of materialen worden daarna in een systeem gebracht. Dit kan worden gedaan door het terug te brengen naar de aanbieder van de prestaties. De aanbieder is waarschijnlijk in nauw contact met andere betrokkenen binnen de productieketen. Naast het terugbrengen van de onderdelen en materialen, moet de demonteur ook feedback geven over de vormgeving van de onderdelen aan de aanbieder.

Financier

De financier is degene die de nodige financiële middelen zal verstrekken om Circulair Economische componenten te ontwikkelen die nodig zijn voor de prestatie.

Figure c: Performance-Service System - model 1



Het model werd tijdens de interviews besproken en enkele conclusies kunnen worden getrokken uit deze interviews. Het volgende kan worden geconcludeerd over dit model:

- Veel onzekerheid bestaat over de inhoud van het model. Neem bijvoorbeeld de lussen die zich richten op het terug brengen van componenten of materialen in het systeem. Veel vragen worden gesteld bij de bespreking van dit onderdeel van het model. Hoe ga je dit aspect controleren? Wie is verantwoordelijk voor het terugbrengen van de componenten in een systeem?
- Alle geïnterviewden zijn het eens dat bij toepassing van dit model op de Technische Universiteit Delft een verandering in de organisatie naar contractmanagement plaats moet vinden. Echter vragen sommige ondervraagden zich af of dit ook daadwerkelijk zal gebeuren binnen de FMVG.

Door de interviews werd duidelijk dat het model nog niet volledig of nog niet consequent was:

- Het model is te statisch. Het ontbreekt aan flexibiliteit ten aanzien van de afnemer. Discussies toonden aan dat dit model niet van toepassing is op alle afnemers en aanbieders in de markt.
- Het model mist verschillende periodes in de tijd. Het probeert alle verschillende perioden vast te leggen in één statisch model. Bijvoorbeeld, we zien een discrepantie als we kijken naar de verschillende handelingen in het model. Bovenaan het model wordt gesteld dat de aanbieder de prestaties levert aan de afnemer. Tegelijkertijd staat op de rechterkant van het model dat de componenten / materialen geretourneerd worden naar de aanbieder. Met gezond verstand kan men concluderen dat deze fase van het model plaatsvindt in een latere periode, maar het roept nog steeds veel vragen op.

Doorontwikkeling van het Prestatie-Dienst Systeem

Na gesprekken met mentoren, deskundigen en studenten werd duidelijk dat het model van de Ellen MacArthur Foundation (zie figuur b) verwarring veroorzaakt. Ten eerste toont het model verschillende stakeholders, zoals de fabrikant, de leverancier en een aanbieder. Het model impliceert dat het allemaal verschillende stakeholders zijn, maar dit kan ook andere vormen aannemen binnen ons huidige systeem. Een bedrijf kan de fabrikant, leverancier van materialen en een aanbieder zijn. In theorie zou het ook mogelijk zijn dat de stakeholder ook zijn eigen gebruiker van prestaties is, zoals weergegeven in figuur d. Het model van de Ellen

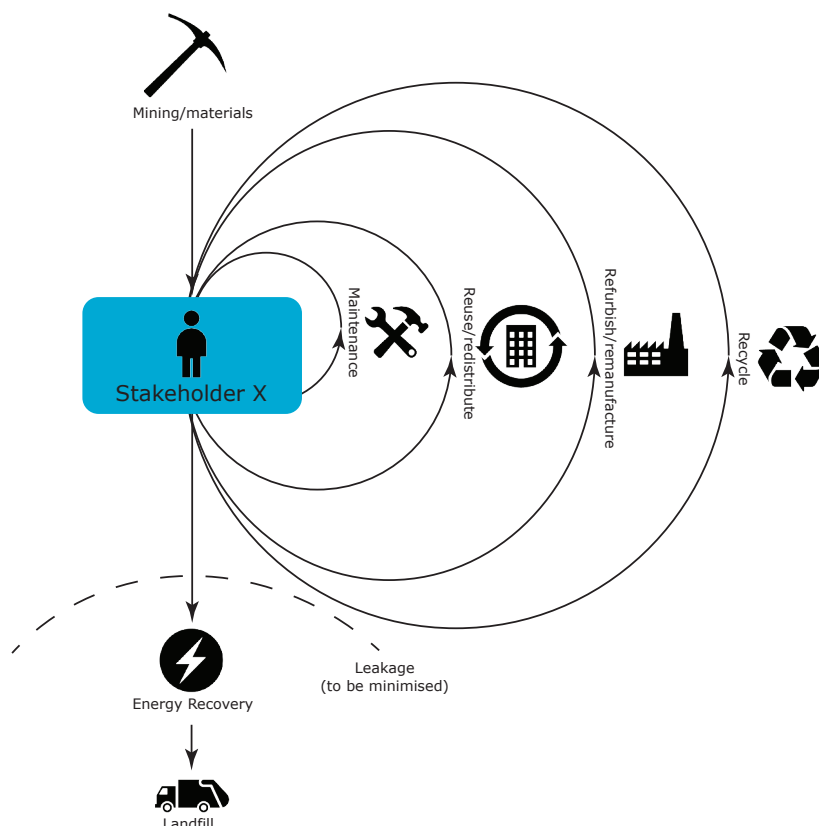


Figure d: Simplificatie van principes van de Circulaire Economie

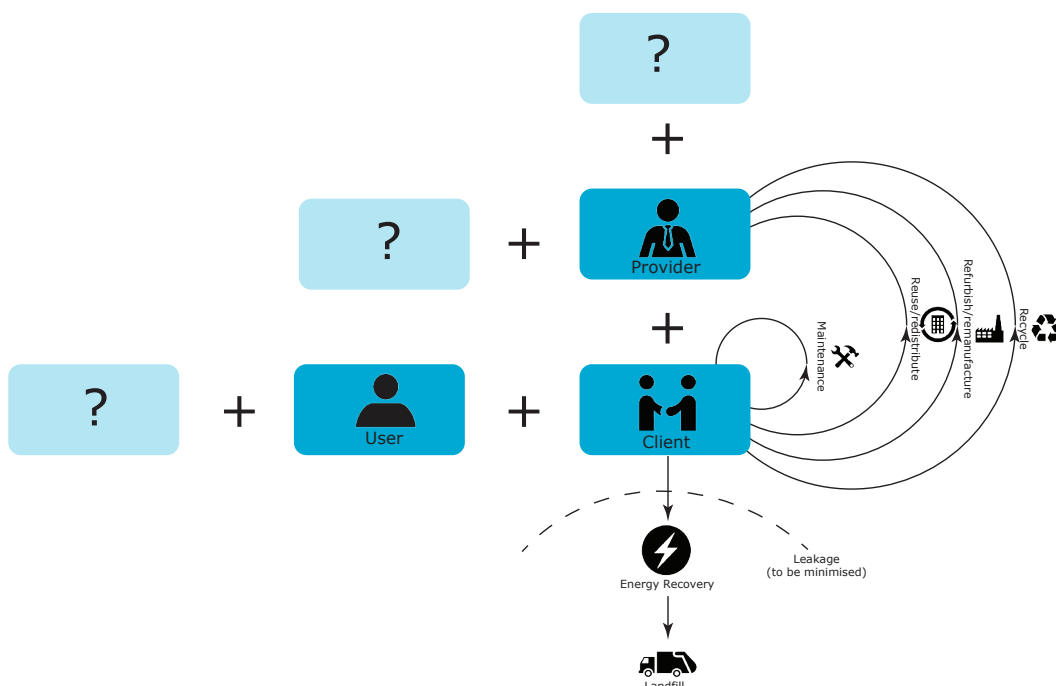


Figure e: Uitbreiding simplificatie model van de Circulaire Economie

MacArthur Foundation is slechts een van de scenario's die mogelijk is.

Het model moet worden aangepast aan de wensen en eisen van de afnemer. Het mag geen uitspraak doen waar een belanghebbende moet staan binnen dit model. Verder zal ergens in het model de lussen terug moeten komen. Het hangt af van de afspraken tussen de opdrachtgever en de aanbieder hoe processen verlopen en hoe de prestaties worden verstrekt.

Het Prestatie-Dienst Systeem kan niet worden verklaard door één model. Ten eerste vanuit het perspectief van de afnemer zijn er drie fasen waarmee rekening moet worden gehouden. Deze fasen zijn het initiatief, het gebruik en het einde van de loop fase. Korte beschrijvingen van deze fasen worden hieronder gegeven:

Initiatief

De afnemer en / of gebruiker hebben nieuwe eisen ten aanzien van de voorzieningen. De afnemer zal deze eisen opschrijven en het aanbesteden op de markt.

Gebruik

Tijdens deze fase zullen de prestaties of producten gebruikt worden. De aanbieder van het onderhoud moet het vereiste niveau van de prestaties te ondersteunen.

Einde van Loop

De prestatie is niet meer nodig of onderdelen moeten worden vervangen om aan nieuwe eisen te voldoen. De elementen worden terug gebracht in een systeem.

Kijkend naar figuur f, ziet men verschillende strategieën die een afnemer kan nemen met betrekking tot aanbesteding van nieuwe eisen van faciliteiten. Onderscheid wordt gemaakt tussen de lineaire economie en de Circulaire Economie. Binnen de lineaire en Circulaire Economische strategie wordt een onderscheid gemaakt tussen 'kopen', 'koop-terugkoop', 'financieel lease', 'Operationele netto lease' en 'Operationele bruto lease'.

Om alle strategieën hanteerbaar te maken in de praktijk is als laatste stap een checklist opgesteld. Met deze checklist kunnen organisaties nagaan of ze alle stappen hebben ondernomen om de transitie naar een Circulaire Economie te bevorderen. Twee werknemers van Gilde Opleidingen hebben aangegeven dat ze deze checklist in het vervolg kunnen gebruiken bij nieuwe aanbestedingen.

Conclusie

Er is geen eenvoudig antwoord op de onderzoeksvraag. Een Prestatie-Dienst Systeem is afhankelijk van een aantal variabelen, zoals de principes van de Circulaire Economie, de context van de opdrachtgever, de activiteiten, organisatie en financiële regelingen. Elk aspect van deze onderzoeksvraag wordt daarom kort behandeld:

Prestatie-Dienst Systeem

Terugreflecterend op de principes van de Circulaire Economie zou de beste strategie een Operationele bruto lease zijn. Het hangt echter van de wensen en eisen van afnemers af of deze strategie het beste bij de behoefte past.

Figure f: Strategieën
(Circulaire Economie)

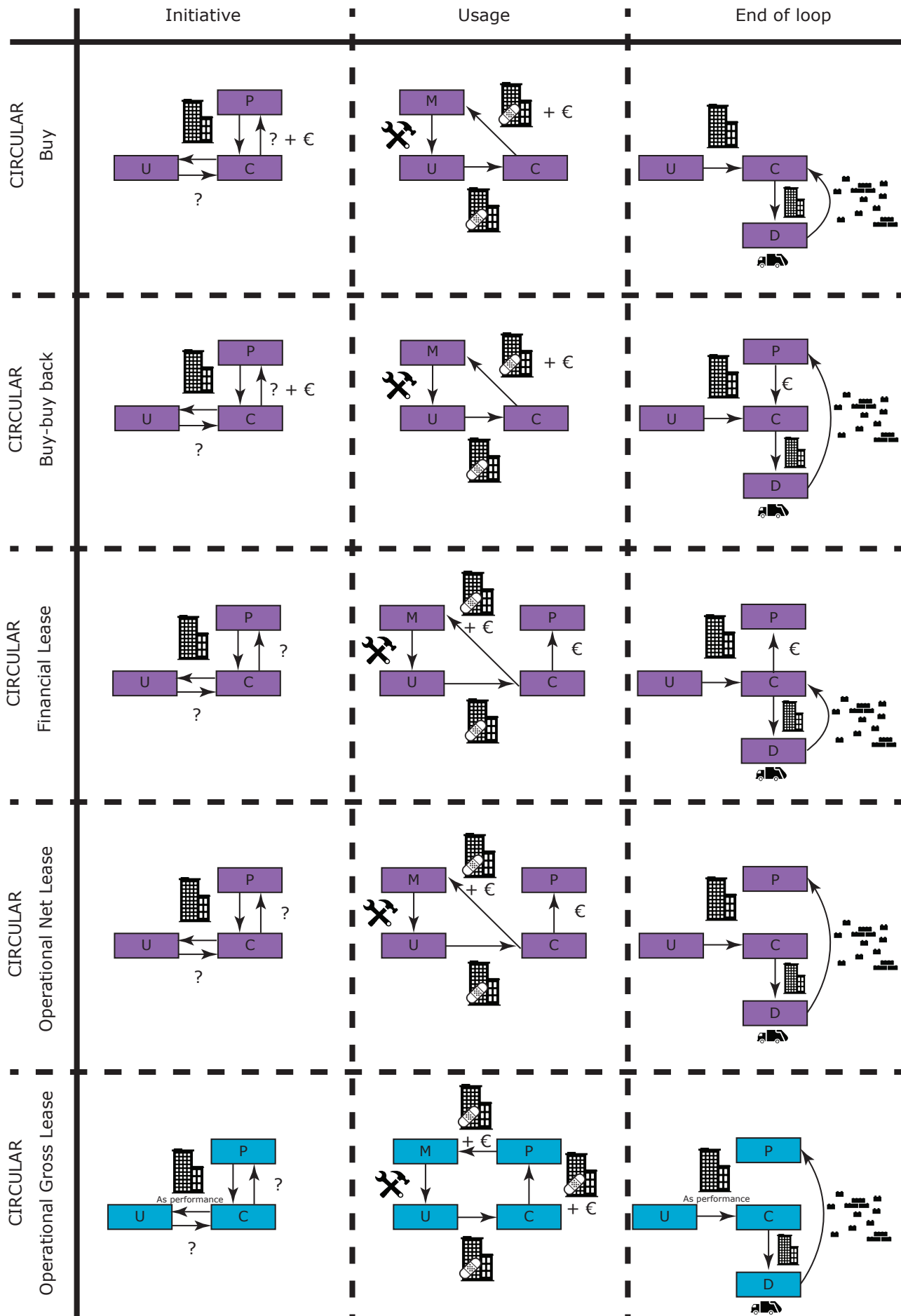
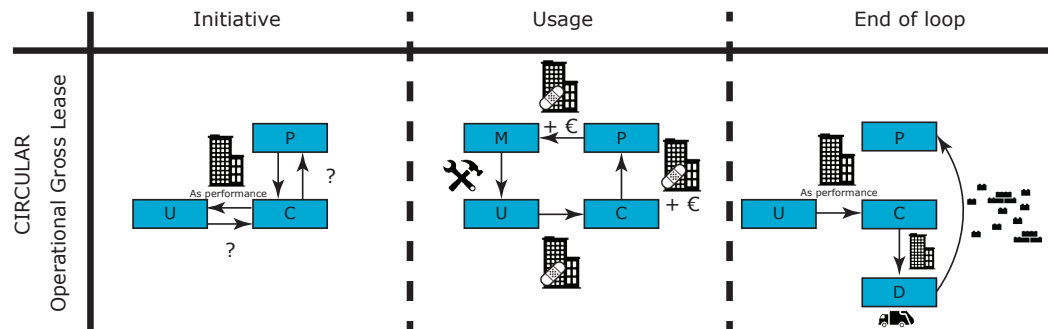


Figure g: De Performance-Service System - Operationele bruto lease (Circulaire Economie)



De afnemer - de onderwijssector

De testcase werd gedaan aan de Technische Universiteit Delft. De universiteit heeft een enorme ambitie met betrekking tot duurzaamheid, maar op dit moment omvat dit alleen de vermindering van de uitstoot van CO₂. Gerelateerd aan de ambitie ten aanzien van duurzaamheid ontwikkelt en beheert de TU Delft haar eigen vastgoed. Indien de TU Delft wil veranderen in de richting van de Circulaire Economie door middel van implementatie van een Prestatie-Dienst Systemen, dan zullen de volgende aspecten moeten worden overwogen:

- verandering binnen de organisatie richting contract management
- Afnemende eigendom van componenten

Bovendien, de afnemer heeft een verantwoordelijkheid ten aanzien van het gebruik van de prestaties richting de aanbieder. Gebruikers hebben veel eisen en wensen, maar ze zullen ook een verandering in hun mind-set moeten krijgen met betrekking tot Circulaire Economie. Dit betekent dat er een kans bestaat dat de gebruiker scholing moet krijgen m.b.t. hun gedrag ten aanzien van prestaties.

Is het model implementeerbaar in bouwprojecten van de educatieve sector?

Het model zal op dit moment geen ondersteuning bieden voor strategische beslissingen. Er zijn verschillende mogelijkheden om dit model te optimaliseren:

- Voeg een voor- en nadelenlijst per strategie toe. Volgens Koopmans zal deze lijst dan kunnen helpen om beslissingen te nemen.
- Ontwikkeling van andere modellen die dit model ondersteunen. Men kan denken aan een beslisboom of multi-criteria-modellen.

De inhoud van het model is goed, maar om dit model operationeel te maken zijn wijzigingen nodig. Door middel van dit model wordt de discussie over de Circulaire Economie gestimuleerd. Het geeft, met behulp van relatief eenvoudige figuren, een goede illustratie van wat de Circulaire Economie is. Hoewel het niet beslissingen zal ondersteunen in zijn huidige status, geeft het model veel verschillende inzichten over de Circulaire Economie in de Nederlandse onderwijssector. Daarom is deze studie een eerste poging om onderzoek naar dit onderwerp te stimuleren. Hopelijk kan dit onderzoek dienen als basis voor toekomstige onderzoeken.

Chapter 1 will elaborate on why this research is conducted. This chapter is split in several parts which explain the problem statement, the research questions and what steps have been taken to come to the final result.

Chapter 2 and 3 will show the results from the literature review. In chapter 2 the Circular Economy will be explained. In chapter 3 the concept of Product-Service Systems is elaborated. As a conclusion the first steps have been taken to develop the Performance-Service System.

The first design is being tested at the Delft University of Technology. The results can be seen in chapter 4. The model is being evaluated and redeveloped.

The final design of the Performance-Service System can be seen in chapter 5. Because this model is split in 15 different strategies, every strategy is being explained on two pages.

Chapter 6 will describe the validation of the strategies. All these strategies have been evaluated and reflected with some employees of the Delft University of Technology. All results of this validation are described and visualised.

In order to operationalise the Performance-Service System, one last adjustment has been made in the model. The model is being altered into a checklist. This checklist is being tested at Gilde Opleidingen, as can be seen in chapter 7.

After testing the last step in this research, all conclusions have been drawn. Furthermore a reflection is given about the process and the subject of the Circular Economy in the built environment. At last some recommendations will be given, so other students or researchers can build on this knowledge.

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1 - INTRODUCTION

The concept of the Circular Economy is still in its infancy. So what are problems and issues to overcome in order to implement this concept in the construction sector? This chapter will describe the problems and issues within the subject of Circular Economy and Performance-Service Systems. Furthermore it provides the research question. At last my motivation to this research within this field is described.

1.1 – Problem

When looking at the principles of the Circular Economy one quickly thinks about flexibility within construction projects. So, Albers (2011) cited in Geraedts (2013) mentions that when definitions such as ‘flexibility’ and ‘parcel out’ are mentioned in the construction sector one quickly talks about cultivation. Clients have changing demands and therefore walls should be disassembled and replaced easily. In a traditional construction model the wall is fixed to the floor. In a lot of situations different parties deal with this floor and wall. The junctions are hardly flexible or adaptable constructed. In order to prevent such issues from happening smart components need to be developed. However, techniques to develop such components are already applicable. It is a question of how to finance and how to implement such components in the current market. Due to current construction methods it is not economic viable to recover materials from buildings (Circle Economy, van Odijk, & van Bovene, 2014).

So, knowledge on how to implement strategies that will stimulate the transition towards the Circular Economy is still lacking. One strategy that could be the answer for current business practices in the construction sector is a Product-Service System. This system advocates the use of performances (services) instead of products. In real estate one could think of shelter as a performance. Still many questions remain unclear. For example, does only one provider deliver performances (in this case real estate as a whole) or are several providers needed in order to get all performances and maintenance included? And how does the provision of performances by multiple actors translate itself in the cash flow schemes? Other questions include ownership, tendering and what the frequency of maintenance for construction components is.

The concept of the Circular Economy and Performance-Service Systems are still in its infancies. As can be seen above, many questions need to be answered. It is therefore that one could say that there is a lack of knowledge about the Circular Economy and Performance-Service Systems within the construction sector. In many cases people do not know how to implement such systems. For example, architects and building companies do not know what potential applications waste can have (Circle Economy, van Odijk, & van Bovene, 2014). They also do not know how to achieve goals in order to get a Circular Economy. So, in addition to this, one of the main questions of the ‘Circle Economy’ (n.d.), a non-profit open platform to stimulate transition to Circular Economy, is: *“How can we make decisions consistent with the vision of a Circular Economy, even with lack of complete data?”* One attempt to stimulate research to the Circular Economy is the ‘green deal circulaire gebouwen’; ‘green deal circular buildings’ (CFP, n.d.), which states that all companies who will sign this contract will contribute to study this matter within the construction sector (CFP, 2014).

Problem statement:

In the current construction sector there is an urgency to implement principles of the Circular Economy. Unfortunately, there is no step-by-step plan on how to make a transition towards a Circular Economical system. There is a lack of, but also a need for, data, information, and knowledge regarding the Circular Economy within the construction sector.

1.2 – Boundaries

In order to make this research manageable a few boundaries had to be determined. Below follows a brief explanation of the stakeholders involved and the building components used in this study.

The educational sector as a client

This study will focus on the client perspective of this system. In this case the client represents stakeholders within the educational construction sector. Stokkers states in an interview that there is urgency among end-users (clients) to have a greater voice within the construction sector. Too much is done according principles of the linear economy, which in turn is negative for clients. Therefore this group will be studied within the framework of a Performance-Service System. Also, as mentioned above, the client does not have the knowledge about such systems. The client wants the best performance for the best price. So the question is what kind of system does meet the needs of the client best?

Secondly, there is a lack of information about costs and benefits of implementing the Circular Economy. Clients do not know if this can be beneficial for their organisation. The educational sector does not know how the Circular Economy will benefit the four values of universities, namely competitive advantage, profitability, productivity and sustainable development (Den Heijer, 2011).

Thirdly, the mind-set of both clients and providers must change. According to the principles of the Circular Economy there must be a shift of ownership, materials retain their value, clients must think in services instead of products (Ellen MacArthur Foundation, 2012, 2013, 2014; Lovins et al., 2013).

The client reflects the decision makers regarding facilities of an organisation. In a lot of circumstances users belong to the client. As mentioned above this study will complement other graduation projects, so a better understanding about the Circular Economy will be provided. The client in this study will be the educational sector of the Netherlands. The educational sector consists of several institutions. One could look at the primary schools, high school, colleges, and universities. Due to limitations this study focuses only on the university and colleges. The Delft University of Technology will be used as a case and some experts in the field are interviewed in order to validate the model.

The educational sector has a lot of societal real estate in their portfolio; therefore they have a social responsibility. Furthermore in order to meet this social responsibility the educational sector should have a long-term vision on sustainability. Further elaboration of the test case can be found in chapter 4.

Components

Another boundary of this research is the focus on small components of a building. In Den Heijer (2013) the importance of good facades is highlighted. She made a few conclusions about the façade and gives a few propositions for the façade brief:

- The façade should contribute to the productivity and support the changing needs of clients;
- Due to shorter functional lifetimes flexibility is becoming an important strategy. “The façade should not dictate fixed solutions for the floor plan (Den Heijer, 2013).”;
- The façade also influences the energy value of buildings. It influences the indoor environment and energy use;

- There is a focus on reducing client's footprint. This will save resources, so the client has the ability to invest in the quality of space;
- Another important aspect is the image of a building reflecting the organisation accommodated in the building. So a façade should have a strategic value for real estate owners.

One can conclude that facades have the potential to have a great impact on the functionality of a building. However Performance-Service Systems that integrate principles of the Circular Economy are very complex, because a lot of different services must be provided in order to keep the loop as small as possible. Furthermore facades must be adaptable for future demands. However, due to lack of experiences with constructions and the complexity it entails if such components are implemented by using Performance-Service Systems, a focus is made on blinds of the facades. Blinds are more easily to manage in the research due to the size. Data is more accessible than data from façades. The Delft University of Technology wants to learn about the leasing possibilities in blinds.

1.3 – Main research Question

The problem statement described above has led to the following research questions:

How to develop and implement a Performance-Service System in constructions of the educational sector regarding operations, organisation and financial schemes?

A few detailed questions are raised in order to answer the main research question. The questions need to be answered in different phases of this graduation project. The main question has led to the following detailed questions:

Subquestions

- What is the Circular Economy?
 - How does the Circular Economy work?
 - What principles of the Circular Economy are applicable in the construction sector?
 - Is it possible to implement these principles within the construction sector?
- Why should there be a Performance-Service System?
- What is a Performance-Service System?
 - A clear definition of a Performance-Service System must be provided.
 - Are there different models within the construction sector that provide Performance-Service Systems (PSS)?
- How does a Performance-Service System look like?
 - What are operations of a Performance-Service System?
 - How does one organise a Performance-Service System?
- What are, from a client perspective, the financial costs and benefits of a Performance-Service System?
 - Is it true that value maintained replaces value added?
 - What are costs to organise such a system?
 - Can a performance fulfil the requirements of the Circular Economy and be financially beneficial for the client?

- Is the educational sector willing to use a Performance-Service System?
 - What is the vision of the university and how does a Performance-Service System fit this vision?
 - Regarding the principles of the Circular Economy, is outsourcing better than owning a performance?
 - What are initial costs of a performance (blind)?
 - What is the residual value of a performance (blind)?
- Does a Performance-Service System fit the needs of a client best?

1.4 – End result

The end result of this graduation project is a Performance-Service System. This system should implement the principles of the Circular Economy in the current construction sector. By developing this system awareness and insights will be provided in the Circular Economy and Performance-Service Systems. Furthermore a checklist based on the Performance-Service System should support decisions of the client.

Therefore, the expected result is twofold, namely practical and scientific. Practically it should support clients making decisions regarding the Circular Economy. Secondly, scientifically this thesis must produce more insights in the new trend of Circular Economy. Definitions have been operationalized in order to implement the Circular Economy into practice.

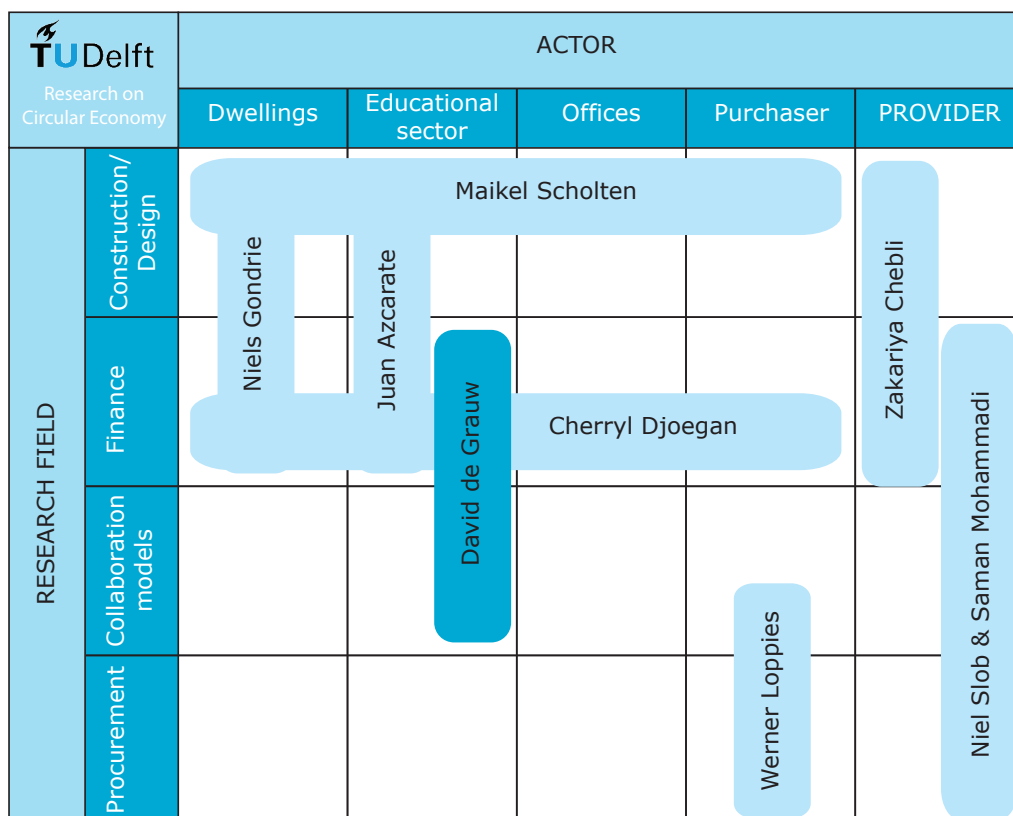


Figure 1: Organization chart
– Studies about the Circular Economy in real estate

1.5 – Relevancy

Scientific relevance

Sustainability is a popular topic, not only in politics and in businesses, but also in the scientific field. A lot of reports have been written about the issues the world is facing. However, knowledge about how to implement measures in our current economic system to face those issues is still lacking. In the Netherlands a few reports have been published about opportunities of the Circular Economy in the Netherlands. Among the organisations that show interest in the subject are MVO Nederland and TNO. Although both organisations are very optimistic about the opportunities this system can provide, none has found an answer on how to implement this system.

This study will add knowledge to a series of studies. Next to this graduation project; other graduates are studying the phenomenon 'Circular Economy'. All graduates or post-doc students studying this subject can be seen in figure 1. Within this framework it is chosen to study this subject from a client perspective. In this way, many aspects of this matter will be explored and studied. In addition to the students mentioned above there is a growing demand among students to study this subject.

Societal relevance

As mentioned above there is an urgency to implement principles of the Circular Economy in our current system. One example is that some of the major companies in the Netherlands have signed a 'Green deal circulaire gebouwen' (Green deal circular buildings). This include companies such as OVG, ABN AMRO, Alliander, Eneco, Dura Vermeer, etc. (duurzaamgebouwd.nl, n.d.). So there is a need for knowledge in the field.

Besides the trends among companies, studies showed that some opportunities are savings in the industry regarding material costs and labour (Lovins et al., 2013). Furthermore, it is believed by TNO (Bastein, Roelofs, Rietveld, & Hoogendoorn, 2013) that the Circular Economy will stimulate employment growth.

Practical relevance

The Performance-Service System will provide answers of where to start when making the transition towards the Circular Economy. This study will show knowledge gaps and will give an recommendation what follow-up studies should focus on. The main goal of the Circular Economy is creating value, in the broadest sense of the word, for every stakeholder. Hopefully, the Performance-Service System will contribute to this goal.

1.6 – Methodology

A problem statement, goal and research questions have been determined. Within this research three fields of interest will be combined in order to develop those requirements. The fields are the 'Circular Economy and in particular Product-Service Systems', 'financial models', and studying this subject from 'client' perspective, which will be reflected by the educational sector. The final result of this study is a Performance-Service System. The Performance-Service System is based on principles of the Circular Economy, Product-Service Systems and own insights. Interviews are conducted and a financial model is validated in order to test the Performance-Service System.

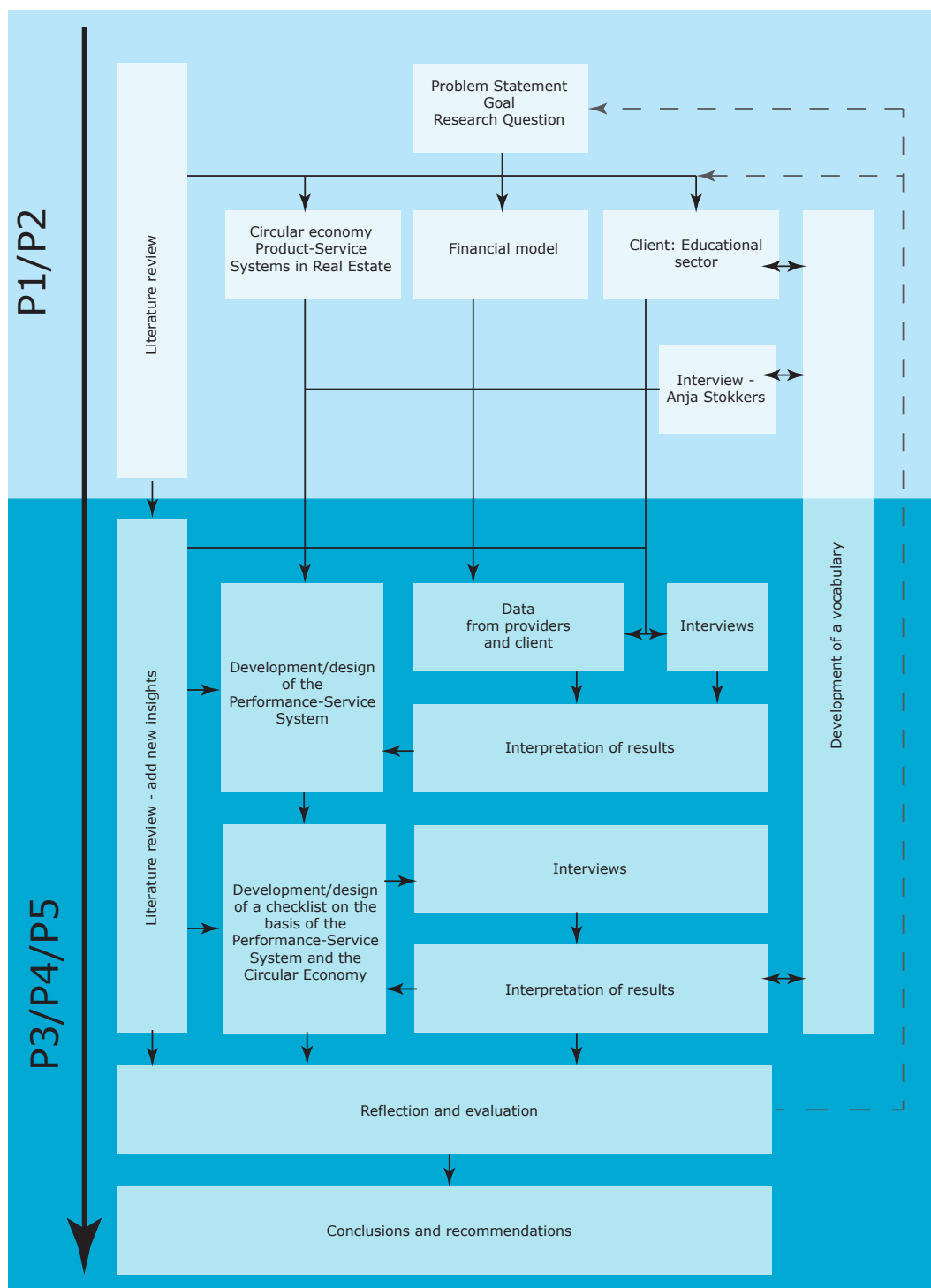


Figure 2: Research design

Literature review

A literature review is conducted in order to show gaps in knowledge and to relate the Circular Economy to Product-Service Systems. According to Kumar (2011) the literature review consists of four steps:

- Searching for literature in the area of the study;
- Reviewing the existing literature;
- Developing the theoretical framework;
- Developing the conceptual framework.

By conducting the literature review one can answer some of the questions such as what is already known in the area? What are gaps in the current body of knowledge? At some point the reader will realize that the Circular Economy is still understudied within the construction sector.

Design of the model

The core of this study is the design and development of the 'Performance-Service System'. This system must deliver some insights in the Circular Economy, but should also be a mean for clients to help them making decisions regarding assets. The first steps in the design are taken by conducting a literature review on the 'Circular Economy' and 'Product-Service Systems'.

Van Doorn (2011) distinguishes two design approaches. The first approach is process oriented. The second approach is design oriented. This study will adopt the second approach. This approach focuses more on the content of what is being designed, rather than the process in order to get this design.

Furthermore the design process follows the elementary model developed by Van Doorn (2011). There are three parts within each design process, namely:

- Analysing;
- Synthesis;
- Evaluation.

In order to design efficiently an interaction is sought between sketches on paper and the different programs on the computer. Sketches were used to quickly draw ideas. Computer programs were used to developing these ideas.

What is done to gain new insights regarding the model?

The focus of this research is the development of a Performance-Service System. During phases 3 and 4, see figure 2, this model is being designed, reflected and evaluated. The results are used to improve the model. Besides the development of the model, financial models and interviews are carried out in order to acquire a better grip and an in depth understanding of the model.

Interviews are carried out with different stakeholders at the Delft University of Technology and stakeholders within other educational institutions. The interviews are semi-structured. This way of interviewing is chosen due to the newness of this subject. Therefore it leaves room for different interpretations. This will help to better formulate definitions, so that in next sessions the subject becomes more and more understandable.

Secondly, the Performance-Service System is evaluated as a whole or in parts during the interviews. At the start of an interview a presentation about five minutes is given in order to give the interviewee a better understanding about the subject. Due to the infancy of the Circular

Economy and especially Performance-Service Systems, a presentation became very convenient. During the interview questions asked were dependent on the interviewee. For example, the interview with Weststrate (2014) focused more on maintenance activities, while the interview with Winkels (2014) focused more on the subject of the sustainable policy of the Delft University of Technology. All interviews were independently and orally conducted. The interviews are recorded and written down in transcript. The following stakeholders are interviewed:

- Anja Stokkers (Director FMVG – TU Delft);
- Rob Weststrate (Maintenance and management FMVG);
- Catelijne Elissen (Real Estate & Campus developer FMVG);
- Tom Wiardi (Project Manager FMVG);
- Chris Hellinga (Delft Energy Initiative);
- Ad Winkels (Policy on sustainability FMVG – TU Delft);
- Atse Koopman (Contract management FMVG);
- Robert van Barneveld (UMC Utrecht);

Evaluation of the model

Results acquired through financial models and interviews are used to develop scenarios. The scenarios will be divided between a 'Circular Economic system' and a 'linear economic system'. These scenarios are used to create a context, in order to understand the subject. The subject of Circular Economy and therefore the Performance-Service System is abstract. Scenarios will help to get better insights by testing the model in practice.

When all scenarios have been developed and evaluated, the conclusions made are used to improve the Performance-Service System. Besides that, the results are reflected on the literature review conducted in the preliminary phase. After this reflection, one will see the research question answered. Finally, conclusions and recommendations for further research are presented.

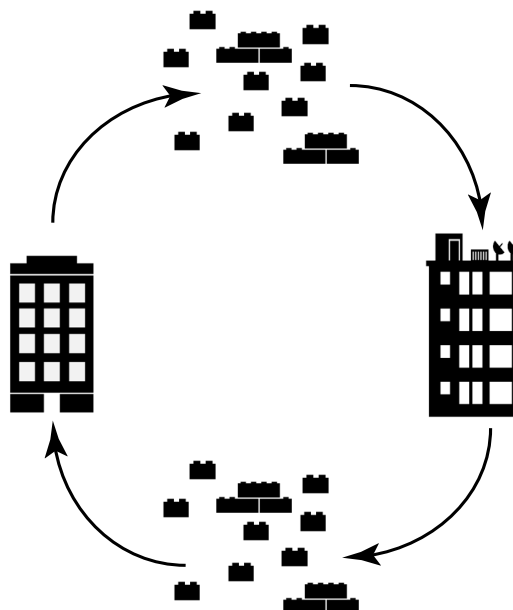
1.7 – Motivation & Vision

Architecture and buildings were my great fascination during my Bachelor. It was in my Bachelor that I learned that sustainability is of great importance for the world and therefore also in real estate. Buildings consume approximately 40 per cent of all energy (Birkeland, 2013; managersonline.nl, 2013) and produce 30 per cent of the carbon emissions in the world (Birkeland, 2013). A lot of opportunities to reduce energy consumption can be found within this sector. However, buildings are very durable and are not easy to replace. It is difficult to change this industry.

Within the development sector a few aspects caught my attention. First of all, there is the issue of depletion of natural resources. Experts are saying that there will be a lack of natural resources within upcoming decades. This will lead to a lack of materials. The real estate sector is also subject to this issue. The real estate development sector should therefore anticipate on this issue.

Another issue is the economical crisis. Since 2007 the economy of the world has been in a recession. In the Netherlands this eventually led to a crisis within the real estate sector. One of the critical points was that banks were not able or willing to finance developers for new projects. Because of the crisis, companies show more interest in the supply-demand question.

Figure 3: Personal vision on real estate and the construction sector



A lot of offices are still vacant in the Netherlands. Most of these offices are not easily adaptable or do not have any adaptive capacity. The question of the in time changing demands cannot be met in a short period. Real estate is a slow market.

In order to create a healthier economic system with sustainability as core value some professionals state that the economy must alter its fundamentals from a linear economy to a Circular Economy (Lovins et al., 2013). However, the Circular Economy requires the necessary alterations in the development sector. I want to contribute to sustainable developments by studying this concept and show that new concepts can be implemented in the development sector.

The most interesting aspect about Lego is the fact that you can build a structure and reorganise all blocks if you want to. It was a miniature version of the real estate sector, because the Lego structures also dealt with functional lifetime. The child's requirements formed a metaphor for functional lifetimes.

Components of Lego can be reused time after time. Components of real buildings cannot be reused in such a way. In a lot of cases when a building is being disassembled or demolished it produces a lot of waste. De Ridder (2011) also mentions this in his book 'Legoliseren van de bouw' (Legolising the building industry). He argues that we should 'Legolise' the construction industry. His vision is that all parties in the construction industry will work with customized construction components. Figure 3 shows a visualization of my vision.

In order to keep up with all trends, such as sustainable development, the real estate sector must consider making changes. However, due to the scale and the complexity of real estate, alterations can only be implemented slowly.

There should be a world in which everything done by human is sustainable. Then the three P's (people, planet and profit) of Elkington (1999) all benefit. First, all people have a shared and lasting prosperity. Secondly, the planet can provide in all needs of next generations. Thirdly, companies and people who implement sustainability make profit. One of the ways to get real estate sustainable is to alter construction components, so these components are more adaptable than traditional components. The sector should reduce its waste. Real estate can contribute to a better living environment. Real estate could be a means that has the ability to respond on current and future demand.

2 - REAL ESTATE & THE CIRCULAR ECONOMY

The fundamentals of our economy are constantly changing due to a few issues that have great impact on our society. Van Nederveen and Gielingh (2009) mention five planetary issues and at this moment the world is still recovering from the financial crisis. The five planetary issues are:

- Depletion of natural resources;
- Devastation of natural conditions;
- Increased standard of living all over the world;
- Ageing of the population in industrialized countries;
- Bankruptcy of the banking system.

Requirements and wishes of people change over time due to these five issues and the behaviour of people. This simply means that demand changes over time. Unfortunately, real estate is a very slow market and cannot keep up with all alterations. In order to meet this demand it is becoming more and more a necessity that properties are flexible and adaptable.

One of the major problems in the Netherlands is the vacancy within the existing stock. There are several options in addressing the vacancy issue. One of the options is transformation of the existing stock. However, Slob and Mohammadi (2010), two former graduates of the University of Technology Delft, also stated that:

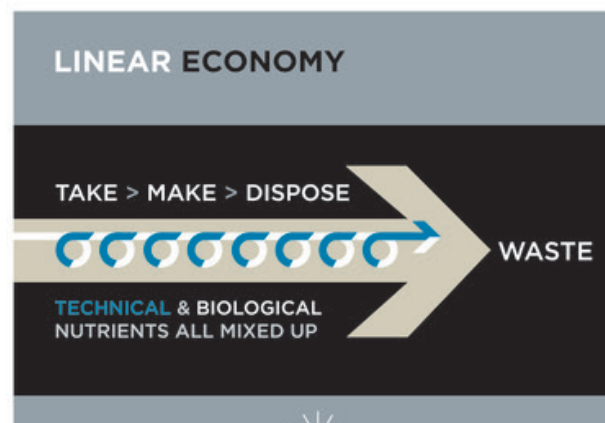
“Transformation of existing buildings helps to react on vacancy but is not always possible because of location, legal, technical or financial reasons. Users will leave the existing buildings behind and these buildings become vacant, redundant and obsolete.”

In order to address all those issues this sector must become more sustainable. The concept of sustainability has been an issue for discussions and different theories for decades. It is a trend that is here to stay. Sustainability has and will have an increasing impact on the construction sector.

One example of a sustainability theory is the concept of ‘cradle-to-cradle’ of Braungart and McDonough (2002). They argue that waste must be food. Unfortunately, real implications are still lacking, especially within the construction sector.

Another important theory, which will be used within this report, is the theory of the ‘Circular Economy’. This is a new concept within the whole framework of sustainability. It builds forth on concepts such as ‘cradle-to-cradle’, but its building blocks are different. Although businesses want to commit to this principle, a lot of aspects are still underexposed. Two of these underexposed aspects are flexibility and adaptability. Some attempts have been made in order to study this subject, however there is still a lack of knowledge within this sector.

Figure 4: Simplified model of the linear economy (Clift & Allwood, 2011)



The Circular Economy is considered to be the counterpart of the linear economy, see figure 4 for a simplified illustration. For decades a linear economic system has been the basis for production and consumption in the world. This system follows a pattern of take-make-dispose. We use natural resources to produce products. These products are being consumed and then these are

thrown away as waste (Braungart & McDonough, 2002; Lovins et al., 2013; Schoolderman et al., 2014).

Furthermore, most innovations are done in order to make production as efficient as possible (Schoolderman et al., 2014). Other reasons, with respect to production processes, to alter the linear economy are mentioned in Schoolderman et al. (2014):

- Waste within the production chain;
- Waste due to end-of-life materials/products;
- Energy usage during production;
- Devastation of eco systems;
- Waste of energy and natural resources.

So briefly, our economic system is linear based, instead the world must alter its economic fundamentals into a Circular Economy (Lovins et al., 2013).

2.1 – Real Estate

Before elaborating on the Circular Economy, a few characteristics of real estate must be explained in order to understand the market. Van Gool (2007) describes real estate as follows:

- Real estate is immovable;
- Real estate can be seen as means of production as an asset;
- Real estate has high unit prices;
- Real estate has high transaction costs;
- Real estate is heterogenic;
- The construction process is long in comparison to other products;
- Real estate has a long economical, functional, technical lifetime.

One barrier is that buildings or assets have an effective lifetime, which is difficult to forecast. It depends on premature obsolescence. Langston, Wong, Hui, and Shen (2007) mention six obsolescence's:

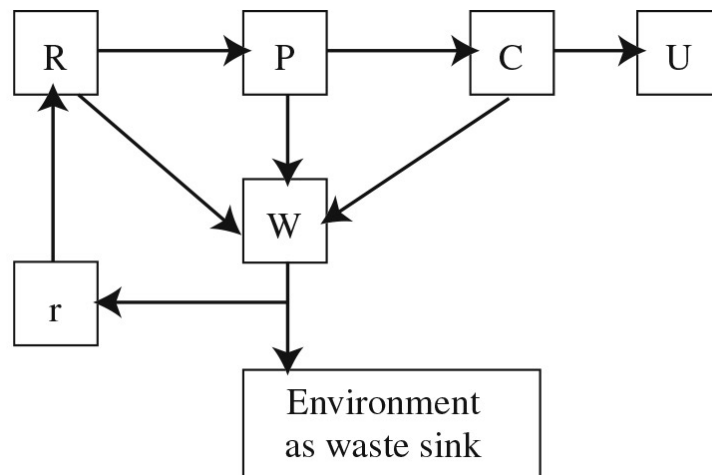
- Physical obsolescence;
- Economic obsolescence;
- Functional obsolescence;
- Technological obsolescence;
- Social obsolescence;
- Legal obsolescence.

Another aspect is demolition of buildings within the current market. New building and demolition are preferred by the construction industry, because this industry wants to keep the business-as-usual course (Thomson, 2010). However, due to the infancy of the Circular Economy and the complexity of buildings it is chosen to focus only on components of buildings.

2.2 – The Circular Economy

The concept of the Circular Economy tries to give an answer to issues the planet is facing. As Stuchtey (2013) states, it could not be simpler. It is about having an economy like a forest, a living growing entity that does and will not waste anything. The economy must be designed in such a way that is regenerative (McKinsey & Company, 2014). Andersen (2006) gives a simplified model of the Circular Economy, see figure 5. As one can see waste is still going into the environmental

Figure 5: Simplified model of the Circular Economy (Andersen, 2006)



sink, because it is almost impossible (at this moment) to reduce waste to a minimum.

Improvements in material selection and product design are at heart in the Circular Economy (Ellen MacArthur Foundation, 2012). The roots of the Circular Economy can be found in the industrial ecology (Andersen, 2006). Other theories which have influenced the concept of Circular Economy are 'cradle-to-cradle', 'natural capitalism', bio-mimicry and the 'performance sharing economy' (Lovins et al., 2013). The industrial economy envisions material symbiosis between otherwise very different companies and production processes. Within the framework of the industrial ecology it is implied that the Circular Economy is beneficial to society and to the economy as a whole, but how to implement the Circular Economy financially within the building environment is still unclear. At last, it is interesting that the Ellen MacArthur Foundation calls it the Circular 'Economy'. This implies that the reuse of a product, component or material is economic beneficial. Although the word economy is used, real implications lack behind. Briefly, the whole system should be optimized. It is not about the current systems, but it is about creating new production processes, new ownerships relations, network, and chains (Van de Kaa, 2013).

Schoolderman et al. (2014) mention three perspectives that form the basis for the Circular Economy. The first perspective is about the ecology focused on relations, loops and patterns of nature. It is an economy in loops, similar to the natural systems, such as the water cycle (Stahel, 1998) Secondly, biology is utilized as field to learn from solutions nature gives. At last, Schoolderman et al. (2014) mention thermodynamics as learning tool to find relationships between energy and matter.

Thinking in circles is not a new concept. One can trace this back to the theories the circular economy is based on. But the Ellen MacArthur Foundation is one of the first to consider economic and business opportunities of circularity. They made a model of the Circular Economy as can be seen in figure 6. A differentiation is made between biological materials and technical materials. Because the business of the construction sector is technical orientated, this study will only focus on the technical materials section of the model.

When looking at the model one sees that it all comes down to closing loops. Looking at the loops of the technical materials this means more usage of renewable energy resources and to minimize impact on ecological systems. Furthermore, materials that are used in our economy can flow right back into ecologic systems (McKinsey & Company, 2014).

One of the fundamental principles of the Circular Economy is that the client wants the service / the performance rather than the product (Webster, 2013). The manufacturing service enterprise does not make a distinction between products and services, but it offers costumers highly individualised solutions (Aurich, Fuchs, & Wagenkencht, 2006).

This means that instead of trading in products, society will trade in performances.

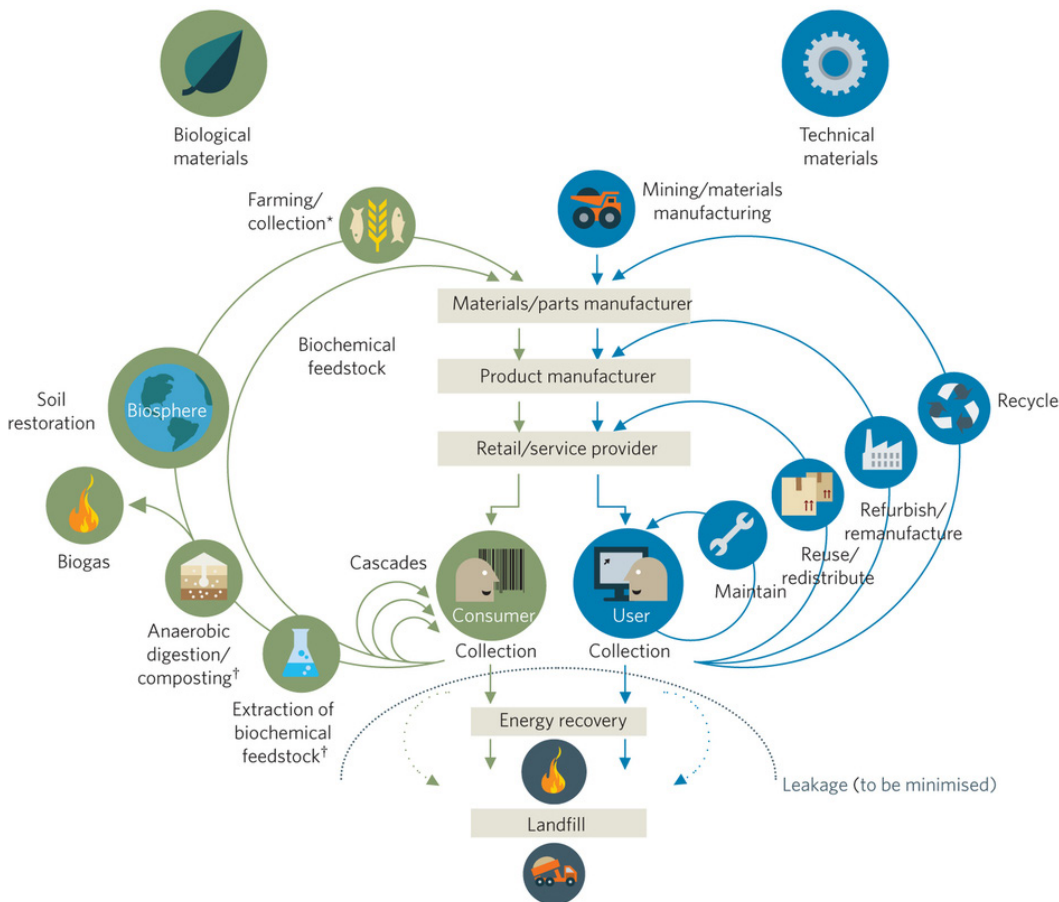


Figure 6: The Circular Economy (Ellen MacArthur Foundation, 2012)

Provided performances can be reused in the future. Another principle is that the provider remains the owner of the components of a performance. One example could be a beam. A beam is a horizontal component that provides wearing off forces. Wearing off forces is the required performance. The beam is just necessary in order to apply the performance. The building as a whole is no longer a building, but a supply of performances.

Bastein et al. (2013) mention a few indirect benefits of the Circular Economy. First of all there is an opportunity to develop and spread knowledge about the development of the Circular Economy in the Netherlands. This contributes to the ambition of the Netherlands to have a knowledge economy (Kamp & Dekker, 2013). Another indirect benefit would be the security of raw materials supplies. This could be of strategic importance for companies, governments and the European Union. The Circular Economy could create new incentives in the manufacturing industry. At this moment the share of the manufacturing industry is shrinking in the Netherlands. The Circular Economy can increase opportunities in the Netherlands for the manufacturing industry to grow. There also will be new incentives for the recycling industry to thrive. This will have its impact on the logistics industry, because the collection of used materials will be everyday practice. The Circular Economy will encourage development of new economic activity (Bastein et al., 2013). However, one should note that there is still no evidence on all indirect benefits.

At last the Ellen MacArthur Foundation (2012) notes that designs that apply principles of the Circular Economy consistently, benefit more in economic terms. So, there is a huge potential in gaining benefit when applying the Circular Economy.

2.3 – Principles of the Circular Economy

In the book of Lovins et al. (2013) several theorists and experts try to explain the 'Circular Economy'. According to all writers there are a lot of principles relating to this theory. In order to operationalize this research proposal a selection of the principles has been made. These principles will be used to measure the impact of the Circular Economy in the construction sector. The principles that have potential to be measured are made bold. All principles are mentioned below.

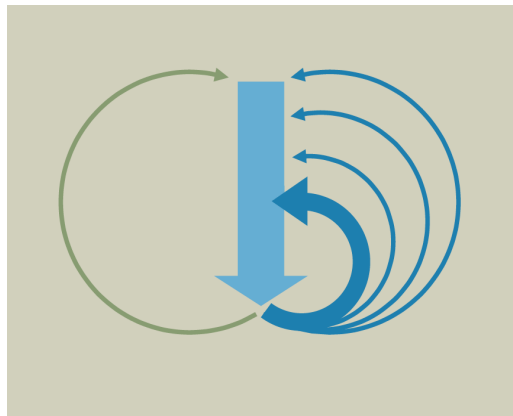
According to Stahel (2013) there are five principles prevailing the Circular Economy:

"Principle 1: The smaller the loop (activity-wise and geographically) the more profitable and resource efficient it is, as can be seen in figure 7.

In addition to this principle the Ellen MacArthur Foundation (2012) refers to the 'power of circling longer', see figure 8. It is about maximizing the number of circles within the Circular Economic system.

Figure 7 (left):
Power of the inner circle
(Ellen MacArthur Foundation, 2012)

Figure 8 (right): Power of
circling longer
(Ellen MacArthur Foundation, 2012)



Furthermore the Ellen MacArthur Foundation (2012) states that it would be wise to use the 'power of cascades'. This means that a certain material or component will be reused for different uses before it would be concluded that it should take another loop or eventually ends as waste. The pure power of using circles is that it increases material productivity and product longevity by maintaining the quality of the uncontaminated materials, see figure 8 (Ellen MacArthur Foundation, 2012).

Principle 2: Loops have no beginning and no end; value maintained replaces value added.

Principle 3: The speed of the circular flows is crucial; the efficiency of managing stock in the Circular Economy increases with a decreasing flow speed.

Principle 4: Continued ownership is cost efficient; reuse, repair and remanufacture without a change of ownership saves double transaction costs.

Principle 5: A Circular Economy needs functioning markets."

Other principles of the Circular Economy are mentioned by the Ellen MacArthur Foundation (2012):

Principle 6: Design out waste

Principle 7: Build resilience through diversity (important for the provider)

Principle 8: Rely on energy from renewable sources

Principle 9: Think in 'systems'

Thinking in systems is about seeing parts or components as a part of the whole. Elements are considered in relation with infrastructure, environment, and social aspects. It is a system with feedback loops (Ellen MacArthur Foundation, 2012).

Principle 10: Waste is food

Other principles include:

Principle 11: The customer wants the service, the performance rather than the product (Webster, 2013).

Principle 12: A Circular Economy corresponds with the objectives of a 'green economy' (Stahel, 2013):

- *Creating an innovation-focused national economy*
- *Promoting an economy in loops and closes local loops*
- **Reducing consumption of non-renewable resources**
- **Efficient use of energy, materials and natural capital**
- **Replacing non-renewable with renewable resources**
- **Creating an energy supply based on renewable energies**

Principle 13: A Circular Economy in the building environment corresponds with criteria for positive development (Birkeland, 2013):

- **Reduce total resource flows over a building's life cycle**
- *Reverse the impacts of the growing disparity of wealth and life quality*
- *Increase ecological carrying capacity beyond pre-industrial conditions*
- *Generate surplus 'eco-services' in relation to floor area as well as ground area*
- *Produce net positive sustainability impacts beyond the given site or system borders*
- **Replace fossil-fuel-based mechanisms with passive and natural systems where possible**
- **Design reversible, adaptable, demountable and/or biodegradable systems**
- **Compensate for past design decisions and their environmental impacts**
- *Future proof the urban environment to reduce risks of flooding, earthquakes and so on*
- *Celebrate the intrinsic values of nature*
- *Create an urban gene bank for regenerating the bioregion*

Principle 14: All parts of the circuit count and the key to vitality lies in rapid, robust, thorough circulation of money, goods, services etc. to all stakeholders (Goerner & Voller, 2013).

A few notes should be made about these principles. All principles emerged from texts of the Ellen MacArthur Foundation. Therefore one can conclude that the principles are not yet hard principles, but these are soft principles that need further exploration. Furthermore, these principles also depend on interpretation. Due to the large number of principles it is possible that some principles may overlap each other. Some principles are made bold in order to make a first attempt to create an assessment list for the Circular Economy in the construction sector.

2.4 – Obstacles for implementing the Circular Economy

One of the main challenges of the Circular Economy is that people should have the capacity to innovate. Therefore knowledge is of great importance for the Circular Economy to succeed. First of all, knowledge that will contribute to the Circular Economy must be integrated in creative industries and design schools (Bastein et al., 2013).

Knowledge management rarely cuts across other sectors (Bastein et al., 2013). However,

because all sectors must work together in order to develop a Circular Economy this is one of the main challenges to overcome. One of the questions is: How is knowledge being exchanged when there is fear of losing competitive advantage?

At this moment there is a lack of a coherent approach for training skills and competences. In order to develop a Circular Economy structures of society are subject to change. Businesses must adopt new business models and this will change the nature of jobs. This suggests that there should be an approach for training skills and competences (Bastein et al., 2013). Skills and competences that must be developed include:

- Applying principles of system thinking;
- Ability to work together in multidisciplinary settings;
- Acceptance of 'Not Knowing'. Universities and schools must provide a more 'process-driven' approach instead of the expert-driven education.

Another knowledge obstacle is the availability of knowledge to companies. Most of the companies do not have access to information in terms of the environmental impact. Furthermore, clients are used to look at the initial purchase price instead of the total cost of ownership and the environmental impact (Fleming & Zils, 2014).

Partnerships should be encouraged between designers and clients at an early stage (Den Heijer, 2013). Giving clients evidence-based knowledge about how new concepts influence their performance is even more important for successfully implementing innovation in the built environment.

As mentioned above, in order to implement the Circular Economy new business models must be developed. Bastein et al. (2013) refer to a study of Tukker in 2004, which states that Product-Service Systems are the most promising for new sustainable business models. Turntoo, a company in the Netherlands, already uses Product-Service Systems in order to change the construction sector (Turntoo, n.d.).

Due to the fact that the Circular Economy is still in its infancy, companies that implement such a system can be seen as frontrunners. Frontrunners are entrepreneurs that are willing to take the risk of new opportunities. One of the first obstacles may be the legislative issues with the municipality and the government when applying Circular Economy principles (Fleming & Zils, 2014). Yet, these frontrunners also face other risks:

- There will be an uneven distribution of costs and benefits. Costs and benefits of innovations at the chain level are often unevenly distributed across links in the chains (Bastein et al., 2013).;
- There will be an uneven distribution of power and resources. Frontrunners are mainly relatively small businesses, therefore they do not have the power and resources to command changes in the market.;
- The last obstacle for frontrunners is that they have no leeway for innovation. It is often very difficult to experiment due to governmental policies.

But next to all obstacles mentioned above there are also obstacles to overcome for product components (Bastein et al., 2013):

- Used components are often more expensive than the resale margin. Therefore these components are less attractive than newly made components.
- Businesses need to work together on repairing and reusing components. A few main requirements are communication, trust and it takes time to build relationships.
- The client tends to look more at the price of purchase than the life-cycle costs of a product or service.

In addition to this list, Fleming and Zils (2014) mention that in a lot of cases clients do not feel the need to use second-hand products. For example, hospital clients are afraid to use second-hand

products, because they cannot assure its quality.

Tissink (2014) wrote an article about demolition of buildings. He states that it is not only important to know the residual value of building materials, but also demolition costs must be calculated. An investor makes its decisions on both costs to determine the residual value of a building.

The Circular Economy will create incentives to develop smart components, which are components designed in such a way that they can be disassembled much easier than traditional components. This contributes to the value of a building, as if it has to be demolished. The option to easily disassemble a component will not be further elaborated within this graduation project. The Circular Economy imposes fundamental new principles and new ways of thinking. In order to make the building environment circular, buildings must be adaptable. Higher initial costs are expected when applying principles of the Circular Economy. Next to the higher initial costs another problem rises within the frames of our current economic system. The party who invests in adaptability of buildings is not the same party that will benefit from these investments (Geraedts, 2009).

2.5 – Part Conclusion

Why do we want to make a transition towards the Circular Economy? Because of all the issues the world is facing. Five issues are considered to be general acknowledged:

- Depletion of natural resources;
- Devastation of natural conditions;
- Increased standard of living all over the world;

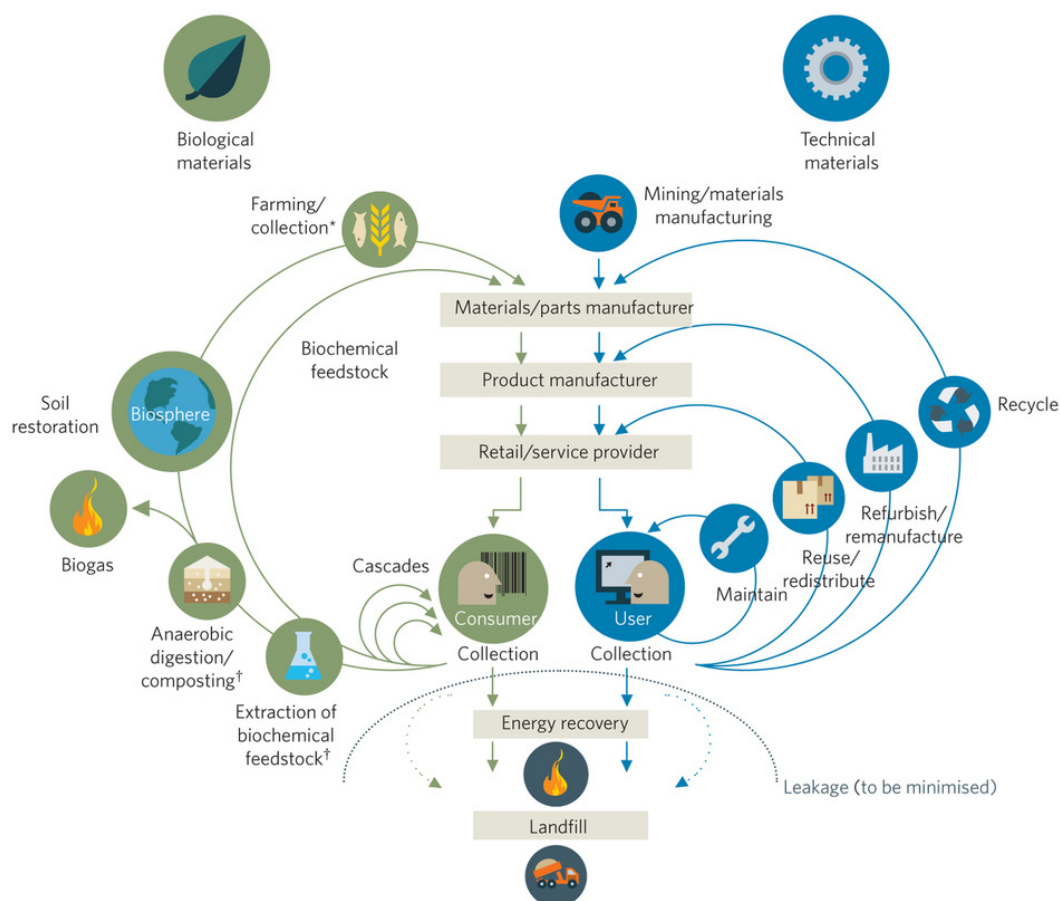


Figure 9: The Circular Economy (Ellen MacArthur Foundation, 2012)

- Ageing of the population in industrialized countries;
- Bankruptcy of the banking system.

These issues are considered to be a result of the linear economy. Our current system applies principles of the linear economy, which means that we follow a pattern of 'take-make-dispose'. Furthermore, this study focuses on constructions of the educational sector. Real estate is a unique kind of asset. In comparison to other assets it can be defined as an immovable, but very costly asset. Due to all the aspects of real estate it is a very unique market within our current system. Because real estate is an asset that is developed for a long period one should also keep different obsolescence's in mind.

In order to face these issues the concept of the Circular Economy is developed. The Circular Economy is a new way of thinking and reshaping the world. There are a lot of different opinions on how to implement this system. All relate to the model developed by the Ellen MacArthur Foundation. Due to foundations in different sustainability theories a lot of principles can be applied within our current system. In order to implement the Circular Economy in the construction sector a selection of these principles is made.

Operations

- Replace fossil-fuel-based mechanisms with passive and natural systems where possible;
- Design reversible, adaptable, demountable and/or biodegradable systems;
- Compensate for past design decisions and their environmental impacts;
- Reduce total resource flows over a building's life cycle;
- Design out waste;
- Rely on energy from renewable sources;
- Reducing consumption of non-renewable resources;
- Efficient use of energy, materials and natural capital;
- Replacing non-renewable with renewable resources;
- Creating an energy supply based on renewable energies.

Organisation

- Continued ownership is cost efficient; reuse, repair and remanufacture without a change of ownership saves double transaction costs;
- The costumer wants the service, the performance rather than the product;
- All parts of the circuit count and the key to vitality lies in rapid, robust, thorough circulation of money, goods, services etc. to all stakeholders.

Finance

- The smaller the loop (activity-wise and geographically) the more profitable and resource efficient it is;
- Loops have no beginning and no end; value maintained replaces value added.

All reports written about the Circular Economy are opportunistic about this system. During the literature review it became clear that there are still a lot of obstacles to overcome:

Obstacles Circular Economy

- The Circular Economy is in its infancy
- There is a knowledge obstacle. In order to overcome the knowledge obstacle the working population must train their skills and competences.
- Behaviour of both the client and provider must change in order to implement the Circular Economy
- Obstacles regarding the design of components. Knowledge of how to design components that apply principles of the Circular Economy is available in some extent in the market, but there is a lack of finance opportunities in order to apply these techniques.
- At last, calculations must be made not only about the residual value of materials, but also the demolition costs. An opportunity lies in broadening the calculations of Life-Cycle Costing

3 - TOWARDS PERFORMANCE-SERVICE SYSTEMS

The Performance-Service System is based on literature of the Circular Economy and Product-Service Systems. Chapter 2 focused on the Circular Economy, so this chapter will focus on Product-Service Systems. At last a differentiation is made between the Performance-Service System and the Product-Service System.

3.1 – Product-Service Systems

Bastein et al. (2013) and Schoolderman et al. (2014) argue that new business cases must be developed with the essence of the Circular Economy in mind. They believe performance-based business cases are therefore preferred. While developing new business cases the use of products, but also the relationship between client and provider, should be reconsidered.

As mentioned in chapter 2, one of the principles is that the client wants a performance/ service instead of the product. This means that a service-agreement must be established between client and provider. Schoolderman et al. (2014) add that it is important to combine service and the performance, both cannot be seen separately. Another important perspective is that sharing knowledge is very important. Companies, research groups and education can strengthen each other by sharing knowledge.

Within the framework of the Circular Economy one can therefore look at 'Product-Service Systems'. Mont (2002) gives a brief explanation of this concept. He uses a quote of Goedkoop, van Halen, te Riele, and Rommens (1999), who state that a Product-Service System is "a marketable set of products and services capable of jointly fulfilling a user's need". Roy (2000) mentions that a key element of Product-Service System is that they are designed and marketed, so that they provide costumers with a particular result or function. The costumers do not have to own or buy the physical products in order to get the result. At last, Aurich et al. (2006) state that "the manufacturing service enterprise no longer distinguishes between products and services but rather provides its customers with highly individualized solutions."

Mont (2002) mentions a few benefits for the consumer:

- they receive greater diversity of choices;
- maintenance and repair services;
- various payment schemes;
- the prospect of different schemes of product use that suit them best in terms of ownership responsibilities.

Product-Service Systems can have an additional incentive for providers. By being innovative as a provider, this could lead to better services that cause lower costs. The higher income streams will benefit providers (Schoolderman et al., 2014).

Mont (2002) describes a few approaches and trends towards the development of the Product-Service System:

- the sale of the use of the product instead of the product itself;
- the change to a 'leasing society';
- the substitution of goods by means of service machines;
- a repair-society instead of throw-away society;
- the change in consumer attitudes from sales to service orientation.

Deckmyn et al. (2014) developed a chart to show differences between different value systems, see figure 10. They divided the system in Product-based value, Product-Service Systems and Service-based value. According to the Circular Economy the client wants the service or the performance rather than a product. However, within the construction sector this performance takes the form of some kind of product due to the physical requirements of real estate. Therefore this research will focus on Product-Service Systems and will exclude Product-based and Service-based value.

Furthermore, Deckmyn et al. (2014) divided the Product-Service System in three categories, namely Product Oriented, Use Oriented and Result Oriented. In order to implement principles of the Circular Economy a Result Oriented Product-Service System is preferable. This corresponds with principles such as continued ownership of a product and the consumer wants the performance rather than the product. It is expected that other principles are more easily implemented using a Result Oriented Product-Service System.

One of the crucial fundamentals of Product-Service System is the technical service provided. These technical services have three advantages: first these services provide the provider with high quality investment goods with a means for differentiating their services from rival providers. Secondly, both service and product-oriented services contribute to a reduced environmental impact. This is realised by a more conscious use of the service and increased resource productivity. And finally, technical services support building up and securing of knowledge intensive jobs and it contributes to a more geographically balanced work distribution (Aurich et al., 2006). A technical service can be referred to as maintenance.

Van Nederveen and Gielingh (2009) tried to implement a Product-Service System into the construction sector. The goal is to keep the buildings fit-for-use in perpetuity. They notified that providers want to keep clients and users satisfied. So the providers must take a proactive attitude. However, it depends on the details of the service level agreement and impact on the agreed price if the provider does the services on an autonomously or by mutual agreement with the client.

The concept of a Product-Service System fits the framework of the Circular Economy. Both assume a proactive attitude of the provider towards the client. The Product-Service System can be seen as a mean in creating a Circular Economy. Aurich et al. (2006) conclude that further research must be done to investigate interrelations between products and technical services (maintenance).

Other theories (such as cradle-to-cradle), on which the concept of the Circular Economy is built, promote partnerships to innovate. These partnerships can be found in the entire chain of a product (service), including manufacturing, distribution, use, disassembly, recovery and reuse (Mulhall & Braungart, 2013). A model of such partnerships is not given, however a Product-Service System could be a model for this.

At last, Aurich et al. (2006) state that:

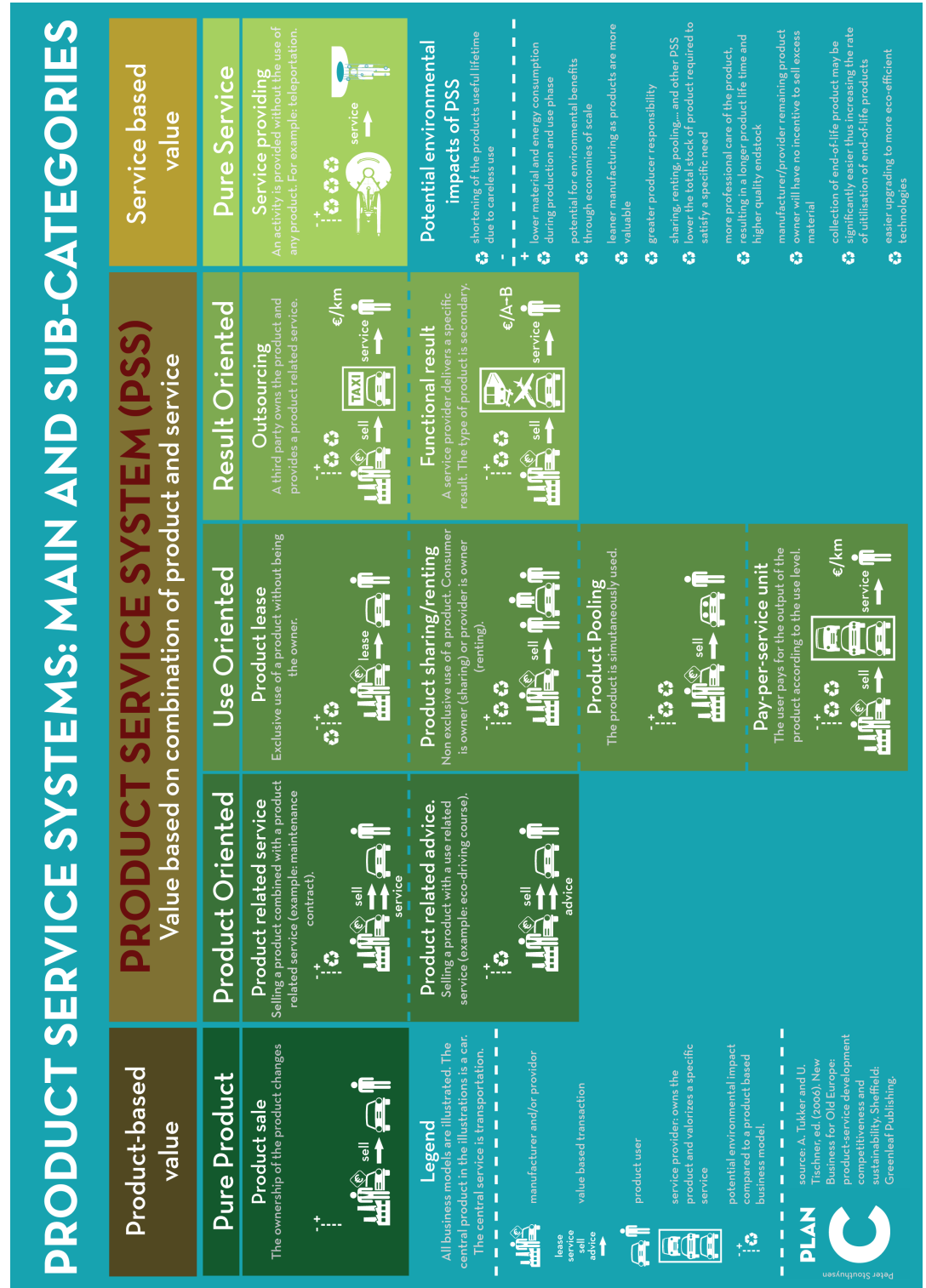
“In order to achieve optimum customer benefits in terms of highly integrated physical and non-physical PSS (Product-Service System) components, an integrated design process based on systematic processes for product and service design as well as corresponding design methods such as design for environment is required. During order taking, the customers together with the service, respectively, distribution branches specify their demands so that selected physical and non-physical components can be individually configured.”

3.2 – Obstacles for implementing Product-Service Systems

Bastein et al. (2013) have written a few lessons learned from a number of experiments from Product-Service Systems:

- It is a strong incentive for producers' (producers may be seen as the provider) to be costumer-driven and eco-efficient. A relationship between costumer and provider is being build. One of the drawbacks may be that consumers will depend too much on the

Figure 10: Product - Service Systems (Deckmyn, Leyssens, Stouthuysen, & Verhulst, 2014)



provider;

- It is a huge change for companies whose core business is selling new products to alter their business models to result-driven Product-Service Systems;
- Transaction costs of switching from current business models to Product-Service Systems may not be too high;
- Risks of Product-Service Systems may not be too high for providers. Also the risk must be easily predictable. However, this is more the case for Business-to-Business (B2B) markets than for Business-to-Customer (B2C) markets (Bastein et al., 2013);
- The client tends to look more at the price of purchase than the life-cycle costs of a product or service. This is an obstacle for the Circular Economy to be successful, however it is also a crucial obstacle for Product-Service Systems to succeed.

Another obstacle is that the governance is also subject to change (Schoolderman et al., 2014). There are a lot of different companies involved in such a system. Questions such as who has the responsibility need to be answered. Due to the span of this research this will not be further elaborated.

3.3 – Performance-Service System and Product-Service Systems

In order to prevent confusion about definitions within the Performance-Service System a few definitions had to be clarified. It is chosen to make a difference between the Product-Service System and the Performance-Service System. One of the main problems within this subject is the vocabulary. Definitions are lacking and should therefore be (re)-developed. One good example is the word services. Within the framework of the Circular Economy one should think in services instead of products. However, the meaning of services is twofold. First it reflects the client's wishes and/or requirements. It is the outcome of a product that fulfils the needs of clients.

Secondly, services are the operations needed in order to keep the service up-to-date up to client's wishes. You can see the confusion this causes. Therefore one should not speak about services as something a client wants.

Rather speak about performances. Webster (2013) and Stahel (2013) are the first to use the word performance within the framework of the Circular Economy. It is however a word that needs to be maintained in order to operationalize the Circular Economy and Product-Service Systems. A Product-Service system (1) differs from a Performance-Service System (2), see table 1. Although the Performance-Service System is inspired by Product-Service Systems, it must be noted that the former is a new design in order to implement Circular Economy principles in the construction sector. Within the Circular Economy 'products' are needed to deliver performances, but they are no longer the core business.

This chapter will elaborate on the definitions of 'performance', 'service' and 'the system'. Definitions found in literature are brought together and a scheme is developed in order to compare the definitions of a Performance-Service System with a Product-Service System.

Performance instead of product

A distinction must be made between a performance and a product. Sempels (2013) mentions that the provider sells an result-integrated solution (mix of products and services). These solutions should provide beneficiaries with a final result that meets the needs of clients. In a Performance-Service System it is also a result-integrated solution, but the mix of products and services includes performances. A product does not necessarily fulfil the performance. A

performance could also be a service, such as a relationship with the customer. A physical product is anything between a pen and an aircraft. Products “are artefacts that can be touched, stored and owned by specific individuals or groups (Kotler (1988) cited in Roy (2000)).”

It means a proposition of a performance, instead of a good (product). Sempels (2013) states that the contract will become a core part of the value proposition, because it should formalise the agreed performance and the service level.

Secondly, a discussion can be held about the use of performance rather than result. Different authors make use of both words when explaining Product-Service Systems. In order to operationalize this system the word performance is chosen instead of result. In the dictionary (Soanes, Elliott, & Hawker, 2006) performance is “an action of performing” or “the capabilities of a machine or product.” Another definition of performance is that it is about fulfilling a certain goal or commitment.

A result on the other hand is “a thing that is caused or produced by something else, the outcome (Soanes et al., 2006).” It is the outcome of something that is already been done. Due to the fact that wishes and preferences of clients and users will change over time the word performance is better used instead of a result. It gives the client the opportunity to ask beforehand a certain performance. Although both words have different definitions, when talking about a Performance-Service System or Product-Service System, they can have overlapping meanings.

For example, a Result Oriented part of Product-Service Systems can be defined as the utility is extracted by the utility provider for the user (Mont, 2002). This principle can also refer to the definition of a performance.

Roy (2000) mentions that selling results, in this case performances instead of a product, can reduce material intensity. The provider will take responsibility for supplying, maintaining, taking back and recycling all physical aspects of this system. In other words clients are rather seeking the utility of the products and services provided (United Nations Environment Programme, n.d.).

Some benefits of selling performance, results, utilisation, and services of goods are mentioned by Stahel (2013). It means that economic actors:

- retain the ownership of goods and embodied resources; and,
- internalise the cost of risk of waste.

Furthermore a shift from buying products to buying performances and system solutions that may have an impact on the environmental impacts of performances that a client wants. However, it requires a higher level of customer (client) involvement. Also it requires education from providers towards the clients (Mont, 2002).

Although, Stahel (2013) mentioned a few benefits, he also describes some criteria for performances. The key criterion is to preserve the quality and value of the existing stock, wealth and welfare. Preserving the quality can refer to manufactured capital. Furthermore, he states that “selling goods as services or performances is the most resource efficient business model for the Circular Economy.”

A performance can be analysed by Key Performance Indicators (KPI's). These are variables in order to transfer management goals into measurable values. However, by looking at experiences of the company they always develop these KPI's. In order to implement the circular economy it may not be wisely to use these KPI's because they cannot be transferred into future functional requirements.

In literature the performance approach is described by the CIB Working Commission W60 (1982) as “the practice of thinking and working in terms of ends rather than means.” It is about the output instead of the input. The focus is on fitness for use instead of the technical descriptions (Brochner, Ang, & Fredrikson, 1999). Straub (2007) adds to this that criteria are “explicitly stated by the client.” It is common practice to believe that a performance should give a

sharper focus on quality instead of price. Another advantage of thinking in performance is that when you talk about the fitness for use instead of technical descriptions the communication between client and provider will improve.

A disadvantage of the performance approach is that authorities have to invest in the competence for expressing, interpreting, and monitoring the requirements of a performance. Another disadvantage is that aesthetics is very difficult to describe as a requirement for performances.

Performances need to be stated in contracts in order to implement them in practice. Therefore a brief explanation of DB-contracting is given. A DB-construction is also called an integrated contract in the Netherlands (Chao-Duivis, Koning, & Ubink, 2013). Within this kind of contracting there are some roles to play by the client and by the contractor. The client can have a passive or active involvement during the execution of the works by the contractor. This means that the client can avail himself or enabling him to check the contractor's work. In some cases the client can order the contractor to make variations. Other important aspects are the clients' liability and duty to cooperate. The following obligations are set out for the client. The client must provide the contractor of information, which is necessary in order to perform. The client must ensure that the contractor has access to land and water supply during the works. Furthermore, the client should provide all the goods specified in the basic contract. There is also the aspect of auxiliary persons. It is likely that a contractor will not do all the work in-house or by themselves. The contractor is free to hire third parties in order to do their work. However, the contractor remains responsible for the work that has to be done. There is a penalty if the client does not pay on time. Furthermore both parties can add milestones in the contract linked to penalties or bonuses in order to get the work done.

The contractor has also a role to play (Chao-Duivis et al., 2013). The UAC-IC 2005 sets out the most important obligation, this is cited in Chao-Duivis et al. (2013): "The contractor is required to carry out the Design and Construction Work in such a way that the works on the completion date stated in the Basic Contract meet the requirements arising from the Contract. If the works do not meet the requirements this constitutes a defect." The second obligation for the contractor is the duty to warn if errors occur or display defects that are clearly, so it would be inconsistent to proceed with the execution of the works without warning.

The Performance within the Performance-Service System can be defined as follows:

A performance is an agreed action of performing that results in an output, utility, goal, function, or commitment whereby a product is not a goal in itself, but subordinate to the performance.

The service component

First a few definitions of the word service will be elaborated below. One can note that this will give confusions about the specific definition of this word. Furthermore, some definitions will be given of different kind of services within the Performance-Service System.

A service [...] has been defined as "any act or performance that one party can offer to another that is essentially intangible and does not result in the ownership of anything. Its production may or may not be tied to a physical product (Kotler 1988 cited in (Roy, 2000))." Although this can be related to all services one can imagine, in this research it is narrowed down to maintenance, reuse/redistribute, refurbish/remanufacture, recycle and revalorisation services. Because it is a service component, it is flexible by nature. Therefore it is better able to respond to the changing needs of clients and conditions (Mont, 2002).

The United Nations Environment Programme (n.d.) adds to the above definition that it is about satisfying the customer needs competitively and lower the environmental impact over the life cycle. Roy (2000) adds to this that result services aim to reduce the material intensity of existing systems.

However, one should keep an eye on the variety services may display. Services can range between physical services and human services. The latter depends on a lesser extent on physical products. Furthermore, services depend more and more on information and communications technology (Barras, 1986).

Aurich et al. (2006) mention that technical services must be provided with the perspective of a clients' view in mind about the product life cycle. Therefore they make a distinction between three phases. First there is the services regarding the product purchasing (e.g. sales counselling), product usage and product disposal. Although the product purchasing is important phase, in this case it should be mentioned at the definition of performance. The client should purchase the performance. The term technical refers to:

- "the investment character of physical and non-physical components;
- the relatively monetary value;
- the business-to-business relation between manufacturers and customers (Aurich et al., 2006)."

Another aspect of the service component is the design. When, how and what kind of maintenance is needed in order to keep the performance up-to-date? In traditional markets the service design is usually performed detached from the product design. This has led to a lot of inefficiency (Aurich et al., 2006). Due to the Performance-Service System the provider is most of the time responsible for both the product design and the service design. Service branches can realize the services needed.

In order to get a better grip on the definition of services Aurich et al. (2006) make a distinction between characteristics:

- First of all, services are mainly non-physical. Therefore resources can be used at minimum consumption level. They note that if services are non-physical it is one of the reasons in the context of dematerialisation;
- Services are not produced and consumed over time. The services are realised and consumed simultaneously as the performance;
- The realization of services requires the integration of clients in terms of providing products and staff.

In addition to the characteristics they describes a function of services. The services either address the client or the provider (Aurich et al., 2006):

- The support function means that the performance must meet the expected product benefit level. They mention that is loosely related to liability;

Aurich et al. (2006) described both characteristics and the functions they suggest some design principles:

- Product dimension is about that products, that will fulfil the performance, must be service friendly.
- Process dimension. Different services can be seen in the lifetime during different processes of a performance. They distinguish the process of a service into three parts, namely: customer order taking, the service realization, and information exchange.

Several definitions of maintenance, reuse, remanufacture, recycle and revalorisation services are given below. These services are called product-life extension services by Roy (2000) which should

increase the useful life of a material and products. Furthermore, it could decrease the amount of energy in order to fulfil the performance. The definitions are given below:

Maintenance refers to small operations in order to fix a performance; this includes cleaning and small technical services. Straub (2009) makes a distinction between corrective, preventive and condition-based maintenance. This is also confirmed by Weststrate (2014). Only he mentions that the TU Delft also has replacement maintenance. Maintenance services have a goal to prolong the life cycle of a product, by comprising maintenance and also upgrading (Mont, 2002).

A definition of '**reuse**' is given by Parker (2007) cited by Hopkinson and Spicer (2013) which says the following;

"Re-use [...] is a generic term covering all operations where an EoL (end of life) product is put back into service, essentially in the same form, with or without repair or remediation."

It means the reuse of a material or component for a similar function with no or little enhancements (Ellen MacArthur Foundation, 2012).

The definition of '**remanufacture**' is also given by Parker (2007) cited in Hopkinson and Spicer (2013):

"The process of recovering an End of Life product and carrying out required restoration to return it to at least Original Equipment Manufacturing performance condition with a product warranty that at least equals that of a comparative product."

This is mostly done at a subassembly level whereby the component is dismantled and recovered (Ellen MacArthur Foundation, 2012).

Whereas '**refurbishment**' means that not only the defective building components are being repaired or replaced, also the out-dated building components are being replaced (Konstantinou, 2014). It therefore helps to return the component to a good working condition. One can think of cleaning, painting, changing fabric or refinishing when using this term (Ellen MacArthur Foundation, 2012).

The definition of '**recycling**' is subject to change. Mulhall and Braungart (2013) state that the old definition of recycling does not include defining contents. This must be done in order that recycling is just about recycling waste. The content must be described so the values of the recyclable materials remain the same value as it was before put into use.

Stahel (1998) also notes that recycling is a prerequisite for the performance economy. However he argues further on that recycling alone is not enough. Recycled materials are more expensive than virgin materials. But remanufactured goods are cheaper than newly made products. Therefore he states that the smaller the loop, the higher the competitive advantage.

Ellen MacArthur Foundation (2012) mentions three forms of recycling:

- Functional recycling: this refers to the recycling of materials for the same or other purposes;
- Downcycling: Refers to the decline of quality of a material when recycling;
- Upcycling: Refers to the increase of quality of a material when recycling. Upcycling is the most preferred recycling option.

"**Revalorisation services**' include offers that aim at closing the product material cycle by taking products back, secondary utilisation of usable parts in new products and recycling of materials if reuse is not feasible (Mont, 2002)."

'Retrofitting' is mentioned by Aurich et al. (2006) as part of the services. However, it is not explained what they meant with retrofitting. Therefore this definition will not be further elaborated in this research.

'Energy recovery' is the process whereby non-recyclable materials are converted into heat, electricity, or fuel (Ellen MacArthur Foundation, 2012).

'Land filling' refers to the disposal of waste in a site where the deposition of solid waste is controlled onto or into land (Ellen MacArthur Foundation, 2012).

In order to describe the services needed Aurich et al. (2006) mention aspects that need to be elaborated. First of all there is the 'description' component. The description covers an overview of services, its relation between the performances and its services, the objectives followed by means of the service, and finally it refers to the system in terms of relevant entities involved and their interactions. Secondly, the 'reference' refers to the performance or user profiles. Thirdly, the component function is about the detailing the above mentioned service functions to a specific case.

At last a difference must be made between physical and non-physical resources (Aurich et al., 2006). Physical resources are the services, which need equipment, supplies, spare parts and vehicles. Whereas non-physical resources are the detailed descriptions of the servicing, the information exchange process as well as corresponding instructions, guidelines, forms, databases, etc.

Finally, the following definition can be given about the word service:

A service is mainly a non-physical action or operation whereby the performance is extended or optimized over time. The service cannot be produced or consumed in itself and is subordinate to the performance.

The System

The system stands for an integrated mix of performances, products and services. Whereas all are described above, the system also covers another important part. Namely the communication or the relationship between provider and client within this system. Different authors describe communication as a service, but in order to get a better grip on all definitions it is left out of the definitions of performance and service.

Aurich et al. (2006) made a distinction between three phases: the product purchasing phase, the product usage phase, and the product disposal phase. Whereas the product usage phase and the disposal phase are both related to the definition of performance and service, it also has a form of communication and relationship between provider and client during these phases.

A few functions mentioned by Aurich et al. (2006) are related to the relationship:

- The requirement fulfilment is to address the clients by complementary offers. This is more or less about contracting and tele-service. However, due to the limitations of this research this will not be discussed;
- At last, there is the information procurement for the provider of the experiences, expectations and suggestions of clients about performance usage.

They also mention that the design principles are influenced by the relationship:

- Process dimension. As mentioned above, different services can be seen in the lifetime during different processes of a performance. They distinguish the process of a service

into three parts, namely: customer order taking, the service realization, and information exchange.

- Information dimension. This dimension is abstracted by two of the characteristics described by Aurich et al. (2006). First of all it's about the detailed information needed in order to choose the right performance level for the client. Secondly, client integration and interaction between client and provider could lead to targeted information procurement.
- They made a last suggestion that the service provision and the corresponding communication channels must be established along the performance life cycle.

The system will be defined as:

The system is a mix of performances, the subordinate products and services, and the communication required between client and provider.

3.4 – Part Conclusion

Goedkoop et al. (1999) give a definition of the Product-Service System. They state that the Product-Service System is “a marketable set of products and services capable of jointly fulfilling a user's need”. Aurich et al. (2006) adds to this definition that “the manufacturing service enterprise no longer distinguishes between products and services but rather provides its customers with highly individualized solutions.” Meaning that the product needed is not a goal in itself. Furthermore, Mont (2002) describes a few approaches and trends towards the development of the Product-Service System:

- “the sale of the use of the product instead of the product itself;
- the change to a 'leasing society';
- the substitution of goods by means of service machines;
- a repair-society instead of throw-away society;
- the change in consumer attitudes from sales to service orientation.”

However, Product-Service Systems do not correspond perfectly with the Circular Economy. Therefore a Performance-Service System will be developed. This system combines principles of the Circular Economy and uses parts of Product-Service Systems. If one should compare the Performance-Service System with Product-Service Systems than it corresponds mostly with the Result-Oriented Product-Service System explained by Deckmyn et al. (2014). Differences between the Product-Service System and the Performance-Service System are outlined in table 2.

Keeping all definitions and theory in mind the following definition will be applied for the Performance-Service System:

The Performance-Service System is a marketable and sustainable set of performances and services capable of jointly fulfilling a user's need.

Whereas a performance is an agreed action of performing that results in an output, utility, goal, function, or commitment whereby a product is not a goal in itself, but subordinate to the performance. Secondly, the service is mainly a non-physical action or operation whereby the performance is extended or optimized over time.

Table 1: Differences Product-Service System and Performance-Service System

Product	Service	System
The product used in the Product-Service System	Relationship client & provider	Integrated solution (mix of products & services)
Output instead of input	The service instead of the good	
Focus on fitness for use	Product, use & result oriented	
	Maintenance	
	Reuse/redistribution	
	Refurbish/ remanufacture	
	Recycle	
	Revalorisation services	
	Utility	
	Results	
	Better able to respond to changing needs and conditions	

Performance	Service	System
Performance instead of a good	Maintenance	Integrated solution (mix of performances, (products) & services)
Utility	Reuse/redistribution	Relationship stakeholders
Result oriented	Refurbish/ remanufacture	Communication
Focus on fitness for use	Recycle	
Better able to respond to changing needs and conditions	Revalorisation services	
	Retrofitting	
	Energy Recovery	
	Land filling	

The service cannot be produced or consumed in itself and is subordinate to the performance. At last, the system is a mix of performances, the subordinate products and services, and the communication required between client and provider.

Developing the Performance-Service System

In figures 11 and 12 one sees the first attempt to develop the Performance-Service System. The model in figure 11 is divided in three phases:

- 1). Production of services (performances)
- 2). Usage
- 3). Disassemble

During phase 1 the performances will be developed. As one can see there are a lot of different stakeholders. First of all the suppliers of materials or other capital assets. Secondly, the manufacturers will develop the components needed in order to get the required performance. At last, the components will be put together into an ensemble. This ensemble should provide the performance.

In the second phase the performance is used. Two main stakeholders can be seen in figure 11, namely the consumer and the maintenance provider. The consumer is the client who pays for the required performance. The maintenance provider should keep the performance

3 - TOWARDS PERFORMANCE-SERVICE SYSTEMS

on the agreed level. There is an interaction between both stakeholders. Furthermore, both the consumer and the maintenance provider should give feedback on the components used towards the responsible stakeholder mentioned in phase 1. This feedback includes technical aspects and the user friendliness of the performance.

The last phase is about the disassembly of the performance. There are three levels of disassembly. First of all one can strip down the performance to all materials used. Most likely this is not applicable in current construction systems. Secondly, what is more probable, is the disassembly of components. Thirdly, one can disassemble the used services.

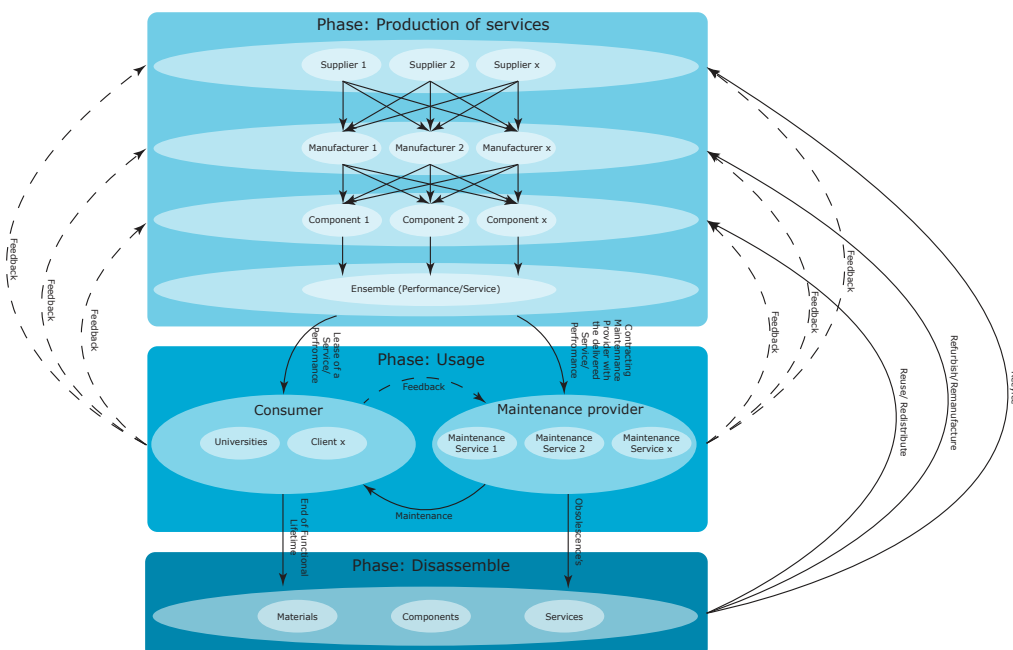
After a discussion with my mentors it became clear this model was too complex. All lines introduced in the model need definitions. Furthermore, it remained unclear why some stakeholders were or were not included in the model. One example relates to the lines introduced in the first phase. Why are there three suppliers? Can there be more or less within the Performance-Service System? Furthermore, what does every arrow mean within this system? Is supplier 1 always connected to all manufacturers? Aren't there any connections between suppliers?

It can be concluded the model above raises a lot of questions and is not applicable in practice. Some adjustments have been made in figure 12. One radical alteration is made in the production of the performances. Because this study focusses on client perspective of the Performance-Service System, it is chosen to put the production of the performances in a black box. This study will not elaborate on the production chain. Another alteration is about the stakeholders used in the model. In model 2 (figure 12) all stakeholders are included who are expected to have a relationship with the client.

Client: The client represents an organisation and the users within this organisation. In most cases the client will also be an user itself. This stakeholder is in close contact with all other stakeholders involved. The client is responsible for any errors that occur due to missuse of the performance by both the client and the users.

User: This stakeholder will use the performance. First of all, there is a need for a certain performance from the user perspective. The user will pass it on towards the

Figure 11: Model Performance-Service System – stage 1



client, who in turn will tender this in the market. The user will only use the performance and is probably not responsible for any errors in the components.

Provider: This stakeholder delivers the performance towards the client. Between the client and the provider agreements will be established regarding the performance, the payments, and the maintenance needed.

Maintenance provider: Works on behalf of the provider. This stakeholder will provide the maintenance needed in order to keep the performance on the agreed level. The client is responsible for reporting errors that occur during the usage phase.

Dismantler: The dismantler is responsible for the disassembly of the components. The components or materials should be brought back into the system. This can be done by bringing it back to the provider of the performances. The provider is probably in close contact with the other stakeholders within the production chain. Furthermore, the dismantler should also give feedback on the design of the components. This must be done in order to stimulate innovations regarding the components.

Financier: This stakeholder is the one who will provide the necessary financial means in order to develop Circular Economical components that will provide the performance.

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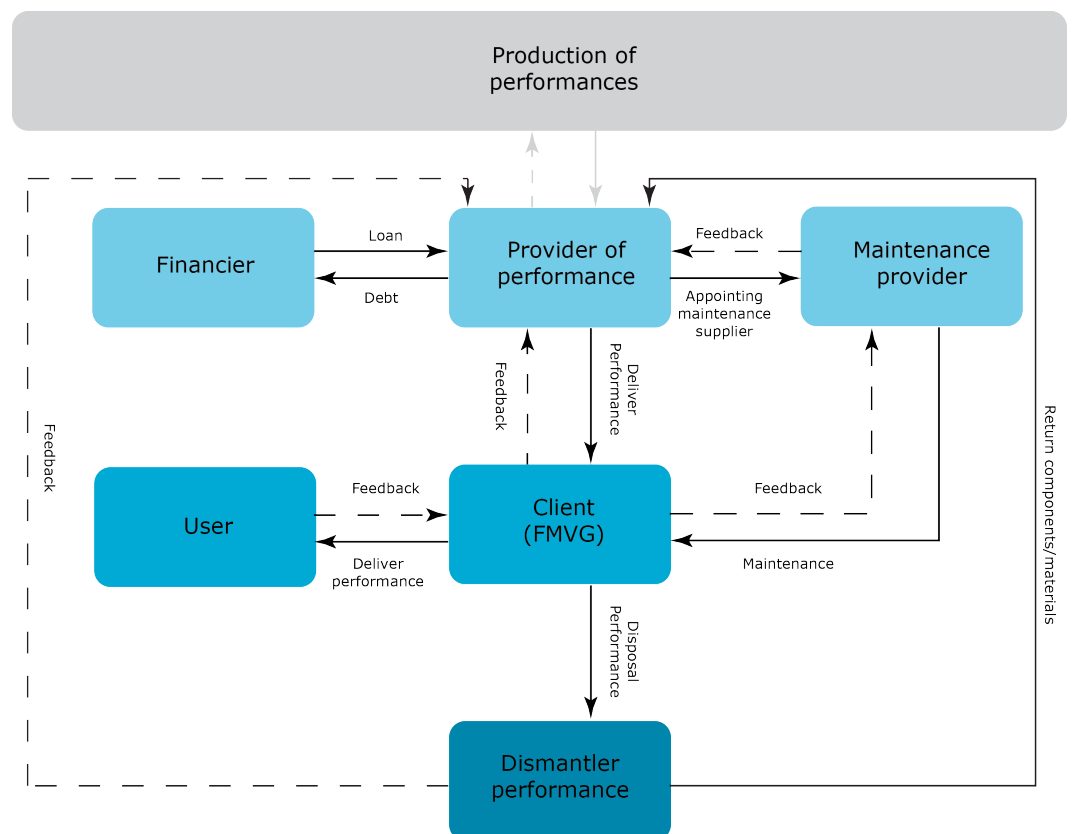
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Dismantler: The dismantler is responsible for the disassembly of the components. The components or materials should be brought back into the system. This can be done by bringing it back to the provider of the performances. The provider is probably in close contact with the other stakeholders within the production chain. Furthermore, the dismantler should also give feedback on the design of the components. This must be done in order to stimulate innovations regarding the components.

Financier: This stakeholder is the one who will provide the necessary financial means in order to develop Circular Economical components that will provide the performance.

This model will be used during interviews with employees of FMVG TU Delft. This will be elaborated in the next chapter.

Figure 12: Model Performance-Service System – stage 2



4 - TEST CASE: DELFT UNIVERSITY OF TECHNOLOGY

This chapter will focus on the Performance-Service System. First, the model will be explained by showing several models. These models are tested and developed by conducting interviews and developing financial schemes. However, in order to get a better grip on the Performance-Service System a few scenarios had to be developed. Within the context of these scenarios the model is tested on organisational, operational and financial level. The organisational and operational levels are combined due to the dependent characteristics on each other. The financial level is also interdependent on the other levels, but it can be developed independently.

The model

The model developed can be seen in figure 13. An extra model is made in order to stimulate discussions during the interview. As an example blinds are placed in the Performance-Service system. Both models are elaborated during the interviews. The focus of this study is from client perspective. Because in a lot of cases the client does not produce performances by itself, it is chosen to leave out the production of performances. One of the statements of the Circular Economy is that the ownership of components transfers from the client towards providers. Clients do not own components in order to get the required performance. This system can be the biological or technical system. The ultimate goal is to reduce waste to a minimum.

The model will be explained by all stakeholders:

Provider of performance (P)

- Provides components to get the required performance
- Gives guarantee performance level will be maintained during the years
- Obligation payments towards maintenance provider
- Relation with client, the maintenance provider and the supply chain where performances are being produced
- Gives feedback on the component of a performance towards supply chain

Maintenance provider (M)

- Delivers maintenance to sustain required performance level
- Close contact with provider of performance
- Obligation to maintain components used by client and user
- Relation with the provider of performances and the client
- Gives feedback on the component of a performance to the provider

Client (C)

- Works on behalf of the users (the client can also be a user in itself)
- Obligation payments towards provider
- Relation with the provider of performances, maintenance provider, and the users
- Gives feedback on the performance to the provider and the maintenance provider

User (U)

- User of the performance
- Differs by organisation what the responsibility level of the user is
- Relation with the client
- Gives feedback performance towards clients

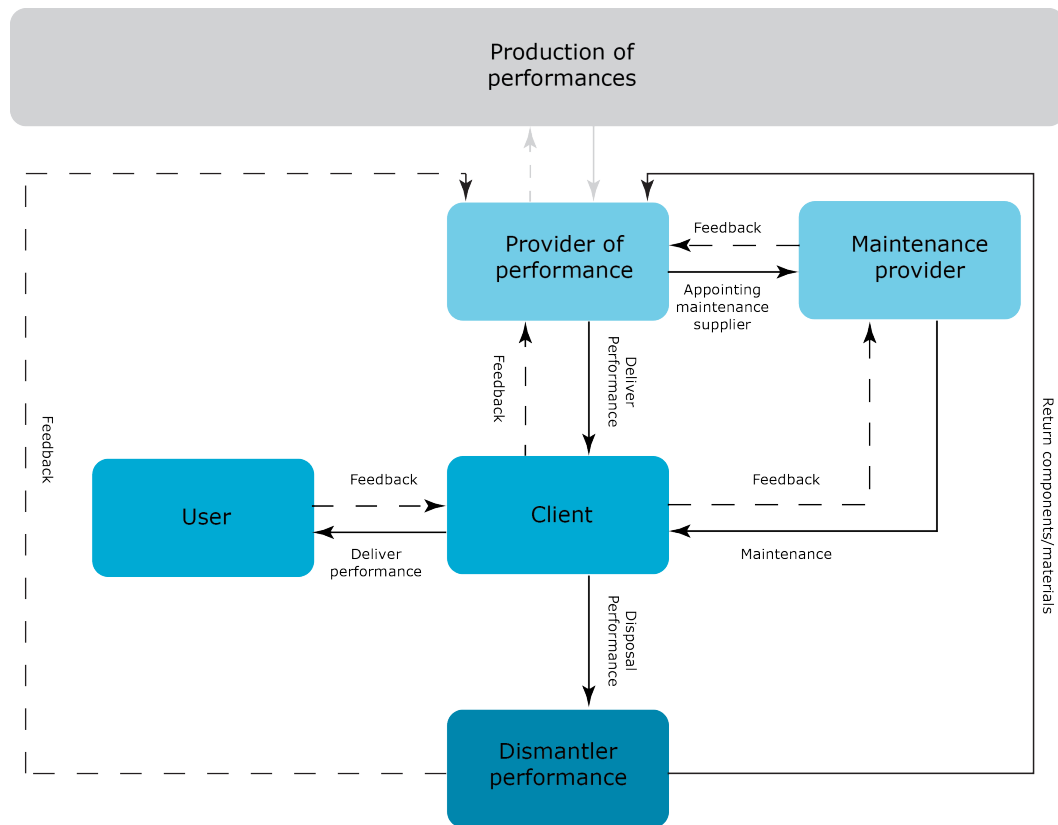


Figure 13:
Performance-Service
System

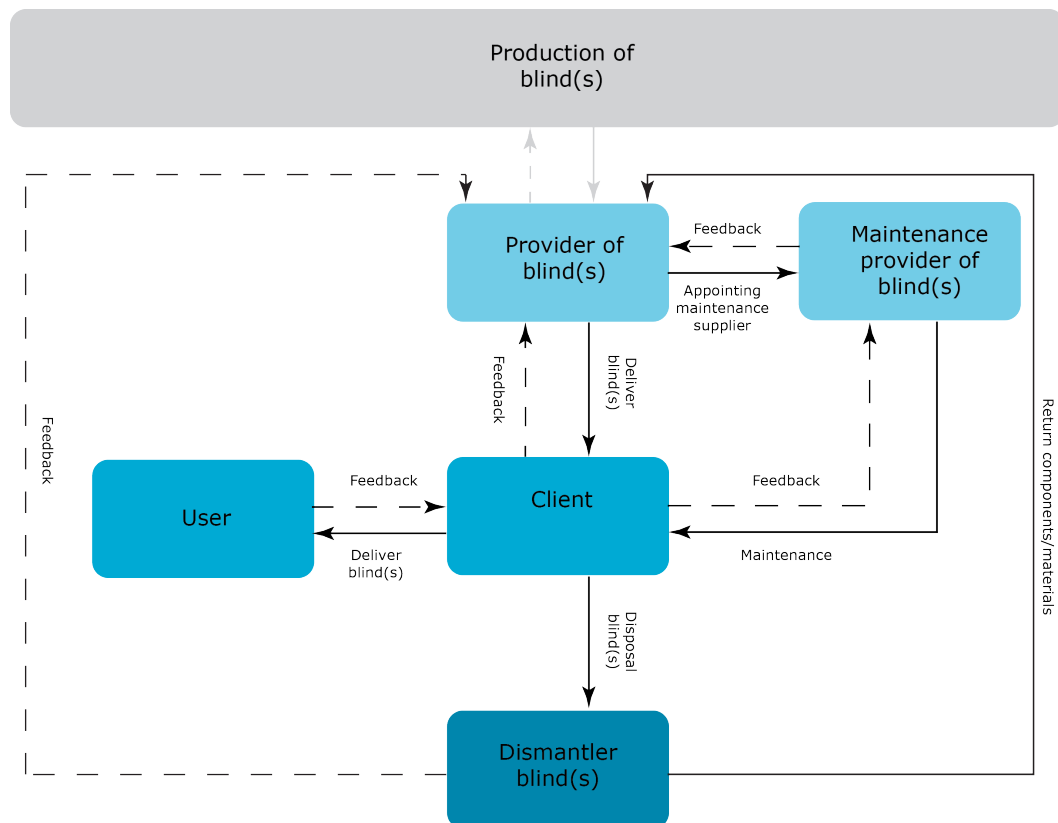


Figure 14:
Performance-Service Sys-
tem - Example: blinds

Dismantler performance (D)

- Dismantles components of the performance
- Responsible to bring components back towards the interested agreed stakeholder
- Relation with provider
- Gives feedback component performance towards provider

4.1 – Context test case

In order to test the model two scenarios are developed, namely the scenario of 'the Circular Economy is thriving' and on the other axe 'traditional market behaviour'.

On the 'Circular Economy is thriving' side it is acknowledged that the transition towards this system has been made. Market parties have seen the benefits of adapting its principles and turn these principles into revenues. Materials and components are brought back into a system as much as possible. This can be an economic system, an ecological system or another system. Other applications of this scenario are as followed:

- Businesses extend responsibility of materials and components;
- Reduce or design out waste streams;
- Encouragement for the standardization of components and protocols to encourage repair, reuse, and recovery of components and materials;
- A focus in this market is the value for users;
- Trouble free services or performances are sought in this system;
- Systems must be designed as entirely dependent on eachother;
- Cooperation between market parties is required next to competition.

The metaphor of this system is about living systems. The whole world is connected with each other. We, as mankind, have influence and limited opportunity to understand this system (Webster, 2013).

On the other side the 'traditional market behaviour' is elaborated, this relates to a linear economic system. It promotes global scale of production to secure low costs of products. It encourages standardization of products as a whole instead of materials and components. Repair, reuse, and recovery are therefore harder to sustain.

Other implications of this scenario are:

- There are no incentives to bring back materials in one of the loops (see figure 6);
- At the point of sale the responsibility for a product shifts from provider to client and so on;
- Economies of scale are in place to decrease production costs and enhance market position;
- The linear economy encourages the standardisation of products;
- Consumption is encouraged to be very efficient and easy, consumption turnover is encouraged;
- There is a focus on a materials flow which must be very short to concern product designers;
- Competition is the main focus for market parties, being the best in their own sector.

As Webster (2013) states: the 'world as machine and parts'. Humans can understand and control everything.

The Pyramid of Performance-Service System in real estate

The Performance-Service System is about new processes within the organisation of the client. These processes influence the client, but also the user of the performances. A Pyramid is developed in order to map obstacles or opportunities relating to the needs of the client and users. This Pyramid is an equivalent of the other Pyramids within the research field. The most important pyramid is the one Maslow made during the forties, which reflects the needs of people. In addition Den Heijer (2011) made a Pyramid with the cumulative functions of real estate. The Pyramid of Performance-Service Systems is developed with all preceding Pyramid's in mind.

A short description of each of the seven layers is given below:

Inspiring people

The Performance-Service System should inspire people to be sustainable in the broadest sense of the word.

Attracting people

The Performance-Service System should ultimately provide in real estate by combining a lot of performances. The easthetics of all components used in order to fulfil the performances should fulfil the requirements of what Maslow calls the Self-Actualization level. Within this level the beautifulniss of components becomes important. Can people relate to the easthetics used for performances?

Stimulate innovations

This level is about the cognitivity of people. The Performance-Service System must stimulate innovations. According to Sniukas (2009) there are four types of innovation:

- Operational innovation
- Management innovation
- Product & Service innovation
- Strategic innovation

In order to implement the Performance-Service System it requires innovations in all fields. For instance, users need to change their behaviour or an organisation must alter their ways of doing.

Support people's activities, status, and image

The Performance-Service System must support the people's activities, status, and image. If this system is implemented accordingly, it is expected that it can better anticipate to changing requirements of clients than traditional real estate. Furthermore, it is expected that this system fulfil the requirements of the performances.

Long-term collaboration models

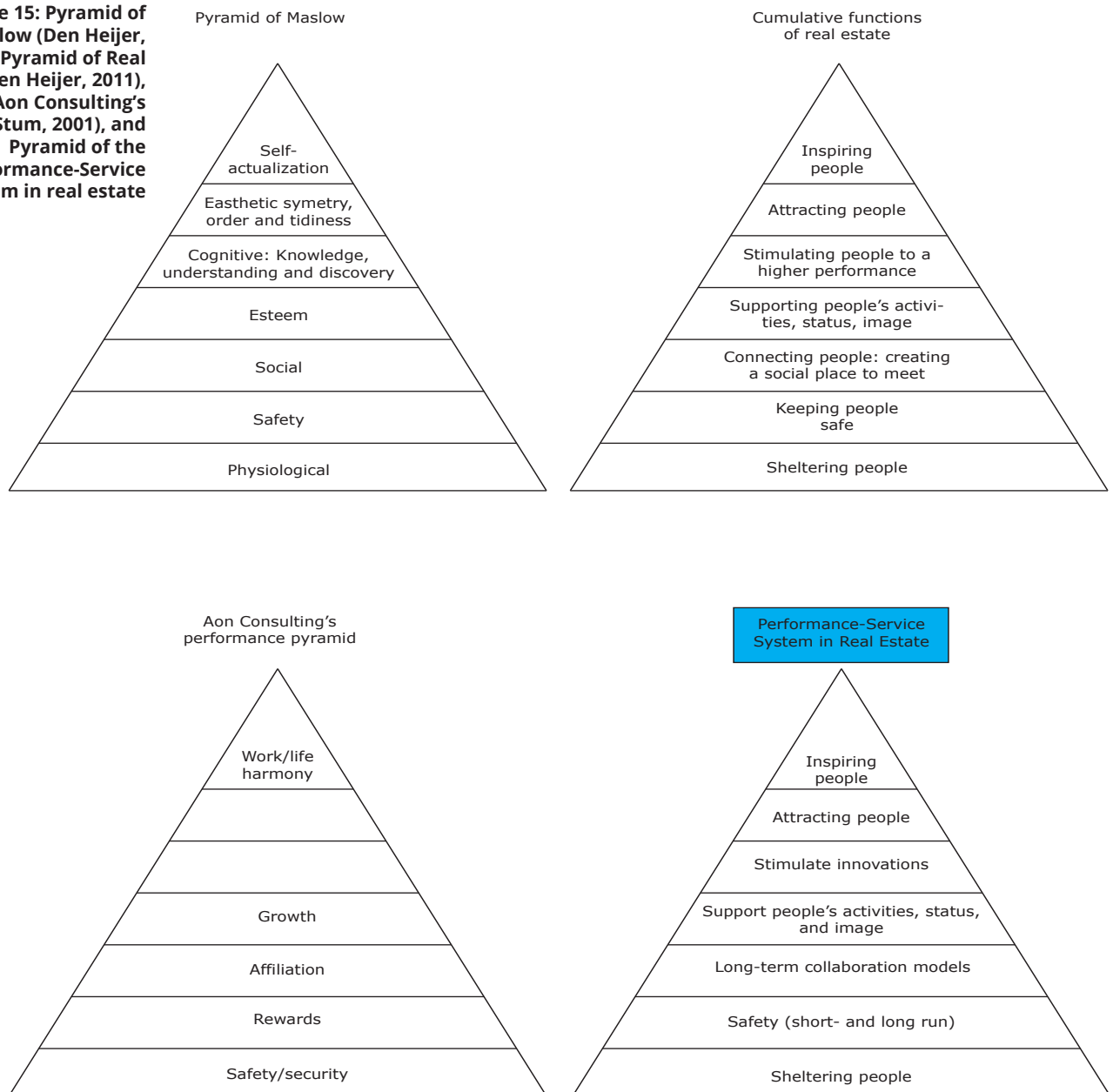
At this level, Maslow relates to social aspect of all human beings. One wants to be a part of a group and needs love and social cohesion. The Performance-Service System creates long-term relationships between clients and providers. Due to the huge overspanning amount of time, trust in one another is very important. In order to trust some businesses over such a long time, one must first create a good social foundation between client and provider.

Safety

The explanation of this layer is twofold. First there is the issue of safety to use components needed in order to get the performance. In real estate this can mean that the construction is solid, is it can be used without any concerns about the danger of collapsing.

Secondly, it concerns the safety over the long run. As mentioned in the introduction a lot of issues are facing us. This system should reduce the risks of all issues. It probably will not affect our generation, but it should provide more safety for upcoming generations.

Figure 15: Pyramid of Maslow (Den Heijer, 2011), Pyramid of Real Estate (Den Heijer, 2011), the Aon Consulting's Pyramid (Stum, 2001), and Pyramid of the Performance-Service System in real estate



Sheltering people

As with the first level in the Pyramid of Maslow, but also in the Pyramid of Real Estate, one can see that this is about the basic needs of people. In real estate the performance is shelter of people.

4.2 – Context case: Delft University of Technology

There are several reasons why universities are a proper study population. Universities have a long-term relationship with their real estate. Secondly, universities in the Netherlands have agreed on the MJA's (meerjarenaafpraak) with Agentschap NL (Van Hal, den Heijer, Teeuw, Aalbers, & Stukje, 2010). This means that they will make an energy efficiency progress of an average of 30 per cent before 2020 and 50 per cent before 2030. Another aim of this agreement is to support energy reduction and the reduction of CO₂ on the campus.

Sustainability is a strategy that is getting more and more important at higher educations. Not just in technical solutions, but also by changing the behaviour of users on the campus (Den Heijer, 2011). At international universities, concepts such as 'Greening the campus' appear in plans and strategies. Universities feel an urgency to set a good example for students. They will take the experience to their future employers. Many students will end up at leading positions, managing decisions on sustainable issues. A change of the mind-set is a mean of implementing sustainable concepts. Furthermore visitors expect innovative solutions of universities with world-class reputations on subjects related to sustainability (TU Delft, 2013). However, Van Hal et al. (2010) also state that facility and campus managers do consult their colleagues and superiors, but rarely ask advice to the academic staff about innovative sustainable solutions. This study is one attempt of the academic field to give advice about sustainable solutions in constructions.

In this study the Delft University of Technology is considered to be the client. Within the organisation of the university FMVG (Facilitair Management & Vastgoed; Facility Management & Real Estate) manages all real estate and constructions on the campus. This organisation works between the requirements and wishes of the user and the Executive Board of the Delft University of Technology. One must note that they make decisions on behalf of both stakeholders. FMVG consists of four departments: real estate development, project management, maintenance and control, and the front offices. One note can be made about the Facility Management, according to Ernst (2013) one of the biggest changes for a facility manager is to think about long-term functionalities.

Vision sustainability Delft University of Technology

Universities, companies and other stakeholders in our society know that some changes need to be made in order to make the world livable for future generations. The first steps are taken in Europe. An agreement has been established in order to reduce energy consumption and decrease CO₂ emissions by 2020 (Schoolderman et al., 2014). The European Union also has the ambition to create new job opportunities and economic growth.

The Delft University of Technology has the following mission statement (TU Delft, 2013):

“De TU Delft draagt substantieel bij aan de duurzame samenleving van de 21ste eeuw door het verrichten van grensverleggend technisch-wetenschappelijk onderzoek van erkend international wereldniveau, door het opleiden van maatschappelijk betrokken ingenieurs en doctors, en door het helpen vertalen van kennis in economisch en maatschappelijk waardevolle technologische innovaties en bedrijvigheid.” (Freely translated: “The Delft University of Technology contributes substantially to a sustainable society in the 21st century by conducting transboundary technical scientific research globally and being acknowledged for that, by educating societal responsible engineers and doctors, and by translating its knowledge into economical and societal relevant valuable innovations and businesses.”)

The Delft University of Technology states that it wants to make a significant contribution to a sustainable society by delivering relevant research and people educated and motivated to be sustainable (TU Delft, 2013, 2014). What is meant with the definition of sustainability remains unclear. Furthermore the university has made a deal with the municipality of Delft, which is the ‘E-Deal Delft energieneutraal 2050’. The university states that it will reduce its CO₂ emissions before 2050. It will focus on decreasing energy use and the sustainable development of energy and intelligent energy systems. This must be translated in the real estate portfolio of the university. The ultimate goal is to have buildings that do not have an impact on the environment. This includes the use of buildings, the production of building components and construction activities (TU Delft, 2013).

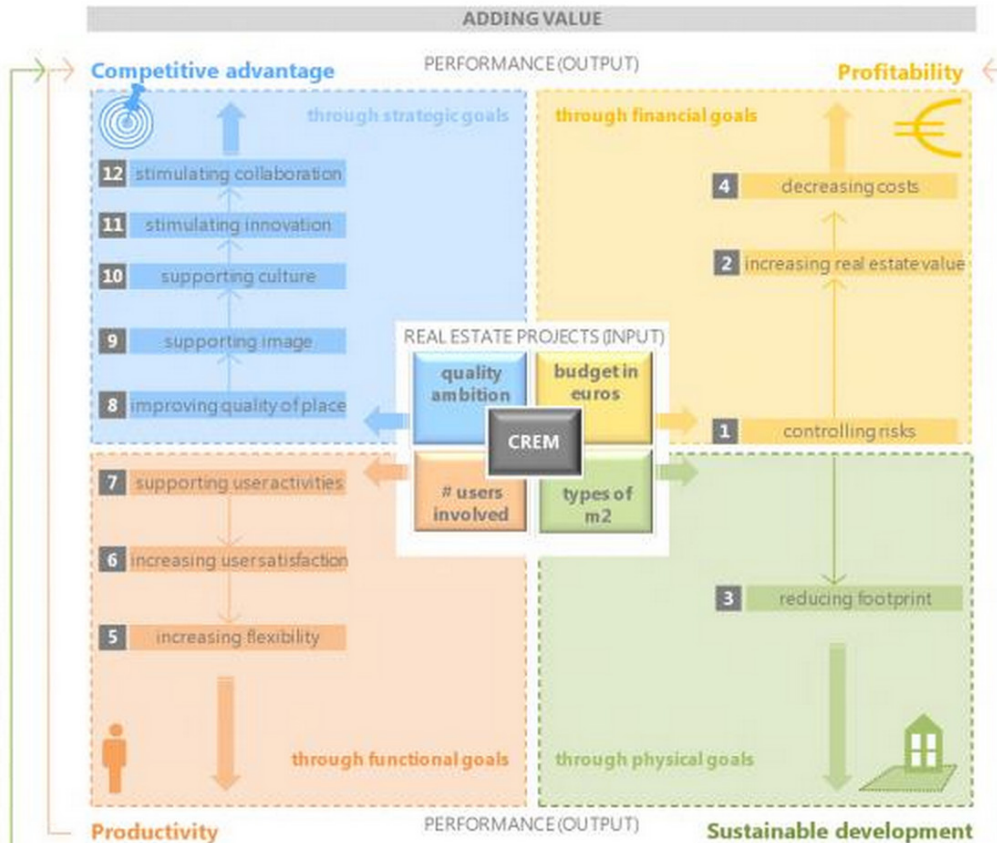
A few buildings of the university have technical and functional obsolescences. This has its impact on the exploitation and could be a risk for the business. The costs of real estate compete with the costs of primary tasks of the university. Therefore the university must use their real estate efficiently. A few means can be used in order to make real estate more efficient. First of all the university must use the amount of square meters optimally. Secondly, the university must have a great focus on sustainability at new (renovation) projects. Thirdly, the university wants to improve the quality of older buildings by increasing the quality of maintenance processes. The building will be assessed according to comfort and reducing CO₂ emissions (TU Delft, 2013).

Value of University's real estate

Within this framework the definition of real estate value of Den Heijer (2011) is used. She makes a difference between four aspects, namely competitive advantage, profitability, productivity and sustainable development. A combination of these four aspects is the value for a university as can be seen in figure 16. One should note that all values are connected and interact with each other. Therefore this research will keep all values in mind during the study.

Den Heijer (2011) concludes that managers of universities do not have the same focus on increasing real estate value as the commercial real estate companies. They rather collaborate with partners in order to increase productivity of students and employees. In several interviews it became clear that FMVG uses this model from Den Heijer (2011) a lot. However, FMVG tends to look more at the competitive advantage and the productivity values than to the financial value of real estate.

Figure 16: Four added values at universities (Den Heijer, 2011)



4.3 - Testing the model

As mentioned above two models (see figures 13 and 14) have been shown during the interviews. On the following pages the results of the interviews are written down. Afterwards conclusions are drawn and evaluated and reflected on the model.

Interviews with the client (FMVG) - general findings

During the interviews it became clear that the Delft University of Technology is not yet ready to implement a Performance-Service System. A few aspects are still in its infancy and must be developed first before reducing the footprint of materials will be common practice. As Koopmans states that it is about a changing mind-set in all of us in the way we look at products. Products are only subordinate to the performance. Simply put, Koopmans is not concerned what product is used for the required performance. The first question we must raise ourselves is what material will have a future value. So besides thinking in performances, one should also alter its perspective about value.

In a few interviews, such as the interviews of Stokkers, Hellinga, Weststrate, Winkels, and Elissen & Wiardi, it was mentioned that the university is only looking at the CO₂ reduction within its real estate portfolio. All members of FMVG that have been spoken to mentioned that at this moment reduction of CO₂ is the core business of their sustainability strategy within real estate, because of agreements with the government and the widespread knowledge about reduction of carbon emissions. Almost no parties are looking further than the reduction of CO₂. According to Winkels one of the main reasons why the Delft University of Technology is only looking at CO₂ reduction, is because the policy about sustainability still has to be written. But also within the reduction of CO₂ FMVG is not innovative. Koopmans gives an example about

the new solar panels the Delft University of Technology has acquired. These solar panels should produce 1,2 megawatt in the following years. After raising the question if the provider has an incentive to produce more than the agreed 1,2 megawatt the answer was *“Nee, we hebben deze kans gemist (Freely translated: “No, we have missed this opportunity.”)*”

Furthermore, Stokkers adds to this discussion that Delft University of Technology educates about sustainability. It is rather strange that the real estate portfolio is not as sustainable as is educated. So, Delft University of Technology should focus much more on sustainability in the broader sense. However, according to Weststrate the information needed in order to make a transition towards the Circular Economy is still lacking. Although a lot has to overcome, during the interviews it became clear that there is a positive feeling among employees of FMVG. Weststrate mentions that the Executive Board of the Delft University of Technology also has a strong incentive to argue for developing sustainable measures among the campus. A general concern is that although there are a lot of positive sounds from Delft University of Technology, it takes a lot of time to implement new innovative ideas. Hellinga gives the following example, in order to lease components several departments, such as department of procurement, the department of law, department of financial control, etc., must evaluate and evaluate this kind of procurement.

In addition to this general concern Ellisen and Wiardi suspect that in the end the financial costs will always have a mark on the decision in a greater or lesser extent. *“Ik zit nu bijvoorbeeld bij een nieuwe ontwikkeling, dan zetten wij voor de duurzaamheid best wel hoge prestatienormen, dus BREEAM excellent, passief huis. Daar wordt in kostenraming ook rekening mee gehouden, dus er is best een flink bedrag gereserveerd voor extra duurzaamheid, maar daar hebben we wel bij gezegd als die extra eisen niet te behalen zijn, dan moet je toch water bij de wijn doen (freely translated: At this moment I'm working in a new project. The ambitions regarding sustainability are quite high, like BREEAM excellent, passive house. But if those agreements can not be met, we have to find a compromise, financially speaking.)”* One can set requirements on quality and sustainability before tendering, but if the budget is exceeded these requirements must always be reconsidered.

One note should be made about the current construction market. Stokkers is not sure the current market is willing to alter their core business to Circular Economy businesses. Current market parties are mainly focussing on making profit. Market parties drive their costs up due to BTW (taxes), yield on the delivered product and the risk. All together this drives the prices of delivered services up. The idea of the Circular Economy does not fit this market yet. Although Stokkers is sceptic about the current market, other employees such as Koopmans believe FMVG will do more projects in a DB(F)MO setting.

Another issue mentioned by Stokkers is that the commercial companies must be transparent in their information of the performances towards the client. Generally speaking, commercial companies keep information for themselves.

One last note is made about definitions. It became clear during the interviews that developing good definitions is of great importance in order to communicate on the same level. During the interview with Hellinga the question was raised why we were talking about blinds. A blind is a product and not a performance. Hellinga suspected that we would be talking about the organisation and the processes behind the organisation in order to implement a Performance-Service System. In addition to this there was a discussion with Elissen and Wiardi about leasing blinds, it became clear that it is not just about the blinds. It is about the indoor climate and blocking of too much sunlight. They mentioned that these outputs are the performances. The architect or the designer of the construction must keep these performances in mind. Therefore in a perfect world all performances are already described and the means in order to deliver these performances are mapped. However, this is probably not the case. At this moment a lot of stakeholders must yet learn how to organise their own working flow when thinking in performances.

The client (FMVG)

In this case the client is the FMVG (Facilitair Management & Vastgoed; Facility Management & Real Estate) of Delft University of Technology. This organisation works between the requirements and wishes of both the user and the Executive Board. They make decisions on behalf of both stakeholders.

Interviews – the client

According to Stokkers, Weststrate, and Ellisen & Wiardi one of the biggest changes FMVG faces is that the organisation should focus on contract-management. At this moment FMVG does everything on its own. They manage their own real estate, provide the necessary maintenance activities, and they are their own developer. However, in terms of the Performance-Service System they will not develop, maintain and construct real estate. They will lease components or an ensemble of components (which could be a building) and the required maintenance. This means that the Delft University of Technology does not own components or the ensemble. Weststrate mentions that due to lease contracts a shift must be made from the department of management and maintenance to the department of contract management or LSA (service-level agreement)-management. *“Je gaat wat meer vanuit contractmanagement en SLA-management organiseren, dan vanuit het technische aspect om het onderhoud te plegen (freely translated: You will maintain by doing contract management instead of concerning about technical aspects).”* Both Stokkers and Van Barneveld mention one requirement in order to implement such a system in the organisation. Providers of performances must be transparent in their information supply. Weststrate adds that contract management should have means in order to assess the agreed contract terms.

FMVG is now experiencing contract management at the new construction of the TNW faculty. There is agreed upon to have a DB(F)MO-contract (Design, Built, (Finance is excluded), Maintenance, and Operating). Koopmans expects that FMVG will use such constructions in the future.

When the Performance-Service System was explained to Stokkers she foresaw a problem within the organisation of a client. She believes that in order to lease complex systems such as facades the organisation must be very smart. She uses an example of a cleaning agreement. It is very difficult to organise such a contract and that is just common business. Imagine how the structure of an organisation becomes so complex if leasing the whole façade. That kind of services are not provided in practice. This has to do with developers and other market parties that want to make profit. Stokkers believes in these kinds of services if these services are combined with other services. So for example, take a security company that provides doors or a cleaning company that provides toilets.

Providers want high yields due to risks and they want a revenue stream that will cover taxes. Besides that, a lot of mistakes are being made, so in a lot of cases you are victim as a client because the client must pay for those costs. Stokker believes that it is cheaper to do it all by yourself than depend on third parties.

The users

As mentioned above FMVG works on behalf of the users. FMVG should meet the requirements and wishes of the users as good as possible in order to keep the level of productivity as high as possible. During the interviews the users are discussed and the results can be seen below.

Interviews

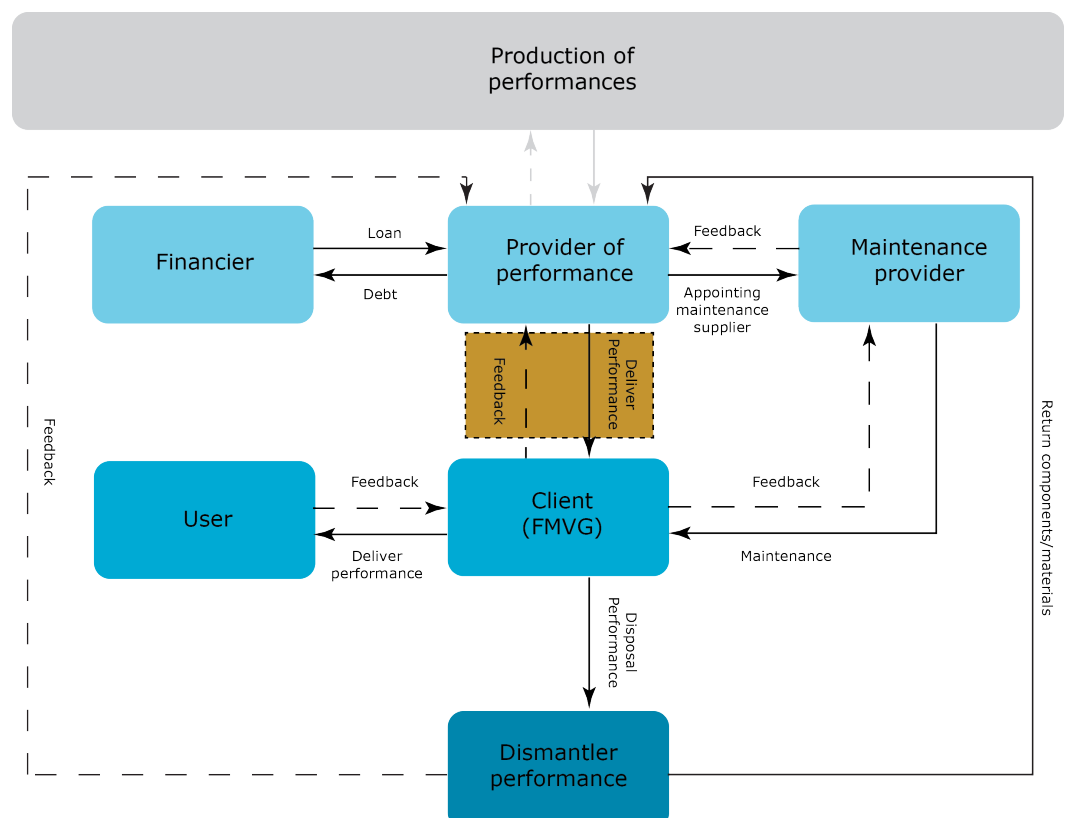
One issue mentioned by Koopmans is the wish of users to be in control. One can design and develop 'smart' systems in order to regulate the indoor climate. But users wish to have the flexibility to control the indoor climate, for instance, by turning on the radiator.

Therefore Stokkers concludes that results on the performances of the real estate must be shown in order to create an opportunity to have a conversation between FMVG and the user. She adds that communication between both is important in order to gain support for developments at the campus. In a discussion with mentors' about Performance-Service Systems one stated that the user gets a lot from FMVG. Van Barneveld discusses that the user must also be educated in how to be sustainable at the campus. For example, one could put a lot of solar panels on the roof and when the building has good insulation. If the user is going to set the heater extremely high, both measurements do not have any impact. Therefore the mind-set of the user must be altered if needed.

Reflection on Performance(s)

The performance is an agreed action of performing that results in an output, utility, goal, function, or commitment whereby a product is not a goal in itself, but subordinate to the performance. The provider will deliver the performance to the client. The provider remains the owner of the components, so there are no transactions costs. The required performance will be stated in contracts. The provider must be responsible for the required maintenance. The client makes sure that the user can use the performance optimally. One way to describe the required performances is to use KPI's (Key Performance Indicators). KPI's can be mentioned in the contract and are measurable. However KPI's are always made after gaining experiences in the performance of the current real estate portfolio. This is not necessarily a problem, because one could also set the norm of KPI higher than the benchmark.

Figure 17: Reflection on performances



Interviews

Weststrate is positive about the system. A provider could benefit from lease-contracts due to longer relationships with clients. Instead of having guaranteed work for one year, they can have work for several years. At this moment there are a lot of framework contracts. These contracts can be concluded for five years and after the agreed period the contract can be expanded by each year. This gives a provider a lot of uncertainty due to the competition in the current market.

Koopmans gives an example about an energy performance that will be delivered at the Delft University of Technology. It is agreed that the solar panels will have a performance of 1,2 megawatt. Although a requirement is stated about the amount of energy and the product used in order to get this amount, there is no agreement made about how the provider will achieve these performances. In order to check the required performance, FMVG will get monthly reports about the progress.

He adds that the contracts designed at FMVG are more or less effort contracts. Therefore contracts state wishes instead of requirements. The 'how' is described well, but the 'what' in contracts is still lacking content. In leasing constructions an organisation should describe all requirements well. FMVG does not have any experience in such constructions.

Weststrate mentions a few chances and risks for the Performance-Service System. A brief outline of those chances and risks is shown below. Opportunities in choosing a Performance-Service System are:

- Stability;
- Quality of the products used in order to get the performance;
- Functioning of the products in order to get the agreed level of performance;
- Liability of the products used;
- And finally reducing costs.

Risks for implementing the Performance-Service System are:

- What if a provider goes bankrupt? What should the client do?
- The changing wishes and requirements of users
- Is the product used reusable when disassembled?
- The changes within an organisation
- Can the provider deliver the same quality asked by the client in performance, but also deliver this quality in contract?
- Risk of errors
 - Risk of touching the component even if it is stated otherwise in the contract;
 - What if the error occurs due to an electrical error, who is responsible? The client, the electricity provider or the provider of the performance?
 - Errors due to changes in the environment (weather, etc.). Who is responsible?
- Planning of maintenance activities

Furthermore in order to lease components as a client, performance requirements must be written down on a detailed level. Weststrate gives an example about blinds that need to go down by one push on the button. If blinds have an error, the provider must deliver the maintenance needed in order to keep the agreed performance level.

Elissen and Wiardi mention that in order to get performances, KPI's are stated in contracts. At this moment KPI's are used at processes, but not at projects of FMVG. Which means that the KPI's are used to measure the progress of projects. They do not know if KPI's are used at performances from providers. Koopmans adds that in many cases no normative norm is

established. So, FMVG has to make some leaps forward in order to use KPI's in the Performance-Service Setting.

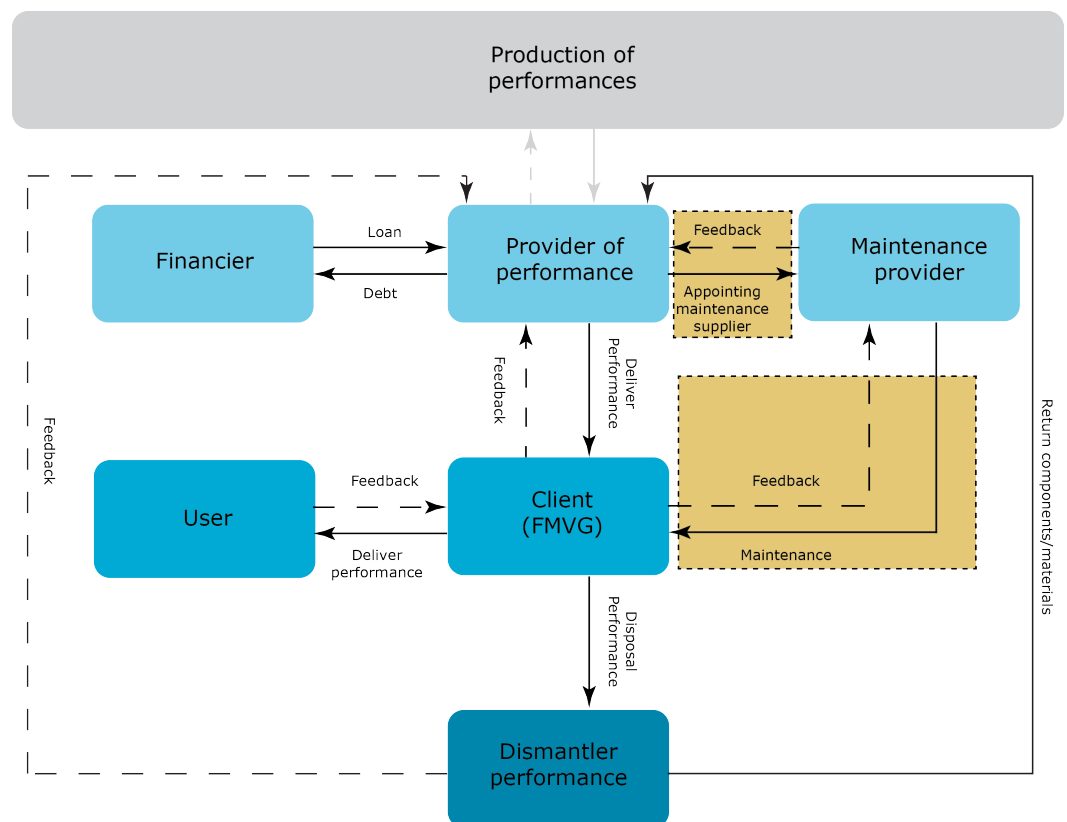
In order to use KPI's one should also be able to monitor the agreed performances. Ellisen and Wiardi asked the question of how to monitor the agreed performance? Is there a database to compare agreed performances? Secondly, to monitor the performance one has to wait a year before the first measurements can be conducted. Although it is not possible at this moment, huge opportunities can be seen at the University. According to Koopmans the Delft University of Technology should be able to develop smart systems that can measure all kinds of performances. In contrast some believe that market parties are better in measuring performances than the Delft University of Technology. External companies should measure the performances asked.

According to Elissen and Wiardi it is due to complexities in real estate using Performance-Service Systems could lead to a lot of contracts for all different performances.

Reflection on Service(s)

The service is mainly a non-physical action or operation whereby the performance is maintained, extended or optimized over time. The service cannot be produced or consumed in itself and is subordinate to the performance.

Figure 18: Reflection on service(s)



Interviews

At the beginning of the interview with Weststrate he confirms that there are three kinds of maintenance activities, namely corrective, preventive and replacement maintenance. This will be the same when leasing instead of buying, but the level of responsibilities of stakeholders is different. He adds that if FMVG uses a Performance-Service System all maintenance activities must be included. Therefore he would like to have a gross lease. As Koopmans puts it: "Het

management en het onderhoudsplan. Eigenlijk zijn we daar niet in geïnteresseerd (freely translated: "The management and the maintenance plan. Basically, we are not interested in this.")." A report about the progress is just fine. Because the provider must deliver a certain level of performance, it does not matter to the client how the provider will deliver this performance. If, for example, a component is broken and therefore the performance will not be achieved, the provider must do the necessary maintenance activities in order to get the performance back.

Leasing a performance with the service included could be an advantage. You could say to a provider: "the blind is broken, fix it." Only one question raised by Elissen and Wiardi is how to monitor the agreed service level?

Weststrate mentions a risk related to the planning of maintenance activities by the provider. *"De TU Delft wordt steeds meer een 24/7 economie. Het wordt steeds moeilijker om onderhoudsactiviteiten te plannen m.b.t. de primaire processen (Freely translated: "The Delft University of Technology is becoming a 24/7 economy. Therefore it is becoming harder to plan maintenance activities due to the primary process of the university.")*." As a maintenance manager you are subordinated to the primary process. The primary process is the core business of a university. One risk is that maintenance activities must take place after the agreed hours, which could lead to higher lease-prices. The risk of planning is mainly a financial risk.

Furthermore, Weststrate also notes that this is different than the planning at corporate businesses. At commercial businesses the maintenance activities start and they do not take the employees into account. At the university, maintenance will always be of secondary importance. The most important aspect remains the primary process. So, planning of maintenance activities is becoming more important when implementing the Performance-Service System.

Elissen and Wiardi conclude that the facility manager will be the one who will manage the contracts. They assess if a certain performance is achieved and otherwise they will point out errors to the provider. Both are not sure if maintenance activities must be included in the contract or that it will be included in the general terms and conditions.

Reflection on dismantling

This part reflects on dismantling components that were used. Due to the design of components and their technical aspects it is not fully discussed during interviews. Both the interviewees and the interviewer do not have expert knowledge about the technical aspects. The topic of the Performance-Service System was discussed in an abstract way. Case studies would be a better method in order to explore technical aspects of components.

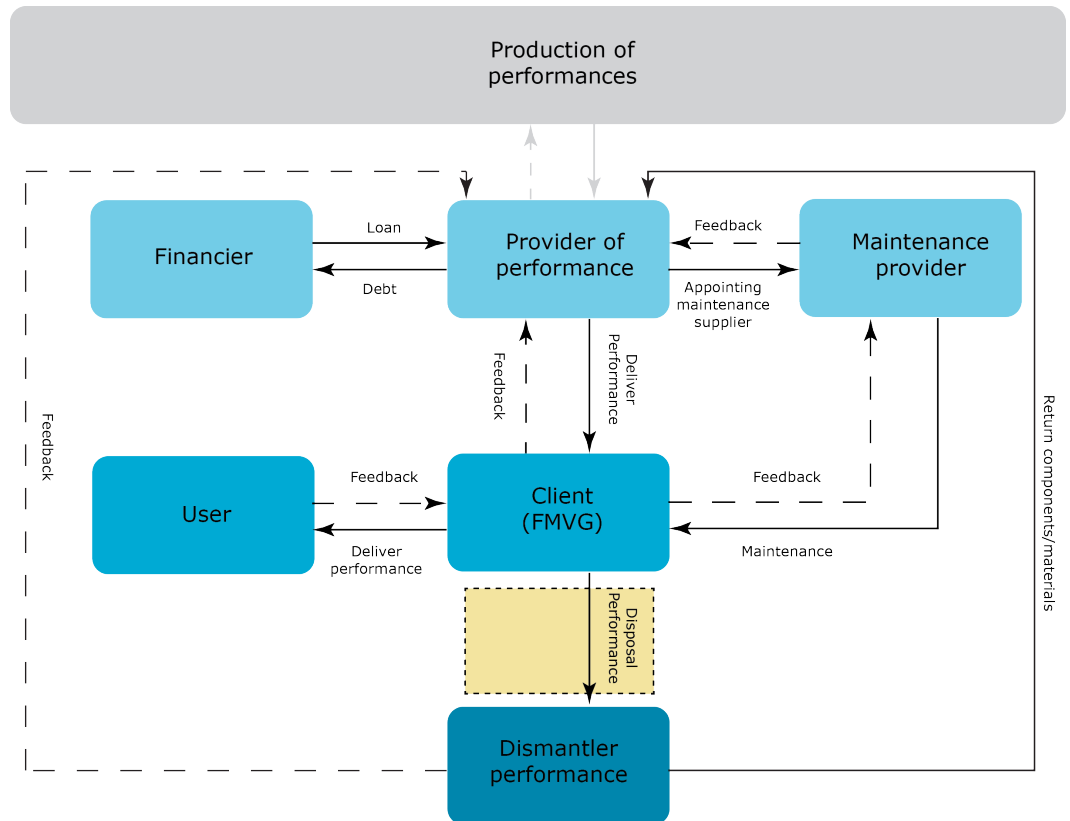
Interviews

When talking about the dismantling part of the model Weststrate gives his view on processes. At this moment FMVG is the manager of the real estate and constructions on the campus. If a certain component is not reused, it will be demolished and probably sent to waste.

There is a concern about the fastness of which changes are made at the Delft University of Technology. Elissen and Wiardi argue that Delft University of Technology changes fast. They raise other questions during the interview, such as: What if a functional lifetime of a component does not meet the economic lifetime of the component? Could it be reused at different locations or aspects at the campus? Maybe the Delft University of Technology should start a department that manages end of life components?

One of the first questions raised by the client is how this will be financially attractive for a provider to dismantle components. Stokkers argues that the materials used will depreciate

Figure 19: Reflection on dismantling



during the usage period. Providers are not willing to take the risk of waiting for the residual value of a component. It is too uncertain what the value of such a component will be in about 5, 10 or even 20 years. The longer the component is in use, the more uncertain the residual value will be. It is expected that the provider will translate these risks in the lease. Which in turn could lead to higher lease payments.

Reflection on closing the loop

Interviews

As mentioned above, Delft University of Technology manages its own real estate. According to Weststrate FMVG set up a program to demolish buildings at the campus. The demolition is done by dismantlers and not by FMVG. The dismantlers may decide what to do with the demolished components.

When addressing the issue of bringing components back into a system this raised a lot of questions from different interviewees. Many of them did not take this principle into account in current or past developments.

Elissen and Wiardi mention that they experience a positive vibe from dismantlers towards sustainability. More and more dismantlers try gaining value through the demolished components by selling it, for instance to a trader in steel. There are even companies, such as 'van Ganzewinkel', that state: waste does not exist.

This part of the Performance-Service System is one of the most uncertain aspects of the system. In the principles of the Circular Economy it is stated that products, materials, components must be reused in order to bring it back into the economy. Hellinga and Koopmans raise a few questions:

- How do you monitor this aspect of the Performance-Service System?
- What does this aspect mean?
- Is it about an integrated component or does not matter whether it is dismantled or not?

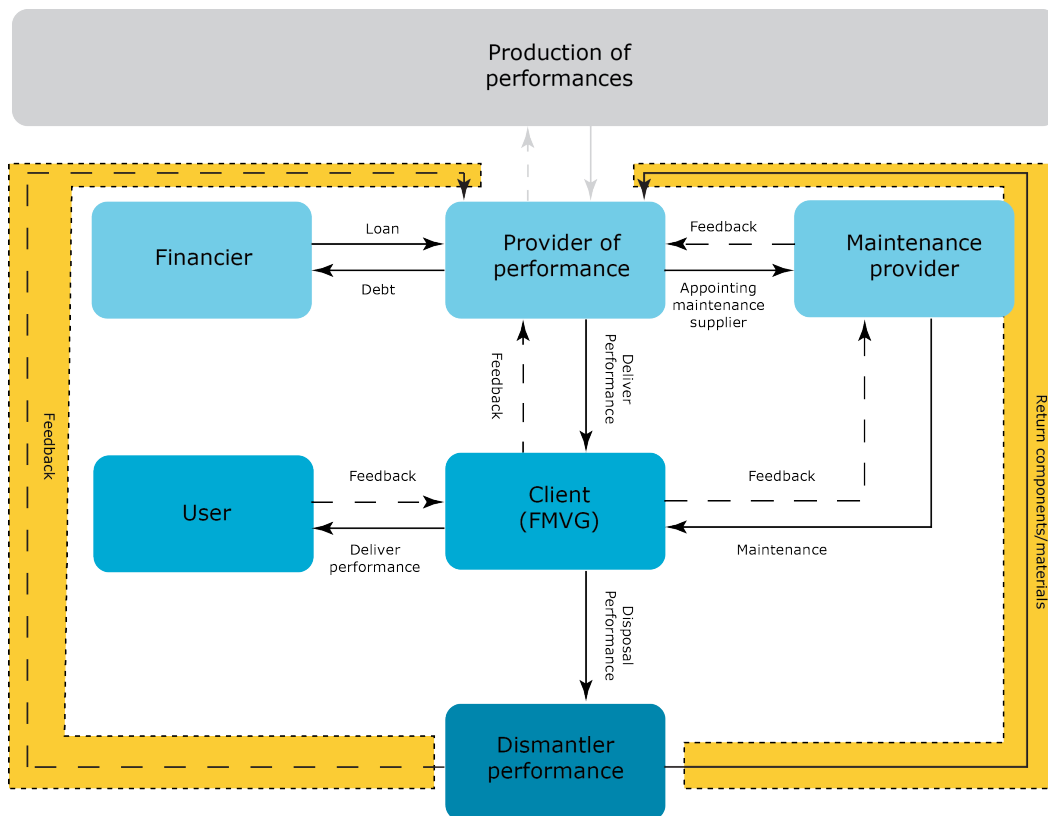


Figure 20: Reflection on closing the loop

- What does Circular Economy mean? Because if you put it in a furnace it also comes back in the economy.
- How careful are providers when recycling?
- How should it be formulated in contracts? And what will happen if the client or provider does not meet the requirements stated in the contract?
- Who will be responsible for the dismantled components?

After raising all those questions, Hellinga argued that an external company must deliver certificates in order to assess if a component or company is 'Circular Economical'. In order to be successful it must have a name in the industry, such as BREEAM or LEED. This new company should state the requirements and assess if companies fulfil these requirements. Hellinga does not believe that Delft University of Technology could arrange such a system. It does not have the resources in order to enforce the current construction industry to be circular.

At the Delft University of Technology one could think about asking users before a development will take place what materials they can use over 30 years. These materials can then be applied in this development and after usage these materials can find a new life with the users.

One final note can be made about the feedback loop of closing the loop. In several interviews it was mentioned that the feedback loop does not exist. There is already a lot of uncertainty about the hard loop of bringing back components and/or materials. It is therefore very difficult to study if such a feedback loop does exist in the model.

Financial models

There are different financial models. Generally, one speaks about buying or leasing. Within the buy-variant one can divide two strategies. Namely, buy and a buy-buy back. The latter means that the provider will take back the assets bought after a specific period. The leasing strategies will be described below.

Leasing of components

A lease in the real estate market can be described as “a written document by which the rights of use and occupancy of land and/or structures are transferred by the owner to another person or entity for a specified period of time in return for a specified rental (Lusht, 2012).” Lusht (2012) and Geltner, Miller, Clayton, & Eichholtz (2007) categorises the lease into five categories, namely flat rental, periodic revaluation, indexed, graduated rental, and percentage.

Leasing can be divided in two main lease concepts, namely operational leases and financial leases. The main differences can be found in two aspects. When taking a financial lease the performance or product will be regarded as an asset. The asset must be mentioned on the budget of an organisation and therefore this organisation must pay taxes of capital (Bierman, 1982).

When using a operational lease the performance or product will not be regarded as an asset that is owned by the client. In this case the lessor remains the owner and has to pay the above mentioned taxes. Depending on the strategy of the client one of these two leases is preferable (Bierman, 1982).

Important lease clauses are the division of expenses. Geltner et al. (2007) differs the expenses into four categories. First there is the gross lease, which means that the landlord (provider) pays the operating expenses. Operating expenses are the services such as electricity, heat, water, cleaning, maintenance, security, and so on. In a net lease, the tenant (client) is responsible for the operating expenses. A hybrid lease involves aspects of both net and gross leases. The landlord and the tenant share the operating expenses. One last lease form is the expense stop. The tenant agrees to pay an amount of money to a certain level and after exceeding this level the expenses are for the landlord.

Lease characteristics affecting the value or rent are (Geltner et al., 2007):

- Space;
- Tenant;
- Date and term of the lease;
- Rent;
- Concessions (rent abatements, tenant improvement allowance, moving expense allowances, etc.);
- Lease covenants;
- Lease options:
 - Renewal;
 - Cancellation;
 - Expansion.

In order to develop lease contracts, which can be implemented in the Circular Economy, the Percentage Lease will be further elaborated. Within the retail sector the percentage rent means that this rent is paid over a minimum amount of sales. This kind of lease is divided between a base rent and the overage rent (Geltner et al., 2007).

This principle of the percentage rent can also be used within the Circular Economy. Productivity of leased space is also related to the amount of errors of components within a year. In the Performance-Service System one wants to stimulate higher quality components. Higher quality of components translates into less errors within a year. Therefore the percentage rent is

tide to the maximum amount of errors within a year. If the amount of errors remain below the agreed level during the year, the provider may expect a percentage above the base rent. If it fails to stay below this maximum, the client does not have to pay this percentage.

The models are developed with the scenarios in mind. All are calculated with the current standards of financial schemes.

Buy

In this case the following aspects have been taken into account:

- Initial purchasing price: required m² blinds * initial price per m² blind
- Operating costs per m² blind
- Growth in operating costs per year
- Loan with a 80% Loan-to-value (LTV) ratio
- Present Value (PV)
- Net Present Value (NPV): Sum of all PV

Buy buy-back

In this case the following aspects have been taken into account:

- Initial purchasing price: required m² blinds * initial price per m² blind
- Operating costs per m² blind
- Growth in operating costs per year
- Loan with a 80% Loan-to-value (LTV) ratio
- Present Value (PV)
- Net Present Value (NPV): Sum of all PV

Plus:

- Buy back based on residual value components

Lease

- Monthly payments
- Lease payments include maintenance costs
- Present value (PV)
- Net present value (NPV): Sum of all PV

Lease (CE)

- Monthly payments
- Lease payments include maintenance costs
- Present Value (PV)
- Net Present Value (NPV): Sum of all PV

One addition is made to the Lease (CE):

- The lease for a CE component is developed with a concept of the retail sector, namely the Percentage Lease. The percentage asked will not be given over a minimum of sales (as in retail), but will be given if the errors of a component are less than the agreed maximum. On the other hand it is possible to impose a penalty if the maximum is exceeded, as can be seen in table 3.

Furthermore a distinction is made between traditional components. That are components that we can buy or lease in the current market. However, it is expected that in order to make the transition towards a Circular Economy one should also develop new innovative components in

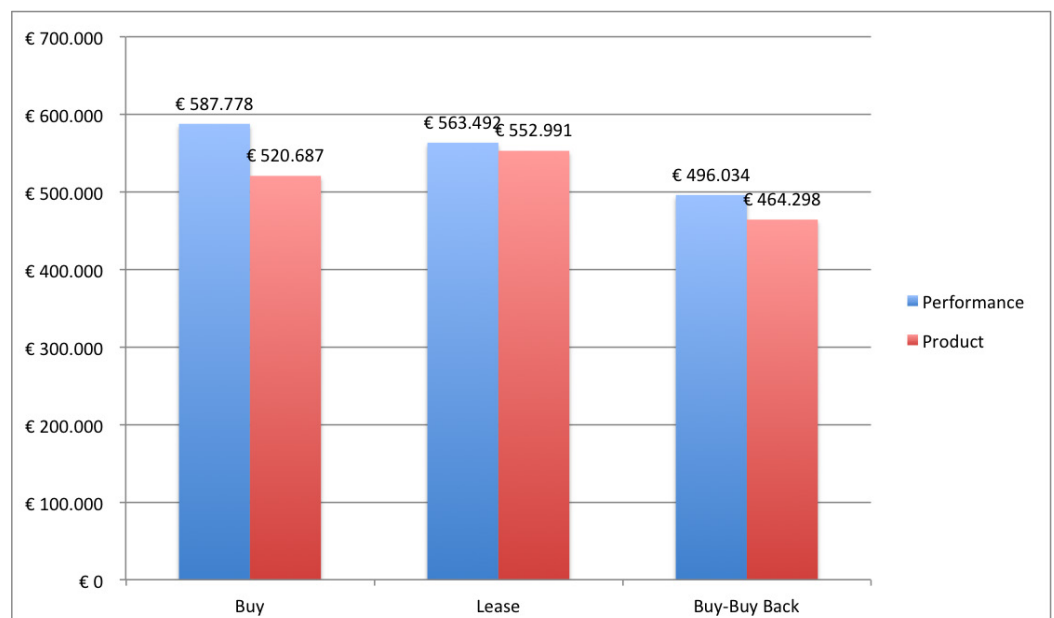
Table 2: Variables cash flow schemes - Scenario TU Delft

	Traditional Economical component	Circular Economical component
General		
Holding Period	20 years	20 years € 332/m ² (10% extra investment traditional component)
Initial purchasing price	€ 302/m ²	8%
Initial yield	8%	€ 0,37/m ² /year (blinds)
Maintenance costs	€ 0,37/m ² /year (blinds)	40 years
Depreciation	40 years	€ 8/m ² component
Depreciation per year	€ 8/m ² component	€ 181/m ² component
Residual value (20 years)	€ 151/m ² component	
Buy-buy back		
Buy-buy back guarantee	40%	60%
Lease		
Base rent per year	€ 1/m ² /component	€ 1/m ² /component
Overage rent (lease)	-	5%
Loan		
LTV	80%	80%
Interest rate	2%	2%
Period	20 years	20 years

Figure 21: Results 20 year calculations scenarios



Figure 22: Results 20 year calculations - penalty Lease (CE)



Bonus/Penalty	
Overage Rent (CE Component)	-€ 2
Overage Percentage Rent	5%
Max errors (breakpoint)	2
Errors in 1 year	4
	2
Excess errors	2

Table 3: Variables in overage lease

the construction sector. The differences made and the variables used in the calculations can be seen in table 2. The calculations made can be seen in the appendices BA - BD.

A few conclusions can be made about the estimations. First of all, these calculations are an estimation of what a component ,developed according to principles of the Circular Economy, could do. Due to the variety of all variables, as can be seen in table 2, in the calculations no comparison can be made. For example, what is estimated when talking about Circular Economical components? One could think in terms of adaptability, cradle-to-cradle, reusability, etc. This makes it very complex. Therefore future research should focus on what kind of variables are needed in the Circular Economy.

When looking at figures 21 and 22 one sees that components that are made by implementing principles of the Circular Economy are in every estimation higher than components developed in a traditional way. Even though the 'Buy-buy back' scenario uses a higher buy-back percentage, this is still not cheaper when looking at the Net Present Values of both cases.

4.4 - Part conclusions

The Delft University of Technology has high ambitions with respect to sustainability. They believe that universities have a moral obligation to educate the sustainability professionals of tomorrow. Secondly, it wants to be an example for visitors. The ultimate goal of the university is to develop buildings that have not a negative impact on the environment.

After conducting interviews with employees of FMVG it became clear that the ambitions are indeed high, but in reality there is still a lot to do. First of all, a good policy must be developed with respect to the real estate and constructions of the Delft University of Technology. Secondly, at this moment the university will only look at reduction of carbon emissions. The university implements measures with respect to the reduction of CO₂ at the campus.

Some conclusions can be drawn from the interviews and will be shown per aspect of the model:

Organisation

Conclusions with respect to clients

- Change towards contractmanagement
- Decreasing ownership of components
- Providers should be transparant in their information towards clients

Conclusions with respect to users

- Users have a lot of requirements and wishes
- Users also need a change in their mindset regarding Circular Economy and should be educated in order to achieve such a mindset

Operations

Conclusions with respect to performances

- Opportunities in choosing a Performance-Service System are:
 - Stability
 - Quality of the products used in order to get the performance
 - Functioning of the products in order to get the agreed level of performance
 - Liability of the products used
 - And finally also reducing costs
- Risks for implementing the Performance-Service System are:
 - What if a provider goes bankrupt? What should the client do?
 - The changing wishes and requirements of users
 - Is the product used reusable when disassembled?
 - The organisation changes
 - Can the provider deliver the same quality asked by the client in performance, but also deliver this quality in contract?
 - Risk of errors

Conclusions with respect to services

- If using a Performance-Service System a gross lease is required
- Maintenance activities need to be planned along the primary processes of the university

Conclusions with respect to Closing the loop

- There are a lot of uncertainties towards closing the loop. First a few questions need to be answered in order to close the loop:
 - How do you monitor this aspect of the Performance-Service System?
 - What does this aspect mean?
 - Is it about an integrated component or doesn't matter whether it is dismantled or not?
 - What does circular economy mean? Because if you put it in a furnace it also comes back in the economy.
 - How careful are providers when recycling?
 - How should it be formulized in contracts? And what will happen if the client or provider does not meet the requirements stated in the contract?
 - Who will be responsible for the dismantled components?

Finance

General conclusions cash flow schemes

- During the development of the financial models a few aspects became clear. First of all it is hard to quantify the principles of the Circular Economy. For example, when applying the Performance-Service System adaptive components must be produced. There is a general expectation that these components have higher initial investment costs. However, how much these investment costs should be, remains unclear.
- Another obstacle is there is no clear general concept regarding financial models within the concept of the Circular Economy. therefore one can think about several variables what could or should be quantified. For instance, when talking about a component that is been made by principles of the Circular Economy. Does this mean the component is made adaptive, reusable, or bio-degradable? And how do you quantify soft factors that play such an important role?
- When looking at the financial schemes, buying or leasing a Circular Economical (CE)-component is always higher than buying or leasing a traditional component. These higher costs are a result of several aspects. First of all, due to a lack of information about the extra investment needed in order to develop CE-components an estimation is made. This estimation translates itself in higher development costs and therefore also higher purchasing or lease prices. Secondly, financial measures that should stimulate buying or leasing CE-components do not result in low market prices.

All interviews made clear that the model was still insufficient. The model is incomplete or inconsequent. The following can be concluded about this first model:

Conclusions with respect to the model

- The model is too static. It lacks flexibility regarding the client. Discussions showed that this scheme does not apply to all clients and providers in the market.
- It lacks to show different periods in time. It tries to capture all different time periods in one static model. For example, when looking at the different operations in the model one could see a discrepancy. At the top of the model it is stated that the provider delivers the performance to the client. At the same time there is an operation going on at the right side of the model that states that the components/ materials used for this performance are returned to the provider. By using common sense one can conclude that this stage in the model occurs in a later time period, however it still leaves a lot of questions.
- It is still uncertain if the stakeholder 'financier' must be included. In several discussions with employees of the Delft University of Technology it became clear that the Delft University of Technology finances its own projects. On the other hand, in a world that would implement all principles of the Circular Economy the client won't finance the performance in such a way. The initial costs for developing the performance are fully for the provider, unless the client and the provider will collaborate in some sort of consortium. This will not be elaborated in this study.

The financial schemes will not have too much influence on the model. Although the schemes do not have any direct influence on the model, the schemes provide some fruitful insights regarding the model.

Pyramid of Performance-Service System in constructions

The Performance-Service System should reflect the needs described in the Pyramid of Performance-Service Systems in constructions. To all levels of this pyramid a brief conclusion is described:

Inspiring & attracting people and stimulate innovations

At these levels of need the Performance-Service System plays a major role. Because the Circular Economy is a new concept that argues society needs to make a transition towards a new kind of system that stimulates sustainable measures. The Performance-Service System tries to give organisations a better grip on this concept and to stimulate people to be creative and innovative. People will be attracted to real estate that is constructed in innovative way.

Supporting people's activities, status, and image

In literature it is mentioned that the Circular Economy will provide new kind of jobs, will support people's activities and therefore its status and image of organisations. However, all statements are expectations of regarding the Circular Economy. Studies are needed in order to proof such effects in society.

Long-term collaboration models

People have a need to be part of a group, because of social cohesion. By using Performance-Service Systems long-term collaborations between client and provider may be established. A lot depends on integrity of both stakeholders.

Safety and sheltering people

There is an urgency to make a transition towards the Circular Economy. All interviewees of people agree that there is a need to change in our society.

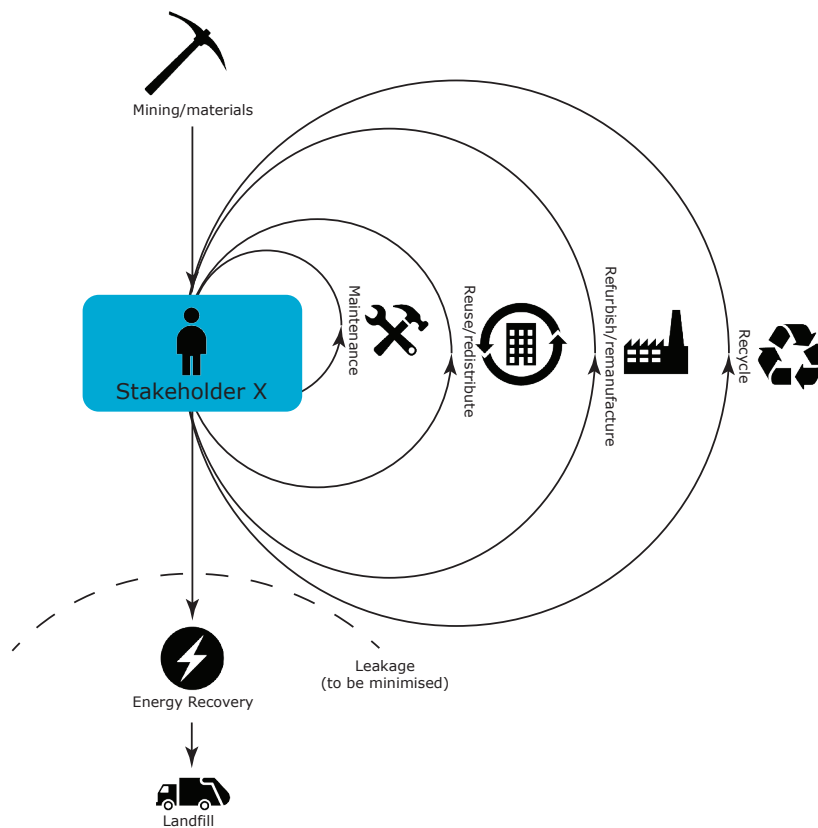


Figure 23: Simplification principles Circular Economy

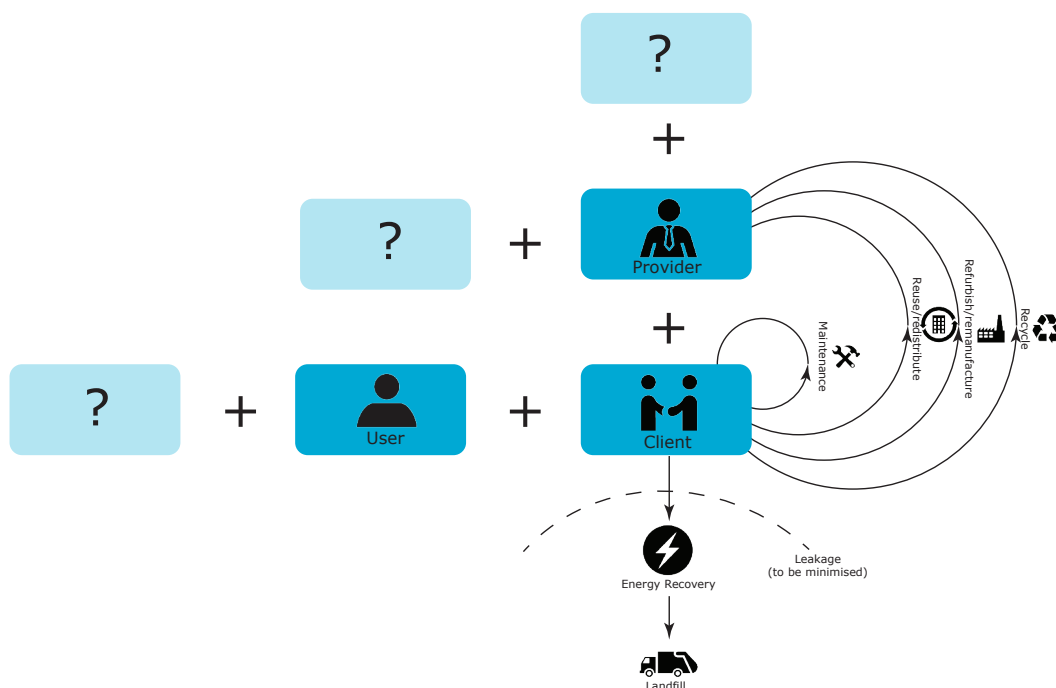


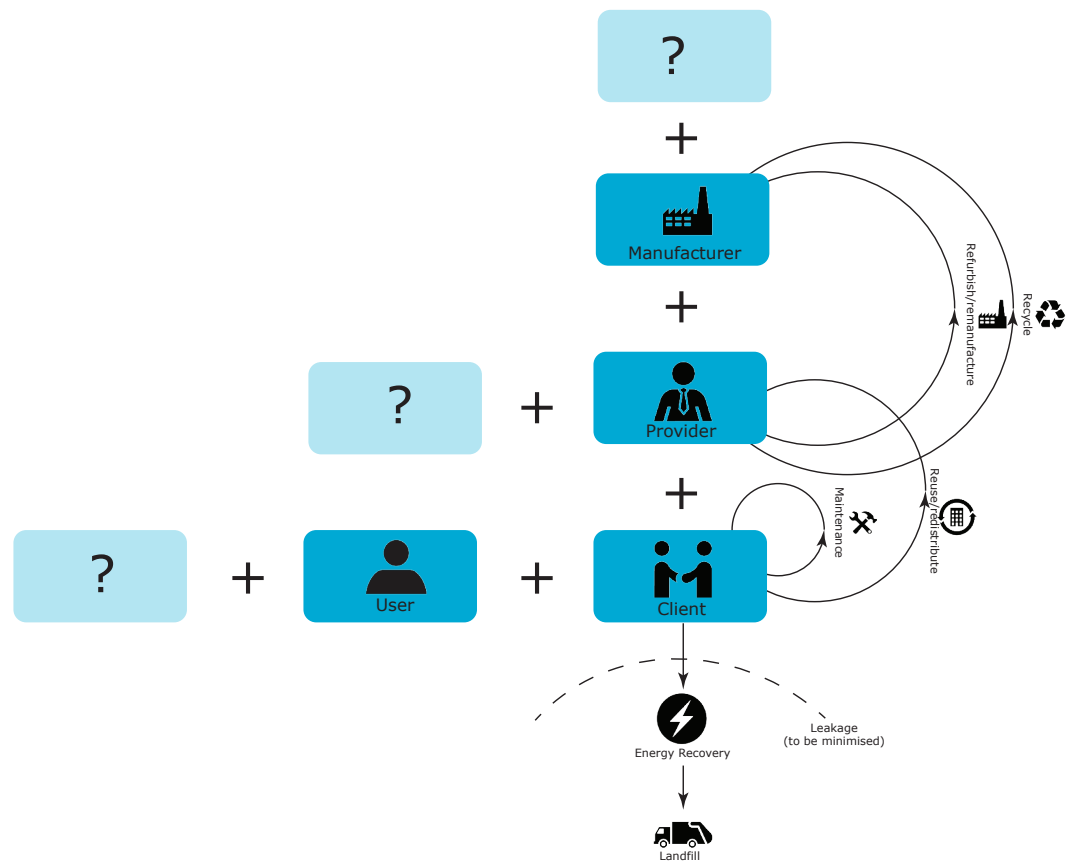
Figure 24: Expansion simplification model Circular Economy

Redevelopment of the Performance-Service System

After discussions with mentors, experts, and students it became clear that the model of the Ellen MacArthur Foundation (see figure 6) creates confusion. First of all, the Ellen MacArthur shows different stakeholders, such as the manufacturer, the supplier, and a provider. The model implies that these stakeholders are all different. But this is not necessarily true within our current system. One company can be a manufacturer, supplier of materials, and a provider at the same time. In theory it would be possible that the stakeholder is its own user of the performance provided, as is illustrated in figure 23. Therefore the model of the Ellen MacArthur Foundation is just one of the possible scenarios.

The model should therefore be adaptable for the wishes and requirements of the client. It should not state where a certain stakeholder must be within the model. Furthermore it must neither state where the loops back should be in the model. It depends on the agreements between the client and the provider how processes continue and how performances will be provided.

Figure 25: Expansion simplification model Circular Economy



5 - PERFORMANCE-SERVICE SYSTEM

5.1 Different strategies

The Performance-Service System cannot be explained by one model. First of all, from a client perspective, there are three phases that need to be taken into account. These phases are the initiative, usage, and the end of loop phase. Short descriptions of these phases are given below:

Initiative

The client and/or user have new requirements regarding facilities. The client will write these requirements down and it will be tendered towards the market.

Usage

During this phase the user and the client will use the performance or product provided. The provider or maintenance provider should sustain the required level of performance.

End of Loop

The performance is no longer needed or components must be replaced in order to fulfil new requirements. The components used will be brought back into a system.

Looking at figure 30, one sees different strategies a client can take regarding new requirements of facilities. A distinction is made between linear economy strategies and Circular strategies. Within the linear and Circular Economical strategy a differentiation is made between 'buy', 'buy-back', 'financial lease', 'Operational net lease', and 'operational gross lease'.

In the initiative phase the question of a new requirement is going from the user, towards the client, towards the provider. The provider will deliver this performance. This phase is used to develop agreements between client and provider.

During the usage phase, there are contact moments if an error occurs. This error leads to a decrease of the agreed performance. Therefore a maintenance provider should solve this error. During the usage phase the client has a monthly payment obligation towards the provider. The provider will manage the maintenance provider. This can be managed in-house or it can be outsourced.

The end of loop phase begins when the usage phase is ended. Components used in order to get the agreed performance level must be brought back into the system. Within the Performance-Service System the provider must be responsible to bring those components back.

Figure 26: Strategies (Linear Economy)

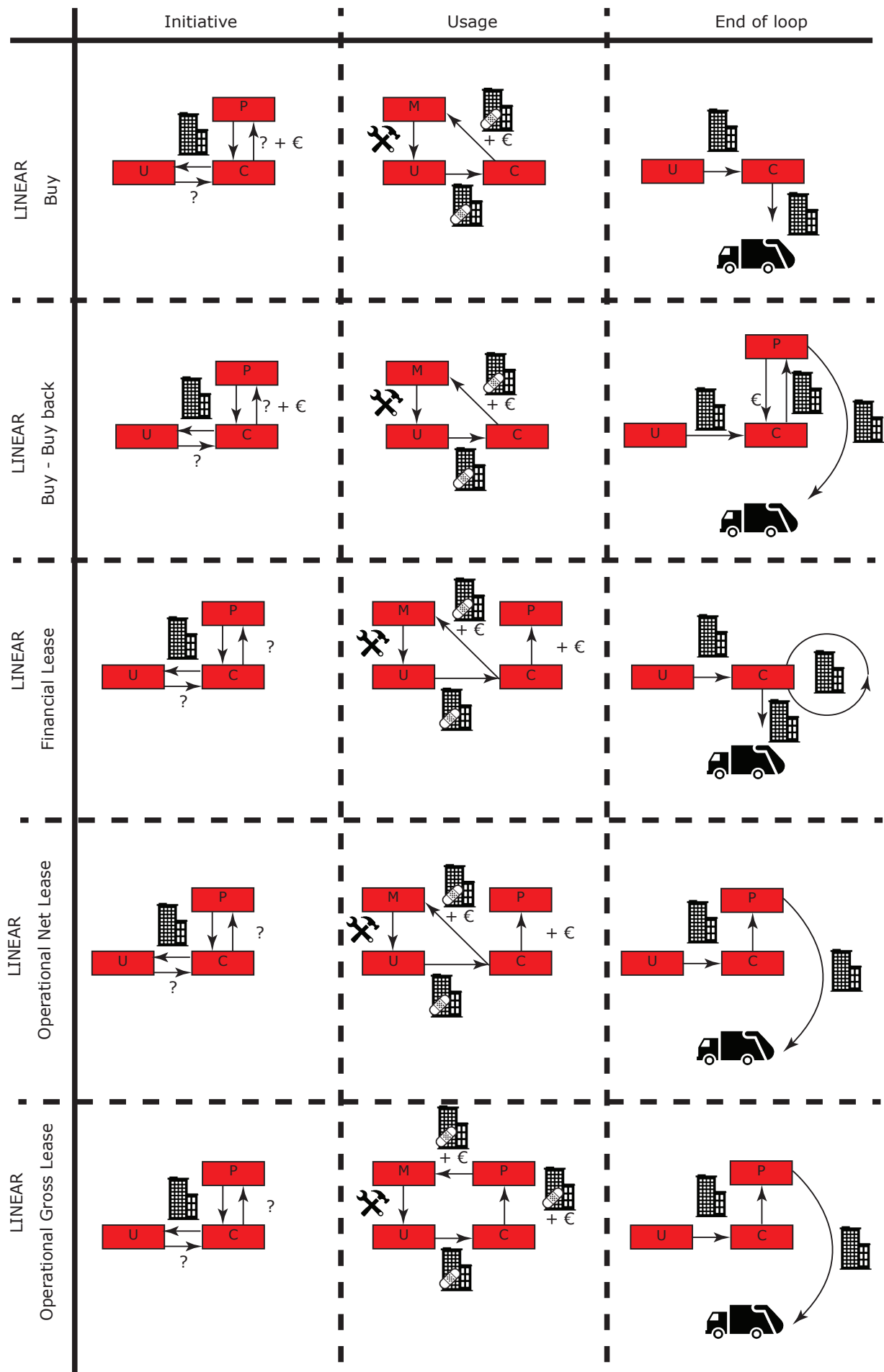


Figure 27: Strategies
(Circular Economy)

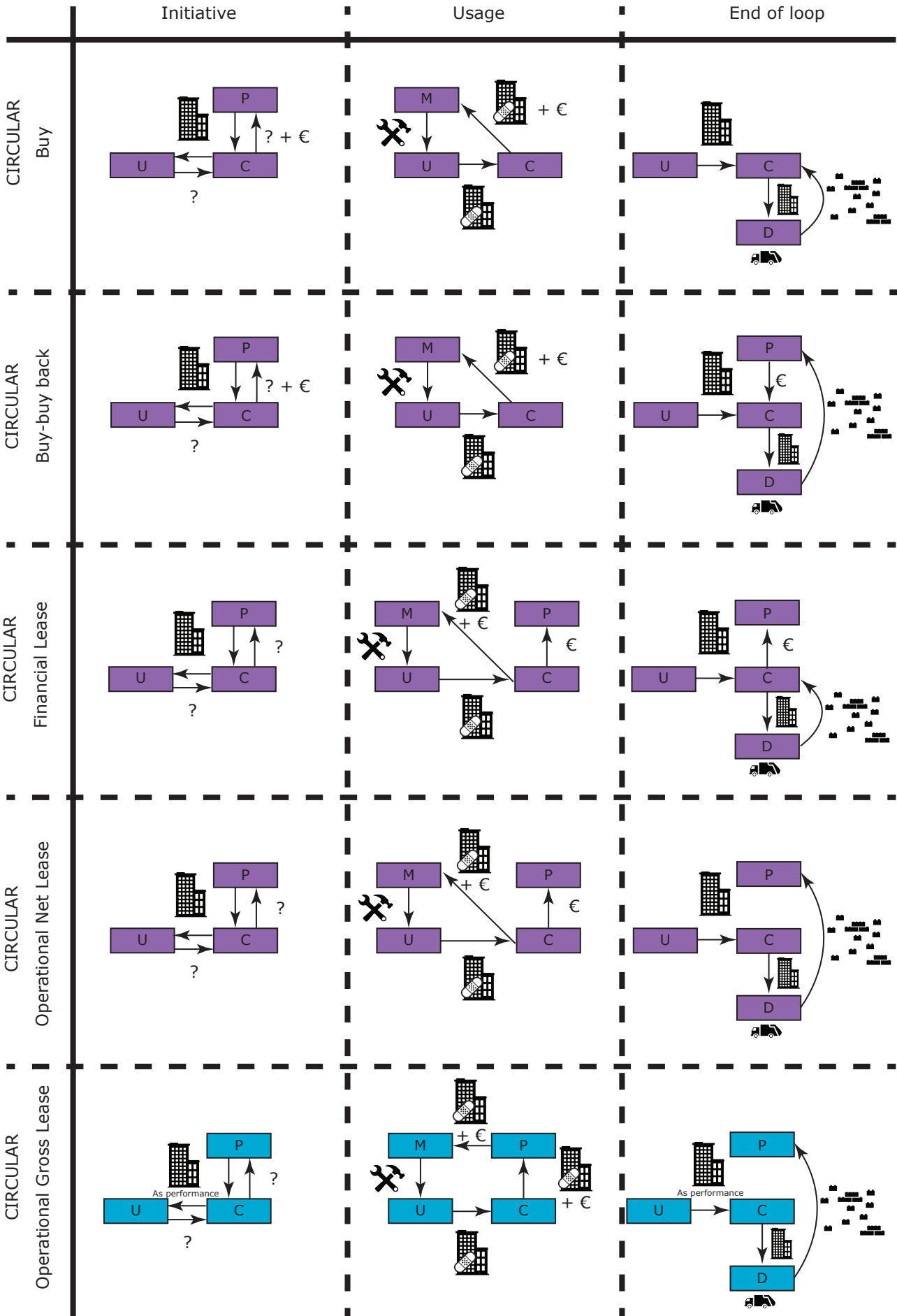
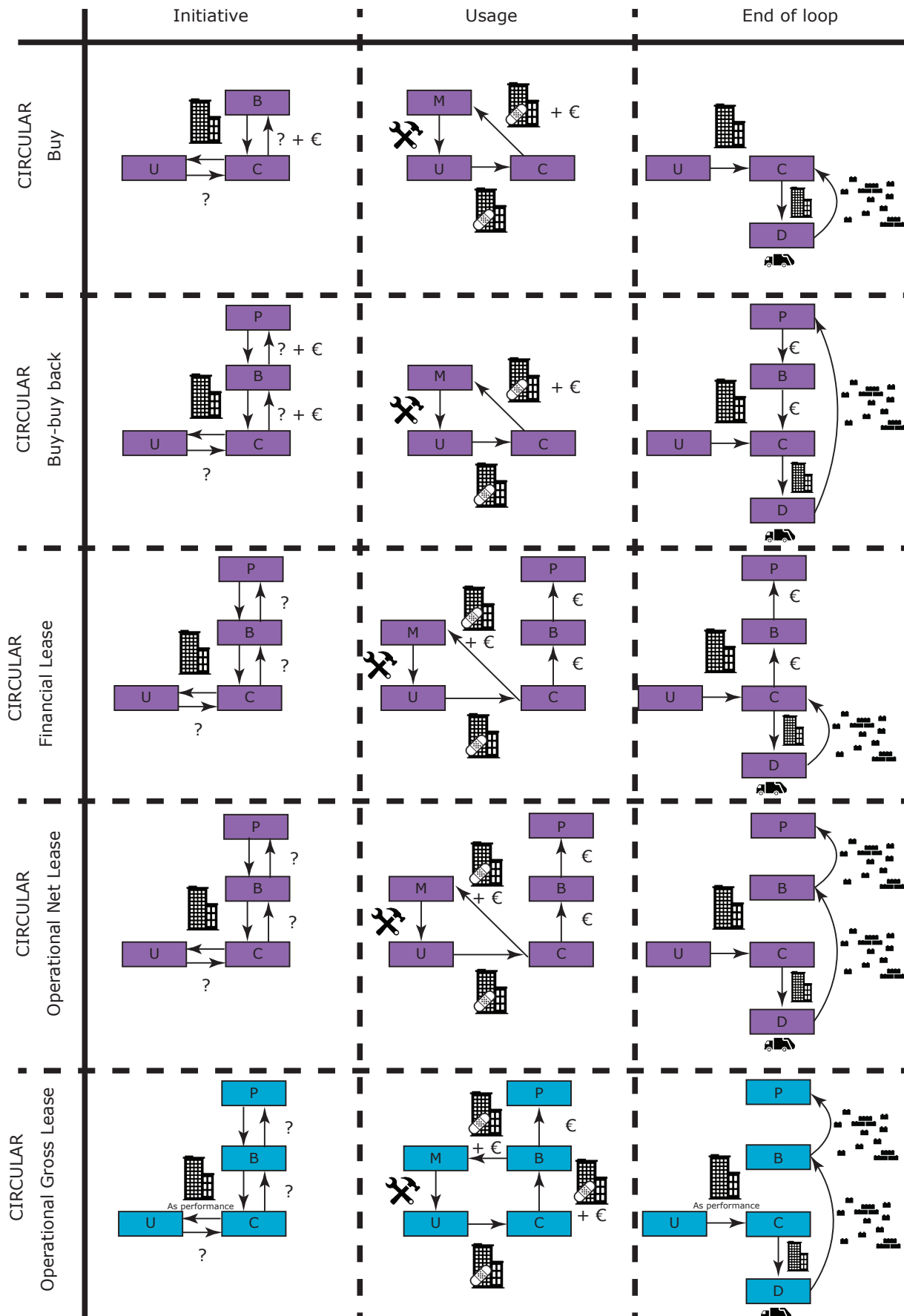


Figure 28: Strategies
(Circular Economy with broker)



Stakeholders

Provider (P)

The provider provides components to get the required performance or product. If the provider does not use a broker in order to sell his products or performances, he will be in close contact with the client. If the principles of the Circular Economy can be applied the provider needs to manage the reuse of components in the industry. Suppliers and manufacturers of the components are not addressed in this model.

Maintenance provider (M)

The maintenance provider will maintain the product or performance that is obtained by the client. The client or provider selects the maintenance provider depending on the strategy chosen. The responsibilities of the maintenance provider are related to the different strategies.

Client (C)

This is the main actor in the models. It works on behalf of the users (the client can also be a user in itself). Depending on the strategy used the client has many responsibilities regarding management, changing wishes, and principles of the Circular Economy.

User (U)

The user is the actor in the system that will use the performance/product. The user maintains a close contact with the client. If an error appears in the component or product, this will be reported to the client. In most cases both the client and the user are of one and the same organisation. Unless the user is the client itself it does not have many obligations. Although the user does not have many obligations, this does not mean the client has no obligations at all when choosing for a strategy of the Circular Economy. In most cases the user must be educated regarding behaviour and their usage of components.

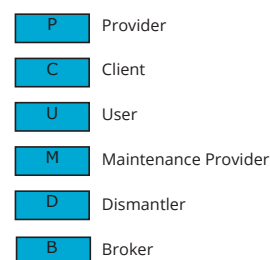
Dismantler (D)

The dismantler is an important stakeholder in the last phase of all strategies. Depending on the strategy used the dismantler will demolish or will dismantle components.

Broker (B)

There are different kinds of brokers. But all of them act like an intermediary between the provider of a specific product or performance and the client. Two kind of brokers are used in developing the strategies:

- Sales agent
 - Broker in the market that will sell products or performances on behalf of a provider. The sales agent is different from the purchasing agent, who acts on behalf of the client.
 - The sales agent receives a fee for every transaction
- Rental agent
 - Broker in the market that leases products or performances on behalf of a provider. In a lot of cases the broker also manages the products/performances
 - The lease payments include a fee for the rental agent



Laws and regulations

The laws and regulation regarding sustainability in the Dutch built environment can be found in the 'Bouwbesluit' (BRIS, 2014).

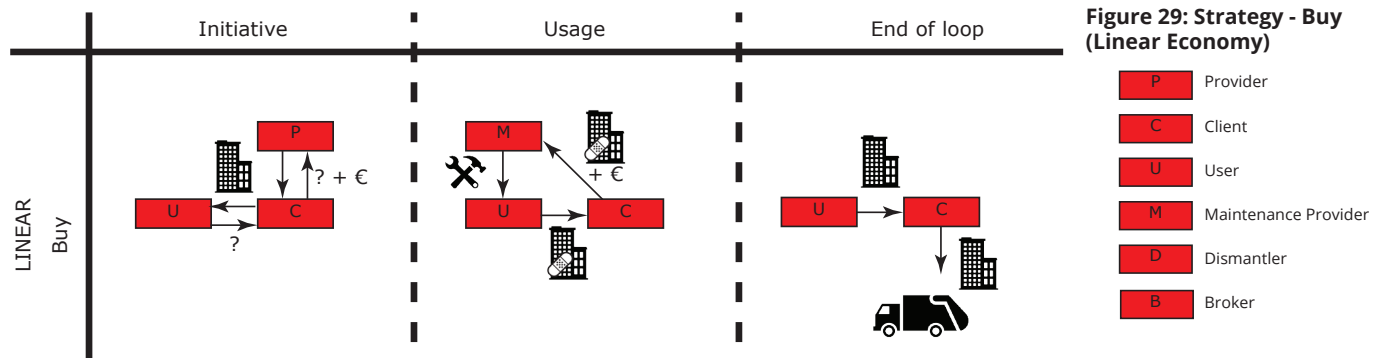
Other notes

* In the Netherlands the minimum base value for depreciation is 50% of the WOZ-value when the asset is owned (Belastingdienst, n.d.).

** Within the concept of the Circular Economy the assumption is made that materials will become scarce. Therefore these resources will maintain a residual value in the market.

Buy (Linear)

Keywords: Linear economy, take-make-dispose, product, buy, ownership, responsibility management



Organisation & Operations

Initiative phase

- Sustainability is not a high priority
- Investment sustainable measures determined by current market behaviours
- Thinking in products instead of performances
- Components designed in a traditional way
- Tendering of a product
- Transfer of ownership product towards the client
 - Client should manage all aspects of owning a product

Usage phase

- Use of energy resources (non- and renewable) determined by market prices
- Client responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider usually different from provider product
 - Public tendering for maintenance provider
- Free use of products by users
 - Code of Conduct states the boundaries

End of usage

- Reducing of waste through current market behaviours
- No incentive to reuse products
- Public tendering for demolition companies

Finance

Initiative phase

- Costs for the client are:
 - Initial acquisition costs
 - Transaction costs
- Financing based on loan

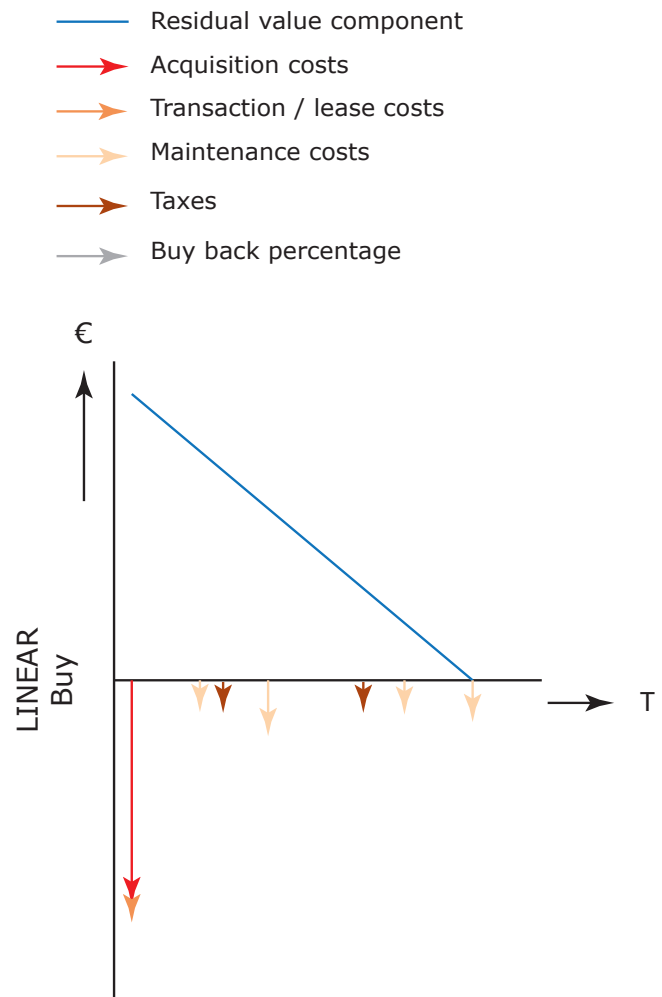
Usage phase

- Costs for the client are:
 - Maintenance costs
 - Costs depend on errors
 - Energy costs
 - Mortgage costs
 - Taxes of capital
- Depreciation of the product during usage
 - Minimum base value for depreciation*

End of usage

- No residual value of the product
- If product is fully depreciated
 - Product is going to be vacant or waste
- If product is not fully depreciated
 - Product is put on the second hand market
 - If no buyer is found, it is going to be vacant or waste
- Risks of owning:
 - Changing demand users
 - Product can not respond on changing requirements
 - Not being able to respond to global environmental issues.

Figure 30: Financial scheme - Buy (Linear Economy)

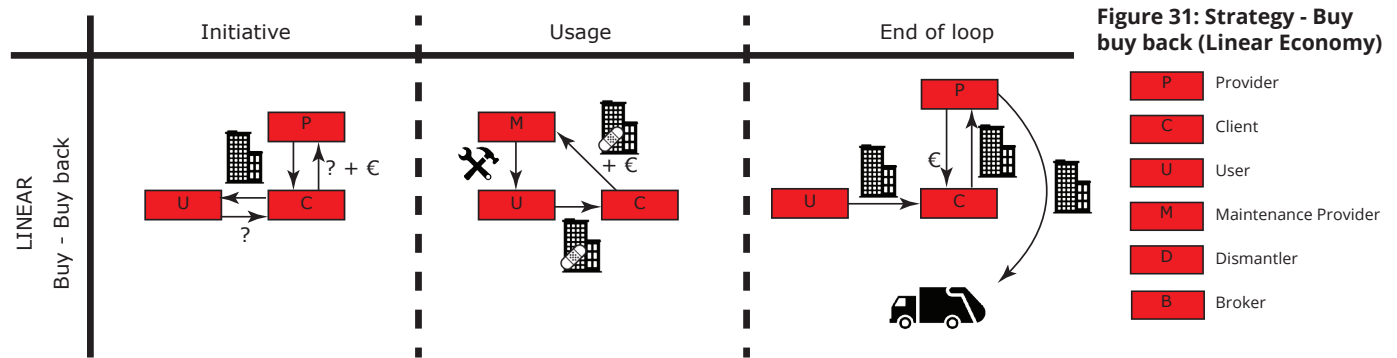


Responsibilities client regarding the principles of the Circular Economy

- The client has no obligations with respect to the Circular Economy

Buy - buy back (Linear)

Keywords: Linear economy, take-make-dispose, product, buy, ownership, take back, responsibility management



Organisation & Operations

Initiative phase

- Sustainability is not a high priority
- Thinking in products instead of performances
- Investment in sustainable measures determined by current market behaviours
- Components designed in a traditional way
- Tendering of a product
- Transfer of ownership product towards the client
- Client should manage all aspects of owning a product

Usage phase

- Use of energy resources (non- and renewable) determined by market prices
- Client responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider usually different from provider product
 - Public tendering for maintenance provider
- Free use of products by user
 - Code of Conduct states the boundaries

End of usage

- Reducing of waste through current market behaviours
- No incentive to reuse product
- Transfer of ownership product towards the provider

Financial

Initiative phase

- Costs for the client are:
 - Initial acquisition costs – market prices
 - Transaction costs
- Financing based on loan
- Percentage buy back should be determined at forehand or afterwards by doing a value estimation

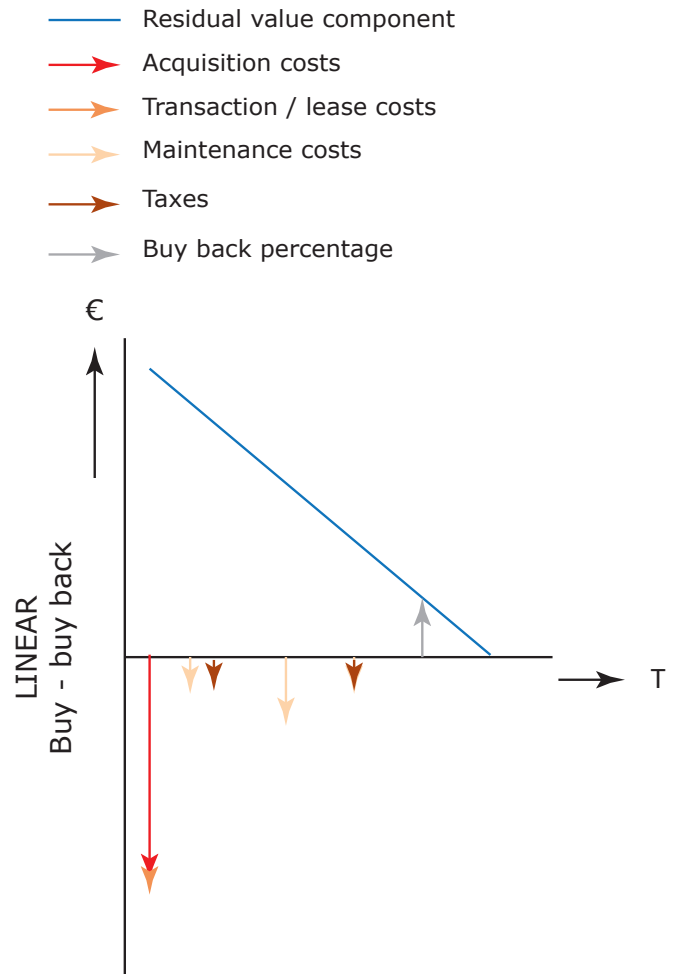
Usage phase

- Costs for the client are:
 - Maintenance costs
 - Costs depend on errors
 - Energy costs
 - Mortgage costs
 - Taxes of capital
- Depreciation of the product during usage
 - Minimum base value for depreciation*
- Insurance is not obligatory

End of Usage

- No residual value of the product
- Client receives 'buy back' percentage on percentage or value estimation basis
- Risks of owning:
 - Changing demand users
 - product can not respond on changing requirements
 - Quality products is determined by market conditions
 - Not being able to respond to global environmental issues

Figure 32: Financial scheme
- Buy buy back
(Linear Economy)

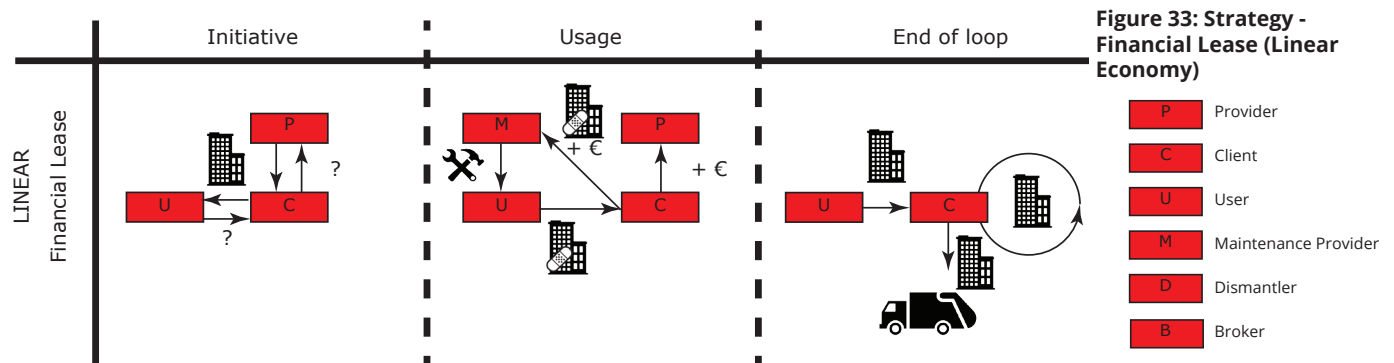


Responsibilities client regarding the principles of the Circular Economy

- The client has no obligations with respect to the Circular Economy

Financial lease (Linear)

Keywords: Linear economy, take-make-dispose, product, lease, maintenance, contract management



Organisation & Operations

Initiative phase

- Sustainability is not the highest priority
- Thinking in products instead of performances
- Investment in sustainable measures determined by lessor
- Components designed in a traditional way
- Tendering of a product
- Provider of product delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the product requirements are stated in contracts
 - Standard market contracts between provider and client

Usage phase

- Use of energy resources (non- and renewable) determined by lessor
- Management client checks, controls and manages product usage
- Client responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider selected by the client

End of usage

- Reducing of waste through current market behaviours
 - No incentive to reuse product
- Options lease contract
 - Extend contract
 - Repel contract
- Client has option to buy the product
- Provider will depreciate product
 - If product is fully depreciated it is going to be waste

Financial

Initiative phase

- Costs for the client are:
 - Costs regarding contract management

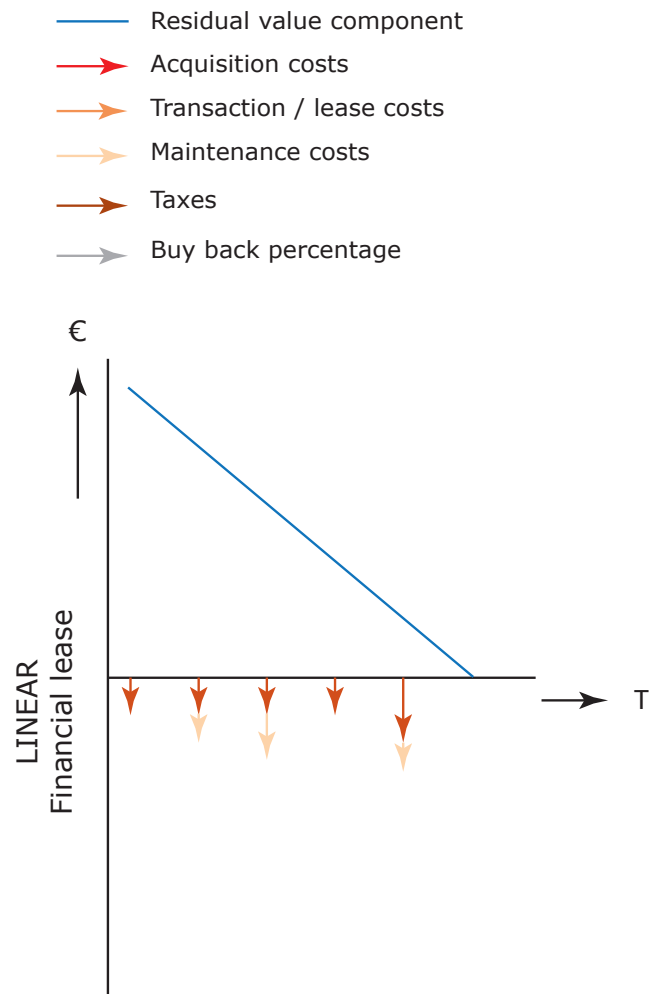
Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Maintenance costs
 - Energy costs
 - Taxes of capital

End of usage

- Buy product

Figure 34: Financial scheme
- Financial lease
(Linear Economy)

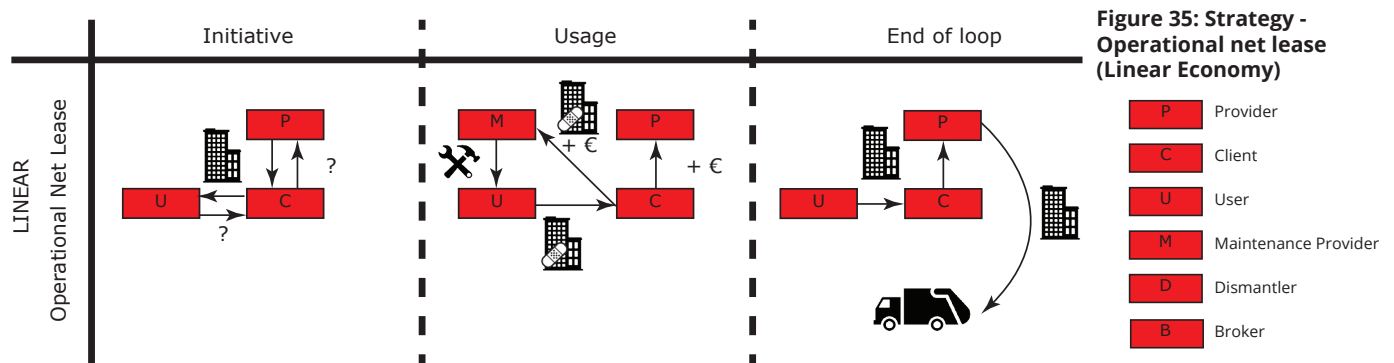


Responsibilities client regarding the principles of the Circular Economy

- The client has no obligations with respect to the Circular Economy

Operational net lease (Linear)

Keywords: Linear economy, take-make-dispose, product, lease, maintenance, contract management



Organisation & Operations

Initiative phase

- Sustainability is not a high priority
- Thinking in products instead of performances
- Investment in sustainable measures determined by lessor
- Components designed in a traditional way
- Tendering of a product
- Provider of product delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the product requirements are stated in contracts
 - Standard market contracts between provider and client

Usage phase

- Use of energy resources (non- and renewable) determined by client
- Management client checks, controls and manages product usage
- Client responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider selected by the client
 - Public tendering for maintenance provider

End of Usage

- Reducing of waste through current market behaviours
- No incentive to reuse product
- Options lease contract
 - Extend contract
 - Repel contract
- Product will be taken back by provider
- Provider will depreciate product
 - If product is fully depreciated it is going to be waste

Financial

Initiative phase

- Costs for the client are:
 - Costs regarding contract management

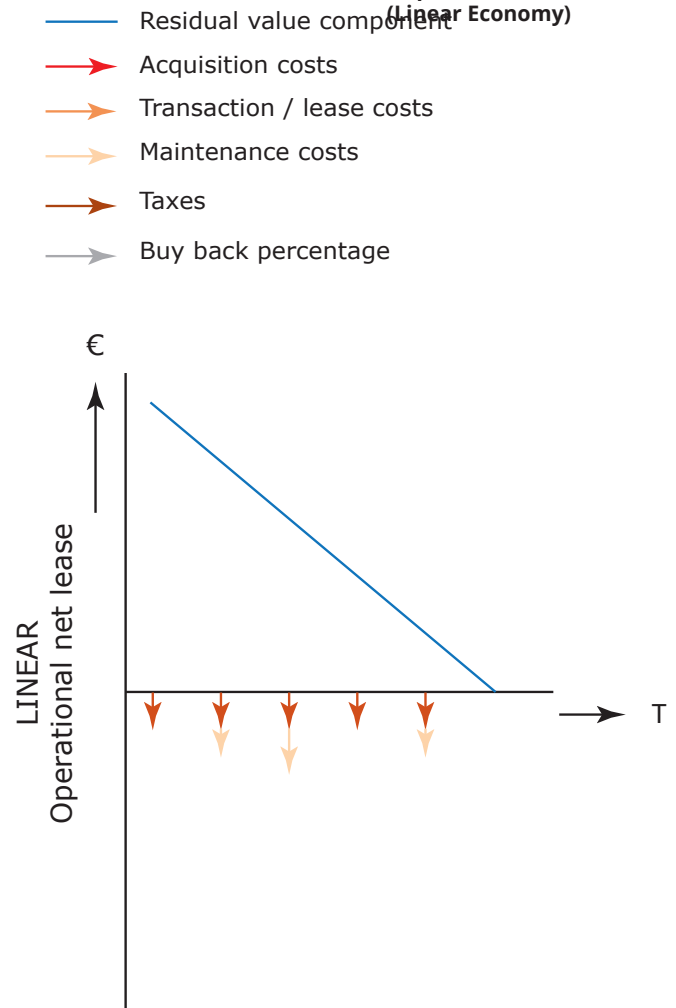
Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Maintenance costs
 - Energy costs
- Taxes
 - All costs of leasing can be subtracted from the profit made

End of usage

- No additional costs

Figure 36: Financial scheme
- Operational net lease
(Linear Economy)

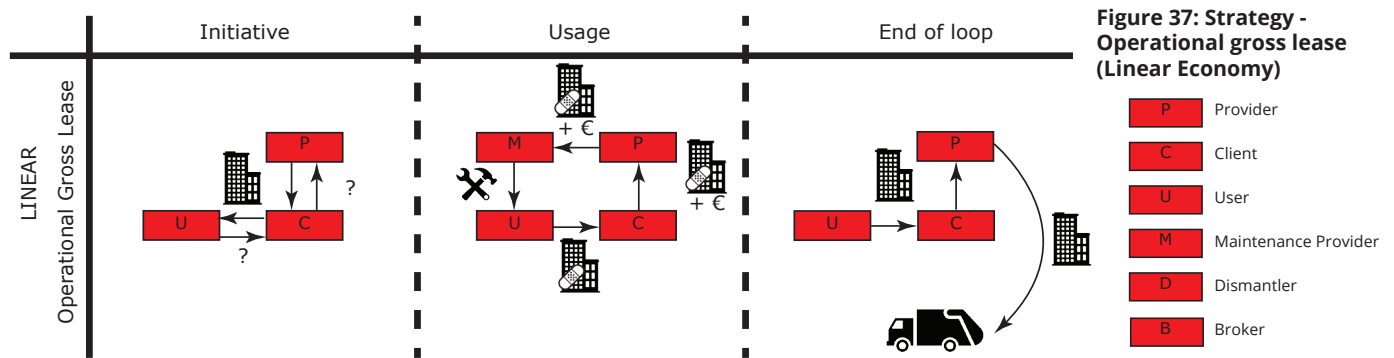


Responsibilities client regarding the principles of the Circular Economy

- The client has no obligations with respect to the Circular Economy

Operational gross lease (Linear)

Keywords: Linear economy, take-make-dispose, product, lease, contract management



Organisation & Operations

Initiative phase

- Sustainability is not a high priority
- Thinking in products instead of performances
- Investment in sustainable measures determined by lessor
- Components designed in a traditional way
- Tendering of a product
- Provider of product delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the product requirements are stated in contracts
 - Standard market contracts between provider and client

Usage phase

- Use of energy resources (non- and renewable) determined by lessor
- Management client checks, controls and manages product usage
- Provider responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider selected by the product provider

End of usage

- Reducing of waste through current market behaviours
 - No incentive to reuse product
- Options lease contract
 - Extend contract
 - Repel contract
- Provider will take back the product
- Provider will depreciate product
 - If product is fully depreciated it is going to be waste

Financial

Initiative phase

- Costs for the client are:
 - Costs regarding contract management

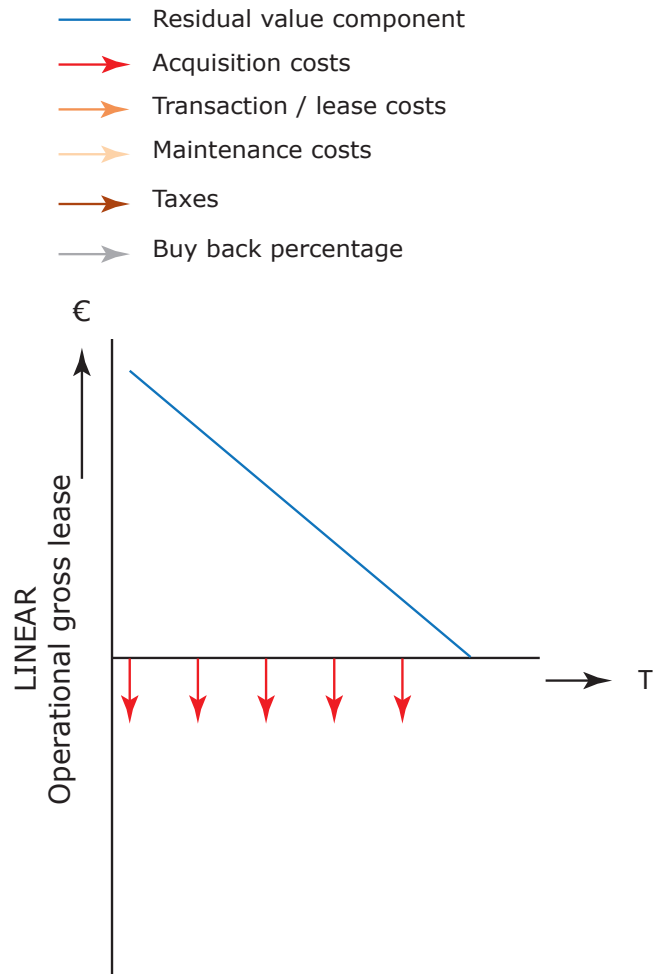
Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Includes maintenance costs
 - Includes energy costs
- Taxes
 - All costs of leasing can be subtracted from the profit made

End of usage

- No additional costs

Figure 38: Financial scheme
- Operational gross lease
(Linear Economy)

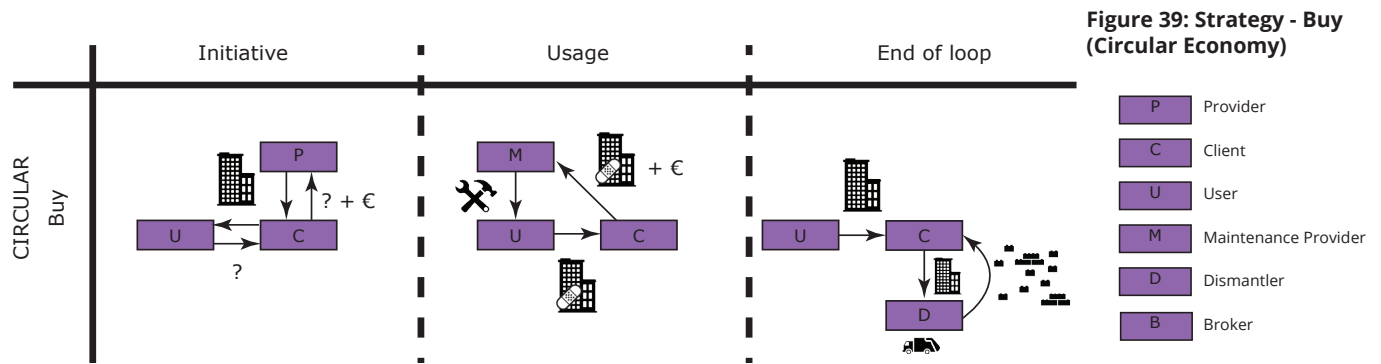


Responsibilities client regarding the principles of the Circular Economy

- The client has no obligations with respect to the Circular Economy

Buy (Circular)

Keywords: Circular economy, sustainability, performance, buy, ownership, responsibility management & end of loop



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
 - Components used in order to get the required performance
- Tendering of performance towards market
 - Client wants transparency of provider regarding information and costs
 - Integrity provider part tender process
- Transfer of ownership components towards the client
 - Client should manage all aspects of owning a component

Usage phase

- Use of renewable energy resources determined by policy client
- Responsible for maintenance activities
 - Maintenance activities determined by errors in the performance
 - Maintenance provider usually different from provider performance
 - Public tendering for maintenance provider
 - Example: Service-level agreements (SLA)
- Free use of products by user
 - Code of Conduct implements principles of the Circular Economy
 - Client responsible for educating users regarding the principles of the Circular Economy and how to apply these in practice

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Client responsible for bringing back components into a system
 - Public tendering dismantling companies

Financial

Initiative phase

- Costs for the client are:
 - Initial investment costs
 - Transaction costs
 - Taxes regarding assets
- Financing based on loan
- Risks for the client are:
 - Higher initial investment costs

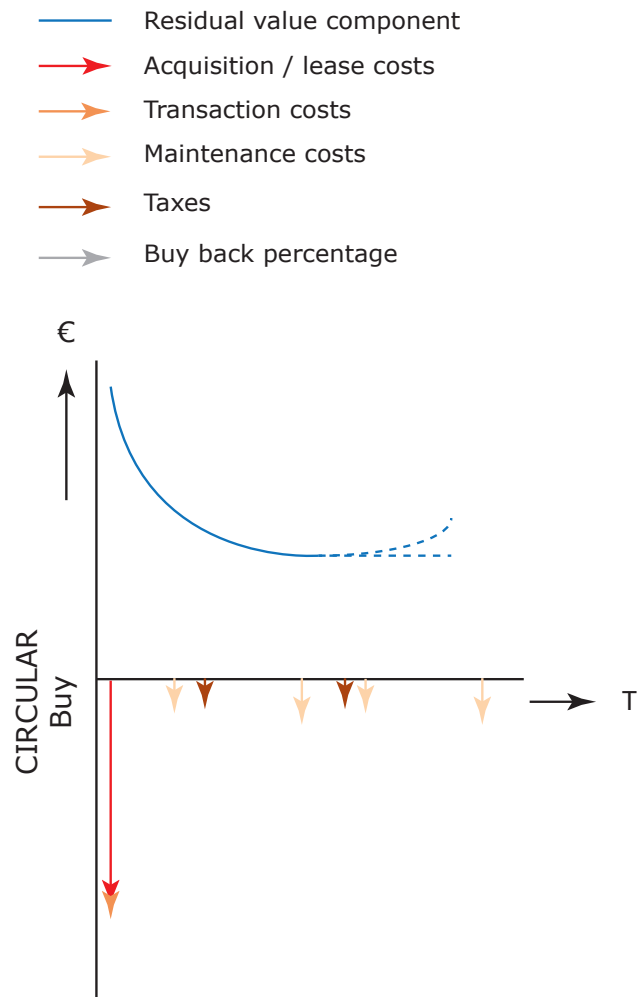
Usage phase

- Costs for the client are:
 - Maintenance costs
 - Energy costs
 - Mortgage costs
 - Taxes of capital
- Minimal depreciation of components

End of loop

- Residual value of the components
- Risks transferred to the client
 - Changing market regarding the components
 - Flaws in design components regarding adaptability, reversibility, demountability, and biodegradability
 - Changing policies regarding sustainability issues

Figure 40: Financial scheme - Buy (Circular Economy)

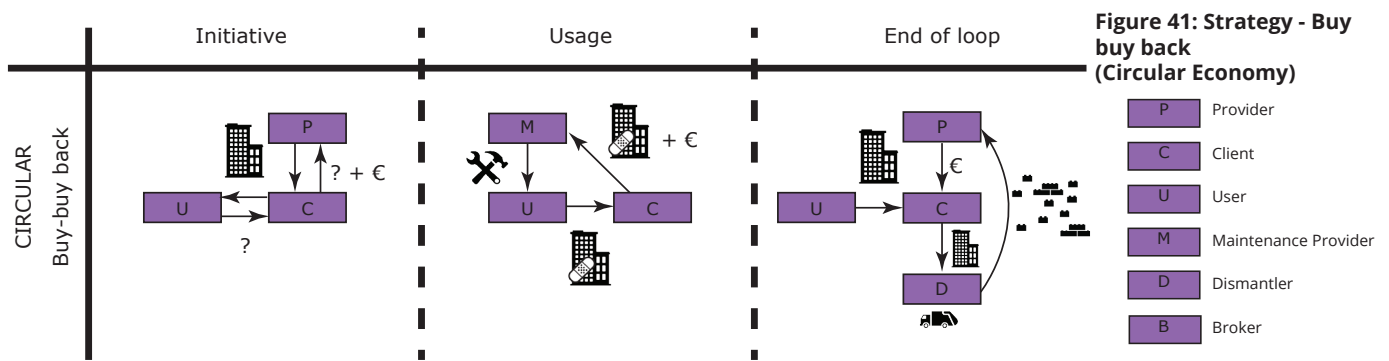


Responsibilities client regarding the principles of the Circular Economy

- Bringing back components into a system. This can be an economic, biological, environmental or any other system. The client believes in that waste is designed out of our society. This can be established by tendering for companies whom carry out principles of the Circular Economy.
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
- The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level.
- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest.

Buy - buy back (Circular)

Keywords: Circular economy, sustainability, performance, buy, ownership, responsibility management



Organisation & Operations

Initiative phase

- Sustainability is a high priority within the organisation
- Investment in sustainable measures is essential
- Thinking in components instead of products
- Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Provider must be transparent regarding information and costs
 - Integrity provider part tender process
 - Agreements must be established with respect to Buy back
- Transfer of ownership components towards the client
- Client should manage all aspects of owning a component

Usage phase

- Use of performances
 - Use of renewable energy resources
 - Use of demountable, adaptive materials and components
- Client responsible for maintenance activities
 - Maintenance activities determined by errors in the performance
 - Maintenance provider usually different from provider performance
 - Public tendering for maintenance provider
 - Example: Service-level agreements (SLA)
- Free use of products by user
 - Code of Conduct implements principles of the Circular Economy
 - Client responsible for educating users regarding the principles of the Circular Economy and how to apply these in practice

End of usage

- Ownership transferred back towards provider of the performance
 - Client is not responsible for bringing back components into a system

Financial

Initiative phase

- Costs for the client are:
 - Initial acquisition costs
 - Transaction costs
 - Taxes regarding assets

- Financing based on loan
- Percentage buy back should be determined at forehand by the provider
- Risks for the client are:
 - Higher initial investment costs

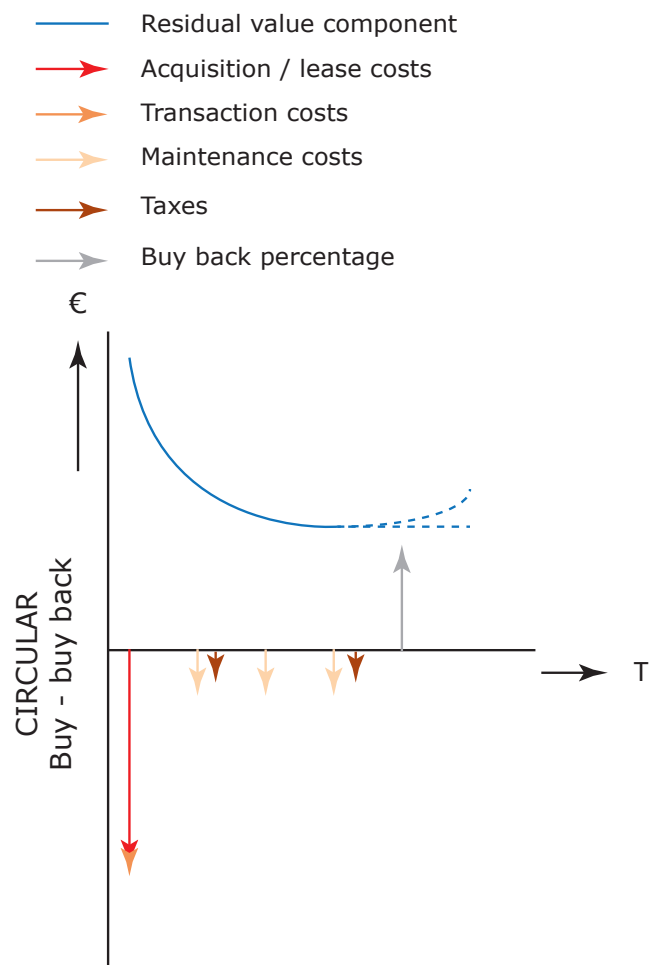
Usage phase

- Costs for the client are:
 - Maintenance costs
 - Energy costs
 - Mortgage costs
 - Taxes of capital
 - Minimal depreciation of components
 - Insurance is not obligatory

End of usage

- Residual value of the components
- Risks transferred to the client
 - Changing market regarding the components
 - Flaws in design components regarding adaptability, reversibility, demountability, and biodegradability
 - Changing policies regarding sustainability issues
- Client receives 'buy back' percentage
 - Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components

Figure 42: Financial scheme - Buy buy back (Circular Economy)



Responsibilities client regarding the principles of the Circular Economy

Organisation & Operations

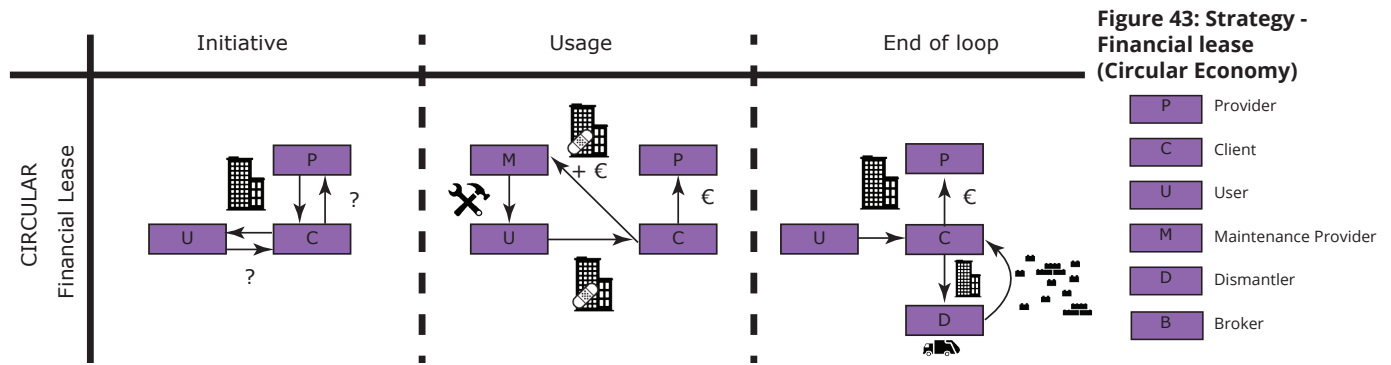
- Organisation client responsible for management with respect to the Circular Economy
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - Waste is designed out of operations in the organisation of the client
- Tender for providers who will take back components/materials
 - The provider brings back components into a system. This can be an economic, biological, environmental or any other system.
 - The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level.
- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest.

Finance

- Client manages and is responsible for all costs of the used components/materials.

Financial lease (Circular)

Keywords: Circular economy, sustainability, performance, lease, ownership, maintenance, contract management & end of loop



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are used in order to get the required performance
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Client wants transparency of provider regarding information and costs
 - Integrity provider part tender process
 - Provider of performances delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the performance requirements are stated in contracts
 - Contracts are based on detailed performances
 - Incentive to deliver high quality performances towards clients

Usage phase

- Use of renewable energy resources determined by policy client
- Management client checks, controls and manages performance usage
- Clients responsible for maintenance activities
 - Public tendering for maintenance provider
 - Maintenance activities determined by errors in the system
 - Example: Service-level agreements (SLA)
- Responsibility client to educate users regarding usage of performances

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Options lease contract
 - Extend contract
 - Repel contract
- Components will be taken back by provider
 - Provider performance will depreciate components to a minimum

- Value components are maintained
- Provider performance has an incentive to reuse components
- Reuse components by provider relies a lot on integrity

Financial

Initiative phase

- Costs for the client are:
 - Contract management costs

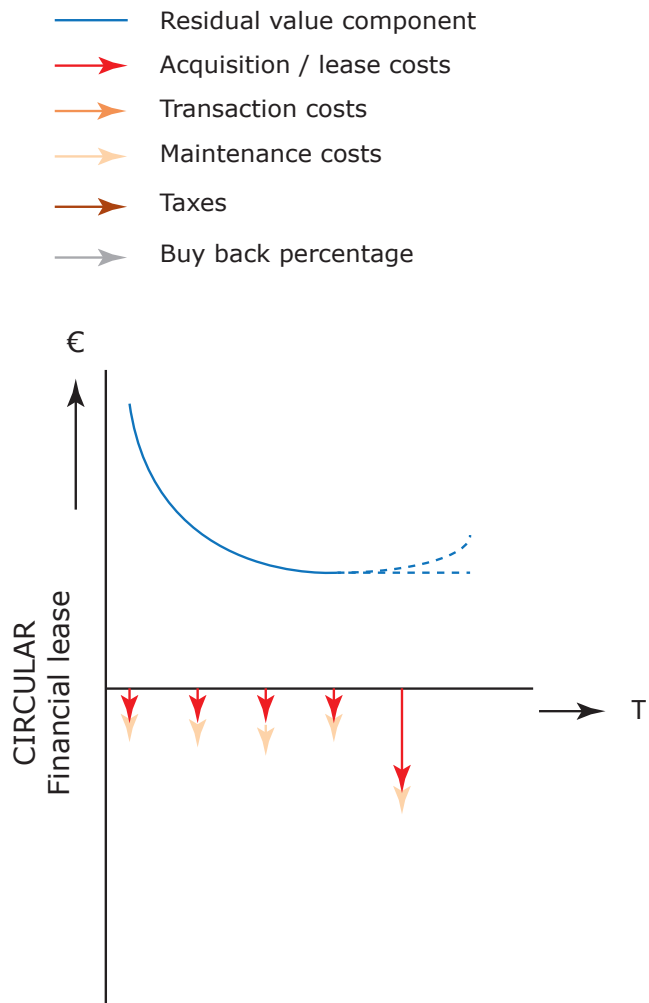
Usage phase

- Costs for the client are:
 - Monthly payments
 - Costs of maintenance activities
 - Taxes of capital
- Value maintained replaces value replacement

End of loop

- Option to buy components of the performance

Figure 44: Financial scheme - Financial Lease (Circular Economy)

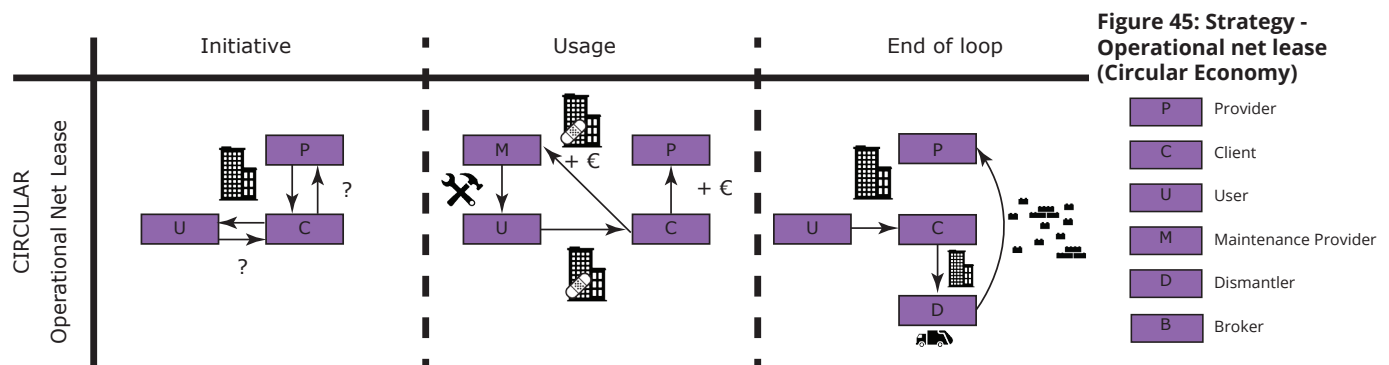


Responsibilities client regarding the principles of the Circular Economy

- Provider is responsible for bringing back components into a system. So the client must:
 - Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Client mainly responsible for managing contracts
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level
- Client responsible for maintaining required end-of-loop value
 - Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest

Operational net lease (Circular)

Keywords: Circular economy, sustainability, product, lease, maintenance, contract management



Sustainability

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are used in order to get the required performance
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Client wants transparency of provider regarding information and costs
 - Integrity provider part tender process
- Provider of performances delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the performance requirements are stated in contracts
 - Contracts are based on detailed performances
 - Incentive to deliver high quality performances towards clients

Usage phase

- Use of renewable energy resources determined by policy client
- Management client checks, controls and manages performance usage
- Clients responsible for maintenance activities
 - Public tendering for maintenance provider
 - Maintenance activities determined by errors in the system
 - Example: Service-level agreements (SLA)
- Responsibility client to educate users regarding usage of performances

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Options lease contract
 - Extend contract
 - Repel contract
- Components will be taken back by provider
 - Provider performance will depreciate components to a minimum
 - Value components are maintained

- Provider performance has an incentive to reuse components
- Reuse components by provider relies a lot on integrity

Financial

Initiative phase

- Costs for the client are:
 - Contract management costs

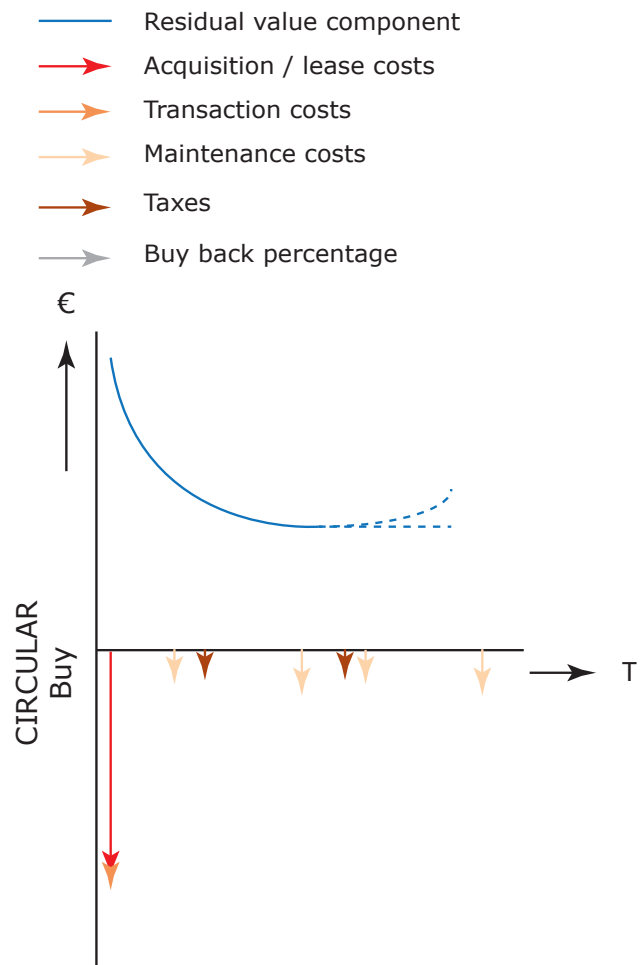
Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Maintenance costs
 - Energy costs
- Value maintained replaces value replacement
- Taxes
 - All costs of leasing can be subtracted from the profit made

End of loop

- No additional costs

Figure 46: Financial scheme - Operational net Lease (Circular Economy)

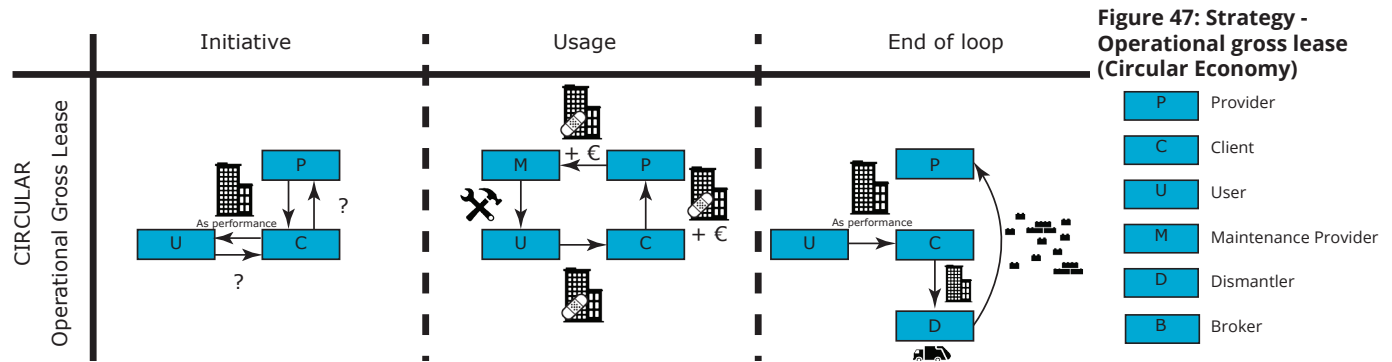


Responsibilities client regarding the principles of the Circular Economy

- Provider is responsible for bringing back components into a system. So the client must:
 - Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Client mainly responsible for managing contracts
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level
 - Client responsible for maintaining required end-of-loop value
- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest

Operational gross lease (Circular)

Keywords: Circular economy, sustainability, performance, lease, contract management



Organisation & Operations

Initiative phase

- Sustainability is a high priority within the organisation
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are needed in order to get the required performance
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
 - Waste is designed out of systems
- Tendering of performance towards market
 - Client wants transparency of provider regarding information and costs
 - Integrity provider part tender process
 - Provider of performances delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the performance requirements are stated in contracts
 - Contracts are based on detailed performances
 - Incentive to deliver high quality performances towards clients

Usage phase

- Use of performances
 - Use of renewable energy resources
 - Use of demountable, adaptive materials and components
 - Organisation client checks, controls and manages the usage of a performance
- Provider performances responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider selected by the performance provider
- Responsibility organisation client to educate users regarding usage of performances

End of loop

- Options lease contract
 - Extend contract
 - Repel contract
- Components will be taken back by provider
 - Provider performance will depreciate components to a minimum
 - Value components are maintained
 - Provider performance has an incentive to reuse components
 - Client must trust in integrity provider with respect to reuse of components by provider

Financial

Initiative phase

- Costs for the client are:
 - Contract management costs

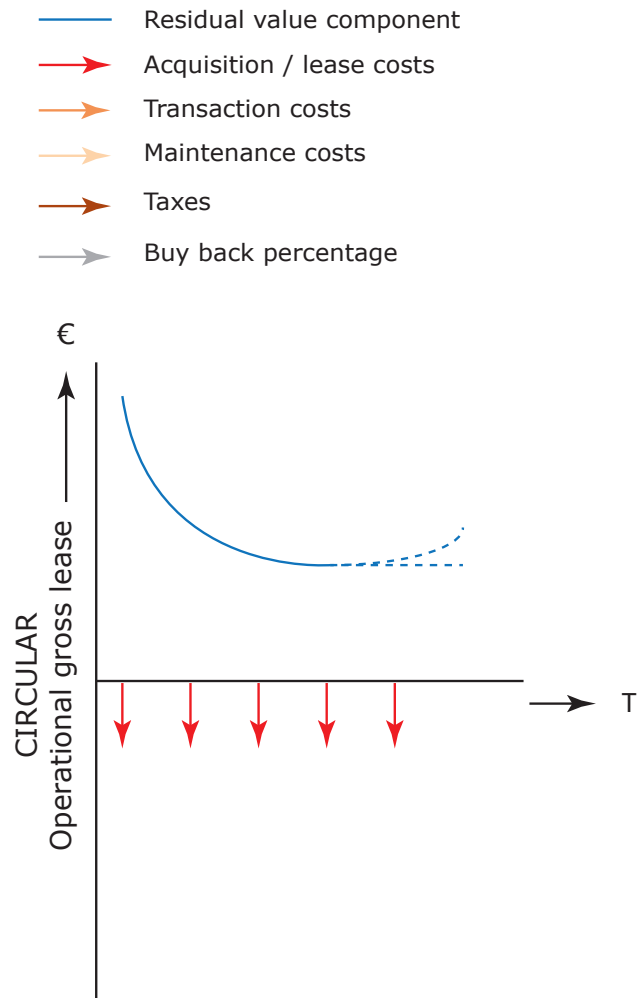
Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Includes maintenance costs
 - Includes energy costs
- Value maintained replaces value replacement
- Taxes
 - All costs of leasing can be subtracted from the profit made

End of usage

- No additional costs
- Components/materials have a residual value**
 - Incentive to reduce waste
 - Incentive to reuse components

Figure 48: Financial scheme - Operational gross Lease (Circular Economy)



Responsibilities client regarding the principles of the Circular Economy

Organisation & Operations

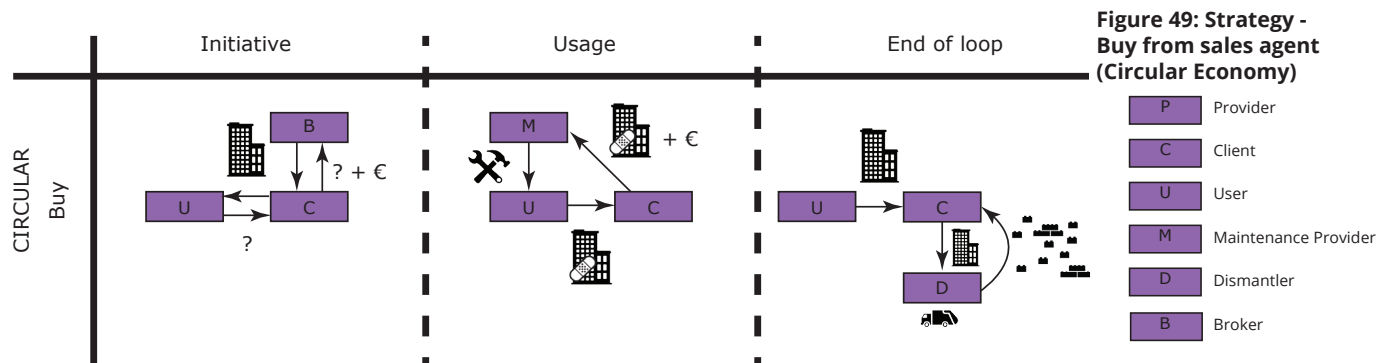
- Organisation client responsible for management with respect to the Circular Economy
 - Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - Waste is designed out of operations in the organisation of the client
- Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
- Focus on contract management within the organisation
 - Detailed description of requirements regarding functionality and the Circular Economy
- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest.

Finance

- Contract management costs and monthly payments

Buy – from sales agent (Circular)

Keywords: Circular economy, sustainability, performance, buy, ownership, responsibility management & end of loop, broker



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
 - Components used in order to get the required performance
- Tendering of performance towards market
 - Client wants transparency of sales agent and provider regarding information and costs
 - Integrity sales agent and provider part tender process
- Transfer of ownership components towards the client
 - Client should manage all aspects of owning a component

Usage phase

- Use of renewable energy resources determined by policy client
- Responsible for maintenance activities
 - Maintenance activities determined by errors in the performance
 - Maintenance provider usually different from provider performance
 - Public tendering for maintenance provider
 - Example: Service-level agreements (SLA)
- Free use of products by user
 - Code of Conduct implements principles of the Circular Economy
 - Client responsible for educating users regarding the principles of the Circular Economy and how to apply these in practice

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Public tendering dismantling companies
 - Client responsible for bringing back components into a system

Financial

Initiative phase

- Costs for the client are:
 - Initial investment costs
 - Transaction costs
 - Fee sales agent
- Financing based on loan
- Risks for the client are:
 - Higher initial investment costs

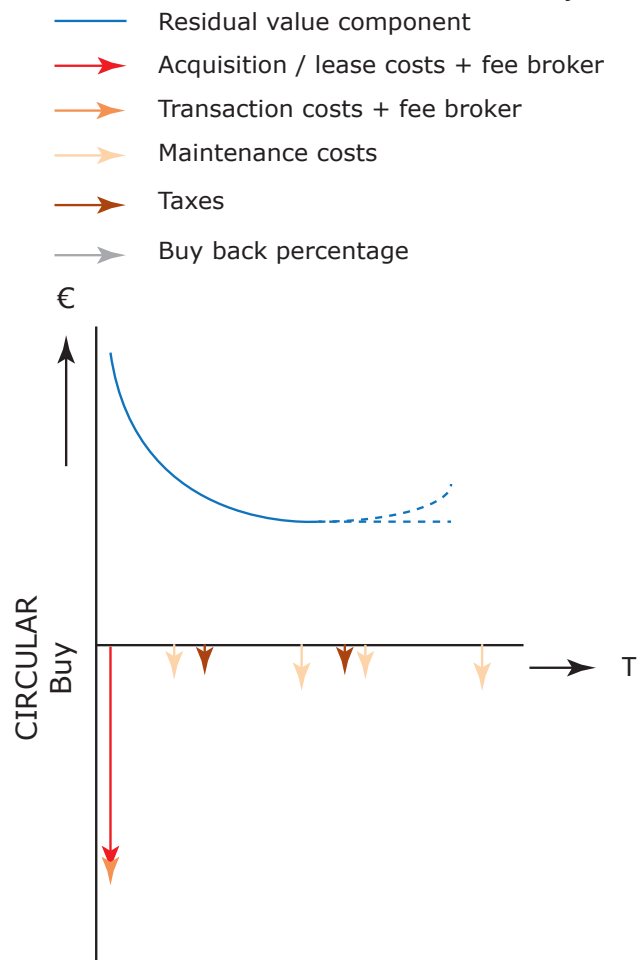
Usage phase

- Costs for the client are:
 - Maintenance costs
 - Energy costs
 - Mortgage costs
 - Taxes of capital
- Minimal depreciation of components
- Insurance is not obligatory

End of loop

- Residual value of the components

**Figure 50: Financial scheme
- Buy from sales agent
(Circular Economy)**

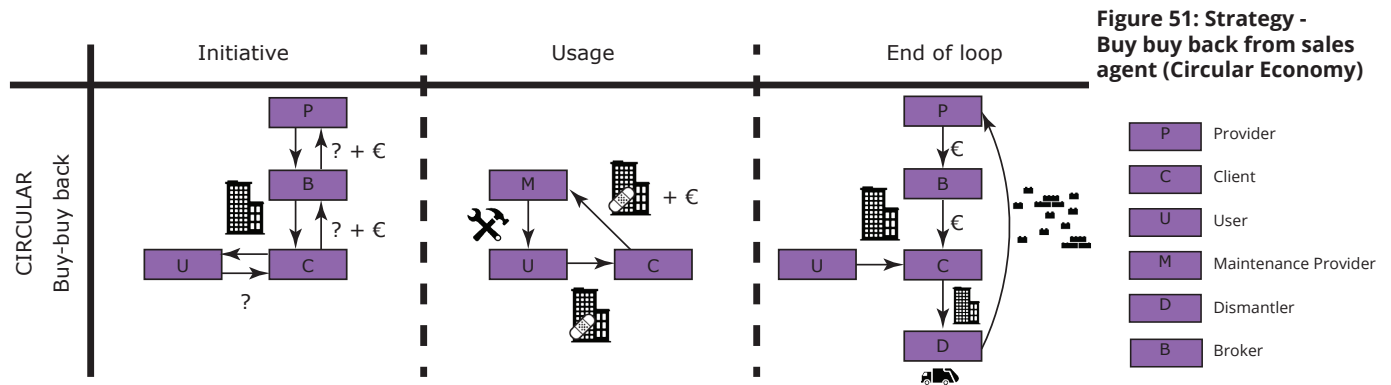


Responsibilities client regarding the principles of the Circular Economy

- The client is responsible for bringing back components into a system.
 - Tender for companies who produce components that can be taken back into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
- The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level.
- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest.

Buy-buy back – from sales agent (Circular)

Keywords: Circular economy, sustainability, performance, buy, ownership, responsibility management, take back, broker



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Client wants transparency of sales agent and provider regarding information and costs
 - Integrity sales agent and provider part tender process
- Transfer of ownership components towards the client
 - Client should manage all aspects of owning a component

Usage phase

- Use of renewable energy resources determined by policy client
- Responsible for maintenance activities
 - Maintenance activities determined by errors in the performance
 - Maintenance provider usually different from provider performance
 - Public tendering for maintenance provider
 - Example: Service-level agreements (SLA)
- Free use of products by user
 - Code of Conduct implements principles of the Circular Economy
 - Client responsible for educating users regarding the principles of the Circular Economy and how to apply these in practice

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Ownership transferred back towards provider of the performance
 - Client is not responsible for bringing back components into a system

Financial

Initiative phase

- Costs for the client are:
 - Initial acquisition costs
 - Transaction costs
 - Fee sales agent
- Financing based on loan
- Percentage buy back should be determined at forehand by the sales agent

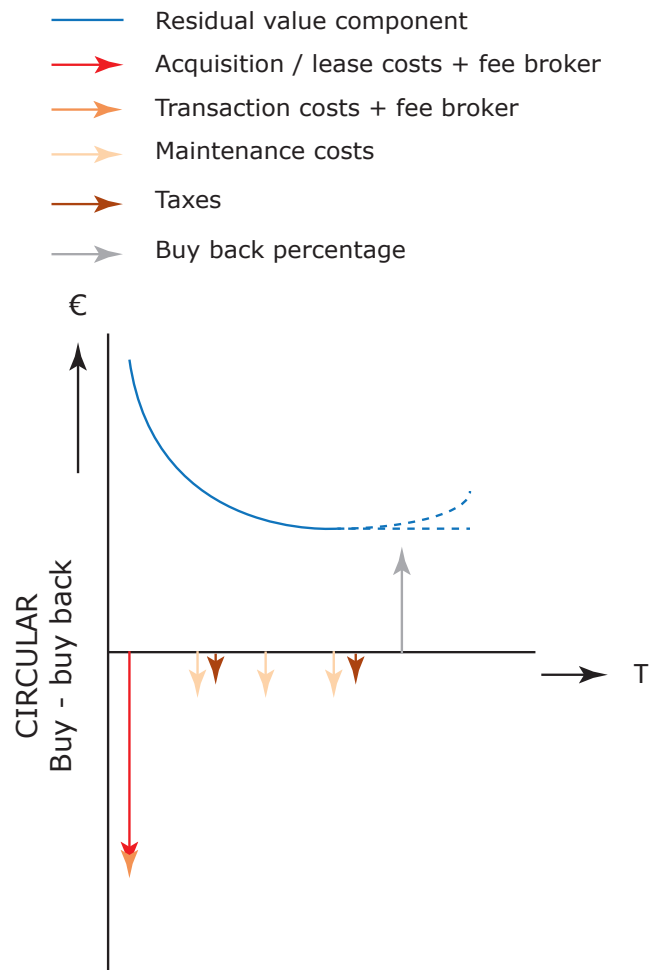
Usage phase

- Costs for the client are:
 - Maintenance costs
 - Energy costs
 - Mortgage costs
 - Taxes of capital
- Minimal depreciation of components
- Insurance is not obligatory

End of loop

- Residual value of the components
- Client receives 'buy back' percentage

Figure 52: Financial scheme - Buy-buy back from sales agent (Circular Economy)

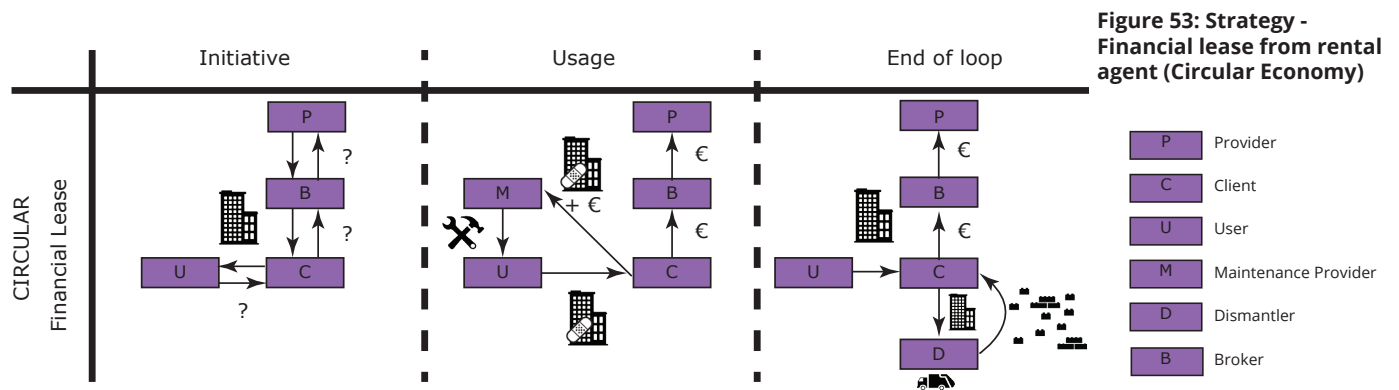


Responsibilities client regarding the principles of the Circular Economy

- The client is responsible for bringing back components into a system.
 - Tender for companies who produce components that can be taken back into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level
- Client responsible for maintaining required end-of-loop value
- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest

Financial lease – from rental agent (Circular)

Keywords: Circular economy, sustainability, performance, lease, maintenance, contract management, broker



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are used in order to get the required performance
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Client wants transparency of rental agent and provider regarding information and costs
 - Integrity rental agent and provider part tender process
 - Provider of performances delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the performance requirements are stated in contracts
 - Contracts are based on detailed performances
 - Incentive to deliver high quality performances towards clients

Usage phase

- Use of renewable energy resources determined by policy client
- Management client checks, controls and manages performance usage
- Client responsible for maintenance activities
 - Public tendering for maintenance provider
 - Maintenance services should be contracted in Service Level Agreements
 - Maintenance activities determined by errors in the system
- Responsibility client to educate users regarding usage of performances

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Options lease contract
 - Extend contract
 - Repel contract
- Components will be taken back by rental agent and provider
 - Rental agent of the performance will depreciate components to a minimum

- Value components are maintained
- Provider of the performance has an incentive to reuse components
- Reuse components by rental agent and provider relies on integrity

Figure 54: Financial scheme - Financial lease from rental agent (Circular Economy)

- Residual value component
- Acquisition / lease costs + fee broker
- Transaction costs + fee broker
- Maintenance costs
- Taxes
- Buy back percentage

Financial

Initiative phase

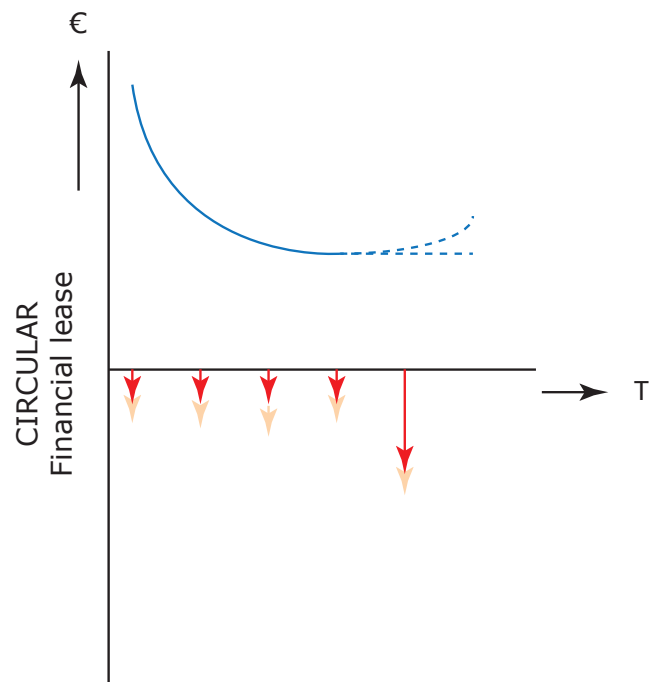
- Costs for the client are:
- Contract management costs

Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Includes fee rental agent
 - Maintenance costs
 - Energy costs
 - Taxes of capital
- Value maintained replaces value replacement

End of loop

- Option to buy components of the performance

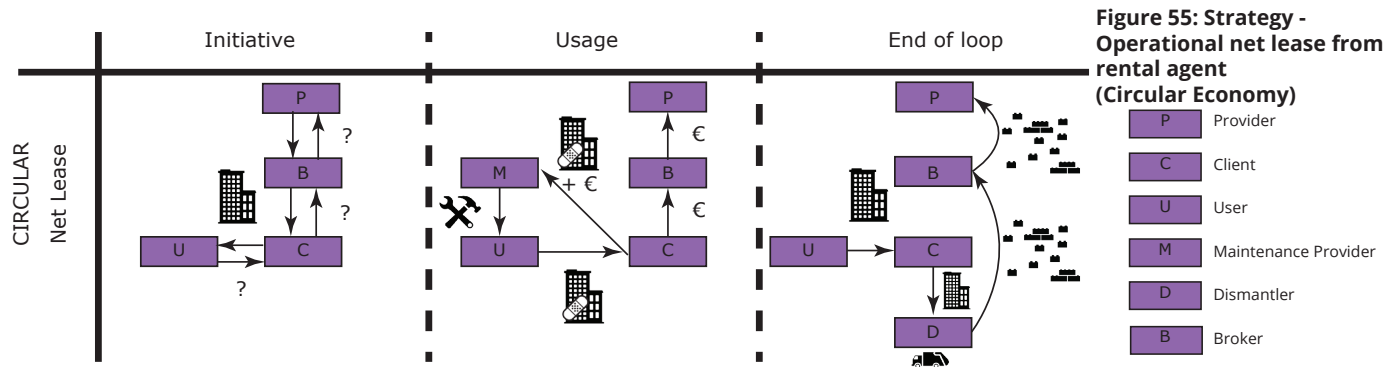


Responsibilities client regarding the principles of the Circular Economy

- Rental agent (on behalf of the provider) is responsible for bringing back components into a system. So the client must:
 - Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Client mainly responsible for managing contracts
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level
 - Client responsible for maintaining required end-of-loop value
 - Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest

Operational net lease – from rental agent (Circular)

Keywords: Circular economy, sustainability, performance, lease, maintenance, contract management, broker



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are used in order to get the required performance
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Client wants transparency of rental agent and provider regarding information and costs
 - Integrity rental agent and provider part tender process
 - Rental agent of performances delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the performance requirements are stated in contracts
 - Contracts are based on detailed performances
 - Incentive to deliver high quality performances towards clients

Usage phase

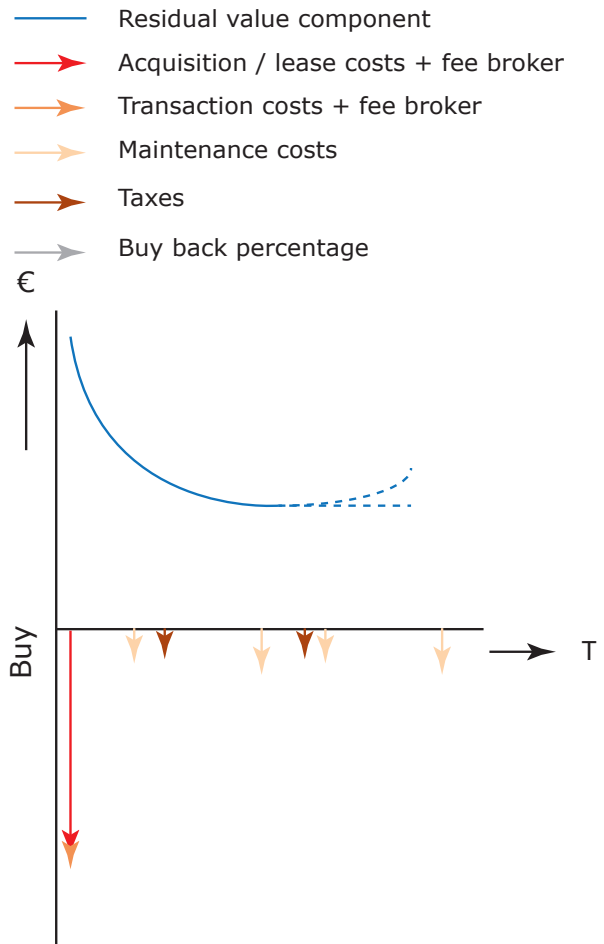
- Use of renewable energy resources determined by policy client
- Management client checks, controls and manages performance usage
- Clients responsible for maintenance activities
 - Public tendering for maintenance provider
 - Maintenance services should be contracted in Service Level Agreements
 - Maintenance activities determined by errors in the system
- Responsibility client to educate users regarding usage of performances

End of loop

- Components have a residual value **
- Incentive to reduce waste
- Incentive to reuse components
- Options lease contract
 - Extend contract
 - Repel contract
- Components will be taken back by rental agent
 - Rental agent performance will depreciate components to a minimum

- Value components are maintained
- Provider performance has an incentive to reuse components
- Reuse components by rental agent and provider relies on integrity

Figure 56: Financial scheme - Operational net lease from rental agent (Circular Economy)



Financial

Initiative phase

- Costs for the client are:
 - Contract management costs

Usage phase

- Costs for the client are
 - Monthly lease payments
 - Includes rental agent fee
 - Maintenance costs
 - Energy costs
- Value maintained replaces value replacement
- Taxes
 - All costs of leasing can be subtracted from the profit made

End of loop

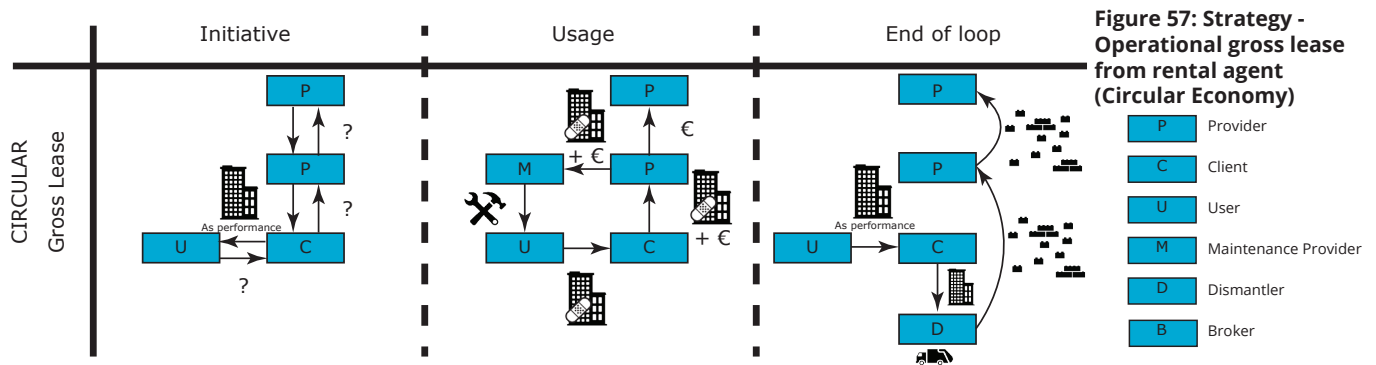
- No additional costs

Responsibilities client regarding the principles of the Circular Economy

- Rental agent (on behalf of the provider) is responsible for bringing back components into a system. So the client must:
 - Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Client mainly responsible for managing contracts
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - The technical, financial, functional, & social values of the components used must be maintained so that the performance remains on the required level
 - Client responsible for maintaining required end-of-loop value
 - Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest

Operational gross lease – from rental agent (Circular)

Keywords: Circular economy, sustainability, performance, lease, contract management, broker



Organisation & Operations

Initiative phase

- Sustainability is a high priority
 - Investment in sustainable measures is essential
 - Thinking in performances instead of products
 - Components are needed in order to get the required performance
 - Components are designed to be adaptive, reversible, demountable and/or biodegradable
- Tendering of performance towards market
 - Client wants transparency of rental agent and provider regarding information and costs
 - Integrity rental agent and provider part tender process
 - Rental agent of performances delivers
- Contract management
 - Contract is concluded between provider and client
 - Agreements about the performance requirements are stated in contracts
 - Contracts are based on detailed performances
 - Incentive to deliver high quality performances towards clients

Usage phase

- Use of renewable energy resources determined by policy client
- Management client checks, controls and manages performance usage
- Rental agent performances responsible for maintenance activities
 - Maintenance activities determined by errors in the system
 - Maintenance provider selected by the rental agent
 - Responsibility client to educate users regarding usage of performances

End of loop

- Components have a residual value **
 - Incentive to reduce waste
 - Incentive to reuse components
- Options lease contract
 - Extend contract
 - Repel contract
- Components will be taken back by rental agent
 - Rental agent will depreciate components to a minimum
 - Value components are maintained
 - Provider performance has an incentive to reuse components

- Reuse components by rental agent and provider relies on integrity

Figure 58: Financial scheme - Operational gross lease from rental agent (Circular Economy)

Financial

Initiative phase

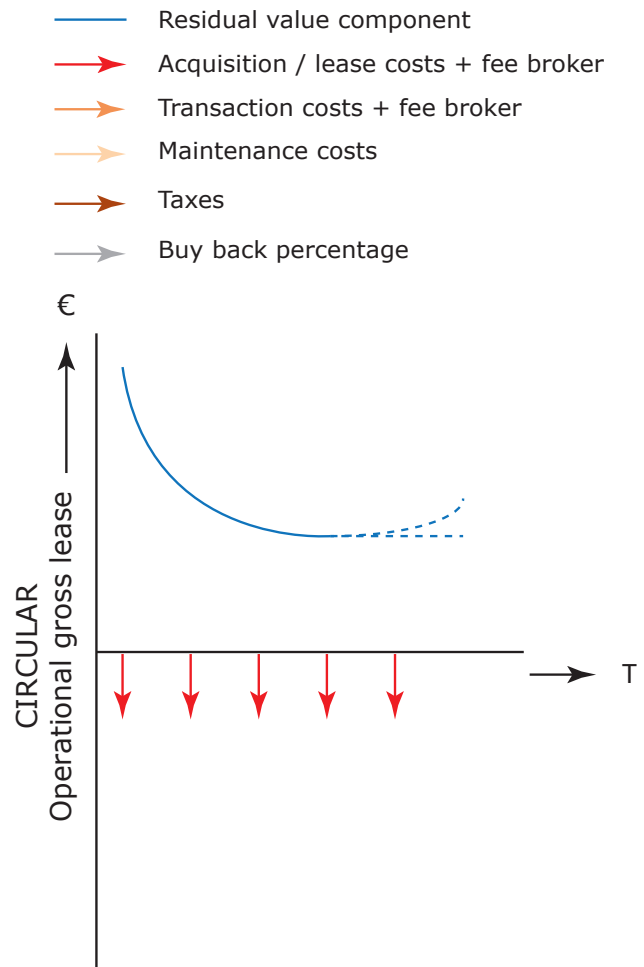
- Costs for the client are:
 - Contract management costs

Usage phase

- Costs for the client are:
 - Monthly payments
 - Includes maintenance costs
 - Includes energy costs
 - Includes fee rental agent
- Value maintained replaces value replacement
- Taxes
 - All costs of leasing can be subtracted from the profit made

End of loop

- No additional costs



Responsibilities client regarding the principles of the Circular Economy

- Rental agent (on behalf of the provider) is responsible for bringing back components into a system. So the client must:
 - Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Develop detailed description of requirements regarding functionality and the Circular Economy
- Client mainly responsible for managing contracts
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions
 - Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest

5.2 Part conclusions

A few notes must be made about the different strategies. First of all, this list of different strategies is not complete. As mentioned before, every client has its own wishes and requirements regarding organisation. Therefore it's possible that strategies are missing in the developed model.

Three colours are used when developing the scenarios, namely the colours red, purple, and blue. Red refers to the Linear Economy. Both purple and blue refer to the Circular Economy, but a small distinction can be made between both strategies. Only strategies that are shown in a blue colour implement all principles of the Circular Economy. In this case that will be the strategy 'Operational gross lease (Circular)', see figure 59.

It's only possible to talk about performances in this strategies. In all other cases the client is responsible for some extent of the performance. If the client is responsible in some extent, one cannot speak in terms of performances. Let's give an example, if a client should buy a performance. It does not buy the performance, but components that should produce the required performance. The client is in this case responsible to keep the required performance. The client should manage all maintenance activities. In this case one can not speak about performances, but talks about products or components. The client is responsible for keeping the products and components up-to-date. Briefly speaking this strategy is considered as a Performance-Service System, because it fits the definition of the Performance-Service System as given in chapter three best.

During the development of all strategies different ways of showing these strategies are explored. Two examples are a multi-criteria model or a decision-supporting model. Although some efforts have been made in order to create such a model, it was not possible to prove scientifically that this model will work due to the time span. A decision is made to process all strategies in a brochure. Showing the brochure to different actors from client perspective and getting feedback will validate the strategies and the Performance-Service System.

Operational gross lease (Circular Economy)

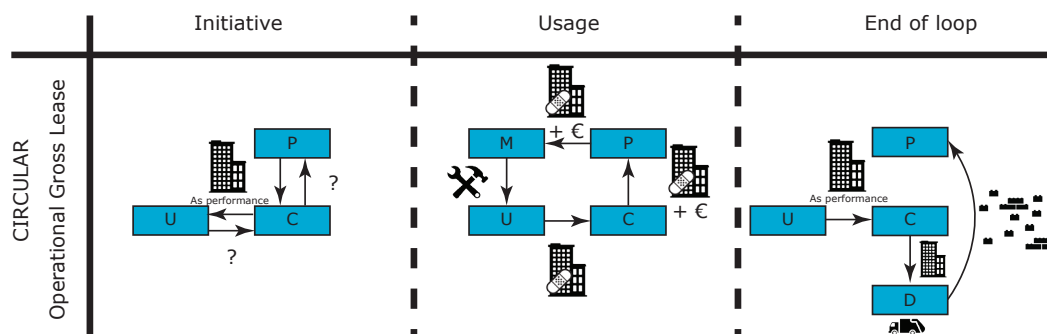


Figure 59:
Performance-Service
System: Operational gross
lease

Operations

- Tender for companies who will take responsibility in bringing components back in into a system. This can be an economic, biological, environmental or any other system.
 - The client believes that waste will be designed out of our society.
 - Detailed description of requirements regarding functionality and the Circular Economy
- Client mainly responsible for managing contracts
- Develop a policy regarding principles of the Circular Economy
 - Use of renewable resources and to design out carbon emissions

- Education of users. The client is responsible for educating users in such a way that principles of the Circular Economy will be maintained and will be propagated to the fullest.

Organisation

- The client develops contracts with the provider. The performance and all relating services must be provided by the provider.
- The client has a focus on contract management within their own organisation.

Finance

Initiative phase

- Costs for the client are:
 - Contract management costs

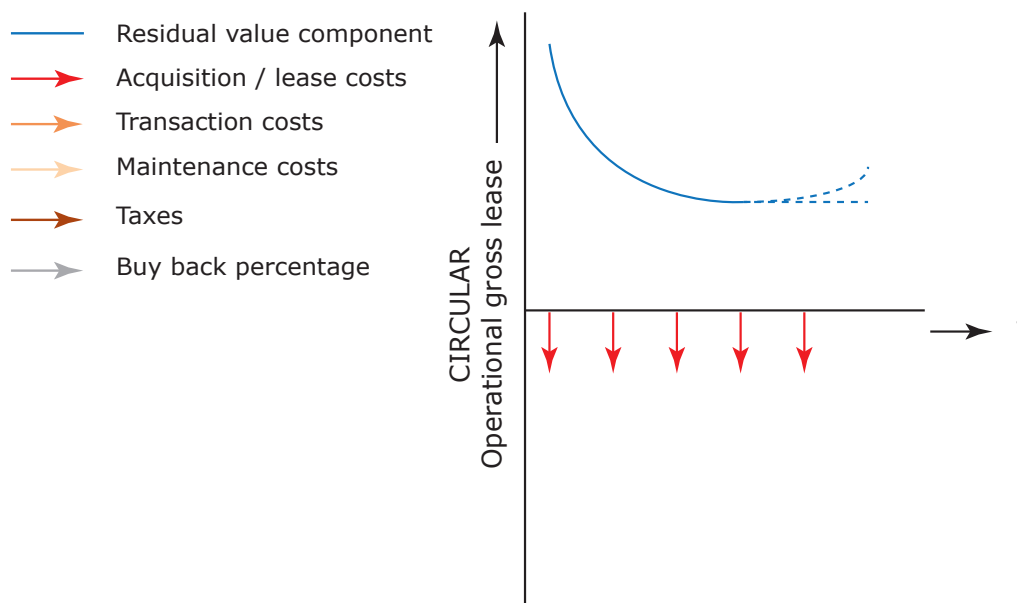
Usage phase

- Costs for the client are:
 - Monthly lease payments
 - Includes maintenance costs
 - Includes energy costs
- Value maintained replaces value replacement
- Taxes
 - No taxes regarding capital

End of usage

- No additional costs

Figure 60: Financial scheme - Operational gross Lease



6 - VALIDATING THE PERFORMANCE- SERVICE SYSTEM

The Performance-Service System and all other strategies are being validated by conducting a second interview with employees of FMVG (Facilitair Management & Vastgoed; Facility Management & Real Estate) and an interview at Gilde Opleidingen. The model is developed and translated into a leaflet, as shown in chapter 5. During the validation three main questions needed to be answered, other questions supported these three questions:

- Is it clear what the model is about?
- Do you understand the model?
- Could you use this model to support a strategic decision?

First of all Koopmans, Slob & Mohammadi, Winkels, and Van Gasselt gave their view on the model. All tried to answer the questions as good as possible.

6.1 – Validating: Atse Koopmans

1). Is it clear what the model is about?

It is clear what the model is about.

2). Do you understand the model?

It is clear what strategies are part of the linear economy and what strategies are part of the Circular Economy. It helped that all strategies are translated in figures instead of just a text.

Sustainability

All texts explaining the model are clear. There is no information missing in the texts.

Management

When discussing the text of the management client Koopmans had a few remarks, which are:

- It can be confusing to mention providers in texts supporting the model, because this model is developed from client perspective. Koopmans adds that it should be clear to what stakeholder is referred to. Otherwise it will be confusing whether the client or someone else is responsible for specific activities.
- After discussing the model it became clear that Koopmans thinks that the model sends a negative message. He uses an example of a house regarding the climate design. This climate design is based on performances and will be translated in the availability of these performances during the day. If a performance is not available at a certain moment, it is considered an error in the performance. In a lot of cases this error means a penalty for the provider. The Circular Economy gives a positive message, but if performances are measured in errors this gives a negative message. Therefore he argues to find a solution in order to deliver positive messages to all stakeholders.
- Koopmans is very interested in closing the loop, but he argues that bringing back components into a system is very difficult. Therefore, he put some question marks at this phase. *At this point during the interview it was explained that for every strategy it differs what kind of responsibility the client has. For example, when the client buys, the responsibility of bringing back components into a certain system is also transferred towards the client.*
- An important question is about the materials that must be taken back. What kind of materials or components can and will be brought into a system? Is the building or are the components and materials reusable?

Structure

- It is unclear what the last paragraph 'responsibilities client' is doing in the leaflet. Some of the questions that were raised are: Why the responsibilities? Is it a boundary for the model? *It was mentioned that these are requirements for the Circular Economy;*
- It is not explained why there are different colours in the model. These colours must be explained in order to prevent confusing.

Finance

This paragraph is clear, but Koopmans has the feeling that there is too much focus on the financial value. Koopmans asks why there are no sustainable costs and benefits mentioned in the brochure. *During the conversation it is mentioned that in a lot of cases decisions regarding facilities are based on finance. This was confirmed by several employees of FMVG during the interviews. Because finance is such an important aspect during decision making it is chosen to highlight this element.*

Definitions

Definitions remain a discussion during the validation. The definition of the performance used in the Performance-Service System is an 'agreed action of performing'. Koopmans argues that it is about the output of a performance. Furthermore he argues that it is still a complex issue to develop definitions that are complete and consequent. He gives an example of a woman in the office. One could develop certain performances for the pleasantness of an office. These performances can be calculated and tested. The room will fulfil all required performances on paper, but the woman will complain it is not pleasant. Then you will have a problem. On paper it fulfils all and in real life it does not fulfil the requirements. How to manage these kind of soft factors?

3). Could you use this model to support a strategic decision?

No, at this moment this model can not be used to support decisions on strategic level. It misses a list of advantages and disadvantages. Koopman argues that the model could not support decisions, but it is a good reflection of the choice in different strategies.

6.2 – Validating: Niel Slob & Saman Mohammadi

Slob and Mohammadi have experience in the field of constructions within the educational sector, especially in combination with the Circular Economy. Therefore they will give a consult to validate the model. Because Slob and Mohammadi recommended some adaptations in the structure, a visualization of these recommendations is made and can be seen in figure 61.

General findings

The following comments have been mentioned during the validation of the model:

- One of the first comments is the lack of brokers in practice in the field of the educational sector. They advise to leave out these alternatives in the model. In many cases the broker is not necessary in the educational sector.

1). Is it clear what the model is about?

Slob and Mohammadi state that the model is not clear. A client wants to have a care-free decision supporting tool. They advice to develop a model whereby the client will answer questions step-by-step. This kind of model will support a strategic decision. This discussion went on by mentioning the comments of Matthijs Prins and Ruud Binnekamp, both teachers at the faculty of Architecture and the Built Environment at the Delft University of Technology. *It is hard to develop such models in a context that has not been proven yet. An attempt has been made in order to develop such a model, but due to shortage of time it is decided to leave this out of the graduation project and recommend this towards other students for future research.*

Although some alterations must be made in order to simplify the model, the different strategies give a good example of the differences between the linear and the Circular Economy. Especially when reading through the pages which explains every strategy, this becomes more clear.

2). Do you understand the model?

Definitions

The definition of performance is discussed. One of the strategies is the Operational Gross Lease, this is the only strategy that includes performances. In this strategy the definition of performance corresponds with the performance used in practice. In all other cases the definition of performance remains unclear. Slob and Mohammadi advice to translate this performance in the model, by showing a figure where the performance is different from the product.

In addition to the comments above they advice to write down the different strategies as if it is commonplace. For example, in the linear economy one does not speak about performances. In the Circular Economy one does only speak in terms of performances at the Operational Gross Lease. This should be clear at once.

After discussing the performance, it became clear that the Operational Net Lease creates some confusions about the whole model. The differences between the Financial Lease, the Operational Net Lease, and the Operational Gross Lease are marginal. That leaves the client with a lot of questions. In order to prevent confusions it would be better to leave the Operational Net Lease out of the brochure. They expect that a simplified model will stimulate discussions about decisions regarding the Circular Economy.

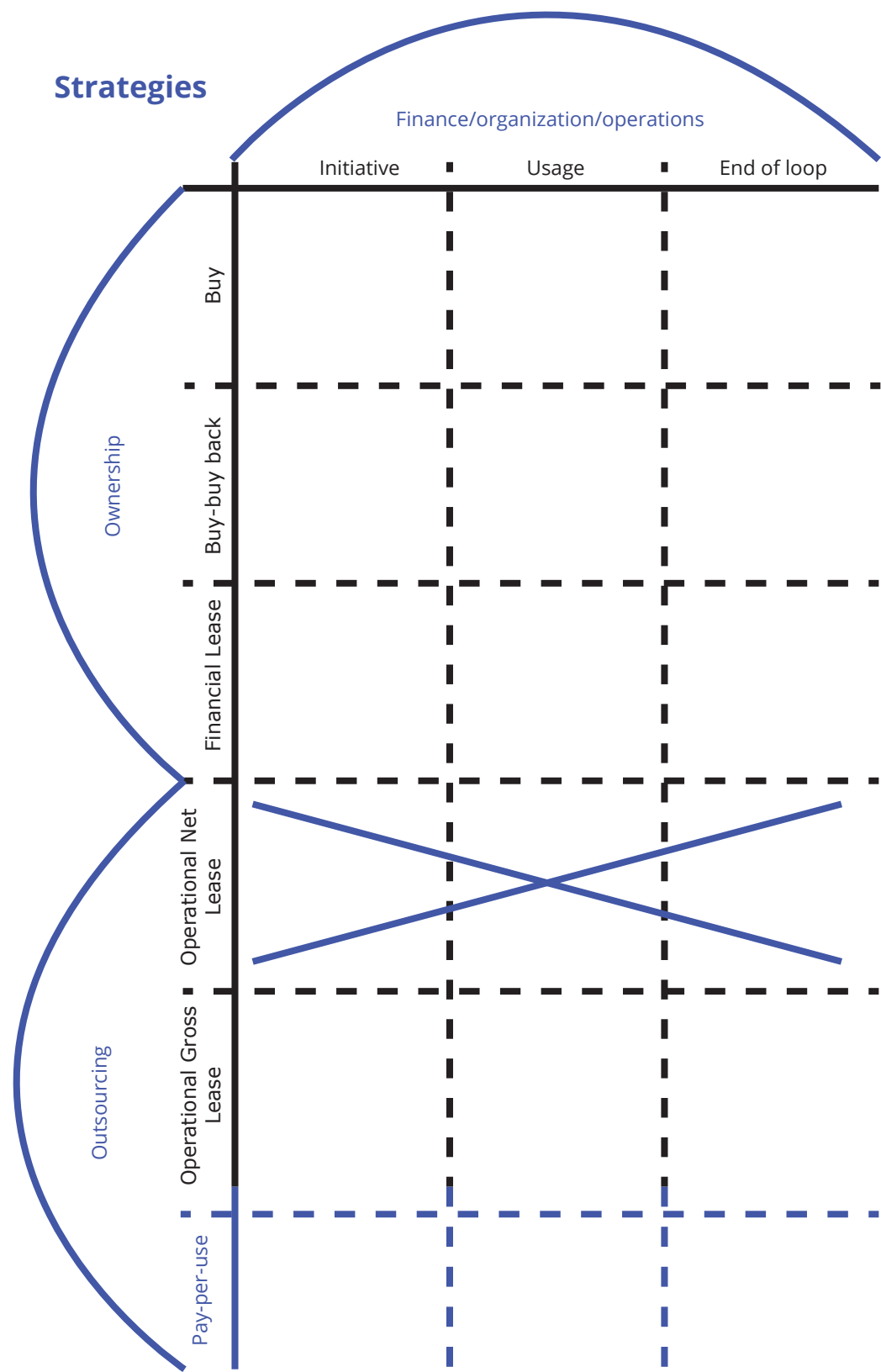
The definition of the initiative phase is unclear. After discussing this definition it was concluded that the description misses information about the moment of taking of a performance. It is recommended to include this information in the final model.

Structure of the model

In close relation to the comments on the definitions, also some comments on the structure of the model have been made. The comments have been translated into figure 61 and can be seen below:

- Within this model a lot of variables are mentioned. Try to explain all variables that are needed in order to solve this complex issue of the Circular Economy in the built environment;
- Try to implement the 'pay-for-use' strategy in the model;
- Divide the model in 'Ownership' and 'Outsourcing';
- The model must be simplified in order to make it understandable for clients;
- The adaptations made in the structure of the model must also be translated in the text. At this moment it is still difficult to understand the texts.

Figure 61: Comments of Slob and Mohammadi on the model



Financial Lease

One final note has been made at the Financial Lease. The mortgage rent will be translated in the Lease payments towards the client.

3). Could you use this model to support a strategic decision?

No, not yet. The content of the model is consequent and almost complete, but it should be translated into an understandable model that could simplify the complexity of the Circular Economy.

6.3 – Validating: Ad Winkels

Winkels is a policy advisor of FMVG (Facilitair Management en Vastgoed; Facility Management and Real Estate). A short presentation was given about the model that was showed to him during the interviews. It was explained what steps were taken in order to design the final model. During the validation a discussion was conducted about the 'Buy (circular Economy)' variant.

1). Is it clear what the model is about?

Yes, the model (Buy (Circular Economy)) is clear. He adds that the difference between the linear economy and the Circular Economy is clear.

After reading the information belonging to the 'Buy (Circular Economy)' a question was asked by Winkels: Do we have freedom to use the components in any way after using them? *It was explained, when choosing for this strategy the client has more responsibilities with respect to the Circular Economy in comparison with the Operational Gross Lease (Circular Economy). When buying it is advisable to think about materials and the way those materials will be used after the usage phase.*

2). Do you understand the model?

Definitions

Winkels mentions that it is important to have a good definition of sustainability. He advises to give this definition in this brochure, so everyone will understand what you are talking about. This definition must be related to the built environment.

Another comment is made about the word performance. It is stated that the client is responsible for the required level. He states it would be wiser to use a minimum instead of the required level, because this leaves room to improve.

Finance

When reading the information Winkels asked if the information of finance is complete. Is the depreciation costs missing. A discussion followed in which it was explained due to the Circular Economy one expects the residual value of components and materials is higher in comparison with the residual values in a linear economy, because of scarcity in natural resources. Another question is asked about profit. Are there revenues in this scheme? Is it possible to translate this in words?

Winkels confirms he understands the model and all information that is given after reading the strategy 'Buy (Circular Economy)'.

3). Could you use this model to support a strategic decision?

Yes, it could support decisions if this brochure is translated into a checklist. One could alter all bullet points in criteria to check if an organisation fulfils all requirements. Winkels adds that in practice it is most likely that not all bullet points will be fulfilled. He thinks that in many cases this is not realistic. Another discussion followed about some aspects of a checklist. Certain decisions will have been made before applying a checklist. This does not correspond with the main idea of this brochure. He does not mention other forms of decision-making tools regarding this brochure.

6.4 – Validating: Dick van Gasselt

Dick van Gasselt is chief accommodations at Gilde Opleidingen. He is in charge of leading a renovation project where principles of the Circular Economy are implemented as good as possible. A short presentation was given about the model and the different strategies. Within the presentation an example was made about the procurement of furniture at Gilde Opleidingen.

1). Is it clear what the model is about?

The model is clear.

2). Do you understand the model?

One notification was made about the usage phase. My example states that during the usage phase a maintenance provider will be hired. However, Gilde Opleidingen has made agreements about guarantees with respect to the furniture. Therefore, if an error occurs during this guarantee period, the provider is responsible for maintenance activities.

3). Could you use this model to support a strategic decision?

It was not possible for him to answer this question. Due to lack of time, he couldn't take a good look at the content of the model. However, he mentioned that one of the main questions that should be answered within the context of the Circular Economy is: How much is a client willing to invest in principles of the Circular Economy? Van Gasselt believes that in a lot of cases implementing principles of the Circular Economy will require a higher investment than traditional components and/or products. Is the client prepared to make this offer? If a client is not willing to make such an offer, one should not bother to discuss the Circular Economy with them.

6.5 – Part conclusions

Three main questions had to be answered during the validation. Conclusions about the content

and presentation of the model can be seen below.

1). Is it clear what the model is about?

At first sight, the model remained unclear. It was confusing what the model is about. After given an oral explanation of the model it was clear to all. The explanation is written down, but there was not enough time to check whether this text also explains the model. It seems complex to simplify a comparison of the linear economy and the Circular Economy in words. At this stage, it is advisable to give an oral presentation about the possibilities of this model and the differences between the linear and the Circular Economy.

2). Do you understand the model?

Definitions

A discussion took place during all validations about definitions of the model. One of the most discussed topics is the definition of the word 'performance'. According to Koopmans it is about the output. In order to prevent confusion Slob and Mohammadi add that performances should be illustrated differently than components or products. Winkels adds that it is advisable to include a definition of sustainability in the brochure.

Completeness model

In some texts information misses, but these are rather small details.

Lay-out

On the lay-out of the model some suggestions have been made:

- The structure used in the model must be brought back in the texts that support every strategy. An example is the different texts per strategy. The texts consist of 'sustainability', 'management', 'finance', and responsibilities of the client regarding the Circular Economy. These texts are not consistent with the model and should therefore be altered. It could be altered in 'operations', 'organisation', and 'finance'.
- It should be clear which strategies are based on the linear economy and which strategies are based on the Circular Economy.

3). Could you use this model to support a strategic decision?

The model will not support decisions in its current state. There are several options to optimize this model:

- Add an advantage and disadvantage list per strategy. According to Koopmans this list could help to base your decisions on.
- Development of other models that will support this model. One can think of a decision tree or multi-criteria-models.
- Translate the brochure into a checklist.

The content of the model is good in its current state, but a few modifications need to be made in order to operationalize this model.

Development of a checklist

As mentioned above, the different strategies show the differences between a linear and the Circular Economy. But at this point it is too complex to be useful in practice. In order to take this graduation to a higher level a first attempt is been made of a checklist.

On the following pages one sees this checklist. The checklist is divided in two parts, namely 'Finance' and 'Organisation & Operations'. This checklist begins with finance because, as Van Gasselt stated before, if an organisation is not willing to invest extra in principles of the Circular Economy, one should not bother to continue propagating the Circular Economy at this organisation.

This checklist contains a lot of questions. The questions are considered to be abstract, because they can be asked at every strategy. In the next chapter of this report the checklist is adapted for the 'Buy-buy back (Circular)' strategy. The checklist will be tested by filling in two components at Gilde Opleidingen.

Checklist Performance-Service System (Buy - buy back (Circular Economy))

Finance

Yes No N/a ?

1). Does the owner have ambitions regarding principles of the Circular Economy (sustainability)?

☐
☐
☐
☐

2). Is the owner willing to take responsibility for the components with respect to principles of the Circular Economy?

☐
☐
☐
☐

3). Does the client want control or wants to be care-free with respect to principles of the Circular Economy?

4). Is the owner willing to make extra investments regarding principles of the Circular Economy?

☐
☐
☐
☐

5). Is it possible for the client to get a loan from the Ministry of Finance?

☐
☐
☐
☐

6). Are there subsidies available with respect to the required performance?

☐
☐
☐
☐

7). In the context of the client being the owner of the components/materials. Is the client willing to invest to keep the required performance during the usage phase?

☐
☐
☐
☐
Organisation & Operations

6a). Does the pre-arranged owner of the components have one of the following business cases with respect to the components and Circular Economy?

- Cradle-to-cradle components (certification of cradle-to-cradle/biodegradable materials)

☐
☐
☐
☐

- Reuse components/materials on location

☐
☐
☐
☐

- Reuse components/materials in an alternative cascade

☐
☐
☐
☐

- Components/materials will be optimized for user after usage

☐
☐
☐
☐

- Reuse of components/materials within the organisation of the owner

☐
☐
☐
☐

- An interested buyer for the components/materials

☐
☐
☐
☐

- Another business case what implements principles of the Circular Economy:.....

☐
☐
☐
☐

6b). Components are designed to be reversible, adaptable, demountable and/or biodegradable so they can support above mentioned business case?

☐
☐
☐
☐

6 - VALIDATING THE PERFORMANCE-SERVICE SYSTEM

Checklist Performance-Service System (Buy - buy back (Circular Economy))

Yes No N/a ?

6c). Does the client use means to check the origin from materials?

- Materials passport?

☐ ☐ ☐ ☐

- Cradle-to-cradle certification?

☐ ☐ ☐ ☐

- Other means:....

☐ ☐ ☐ ☐

7). Provider is transparant about costs and information with respect to the business case?

☐ ☐ ☐ ☐

8). Renewable energy resources are used during:

- Production

☐ ☐ ☐ ☐

- Initiative phase

☐ ☐ ☐ ☐

- Usage

☐ ☐ ☐ ☐

- End-of-loop

☐ ☐ ☐ ☐

9). Is the provider willing to give guarantees with respect to principles of the Circular Economy?

☐ ☐ ☐ ☐

- warranty

☐ ☐ ☐ ☐

- Letter of intent

☐ ☐ ☐ ☐

10). Are agreements established between owner and maintenance provider with respect to principles of the Circular Economy (example: Service-Level Agreement)?

☐ ☐ ☐ ☐

User

11). From client perspective - Are principles of the Circular Economy implemented in the Code of Conduct from the organisation?

☐ ☐ ☐ ☐

12). Is the client going to give education about the following aspects with respect to the Circular Economy?

- Does the client inspire users regarding the Circular Economy?

☐ ☐ ☐ ☐

- Does the client inform users about the Circular Economy?

☐ ☐ ☐ ☐

Checklist Performance-Service System (Buy - buy back (Circular Economy))

	<i>Yes</i>	<i>No</i>	<i>N/a</i>	<i>?</i>
- Does the client stimulate users to implement principles of the Circular Economy in their daily routine?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Does the client support the image, status and activities by implementing the Circular Economy?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7- RENOVATION GILDE OPLEIDINGEN

This chapter will elaborate on testing the strategies at developments at Gilde Opleidingen in Venlo, the Netherlands. Gilde Opleidingen is an educational institute for secondary vocational education. They are going to renovate their facilities during July and August. Gilde Opleidingen is very interested in the concept of the Circular Economy. Van Gasselt, chief accommodations at Gilde Opleidingen, has stated to develop as many as possible projects according to the principles of the Circular Economy. This renovation project is the first attempt to implement these principles (gilderenovatie.nl, 2015). Gilde Opleidingen will use the 'buy-buy back (Circular Economy)' strategy in this project. Two components were chosen in order to test this 'buy-buy back (Circular Economy)'. First, this chapter will elaborate on furniture. Secondly, the model is tested by implementing and reflecting on the use of solar panels.

A note should be made about the educational sector. In order to finance projects regarding their own accommodations they can get a loan from the government. This loan is cheaper in comparison with mortgages offered in the market. Therefore, in a lot of cases the educational sector will choose a 'buy (Circular Economy)' or a 'buy-buy back (Circular Economy)' strategy, because these strategies result in lower costs than leasing.

7.1 – Furniture and the 'Buy-buy back' strategy

General information

Client:	Gilde Opleidingen
Location:	Venlo, the Netherlands
Project:	Renovation school building
Completion:	September 2015-06-09
Companies:	Bam Utiliteitsbouw Re-Born Global Architecture
Procurement:	School and office furniture
Provider:	Ahrend

The procurement consists of two parcels. The first parcel includes office furniture. The other parcel includes school furniture. The procurement asks standard office furniture for the purpose of office, education-, or meeting rooms and related services. One of the requirements was the implementation of principles of the Circular Economy (TenderNed, 2015). Ahrend won the procurement and will provide Gilde Opleidingen furniture.

The strategy 'Buy-buy back (Circular)' of the model was filled in by using the information provided by Re-Born. Three actors are important in this strategy, as can be seen in figure 62. First of all there are the users, which are the students and teachers of Gilde Opleidingen. Secondly, Gilde Opleidingen operates as a facility manager. And finally, Ahrend will be the provider of the required furniture. All phases of the strategy will be described by the aspects organisation & operations, and finance.

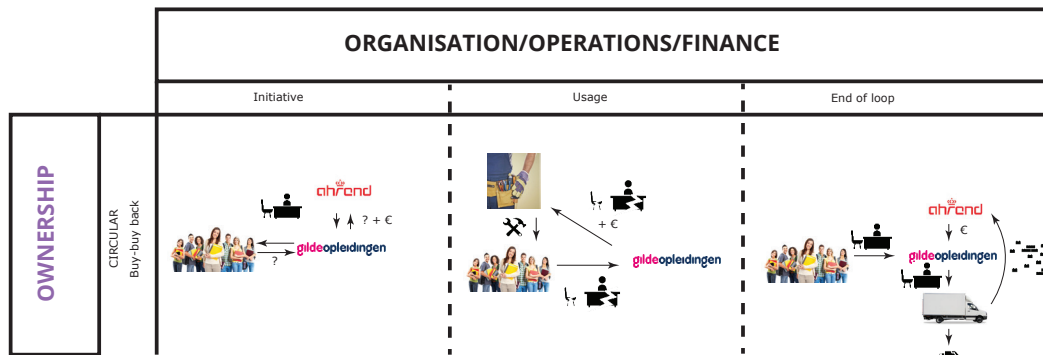


Figure 62: Procurement furniture Gilde Opleidingen Venlo – Strategy 'Buy-buy back (Circular)'

Initiative phase

Organisation & Operations

Gilde Opleidingen and the users needed new furniture for educational purposes. They procured this towards the market and Ahrend won the procurement. In a Circular Economy one should also set requirements with respect to sustainability. In this case providers got the opportunity to gain bonus points if they implemented principles of the Circular Economy. One measure with respect to the Circular Economy is that furniture, both the desks and chairs, are designed to be adaptive, reversible, demountable, or biodegradable. Furthermore, the client must be willing to invest more in sustainable measures. There are special agreements with respect to financial means in the educational sector. The educational sector has the opportunity to apply for loan at the government.

Ahrend mentions on their website that they are a cradle-to-cradle company (Ahrend, n.d.), but for unknown reasons they do not want to give a guarantee on the buy back of the furniture. The negotiations with respect to the buy back stranded when writing this report.

Finance

Gilde Opleidingen will buy the furniture and Ahrend will deliver. The ownership of the furniture will be transferred towards Gilde Opleidingen. Therefore Gilde Opleidingen will be responsible for maintaining the furniture from that moment on.

Usage Phase

Organisation & Operations

Gilde Opleidingen and the users will use the furniture for approximately ten years. During the usage Gilde Opleidingen will be responsible for the maintenance activities. Therefore they need to tender this kind of activities in the market. At this moment there are no established agreements with respect to furniture. Ahrend has agreed on a guarantee period. During this period Ahrend will maintain or deliver furniture. Gilde Opleidingen has not made agreements regarding that period.

Gilde Opleidingen has a Code of Conduct in the form of staff regulations. However, in this case it does not mention anything related to the Circular Economy. One general rule states that the user will be held responsible if he or she will damage properties, areas, or the equipment of Gilde Opleidingen (Stichting Gilde Opleidingen, 2012).

Finance

During this phase Gilde Opleidingen will only have costs if an error occurs in the furniture. For example, a chair or desk is broken.

End of loop*Organisation & Operations*

Gilde Opleidingen will dispose the furniture. During this phase the ownership of the furniture will transfer back to Ahrend. However, the responsibility of Ahrend with respect to the furniture depends on the agreements made during the initiative phase.

If Ahrend will take the furniture back, they will be responsible for bringing back the components of this furniture into a certain system. Ahrend may reuse or refurbish the furniture. But could also sell it on the second-hand market. Another option occurs when the furniture is designed to be biodegradable.

Finance

Due to the stranded negotiations with Ahrend, there is no buy back percentage Gilde Opleidingen will receive. Therefore the costs of removing, dispose or bringing back the furniture in another system is for Gilde Opleidingen.

Validating the model and the checklist

Theelen is responsible for the procurement of furniture at Gilde Opleidingen. She was asked if she understood the model and if she could use the checklist in future procurements. The checklist can be seen in appendix D.

1). Is it clear what the checklist is about?

Yes, the checklist is clear. Theelen understands the differences between the linear and the Circular Economy. The case study with respect to the furniture is filled in correctly.

2). Is the checklist clear?

The checklist is filled in with the furniture as example. Theelen finds the checklist very clear. She mentions that she is not missing any information and that the list seems to be complete.

3). Could you use the checklist to support a strategic decision?

Theelen mentions that she needed this checklist a few weeks back. She could have used this checklist during the negotiations with Ahrend. To the outside world Ahrend seems leading regarding principles of the Circular Economy, but during the negotiations it became clear that even Ahrend is still in its infancy with respect to these principles.

Together with Theelen the checklist was filled in. Some comments are made with respect to the checklist:

- Gilde Opleidingen is not willing to make extra investments for furniture with respect to principles of the Circular Economy. Theelen mentions that one reason could be the opinions of users. They only want the furniture and she believes that the user does not care whether the furniture is biodegradable or developed in a traditional way.

- There are no business cases with respect to the buy back of furniture by Ahrend, because the negotiations stranded. But it is a good list that can be used in future procurements.
- Theelen did not consider a warranty or a letter of intent with respect to the buy back, but in future procurements this is one aspect that needs to be taken in mind.
- Because Gilde Opleidingen has many different departments, it will be difficult to educate users.

7.2 – Solar panels and the ‘Buy-buy back’ strategy

General information

Client:	Gilde Opleidingen
Location:	Venlo, the Netherlands
Project:	Renovation school building
Completion:	September 2015-06-09
Companies:	Bam Utiliteitsbouw Re-Born Global Architecture
Procurement:	Solar panels
Provider:	?

One of the requirements of Gilde Opleidingen with respect to the renovation of the building is that they want make use of a renewable energy resource instead of traditional energy resources. Therefore they procure for solar panels.

In the current situation Gilde Opleidingen uses 450.000 kWh. A calculation, made by M3E Subsidie Advies (2015), shows that the solar panels will produce 282.180 kWh. This is not sufficient for the required amount, but when using solar panels with subsidies this will cause lower costs.

As is described above regarding furniture, Gilde Opleidingen will also use a ‘Buy-buy back (Circular Economy)’-strategy. The strategy will be described by using three phases. Furthermore, all aspects within each phase will be divided in the categories organisation, operations, and finance. One must note that a provider of solar panels is not yet selected.

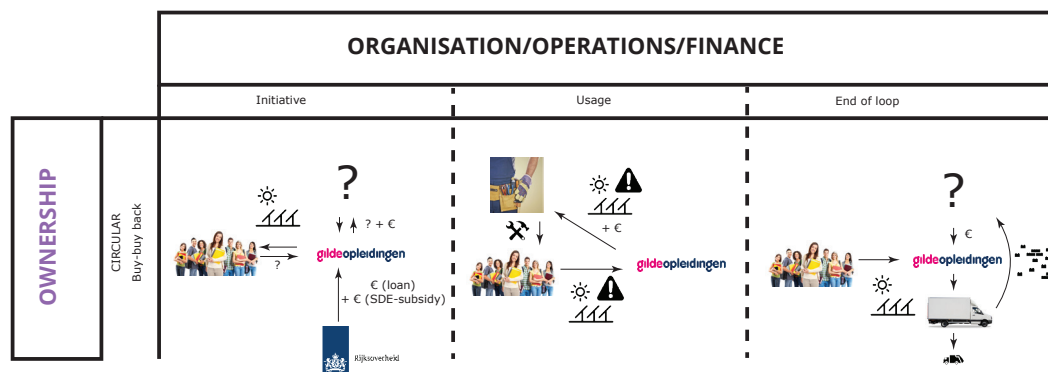


Figure 63: Procurement solar panels Gilde Opleidingen Venlo – Strategy ‘Buy-buy back (Circular)’

Initiative phase

Organisation & Operations

The users of Gilde Opleidingen need energy in order to support their primary processes. Gilde Opleidingen acts on behalf of the users to procure energy towards the market. In addition Gilde Opleidingen has an ambition to use sustainable resources. Therefore they procure for solar panels, because these elements produce renewable energy. Finally, the ownership rights will be transferred towards Gilde Opleidingen.

Gilde Opleidingen is looking for a provider with respect to the Solar Panels. Because the procurement is still going on, it is difficult to elaborate on all aspects regarding the principles of the Circular Economy. In order to guarantee the 'buy back' the provider should sign the warranty. Another option Gilde Opleidingen is to look at ESCo's (Energy Service Companies). An ESCo means that Gilde Opleidingen will only receive the energy and not the ownership on the solar panels (esconetwerk.nl, n.d.). This requires another strategy of Gilde Opleidingen.

Finance

Because Gilde Opleidingen wants to procure for solar panels they have the opportunity to obtain a subsidy. The revenue stream will consist of two components. These revenues will be used to invest in the solar panels. Costs of buying solar panels are the acquisition costs, transaction costs, and taxes regarding assets.

Usage

Organisation & Operations

A part of the energy of Gilde Opleidingen is gained by renewable energy resources. The solar panels that excite these energy resources have yet to be obtained. Therefore it is not possible to check whether the components are demountable and/or adaptive materials and components.

Because the ownership rights are transferred towards Gilde Opleidingen they will be responsible for the maintenance activities. Unless some agreements are established between Gilde Opleidingen and the provider regarding maintenance activities, Gilde Opleidingen should procure for external maintenance providers.

Gilde Opleidingen does not have any statements with respect to the use of energy in their Code of Conduct. Only one rule is generally applicable. Users will be held responsible if they damage properties, the areas, and all equipments of Gilde Opleidingen (Stichting Gilde Opleidingen, 2012). This includes solar panels.

Finance

Gilde Opleidingen will have costs regarding the use of energy. These costs are divided by the energy of the solar panels and the traditional energy resources. Furthermore some incidental costs regarding maintenance activities are at place.

End-of-loop

Organisation & Operations

In this case the solar panels are outdated or Gilde Opleidingen wants a new energy performance. Therefore the components that are placed at the roofs must be taken back by the provider. As mentioned above Gilde Opleidingen is still in the procurement phase. Therefore the agreements between Gilde Opleidingen and the provider can not be described.

Finance

If the provider takes back the solar panels, Gilde Opleidingen will receive an agreed percentage of the investment costs.

Validating the model and the checklist

Together with Van Gasselt the checklist was filled in, as can be seen in appendix e. Van Gasselt is responsible with respect to the renovation of Gilde Opleidingen. He was asked if the checklist could be helpful in future developments and procurements.

1). Is it clear what the checklist is about?

The checklist is considered clear. Van Gasselt understands the differences between the linear and the Circular Economy. In conversation with Van Gasselt it became clear that Gilde Opleidingen will not procure for solar panels. This has to do with several reasons:

- Gilde Opleidingen is indirectly influenced by the government. Therefore it is impossible for Gilde Opleidingen to apply for subsidies.
- Gilde Opleidingen buys its energy collectively with other educational institutions. This kind of energy is much cheaper due to this collectivity.

One can conclude that even though the ambitions are high, obstacles with respect to regulations have to be overcome.

2). Is the checklist clear?

Together with Van Gasselt the checklist is filled in, using the solar panels as an example. Van Gasselt thinks the checklist is clear and seems to be complete.

3). Could you use the checklist to support a strategic decision?

Van Gasselt mentions that the checklist could be used during future procurements. Gilde Opleidingen will do more renovation projects in the upcoming years. Van Gasselt is willing to give this checklist a try during new procurements of these renovations.

7.3 – Part Conclusions

A few conclusions can be drawn after testing the checklists at Gilde Opleidingen.

Model

The test case of furniture confirms the statement made in chapter 4, namely that the Performance-Service System needs to be flexible in such a way that it can be applied in every scenario. In this case the usage phase can be divided into two parts. First of all there is a period in which Ahrend gives a guarantee with respect to the furniture. After this period Gilde Opleidingen will be responsible for the maintenance activities.

Checklist

As a part of this graduation project a checklist is developed in order to accelerate the transition towards the Circular Economy. The different strategies as described in chapter 5 are the basis.

Both Theelen and Van Gasselt see opportunities to use this checklist for future procurements regarding facilities and renovation projects.

When filling in the checklist it became clear that there is still a gap regarding the Circular Economy and ambitions of Gilde Opleidingen. In both cases more than half of the checklist could not be answered 'yes'. This means that in both cases there are a lot of opportunities to improve the project regarding principles of the Circular Economy.

CONCLUSIONS, RECOMMENDATIONS, AND REFLECTION

This chapter will elaborate on conclusions and the reflection of this graduation project. In this chapter the main research question and the sub-questions will be answered. After answering the research questions, recommendations regarding future research and gaps in the field of knowledge will be provided. At last, a reflection on this graduation project will be given.

Conclusions

In the beginning of this research a few sub-questions were developed in order to contribute to find an answer for the main research question. Brief answers are given at all sub-questions.

Conclusions with respect to the Circular Economy

The Circular Economy is explained by answering a few research questions. The development of the Performance-Service System gave some insights regarding the model of the Ellen MacArthur Foundation (see figure 62). All conclusions can be seen below.

What is the Circular Economy?

The Circular Economy is a relatively new concept in the field of sustainability. Complementing different theories of sustainability, such as 'Cradle-to-cradle', 'Performance-based economy', and 'Biomimicry' formed the Circular Economy. The Ellen MacArthur Foundation developed a model based on the Circular Economy, as can be seen in figure 62. Due to its foundations in different sustainability theories the Circular Economy includes a lot of different principles. These principles can be applied in our current economic system in order to become more sustainable.

How does the Circular Economy work?

In order to make the transition towards the Circular Economy a lot of principles need to be implemented in our current system. These principles will be explained at the following question below. In this part the model developed by the Ellen MacArthur Foundation will be elaborated. As one can see in figure 64, the model consists of two parts, namely the biological materials and the technical materials. Within this graduation project only the technical materials part is elaborated. The biological materials part is also of great importance in the Circular Economy, but it is very difficult to implement principles of this part in the construction sector. Although, sustainable visions describe a world where biological materials are flourishing. At this moment, it is not possible in our current society. Especially in the construction sector components are developed in such a way that it is still not possible to make them bio-degradable.

When looking at the technical materials part of the model a few aspects become clear. First of all one should think in loops, materials are brought back into a system. All is done to design out waste. Another important aspect of the model is to think in performances. This aspect cannot be seen in the model itself, but is one of the essential aspects of this theory.

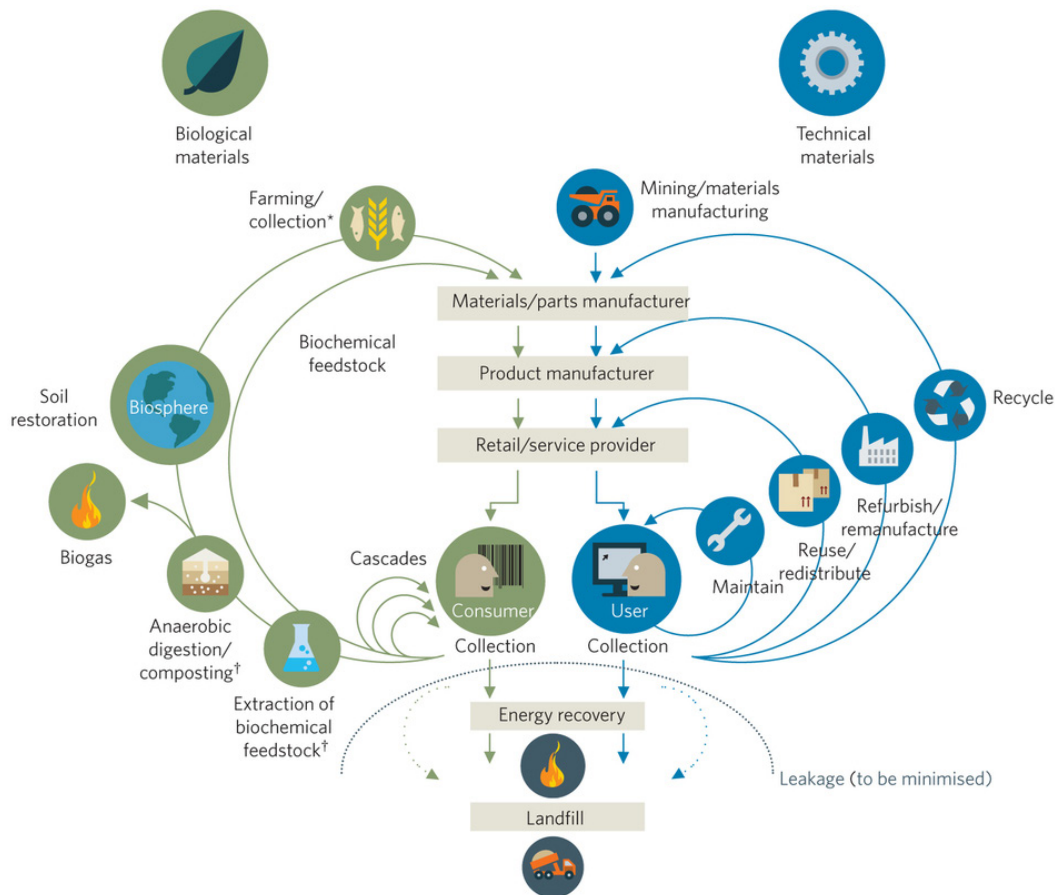


Figure 64: The Circular Economy (Ellen MacArthur Foundation, 2012)

What principles of the Circular Economy are applicable in the construction sector?

Operations

- Replace fossil-fuel-based mechanisms with passive and natural systems where possible;
- Design reversible, adaptable, demountable and/or biodegradable systems;
- Compensate for past design decisions and their environmental impacts;
- Reduce total resource flows over a building's life cycle;
- Design out waste;
- Rely on energy from renewable sources;
- Reducing consumption of non-renewable resources;
- Efficient use of energy, materials and natural capital;
- Replacing non-renewable with renewable resources;
- Creating an energy supply based on renewable energies.

Organisation

- Continued ownership is cost efficient; reuse, repair and remanufacture

without a change of ownership saves double transaction costs;

- The customer wants the service, the performance rather than the product;
- All parts of the circuit count and the key to vitality lies in rapid, robust, thorough circulation of money, goods, services etc. to all stakeholders.

Finance

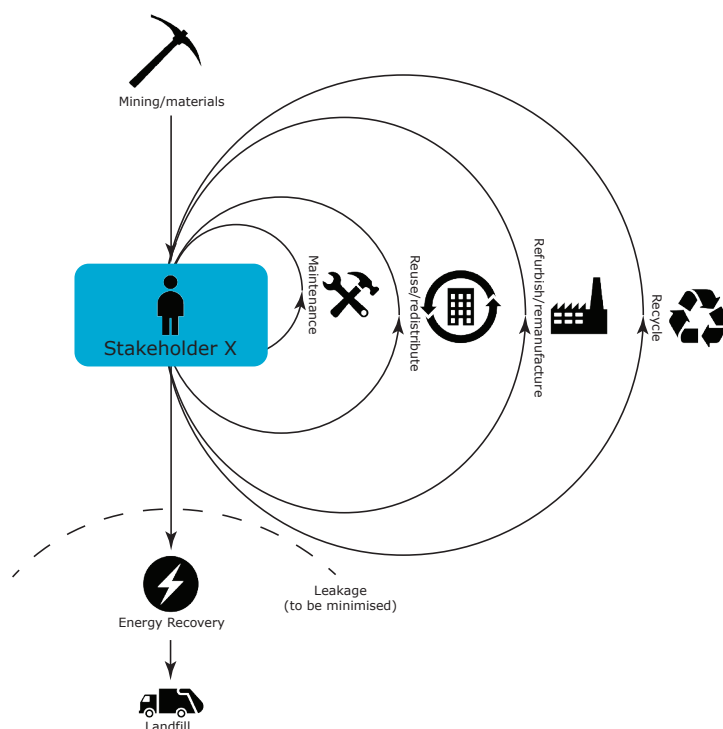
- The smaller the loop (activity-wise and geographically), the more profitable and resource efficient it is;
- Loops have no beginning and no end; value maintained replaces value added.

Is it possible to implement these principles within the construction sector?

Yes, it is possible to implement these principles. However, there are some obstacles that need to be overcome. A few obstacles are mentioned below:

- The Circular Economy is in its infancy;
- There is a knowledge obstacle. In order to overcome the knowledge obstacle the working population must train their skills and competences;
- Obstacles regarding the design of components. Cognition of how to design components that apply principles of the Circular Economy is in some extent available in the market, but there is a lack of finance opportunities in order to apply these techniques;
- Calculations must be made not only with respect to the residual value of materials, but should include demolition costs. An opportunity lies in broadening Life-Cycle Costing calculations;
- The last knowledge obstacle is the knowledge for companies. Most of the companies do not have access to information in terms of the environmental impact.

Figure 65:
Simplification principles
Circular Economy



CONCLUSIONS, RECOMMENDATIONS, AND REFLECTION

Is it true that value maintained replaces value added?

The principle of 'value maintained replaces value added' remains a hypothesis. Although a lot of reports conclude that this principle will be true in the upcoming years, there is a lack of scientific evidence to prove its robustness.

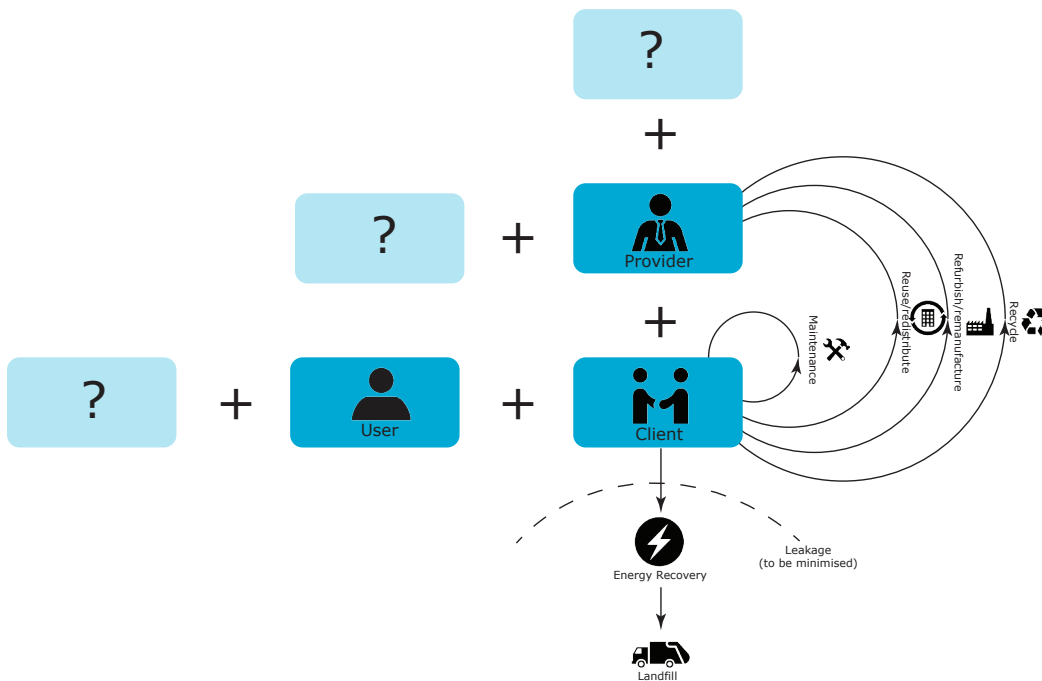


Figure 66: Expansion simplification model Circular Economy

Comments on the Circular Economy

When looking deeper into the model of the Ellen MacArthur Foundation one may see that the model creates some confusion. Two other models will contribute to the discussion as can be seen in figures 65 and 66.

First of all, their model shows different stakeholders, such as the manufacturer, the supplier, and a provider. The model implies that these are all different stakeholders. But this is not necessarily true within our current system. As one can see in figure 65 one company can be a manufacturer, supplier of materials, and a provider at the same time. Stakeholder X reflects all stakeholders. In theory it is possible that this stakeholder is also its own user of the performance provided. The model can be adapted into individual solutions as long as the two main principles, such as thinking in loops and thinking in performances, are being implemented in the model.

Secondly, the model should therefore be adaptable to the wishes and requirements of the client. It should not state where a stakeholder is located in the model. Furthermore neither must it state where the loops should be located in the model. It depends on agreements between the client and the provider how processes will continue and how performances will be provided. It is possible for every client to adapt the model to their own requirements regarding processes. Therefore the model of the Ellen MacArthur Foundation can be considered as one of the possible scenario's.

Conclusions with respect to the Performance-Service System

Why should there be a Performance-Service System?

The Circular Economy is still in its infancy. Therefore means are missing in order to make the transition towards the Circular Economy. The Performance-Service System is a model that tries to help clients to choose whether they want to make the transition towards the Circular Economy. This model provides insights regarding opportunities and obstacles of the Circular Economy within the construction sector. On the other hand the model gives insights how the Circular Economy would influence the organisation. The Performance-Service System is a first attempt to simplify the concept of the Circular Economy. It tries to provide clients tools to make the transition towards the Circular Economy.

In literature and interviews a few opportunities have been mentioned when choosing a Performance-Service System:

- Stability;
- Quality of the products used in order to get the performance;
- Functioning of the products in order to get the agreed level of performance;
- Liability of the products used;
- And finally reducing costs.

But in opposition to the opportunities there are also some risks:

- What if a provider goes bankrupt? What should the client do?;
- The changing wishes and requirements of users;
- Is the used product reusable when disassembled?;
- The changes within a organisation;
- Can the provider deliver the same quality asked by the client in performance, but also deliver this quality in contract?;
- Risk of errors;
- Maintenance activities need to be planned along the primary processes of the university.

Another aspect is that there is a lot of uncertainty towards closing the loop. First a few questions need to be answered in order to close the loop:

- How do you monitor this aspect of the Performance-Service System?;
- What does this aspect mean?;
- Is it about an integrated component or does it not matter whether it is dismantled or not?;
- What does Circular Economy mean? Because if you put materials or components in a furnace it also comes back in the economy.;
- How careful are providers when recycling?;
- How should it be formulized in contracts? And what will happen if the client or provider does not meet the requirements stated in the contract?;
- Who will be responsible for the dismantled components?

What is a Performance-Service System?

Keeping all definitions and theory in mind the following definition will be applied to the Performance-Service System:

The Performance-Service System is a marketable and sustainable set of performances and services capable of jointly fulfilling a user's need.

Whereas a performance is an agreed action of performing that results in an output, utility, goal, function, or commitment whereby a product is not a goal in itself, but subordinate to the performance. Secondly, the service is mainly a non-physical action or operation whereby the performance is extended or optimized over time. The service cannot be produced or consumed in itself and is subordinate to the performance. And at last, the system is a mix of performances, the subordinate products and services, and the communication required between client and provider.

The Performance-Service System is a tool to support strategic decision making for clients with respect to constructions. This model includes information about the organisation, operations and the finance. The model should provide the client with a lot of different sets of information so they can make founded decisions.

Are there different models within the construction sector that provide Performance-Service Systems?

Product-Service Systems are close to what a Performance-Service System is. However, it does not include all principles of the Circular Economy. Definitions of both systems differ. Complementing principles of the Circular Economy and Product-Service Systems are used to develop the Performance-Service System. Differences between Product-Service Systems and the Performance-Service System can be seen in table 4.

The definition of the word 'service' within a Product-Service System is unclear. The meaning of this word is twofold, first of all it means the required output. Secondly, it means all services are needed in order to keep this required output. This could lead to a lot of confusions, therefore the Performance-Service System adapts a different approach.

What are, from a client perspective, the financial costs and benefits of a Performance-Service System?

Due to the lack of data, it is difficult to answer this question. Although hard evidence misses in this graduation project, one could see the differences in financial schemes for different strategies. For every strategy a description of the financial responsibilities is provided.

Figure 67 shows the financial scheme of the Operational Gross Lease (Circular Economy). As one sees, an assumption is made of what the residual value of components and materials will do. Proponents of the Circular Economy and other reports in the field of sustainability state that there will be a scarcity of raw materials. This would result in increasing material prices. Therefore the residual value of components and materials used will also rise. Within the Operational Gross Lease the client has monthly lease payments. These payments include costs for maintenance. This form is care-free for the client, although its organisation should focus on contract management.

Table 4: Difference between Product-Service Systems and Performance-Service Systems

Product	Service	System
The product used in the Product-Service System	Relationship client & provider	Integrated solution (mix of products & services)
Output instead of input	The service instead of the good	
Focus on fitness for use	Product, use & result oriented	
	Maintenance	
	Reuse/redistribution	
	Refurbish/ remanufacture	
	Recycle	
	Revalorisation services	
	Utility	
	Results	
	Better able to respond to changing needs and conditions	

Performance	Service	System
Performance instead of a good	Maintenance	Integrated solution (mix of performances, (products) & services)
Utility	Reuse/redistribution	Relationship stakeholders
Result oriented	Refurbish/ remanufacture	Communication
Focus on fitness for use	Recycle	
Better able to respond to changing needs and conditions	Revalorisation services	
	Retrofitting	
	Energy Recovery	
	Land filling	

Figure 67: Financial scheme - Operational Gross Lease

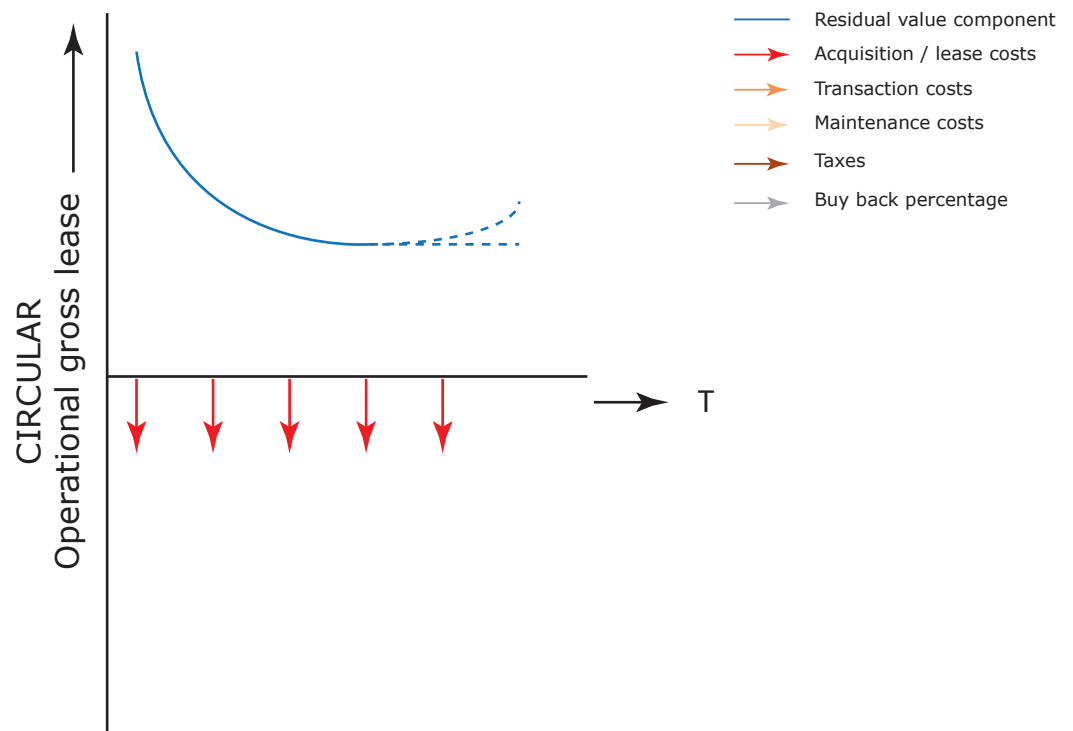
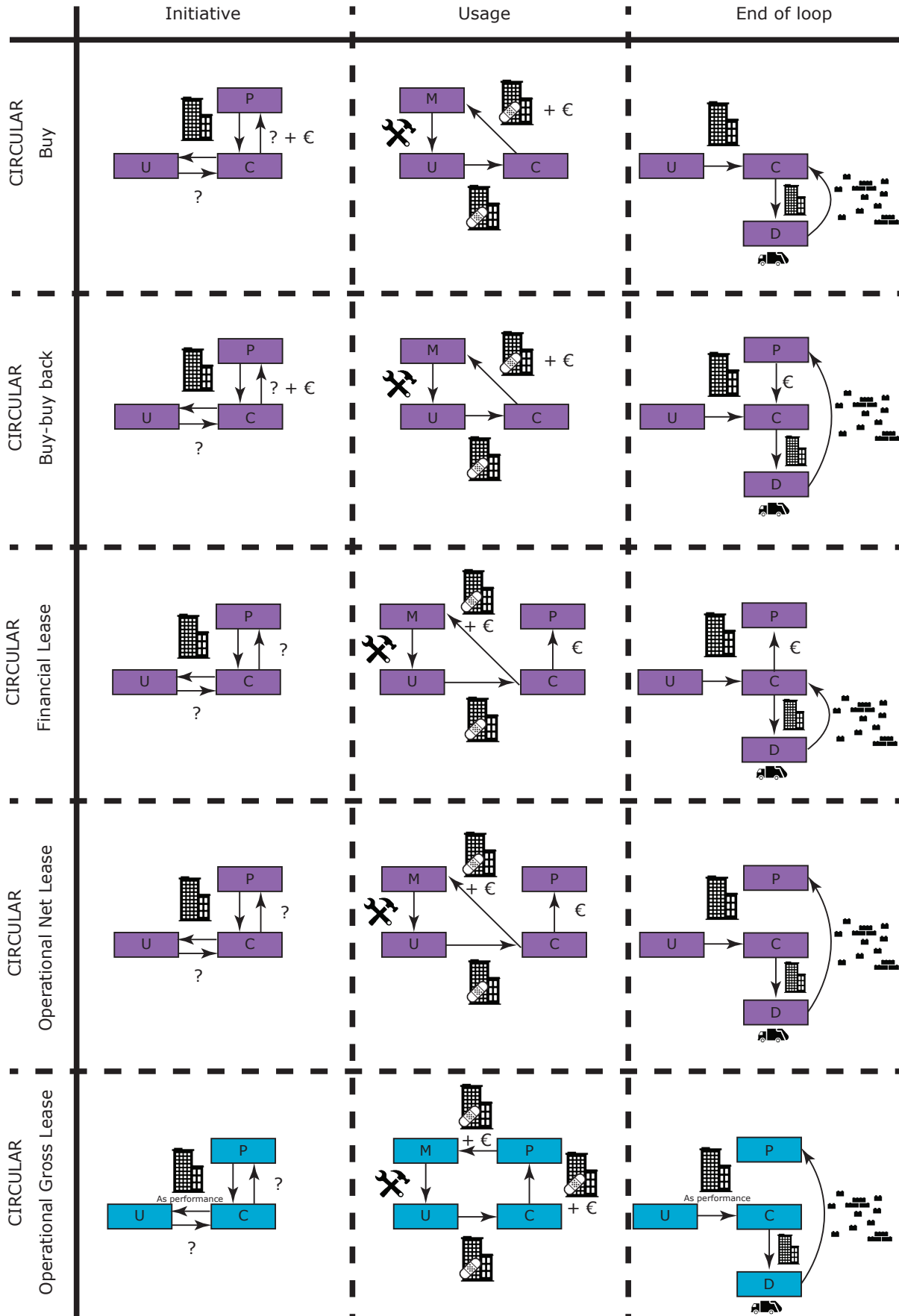


Figure 68: Strategies
(Circular Economy)



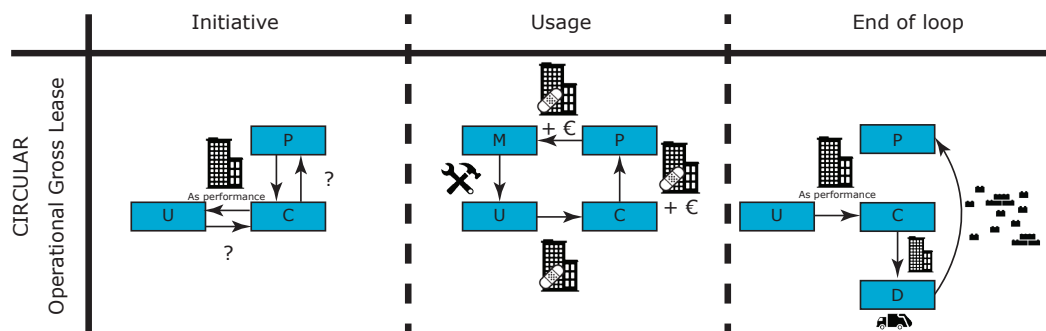
What does a Performance-Service System looks like?

Looking at figure 68, one sees different strategies regarding the procurement of new facilities. Differentiation is made between linear economy strategies and the Circular Economy. Figure 66 shows strategies of the Circular Economy.

All strategies are explained in terms of organisation, operations and financial schemes. The organisation and the operations will be explained below. The financial scheme will not be elaborated because this would be different for every strategy.

At this moment, only the Operational Gross Lease (Circular Economy) fulfils the requirements of the Circular Economy, see figure 69. This is the only strategy in which clients can procure in performances. In all other cases the client is in some degree responsible for the components and/or materials that are needed. In all those cases one cannot speak about performances, because the one who is responsible for the performance is the client itself. This is the same when the client is responsible for the product.

Figure 69: The Performance-Service System



What are operations of a Performance-Service System?

Phases

The Performance-Service System cannot be explained by one model. First of all, from a client perspective, there are three phases that need to be taken into account. These phases are the initiative, usage, and the end of loop phase. Short descriptions of those phases are given below:

Initiative

The client and/or user have new requirements regarding facilities. The client will write these requirements down and it will be tendered towards the market. This phase includes the moment of taking components or the performance.

Usage

During this phase the user and the client will use the performance or product provided. The provider or maintenance provider should sustain the required level of performance.

End of Loop

The performance is no longer needed or components must be replaced in order to fulfil new requirements. The used components will be brought back into a system.

How does one organise a Performance-Service System?

Provider of performance (P)

- Provides components to get the required performance
- Guarantees performance level will be maintained during the years
- Obligation payments towards maintenance provider
- Relation with client, the maintenance provider and the supply chain where performances are being produced
- Provides feedback on the component of a performance towards supply chain

Maintenance provider (M)

- Delivers maintenance to sustain required performance level
- Close contact with provider of performance
- Obligation to maintain components used by client and user
- Relation with the provider of performances and the client
- Provides feedback on the component of a performance to the provider

Client (C)

- Works on behalf of the users (the client can also be a user in itself)
- Obligation payments towards provider
- Relation with the provider of performances, maintenance provider, and the users
- Provides feedback on the performance to the provider and the maintenance provider

User (U)

- User of the performance
- Differs by organisation what the responsibility level of the user is
- Relation with the client
- Provides feedback performance towards clients

Dismantler performance (D)

- Dismantles components of the performance
- Responsible to bring components back towards the interested agreed stakeholder
- Relation with provider
- Gives feedback component performance towards provider

Conclusions with respect to the client

What are the costs to organise a Performance-Service System at universities?

When looking at the cash flows schemes developed in chapter 4 one could see that investing in components that implement principles of the Circular Economy and the Performance-Service System will be more expensive than components with respect to current market prices. However, one should keep other values in mind when choosing for a Performance-Service System:

- The quality of components is going to be higher
- The reusability of components will be higher

- Waste is designed out as much as possible
- The primary processes will suffer little from maintenance activities due to higher quality components

Can a performance fulfil the requirements of the Circular Economy and be financially beneficial for the client?

At this moment the Circular Economy cannot be financial beneficial from client perspective. It can support other primary processes and therefore support requirements of the client. But agreements must be developed. Furthermore a lot depends on trust between the provider and the client.

Is the educational sector willing to use a Performance-Service System?

Opinions regarding leasing differ. Some employees of FMVG mention that the organisation will change their behaviour in future construction developments, but still there is some doubt about the implementability of leasing instead of buying components and/or materials. One of the obstacles is not knowing if the provider is integer. There are some concerns about the integrity of the provider.

What is the vision of the client and how does a Performance-Service System fit this vision?

The Delft University of Technology has high ambitions with respect to sustainability. They believe that universities have a moral obligation to educate the sustainability professionals of tomorrow. Secondly, it wants to be an example for visitors. The ultimate goal of the university is to develop buildings that do not negatively impact the environment.

After conducting interviews with employees of FMVG it became clear that the ambitions are indeed high, but in reality there is still a lot to do. First of all, a good policy must be developed with respect to the real estate and constructions of the Delft University of Technology. Secondly, at this moment the university will only look at reduction of carbon emissions. All measures the university is implementing at the campus are with respect to the reduction of CO₂. Therefore opinions differ about Performance-Service Systems. Some are willing, but others argue that the market is not ready to implement Performance-Service Systems.

What are the needs of the educational sector regarding leasing/buying of construction components?

Two main concerns include the transparency and the integrity of providers in the market. If commercial companies overcome these issues, then the educational sector would be willing to lease.

Regarding the principles of the Circular Economy, is outsourcing better than owning a performance?

It depends on the client if outsourcing would be better than owning performances. For an organisation such as the Delft University of Technology it could also be an opportunity to set up their own end-of-loop department. Used materials can be transferred to faculties for research

CONCLUSIONS, RECOMMENDATIONS, AND REFLECTION

purposes. In this case the Delft University of Technology would be responsible for implementing the principles. Other opportunities lay in outsourcing performances. Than the responsibility to implement the principles of the Circular Economy lies at the selected provider.

What are initial costs of a performance? / What is the residual value of a performance?

Due to the lack of data regarding the Circular Economy in the built environment no answers can be given to both questions. First of all, a set of measurable variables must be developed.. Furthermore data of providers what initial costs will be. What are risks involved and how will they quantify these risks?

Does a Performance-Service System fit the demand of a client best?

It depends on the wishes and requirements of the client whether the Performance-Service System fits the needs best. Although the Performance-Service System implements all principles of the Circular Economy it is not stated that this system is therefore best regarding sustainability issues.

Looking at FMVG it can be concluded that the Performance-Service System does not fulfil the requirements of this organisation. In this case the strategy of 'Buy (Circular Economy)' would fulfil the needs best, see figure 70.

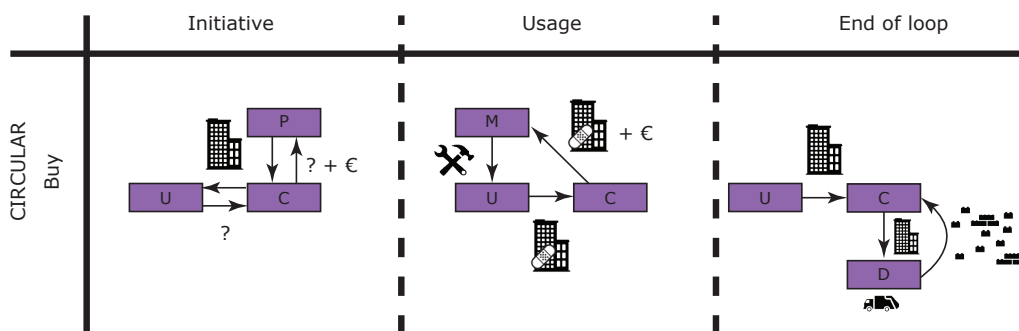


Figure 70: Strategy - Buy (Circular Economy)

Answering the main research question

How to develop and implement a Performance-Service System in constructions of the educational sector regarding operations, organisation and financial schemes?

There is no simple answer to this research question. How to implement the Performance-Service System depends on a few variables, such as principles of the Circular Economy, context of the client, the operations, organisation and financial schemes. Therefore every aspect of this research question will be briefly discussed:

Performance-Service System

The Performance-Service System is a marketable and sustainable set of performances and services capable of jointly fulfilling a user's need.

Whereas a performance is an agreed action of performing that results in an utility,

goal, function, or commitment whereby a product is not a goal in itself, but subordinate to the performance. Secondly, the service is mainly a non-physical action or operation whereby the performance is extended or optimized over time. The service cannot be produced or consumed in itself and is subordinate to the performance. And at last, the system is an integrated mix of performances, and the subordinate products and services needed, and the communication required between client and provider.

According to the principles of the Circular Economy the best strategy would be to use an Operational Gross Lease. It depends on the clients wishes and requirements if this strategy fits the needs best.

Clients - the educational sector

The test case was conducted at the Delft University of Technology. The university has a huge ambition with respect to sustainability, but at this moment this only includes the reduction of carbon emissions. In addition to the ambition regarding sustainability Delft University of Technology develops and manages its own real estate. If Delft University of Technology wants to change towards the Circular Economy by implementing Performance-Service Systems than the following aspects should be taken in consideration:

- Change within the organisation towards contract management
- Decreasing ownership of components

Furthermore, the client has a responsibility towards the provider when using the required performance. Users have a lot of requirements and wishes, but they also need a change in their mind-set regarding Circular Economy. This means that there is a probability that the users must be educated in their behaviour regarding performances.

Conclusion

As a final conclusion, the model will not support decisions in its current state. There are several options to optimize this model:

- Add a pros and cons list per strategy. According to Koopmans this list could help to base your decisions on.
- The development of other models that support this model. One can think of a decision tree or multi-criteria-models.

The content of the model is good, but in order to operationalize this model a few modifications need to be made. It can be said, due to the model the discussion about the Circular Economy is stimulated. It gives, by using relatively simple figures, a good illustration of what the Circular Economy is all about. Although it does not support decisions in its current state, the model gives a lot of different insights of the Circular Economy in the Dutch educational sector.

As a final step of this graduation project a checklist is developed. This checklist was tested at Gilde Opleidingen. It can be concluded that the checklist is a good first attempt to operationalize the Circular Economy in practice. Therefore this study stimulates research relating to this subject. Hopefully, this study can serve as a base for future researches.

REFLECTION

In this reflection I will elaborate on my experiences and study goals set up in the beginning of this graduation project.

Relationship research and the Performance-Service System

This research and the design of the Performance-Service System cannot be seen as two static elements. Both are developed simultaneously and both complemented each other during this graduation project. Due to the iterative process it was possible to easily complement both aspects of this thesis.

The research part consisted of a literature review and interviews from a test case. During the literature review it became clear that a lot of the Circular Economy was still underexposed in the scientific field. Not many articles have been written about the Circular Economy and especially not within the boundaries of the built environment. This made it hard to find common ground in the scientific field. Secondly, this made me think about definitions that should be used in the Circular Economy, because there is not a good definition given within this field. By clearing the definitions of the Circular Economy it was possible to reflect on the Performance-Service System. The Performance-Service System could be tested and compared to what was written.

Methodology and the Performance-Service System

Due to the novelty of this research in the field some obstacles had to overcome. First of all there was the lack of existing literature that would cover this field in the real estate and construction sector. In this case I was fortunate to have two experts of Circular Economy who were willing to advice me through the entire graduation project. Because a lot of research must be done in the field of Circular Economy one should be careful that he/she will not get lost in the broad, but very interesting topic.

After setting up my research design I started conducting interviews in order to understand the principles of the Circular Economy. Furthermore those interviews were very insightful regarding obstacles and opportunities that the Performance-Service System provides. But one should be aware of the communication style between interviewer and interviewee, because in the field many definitions can be found of the Circular Economy. In a lot of cases one simply thinks in terms of 'cradle-to-cradle', although the Circular Economy encompasses also the economical part of our society.

Furthermore the theme of the Performance-Service System created flexibility in how to study this subject. However, as mentioned before, one should be careful not to lose oneself in the broad concept of Circular economy. During the process this was an incentive to choose my focus very fast. But due to new insights I would not recommend to focus too much. When focussing too much in such a new topic, one sets up too much boundaries and creativity, which a new subject requires, will find a dead end.

At last, I want to elaborate on the used methods during the graduation project. One of the core methods used is sketching and drawing new insights on a sketch role. It was advised by my mentor to use the sketch role, which I had used a lot during the Bachelor. It helped to figure out

thoughts, organise and structure them in order to communicate them to others (interviewees, mentors, and other interested). It was also fruitful to switch between several layers of the design in order to reflect, evaluate and adapt the model when necessary. One should note that this was not the only method used. A good interaction was sought between the sketch role and other media instruments.

Circular Economy and the graduation Lab Design & Construction Management

Together with Werner Loppies and Zakariya Chebli we are the first group at the faculty of Architecture and the Built Environment at the Delft University of Technology graduating at the topic of Circular Economy. Students, even mentors were not familiar with this topic. For both actors it was sometimes difficult to understand the matter. During the whole process everyone learned from each other by discussing this topic a lot. Every session new findings or thoughts were shared until we got to the core of the Circular Economy in the built environment.

The Circular Economy fits partly the graduation lab of Design & Construction Management. This is not too shocking, because it is a very broad subject and has links with every lab on the faculty of Architecture and the Built Environment and even beyond this faculty. The Circular Economy would affect whole societies if implemented. Therefore a second mentor in another field is advisable.

I had the opportunity to link my graduation with a research of two PhD-students at the faculty of Architecture and the Built Environment. Both study this subject within the boundaries of the built environment. Therefore thoughts could be shared and I could learn from all preparations they had done for their own research.

Although the subject is new at the Faculty of Architecture and the Built Environment I would recommend other students and researchers to study this subject more thoroughly. There is a need in our society to alter our economic system. The Circular Economy could be the solution to all issues.

A Performance-Service System

One of the hardships of this subject is the exploring phase. It takes a lot of time in order to get grip on the subject. Due to the lack of information and scientific evidence, it was hard to devise a result for this graduation project. Difficulties in finding a relevant end result were part of a major part of this graduation project.

In addition to the model that is elaborated in this report, I wanted to design a decision support model. One could think of a multi-criteria model or a decision tree. Due to lack of time and boundaries of this graduation such a model is not developed. Therefore I would like to see if new graduate students could develop these models.

At last, I am proud of what is developed. This model shows a lot of various insights regarding the Circular Economy in the built environment. First of all a lot of different opportunities have been shown. Tools and thoughts on how to make a transition in our economic system have been explored. Furthermore obstacles are exposed and therefore new students can explore for solutions of these obstacles.

Another advantage of this model is that it made it possible to communicate with stakeholders and made them clear what the Circular Economy is all about. By using figures a lot of the Circular Economy became clear to all people spoken to.

During the graduation research a lot of sustainable measures inspired me. However, not

CONCLUSIONS, RECOMMENDATIONS, AND REFLECTION

all my thoughts could be written down in this report. Therefore I committed myself to start a foundation with fellow students in order to stimulate research in the field of Circular Economy. As this moment, the group of students and professionals who are interested in this topic is growing. There is certainly a demand for more knowledge within this field. Hopefully my study can contribute to this knowledge.

Recommendations

A lot of recommendations can be given with respect to the Circular Economy in the built environment. This part will be divided in two parts. First of all a detailed recommendation will be given regarding the Performance-Service System. Furthermore, a list of subjects that need further exploration will be provided.

Recommendation with respect to the Performance-Service System

The Performance-Service System gives insights about opportunities and obstacles of the Circular Economy in the construction sector. However in order to develop a model that would be implementable in practice a few modifications must be made. One small attempt is already done in this report regarding a checklist. The following models can be developed with the Performance-Service System as a basis. All models must contribute to the decision making process of a client in order to fulfil their needs.

The checklist

The model could be transferred into a checklist. This checklist must be guidance for clients in order to check whether they are implementing principles of the Circular Economy within their own organisation. A few questions must be answered during the development of the checklist:

- Is every question measurable?
- Does the order of questions support the understanding of the Circular Economy and the chosen strategy?

A multi-criteria model

The strategies of the model can be used to develop a multi-criteria model. A multi-criteria model could support decisions of a client regarding their own facilities and the Circular Economy. When developing such a model the measurability of aspects becomes even more important in comparison with the checklist. The following questions may contribute to develop this model:

- How to quantify different aspects of the Circular Economy?
 - For example: how to quantify the reuse of components?
 - For example: how to quantify soft factors?
- What aspects are of primary importance and what aspects of secondary?
- What are different kinds of multi-criteria models?

A disadvantage and advantage list

Another option to optimize the Performance-Service System would be adding an (dis)-advantage list. What are advantages in choosing one strategy over another? What are obstacles and opportunities with respect to the Circular Economy and primary processes? One of the main questions is how a strategy is optimally supporting the primary processes of this organisation?

Cash flow schemes

The abstract cash flow schemes of the different strategies are mapped in the model. However, it

lacks calculations. Therefore a study with respect to the calculations would be advisable in order to gain detailed insights regarding the Performance-Service System. A small attempt has been made, as can be seen in appendix BB, but it lacks repetition and the foundation to scientifically prove the concept of the Circular Economy.

Recommendation with respect to the Circular Economy

The Circular Economy is a concept that combines theories from different sustainable perspectives. However, because it includes a lot of different principles one could discuss the foundations of the Circular Economy. The following questions come to mind when discussing the Circular Economy:

- What does the Circular Economy mean in the construction sector?
- Is outsourcing better than owning components or materials from client perspective?
- Is the smallest loop the most sustainable loop?
- Is the smallest loop the most resource efficient loop?
- Is it possible for all stakeholders to benefit?
- Is the Circular Economy really going to work?
- What kind of alterations are needed in society in order to make the transition towards the Circular Economy?
- Clarity of definitions
- What kind of influence does the law have on implementing principles of the Circular Economy?
- How does the Circular Economy influence primary processes of organisations?
- How does the Circular Economy influence user satisfaction?

Recommendations with respect to other means and studies

The Circular Economy influences whole society. Therefore a lot of studies can be done outside the scope of this research project. A list of possible studies can be seen below:

- Labels of the Circular Economy regarding companies
- Financial schemes regarding clients, but also regarding providers
- Contracts that will sustain Circular Economy principles
- Tools and means are necessary in order to monitor performances
- Tools and means are necessary in order to monitor the loop back
- Integrity measurement tools
- Calculation models such as Life Cycle Costing or Life Cycle Assessments that integrate principles of the Circular Economy
- Means that could help clients to educate users
- Service-Level Agreements that implements principles of the Circular Economy

Recommendations regarding the novelty of this subject

During this graduation project several findings were noted. These findings are related to the Circular Economy in the construction sector:

- A lot is happening, but almost nothing is written down or communicated
- Lack of scientific evidence
- Although there is an urgency for companies to implement principles of the Circular

Economy, commercial companies are restrained on co-operation

- Within a short period we were the experts
- Avoid the use of jargon
- In a lot of cases the context of the research had to be explained
- There is a growing need for means

There were also some obstacles:

- Jungle of definitions
- The definition of the 'Circular Economy' is too broad
- Based on a lot of different sustainable movements
- A lot of variables
- No clear definition of the Circular Economy
- Therefore it also lacks a definition in the construction sector
- 'Circular economy' is becoming a buzz-word
- Everybody got its own opinion about this definition
- It is a mean and not a goal in itself
- This definition goes beyond just the project, it also includes processes
- Dynamic process of doing research
- Lack of valid cases
- How can you select cases on the criteria of 'Circular Economy'?

Recommendations regarding the process of graduation projects

Studies in the Circular Economy can be very difficult due to a lot of different opinions, unclarity about definitions, and the uncertainties regarding this concept. Therefore a few recommendations with respect to the process:

- Do not lose yourself in:
 - Literature
 - Opinions of different experts
- Develop you own opinion;
- Develop your own definitions as soon as possible if the current literature is not satisfying;
- Do not focus too soon or too late;
- Try to structure your work;
 - Especially in writing it down, otherwise you will find yourself confused about your own words
- Be aware that conducting research on one subject for the next half of a year is quite long;
- Choose your subject wisely;
- Do not be afraid to step up to people and talk;
- It is okay to look beyond the borders of your own sector as long as you do not lose yourself;
- Although it is fantastic subject:
 - There is lack of time to study everything
 - Planning is crucial

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APPENDICES

APPENDIX A: List of interviewees

Interviews

Anja Stokkers (director FMVG – TU Delft)
Rob Weststrate (Maintenance and management FMVG)
Catelijne Elissen (Real Estate & Campus developer FMVG)
Tom Wiardi (Project Manager FMVG)
Chris Hellinga (Delft Energy Initiative)
Ad Winkels (Policy on sustainability FMVG – TU Delft)
Atse Koopman (Contract management FMVG)
Robert van Barneveld (UMC Utrecht)

Validation

Ad Winkels (Policy on sustainability FMVG – TU Delft)
Atse Koopman (Contract management FMVG)
Niel Slob & Saman Mohammadi
Dick van Gasselt (Chief accomodations)

Test case: Gilde Opleidingen

Dick van Gasselt (Chief accomodations)
Krista Theelen (Faciltair manager)

APPENDIX B: Interview scheme employees FMVG

Algemeen

- 1). Mag ik dit gesprek opnemen?
- 2). Lineair vs. Circulair
- 2). U heeft nu het verhaal over PSS en CE gehoord, heeft u daar nog vragen over?
- 3). Als u vragen hebt, dan graag stellen. Dat helpt mij met het verbeteren van mijn communicatie.
- 4). Lijkt u het leuk en interessant om nog een keer of twee met mij te zitten zodat dit model gereflecteerd, verbeterd kan worden?

Model (1)

- 1). Vanuit dit perspectief gaat FMVG zonwering leasen. Is FMVG bereid dat te doen?
Hoe staat FMVG ertegenover dat de aanbieder de eigenaar blijft van zonwering?
- 2). Welke prestatie-eisen/KPI's gebruiken jullie om zonwering in te kopen?
- 3). Doen jullie alles op basis van prestatie-eisen/KPI's?
- 4). Hoe gaan jullie om met innoverende oplossingen?
In hoeverre hebben jullie mogelijkheden om innovaties te eisen aan de huidige bouwindustrie?
Welke middelen hebben jullie tot jullie beschikking?
- 5). Welke KPI's zouden extra opgenomen moeten worden voor dit systeem?
- 6). Welke informatie is daarvoor nodig?
Kijken jullie bijvoorbeeld naar de life-cycle costs van een materiaal?
- 7). Zal FMVG dat gaan doen (nu of in de toekomst)?
- 8). Bestaat de terugkoppeling loop?
- 9). Hoe ziet FMVG dit voor zich?
- 10). Hoelang zal FMVG contractduren aangaan?
- 11). Als u prestatie-eisen opstelt, zijn er verschillen bestaan tussen nieuwbouw (TNW) en bestaande bouw (CT)?
- 12). Denkt u dat FMVG dit model zou kunnen gebruiken bij CITG en TNW?
- 13). Welke informatie hebben jullie als organisatie nodig om voor een duurzame beslissing te kiezen? (vraag door op footprint)
Op wat voor een manier willen jullie informatie hebben over de footprint?
Zal FMVG in de toekomst naar de footprint gaan kijken?
- 14). Er wordt van FMVG verwacht dat jullie een grote mate van betrokkenheid tonen om de prestatie te verbeteren. Hoe zal FMVG dat gaan doen? Bestaat die terugkoppeling wel?

Model (2)

- 1). Vanuit de gedachte van FMVG. Zal de aanbieder de onderhoudsaanbieder selecteren of doet FMVG dat zelf?
- 2). Zit daar dan alleen klein onderhoud in?
- 3). De terugkoppelingsloop. Willen jullie dat als FMVG via de aanbieder laten lopen of direct met de onderhoudsaanbieder? En waarom?
- 4). Welke vorm van lease zou het beste bij FMVG passen (bruto, netto, hybrid, expense

stop)?

5). Gebruiken jullie voor de onderhoudsaanbieder nog extra prestatie-eisen of zijn dat dezelfde als bij de prestatie en is dit onderdanig aan de prestatie?

Model (3)

1). Hoe interessant is de ontkoppeling van de prestatie voor jullie?

2). Willen jullie daar sturing op hebben?

3). Welke middelen heeft FMVG om hierop aan te sturen?

Is het terugbrengen van componenten in de markt controleerbaar?

4). Wie gaat daar verantwoordelijk voor zijn? Een externe partij of een nieuwe afdeling van FMVG?

5). Gaat de terugkoppeling via FMVG of rechtstreeks naar de aanbieder?

Slot

1). Heeft u nog algemene opmerkingen over mijn model?

**Right: Lease -
traditional component**

Left: Lease - CE Component

CE Component (without loan)	Year	Cash Flows										Totals		NPV C
		PMT (Lease)	Residual Value	Concessions	Maintenance costs	Payment	Principal	Interest	OLB (Begin)	OLB (End)	Total costs	PV		
	2013	C	-		€	-	€	-	€	-	€	-	-	563,492
	2014	C	-		€	-	€	-	€	-	€	-	€	
	2015	C	-		€	-	€	-	€	-	€	-	€	
	2016	C	-		€	-	€	-	€	-	€	-	€	
	2017	C	7,403		€	-	€	-	€	-	€	7,403	6,086	
	2018	C	22,291	0	€	-	€	-	€	-	€	22,291	17,449	
	2019	C	36,064	0	€	-	€	-	€	-	€	36,064	28,371	
	2020	C	39,767	0	€	-	€	-	€	-	€	39,767	28,224	
	2021	C	41,538	0	€	-	€	-	€	-	€	41,538	28,072	
	2022	C	43,380	0	€	-	€	-	€	-	€	43,380	27,915	
	2023	C	45,296	0	€	-	€	-	€	-	€	45,296	27,755	
	2024	C	47,290	0	€	-	€	-	€	-	€	47,290	27,592	
	2025	C	49,364	0	€	-	€	-	€	-	€	49,364	27,425	
	2026	C	51,520	0	€	-	€	-	€	-	€	51,520	27,255	
	2027	C	53,764	0	€	-	€	-	€	-	€	53,764	27,082	
	2028	C	56,098	0	€	-	€	-	€	-	€	56,098	26,907	
	2029	C	58,526	0	€	-	€	-	€	-	€	58,526	26,730	
	2030	C	61,051	0	€	-	€	-	€	-	€	61,051	26,550	
	2031	C	63,678	0	€	-	€	-	€	-	€	63,678	26,369	
	2032	C	66,410	0	€	-	€	-	€	-	€	66,410	26,186	
	2033	C	69,252	0	€	-	€	-	€	-	€	69,252	26,001	
	2034	C	72,209	0	€	-	€	-	€	-	€	72,209	25,815	
	2035	C	75,284	0	€	-	€	-	€	-	€	75,284	25,628	
	2036	C	78,483	0	€	-	€	-	€	-	€	78,483	25,440	
	2037	C	81,810	0	€	-	€	-	€	-	€	81,810	25,251	
	2038	C	87,160	0	€	-	€	-	€	-	€	87,160	19,738	
	2039	C	34,489	0	€	-	€	-	€	-	€	34,489	9,652	

CE Component (without loan)	Year	PMT (Lease)	Residual Value	Concessions	Maintenance costs	Payment	Principal	Interest	OLB (Begin)	OLB (End)	Total costs	PV	NPV	
													C	563,492
2013	C	-	-	-	-	€ -	€ -	€ -	€ -	€ -	€ -	€ -	-	-
2014	C	-	-	-	-	€ -	€ -	€ -	€ -	€ -	€ -	€ -	-	-
2015	C	-	-	-	-	€ -	€ -	€ -	€ -	€ -	€ -	€ -	-	-
2016	C	-	-	-	-	€ -	€ -	€ -	€ -	€ -	€ -	€ -	-	-
2017	C	7,403	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 7,403	€ 6,086	-	-
2018	C	22,291	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 22,291	€ 17,449	-	-
2019	C	38,064	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 38,064	€ 28,371	-	-
2020	C	39,767	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 39,767	€ 28,224	-	-
2021	C	41,538	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 41,538	€ 28,072	-	-
2022	C	43,380	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 43,380	€ 27,915	-	-
2023	C	45,296	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 45,296	€ 27,755	-	-
2024	C	47,290	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 47,290	€ 27,592	-	-
2025	C	49,364	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 49,364	€ 27,425	-	-
2026	C	51,520	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 51,520	€ 27,255	-	-
2027	C	53,764	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 53,764	€ 27,082	-	-
2028	C	56,098	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 56,098	€ 26,907	-	-
2029	C	58,526	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 58,526	€ 26,730	-	-
2030	C	61,051	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 61,051	€ 26,550	-	-
2031	C	63,678	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 63,678	€ 26,369	-	-
2032	C	66,410	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 66,410	€ 26,186	-	-
2033	C	69,252	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 69,252	€ 26,001	-	-
2034	C	72,209	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 72,209	€ 25,815	-	-
2035	C	75,284	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 75,284	€ 25,628	-	-
2036	C	78,483	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 78,483	€ 25,440	-	-
2037	C	81,810	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 81,810	€ 25,251	-	-
2038	C	84,160	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 84,160	€ 19,738	-	-
2039	C	34,489	-	0	-	€ -	€ -	€ -	€ -	€ -	€ 34,489	€ 9,652	-	-

Right: Buy-Buy back - traditional component

Left: Buy-buy back CE Component

Reproduction component Year		Initial purchase price	Concessions	Maintenance costs	Payment	Principal	Interest	OLB (Begin)	OLB (End)	Buy Back	Total costs	PV	NPV
2013				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	
2014				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	
2015				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	
2016				€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	
2017	€	28.299		€ 224	€ 37.426	€ 25.187	€ 12.239	€ 611.973	€ 586.786	€ -	€ 65.949	€ 54.215	
2018	€	53.231		€ 231	€ 37.426	€ 23.691	€ 11.736	€ 586.786	€ 561.095	€ -	€ 90.888	€ 71.146	
2019	€	51.706		€ 238	€ 37.426	€ 26.204	€ 11.222	€ 561.095	€ 534.891	€ -	€ 89.370	€ 66.613	
2020				€ 245	€ 37.426	€ 26.728	€ 10.698	€ 534.891	€ 508.163	€ -	€ 37.671	€ 26.736	
2021				€ 252	€ 37.426	€ 27.263	€ 10.163	€ 508.163	€ 480.900	€ -	€ 37.678	€ 25.463	
2022				€ 260	€ 37.426	€ 27.808	€ 9.618	€ 480.900	€ 453.091	€ -	€ 37.686	€ 24.251	
2023				€ 268	€ 37.426	€ 28.364	€ 9.062	€ 453.091	€ 424.727	€ -	€ 37.694	€ 23.097	
2024				€ 276	€ 37.426	€ 28.932	€ 8.495	€ 424.727	€ 395.795	€ -	€ 37.702	€ 21.997	
2025				€ 284	€ 37.426	€ 29.510	€ 7.916	€ 395.795	€ 366.285	€ -	€ 37.710	€ 20.950	
2026				€ 292	€ 37.426	€ 30.101	€ 7.326	€ 366.285	€ 336.184	€ -	€ 37.719	€ 19.954	
2027				€ 301	€ 37.426	€ 30.703	€ 6.724	€ 336.184	€ 305.482	€ -	€ 37.727	€ 19.004	
2028				€ 310	€ 37.426	€ 31.317	€ 6.110	€ 305.482	€ 274.165	€ -	€ 37.736	€ 18.100	
2029				€ 319	€ 37.426	€ 31.943	€ 5.483	€ 274.165	€ 242.222	€ -	€ 37.745	€ 17.229	
2030				€ 329	€ 37.426	€ 32.582	€ 4.844	€ 242.222	€ 209.641	€ -	€ 37.755	€ 16.419	
2031				€ 339	€ 37.426	€ 33.233	€ 4.193	€ 209.641	€ 176.407	€ -	€ 37.765	€ 15.638	
2032				€ 349	€ 37.426	€ 33.898	€ 3.528	€ 176.407	€ 142.509	€ -	€ 37.775	€ 14.895	
2033				€ 360	€ 37.426	€ 34.576	€ 2.850	€ 142.509	€ 107.933	€ -	€ 37.786	€ 14.187	
2034				€ 370	€ 37.426	€ 35.268	€ 2.159	€ 107.933	€ 72.665	€ -	€ 37.797	€ 13.513	
2035				€ 381	€ 37.426	€ 35.973	€ 1.453	€ 72.665	€ 36.692	€ -	€ 37.808	€ 12.871	
2036				€ 393	€ 36.692	€ 35.959	€ 734	€ 36.692	€ 734	€ 32.495	€ 31.357	€ 12.021	
2037				€ 405	€ 734	€ 719	€ 15	€ 734	€ 15	€ 61.125	€ 60.693	€ 9.678-	
2038				€ 417	€ 15	€ 14	€ 0	€ 15	€ 0	€ 17.838-	€ 17.838-	€ 16.495-	
2039				€ 429	€ 0	€ 0	€ 0	€ 0	€ 0	€ 59.373	€ 58.944	€ 16.495-	

CE Component													
Year	Initial purchase price	Concessions	Maintenance costs	Payment	Principal	Interest	OLB (begin)	OLB (End)	Buy Back	Total costs	PV	NPV	
2013	35,745 67,237 65,311	€	-	€	-	€	-	€	€	-	€	€ 496,034	
2014		€	-	€	-	€	-	€	€	-	€		
2015		€	-	€	-	€	-	€	€	-	€		
2016		€	-	€	-	€	-	€	€	-	€		
2017		€	224	€	41,169	27,705	€	13,463	673,170	€	77,138		€
2018		€	231	€	41,169	28,260	€	12,909	645,465	€	108,637		€
2019		€	238	€	41,169	28,825	€	12,344	617,205	€	106,717		€
2020		€	245	€	41,169	29,401	€	11,768	588,380	€	106,717		€
2021		€	252	€	41,169	29,989	€	11,180	558,979	€	106,717		€
2022		€	260	€	41,169	30,589	€	10,580	528,990	€	106,717		€
2023	€	268	€	41,169	31,201	€	9,968	498,401	€	106,717	€		
2024	€	276	€	41,169	31,825	€	9,344	467,200	€	106,717	€		
2025	€	284	€	41,169	32,461	€	8,707	435,375	€	106,717	€		
2026	€	292	€	41,169	33,111	€	8,058	402,914	€	106,717	€		
2027	€	301	€	41,169	33,773	€	7,396	369,803	€	106,717	€		
2028	€	310	€	41,169	34,448	€	6,721	336,030	€	106,717	€		
2029	€	319	€	41,169	35,137	€	6,032	301,582	€	106,717	€		
2030	€	329	€	41,169	35,840	€	5,329	266,445	€	106,717	€		
2031	€	339	€	41,169	36,557	€	4,612	230,605	€	106,717	€		
2032	€	349	€	41,169	37,288	€	3,881	194,048	€	106,717	€		
2033	€	360	€	41,169	38,034	€	3,135	156,760	€	106,717	€		
2034	€	370	€	41,169	38,794	€	2,375	118,726	€	106,717	€		
2035	€	381	€	41,169	39,570	€	1,599	79,932	€	106,717	€		
2036	€	393	€	40,362	39,554	€	807	40,362	€	106,717	€		
2037	€	405	€	807	791	€	16	807	€	106,717	€		
2038	€	417	€	16	16	€	0	16	€	106,717	€		
2039	€	429	€	0	0	€	0	0	€	106,717	€		
										Buy Back	Total costs	PV	NPV
										€	€	€	€
										€	€	€	€
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APPENDIX D: Checklist Performance-Service System - Furniture

Finance

Yes No N/a ?

1). Does the client have ambitions regarding principles of the Circular Economy (sustainability)?

☒ ☐ ☐ ☐

2). Is the client willing to take responsibility for the components with respect to principles of the Circular Economy?

☐ ☐ ☐ ☒

3). Does the client want control or wants to be care-free with respect to principles of the Circular Economy?

4). Is the client willing to make extra investments regarding principles of the Circular Economy?

☐ ☒ ☐ ☐

5). Is it possible for the client to get a loan from the Ministry of Finance?

☐ ☒ ☐ ☐

6). Are there subsidies available with respect to the required performance?

☐ ☒ ☐ ☐

7). In the context of the client being the owner of the components/materials. Is the client willing to invest to keep the required performance during the usage phase?

☐ ☒ ☐ ☐

Organisation & Operations

6a). Does the pre-arranged owner of the components have one of the following business cases with respect to the components and Circular Economy?

- Cradle-to-cradle components (certification of cradle-to-cradle/biodegradable materials)

☐ ☐ ☐ ☒

- Reuse components/materials on location

☐ ☐ ☐ ☒

- Reuse components/materials in an alternative cascade

☐ ☐ ☐ ☒

- Components/materials will be optimized for user after usage

☐ ☐ ☐ ☒

- Reuse of components/materials within the organisation of the owner

☐ ☐ ☐ ☒

- An interested buyer for the components/materials

☐ ☐ ☐ ☒

- Another business case what implements principles of the Circular Economy:.....

☐ ☐ ☐ ☒

	Yes	No	N/a	?
6b). Components are designed to be reversible, adaptable, demountable and/or biodegradable so they can support above mentioned business case?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
6c). Does the client use means to check the origin from materials?				
- Materials pasport?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Cradle-to-cradle certification?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Other means:.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
7). Provider is transparant about costs and information with respect to the business case?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8). Renewable energy resources are used during:				
- Production	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Initiative phase	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Usage	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
- End-of-loop	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Warranty				
9). Is the provider willing to give guarantees with respect to principles of the Circular Economy?				
- warranty	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Letter of intent	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10a). Is the provider willing to sign a guarantee document with respect to the 'buy back' of components?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10b). If not, is the provider willing to sign an intention document with respect to the 'buy back' of the components?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11). Are agreements established between owner and maintenance provider with respect to principles of the Circular Economy (example: Service-Level Agreement)?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Yes No N/a ?

User

10). From client perspective - Are principles of the Circular Economy implemented in the Code of Conduct from the organisation?

☒
☒
☐
☐

11). Is the client going to give education about the following aspects with respect to the Circular Economy?

- Does the client inspire users regarding the Circular Economy?

☐
☒
☐
☐

- Does the client inform users about the Circular Economy?

☐
☒
☐
☐

- Does the client stimulate users to implement principles of the Circular Economy in their daily routine?

☐
☒
☐
☐

- Does the client support the image, status and activities by implementing the Circular Economy?

☐
☒
☐
☐

APPENDIX E: Checklist Performance-Service System - Solar Panels

Finance

Yes No N/a ?

1). Does the client have ambitions regarding principles of the Circular Economy (sustainability)?

☒☐☐☐

2). Is the client willing to take responsibility for the components with respect to principles of the Circular Economy?

☒☐☐☐

3). Does the client want control or wants to be care-free with respect to principles of the Circular Economy?

Care-free

4). Is the client willing to make extra investments regarding principles of the Circular Economy?

☒☐☐☐

5). Is it possible for the client to get a loan from the Ministry of Finance?

☒☐☐☐

6). Are there subsidies available with respect to the required performance?

☒☐☐☐

7). In the context of the client being the owner of the components/materials. Is the client willing to invest to keep the required performance during the usage phase?

☒☐☐☐*Organisation & Operations*

6a). Does the pre-arranged owner of the components have one of the following business cases with respect to the components and Circular Economy?

- Cradle-to-cradle components (certification of cradle-to-cradle/biodegradable materials)

☐☐☐☒

- Reuse components/materials on location

☐☐☐☒

- Reuse components/materials in an alternative cascade

☐☐☐☒

- Components/materials will be optimized for user after usage

☐☐☐☒

- Reuse of components/materials within the organisation of the owner

☐☐☐☒

- An interested buyer for the components/materials

☐☐☐☒

- Another business case what implements principles of the Circular Economy:.....

☐☐☐☒

	Yes	No	N/a	?
6b). Components are designed to be reversible, adaptable, demountable and/or biodegradable so they can support above mentioned business case?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
6c). Does the client use means to check the origin from materials?				
- Materials passport?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Cradle-to-cradle certification?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Other means:.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
7). Provider is transparent about costs and information with respect to the business case?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8). Renewable energy resources are used during:				
- Production	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Initiative phase	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
- Usage	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- End-of-loop	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Warranty				
9). Is the provider willing to give guarantees with respect to principles of the Circular Economy?				
- warranty	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
- Letter of intent	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10a). Is the provider willing to sign a guarantee document with respect to the 'buy back' of components?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10b). If not, is the provider willing to sign an intention document with respect to the 'buy back' of the components?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11). Are agreements established between owner and maintenance provider with respect to principles of the Circular Economy (example: Service-Level Agreement)?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Yes No N/a ?

User

10). From client perspective - Are principles of the Circular Economy implemented in the Code of Conduct from the organisation?

☐ ☒ ☐ ☐

11). Is the client going to give education about the following aspects with respect to the Circular Economy?

- Does the client inspire users regarding the Circular Economy?

☐ ☒ ☐ ☐

- Does the client inform users about the Circular Economy?

☐ ☒ ☐ ☐

- Does the client stimulate users to implement principles of the Circular Economy in their daily routine?

☐ ☒ ☐ ☐

- Does the client support the image, status and activities by implementing the Circular Economy?

☐ ☒ ☐ ☐

APPENDIX F: Warranty buy back (Circular)

As one put it as mentioned above, the take back of furniture by Ahrend seems relatively simple. But in order to guarantee Ahrend will take back its furniture, some agreement must be established. In the Netherlands a distinction is made between a 'buy back guarantee' or a 'buy back intention'. In order to operationalize the taking back of components by a provider some means had to be developed. One can use this means as a checklist or as a warranty.

Warranty – buy back

Goal

An agreement is established between provider of component X and the client of the 'buy back'-part of this strategy. The provider agrees to give a warranty for reusing components. In order to stimulate the reusability of components the provider will provide means and tools.

Parties have agreed on the following:

- 1). Both parties are prepared and have the means to enter a commitment.
- 2). Gilde Opleidingen will coordinate the agreed commitment.
- 3). Parties will propagate the actions of intent within their own spheres of influence.
- 4). Agreements with respect to technical & financial requirements
 - Provider states terms of conditions with regard to taking back of components. The following aspects must be described:
 - Assemble
 - Disassemble
 - Technical specifications with regard to installations
 - Provider describes product specifications:
 - Composition materials and joints of the component
 - Initial durability component based on current state
 - Origin of materials
 - The provider guarantees the take back of XX per cent of the components
 - Provider calculates a 'buy back'-percentage of components during the initial phase and guarantees the percentage towards client
 - Provider and client agree on dissolution conditions
- 5). Agreements with respect to period
 - During the initial phase agree both parties on the period of usage and the take-back moment by the provider.
- 6). Agreements with respect conversations and negotiations
 - Provider continues conversations with client
 - Agreements on conversations and negotiations are established at least one year before the take-back moment
- 7). Agreements with respect to a feasibility study
 - The provider agrees on developing a feasibility study regarding the buy back of components

- The feasibility study has the following requirements
 - Buy back percentage of components
 - Business case for those components
- The feasibility study will be developed during the initiative phase and communicated with the client
- Both parties share costs of the feasibility study

8). Provisions

- Unforeseen circumstances
- Altered circumstances
- Contract purchase

Agreed and signed at (dd/mm/yyyy) in (place).

.....
Legally represented by

.....
(Mailbox)
(zip code) (place)

- The following options can be used as a business case:
 - Cradle-to-cradle (components are biodegradable/certification)
 - Reuse components on location
 - Reuse components in an alternative cascade
 - Components optimized for user
 - Reuse of components within the provider's organization
 - Provider has an interested buyer for components

APPENDIX G: Letter of Intent buy back (Circular)

Goal

An agreement is established between provider of component X and the client of the 'buy back'-part of this strategy. The provider agrees to give a intention for reusing components. In order to stimulate the reusability of components the provider and client will provide means and tools.

Parties have agreed on the following:

- 1). Both parties are prepared and have the means to enter a commitment.
- 2). Gilde Opleidingen will coordinate the agreed commitment.
- 3). Parties will propagate the actions of intent within their own spheres of influence.
- 4). Agreements with respect to technical & financial requirements
 - Provider states terms of conditions with regard to taking back of components. The following aspects must be described:
 - Assemble
 - Disassemble
 - Technical specifications with regard to installations
 - Provider describes product specifications:
 - Composition materials and joints of the component
 - Initial durability component based on current state
 - Origin of materials
 - Provider calculates a 'buy back'-percentage of components one year before the buy back
 - Provider and client agree on dissolution conditions
- 5). Agreements with respect to period
 - During the initial phase agree both parties on the period of usage and the take-back moment by the provider.
- 6). Agreements with respect conversations and negotiations
 - Provider intend to continue conversations with client
 - Agreements on conversations and negotiations are established at least one year before the take-back moment
- 7). Agreements with respect to a feasibility study
 - The provider agrees on developing a feasibility study regarding the taking back of components
 - The feasibility study has the following requirements
 - Estimation of the buy back percentage of components
 - Business case for those components
 - The feasibility study will be developed during the usage phase and communicated with the client
 - The provider is responsible for the costs
- 8). Provisions
 - Unforeseen circumstances
 - Altered circumstances

- Contract purchase

Agreed and signed at (dd/mm/yyyy) in (place).

.....
Legally represented by

.....
(Mailbox)
(zip code) (place)

- The following options can be used as a business case:
 - Cradle-to-cradle (components are biodegradable/certification)
 - Reuse components on location
 - Reuse components in an alternative cascade
 - Components optimized for user
 - Reuse of components within the provider's organization
 - Provider has an interested buyer for components

