Suppliers going circular

An examination of the transition from product-based business models to a performance-based business model in the construction industry.

master thesis R. Stigter

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Acknowledgements

Exactly one year ago I started the graduation process at the faculty of Architecture at the Delft University of Technology. After an interesting year the research has finally been finished. With this graduation a study period of 5.5 years come to an end. Proud as I am, I need to thank many for their support during this period.

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Ruud Stigter
Preface

This is the master’s thesis of Ruud Stigter, student Real Estate & Housing. This is the last assignment of many on the faculty of Architecture at the Delft University of Technology. This thesis will discuss the concept of circular economy as presented by the Ellen MacArthur Foundation (2012).

Despite the significant amount of reports about the circular economy and the increasing popularity by both market parties and politics, empirical scientific research on the implementation of circular economy, especially in the construction industry, is lacking and it seems to the author that the terminology is used rather diffused and incoherent when different sources are examined.

This research will discuss the issues concerning the implementation of the circular economy theory in the built environment and will design the financial part of a business model in which suppliers can operate within the set boundary conditions of the circular economy.
Abstract – Het concept circulaire economie wordt steeds populairder. Vooral de laatste jaren is er veel geschreven over de mogelijkheden en uitdagingen met betrekking tot de implementatie van het concept (hoofdstuk 2). Ondanks de groeiende interesse van zowel de politiek als het bedrijfsleven, wordt de terminologie diffuus en incoherent gebruikt. Uitgebreid literatuuronderzoek, interviews en aspect studies over zowel de circulaire economie en de karakteristieken van de bouwsector hebben geresulteerd in een nieuwe definitie van het concept met daarbij behorende randvoorwaarden (hoofdstuk 3 en 4). Met deze randvoorwaarden konden conventionele business modellen van toeleveranciers worden onderzocht. Door dit te doen zijn 13 nieuwe kosten en risico’s geïdentificeerd die ontstaan bij de implementatie van het circulaire economie concept die toeleveranciers mee moeten nemen in hun bedrijfsoveriging (hoofdstuk 5). Deze 13 kosten en risico’s hebben geleid tot een nieuw business model die vervolgens is onderzocht met een case study: het leveren van de prestatie ‘draagconstructie’. Het doel van deze case study is om te onderzoeken in hoeverre de implementatie van het circulaire economie concept rendabel kan zijn voor toeleveranciers in de bouw (hoofdstuk 6).

Key words – circulaire economie, toeleveranciers, business models, bouwsector, implementatie, case study

1. Introductie

Vooral de laatste jaren is veel geschreven over het circulaire economie concept (hierna ook wel ‘het concept’). Het is uitvoerig gepromoot door voornamelijk de Ellen MacArthur Foundation via een serie van rapporten in samenwerking met onderzoeksbureau McKinsey & Company. De stichting zelf is ‘The Circular 100’ gestart, een wereldwijd platform waar bedrijven en innovators samen kunnen komen. Het doel van dit platform is om de transitie van de huidige lineaire economie naar een circulaire economie te versnellen. (Ellen MacArthur Foundation, 2012).

Ook op politiek niveau is een grote interesse in meer onderzoek naar het concept. De Europese Commissie heeft eind 2015 het ‘Circular Economy Package” aangenomen. Dit pakket omvat herziende wetsvoorstellen inzake afvalstoffen met als doel het mondiale concurrentievermogen te verbeteren en de duurzame economische groei te stimuleren. Hiermee hopen zij ook dat dit pakket bijdraagt “to close the loop of life cycles”.

Niet alleen op Europees niveau is er verregaande interesse; ook in Nederland zijn er meer en meer initiatieven te zien in de markt. Het initiatief “Green Deal Circulaire Gebouwen”, een samenwerking tussen de overheid en het bedrijfsleven, poogt de implementatie van circulaire economie in de bouwsector te bevorderen. Dit initiatief is al door meer dan 60 bedrijven gesteund. Daarnaast zijn verschillende stichtingen opgericht, zoals “Building the CE” en “Stichting Circulaire Economie”, om meer kennis te vergaren met als doel de transitie van een lineaire naar een circulaire economie te bewerkstelligen.

a. Probleemstelling

De transitie van een lineaire naar een circulaire economie heeft consequenties voor de business modellen van betrokken partijen in de bouwsector. Een sleutelprincipe van de circulaire economie is de verschuiving van producten naar diensten en prestaties (Stahel, 2006). Dit betekent dat de bedrijfsoveriging verandert van product georiënteerde business modellen naar prestatiegerichte business modellen. Volgens het concept circulaire economie vindt hierdoor een verschuiving plaats in eigenaarschappen. Daar waar toeleveranciers in de huidige situatie hun producten verhandelen, blijven deze partijen in een circulaire economie verantwoordelijk voor hetgeen zij produceren.

Als het concept circulaire economie als gepresenteerd door de Ellen MacArthur Foundation nader is bekeken, vindt men financiële, juridische, sociale, mentale en operationele uitdagingen in de praktische implementatie (Kok et al, 2005); de bedrijfsstructuur moet veranderen. Ondanks de significante hoeveelheid rapporten over de circulaire economie en de toenemende populariteit onder zowel marktpartijen als de politiek, ontbreekt empirisch wetenschappelijk onderzoek over de implementatie van circulaire economie, met name in de bouwsector. Verder
lijkt het dat de terminologie nogal diffuus en incoherent wordt gebruikt wanneer de bronnen nader worden bekeken.

b. Doel
Dit onderzoek zal het concept circulaire economie zoals deze is gepresenteerd door de Ellen MacArthur Foundation (2011) kritisch onderzoeken. Het onderzoek zal de kwesties die ontstaan bij de praktische implementatie van circulaire economie in de bouwsector bespreken, om vervolgens een financieel gedeelte van een business model te ontwerpen waarmee binnen de te stellen randvoorwaarden geopereseerd kan worden. Het concept circulaire economie impliceert een verandering van product georiënteerde business modellen naar prestatiegerichte business modellen. Het onderzoek bekijkt de ‘prestatie’ vanuit een economische perceptie; dat wil zeggen dat bedrijven dezelfde producten gebruiken en enkel de manier waarop de consument bereikt wordt zal veranderen (product service system).

c. Onderzoeksvragen
De hoofdvraag van dit onderzoek is:

In hoeverre is a) de implementatie van het concept circulaire economie in de bouwsector van invloed op de bedrijfsvoering van toeleveranciers en b) hoe moet het financiële gedeelte van een business model binnen de randvoorwaarden van het concept circulaire economie worden ontworpen?

Om deze vraag te beantwoorden is een stappenplan gemaakt:

- Wat houdt het concept circulaire economie in en in hoeverre is dit concept volledig?
- Wat zal de implementatie van de circulaire economie betekenen voor de bouwsector?
- In hoeverre kunnen marktpartijen bijdragen aan de discussie over circulaire economie in de praktijk en op welke manier kunnen de randvoorwaarden worden ontworpen?
- In hoeverre zullen de business modellen van toeleveranciers in de bouw veranderen met de implementatie van het concept circulaire economie?
- Hoe moet het financiële gedeelte van een business model worden ontworpen in het licht van het concept circulaire economie?
- Case study: ‘draagconstructie’ als prestatie.

d. Methodiek
Ondanks het grote aantal rapporten over het concept, blijft vrijwel alle literatuur tamelijk oppervlakkig. Een stevige theorie waar dit onderzoek op kan worden gebaseerd ontbreekt. Daarom is dit onderzoek vooral van exploratieve aard, gebruikmakend van de volgende methoden:

- Literatuuronderzoek
- Aspect studies
- Interviews
- Modeleren

e. Leeswijzer
Dit artikel is als volgt opgebouwd. Het eerste hoofdstuk gaat over het concept circulaire economie. Hierin wordt het concept uitvoerig bediscussieerd en besproken in hoeverre de theorie compleet is. Uiteindelijk zal een werkbare definitie worden ontworpen. Het tweede hoofdstuk gaat over de bouwsector en diens karakteristieken. Met deze karakteristieken in ogenschouw nemend wordt gekeken naar de obstakels en uitdagingen die ontstaan bij de praktische implementatie van het concept. Aan de hand van deze informatie wordt het concept circulaire economie verder uitgediept door actoren te definiëren en randvoorwaarden op te stellen. Deze randvoorwaarden worden in hoofdstuk vier geprojecteerd op de huidige business modellen van toeleveranciers. Er zullen nieuwe kosten en risico’s ontstaan, die worden geïmplementeerd in het ontwerp van het business model in hoofdstuk vijf. Als laatste wordt een case study beschreven om te onderzoeken in hoeverre er financiële potentie zit in het concept circulaire economie voor de toeleveranciers van ‘draagconstructie’ als prestatie.
2. Concept circulaire economie

a. Het concept
Circulaire economie probeert verspilling ‘weg te ontwerpen’ uit productieprocessen door het lineaire consumptiepatroon te veranderen naar een patroon dat is gebaseerd op circulaire bewegingen. (figure 1; Ellen MacArthur Foundation, 2014). Figuur 1 probeert tevens de organisatie van de economie te illustreren. Wat meteen opvalt zijn de twee verschillende kringlopen: de biologische en de technische kringloop. De technische kringloop van producten en grondstoffen rechts in het blauw en de biologische kringloop links in het groen. Het concept probeert het overbodig gebruik van grondstoffen tegen te gaan door deze kringlopen zo veel mogelijk te sluiten. Een belangrijke drijfveer hierachter is dat het in de toekomst goedkoper gaat worden om producten te hergebruiken dan nieuw te laten maken, doordat verondersteld wordt dat de grondstofprijzen een significante groei gaan doormaken (Ellen MacArthur Foundation, 2014). De kringlopen in figuur 1 geven voorbeelden van de routes die genomen kunnen worden wanneer een levenscyclus van een product is geëindigd. Wat belangrijk is om te noemen is dat de ‘korte’ routes worden geprefereerd boven de ‘lange’ routes; ‘maintenance’ wordt bijvoorbeeld gunstiger geacht dan ‘refurbish/remanufacture’, vanwege de extra kosten bij lager zijn bij kortere cycli ten opzichte van langere cycli (Ellen MacArthur Foundation, 2014).

b. Circulaire economie en cradle-to-cradle
Het concept circulaire economie is verre van nieuw. De bovenstaande beschrijving van het concept vertoont serieuze gelijkenissen met het concept cradle-to-cradle (c2c). Het c2c concept is een aanpak voor het ontwerpen van producten, processen en systemen dat de hele levenscyclus in ogenschouw neemt. Het doel is om biologische en technische grondstoffen te herstellen, met positieve effecten op zowel de winstgevendheid, het milieu en de menselijke gezondheid (McDonough & Braungart, 2002).

Wanneer het gaat over het doel om te hergebruiken, in zowel de technische als de biologische kringloop, het gebruik van energie en het sluiten van kringlopen om verspilling tegen te gaan, vertonen de twee concepten gelijkenissen (Van Dijk et al., 2014). Echter, de circulaire economie stelt een concept voor vanuit een economisch perspectief, waarin duurzaamheid kan worden gezien als een ‘bijvangst’ naast een verandering in systemen, waarbij het c2c concept enkel focust op de kringlopen en hergebruiken.
De bovenstaande opmerking komt best naar voren wanneer gekeken wordt naar wat de circulaire economie probeert te doen als het aankomt op het prikkelen van verschillende actoren in het proces. In het concept circulaire economie worden geen producten verhandeld, maar prestaties en diensten. Dit zorgt er voor dat producten na de technische levensduur worden geretourneerd naar de fabrikant. Wanneer het product is geïnfecteerd met giftige stoffen, moeilijk te demonteren is, inefficiënt is of van lage kwaliteit is, komt de fabrikant voor hoge kosten te staan. Dit is het belangrijkste verschil met de andere denkrichtingen en het huidige consumptiepatroon. Door het veranderen van verantwoordelijkheden, zorgt het concept circulaire economie er voor dat bepaalde kosten die normaal niet voor rekening van een fabrikant vielen, nu wel moeten worden geïnternaliseerd. Dit zorgt ervoor dat zuinig zal worden omgesprongen met grondstoffen en producten zo efficiënt en kwalitatief hoogwaardig mogelijk moeten worden vervaardigd.

De circulaire economie zorgt voor een verschuiving van lineaire naar circulaire consumptie. Door dit te doen, zullen fabrikanten er zelf baat bij hebben duurzame producten te ontwerpen die het mogelijk maken om kringlopen te doen sluiten. Nog sterker: het is in het voordeel van de fabrikant zuinig om te springen met grondstoffen en producten zo efficiënt en kwalitatief hoogwaardig mogelijk te maken, aangezien de fabrikant verantwoordelijk is en niet de gebruiker.

c. De literatuur
Het concept circulaire economie zoals gesteld door de Ellen MacArthur Foundation moet worden bekeken met een kritische blik. Wanneer het concept nader wordt onderzocht, lijkt deze niet compleet. Zo is het niet mogelijk om een algemeen gebruikte definitie te herleiden.


De circulaire economie gaat niet over duurzaamheid; duurzaamheid is slechts een consequentie van de implementatie van circulaire economie. Verder beschrijft Mentink (2014) een ontbrekende hiërarchie in de doelen en middelen in de huidige literatuur. Daarnaast wordt het verlengen van levensduren genoemd als manier voor het sluiten van kringlopen, terwijl het verlengen van de levensduur de kringloop louter verlengt. Verder moet onderscheid worden gemaakt tussen een in de praktijk haalbare circulaire economie en een ideale economie. Afsluitend, de circulaire economie zoals het wordt gepresenteerd geeft geen teruggisting over waar de eigenaarschappen van de grondstoffen liggen en op welke manier gehandeld kan worden in de economie.

In an attempt to come up with an overview of what is circular economy and what it is not, Mentink (2014) tried to order the different aspects of circular economy thinking in a single schedule (figure 23). By examining this figure it becomes immediately apparent that implementation of the circular economy in a business chain brings more complexity than the model provided by the Ellen MacArthur Foundation (2014) shows. It also shows that there is a sort of hierarchy in thinking about the circular economy and that some factors might be considered more important or at a higher level than others. What also comes to show is that the circular principles provided by the Ellen MacArthur Foundation (depicted in figure 23 in red) seem to appear at ‘random’ places in the hierarchy and to be of a different importance in implementing circular economy thinking, something that is not (directly) acknowledged by looking at the model the Ellen MacArthur foundation provided.

Het literatuuronderzoek heeft geleid tot een nieuwe definitie:

‘een circulaire economie is een economisch systeem met gesloten materiaalkringlopen, gebaseerd op een financiële prikkel’.

Het is belangrijk de financiële prikkel toe te voegen aan de definitie, aangezien dit de belangrijkste drijfveer is achter deze theorie. De financiële prikkel kan zorgen dat de praktijk de uitgangspunten van de circulaire economie gaat omarmen.
### 3. The bouwsector en de circulaire economie

#### a. Karakteristieken
De huidige bouwprocessen gaan door verschillende fases die kunnen worden geïdentificeerd als: initiatief, ontwerp, realisatie en gebruik. Daar waar de initiatieffase als doel heeft om de noodzaak voor een gebouw of service te bepalen, focust de ontwerpfase op het ontwerpen hiervan. Nadat het ontwerp is gemaakt, start de realisatiefase. In deze fase wordt het ontwerp daadwerkelijk gerealiseerd, om vervolgens in gebruik te worden genomen (Wamelink, 2010). Wat belangrijk is te noemen, is dat deze fases zijn ontworpen om van de ene fase in de andere fase over te gaan. De praktijk leert dat vrijwel niet is nagedacht over welke fase na de gebruiksfase ingegaan moet worden. De bouwprocessen zoals hierboven beschreven zijn vrij duidelijk, maar het wordt gecompliceerder wanneer de fases worden gekoppeld aan de actoren die deze fases uitvoeren (figuur 2).

![Diagram bouwproces](image)

Wanneer de hiervoor genoemde fases worden gekoppeld aan de belanghebbenden in het proces, wordt het meteen duidelijk dat een bouwproces complex is. De koppeling is gedaan met behulp van de theorieën van Wamelink (2010) en Winch (2010). Tijdens de initiatieffase is het voornamelijk de opdrachtgever die zich bezig moet houden met de vraag van het project.

Wanneer de ontwerpfase is begonnen, worden architecten en adviseurs betrokken in het ontwerpproces en gevraagd een ontwerp te maken die voldoet aan de vraag die gesteld is in de initiatieffase. Hoewel het aantal belanghebbenden in deze fase normaal gesproken vrij klein is, is er geen limiet op het aantal adviseurs. Hier geldt meestal: hoe complexer de vraag, hoe meer adviseurs er zijn betrokken.

Vervolgens begint de realisatiefase, waarbij nieuwe belanghebbenden intrede doen in het proces. De belangrijkste belanghebbende is de aannemer die verantwoordelijk is voor het ontwerp. Normaal gesproken neemt deze aannemer ook weer onderaannemers aan, alsmede een aantal specialisten.

Als het project gerealiseerd is, begint de gebruiksfase. Hier neemt de opdrachtgever het project zelf in gebruik, of verkoopt/verhuurt het aan derden. Een belangrijke pion in deze fase is de facility manager, deze is verantwoordelijk voor het zorgdragen van het project tijdens de gebruiksfase (Riratanaphon, Van Der Voordt & Sarasoja, 2012).

Zoals blijkt uit de korte omschrijving hierboven, draait het bouwproces om een ingewikkeld spel van verschillende belanghebbenden tijdens verschillende fases van een project. Dit zorgt voor complexiteit, vooral wanneer het gaat om de manier van samenwerken in elk project. Dit maakt elk project uniek. Wat ook duidelijk wordt, is dat aan de supply side veel veranderingen gaande zijn tijdens een proces (figuur 2). Er is niet een enkele acteur aan de supply side die aanwezig is tijdens het gehele proces. Aan de ownership side daarentegen, zijn veranderingen relatief schaars en wanneer veranderingen zich voordoen, zijn deze waarschijnlijk al vooraf ingecalculeerd (figuur 2). Het kan worden geconcludeerd dat de ownership side van het proces meer op de lange termijn is gericht en de supply side meer korte termijn georiënteerd.

Kortgezegd, de bouwsector wordt gekarakteriseerd door zijn projectmatige karakter, dat unieke producten voortbrengt. Door de uniciteit van de producten verschilt elk project in de sector van elkaar, met daarbij een verschillende samenstelling van actoren per project. Verder kan worden gezegd dat weinig is aandacht wordt gegeven aan wat er met een product moet gebeuren aan het einde van de levensduren. Dit komt waarschijnlijk door
b. Aspect studies

Voor dit onderzoek zijn drie verschillende aspect studies gedaan. In deze aspect studies zijn de basisprincipes van het concept circulaire economie geprojecteerd op de bouwsector. De aspect studies hadden betrekking op eigenaarschappen, financiering en componenten. Er kan worden geconcludeerd dat wanneer het concept circulaire economie wordt geïmplementeerd op de bouwsector, de scheiding tussen eigenaarschappen en toeleveranciers veranderd en vervaagd. Het heeft eveneens gevolgen voor de betrokken duur van periode waarin partijen worden betrokken; deze verschuift daardoor van een korte naar een lange termijn gerichte aanpak. Wanneer het aankomt op de financiering kan worden gezegd dat het leasen in plaats van verkopen van objecten onder de huidige omstandigheden niet logisch is voor toeleveranciers. Bij deze aspect study is gekeken naar de balans van een grote bouwer in Nederland en onderzocht wat de gevolgen zijn van het leasen van de woningvoorraad. Het blijkt dat het leasen van objecten een negatieve impact heeft op zowel de liquiditeit als de solvabiliteit. Daarnaast zorgt het voor ‘deadweight’ capital in de vorm van vaste activa op de balans. Het duurt een lange tijd voordat de hoge investeringen worden teruggestort, voor zover dat op dit moment al te zeggen is. Andere strategieën zoals het koop-terugkoop model en het hergebruiken zijn ook niet winstgevend bevonden. Ten derde is het aantal bouwproducten onderzocht. Het blijkt dat het aantal bouwproducten een belangrijke rol speelt in de haalbaarheid van de implementatie van het concept. Hoe meer verschillende bouwproducten, hoe meer verschillende levensduren in een gebouw zitten.

c. Obstacles

De uitdagingen die gevonden zijn tijdens de aspect studies zijn vergeleken met de obstakels uit de studie van Kok et al. (2013). Het blijkt dat de grootste obstakels in de bouwsector zich bevinden op organisatorisch niveau, namelijk zaken rond eigenaarschappen, aansprakelijkheden en verantwoordelijkheden. Dit organisatorische obstakel is naast financiële en technologische obstakels gevonden in alle drie de aspect studies. Een andere vergelijking met de studie van Loppies (2015) toont de organisatorische problemen aan, naast de technische uitdagingen.

4. Circulaire economie verder gedefinieerd

a. Building product provider (toeleveranciers)

Dit hoofdstuk gaat dieper in op het definiëren van de circulaire economie en zijn spelers. Zoals aangegeven in de probleemstelling wordt de terminologie diffuus en incoherent gebruikt. Daarom is het belangrijk dat de te gebruiken terminologie gedefinieerd wordt voor het vervolg van het onderzoek. De termen leverancier en dienstverlener zijn zeer belangrijk in het concept circulaire economie; het is vrij onduidelijk welke partij wordt bedoeld met deze terminologie. Is de leverancier ook de dienstverlener, of is het een andere entiteit? Volgens de Cambridge Dictionary is een leverancier “een bedrijf of persoon dat... in plaats van producten verkoopt’. Het ene sluit het andere blijkbaar niet uit. Met deze gedachte is het productieproces van een stopcontact nader onderzocht. In een stopcontact zitten 11 verschillende grondstoffen, verpakt in drie hoofdmateriaal: plastic, koper en roestvrij staal. Volgens de principes in de circulaire economie is het onzeker in hoeverre producten worden verhandeld. Als wordt aangenomen dat producten niet veranderen van eigenaar kunnen er 15 verschillende eigenaren worden geïdentificeerd in enkel een stopcontact (11 grondstofwinners, 3 fabrikanten, 1 assembler).

Om een functioneel business model te ontwerpen is het belangrijk duidelijk te hebben wat voor entiteit er wordt bedoeld met een leverancier en/of dienstverlener. Dit is uitgelegd aan de hand van de studie van Mohammad, Prins & Slob (2015).
De auteurs beschrijven een circulaire economie waarin drie verschillende goederen voorkomen: producten, componenten en complexe componenten. Om de terminologie consistent te houden en beter te laten aansluiten op de praktijk is voor dit onderzoek de terminologie aangepast naar de volgende producten: materialen, componenten en elementen (figuur 3 en 4). De economie wordt gekarakteriseerd door een ketenmarkt, waarin drie verschillende typen ketenpartijen actief zijn (figuur 3): grondstofwinners (extractor), assemblers en dienstverleners (service provider). De economie kent twee verschillende markten, namelijk de ketenmarkt en de diensten- en prestatiemarkt. Op de ketenmarkt kunnen producten worden verhandeld en dus ook veranderen van eigenaar. Op de diensten- en prestatiemarkt kunnen toeleveranciers hun producten via een operationele lease constructie aan een consument aanbieden. Wanneer een ketenpartij zich op deze markt bevindt, is het per definitie een dienstverlener. Ook hier is de financiële prikkel ook aanwezig, aangezien ketenpartijen eigenaar blijven van hun materialen, componenten of elementen (Mohammadi et al., 2015). In figuur 4 zijn de definities gegeven, zoals deze worden gebruikt voor de rest van het onderzoek.

Figure 3 Circulair economie entiteiten (gebaseerd op Mohammadi, Prins & Slob, 2015)

Figure 4 Definities in een circulaire economie (eigen illustratie)
b. Circulaire economie en een duurzame economie

Volgens Mohammadi et al. (2015) is het concept circulaire economie een economisch systeem waarin de maatschappij is ontworpen op dusdanige wijze dat door de acties van de ‘homo economicus’ duurzaamheid is gewaarborgd. Door de aanname dat de grondstofprijzen zullen stijgen in de toekomst zijn ketenpartijen inderdaad gemotiveerd om producten zolang mogelijk in de kringlopen te houden. Verschillende rapporten onderschrijven de economische kansen van het concept door juist deze aanname (TNO, 2013; McKinsey & Co, 2015).

Tijdens dit onderzoek werd het meer en meer duidelijk dat een significant aantal bronnen het concept circulaire economie als een middel ziet om een duurzame economie te bereiken. In rapporten, brainstorm sessies of conferenties wordt de relatie tussen duurzaamheid en het concept benadrukt.

In hoofdstuk 2 is reeds gemeld dat het concept niet gaat over duurzaamheid; het is immers een economisch systeem. Het concept is daarentegen gepromooid en aangenomen als een middel om duurzaamheid te bereiken. Het concept heeft zeker aspecten die duurzaam genoemd kunnen worden, het is alleen niet zo ongecompliceerd als wordt aangenomen. In de optiek van de auteur kan een lineaire economie net zo (of net zo min) duurzaam zijn als een circulaire economie.

Het sluiten van materiaal kringlopen kan een belangrijke oplossing vormen voor de uitputting van de grondstoffen. In hoeverre dit duurzaam is, hangt van veel meer dingen af dan alleen het sluiten van de kringlopen. Wanneer een vergelijking wordt gemaakt tussen een lineaire proces dat wordt ingericht met behulp van duurzame energie, zonder giftige bijproducten en waarbij wordt geproduceerd onder verantwoorde omstandigheden en het circulair proces waarbij materialen constant worden teruggenomen in de kringloop, waarbij wel giftige stoffen en kernenergie gebruikt worden in het productieproces, kan worden afgevraagd welke van deze economieën het ‘duurzaamst’ is.

In het concept circulaire economie wordt duurzaamheid gewaarborgd door het toevoegen van richtlijnen aan een economisch systeem. Het is onduidelijk waar in het concept de scheidingslijn ligt tussen circulair en duurzaam. De term circulair impliceert dat het gaat om het sluiten van kringlopen. Zoals hierboven is getracht uit te leggen is het sluiten van kringlopen niet automatisch duurzaam. Entiteiten moeten ethisch opereren en meer is nodig dan enkel het sluiten van de kringloop. Zo is ook het gebruik van groene energie, het niet gebruiken van giftige stoffen en een maatschappelijk rechtvaardigde productie van belang voor de duurzaamheid van de economie.

c. Randvoorwaarden

Om de hierboven genoemde redenen wordt een belangrijk onderscheid gemaakt in het opstellen van de randvoorwaarden. Aangezien duurzaamheid enkel wordt gewaarborgd door het toevoegen van randvoorwaarden aan een economisch systeem, komt dit ook terug in de randvoorwaarden. De ‘Harde’ voorwaarden moeten worden voldaan om aan ‘het sluiten van de kringlopen’ te voldoen. De ‘zachte’ randvoorwaarden zijn opgesteld om de economie duurzaam te maken.

‘Harde’ randvoorwaarden (Mohammadi et al., 2015)
- Producten moeten in de technische kringloop worden gehouden.
- Het wisselen van kringlopen is ook onderdeel van circulaire economie.
- De technische producten die worden afgebroken tijdens de gebruiksperiode, of wanneer ze niet langer bruikbaar zijn in de technische kringloop, moeten worden teruggenomen aan de biologische kringloop.

‘Zachte’ randvoorwaarden
- Er wordt groene energie gebruikt bij de productie-, gebruiks- en consumptieprocessen.
- Er worden geen giftige materialen gebruikt bij de productie-, gebruiks- en consumptieprocessen.
- Ketenpartijen moeten proberen de aarde te behouden voor toekomstige generaties.
- Ketenpartijen kiezen voor wereldwijde welvaart.
- ‘Social- justice & fairness’ is normatief voor het menselijk handelen en ketenpartijen dienen overeenkomstig te opereren.

Aannames
- Stijgende grondstofprijzen.
- Ketenpartijen opereren met als doel winst te maximaliseren.
In deze voorwaarden is het niet nodig te vermelden dat ketenpartijen eigenaarschap behouden over de producten. Aangezien aangenomen wordt dat de grondstoffenprijzen in de toekomst significant zullen stijgen, wordt aangenomen dat het in het beste voordeel van de ketenpartij is deze grondstoffen in bezit te houden. Door de stijgende prijzen wordt aangenomen dat grondstoffen potentiële ‘goudmijnen’ zijn.

5. Business model implicaties

Dit hoofdstuk zal de hiervoor gestelde randvoorwaarden projecten op de conventionele business modellen van toeleveranciers. Allereerst wordt het lineaire proces beschreven. Daarna wordt onderzocht wat er gebeurd als een ketenpartij in een circulaire economie gaat opereren op de diensten- en prestatiemarkt. Daar zullen nieuwe kosten en risico’s ontstaan, welke zullen worden toegelicht.

Figure 5 Lineaire situatie (eigen illustratie)

Het symbool links representeert de toeleverancier. The toeleverancier krijgt een order voor de levering van een product. Er wordt verondersteld dat de toeleverancier geld moet lenen om de productie te starten. Hiervoor gaat deze naar de bank. Vervolgens wordt het product geproduceerd en geleverd. De verkoopprijs wordt ontvangen (S). Hieruit wordt de lening terugbetaald (L), vermeerderd met de rente die aan de bank is verschuldigd (I). Uiteindelijk blijft de toeleverancier over met bepaalde winst.

<table>
<thead>
<tr>
<th>Stap 1</th>
<th>Verkrijgen financiering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stap 2</td>
<td>Start productieproces</td>
</tr>
<tr>
<td>Stap 3</td>
<td>Leveren van product</td>
</tr>
<tr>
<td>Stap 4</td>
<td>Assembleren van product naar gebouw</td>
</tr>
<tr>
<td>Stap 5</td>
<td>Ontvangen verkoopprijs</td>
</tr>
<tr>
<td>Stap 6</td>
<td>Terugbetalen lening en rente</td>
</tr>
<tr>
<td>Stap 7</td>
<td>De toeleverancier blijft over met winst</td>
</tr>
</tbody>
</table>

Tijdsduur: een jaar tot drie jaar
Table 1 Lineair proces (eigen tabel)

b. Circulair

De circulaire situatie is geïllustreerd in figuur 6. Het financieringsproces en het productieproces zijn gescheiden om een duidelijker beeld te geven van het verschil tussen deze processen. De toeleverancier staat aan de top van de cirkel. De ketenmarkt is niet meegenomen in dit voorbeeld. Ook hier is het proces stapsgewijs uitgelegd aan de hand van figuur 6 en 7.

Wederom ontvangt de toeleverancier een order, alleen is de vraag in dit voorbeeld anders. In plaats van het leveren van bijvoorbeeld een stalen balk, ontvangt de toeleverancier nu een order voor het leveren van de ‘draagconstructie’ als prestatie.
Suppliers going circular

Figure 6 circulaire situatie (eigen illustratie)

<table>
<thead>
<tr>
<th>Stap</th>
<th>Beschrijving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stap 1</td>
<td>Controleren huidige voorraad</td>
</tr>
<tr>
<td>Stap 2</td>
<td>Start productieproces/hernieuwen huidige voorraad</td>
</tr>
<tr>
<td>Stap 3</td>
<td>Monteren van het product</td>
</tr>
<tr>
<td>Stap 4</td>
<td>Het leveren van de prestatie, inclusief het zorgdragen voor onderhoud,</td>
</tr>
<tr>
<td></td>
<td>toezicht houden op de prestatie en het bijhouden van de klantcontacten</td>
</tr>
<tr>
<td>Stap 5</td>
<td>Demonteren van het product</td>
</tr>
<tr>
<td>Stap 6</td>
<td>Transport terug naar de toeleverancier</td>
</tr>
</tbody>
</table>

Tijdsduur: van een paar jaar naar 20 jaar

Table 2 circulair proces (eigen tabel)

Figure 7 circulaire situatie financiering (eigen illustratie)

<table>
<thead>
<tr>
<th>Stap</th>
<th>Beschrijving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stap 1</td>
<td>Verkrijgen financiering</td>
</tr>
<tr>
<td>Stap 2</td>
<td>Verkrijgen van het leasebedrag</td>
</tr>
<tr>
<td>Stap 3</td>
<td>Betalen van de rente tijdens de gehele periode</td>
</tr>
<tr>
<td>Stap 4</td>
<td>Earning profit</td>
</tr>
<tr>
<td>Stap 5</td>
<td>Betalen van transport, demontage, onderhoud, toezicht en management</td>
</tr>
</tbody>
</table>

Tijdsduur: van een paar jaar naar 20 jaar

Table 3 circulair proces financiering (eigen tabel)
Wanneer de circulaire situatie wordt vergeleken met de lineaire situatie, ziet men belangrijke verschillen. Het tijdsvenster is significant langer bij de circulaire situatie. Dit zorgt voor een lange termijn betrokkenheid van toeleveranciers bij een gebouw. Daarnaast ligt de verantwoordelijkheid van het product bij de toeleverancier, waardoor onderhoud-, toezicht- en managementkosten ontstaan. De financieringsstructuur ondervindt tevens een structurele verandering; toeleveranciers gaan nu een langlopende lening aan, in plaats van de normale kortlopende lening. Daarnaast moeten ketenpartijen de kringloop sluiten (zie randvoorwaarden), dit is een belangrijk onderdeel van het concept circulaire economie en wordt op dit moment vaak weggelaten of vergeten. Ketenpartijen moeten middelen reserveren voor demontage en het hernieuwen van het product voor een volgende contractperiode.

De nieuwe elementen die ontstaan zijn opslag, (de)montage, transport, financieringsstructuren, lange termijn klantcontacten onderhouden en het toezicht houden op de prestatie.

1. (De)montage kosten: de kosten die gemaakt moeten worden om een product te (de)monteren.
2. Opslag kosten: de kosten die gemaakt moeten worden om producten op te slaan.
3. Transport kosten: de kosten die gemaakt moeten worden om producten te transporteren van en naar de toeleverancier.
4. Toezicht kosten: de kosten die gemaakt moeten worden om toezicht te houden op de prestatie.
5. Management kosten: de kosten die gemaakt moeten worden om activiteiten te managen (zoals klantcontacten).
6. Onderhoudskosten: de kosten die gemaakt moeten worden om producten te onderhouden.
7. Hernieuwingskosten: de kosten die gemaakt moeten worden om producten te hernieuwen voor het leveren van de prestatie.
8. Terugkeerkosten: de kosten die gemaakt moeten worden om producten terug te brengen in de biologische kringloop.
9. Economische risicopremie: de kosten die gereserveerd moeten worden voor economische risico’s.

De volgende kosten zijn uitermate belangrijk en vereisen speciale vermelding.

10. Financieringskosten: de kosten die gemaakt moeten worden om bedrijfsactiviteiten te financieren

Het business model van de toeleverancier zal veranderen van product-gebaseerd naar prestatie-gebaseerd. De toeleverancier heeft langlopende schulden in plaats van kortlopende. In een circulaire economie wordt verondersteld dat de financiering ‘bottom up’ gebeurt. In plaats dat banken een bepaald product financieren, moeten zij nu een contract aangaan voor het financieren van grondstoffen. De grondstoffenmarkt verschilt significant van de vastgoedmarkt, met hierbij verschillende risicoprofielen en winstmarges. Het is nog maar de vraag of banken bereid zijn een financiering aan te gaan met als onderpand een product dat vastzit in een gebouw.

11. Substitutie risicopremie: de kosten die gemaakt moeten worden voor het dekken van het risico van substitutiegoederen.

Dit is misschien wel het belangrijkste en meest uitdagende aspect van deze uitkomsten. Vooral in een dergelijke markt met snel veranderende technologische ontwikkelingen en lange levensduren, is het onzeker of de bouwproducten van vandaag ook de conventionele bouwproducten van morgen zullen zijn.

Het is zeker niet ondenkbaar dat door nieuwe regelgeving of andere inzichten anders naar een product wordt gekeken. De afgelopen decennia is het meer dan eens voorgekomen dat een product wordt verboden door regelgeving (zoals bijvoorbeeld asbest). Een andere reden kan zijn dat nieuwe eisen worden gesteld aan producten, hetgeen een bepaald product onbruikbaar maakt voor hergebruik (zoals bijvoorbeeld nieuwe dimensies aan liggers). Daarnaast kunnen nieuwe constructiemethoden ontstaan (zoals bijvoorbeeld 3D printen).

De uniciteit van de bouwsector is dat producten voor een zeer lange periode worden gebruikt. Dit maakt de zekerheid op hergebruik een stuk onzekerder dan in andere markten. Aangezien men niet in staat is om de toekomst te voorspellen, moeten toeleveranciers aannames maken over het gebruik van een product met betrekking tot winstverwachtingen over een lange periode.
a. Markten in een circulaire economie

Deze paragraaf zal kort beschrijven op welke manier producten verhandeld kunnen worden in de ketenmarkt. In figuur 8 zijn zeven verschillende opties gegeven waarin de compositie van een product kan veranderen. De iconen (huis en vliegtuig) zijn beschreven als objecten.

<table>
<thead>
<tr>
<th>Compositie</th>
<th>Functie</th>
<th>Object</th>
<th>Voorbeeld</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Gelijk</td>
<td>Gelijk</td>
<td>Gelijk</td>
<td>Stalen constructie woning (onbehandeld) -&gt; stalen constructie woning (onbehandeld)</td>
</tr>
<tr>
<td>2 Gelijk</td>
<td>Anders</td>
<td>Gelijk</td>
<td>Stalen constructie woning (onbehandeld) -&gt; stalen gevelbekleding woning (onbehandeld)</td>
</tr>
<tr>
<td>4 Gelijk</td>
<td>Gelijk</td>
<td>Anders</td>
<td>Stalen constructie woning (onbehandeld) -&gt; stalen constructie vliegtuig (onbehandeld)</td>
</tr>
<tr>
<td>4 Gelijk</td>
<td>Anders</td>
<td>Gelijk</td>
<td>Stalen constructie woning (onbehandeld) -&gt; staal in motor vliegtuig (onbehandeld)</td>
</tr>
<tr>
<td>5 Anders</td>
<td>Gelijk</td>
<td>Gelijk</td>
<td>Stalen constructie woning (onbehandeld) -&gt; stalen constructie woning (behandeld)</td>
</tr>
<tr>
<td>6 Anders</td>
<td>Anders</td>
<td>Gelijk</td>
<td>Stalen constructie woning (onbehandeld) -&gt; stalen gevelbekleding woning (behandeld)</td>
</tr>
<tr>
<td>7 Anders</td>
<td>Anders</td>
<td>Anders</td>
<td>Stalen constructie woning (onbehandeld) -&gt; staal in motor vliegtuig (behandeld)</td>
</tr>
</tbody>
</table>

Table 4 voorbeelden van compositie van product in een circulaire markt (eigen tabel)

Een element kan worden verhandeld, zodat deze volledig hergebruikt kan worden. Het kan ook gebeuren dat een deel van het element moet worden vervangen, wat resulteert in een nieuwe compositie. Daarnaast is het mogelijk dat elementen in een nieuwe cyclus een andere functie krijgen.

Dit is belangrijk om te noemen, aangezien een product in een bepaalde functie te maken heeft met bepaalde macro- en micro-economische factoren die kunnen verschillen wanneer hetzelfde product in een andere functie wordt gebruikt. Dit betekent ook dat er verschillende winsten kunnen worden behaald. Hierdoor zal een ketenpartner in een circulaire economie voorzichtiger zijn met het toewijzen van de grondstoffen. Dit wordt toegelicht met een voorbeeld:

Een ketenpartner bezit 1000 kilogram staal. De ketenpartner is betrokken in zowel de bouwsector als de auto-industrie. In het voorbeeld wil de ketenpartner bezit blijven houden over het staal en kiest er daarom voor om enkel de prestatie te verhandelen. In de auto-industrie wordt het staal gebruikt voor bijvoorbeeld de carrosserie. In de bouwsector zal het dienstdoen als draagconstructie. De gemiddelde levensduur van een auto is 10 jaar; de draagconstructie van een kantoorgebouw is door Cooper et al. (2014) vastgesteld op 110 jaar. Met andere woorden, het staal wordt in de bouwsector veel langer gebruikt dan in de auto-industrie. Aan de andere kant kan de auto-industrie (financieel) een stuk interessanter zijn per kilogram staal. Om deze reden is aan de lijst met kosten de volgende risicopremie toegevoegd:

12. Allocatie risicopremie: de kosten die gemaakt moeten worden om marktimperfecties in te dekken.
Daarnaast moet gekeken worden naar de complexiteit van een gebouw. Hoe complexer een element ‘vastzit’ in een gebouw, hoe moeilijker het wordt om dit element terug te krijgen en nogmaals te verhandelen. Dit heeft dus invloed op de potentie tot hergebruik van een product in de toekomst.

13. Complexiteit risicopremie: de kosten die gemaakt moeten worden om de complexiteit van een element in een gebouw te dekken.

6. Ontwerp van het business model

Het ontwerp van dit business model zal focussen op de financiële aspecten: de kostenstructuur en de inkomstenstromen. De kostenstructuur omvat de monetaire gevolgen van de middelen in het business model en de inkomstenstromen beschrijven de manier waarop een bedrijf geld verdient. Vervolgens wordt dit model ingevuld door middel van een case study: het leveren van de prestatie als ‘draagconstructie’. Het doel van de case study is om te ontdekken in hoeverre het financieel haalbaar is om deze dienst in een circulaire economie te leveren aan consumenten.

a. Het model

De focus van het business model ligt bij het verkopen van prestaties in plaats van producten. De hoofdactiviteit is dat het business model consumenten datgeen levert wat ze het liefst willen: de prestatie dat een product levert. De toegevoegde waarde zelf is niet iets nieuws, namelijk het leveren van een draagconstructie, alleen in dit business model is het de prestatie en niet het product dat wordt verkocht. Daarnaast wordt de consument alles uit handen genomen, het model draagt zorg voor de onderhoud, (de)montage en transport. Daarbij hoeft de consument geen hoog startkapitaal te hebben.

Figure 9 Business model (eigen illustratie)
a. Opbrengsten
De opbrengsten zijn gegenereerd op twee manieren. De eerste is het verdienen van een lease bedrag. Verschillende modellen kunnen hiervoor worden gebruikt:

- Betalen per termijn (dag/maand/jaar).
- Betalen per gebruik (bijvoorbeeld kantoortijden).

Het bedrag zelf kan gebaseerd zijn op de karakteristieken van een product; in het geval van een stalen ligger:

- Draagkracht (€ per N/m²).
- Het leveren van een draagconstructie (hoe dit gedaan wordt, is aan de toeleverancier).

Het andere deel van de opbrengstenstromen is gebaseerd op de stijging van de waarde van de grondstoffen. Zoals reeds omschreven, gaat het concept circulaire economie uit van toenemende schaarste van grondstoffen met corresponderende groei van de prijzen.

b. Kostenstructuur
De kostenstructuur is gebaseerd op de resultaten uit hoofdstuk 5. Deze zijn samengevat in de volgende tabel en kunnen worden verdeeld in vier categorieën.

<table>
<thead>
<tr>
<th>Categorie</th>
<th>Kosten</th>
<th>Implementatie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Onderhoud X% / jaar</td>
<td>Vast bedrag / einde contractperiode</td>
</tr>
<tr>
<td></td>
<td>Hernieuwen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Hergebruik</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Recycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reviseren</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Terugbrengen</td>
<td></td>
</tr>
<tr>
<td>Potentie</td>
<td>Substitutie risicopremie X% / jaar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allocatie risicopremie X% / jaar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complexiteit risicopremie X% / jaar</td>
<td></td>
</tr>
<tr>
<td>Economisch</td>
<td>Toekomstige prijsschommelingen X% / jaar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Algemene risicopremie X% / jaar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energieprijzen risicopremie X% / jaar</td>
<td></td>
</tr>
<tr>
<td>Organisatorisch</td>
<td>Transport Vast bedrag / einde contractperiode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Management X% / jaar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(de)montage Vast bedrag / einde contractperiode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Opslag Vast bedrag / einde contractperiode</td>
<td></td>
</tr>
</tbody>
</table>

Table 5 lijst met kosten gecategoriseerd (eigen tabel)

c. Case study: ‘draagconstructie’ als prestatie
Het doel van deze case study is te onderzoeken in hoeverre het (financieel) haalbaar is de draagconstructie van een gebouw als prestatie op de markt te brengen. Het gekozen product waarmee de prestatie wordt uitgevoerd is een stalen ligger.

Case: een consument vraagt de prestatie ‘draagconstructie’ voor een nieuwe te realiseren gebouw. Om het simpel te houden zal de case worden gelimiteerd tot een enkele ligger. De volgende ligger is voldoende bevonden om aan de eisen van de consument te voldoen:

- Materiaal Staal
- Omschrijving HEB300
- Kwaliteit SJ235JRG2
- Lengte 6m
- Waarde in 2015 (www.staalprijzen.nl) € 966,-
- Product service system Operational Lease
- Contractperiode 10 jaar
- Lease percentage 10%
- Product index (groei in grondstofprijzen) 4%
- CPI (inflatie) 2,1%
Na een contractperiode van 10 jaar wordt aangenomen dat de ligger wordt verkocht aan een andere ketenpartner. Dit is gedaan om de waardestijging van het product in het model mee te nemen. De verkoopprijs van de ligger na jaar 10 is de huidige marktwaarde geaccumuleerd met de verwachte groei van de grondstofprijzen.

Het leasebedrag is in beginsel vastgezet op 10% van de waarde van de balk voor de termijn van 10 jaar. De contante waarde van alle leasebedragen op dit moment is €1007, - , meer dan de huidige waarde van de balk. Aan de andere kant wordt de consument alles uit handen genomen en hoeft deze niet op te draaien voor onderhoud, (de)montage en andere kosten, factoren die allen de bereidheid om te betalen kunnen beïnvloeden.

### Case study: steel beam

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Costs</th>
<th>Risk premiums</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Production cost (/m) € 133,00</td>
<td>Substitution (/yr) 2%</td>
</tr>
<tr>
<td>Description</td>
<td>Maintenance (p/y) 0%</td>
<td>Allocation (/yr) 0%</td>
</tr>
<tr>
<td>Quality</td>
<td>Renewing cost (end) - reuse 10%</td>
<td>Complexity (/yr) 0%</td>
</tr>
<tr>
<td>Size (m)</td>
<td>- withdrawal</td>
<td>Future price fluc, 2%</td>
</tr>
<tr>
<td>Product service system</td>
<td>- recycle</td>
<td>Energy (/yr) 1%</td>
</tr>
<tr>
<td>First contract period (yr)</td>
<td>Transport (/km) € 0,21</td>
<td>General (/yr) 2%</td>
</tr>
<tr>
<td>Value in 2015 € 966,00</td>
<td>(Dis)assembly 15%</td>
<td>Total 7%</td>
</tr>
<tr>
<td>Lease percentage 10%</td>
<td>Storage (/m in 2015) € 15,00</td>
<td></td>
</tr>
<tr>
<td>Depreciation (yr) 0%</td>
<td>Management 2%</td>
<td></td>
</tr>
<tr>
<td>IRR 4%</td>
<td>Monitoring 0,40%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product index (p/y) 4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI 2%</td>
</tr>
<tr>
<td>Distance (km) 200</td>
</tr>
</tbody>
</table>

Figure 10 variables in spreadsheet (eigen illustratie)

Alle variabelen zijn voornamelijk door middel van aannames gekwantificeerd (figuur 10). Met de huidige beginwaarden is een rendement gevonden van 4,4%. Dit betekent dat onder deze omstandigheden het leveren van de prestatie ‘draagconstructie’ lucratief kan zijn. Het grote aantal aannames die veelal onzeker zijn, helpt daarentegen niet mee aan de betrouwbaarheid van deze conclusie. Hiermee is ook meteen de zwakte van dit model genoemd.

Een gevoeligheidsanalyse heeft aangetoond dat twee variabelen van grote invloed zijn op de uitkomsten: het product index en het leasepercentage. Aangezien er een limiet is aan de hoogte van het leasebedrag, kan worden geconcludeerd dat de groei van grondstofprijzen, onder de gestelde voorwaarden van dit onderzoek, de financiële haalbaarheid van deze case study bepalen.

### 7. Conclusie

De hoofdvraag van dit onderzoek is:

In hoeverre is a) de implementatie van het concept circulaire economie in de bouwsector van invloed op de bedrijfsvoering van toeleveranciers en b) hoe moet het financiële gedeelte van een business model binnen de randvoorwaarden van het concept circulaire economie worden ontworpen?

Dit onderzoek heeft een kritische blik geworpen op het concept circulaire economie zoals deze is gepresenteerd door de Ellen MacArthur Foundation (2011). Ondanks de groeiende populariteit mag het concept zelf niet zondermeer worden aangenomen. Door de incompleetheid en het diffuus gebruik van de theorie was het bijvoorbeeld niet mogelijk om een definitie van het concept te geven. Zodoende moest een nieuwe theorie worden gemaakt, waarbij een belangrijk onderdeel was weggelegd voor de financiële prikkel binnen het concept circulaire economie:

‘een circulaire economie is een economisch systeem met gesloten materiaalkringlopen, gebaseerd op een financiële prikkel’.
Het is uitermate belangrijk de financiële prikkel toe te voegen aan de definitie, aangezien dit de belangrijkste drijfveer is achter deze theorie. Deze drijfveer kan ervoor zorgen dat de praktijk de uitgangspunten van de circulaire economie gaat omarmen.

De bouwsector wordt gekarakteriseerd door zijn projectmatige karakter, dat unieke producten voortbrengt. Door de unicité van de producten wordt elke project in de sector verschillend van de ander, met een verschillende samenstelling van actoren per project. Verder kan worden gezegd dat weinig aandacht wordt gegeven aan wat er met een product moet gebeuren aan het einde van de levensduren. Dit komt waarschijnlijk door de lange gebruiksteriode van een gebouw en de verschillende levensduren van de verschillende elementen in een gebouw.

De bouwsector is verantwoordelijk voor het gebruik van 40 tot 50% van de natuurlijke bronnen, 30% van de primaire energiebehoefte in de OECD landen, 40% van de uitstoot van broeikasgassen en 10 tot 30% van de afvalstromen in de Europese Unie (Uhlein & Eder, 2009) (Schoolderman et al., 2014; OECD, 2008; Uhlein & Eder, 2009; APRICOD, 2006). Deze cijfers benadrukken het belang van een andere manier van consumeren en gebruik van grondstoffen. De gevonden karakteristieken maken de bouwsector daarentegen tevens ook een lastig sector om de principes van de circulaire economie toe te passen.

Tijdens dit onderzoek zijn randvoorwaarden opgesteld waaraan een business model moet voldoen waarin de principes van de circulaire economie zijn geïmplementeerd. Hierbij moet een belangrijk onderscheid worden gemaakt tussen ‘harde’ en ‘zachte’ randvoorwaarden. Deze zijn opgesteld om het verschil tussen een circulaire economie en een duurzame economie aan te geven.

Deze randvoorwaarden zijn geprojecteerd op conventionele business modellen van toeleveranciers in de bouwsector. Er zijn 13 nieuwe kosten en risico’s geïdentificeerd die mee genomen moesten worden in het ontwerp van een nieuw model. Belangrijke extra kosten zijn: transport-, toezicht-, opslag- en (de)montagekosten. Door de lange doorlooptijden van contracten in de bouw zijn tevens aanzienlijke risico’s te noemen, zoals het risico op substitutiegoederen. De conventionele bouwproducten van vandaag hoeven niet over 10 jaar nog steeds conventioneel te zijn.

Het business model, geïllustreerd in figuur 9, heeft de variabelen geïmplementeerd. Het model is vervolgens ingevuld met een case study: het leveren van de prestatie ‘draagconstructie’. Het grote aantal aannames in dit model, draag niet bij aan de betrouwbaarheid. Echter, een gevoeligheidsanalyse toont aan dat er twee variabelen grote invloed hebben op de uitkomsten: de product index (verwachte groei in grondstofprijzen) en de lease percentage. Aangezien wordt geëist dat er een limiet zit op het leasebedrag, is de sleutelvariabele in de financiële haalbaarheid van de case study de product index Deze variabele bepaalt de (financiële) haalbaarheid in een business model.

Uiteindelijk kan er algemeen worden geconcludeerd dat er twee factoren van grote invloed zijn op de financiële haalbaarheid van de implementatie van het concept circulaire economie. Ten eerste, de winstgevendheid van leaseconstructies is hevig afhankelijk van de groei van grondstofprijzen. Ten tweede, de financiële waarde van producten in een bouwproject hangt sterk af van de bruikbaarheid na een eerste contractperiode (substitutie risk premium)
Summary

Abstract – The circular economy concept is gaining popularity. Especially in the recent years a lot has been written about the benefits and challenges of the topic. Despite the growing interest on both political and market level, the terminology is used diffused and incoherent. This research examines the circular economy concept as posed by the Ellen MacArthur Foundation. The aim of this research is to design financial section of a business model in a circular economy. Extensive literature review, interviews and aspect studies on both the circular economy concept and the construction industry have resulted in a new definition of circular economy with corresponding boundary conditions. With these boundary conditions, conventional business models of building product providers (suppliers) have been critically assessed. By doing this, 13 costs and risks have been identified and incorporated in the design of the financial section of a business model. At last, the business model has been assessed by means of a case study: providing the structure of a steel beam. It can be concluded that the key variable that determines the financial viability is the circular economy axiom of rising resource prices.

Key words – circular economy, suppliers, business models, construction industry, implementation, case study

1. Introduction

Especially in the last years a lot has been written about the circular economy. It has been promoted by the Ellen MacArthur Foundation via various reports in corporation with McKinsey & Company and this has been picked up by various institutions. The foundation started The Circular Economy 100, a global platform bringing together leading companies, emerging innovators and regions to accelerate the transition to a circular economy (Ellen MacArthur Foundation, 2012).

Also on political level there is growing interest in more research in the circular economy. In December 2015, the European Commission adopted the “Circular Economy Package, which includes revised legislative proposals on waste to stimulate Europe’s transition towards a circular economy which will boost global competitiveness, foster sustainable economic growth and generate new jobs”. It is hoped that the actions will contribute to “close the loop of life cycles”.

Not only on European level circular economy is gaining momentum. Also in The Netherlands more and more initiatives are popping up in the field. Initiatives such as ‘The Green Deal’, a cooperation between government, businesses and institution, tries to implement the circular economy in the built environment. The initiative is gaining interest and is already signed by more than 60 companies. Next to that, there are foundations such as ‘Building the CE’ and ‘Stichting Circulaire Economie’ trying to gain more knowledge about the circular economy.

a. Problem statement

The transition from a linear to a circular economy has consequences for the business models of parties involved in the construction sector. A key principle of the circular economy is the transition from sales of products to sales of services (Stahel, 2006). This means that businesses change from a product-based business model to a performance-based business model. In theory, the implementation of circular economy will cause a shift in ownership. Instead of selling products the suppliers will remain responsible for the life cycle of their product.

If the circular economy theory as promoted by the Ellen MacArthur foundation (2012) is examined, financial, legal, social, mental and operational challenges arise on the practical implementation (Kok et al., 2005); the business structure needs to change. Despite the significant amount of reports about the circular economy and the increasing popularity by both market parties and politics, empirical scientific research on the implementation of circular economy, especially in the construction industry, is lacking and it seems to the author that the terminology is used rather diffused and incoherent when different sources are examined.

b. Aim

This research will critically examine the circular economy theory as posed by the Ellen MacArthur foundation (2011). This paper will discuss the issues concerning the implementation of the circular economy theory in the built environment and will design the financial part of a business model in which building product providers can...
operate within the set boundary conditions of the circular economy. Circular economy will cause a shift from product based business models to performance based business models. This research will view the ‘performance’ from an economical perception. This means that businesses operate with the same products, only the product service systems will differ. With the design of the financial section of the business model it is aimed to show the financial potential of the circular economy concept.

c. Research questions
The main question of this research is:

To what extent is a) the implementation of the circular economy theory in the construction industry of influence on the business models of building product providers and b) how should the financial aspects of a business model be designed within boundary conditions of the circular economy theory?

In order to answer this questions, a six step approach is made:

- What does the circular economy enhance and to what extent is the concept irrefutable?
- What will the implementation of the circular economy mean for the construction sector?
- To what extent can market parties contribute to the discussion of circular economy in practice and how can the boundary conditions be defined?
- To what extent will business models of building service suppliers change with the implementation of the circular economy theory?
- How should the financial aspects of a business model be designed within the set boundary conditions?
- Case study: ‘structure’ as performance.

d. Methods
There is a significant amount of reports available on the topic, however they all remain rather theoretical. In short, there is not a solid ground theory to base this research on. Therefore will this research be of explorative nature, mainly using the following data collection methods:

- Literature review
- Aspect studies
- Interviews
- Modelling

e. Readers’ guide
This article is set up as follows. The first chapter will describe the circular economy concept. It will thoroughly discuss to what the concept enhances and to what extent the concept can be called complete. After criticism, a working definition of circular economy is designed. The next section will project the circular economy concept on the construction industry, aiming to identify characteristics and obstacles with respect to the implementation of circular economy principles. Third, boundary conditions of a circular economy are given. Once actors and boundary conditions have been defined, the conventional business model can be assessed. This chapter will describe the consequences of the change from product-based business models to performance-based models in the construction industry. Subsequently, a new business model is designed. In the last part of this paper it is explored to what extent the model is financially viable for a building product provider of a beam to implement circular economy principles.
2. Circular economy concept

a. The concept
Circular economy tries to design waste out of production processes by changing the linear consumption pattern to one where consumption is based on circular movements, thereby replacing the end of life concept with restoration (see figure 11) (Ellen MacArthur Foundation, 2014). What also can be seen in figure 11 is the basic organization of the circular economy, what is important to note are the two main cycles, the technical life cycle of the product and its resources on the right in blue, and the biological life cycle on the left in green. Circular economy attempts to create value by letting products ‘ride the cycle’, or in other words by adapting products when they no longer deliver the requested performance instead of disposing of them. An important driver behind this thinking is that it in the future this would be a cheaper alternative over starting with fresh new products as the commodity prices would be a lot higher given their finiteness (Ellen MacArthur Foundation, 2014). The cycles in figure 11 give examples of the routes that can be taken after the product’s lifespan has ended, what is important to add with respect to these routes is that the ‘shorter’ routes are preferred over the longer ones. When looking at figure 11, maintenance would be for instance preferred over the ‘refurbish/remanufacture’ cycle. This because the extra costs associated with shorter cycles are lower than those associated with longer cycles (Ellen MacArthur Foundation, 2014).

![Figure 11 Depiction of the circular economy concept. With on the right side the technical cycle (blue) and on the left side the biological cycle (green) (Ellen MacArthur Foundation, 2014).](image)

b. Circular economy and cradle-to-cradle
All of the above explanations surrounding the circular economy concept could sound familiar as they demonstrate a close resemblance to the cradle-to-cradle concept. The cradle-to-cradle concept is an approach for designing products, processes and systems that takes the whole product life cycle into account. The purpose is to restore continuous cycles of biologic- and technical nutrients, with long-term positive effects on profitability, environment and human health (McDonough & Braungart, 2002). When it comes to objectives for re-use, both at a technical and biological level, the use of energy, and closing ‘business-loops’ in order to prevent waste, are essentially transferrable between the two concepts (Van Dijk et al., 2014). Circular economy however proposes a concept from the thought of economics and whereby sustainability
can be seen as the major catch alongside a change in systems, whereas the cradle-to-cradle philosophy focuses more on the ‘loops’ and re-use itself.

The above notion comes best to the fore in what the circular economy tries to do when it comes to incentivizing different actors in the process. In circular economy theory it is in the producer’s own interest to follow the cycles as he stands to gain most from it, this is because in circular economy theory the producer often does not sell his or her product but leases it to the customer (Ellen MacArthur Foundation, 2014). At the end of the product life cycle the product therefore is returned to the manufacturer. When the product that the manufacturer returns is filled with toxic materials, is unable to be disassembled in an easy way or uses low-quality materials, it is the manufacturer that is confronted with the costs to properly dispose of the product. This is the key-difference between other sustainable schools of thought and the current linear consumption pattern. By shifting responsibilities, actors will face costs for not using the correct methods or products that enable ‘cycle-riding’, thereby internalizing costs that could previously be considered as external.

The circular economy will impose a shift from linear consumption to circular consumption. In doing so, the circular economy will make it more attractive for manufacturers to make sustainable, durable products that are able to ‘ride the life cycles’. Put more strongly it is in the manufacturer’s own best interest to produce these products this way as in the circular economy model, he or she will remain responsible for the product instead of the consumer.

c. State of literature

The circular economy theory as provided by the Ellen MacArthur Foundation should not be accepted without criticism; due to incompleteness of literature and theory it is for instance as of yet not possible to give one generally used definition of circular economy.

The explanation that was given of the concept of circular economy earlier on in this analysis serves as an excellent example to acquaint someone with the circular school of thought. However, when a closer look is given to the exact definition of a circular economy, it appears that there is some debate in literature (Mentink, 2014). According to Kok, Wurpel, and Ten Wolde (2013), Mentink (2014) and De Grauw (2015) there is no clear definition, since the transition to circular economy will be a nonlinear process, in which many components are uncertain. Also circular economy thinking is not about sustainability, sustainability is a consequence of implementing the circular economy. Furthermore, current literature describes the circular economy at different levels without acknowledging these levels, also life extension (one of the loops in the Ellen MacArthur Foundation model) does not close a loop it merely prolongs one. It can also be discussed if downgrading of materials does not fit the circular economic model as it does entail closing a loop (albeit a different one). Furthermore a difference should be made between a practically achievable circular economy and an ideal one, where the former tries to come as close to the latter as possible. Lastly, circular economic theory as it stands does not provide any feedback on where the ownership of resources should take place. A new definition has been made:

‘a circular economy is an economic system with cyclical material loops based on a financial incentive’.

It is believed that, opposed to literature, it is important to include incentivizing, since this could be the main driver for businesses to embrace circular economy principles.
3. The construction industry and circular economy

a. Characteristics

Current construction processes generally go through several stages, these stages can be identified as: initiative, design, construct, and use. Where the initiative stage serves to define the need for a certain building or service, the design phase focuses on designing the need as it were. After the design has been made the process moves into the next phase, which is called the construction phase. In this phase construction of the design takes place, after construction is finished the use phase commences (Wamelink, 2010). What is worth noting is that these phases are designed to flow in one another like a circle, practice however learns that after the use-phase commences, little thought will be given to a new cycle (Yin & Menzel, 2011). The construction process as described above seems neat and clear-cut, but it becomes more complicated when the phases are coupled to the actors that are needed in order to execute the different phases, these will be discussed below.

When the aforementioned phases are coupled to the stakeholders in the process, it immediately becomes clear that the construction process is a complex one. The coupling of stakeholders to the earlier defined phases is done according to Wamelink (2010) and Winch (2010). During the initiative phase it is mostly up to the client to show the initiative to start a new project and think about the question what he or she needs. Once the design phase is entered, architects and advisors usually become involved to try and design a solution for the need that was established in the initiative phase. Although the amount of stakeholders involved in this phase usually is quite small, there is no limit to the amount of advisors that can be consulted here and in complex projects it might be that there are already a lot of different actors involved in this stage.

After the design phase is finished and the construction phase starts, other actors make their way into the process. The most important new stakeholder in the project at this stage is the contractor that is (usually) responsible for executing the design. The contractor usually is not able to construct the entire project on its own, and therefore enlists the help of sub-contractors and possibly its own advisors. The architect, earlier advisors, and client may also still be involved in this stage.

Hereafter the use-phase commences and the client starts using the commissioned project, or it sells the project to a third party, and then could possibly rent it back or not. Another important actor in this phase is the facility manager, who is responsible for taking care of the project during the use-phase (Riratanaphong, Van Der Voordt, & Sarasoja, 2012).

As can be seen from the short description above, the construction process revolves around an intricate play of different stakeholders during different phases of the project. This makes for complexity, especially since the way in which the above stakeholders cooperate is different in each project, making each project a ‘one-off’ and unique. What also becomes apparent is that on the supply side there are a lot of changes throughout the process when it comes to which parties are present in the project. There is not one single actor on the supply side that is present throughout the entire construction process. On the ownership side however, changes are relatively rare and if they occur, these changes were probably foreseen at the start of the project. It can therefore be argued that the ownership side of the process is more long-term oriented (with exception of the project developer), and the supply side more short-term oriented.
In short, the construction industry can be characterized by its project-based nature, delivering unique products (buildings). Due to the uniqueness of its products, each and every project in the industry is also different from one-another, with a different composition of stakeholders in each project. Also there is not a lot of thought given to end-of-life situations, probably because of the long time span surrounding the buildings, and the different components within the building have different lifetimes.

b. Aspect studies
Three different short aspect studies (ownerships, finance and components) have been done that showed the practical implications of implementation of the circular economy in the construction industry. From these exercises it can be concluded that, when circular economy theory is brought to the ‘standard’ construction process, the division between ownership and supplying party changes and becomes blurry, it also affects the time scope of the involved parties. When it comes to business financing, it can be said that leasing the objects constructed instead of selling them in order to retain ownership does not make sense from a supplier’s perspective. Leasing impacts both the company’s liquidity and solvability in a negative way. It also causes a lot of deadweight capital in the form of solid assets on the company’s balance sheet. From the second year onwards, the company’s result would recover for the most part, however there would still remain a loss when compared to the selling strategy. Other strategies like a buy-buy-back model or reintroducing a product were also found to be unlikely profitable activities. When it comes to building components (i.e. the products) a shift in demands will be needed when circular economy theory is implemented. Furthermore, the amount of individual building components plays a role in the feasibility of the circular economy in the construction industry, where the more components inherent in a building the less likely it seems that circular construction is feasible.

c. Obstacles
After comparing the aspect studies with the obstacles found by Kok et al. (2013), it has become clear that the biggest obstacle for the construction industry can be found at the organizational level, around issues concerning responsibilities, liabilities and ownership. This obstacle was found in all three of the exercises, next to that financial and technological obstacles play an important role in the construction industry. Another comparison with research done by Loppies (2015) also shows that organizational issues are present, along with technological challenges. This last comparison did not show financial challenges, this was however not researched by Loppies (2015).

4. Circular economy further defined
a. Building product provider
This chapter tries to further define the circular economy and the actors operating in this economy. The term supplier and service provider is important in the circular economy concept. However, it seem unclear what entity is meant with these terms. Is the service provider the same party as the supplier, or is a different entity needed? According to the Cambridge dictionary a supplier is “a company or person that provides things that people want or need, especially over a long period of time”. According to Stahel (2006) a service provider is one who ‘sells services instead of goods’. In this light, one does not exclude the other.

If one examines the production process of a simple wall socket, 11 different raw materials can be identified, manufactured in 3 different main components (plastics, copper and stainless steel). In the light of the circular economy principles it is unclear to what extent an entity owns or sells materials. If it is assumed that no products are transferred in ownerships, 15 different ‘owners’ can be identified in just a simple wall socket (11 raw materials, 3 manufacturers, 1 assembler).

In order to create a functional business model it is important to clarify what entity is meant with supplier and/or service provider, therefore the term ‘building product provider ’ will be used. This is explained according the study is Mohammadi, Prins and Slob (2015).
They describe a circular economy involving three different types of goods: products, components and complex components. For this research, the terms are changed into ‘material’, ‘component’ and ‘element’. A material is a raw material. Two or more materials make a component. Furthermore, two or more components can make an element. Each of these ‘states’ can be called ‘building products’.

This economy is characterized by a chain market in which three different types of chain partners: extractors, assemblers and service providers. This concept is illustrated in figure 13. There are two different markets in this economy, one is the market where the chain partners operate on. On the contrary of what is stated above, they can buy or sell their product; transferring the ownership from one party to the other.

**A building product provider is the service provider of a building product**

- A building product is a material, component or element.
  - A material is a raw material extracted from the earth
  - A component is a composition of products
  - An element is a composition of components.

- A service provider is a chain partner that operates on the services and performance market (B2C).

- A chain partner is a partner that trades on the chain market (B2B).
  - A partner is an entity or a person
  - A partner is either an extractor or assembler
    - An extractor is the producer of a product
    - An assembler is the producer of a component or complex component
  - Trading concerns transactions with transferring building materials
  - A chain market is the market where materials are traded

- The services and performance market is the market where services and performances are traded with customers.
  - A service or performance are a trade that is intangible and does not result in ownership
  - A customer is the user of services.
The other market is the services and performances market where the building product providers can trade with customers, using operational lease constructions. When a chain partner operates on the services and performance market with customers, it is by definition a service provider. In this concept called ‘radical circular economy’ the financial incentive is still secured, since the chain partners retain ownership of the materials/components/elements customers use (Mohammadi et al., 2015). With this in mind definitions have been made that will be used for the sequence of this research (figure 14).

a. Circular economy as a sustainable economy

According to Mohammadi et al. (2015) the circular economy is an economic system in which the society is designed in such a way that due to the actions of the ‘homo economicus’ sustainability is secured. Due to the assumption of rising resource prices, chain partners are indeed motivated to keep products in the chain as long as possible if they have ownership. Several reports describe the economic benefits of this concept for this reason (TNO, 2013; McKinsey & Co, 2015).

During this research it became clear that a significant amount of sources describe the circular economy as a mean to create a sustainable economy. Whether it is in literature, conferences, brainstorm sessions or videos; the relationship between circular economy and sustainability is highlighted.

Already in chapter two it is stated that the circular economy is not about sustainability; it is an economic system. However, it has been promoted and adopted as a mean to create a sustainable system. This could be the case, however it is not as straightforward as one thinks. According to the author a linear economy can just be as sustainable (or just as polluting) as a circular one.

Closing material loops can be an important solution to the depletion of resources. However, whether or not this is instant sustainable can be questioned. Imagine a linear economy in which only green energy is used, no toxic materials are added in production processes and products are made to last as long as possible, and products are made in a social fair way (such as no use of child labor). Subsequently, imagine a circular economy where products are returned in the loop with the use of toxic materials during the life cycle of a product (for example in the mining/production processes) and using nuclear energy.

In a circular economy sustainability is assured by adding guidelines to an economic concept. A circular economy is an economic system which does not have to be sustainable on its own. To create a sustainable economy (linear or circular), parties need to be aware that more is needed than only closing the material loops (think of green energy, socials justice and fairness, no toxic products used in production). Parties need to operate ethically. It is believed that this awareness is significantly lacking.

b. Boundary conditions

It is believed that an important distinction has to be made in defining the boundary conditions. Since sustainability is only secured by adding guidelines to an economic concept, there are two ‘levels’ created. The ‘hard’ conditions need to be fulfilled to meet the requirements of a circular economy. The ‘soft’ conditions need to be fulfilled to create a more sustainable economy.

‘Hard’ conditions (Mohammadi et al., 2015):
- Products have to be kept in the technical loop.
- Switching between the loops is part of CE.
- The technical products that degrade during their period of use (lifecycle), or when they are no longer usable within the technical cycle, must be returned to the biological cycle

‘Soft’ conditions:
- Green energy is used in the production, use and consumption processes
- No toxic materials are used in the production, use and consumption processes
- Chain partners have to operate maintaining earth for future generations
- Chain partners opt for global prosperity
- Social -justice and -fairness is normative for human action and chain partners operate accordingly

Assumptions
- Rising resource prices
- Chain partners operate to maximize their profit
There is no need to add the condition of retaining ownerships, which has been so important during this research so far. With the assumed rising resource prices and if it is assumed that chain partners’ goal is to maximize their profits, they already operate accordingly because it should be the most financially beneficial way of governance. Due to the assumed rising resource prices, it is believed that raw materials are potential ‘gold mines’.

5. Business model implications

This section will illustrate the challenges that arise with the implementation of the boundary conditions of a circular economy for building product providers. First, the current building process is described, with specific focus on the financial sections of this business model. Next, a situation is shown where a building product provider receives an order in a circular way.

![Figure 15 Linear situation (own image)](image)

The symbol on the left represents a provider of steel beams. The provider receives an order for an X amount of beams. Since the company is not able to fund its resources with own equity the provider needs to visit the bank for a loan. Next, the production process starts and once the products are finished they are transported and assembled at the building site. After the delivery, the provider collects the selling price and pays back the loan and interest. Note the short duration time of this process.

| Step 1 | Acquire finance |
| Step 2 | Start production process |
| Step 3 | Product delivery |
| Step 4 | Building finished |
| Step 5 | Collection selling price (S) |
| Step 6 | Pay back debt service (I) + remaining debt balance (L) |
| Step 7 | Profit |

Table 6 linear process (own table)

b. Circular

The circular situation is illustrated in figure 16. The financing process and the production process are separated to make the situation clearer. The building product provider is shown on top of the circle. This example will illustrate the issues arising in a circular economy on the services and performance market. The chain market is left out of this example. Again, the process is step by step explained with reference to figure 16 and 17.

Again the building product provider receives an order, however the demand is different. Instead of the order for an X amount of beams, the provider receives an order for providing the service ‘structure’ for a building.
Figure 16 circular situation (own image)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Check current supply</td>
</tr>
<tr>
<td>Step 2</td>
<td>Start production process/renew building product for new service</td>
</tr>
<tr>
<td>Step 3</td>
<td>Assemble products, components or elements to final building product</td>
</tr>
<tr>
<td>Step 4</td>
<td>Provide the service to the customer, including maintenance, monitoring and managing the customer relationship</td>
</tr>
<tr>
<td>Step 5</td>
<td>Disassemble products</td>
</tr>
<tr>
<td>Step 6</td>
<td>Return to building product provider</td>
</tr>
</tbody>
</table>

Duration: few years to 20 years or more

Table 7 circular process (own table)

Figure 17 circular situation finance (own image)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Acquire finance</td>
</tr>
<tr>
<td>Step 2</td>
<td>Earn lease</td>
</tr>
<tr>
<td>Step 3</td>
<td>Pay debt service every year</td>
</tr>
<tr>
<td>Step 4</td>
<td>Profit</td>
</tr>
<tr>
<td>Step 5</td>
<td>Pay for disassembly; transport and storage</td>
</tr>
</tbody>
</table>

Duration: few years to 20 years or more

Table 8 circular process finance (own table)
If the circular situation is compared to the linear situation, significant differences can be seen. The time scope is much longer in a circular process. This means a long term commitment of the building product provider. Next to that, the responsibility over the product (and performance) lies at the provider, adding maintenance, monitoring and management issues. The funding structure makes a structural change; business are now involved into long-term debts. Then businesses have to ‘close the loop’, causing the business to reserve funds for (dis)assembly and renewing the product for a second contract period.

New elements that arise are storage, (dis)assembly, transport, different finance structures, management and monitoring situations.

1. (dis)Assembly cost: the cost to be incurred to assemble and disassemble building.
2. Storage cost: the cost to be incurred to store products.
3. Transport cost: the cost to be incurred to transport products.
4. Monitor cost: the cost to be incurred to monitor the performance of products.
5. Management cost: the cost to be incurred to manage business activities.
6. Maintenance cost: the cost to be incurred to maintain products.
7. Renewing product cost: The cost to be incurred for renewing products for providing performance.
8. Withdrawal cost: the cost to be incurred to return products to the biological chain.
9. Economical risk premiums: The cost to be incurred to cover economical risks.

Special attention need to be given to the following two costs: financing and substitution risk premium.

10. Financing cost: the cost to be incurred to finance business activities.

The business model of the supplier will shift from a product-based business model to a performance-based business model. Now, the supplier will have a long-term debt instead of a short-term debt. In the circular economy building it is believed that the funding is done from the bottom. Instead of banks funding a certain product they now have to engage a long-term contract funding resources. The resource market differs substantially from the real estate market, characterized by different risk and returns requiring different knowledge and skills. Furthermore, a problem occurring in the transition from a product-based business model to a performance-based is the high up front capital needed for this financial structure.

11. Substitution risk premium: The cost to be incurred to cover the risk of arising substitution goods.

This is the risk for the substitution of one’s product. It is probably the most interesting and challenging variable in this list. Especially in such a changing environment with rapid technological developments and long life spans, is it unclear if conventional building products are still the way to go after a contract period of, for instance, 20 years.

Risks can be new regulations or insights about a building product. It could very well be that a common product is prohibited by law (such as asbestos) when new findings are discovered. Another reason could be new requirements to products, making current products unfit for reuse (such as dimensions) or the use of new construction methods (such as 3D printing).

The uniqueness of the built environment is that products are to be used for such a long period that the usefulness of products becomes highly uncertain. Since one is unable to predict the future, building product providers need to make assumptions about the utility of its product concerning turnover rates and profit calculations over a large period of time. Imagine a situation where a building product provider’s product becomes profitable after a certain period which in retrospect could not be reached.
c. Circular economy trading

This section will briefly zoom in on the way products can be traded in a circular economy. In the figure, seven different options are given in which the composition of an element is shown during its life cycle. The icons (building and airplane) are described as 'objects'. The trades are given in a random order; they can occur any time during the life cycle.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Function</th>
<th>Object</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel structure dwelling (untreated)</td>
</tr>
<tr>
<td>Same</td>
<td>Different</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel cladding dwelling (untreated)</td>
</tr>
<tr>
<td>Same</td>
<td>Same</td>
<td>Different</td>
<td>Steel structure dwelling (untreated) -&gt; steel structure airplane (untreated)</td>
</tr>
<tr>
<td>Same</td>
<td>Different</td>
<td>Different</td>
<td>Steel structure dwelling (untreated) -&gt; steel engine parts airplane (untreated)</td>
</tr>
<tr>
<td>Different</td>
<td>Same</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel structure dwelling (treated)</td>
</tr>
<tr>
<td>Different</td>
<td>Different</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel cladding dwelling (treated)</td>
</tr>
<tr>
<td>Different</td>
<td>Different</td>
<td>Different</td>
<td>Steel structure dwelling (untreated) -&gt; steel engine parts airplane (treated)</td>
</tr>
</tbody>
</table>

Table 9 different composition of products in a circular market (own table)

This section identifies in what kind of form a product can be traded. An element can be traded as it is, delivering the same function in the same object (such as reuse). It can also occur that a component of an element is replaced (due to failure of a component, for example), resulting in a different composition. Furthermore it is possible that elements are used performing different functions.

This is important to mention, since a product that has X function could have to deal with different macro and micro economic factors compared to products with Y function. This also means that different profits can be made. This all causes that, keeping in mind that a chain partner retains ownerships, the chain partner is cautious in its choice in the allocation of its resources.

To clarify this situation an example is given: imagine a chain partner with 1000 kilograms of steel in stock. The chain partner is involved in both the construction and automotive sector. In this example the chain partner does not want to sell the steel and therefore only offers the performance. In the automotive sector the steel is used for, for example, the bodywork (providing performance ‘structure’ for a car). In the construction industry the steel is used for the structure of a building (providing performance ‘structure’ for a building). The average life cycle of a car is set at 10 years; for the steel structure 110 years is given (Cooper et al., 2014). In other words, steel is used far longer in the construction industry compared to the automotive industry before it has to be recycled. On the other hand, it could be that the revenue models are much more interesting in the automotive industry for 1 kilogram steel. Next to these financial reasons, it could also be that one market is ‘safer’ or more ‘stable’ than the other. One can think of changing regulations or new emerging trends in different sectors (strongly related to
substitution risk). It is believed that a premium has to be added in the business model to cover for market imperfections.

12. Allocation premium: the cost to be incurred to cover for market imperfections.

Furthermore it is believed that a premium has to be added to the selling price in terms of 'likeliness' a material can be retrieved to the owner. The less complex a material is ‘packed’ in a component, the more likely it is to change in objects and therefore enlarges the future potential of a material. Therefore the following risk premium need to be added as well:

13. Complexity premium: the cost to be incurred to cover for the complexity of the composition of materials.

Furthermore it is believed that a premium has to be added to the selling price in terms of 'likeliness' a material can be retrieved to the owner. The less complex a material is ‘packed’ in a component, the more likely it is to change in objects and therefore enlarges the future potential of a material. Therefore the following risk premium need to be added as well:

6. Design of the business model

The design of the business model will focus on the financial aspects: cost structure and revenue streams. The cost structure sums up the monetary consequences of the means employed in the business model and the revenue streams describe the way a company makes money through a variety of revenue flows. Next, a case study has been done on providing the performance ‘structure’ for a building. The aim of the case study is to determine to what extent the designed business model is able to determine the (financial) viability of providing the service ‘structure’ in a circular economy.

a. Business model

The main focus of this business model is the sale of services instead of products. This means that this business model provides customers with the service the materials deliver. Next to that, the performance need to be monitored. Furthermore, the materials need to be allocated which yield the greatest return.

The added value in itself is not new. However, in this business model the building product provider provides a service to a customer. The assembly, maintenance and disassembly is completely taken care of, leaving the customer with the thing he wants most: the performance. With this approach, a customer does not need high up front cost for something he does not need.

![Business model diagram](image)

Figure 19 Business model (own image)
b. Revenue model
In this business model, the revenues are generated in two ways. The first one is earning a lease amount. Various models can be used:

- Pay per fixed term (day/month/year)
- Pay per use (amount of time customer is using the beam, such as office hours)

The payment itself can be based on characteristics of a product. In case of a steel beam:

- Bearing strength of the beam (€ per N/m²)
- Providing structure of a building

The other part of the revenues is based on the value increase of the raw materials. It is believed that due to the increase in world population, the prices of raw materials will rise. In a circular economy, products are seen as an investment opportunity, which is believed to grow significantly in the future.

c. Cost structure
The cost structure are as defined in the previous chapter. They can roughly be separated in four different categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Maintenance</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Renewing cost</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reuse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Recycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Remanufacture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Withdrawal</td>
<td>Fixed amount / end of contract period</td>
</tr>
<tr>
<td>Potential</td>
<td>Substitution risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Allocation risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Complexity risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td>Economical</td>
<td>Future price fluctuations</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>General risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Energy prices risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td>Organizational</td>
<td>Transport</td>
<td>Fixed amount / end of contract period</td>
</tr>
<tr>
<td></td>
<td>Management</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>(dis)Assembly</td>
<td>Fixed amount / end of contract period</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
<td>Fixed amount / end of contract period</td>
</tr>
</tbody>
</table>

Table 10 list of additional costs (own table)

d. Case study: ‘structure’ as performance
This section will add numbers to the ‘variables’ mentioned by means of a case study. The aim of the case study is to determine to what extent the designed business model is able to determine the (financial) viability of providing the service ‘structure’ in a circular economy. The product used for providing the performance is a steel beam. The product is chosen since it is believed that steel structure products are well suited for a circular economy.

Case: a customer demands the performance ‘structure’ for a new building. The case will be limited to the performance of one single beam. It is assumed that the following product is sufficient in providing the performance for the customer:

- Material Steel
- Description HEB300
- Quality SJ235JRG2
- Size 6m
- Value in 2015 (www.staalprijzen.nl) € 966,-
### Case study: steel beam

#### Basic information

<table>
<thead>
<tr>
<th>Material</th>
<th>Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>HEB300</td>
</tr>
<tr>
<td>Quality</td>
<td>S235JRG2</td>
</tr>
<tr>
<td>Size (m)</td>
<td>6</td>
</tr>
<tr>
<td>Product service system</td>
<td>Lease</td>
</tr>
<tr>
<td>First contract period (yr)</td>
<td>10</td>
</tr>
<tr>
<td>Value in 2015</td>
<td>€ 966.00</td>
</tr>
<tr>
<td>Lease percentage</td>
<td>10%</td>
</tr>
<tr>
<td>Depreciation (yr)</td>
<td>0</td>
</tr>
<tr>
<td>IRR</td>
<td>4%</td>
</tr>
<tr>
<td>Product index</td>
<td></td>
</tr>
<tr>
<td>Product index (p/y)</td>
<td>4%</td>
</tr>
<tr>
<td>Other assumptions</td>
<td></td>
</tr>
<tr>
<td>CPI</td>
<td>2%</td>
</tr>
<tr>
<td>Distance (km)</td>
<td>200</td>
</tr>
</tbody>
</table>

#### Costs

- Production cost (/m) € 133.00
- Maintenance (p/y) 0%
- Renewable cost (end): 10%
- - reuse 0%
- - remanufacture 10%
- - withdrawal 0%
- - recycle 0%
- Transport (/km) € 0.21
- (Dis)assembly 15%
- Storage (/m in 2015) € 15.00
- Management 2%
- Monitoring 0.4%

#### Risk premiums

- Substitution (/yr) 2%
- Allocation (/yr) 0%
- Complexity (/yr) 0%
- Future price fluctuation 2%
- Energy (/yr) 1%
- General (/yr) 2%
- Total 7%

| Assumed sale at y 11 |  |

Figure 20 variables in spreadsheet (own image)

All the other cost have been quantified, mainly by means of assumptions (figure 20). An internal rate of return of 4.4% has been found. This means that all the added costs and risk premiums, a positive result emerged. As said, a great part of these cost are estimated and assumed, so questions can be raised about the reliability of the outcomes. However it shows that under the ‘right’ circumstances profit can be made.

A sensitivity analysis showed that there are two variables which have the biggest influences on the outcomes: the product index and the lease percentage. The conclusion that can be drawn from this case study is unequivocal: the key issue is axiom of the growth in resource prices. There is a limit to the height of the lease price; therefore the growth in resource prices, based on scarcity and under the set conditions of this study, will determine the financial viability of the business model. This the key to the success of the transition from a linear economy to a circular economy.
7. Conclusion

The main question of this research is:

To what extent is a) the implementation of the circular economy theory in the construction industry of influence of the business models of building product providers and b) how should the financial aspects of a business model be designed in order to operate successful within the boundary conditions of the circular economy theory.

This research critically examined the circular economy concept as posed by the Ellen MacArthur foundation. Despite the growing popularity, the theory itself should not be accepted without any criticism. Due to incompleteness of literature and theory it is for instance not possible to give one generally used definition of circular economy. Therefore a new definition of circular economy has to be established. After reviewing a lot of literature and conducting various discussions the following definition is made:

‘a circular economy is an economic system with cyclical material loops based on a financial incentive’.

Wherein ‘economic system’ refers to a combination of more than one interrelated parts or components that show how people deal with scarcity, ‘cyclical material loops’ refers to a loop that makes it possible for materials to keep cycling in these loops, and where ‘a financial incentive refers to a prospect on financial merits.

The construction industry is characterized by its project-based nature, delivering unique products (buildings). Due to the uniqueness of its products, each and every project in the industry is also different from one-another, with a different composition of stakeholders in each project. Also there is not a lot of thought given to end-of-life situations, probably because of the long time span surrounding the buildings, and the different components within the building have different lifetimes. Furthermore the industry is capital-intensive and relies a lot on manual labor in order to realize its products.

The built environment nowadays is responsible for using 40 to 50% of the natural resources, 30% of the primary energy demand in OECD-countries, 40% of the emissions of greenhouse gases and 10 to 30% of the waste flow in the European Union (Uihlein & Eder, 2009) (Schoolderman et al., 2014; OECD, 2008; Uhllein & Eder, 2009; APRICOD, 2006). These figures stresses the urgency of resource efficiency in the construction industry. However, the characteristics of the construction industry makes the implementation of circular economy significantly more difficult and contradicts circular economy principles, such as minding a product’s life cycle.

During this research, boundary conditions have been set up and actors involved in a circular economy have been identified. It has been found important to divide the boundary conditions into ‘hard’ and ‘soft’ conditions in order to stress the difference between a ‘sustainable’ and a ‘circular’ economy. The ‘hard’ conditions need to be fulfilled to meet the requirements of a circular economy. The ‘soft’ conditions need to be fulfilled to create a more sustainable economy.

It can be concluded that the implementation of circular economy principles cause a significant shift in business models of building product providers. The implementation will cause a shift for building product providers from short-term to long-term governance, adding new risks and costs. Furthermore, the responsibility for the performance cause the chain partner to implement maintenance, management, transport and (dis)assembly in the business model. In short, the application of the boundary conditions to the conventional business models and markets have resulted in 13 additional issues that have to be incorporated in the design of a new business model. These issues are implemented as costs and risk premiums and can roughly be divided into four different categories: product, organizational, economical and potential.

The business model is illustrated in figure 19, incorporating all these risks and costs. The model is examined by means of a case study: providing structure for a building. This research shows that the financial uncertainties of implementing circular economy in practice can be brought down to two factors. First, the profitability of leasesolutions depends heavily upon resource prices. Second, the financial value of materials inserted in a construction project depends on their usability at the end-of-loop situation.
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Part One
Introduction

This chapter will introduce and discuss the research proposal. First, a personal motivation will be given, followed by the problem statement, research question(s), intended product and relevance. Finally, the research design will be explained.

PERSONAL MOTIVATION

In 2014 I was in the fortunate position to do my free electives at the University of Melbourne in Australia. Next to having a great time I had various interesting subjects. One of these subjects was part of the Master of Construction and was called Construction Industry and Environment. This subject aims to develop an understanding and awareness of the life cycle environmental effects of building design and construction, including approaches that can be used to assess and minimise them.

Also this subject emphasizes the upcoming shortages of raw materials and stresses the urgency to change the way we build. It made me more aware of the importance of reducing the environmental impact of buildings. This is the time for new insights, different building methods and more awareness in the built environment in order to deal with the upcoming shortages of earths’ resources and to create a more sustainable world for us, and more important, for next generations.

After this subject I was sure I wanted to do my graduation in this field. What is more interesting and exciting than doing the research about the main challenge the world population has to deal with in the upcoming decennia (and further)? The circular economy concept gives a fresh view on how to deal with the resource depletion. In some sectors there are already interesting initiatives or businesses adapting circular economy principles; the questions is to what extent the concept is applicable to the construction industry.

We are at a crossroad; the way we consume has to change. New business- and contract models are needed and innovations like Turntoo of Thomas Rau make me very exciting and eager to do more research about this in the Real Estate sector.

PROBLEM STATEMENT

Especially in the last years a lot has been written about the concept. It has been promoted by the Ellen MacArthur Foundation via various reports in corporation with McKinsey & Company and this has been picked up by various institutions. The foundation started The Circular Economy 100, a global platform bringing together leading companies, emerging innovators and regions to accelerate the transition to a circular economy (Ellen MacArthur Foundation, 2012).

There are also examples to mention where it is claimed that the circular economy is used in practice. Carpet manufacturer DESSO says it has been working with the principle for years and it has brought them significant advantage over their competitors. Recently it has been announced that Philips will use ‘circular lighting’ for the new lights at Schiphol Airport. Next to that, there is the town hall in Brummen, claimed to be the first circular building in the Netherlands.

Also on political level there a growing interest in more research in the circular economy. The European Commission is aiming to present a new, more ambitious circular economy strategy in the end of 2015, ‘to transform Europe into a more competitive resource-efficient economy, addressing a range of economic sectors, including waste’.

Not only on European level circular economy is gaining momentum. Also in The Netherlands more and more initiatives are popping up in the field. Initiatives such as ‘The Green Deal’ tries to implement the circular economy in the built environment. The initiative is gaining interest and is already signed by more than 60 companies. Next to that, there are foundations such as ‘Building the CE’ and ‘Stichting Circulaire Economie’ trying to gain more knowledge about the circular economy.

The transition from a linear to a circular economy has consequences for the business models of parties involved in the construction sector. A key principle of the circular economy is the transition from sales of products to sales of services (Stahel, 2006). This means that businesses change from a product-based business model to a
performance-based business model. In theory, the implementation of circular economy will cause a shift in ownership. Instead of selling products the suppliers will remain responsible for the life cycle of their product.

For the suppliers financial, legal, social, mental and operational challenges arise (Kok et al, 2005); the business structure needs to change. Despite the significant amount of reports about the circular economy and the increasing popularity by both market parties and politics, empirical scientific research on the implementation of circular economy, especially in the construction industry, is lacking and it seems to the author that the terminology is used rather diffused and incoherent when different sources are examined.

**RESEARCH QUESTIONS**

The problem statement has resulted in the following main question:

To what extent is a) the implementation of the circular economy theory in the construction industry of influence on the business models of building product providers and b) how should the financial aspects of a business model be designed within boundary conditions of the circular economy theory.

This research question will be answered with the following sub question:

- What does the circular economy enhance and to what extent is the concept irrefutable?

This chapter will describe the circular economy concept. It will thoroughly discuss to what extent the concept is complete. After criticism, a working definition of circular economy is designed.

- What will the implementation of the circular economy mean for the construction sector?

The construction sector is a unique sector with its own characteristics. This chapter will elaborate on those characteristic and obstacles with respect to the circular economy principles.

- To what extent can market parties contribute to the discussion of circular economy in practice and how can the boundary conditions be defined?

The main aim of this chapter is to design boundary conditions of a circular economy. Since the diffused use of the terminology it is unclear to what conditions a business model should comply.

Three market parties that are in some way involved in circular economy are interviewed. The interviewees are asked for the meaning of circular economy for their business. The aim of the interviews is to see to what extent interviewees answer in compliance with the own findings on circular economy described in chapter one and two.

- To what extent will business models of building product providers change with the implementation of the circular economy theory?

This chapter will project the set boundary conditions of chapter three into practice, describing the consequences of the change from product-based business models to performance-based models in the construction industry. Furthermore, this chapter will briefly describe the way trading could be done in the economy.

- Design financial business models in the circular economy.

Chapter five will put the findings into the financial section of a business model, focussing on the revenue streams and cost structure.

- Case study: ‘structure’ as a performance.

In this chapter the business model is projected on the life cycle of a steel beam. It is explored to what extent it is financially viable for a building product provider of a beam to implement circular economy principles.

**OBJECTIVE AND INTENDED PRODUCT**

Circular economy will cause a shift from product-based business models to performance-based business models. This research will view the ‘performance’ from an economical perception. This means that businesses operate with the same products, only the product service systems will differ.
The objective of this research is to design the financial section of a business model in which building product providers can operate within the set boundary conditions of the circular economy.

This research is initially made for building product providers in the construction industry and, if working correctly, for suppliers interested in implementing the circular economy concept in all kinds of sectors. The intended product will be the financial aspects of the business model, including cost structures and revenue models.

RESEARCH DESIGN

This section will discuss the research design and the methods that will be used. The research mainly involves six steps, shown in the following figure. The steps correspond with the research questions as given in the previous paragraphs.

![Figure 21a six-step approach (own image)]

The structure of this research is based on the main findings of literature reviews on the topic of circular economy. It appeared that a lot has been written on this topic. The circular economy concept has been boosted by the Ellen MacArthur Foundation in 2012 and since then the topic has gained popularity amongst companies, universities and governments on global scale. This has resulted in a significant amount of reports and papers on the one hand and initiatives such as the establishments of foundations to promote the topic on the other hand. Despite the amount of literature available, they all remain rather theoretical. It could be concluded that empirical scientific research on the implementation of circular economy, especially in the construction industry, is lacking and it seems to the author that the terminology is used rather diffused and incoherent when different sources are examined.

In short, there is not a solid ground theory to base this research on. Therefore will this research be of explorative nature, mainly using the following data collection methods:

- Aspect studies

Because of the above mentioned argument of the lack of empirical evidence this method gains importance. Since there is not a solid ground theory, thought studies could give certain insights in the circular economy concept which not yet have been acknowledged.

- Interviews

The interviews will be mainly of explorative nature. Interviewees could be of any nature, preferably but not necessarily in the construction industry.

- Modelling

A big part of the research will be based on modelling. Since there is no ground theory to base this research on, this method is used to discuss the specific opportunities and challenges that lay ahead in the circular economy concept for parties in the construction industry.
**RELEVANCE**

It is believed that this research can add value on two different levels. First, the scientific relevance will be discussed, followed by the social relevance.

**Scientific relevance**

As already stressed in the problem statement, current literature on the concept of the circular economy tend to remain rather theoretical. It seems that not much thought has been given to the practical implementation of the concept. Furthermore, the circular economy concept as posed by the Ellen MacArthur Foundation (2012) should not be accepted without a critical view (Mentink, 2014; De Grauw, 2015; Mohammadi, Slob & Prins, 2015; Kok et al., 2013). Extensive literature review has revealed a lack of business models ready for circular economy practice. This research aims to design the financial section of a business model by critical reviewing the current literature and reports. With the aforementioned six-step-approach the circular economy principles are mapped, boundary conditions are designed and subsequently projected to conventional business models of suppliers. With the results, a new business model will be designed.

**Social relevance**

The economy has been dominated by a one-way or linear model of production and consumption. In this model goods are manufactured from raw materials, sold, used and thrown away (EMF, 2012). This has brought society a lot of prosperity and there is still room for this model to grow geographically. However, people more and more realize the need for productivity gains and resource efficiency. According to the Ellen MacArthur Foundation (2012) people are living on a ‘consumption time bomb’. Resources are running out. On the contrary, the global middle class will more than double in size to nearly 5 billion in 15 years which will result in a consumption increase and material intensity (EMF, 2012). By 2050, the population will grow over 9 billion people, most of them enjoying increasing wealth (Godfray et al., 2010). This will lead to an economy demanding three times the amount of resources currently used (Planing, 2014). Other research even concludes that over 99% of the material flow generated in order to produce goods ends up in waste disposal after 6 months (Hawken, Lovins, & Lovins, 2013). It can be questioned if these figures are exact, however the urgency of a fundamental change of our economy should not be denied.
Looking at the construction industry the following figures can be mentioned. The built environment nowadays is responsible for using 40 to 50% of the natural resources, 30% of the primary energy demand in OECD-countries, 40% of the emissions of greenhouse gases and 10 to 30% of the waste flow in the European Union (Uihlein & Eder, 2009) (Schoolderman et al., 2014; OECD, 2008; Uihlein & Eder, 2009; APRICOD, 2006).

The circular economy theory is about designing out waste and optimize use of the resources. There is great potential in the theory since, at some point, our resources are depleted and the world has to use the resources available. The current linear economy has been here for more than 200 years. It has been sufficient for a long time, but at this point in time, it is believed that our current way of consuming should change. The circular economy theory could be an answer to counter these developments, however more research is needed.

READERS’ GUIDE

The report will be written according to figure 21a and 21b. First, the circular economy concept will be discussed, followed by an examination of this concept in the construction sector. Third, the circular economy concept is further defined, trying to border and define actors and boundary conditions. Next, it is researched in what way business models of building product providers will change. Finally, the financial aspects of a business model will be designed and examined in a case study. This research will be mainly of explorative nature. By trying to model the circular economy concept in a construction project, challenges and opportunities will be found during this research, all incorporated in the design of a circular economy business model. Afterwards, a conclusion will be given as well as a critical reflection of this research by several market experts.
Part Two
1

THE CIRCULAR ECONOMY CONCEPT

The circular economy concept
Current state of literature
The definition of a circular economy
Conclusion
1 The circular economy concept

This report will establish a definition of the circular economy that is useable in future circular construction industry research. This is important because as of this moment there is not one single, clear definition of the circular economy being used in literature. The first part of this report will start with an attempt to define the concept of circular economy following existing literature, to give readers a working definition of what it is circular economy attempts to do. The next section will deal with the exact definition of circular economy and why it is difficult to state a generally accepted definition.

1.1 THE CIRCULAR ECONOMY CONCEPT

This section will give a general introduction of the circular economy concept as it is presented through literature. It will also provide some background as to why circular economy thinking exists and what sets it apart from other schools of thought. At the end of this section the reader will have a basic understanding of the circular economy concept.

The need for a circular economy

Since the beginning of the Industrial Revolution 200 years ago our economy has been characterized with consuming. Nowadays products are even designed in a way that they do not live up to our expectations after a few years. This is because in the current economy companies benefit from a short lasting product. Planing (2014) and Stahel (2012) describe this as a misaligned profit-share along the supply chain, causing an imperfect product design. The circular economy concept stems from the believe that linear consumption will reach its limits in the foreseeable future, and builds upon different earlier concepts like for instance cradle-to-cradle theory (Ellen MacArthur Foundation, 2014; Van Dijk et al., 2014).

The thought that linear consumption is reaching its limits originates for instance from the fact that the amount of resources that are available for use will decline steadily over the next years and decades. This leaves little to play with for future use, especially since the rate of recycling is low for most resources (Ellen MacArthur Foundation, 2014; Mentink, 2014). Other research concludes that over 99% of the material flow generated in order to produce goods, ends up as waste and is disposed after 6 months (Hawken et al., 2013). It can be questioned if these figures are exact, however it describes the urgency of a fundamental change of our economy. The reason that the rate of recycling is low under a linear consumption pattern is that there in general is no premium or gain on re-using materials, this leads to the take-make-dispose model that is used by most manufacturers nowadays (Ellen MacArthur Foundation, 2012). Take-make-dispose refers to the process where resources are taken from the environment, consequently used as part of making a product, and where that product is afterwards disposed back into the environment as it has no further use. This is occurring while the global middle class will more than double in size to nearly 5 billion people in the next 15 years, which will result in an increase in consumption and material intensity (Ellen MacArthur Foundation, 2012). By 2050, the population will grow to over 9 billion people, most of them enjoying increasing wealth (Godfray et al., 2010). This will lead to an economy demanding three times the amount of resources we currently use (Planing, 2014).

The circular economy concept

The Ellen MacArthur Foundation is the main promoter of the circular economy, which tries to design waste out of production processes by changing the linear consumption pattern to one where consumption is based on circular movements, thereby replacing the end of life concept with restoration (see figure 22) (Bakker et al., 2014; Ellen MacArthur Foundation, 2014; Preston, 2012). So why has the circular economy concept increased in popularity the previous years, with amongst others the Ellen MacArthur Foundation actively promoting it? According to Planing (2014), three major changes led to this development. The first change has to do with increasingly volatile commodity prices. Raw material prices are on a constant rise and become increasingly volatile, which makes it more interesting to recover these materials after a product’s life ends (Bakker et al., 2014). The second change is the technical capacity of information systems, technology enables new business models, which were not feasible before. Thirdly, there is a shift in consumer behavior that leads to a performance over an ownership mentality.
The basic organization of the circular economy can be seen below in figure 22. What is important to note are the two main cycles, the technical life cycle of the product and its resources on the right in blue, and the biological life cycle on the left in green. Circular economy attempts to create value by letting products ‘ride the cycle’, or in other words by adapting products when they no longer deliver the requested performance, instead of disposing of them. An important driver behind this thinking is that this would be a cheaper alternative over starting with fresh, new products as future commodity prices would be a lot higher given their finiteness (Ellen MacArthur Foundation, 2014). The cycles in figure 22 give examples of the routes that can be taken after the product’s lifespan has ended, what is important to add with respect to these routes is that the ‘shorter’ routes are preferred over the longer ones. When looking at figure 22, maintenance would be for instance preferred over the ‘refurbish/remanufacture’ cycle. This because the extra costs associated with shorter cycles are lower than those associated with longer cycles (Ellen MacArthur Foundation, 2014).

The difference between circular economy and other systems’ thinking
All of the above explanations about the circular economy concept could sound familiar as they demonstrate a close resemblance to the cradle-to-cradle concept. When it comes to objectives for re-use, both at a technical and biological level, the use of energy, and closing ‘business-loops’ in order to prevent waste, these are essentially transferrable between the two concepts (Van Dijk et al., 2014). Also the environmental issues in the previous paragraphs do not describe anything new. In the past decennia different parties discussed resource depletion and tried to design new models to step away from the linear model. Amongst those parties there is a wide acceptance that the current linear model is obsolete and should be replaced by a new, more sustainable model. This is also where the Circular Economy concept comes from, it is not Ellen MacArthur who invented the concept ‘Circular Economy’. The term itself has been used decades ago. In fact, it is a combination of a lot of different sustainable models from previous decades.

Stahel has been an expert on alternative models for more than 40 years. The Swiss architect performed several researches on the limits to our growth, and together with Giarini he emphasizes the need to change our consuming behavior (Stahel & Giarini, 1993). He was also the first person to introduce the Cradle-to-Cradle model, which is an approach for designing products, processes and systems that takes the whole product life cycle into account. The purpose is to restore continuous cycles of biologic- and technical nutrients, with long-term positive effects on profitability, environment and human health (McDonough & Braungart, 2002). Another model, biomimicry, is inspired by nature where all used materials can provide nutrition for further use without compromising the
existent. Reap, Baumeister and Bras (2005), for example, described the potential of biomimicry as a sustainable design tool. This is just a small sample of many more sustainable models, such as; life cycle analysis, the performance economy (Stahel, 2010), industrial ecology (Ayres et al., 1996), blue economy, and regenerative design (Bakker et al., 2014; Lyle, 1996).

So what sets circular economy thinking apart from the aforementioned schools of thought? Circular economy is different in the way that it proposes a concept from the thought of economics, whereby sustainability can be seen as the major catch alongside a change in systems, whereas the cradle-to-cradle philosophy and other schools of thought focus more on the ‘loops’ and re-use themselves.

It is believed that the term ‘economy’ is the thing that makes this concept different from the others. The circular economy combines the aforementioned schools of thought, with a major hint to the cradle-to-cradle concept. What is added, is that the circular economy theory is about an economic system, in which all the schools of thought are secured. It is about the actors in an economy and the way they have to deal with resources. An example is the shift from product-thinking to performance-thinking.

The above notion comes best to the fore in what the circular economy tries to do when it comes to incentivizing different actors in the process. In the circular economy theory it is in the producer’s own interest to follow the cycles as he stands to gain most from it, this is because in circular economy theory the producer often does not sell his or her product but leases it to the customer (Bakker et al., 2014; Ellen MacArthur Foundation, 2014; Roos, 2014). At the end of the product life cycle the product therefore is returned to the manufacturer. When the product that the manufacturer returns is filled with toxic materials, is unable to be disassembled in an easy way or uses low-quality materials, it is the manufacturer that is confronted with the costs to properly dispose of the product. This is the key-difference between other sustainable schools of thought and the current linear consumption pattern. By shifting responsibilities, actors will face costs for not using the correct methods or products that enable ‘cycle-riding’, thereby internalizing costs that could previously be considered as external.

Concluding remarks
This section introduced the circular economy concept and indicated that it will impose a shift from linear consumption to circular consumption. In doing so, the circular economy will make it more attractive for manufacturers to make sustainable, durable products that are able to ‘ride the life cycles’. Put more strongly it is in the manufacturer’s own best interest to produce these products this way as in the circular economy model, he or she will remain responsible for the product instead of the consumer. This section also explained the difference between circular economy thinking and the cradle-to-cradle school of thought, this is mainly based upon the incentive thinking behind the circular economy that was explained above, whereby a more sustainable and durable world in circular economy is more of a consequence of the incentive shift, as opposed to the goal through the entire process as proposed by cradle-to-cradle thinking.

1.2 CURRENT STATE OF LITERATURE
This section will deal with the validity of the current theory as it was presented in the earlier section; the circular economy concept. This will be done as it has become apparent when reading further literature that the theory as proposed by the Ellen MacArthur Foundation shows some inconsistencies. It is important to note that this section does not serve as a rejection of circular economy thinking but more as an indication of the current state of literature, and therefore the need to come up with an industry-specific definition.

The definition of circular economy
The explanation that was given of the concept of circular economy earlier on in this analysis serves as an example to acquaint someone with the circular school of thought. However, when a closer look is given to the exact definition of a circular economy, it appears that there is some debate in literature (Mentink, 2014). According to Kok, Wurpel, and Ten Wolde (2013), Mentink (2014) and De Grauw (2015) there is no clear definition, since the transition to a circular economy will be a non-linear process, in which many aspects are uncertain. According to Mentink (2014) the Ellen MacArthur Foundation describes the concept as:

“an industrial economy that is restorative by intention’.
Mentink (2014) furthermore notices that the reports of the Ellen MacArthur on the circular economy lack a definition that is well thought-out. Based on this definition of the Ellen MacArthur Foundation and supported by other literature on the subject, Mentink (2014) himself comes up with the following definition:

’a circular economy is an economic system with closed material loops’.

The above examples indicate that there is as of yet not one clear definition of what the circular economy is and what it is not, also every author that writes in relation to the circular economy concept seems to have their own ideas about the definition of the concept. This seems to hollow the concept of circular economy towards a popular term or so-called ‘empty barrel’, a notion that is affirmed by Mentink (2014). What also becomes apparent is that circular economy thinking does not talk about sustainability and is ultimately, as stated earlier in this analysis, not about sustainability (Mentink 2014; Stahel, 2012). It is merely an effect of manufacturers working in a circular economic model.

Loppies (2015) designed his definition after reviewing the literature (EMF, 2012; Kok et al., 2013) and interviews with experts with the following result:

‘An economical and industrial system, ecologic and economical regenerative by design, maximizing value retention and minimizing value destruction, aiming to retain the quality of life as much as possible’.

Again, a slightly different definition emerged, but also some overlaps can be mentioned. Quite logical, all three definitions speak about an economic system in which regeneration and ‘closed loops’ are key principles.

The circular economy concept itself
Following from the previous paragraph, the problem lies not only with a contested definition, this is illustrated through the following examples:

1) In an attempt to come up with an overview of what is circular economy and what it is not, Mentink (2014) tried to order the different aspects of circular economy thinking in a single schedule (figure 23). By examining this figure it becomes immediately apparent that implementation of the circular economy in a business chain brings more complexity than the model provided by the Ellen MacArthur Foundation (2014) shows. It also shows that there is a sort of hierarchy in thinking about the circular economy and that some factors might be considered more important or at a higher level than others. What also comes to show is that the circular principles provided by the Ellen MacArthur Foundation (depicted in figure 23 in red) seem to appear at ‘random’ places in the hierarchy and to be of a different importance in implementing circular economy thinking, something that is not (directly) acknowledged by looking at the model the Ellen MacArthur foundation provided.

2) According to the Ellen MacArthur foundation (2012) an important characteristic is life extension. It could be questioned if this has anything to do with closing the material loops. The product should be designed in a way that it can be returned in the loops, minimizing waste and maximizing value. What happens after the products’ life should be of more importance than extending the functional use of a product.

3) Circular economy theory is about closing the loops. Materials should be reused as much as possible before they are renovated and recycled, but how bad is recycling/downgrading? An example is the construction of roads. A great part of the waste of concrete components in demolished buildings are used for the construction of new roads. In fact, these roads consist for a great deal of this waste. According to the theory the concrete components should be reused first, which means the road construction can’t use the concrete waste. In this way, new alternatives to build the road have to found. It could be argued if this is more sustainable.
Figure 24 Hierarchy of different concepts in circular economy thinking (Mentink, 2014)
4) A 100% circular economy does not exist; new raw materials are always needed (Mentink, 2014). Therefore there should be a difference between the ideal circular economy, which bans out all waste and uses only renewable energy and one that is practically achievable as the latter one is not. This is due to several reasons as pointed out by Mentink (2014, p. 20):

- Either there would have to be zero losses of technical material, or all materials would have to be biodegradable
- Fully closed material loops imply zero material inputs (implying an ever continuing status quo)
- Closed material loops imply endless loops, but certain materials can only be re-used for a certain amount of times
- Endless loops would also require endless amounts of energy

The above reasons show why a full circular economy is not achievable, and why there needs to be a difference between an ideal circular economy and a practical circular economy. The practical circular economy should however aim for the 'highest' possible affinity with the ideal circular economy.

5) The full implementation of the theory in practice will lead to great complexity in the loops. For instance, the production process of steel involves several steps, from mining the raw materials to the application of coating on the steel beam. According to the theory suppliers will retain the products in order to reuse it. But there are numerous steps between the mining of resources and the actual product. The theory is not clear about how far back the loops should be taken.

Concluding remarks
This section showed that different authors use the terminology rather diffused and incoherent. An attempt is made to pursue an economic model that is relatively ideological but, especially in the built environment, has not sufficiently been examined in the implementation. Therefore it is as of yet not possible to give one generally used definition of circular economy. Also circular economy thinking is principally not about sustainability, sustainability is a consequence of implementing the circular economy. Furthermore, current literature describes the circular economy at different levels without acknowledging these levels, also life extension (one of the loops in the Ellen MacArthur Foundation model) does not close a loop; it merely prolongs one. It can also be discussed if downgrading of materials does not fit the circular economic model as it does entail closing a loop (albeit a different one). Furthermore a difference should be made between a practically achievable circular economy and an ideal one, where the former tries to come as close to the latter as possible. Lastly, circular economic theory as it stands does not provide any feedback on where the ownership of resources should take place.

1.3 THE DEFINITION OF A CIRCULAR ECONOMY
This section will introduce a definition of the circular economy that is useful in further research. This definition is based on the review of the circular economy concept and its shortcomings, which were both elaborated in previous paragraphs. To make this definition more than another empty barrel, also some preconditions and context are given in order to ground the definition.

The definition of a circular economy
Following the previous paragraphs in this chapter it has become apparent that due to the vague boundaries surrounding the circular economy concept, the definition of the concept should be kept at a relatively high abstraction level. Therefore it is the authors’ belief that an adapted definition of Mentink (2014) provides the best definition of the circular economy concept:

’a circular economy is an economic system with cyclical material loops based on a financial incentive’.

Wherein ‘economic system’ refers to a combination of more than one interrelated parts or components that show how people deal with scarcity, ‘cyclical material loops’ refers to a loop that makes it possible for materials to keep cycling in these loops, and where ‘a financial incentive refers to a prospect on financial merits.

This definition does not contain anything related to the terms sustainability or value creation as the review in previous paragraphs has shown that these are side effects of a functioning circular economy. Also this definition contains the words ‘financial incentive’, as circular economic theory ascertains that this is the main reason for
participating and therefore an indispensable part of circular economic thinking. This is not covered by the ‘economic system’ part of the definition as economics addresses the concept of utility of which a financial incentive could be a part, but this does not necessarily need to be the case.

Context and preconditions concerning the definition of a circular economy

Considering the shortcomings that were established in the previous paragraph, this section will ground the definition of a circular economy in order to make it more than an empty barrel.

1. A circular economy can (for reasons stated before) never be fully circular (which is the reason in the definition itself, the term closed loops is replaced by cyclical loops). A circular economy should however aim to come as close to a 100% circular economy as possible.

2. Life extension is not considered another loop as the product stays the same, no further alterations are required for this action. This has therefore nothing to do with circular design.

3. Downgrading through/or recycling is not a problem when it prevents using new resources.

4. In industries where there are several steps that need to be taken from mining a resource towards making it a product it should be examined at industry level which party should retain ownership of the needed resources.

1.4 CONCLUSION

The first section of this chapter introduced the circular economy concept and indicated that it will impose a shift from linear consumption to circular consumption. In doing so, the circular economy will make it more attractive for manufacturers to make sustainable, durable products that are able to ‘ride the life cycles’. Put more strongly it is in the manufacturer’s own best interest to produce these products this way as in the circular economy model, he or she will remain responsible for the product instead of the consumer. This section also explained the difference between circular economy thinking and the cradle-to-cradle school of thought, this is mainly based upon the incentive thinking behind the circular economy that was explained above, whereby a more sustainable and durable world in circular economy is more of a consequence of the incentive shift as opposed to the goal through the entire process as proposed by cradle-to-cradle thinking.

The second part of this chapter showed that the circular economy theory as provided by the Ellen MacArthur Foundation should not be accepted without criticism; due to the current state of literature and theory it is for instance as of yet not possible to give one generally used definition of circular economy. Also circular economy thinking is principally not about sustainability, sustainability is a consequence of implementing the circular economy. Furthermore, current literature describes the circular economy at different levels without acknowledging these levels, also life extension (one of the loops in the Ellen MacArthur Foundation model) does not close a loop; it merely prolongs one. It can also be discussed if downgrading of materials does not fit the circular economic model as it does entail closing a loop (albeit a different one). Furthermore a difference should be made between a practically achievable circular economy and an ideal one, where the former tries to come as close to the latter as possible. Lastly, circular economic theory as it stands does not provide any feedback on where the ownership of resources should take place.

The last section of this chapter focused on establishing a definition of a circular economy as it was noted earlier that there is not one, single definition yet. This section came up with the following definition: ‘a circular economy is an economic system with cyclical material loops based on a financial incentive.’ Also some context and preconditions were given in order to ground the definition, and make it more than an ‘empty barrel’.
2
THE CONSTRUCTION INDUSTRY AND THE CIRCULAR ECONOMY

Construction industry characteristics
Aspect studies in circular economy thinking
Obstacles for implementation of circular economy and the construction industry
Conclusion
2 The construction industry & circular economy

This chapter has been made in cooperation with Robert van den Brink (see appendices for contact details)

This section will describe general characteristics of the construction industry, this is done in order to be able to relate the construction industry to the earlier established definition of circular economy. Although some products are already connected to the circular economy through for instance experiments of companies, there is little to no material to be found on the implementation of the circular economy in the construction industry (Bakker et al., 2014; Bom, 2012). This is despite the fact that real estate is responsible for one third of global energy use, also 40-50% of raw materials that are used each year are devoted to the construction industry, and the sector accounts for 40% of solid waste streams (Antink et al., 2014). There is therefore a need to translate the circular economy to the construction industry. After the general description of the construction industry is made, this section will focus on what kind of effects the implementation of the circular economy might have on the construction industry. This will yield an overview of the issues that occur within the construction industry regarding this implementation.

2.1 CONSTRUCTION INDUSTRY CHARACTERISTICS

The construction industry is typified by its project-based nature, it focuses on separate projects delivering different buildings (which are i.e. the end-products) (Vrijhoef, 2011). Where the building can be seen as a collection of different components that together form an entity that can be described as a building. A building is as such a collection of interrelated parts or components at different scale levels (Prins, 1992). Figure 24 shows the organizational model surrounding the realization of a building (partly deduced from Segerstedt and Olofsson (2010)), it can be seen that a building apart from forming a collection of parts, also forms a collection of stakeholders. These different actors all come together at a certain point in the building process in order to realize a building (which will be described below). It is important to keep in mind that the different stakeholders in a construction project have different needs and objectives for participating in the project (figure 24).

![Graphical depiction of a construction project with the different actors and their needs](image)

Figure 25 Graphical depiction of a construction project with the different actors and their needs (partly deduced from Segerstedt & Olofsson, 2010).

The project organization depicted in figure 24 does not create a building overnight, each construction project generally goes through several stages; these phases can be identified as: initiative, design, construct, and use. Where the initiative phase serves to define the need for a certain building or service, and the following design phase focuses on designing the need as it were. After the design has been made the process moves into the next phase, which is called the construction phase. In this phase construction of the design takes place, after
construction is finished the use phase commences (Wamelink, 2010). What is worth noting is that these phases are designed to flow in one another like a circle, practice however learns that after the use-phase commences, little thought will be given to a new cycle (Yin & Menzel, 2011).

The construction process as described above seems neat and clear-cut, but it revolves around an intricate play of different stakeholders during different phases of the project. This makes for complexity, especially since the way in which the above stakeholders cooperate is different in every project, making each project a ‘one-off’ and unique (Segerstedt & Olofsson, 2010; Wamelink, 2010). What also becomes apparent is that on the supply side there are a lot of changes throughout the process when it comes to which parties are present in the project (see figure 25). There is not one single actor on the supply side that is present throughout the entire construction process. On the ownership side however, changes are relatively rare and if they occur, these changes were probably foreseen at the start of the project. It can therefore be argued that the ownership side of the process is more long-term oriented (with exception of the project developer), and the supply side more short-term oriented.

Besides revolving around unique projects, the construction industry is also characterized by a relatively high amount of unique components that are being assembled in an artisanal way. There is not a lot of automation or generalization present in the industry (Eastman et al., 2008). Therefore a production chain like ‘make-to-stock’, which is common in other manufacturing industries, does not exist in the construction industry (Segerstedt & Olofsson, 2010).

A building is also characterized by a relatively long lifetime when compared to most consumer products, it is not designed to be replaced in two or three years. However a building is a sum of many components and these components all have different lifetimes themselves. A building is made out of hundreds or thousands of materials, all with different lifetimes, varying from a few months to hundreds of years (concrete, brickwork). Furthermore the construction industry is capital-intensive, meaning that a lot of the costs (75%) can be traced back to material use and labour alone (Vrijhoef & Koskela, 2000). Or in other words, the added value of delivered services is low when compared to the costs of the materials being used.

Concluding remarks
Summing up the current construction industry can be characterized by its project-based nature, delivering unique products (buildings). Due to the uniqueness of its products, each and every project in the industry is also different from one-another, with a different composition of stakeholders in each project. Also there is not a lot of thought given to end-of-life situations, probably because of the long time span surrounding the buildings, and the different components within the building have different lifetimes. Furthermore the industry is capital-intensive and relies a lot on manual labour in order to realize its products.

2.2 ASPECT STUDIES IN CIRCULAR CONSTRUCTION THINKING
Under influence of the circular economy the way in which buildings are realized will change, this becomes clear when looking at the description and definition of circular economy in chapter 1, and by looking at examples of products in other markets that already claim to be circular (MVO Nederland, 2014; Deckmyn et al., 2014). As of yet there is however no precedent of what the construction process is going to look like under the influence of the circular economy. This section will therefore discuss current construction processes and their (in-)applicability...
with circular economy theory, this will be done through examining three different aspects that will be subject to change under the influence of circular economy implementation; ownership, business finance, and building components (i.e. the products). For these exercises the earlier established definitions and preconditions of a circular economy (chapter 1) are used, if any other assumptions are made these will be noted separately with each exercise. The result of these exercises yield an overview of the possibilities of implementation of circular economy in the construction industry, this section merely summarizes the results, for a complete overview of the exercises the reader is referred to the appendices.

Ownership in the circular construction industry
When circular economy theory is brought to the ‘standard’ construction process, the division between ownership and supplying party changes and becomes blurry. It can be argued that in this line of thought ‘traditional’ ownership disappears and shifts towards the supply side parties. This complicates the process as supplying parties, contrary to the traditional ownership parties are subject to change throughout the process and there would therefore be a lot of different parties involved that can call themselves owners. It also affects the time scope of the involved parties, where supplying parties usually have a relatively short-term involvement and ownership parties a long-term involvement, in the circular process this division has disappeared, leaving the supplying parties to have to adjust their time scope to more long-term involvement. Leaving one owner would not solve this problem as well, as it undermines the incentives that drive the other suppliers in a circular economy.

Business financing in the circular construction industry
Leasing the objects constructed instead of selling them in order to retain ownership does not make sense from a contractor’s perspective in the current market situation and funding structures. This exercise shows that leasing impacts both the company’s liquidity and solvability in a negative way. It also causes a lot of deadweight capital in the form of solid assets on the company’s balance sheet. From the second year onwards, the company’s result would recover for the most part, however there would still remain a loss when compared to the conventional strategy, this is mostly influenced by labour costs. The current model where another party takes on these costs therefore makes sense.

A buy-buy-back model would diminish these negative results at the start of the timeline, but would replace the negative effects to later stages in the timeline. This option does therefore not offer a viable way around the problems observed above. Also reintroducing the product with low alteration costs at a later point in time becomes therefore difficult, as the leasing model puts a lot of strain on the company. The income and/or savings from reintroducing would therefore have to be of a considerable size in order to justify the leasing model.

Building components in the circular construction industry
Following this exercise it could be concluded that the more components there are involved in a building, the more difficult it gets to implement the circular economy principle (See appendix). With an increasing number of components significant organizational issues arise; all these components have to be maintained at different points in time. With this, also legal issues arise. For instance, it has to be clear who is responsible for the connections between components. Furthermore, contractors need to have knowledge of the connections with other components, preferably about the other component itself as well to make sure the maintenance process of one component does not compromise the functionality of the other. Concluding, flexible connections have to be designed keeping in mind the reachability issue as well (table D5 shows the main differences between the current and a (possible) circular situation).

Concluding remarks
This section focused on three different short exercises that showed practical implications of implementation of the circular economy in the construction industry. From these exercises it can be concluded that; when circular economy theory is brought to the ‘standard’ construction process, the division between ownership and supplying party changes and becomes blurry. This complicates the process as supplying parties, contrary to the traditional ownership parties are subject to change throughout the process and there would therefore be a lot of different parties involved that can call themselves owners. It also affects the time scope of the involved parties. When it comes to business financing, it can be said that leasing the objects constructed instead of selling them in order to retain ownership does not make sense from a supplier’s current perspective. Leasing impacts both the company’s liquidity and solvability in a negative way. It also causes a lot of deadweight capital in the form of solid assets on the company’s balance sheet. From the second year onwards, the company’s result would recover for the most part.
part, however there would still remain a loss when compared to the selling strategy. Other strategies like a buy-
buy-back model or reintroducing a product were also found to be unlikely profitable activities. When it comes to
building components (i.e. the products) a shift in demands will be needed when circular economy theory is
implemented. Furthermore, the amount of individual building components plays a role in the feasibility of the
circular economy in the construction industry, where the more components inherent in a building the less likely it
seems that circular construction is feasible.

2.3 OBSTACLES FOR IMPLEMENTATION OF THE CIRCULAR ECONOMY AND
THE CONSTRUCTION INDUSTRY

This section will make a comparison between the three exercises that were made and earlier research on obstacles
for implementation of the circular economy. This earlier research focuses on the implementation of the circular
economy in general, it is not specifically done for the construction industry. In this way, this section will also make
a comparison between the general obstacles and their relevance towards the construction industry. This will yield
an overview of the obstacles that are relevant to the construction industry following the earlier made exercises
(for the complete comparison and obstacles, see appendix).

The general obstacles for implementation of the circular economy

The obstacles that will be discussed in this section were found by Kok, Wurpel, and Ten Wolde (2013) in an attempt
to create a roadmap towards the circular economy. These obstacles are considered to be general and valid for all
actors that want to partake in the circular economy, it is important to stress that this list is not exhaustive. All the
obstacles can be found in table B1, as clear as these obstacles are, their generality makes them abstract and hard
to place in specific contexts without further information. This also means that the roadmap created by Kok et al.
(2013) does not specify its steps in the depth needed to be directly applicable to certain industries, or as the
authors call it: ‘a transition without a blueprint’. Tying the previously elaborated exercises to these obstacles
should therefore make them operational and define the problem at hand in the construction industry (although it
needs to be noted that like the list of obstacles, the exercises are also not exhaustive). Please observe that Kok et
al. (2013) also do not see sustainability as a separate category, but as a result of the circular economy (figure 26).

When comparing the exercises with the obstacles provided by Kok et al. (2013), it becomes clear that the problems
surrounding the implementation of the circular economy in the construction industry reside along the categories
‘financial’ and ‘technological’. As figure 26 shows, almost all of the connections are to be found in these categories.
The biggest match is however made with the institutional obstacle; ‘governance issues concerning responsibilities,
liabilities, and ownership’. In the context of the construction industry it would however be more fitting to talk
about an organizational obstacle at the level of the individual actors amongst themselves, therefore institutional
is replaced by organizational in figure 26. There is one other obstacle that makes the same amount of connections
as the organizational obstacle, namely: ‘limited attention for end-of-life phase in current product design’, this
obstacle was also found in all three exercises. It reflects the project-based processes that are common in the
construction industry and the uniqueness of each building created, as was discussed in section 2.1. However this
last obstacle is arguably less important than the institutional obstacle as one might infer that implementation of
the circular economy should leave this obstacle immediately redundant.
Concluding remarks
After comparing the exercises with the obstacles found by Kok et al. (2013), it has become clear that the biggest obstacle for the construction industry can be found at the organizational level, around issues concerning responsibilities, liabilities and ownership. This obstacle was found in all three of the exercises, next to that financial and technological obstacles play an important role in the construction industry. Another comparison with research done by Loppies (2015) also shows that organizational issues are present, along with technological challenges. This last comparison did not show financial challenges, this was however not researched by Loppies (2015).

2.4 CONCLUSION
Currently the construction industry can be characterized by its project-based nature, delivering unique products (buildings). Due to the uniqueness of its products, each and every project in the industry is also different from one-another, with a different composition of stakeholders in each project. Also there is not a lot of thought given to end-of-life situations, probably because of the long time span surrounding the buildings, and the different components within the building have different lifetimes. Furthermore the industry is capital-intensive and relies a lot on manual labor in order to realize its products.

The second section of this chapter focused on three different short exercises that showed the practical implications of implementation of the circular economy in the construction industry. From these exercises it can be concluded that; when circular economy theory is brought to the ‘standard’ construction process, the division between ownership and supplying party changes and becomes blurry, it also affects the time scope of the involved parties. When it comes to business financing, it can be said that leasing the objects constructed instead of selling them in order to retain ownership does not make sense from a supplier’s perspective. Leasing impacts both the company’s liquidity and solvability in a negative way. It also causes a lot of deadweight capital in the form of solid assets on the company’s balance sheet. From the second year onwards, the company’s result would recover for the most part, however there would still remain a loss when compared to the selling strategy. Other strategies like a buy-buy-back model or reintroducing a product were also found to be unlikely profitable activities. When it comes to building components (i.e. the products) a shift in demands will be needed when circular economy theory is implemented. Furthermore, the amount of individual building components plays a role in the feasibility of the circular economy in the construction industry, where the more components inherent in a building the less likely it seems that circular construction is feasible.

The last section tied the exercises from the second section with general obstacles for implementation of the circular economy provided by literature. Through this comparison it has become clear that the biggest obstacle for the construction industry can be found at the organizational level, around issues concerning responsibilities, liabilities and ownership. This obstacle was found in all three of the exercises and other literature, next to that financial and technological obstacles play an important role in the construction industry.
3
FURTHER DEFINING THE CIRCULAR ECONOMY

Interviews
Defining the actors
Boundary conditions in a circular economy
Conclusion
3 Further defining the circular economy

As stated in previous chapters the terminology is used diffused and a new circular economy definition has been made. However, a definition of the concept is not enough; more terms need to be defined before one can say something useful about the design of a business model for a circular economy. This section will form a definition of building product providers and define the boundary conditions of a circular economy. The first part of this chapter will describe the interviews that has been done with parties that are actively involved in the circular economy. The main aim of these interviews is to determine what circular economy mean for these actors and in what way these actors deal with circular economy principles. The second part of this chapter is mainly explorative, trying to model the circular economy principles in an imaginative project. With the use of modelling circular economy principles and the outcomes of the interviews and literature reviews, terminologies are determined. Finally, boundary conditions are set and assumptions are made for the sequel of this research.

3.1 INTERVIEWS

The main aim of the interviews was to address the following question: What does the circular economy mean for these actors and how do these actors deal with the circular economy. Furthermore it was aimed that the interviews could contribute to the creation of definitions regarding circular economy. First, the interview method is discussed. Next, the findings are discussed, followed by a conclusion.

Sample

As concluded in previous sections, the construction sector does not provide a lot of examples regarding the circular economy. Therefore three specialists were invited to take part in this study. For this research the convenience sample approach was adopted. Two of the respondents are active in the construction industry, one is active in another sector.

One of these two is a big contractor in the Netherlands. They were the main contractor on the town house of the municipality in Brummen, claimed to be the first circular economy building in the Netherlands. They are also involved in the initiative of the ‘circular railway’. The other one is a real estate consultant, specialized in circular procurement. The third interviewee is active in the office furniture industry, using circular economy principles for producing and selling office chairs.

The samples were selected because they have all showed their interest in the circular economy in different ways. One sample was actively presenting itself on this subject during several circular economy seminars. Others were chosen because they joined the Circular Economy 100, an initiative of the Ellen MacArthur Foundation. The Circular Economy 100 is a pre-competitive innovation program established to enable organizations to develop new opportunities and realize their circular economy ambitions faster, bringing businesses and corporations together.

Findings

The data supports the relationship between circular economy and sustainability. Sustainability in the circular economy is about closing material loops, long-term thinking and social justice and fairness. The respondents were unanimous with respect to the importance of these three factors. Whereby closing material loops deals with identifying the nature of resources and in what way resources can be returned into material loops. In addition to closing loops, respondents stated that parties have to shift their mind-set from short-term to long-term thinking. They have to think about the life cycle of a product beyond its technical life span.

Furthermore it is important that the parties need to use a holistic view in this whole process, the respondents refer to this as social justice and fairness. With that, everything that is involved in the whole life cycle of a product is important, from people, raw materials, production processes and customer relationships.

Only one of the respondents believed that conventional business models are suitable for a circular economy. Two of the respondents acknowledged the fact that parties need to change their business models in order to successfully adopt circular economy principles, since new revenue models and cost structures will arise.

However, respondents did unanimously agree upon the fact that finance is of importance to a circular economy. One of the respondents believed that a transition from a linear to a circular economy could only occur when it is cost neutral to parties. Two of the respondents state that the circular economy principles are an opportunity for
them to increase their profitability. According to them this can be done with service agreements, energy efficient measures and the reuse of raw materials.

All respondents agree on the fact that the client has an important role to play in the transition. When the demand from clients is lacking, there is not a real incentive for parties to adopt the circular economy principles and correspondingly innovation. If clients change their demand, parties are forced to innovate their businesses.

Innovation in laws and regulations is deemed necessary by the respondents for a circular economy to work efficiently. One respondent recites a situation where parties wanted to implement circular economy in a project, but encountered regulations, which did not enable them to adopt the concept. Another respondent mentions a case where it is legally determined what is to be done with materials in the end of the technical life cycle of a product. With the use of audits it is then monitored and controlled if parties are acting in compliance with the rules.

Respondents were unanimously enthusiastic about the circular economy and acknowledged its opportunities. At the same time, they find that there are difficulties and challenges associated with the transition. One of the respondents stated that a change is only feasible if the concept is widely supported amongst the whole chain of a sector. A transition cannot occur through an individual party. Another respondent tackles this issue, by acting as a ‘chain director’, operating on the whole chain. It can be concluded that supply chains are of importance in a circular economy and that innovation on several subjects is needed to accelerate this transition.

Discussion
The main aim of these interviews was to address the following question: What does the circular economy mean for these actors and how do these actors deal with the circular economy. This question was posed since a clear answer was not provided through the literature review. From the interviews it becomes apparent that the way parties deal with the circular economy concept is different for each interviewed actor. No unilateral approach to the circular economy has been found.

Also some debate is possible about the way a circular economy can be reached. One of the respondents believed that a transition would occur using legal measures, such as audits. Another respondent is already implementing the principle for years (claiming to be successful already) without these legal measures. Another party believes that transition will be achieved through dialogue amongst chain partners, with acknowledgement of a special role for the client. It was found important in all actors that stakeholders included the whole supply chain in the project. The position of the client is no different in a conventional process; without the demand of the client there is no project. However, the special role now is that clients need to actively participate in creating the project.

Next to that, one respondent believed that conventional business models do not need to change to enable circularity, whereas the other respondents do believe a change is needed and see a (financial) chance for these business models in reality. The one respondent that did not opt for changing business models believed that implementation is realized through a change in legal framework. However through the literature review it was also found that a change is needed with regard to this point, as various articles acknowledge the change from sales-based business models to performance-based business models. However, respondents did unanimously agree upon the fact that finance is of importance to a circular economy, stressing the economic potential that was found through literature.

Therefore at this point the findings appear to be contradictory. On the one hand, two out of three respondents (as well as literature) agree on the necessity of changing business models and acknowledge the importance of finance. On the other hand, no common definitions of -or approaches to- circular economy can be identified. Logically, if no definition or approach can be stated, it remains unclear to which conditions a business model has to conform. To put more simply: business models need to change, but it is unclear in what way and to which conditions. The authors believe that if ‘new’ business models are designed, more research is needed on the circular economy concepts and all its characteristics. A unilateral vision towards the circular economy concept is required for further developments.

Lastly, all respondents do believe that a circular economy is about sustainability, as was also found in literature. Whereby closing material loops, long-term thinking and social fairness are all part of circular sustainability.

Concluding remarks
The parties interviewed for this study all believed that a circular economy is about sustainability, highlighting long-term thinking, closing material loops, and social fairness. Also all the parties agreed upon the importance of finance.
in a circular economy, as well as acknowledging the importance of the inclusion of the whole supply chain in the process. These arguments were also observed (although less specific) in literature.

However, also in concurrence with literature, there was no consensus on the other interview subjects. Some actors wanted to stress the importance of altering business models, others did not see this as an important issue. Furthermore all the interviewees stressed that the client, supply chain, and legal issues were important. However they had different thoughts on why these were important and to what ends. Logically, if no definition or approach can be stated, it remains unclear to which conditions a business model has to conform.

Therefore in the end it can be stated that there is a consensus on the fact that circular economy is linked with the topics sustainability, finance, and integrated supply chains. Also the same factors were found important by all interviewees as well as literature, for the circular economy to function. However, the degree of their importance as well as their approach was different for all the interviewees. Therefore in response to the main question it can be stated that, there is no unilateral circular process with the same characteristics. It is therefore also not possible to (safely) determine in what way a circular construction process is different from a regular process. It can highly be questioned if interviews provide solid ground for setting up terminologies.

3.2 DEFINING THE ACTORS

For this research it is necessary to define the building product provider. As explained in the problem statement definitions are used rather diffused in literature about circular economy. This section will create definitions that will be used for the rest of the research. The theory of the Ellen MacArthur foundation elaborates significantly about suppliers and service providers. The service provider also plays a key role in the performance economy described by Stahel (2006). According to him, a service provider is one who ‘sells services instead of goods’. Furthermore the dictionary gives the following definition for suppliers: “a company, person, etc. that provides things that people want or need, especially over a long period of time.” Both definitions gives room for different interpretations.

In the search for an answer, the production process of a simple wall socket has been examined (Appendix). It has been found that 11 raw materials are necessary for the production. Those raw materials are then manufactured into three main materials: plastics, copper and stainless steel. The last phase is the assembly of those materials into the final wall socket.

In this light, every actor in the building process could be called a supplier, since they all provide goods for the next actor. With the boundary condition that no goods are transferring in ownership - there are 15 different owners of just one single wall socket. They all have a certain share in the socket. This raises questions on organizational, legal and financial level.

Forming definitions

In the wall socket example a lot of suppliers can be identified. The more suppliers added in the process, the more complex the organization will be. To design a framework and come up with clear definitions for the actors in a circular economy, the study of Mohammadi, Prins and Slob (2015) is used. They describe a circular economy involving three different types of goods: products, components and complex components. For this research, the terms are changed into ‘material’, ‘component’ and ‘element’. A material is a raw material. Two or more materials make a component. Furthermore, two or more components can make an element. Each of these ‘states’ can be called ‘building products’.

This economy is characterized by a chain market in which where are three different types of chain partners: extractors, assemblers and service providers. This concept is illustrated below.
There are two different markets in this economy. One is the market where the chain partners operate on. On the contrary of what is stated above, they can buy or sell their product; transferring the ownership from one party to the other. The other market is the services and performances market where the suppliers can trade with customers, using operational lease constructions (figure 27). When an assembler operates on the services and performance market with customers, it is by definition a service provider. In this concept the financial incentive is still secured, since the suppliers retain ownership of the products/components/elements customers use (Mohammadi et al., 2015).

With this in mind the following definitions can be made:

- A building product provider is the service provider of a building product
- A building product is a material, component or element.
  - A material is a raw material extracted from the earth
  - A component is a composition of products
  - A element is a composition of components.
- A service provider is a chain partner that operates on the services and performance market (R2C).
- A chain partner is a partner that trades on the chain market (R2B)
  - A partner is an entity or a person
  - A partner is either an extractor or assembler
    - An extractor is the producer of a product
    - An assembler is the producer of a component or complex component
  - Trading concerns transactions with transferring building materials
  - A chain market is the market where materials are traded
  - The services and performance market is the market where services and performances are traded with customers
    - A service or performance is a trade that is intangible and does not result in ownership
    - A customer is the user of services

Figure 28 Circular economy entities (based on Mohammadi, Prins & Slob, 2015)
Figure 29 defining the actors in the economy (own image)
Concluding remarks
After reviewing the manufacturing process of a wall socket it became apparent that even a simple wall socket could have 15 different owners, if no building products are transferred in ownership. In order to design new business models, it is important to determine which actors are operating in the circular economy. Until now, it was unclear what was meant with service provider and/or supplier. Therefore, new definitions have been made (figure 29), focusing on the building product provider. Once this structure is clear, boundary conditions can be designed.

3.3 BOUNDARY CONDITIONS FOR OPERATING IN A CIRCULAR ECONOMY
To determine whether or not a building product provider meets the requirements of a circular economy, boundary conditions have to be set. Currently, there is a lack of these requirements. As a consequence, there are numerous projects popping up in the field claiming to use the circular economy principles. The best example is the town hall in Brummen, which was originally promoted as the first example of a circular economy building in the Netherlands. However, this statement became more moderate after some criticism, when it was clear that no agreements has been made about what happens with the products at the end of the contract period. If a financial business model is to be designed, it is important to make clear what conditions have to be met in order to call a project a circular economy project.

According to Mohammadi et al. (2015) the circular economy is an economic system in which the society is designed in such a way that due to the actions of the ‘homo economicus’ sustainability is secured. Due to the assumption of rising commodity prices, chain partners are indeed motivated to keep products in the chain as long as possible if they have ownership. Several reports describe the economic benefits of this concept for this reason (TNO, 2013; McKinsey & Co, 2015).

Circular economy vs sustainability
During this research it became clear that a significant amount of sources describe the circular economy as a mean to create a sustainable economy. Whether it is in literature, conferences, brainstorm sessions or videos; the relationship between circular economy and sustainability is highlighted. The author does not thinks that this could not be the case, but believes that the relation is not as straightforward as all sources describe. Already in chapter one it is given that the concept is not about sustainability. This section will briefly explain this further.

A circular economy is an economic system, as well as a linear economy is an economic system. Even though the definition of an economic system can be discussed as well; it is broadly supported that the term ‘economy’ is about ‘the production and consumption of goods and services’ and about ‘the allocation of scarce resources’. It is surely not about sustainability.

The Ellen MacArthur foundation secures sustainability by stating that only green energy is used in the whole economy, there is no waste and no toxic materials are used during the whole life cycle of building products.

Evidently it can be stated that our linear economy has to make a transition to a circular one; the circular economy ‘supporters’ are gaining momentum. More and more conferences, seminars and other events on the topic are emerging. The author acknowledges the fact that opportunities are apparent in the concept, but believes that awareness is needed.

‘A linear economy is just as much (or just as little) about sustainability as a circular economy’.

Closing material loops can be an important solution to the depletion of resources. However, whether or not this is instant sustainable can be questioned. Imagine a linear economy in which only green energy is used, no toxic materials are used in production processes, products are made to last as long as possible, and products are manufactured in a social fair way (such as no use of child labor). Subsequently, imagine a circular economy where products are returned in the loop with signs of toxic materials (for example in the mining/production processes) and using nuclear energy.

Which of these economies can be called the most sustainable?
In the circular economy concept sustainability is assured by adding guidelines to an economic system. A circular economy is an economic system which does not have to be sustainable on its own. In fact, it can just be as (or just as little) polluting as a linear one. To create a sustainable economy (linear or circular), parties need to be aware
that more is needed than only closing the product loops. Parties need to operate ethically. It is believed that this awareness is significantly lacking, not only amongst market parties but also on policy making level.

Boundary conditions
It is believed that an important distinction has to be made in defining the boundary conditions. Since sustainability is only secured by adding guidelines to an economic concept, there are two ‘levels’ created. The ‘hard’ conditions need to be fulfilled to meet the requirements of a circular economy. The ‘soft’ conditions need to be fulfilled to create a more sustainable economy.

‘Hard’ conditions (Mohammadi et al., 2015)
- Products have to be kept in the technical loop.
- Switching between the loops is part of CE.
- The technical products that degrade during their period of use (lifecycle), or when they are no longer usable within the technical cycle, must be returned to the biological cycle.

‘Soft’ conditions
- Green energy is used in the production, use and consumption processes.
- No toxic materials are used in the production, use and consumption processes.
- Chain partners have to operate maintaining earth for future generations.
- Chain partners opt for global prosperity.
- Social -justice and -fairness is normative for human action and chain partners operate accordingly.

Assumptions
- Rising resource prices.
- Chain partners operate to maximize their profit.

Due to the assumed rising resource prices, there is no need to add the condition of retaining ownerships (i.e. the use of performance-based business models), which has been so important during this research so far. With the assumed rising resource prices and if it is assumed that chain partners’ goal is to maximize their profits, they already operate accordingly because it should be the most financially beneficial way of governance.

For the same reason there is no need to state that consumers are not able to buy goods. In a circular economy with rising resource prices, there is no need to set this a boundary condition, since chain partners would rather remain owner over such a valuable asset. It is for this reason that consumers should not be able to obtain ownership of products. And if for some reason consumers are able to become owner of a material, it is believed that consumers will operate in the same way as the chain partner since it is in its own benefit to take best care of the product.

- A circular economy does not require green energy to operate.
- A circular economy does not require social sustainability to operate.

The distinction is made between ‘hard’ and ‘soft’, because the circular economy concept does not require pure sustainable action in the current market with the current regulations and tax systems.

3.4 CONCLUSION
First, an attempt has been made to define actors involved in a circular economy. Interviews has not been found satisfactory in answering the research questions. With the help of the production process of a simple wall socket the difficulties with implementing circular economy principles in building products regarding terminology has been explored. If a market exists where only services are sold, rather than goods, a wall socket could have 15 different owners; not to mention what this could mean for a whole building.

The study of Mohammadi et al. (2015) has been useful. The following definition for building product providers has been given:

‘A building product provider is the service provider of a building products’.

This definition creates new uncertainties that also require definitions, shown in chapter 3.2.
The second part of this chapter aimed to design the boundary conditions of performing in a circular economy. Since it is believed that ‘sustainability’ and ‘circular economy’ need to be split. Therefore a distinction is made between ‘hard’ and ‘soft’ conditions. The ‘hard’ condition are made to fulfill requirements in a circular economy:

- Products have to be kept in the technical loop.
- Switching between the loops is part of CE.
- The technical products that degrade during their period of use (lifecycle), or when they are no longer usable within the technical cycle, must be returned to the biological cycle.

The rest are ‘soft boundaries, which means that they are not necessary to be met in order to realize a circular economy. But once they have been met, the circular economy could also be called sustainable. Note that ‘sustainability’ and ‘a circular economy’ are separated terms in this research, despite the fact that reports and other literature use it in the same breath.
CIRCULAR ECONOMY CONCEPT

CONSTRUCTION INDUSTRY

BOUNDARY CONDITIONS

DESIGN NEW MODEL

CASE STUDY
4 BUSINESS MODEL IMPLICATION

Implementing circular economy illustrated
Circular economy trading
Conclusion
4 Business model implications

As explained in the previous chapters will the implementation of the circular economy theory cause a shift in business models. In a circular economy businesses have to make the shift from a product-based business model to performance-based business model. This chapter will further discuss the effects of this implementation and aims to illustrate the challenges that lay ahead with the implementation opposed to the current situation. The main question to be answered is:

‘to what extent will business models of building product providers change with the implementation of the set boundary conditions of the circular economy?’

First, the supplying process of building product providers implementing circular economy principles will be compared to the ‘current’ situation in order to frame the possible unidentified implications and challenges. The second paragraph tries to explore the issues that arise in circular economy markets. The remaining part of this chapter will be of explorative nature as well. At last, a financial calculation example is made to identify the possible financial benefits of retaining ownerships over a steel beam.

4.1 IMPLEMENTING CIRCULAR ECONOMY ILLUSTRATED

This section will illustrate the challenges that arise with the implementation of circular economy for building product providers. First, the current building process is described, with specific focus on the financial sections of this business model. Next, a situation is shown where a building product provider receives an order of a customer for an X amount of beams in a circular economy.

The building product provider chosen for this paragraph is the provider of a steel beam in the construction industry. The following three illustrations will focus on money streams in a linear and a circular situation. First, the linear situation is shown, followed by the revenue and cost streams in a circular building process.

Linear

The symbol on the left represents a provider of steel beams. The provider receives an order for an X amount of beams. Since the company is not able to fund its resources with own equity the provider needs to visit the bank for a loan. Next, the production process starts and once the products are finished they are transported and assembled at the building site. After the delivery, the provider collects the selling price and pays back the loan and interest. Note the short duration time of this process.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Acquire finance</td>
</tr>
<tr>
<td>Step 2</td>
<td>Start production process</td>
</tr>
<tr>
<td>Step 3</td>
<td>Product delivery</td>
</tr>
<tr>
<td>Step 4</td>
<td>Building finished</td>
</tr>
<tr>
<td>Step 5</td>
<td>Collection selling price (S)</td>
</tr>
<tr>
<td>Step 6</td>
<td>Pay back debt service (I) + remaining debt balance (L)</td>
</tr>
<tr>
<td>Step 7</td>
<td>Profit</td>
</tr>
</tbody>
</table>

Table 12 linear process (own image)

Circular

The circular situation is illustrated in figure 30. The financing process and the production process are separated to make the situation clearer. The building product provider is shown on top of the circle. This example will illustrate
the issues arising in a circular economy on the services and performance market. The chain market is left out of this example. Again, the process is step by step explained with reference to figure 30 and 31.

Again the building product provider receives an order, however the demand is different. Instead of the order for an X amount of beams, the provider receives an order for providing the service ‘structure’ for a building.

![Figure 31 circular situation (own image)](image1)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Check current supply</td>
</tr>
<tr>
<td>Step 2</td>
<td>Start production process/renew building product for new service</td>
</tr>
<tr>
<td>Step 3</td>
<td>Assemble products, components or elements to final building product</td>
</tr>
<tr>
<td>Step 4</td>
<td>Provide the service to the customer, including maintenance, monitoring and managing the customer relationship</td>
</tr>
<tr>
<td>Step 5</td>
<td>Disassemble products</td>
</tr>
<tr>
<td>Step 6</td>
<td>Return to building product provider</td>
</tr>
</tbody>
</table>

Duration: few years to 20 years or more

Table 13 circular process (own table)

![Figure 32 circular situation finance (own image)](image2)
Step 1: Acquire finance
Step 2: Earn lease
Step 3: Pay debt service every year
Step 4: Profit
Step 5: Pay for disassembly, transport and storage

Duration: few years to 20 years or more

Table 14 circular process finance (own table)

If the circular situation is compared to the linear situation, significant differences can be seen. The time scope is much longer in a circular process. This means a long term commitment of the building product provider. Next to that, the responsibility over the product (and performance) lies at the provider, adding maintenance, monitoring and management issues. The funding structure makes a structural change; business are now involved into long-term debts. Then businesses have to ‘close the loop’, causing the business to reserve funds for (dis)assembly and renewing the product for a second contract period.

Concluding remarks
New elements that arise are storage, (dis)assembly, transport, different finance structures, management and monitoring situations.

- (dis)Assembly cost: The cost to be incurred to assemble and disassemble building

The steel beams have to be disassembled and transported from the building. It is unclear which party is responsible for disassembly, or which party finances for disassembly.

- Storage cost: The cost to be incurred to store products.

After disassembly, the building products have to be stored. This will lead to insecurity, risks and costs.

- Transport cost: The cost to be incurred to transport products.

Building products have to be transported. This cost could occur multiple times in the process, since products have to be transported from old building site to storage to new building site.

- Financing cost: The cost to be incurred to finance business activities.

The business model of the supplier will shift from a product-based business model to a performance-based business model. Now, the supplier will have a long-term debt instead of a short-term debt. In the circular economy building it is believed that the funding is done from the bottom. Instead of banks funding a certain product they now have to engage a long-term contract funding commodities. The resource market differs substantially from the real estate market, characterized by different risk and returns requiring different knowledge and skills.

Furthermore, a problem occurring in the transition from a product-based business model to a performance-based is the high up front capital needed for this financial structure. In order to find a solution, Rolls Royce has been taken as an example. As a manufacturer of airplane engines, Rolls Royce decided not to sell their engines, but to apply a different service system: pay per use. The consumer now pays per hour that the engine is working; the engine remains ownership of Rolls Royce. Rolls Royce has generated a lot of profit with this business model, however the downside is that it requires a high initial investment. They solved with the use of a ‘financial partner’, providing them with an investment. In return, this partner was entitled to a certain percentage of the earned lease amount. This structure could solve the problem if a chain partner does not have the ability to fund it on its own (Baines & Lightfoot, 2013).

- Monitor cost: The cost to be incurred to monitor the performance of products.

Cost have to made to monitor the performance over time of the product. It has to be made sure that the performance a product delivers meets or exceeds the required performance. The monitoring of the performance is part of the responsibility of the provider and should therefore be incorporated in the business model.

- Management cost: The cost to be incurred to manage business activities.

With the transition from a product-based business model to a performance based model, new management issues arise. One of these cost is maintaining customer relationships. A contract for the delivery of performance in the
construction sector could last for years. This means that providers and customers enter a long term relationship as well.

Furthermore, investments have to be made in the allocation of products after the first contract period. A sales team is needed with the main activity is to find new customers for the already existing supply of products.

- **Maintenance cost**: The cost to be incurred to maintain products.

The ownership of the product lies at the building product provider. This means that this chain partner is responsible for maintenance, ensuring the quality of the performance.

- **Renewing product cost**: The cost to be incurred for renewing materials for providing a performance.

Cost have to be added for renewing the product; making it ready for a new contract period (recycle, remanufactured or withdrawal).

- **Withdrawal cost**: The cost to be incurred to return products to the biological chain.

In order to bring back products back in the biological cycle, cost have to be made. If it is not possible to reuse, recycle, remanufacture or downgrade the product, cost have to be made to bring back the products in the biological cycle. It is believed that this cost have to be added in the business model.

- **Economical risk premiums**: The cost to be incurred to cover economical risks.

Next to these extra costs on product and organizational level, there are also some economic factors of which no influence can be enforced. One can think of future price fluctuations; risk premiums have to be incorporated to cope with insecurity in exchange rates (common in commodity investments).

- **Substitution risk premium**: The cost to be incurred to cover the risk of arising substitution goods.

This is the risk for the substitution of one’s product. The period of use for buildings, has to be assumed. According to Adalberth (1997) the management phase is assumed to be 50 years, as the economic life-span of a building is about 40 to 50 years. It is probably the most interesting and challenging variable in the construction industry. Especially in such a changing environment with rapid technological developments it is unclear if conventional building products are still the way to go after a contract period of, for instance, 20 years.

- **Regulations/new insights**

A big part of this risk premium can be attributed to legislation and political decisions. Take for example the use of asbestos; a very common product used in the building industry the past decennia. Since it was discovered that the product is highly toxic and it could cause cancer, the use of the building products has been prohibited by law. Imagine what could happen to building product providers owning asbestos and suddenly became illegal due to its toxic characteristics.

Another reason could be new requirements assigned to certain product. Take for example the size of wooden products. Due to new requirements different dimensions are used than recently was common. There are many more examples of building products to mention which were common, but due to different reasons are not conventional products anymore.

- **Life cycle assessments**

Also in terms of life cycle assessments products differ significantly. Especially with the discussions about the environmental impact of products this could become more important. Bribián, Capilla and Usón (2011) did research about the environmental impact of bricks and tiles, insulation products, cement and concrete, and wood products using life cycle assessments. If the insulation study is closer examined, it appeared that EPS foam slabs have a significantly higher carbon footprint opposed to sheep wool. Similar results are found for the other categories as well.

The results in itself are not ‘shocking’. But a possible scenario could be that products with a low carbon footprint are encouraged to be used by pressure from, for instance, governmental level with subsidies. On the contrary, it could be that products with a high carbon footprint are even prohibited due to environmental considerations.
Developments
Building product providers logically have to make their business models and profit calculations based on the situation currently available. A big aspect of the circular economy is that building product providers make their profit due to the rising commodity prices due to scarcity. However, the scarcity of today does not have to be the scarcity of tomorrow.

Rapid technological developments could shift the demand for one raw material to another. Processes such as 3D printing is becoming popular in mainstream architectural modelling applications (Buswell, Soar, Gibb & Thorpe; 2007). 3D printing of buildings enables manufacturers to accelerate the building process and also to lower the production cost. The 3D printing technology has been widely used in other sector than the construction industry, there are more and more examples of complete 3D printed buildings.

The technology is faster and cheaper than conventional building methods (Bogue, 2013). Imagine an industry where 3D printing is the way to go in constructing a building. The building now consist of fiberglass, steel, cement, and special additives. The demand for these products will rise and on the contrary, for instance, the demand for a wooden structure will drop.

Conclusion
The uniqueness of the built environment is that products are to be used for such a long period that the usefulness of products becomes highly uncertain. Since one is unable to predict the future, building product providers need to make assumptions about the utility of its product concerning turnover rates and profit calculations over a large period of time. Imagine a situation where a building product provider’s product becomes profitable after a period which in retrospect could not be reached.

4.2 CIRCULAR ECONOMY TRADING

Figure 33 Circular economy markets (own image)
This section will briefly zoom in on the way products can be traded in a circular economy. In the figure, seven different options are given in which the composition of an element is shown during its life cycle. The icons (building and airplane) are described as ‘objects’ (figure 32). The trades are given in a random order; they can occur any time during the life cycle.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Function</th>
<th>Object</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Same</td>
<td>Same</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel structure dwelling (untreated)</td>
</tr>
<tr>
<td>2 Same</td>
<td>Different</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel cladding dwelling (untreated)</td>
</tr>
<tr>
<td>3 Same</td>
<td>Same</td>
<td>Different</td>
<td>Steel structure dwelling (untreated) -&gt; steel structure airplane (untreated)</td>
</tr>
<tr>
<td>4 Same</td>
<td>Different</td>
<td>Different</td>
<td>Steel structure dwelling (untreated) -&gt; steel engine parts airplane (untreated)</td>
</tr>
<tr>
<td>5 Different</td>
<td>Same</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel structure dwelling (treated)</td>
</tr>
<tr>
<td>6 Different</td>
<td>Different</td>
<td>Same</td>
<td>Steel structure dwelling (untreated) -&gt; steel cladding dwelling (treated)</td>
</tr>
<tr>
<td>7 Different</td>
<td>Different</td>
<td>Different</td>
<td>Steel structure dwelling (untreated) -&gt; steel engine parts airplane (treated)</td>
</tr>
</tbody>
</table>

Table 15 trading in a circular economy; different composition of products during its life cycle (own table)
This section identifies in what kind of form a product can be traded. An element can be traded as it is, delivering the same function in the same object (such as reuse). It can also occur that a component of an element is replaced (due to failure of a component, for example), resulting in a different composition. Furthermore it is possible that elements are used performing different functions.

Relevance
The importance of this study lies in the characteristics of different markets. An object, such as a building or an airplane, appears on different markets. Each market has its own characteristics; on macro and micro level. Furthermore, products provide their services in different environments.

To clarify this situation an example is given: imagine a chain partner with 1000 kilograms of steel in stock. The chain partner is involved in both the construction and automotive sector. In this example the chain partner does not want to sell the steel and therefore only offers the performance. In the automotive sector the steel is used for, for example, the bodywork (providing performance ‘structure’ for a car). In the construction industry the steel is used for the structure of a building (providing performance ‘structure’ for a building). The average life cycle of a car is set at 10 years; for the steel structure 110 years is given (Cooper et al., 2014). In other words, the service life of steel is far longer in the construction industry compared to the automotive industry before it has to be recycled. On the other hand, it could be that the revenue models are much more interesting in the automotive industry for 1 kilogram steel. Next to these financial reasons, it could also be that one market is ‘safer’ or more ‘stable’ than the other. One can think of changing regulations or new emerging trends in different sectors (strongly related to substitution risk).

The products are used differently, giving different life cycles and different depreciation rates in different markets for the same amount of product. Furthermore if it is assumed that profit margins of products are lower for cars opposed to buildings, there is no incentive for a service provider of steel to operate on the automotive market. Admittedly, this situation only occurs in a market where the demand exceeds the supply. However, this is one of the ground principles of the circular economy concept.

Change in objects
Moving further along this line, one can state that the further a building product is incorporated in a building, the harder it is to change of object and the harder it is to retrieve ones product. The harder it is to retrieve ones product, the less likely it is to shift between objects (and sectors). It is believed that a premium have to be added to the ‘likeliness’ a product can change between markets.

Concluding remarks
The previous paragraph illustrates a situation which could be called an ‘allocation dilemma’. With the retaining ownerships for chain partners, they have a motivation whether or not to operate on certain sectors. The supplier all of a sudden becomes responsible for the product. This means that, opposed to the linear situation, the chain partner suddenly cares for its product and this will emerge in its choice for markets to allocate its resources in. The chain partner will always choose for the market in which the exploitation of its resources are the most beneficial; not only financial, but also in terms of life expectancies and geographical location of its product. Furthermore, a chain partner would always choose for other certified chain partners to work with, such as certified extractors, (dis)assemblers or maintainers.

- **Allocation premium**: The cost to be incurred to cover for market imperfections

  The supplier could solve this by adding a certain premium percentage on its prices for different markets. However, this means that in this (imaginary) example, airplanes will become more expensive in a circular economy compared to a linear economy. It could be questioned whether or not this will occur in reality, but theoretically it is not inconceivable.

- **Complexity premium**: The cost to be incurred to cover for the complexity of the composition of products

  Furthermore it is believed that a premium has to be added to the selling price in terms of ‘likeliness’ a product can be retrieved to the owner. The less complex a product is ‘packed’ in a building, the more likely it is to change in objects and therefore enlarges the future potential of a product.

Both risk premiums also differ per chain partners. For example, the both the risk premiums are more apparent for chain partners owning raw materials opposed to chain partners working with goods ready to use for consumers.
4.3 CONCLUSION

The main question to be answered this chapter is: to what extent will business models of building product providers change with the implementation of the circular economy theory?

Once the building product provider has been identified, its business model could be assessed. An example is given where a customer orders a steel beam. The standard linear situation is compared to a situation where circular principles are incorporated. Focusing on the cost and revenue streams, it can be concluded that various issues arise that not yet have been answered. The list can be roughly divided into four categories: material, potential, economical and organizational.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Maintenance X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Renewing cost</td>
<td>Fixed amount / end of contract period</td>
</tr>
<tr>
<td></td>
<td>- Reuse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Recycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Remanufacture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Withdrawal</td>
<td></td>
</tr>
<tr>
<td>Potential</td>
<td>Substitution risk premium X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allocation risk premium X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complexity risk premium X% / year</td>
<td></td>
</tr>
<tr>
<td>Economical</td>
<td>Future price fluctuations X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General risk premium X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy prices risk premium X% / year</td>
<td></td>
</tr>
<tr>
<td>Organizational</td>
<td>Transport Fixed amount / end of contract period</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Management X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitoring X% / year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(dis)Assembly Fixed amount / end of contract period</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage Fixed amount / end of contract period</td>
<td></td>
</tr>
</tbody>
</table>

Table 16 list of additional costs for a building product provider in a circular economy (own table)

The second part of this chapter describes circular economy markets. The way that a material can be traded is closer examined. It has been found that once a material has been traded, roughly three directions can be mentioned: change in composition, change in function and change in object. This is important to mention, since a product that has X function could have to deal with different macro and micro economic factors compared to products with Y function. This also means that different profits can be made. This all causes that, keeping in mind that a chain partner retains ownerships, the chain partner is cautious in its choice in allocation of its resources. Furthermore it is believed that a premium has to be added to the selling price in terms of 'likeliness' a material can be retrieved to the owner. The less complex a material is ‘packed’ in a component, the more likely it is to change in objects and therefore enlarges the future potential of a material.
5&6

THE DESIGN OF THE BUSINESS MODEL

Part one | The model
Part two | Case study
Conclusion
5 The design of the business model

This chapter will consist of two parts. The first will design a circular economy business model, with specific focus on the financial aspects. The financial aspects are divided into two parts: the cost structure and the revenue streams (table X). In the second part of this chapter a case study is done: the designed business model is applied to the building product provider of a steel beam; providing the performance ‘structure’. A discounted cash flow model (DCF) is made in order to determine the return on investments under the set circumstances.

### Table 17 financial aspects of a business model (based on Osterwalder & Pigneur, 2005)

<table>
<thead>
<tr>
<th>Financial Aspects</th>
<th>Cost Structure</th>
<th>Sums up the monetary consequences of the means employed in the business model.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue Streams</td>
<td>Describes the way a company makes money through a variety of revenue flows.</td>
<td></td>
</tr>
</tbody>
</table>

5.1 PART ONE | THE MODEL

The main focus of this business model is the sale of services instead of products, which is unique for a steel beam provider in the construction industry. The main activity is to operate as a service provider of steel structure product. This means that this business model provides customers with the service the products deliver. Next to that, the performance need to be monitored and maintained. Furthermore, the product need to be allocated which yield the greatest return.

Value is created for any customer or organization in the construction sector which are of a specific performance. This could be in every sector of the industry, such as the private sector and the public sector.

The added value in itself is not new. However, in this business model the building product provider provides a service to a customer. The assembly, maintenance and disassembly is completely taken care of, leaving the customer with the thing he wants most: the performance. With this approach, a customer does not need high up front cost for something he does not need.

Since customers pay for the performance the steel beam delivers during the contract period, a significant amount of the resources need to be spend on customer relationships.

[Figure 34 Product service systems (retrieved from http://www.plan-c.eu)]
Revenues streams
In this business model, the revenues are generated in two ways. According to the fundamentals of the circular economy, selling a product is not in a chain partner’s best interest. Therefore, the ‘pay per service unit’, ‘product lease’ and ‘functional result’ can be used for this model (figure 33). One part of the revenues will be generated by collecting a certain lease amount \( X \) for the contract period \( Y \). The customer will pay for the performance the material provides. The lease could be a payment per year, month or day. However, due to the long lifespan of a product, a payment per month or per year would be logical. The lease amount will be based on all the costs listed below, added with a profit margin.

Various revenue models can be used:

- Pay per fixed term (day/month/year)
- Pay per use (amount of time customer is using the beam, such as office hours)

The payment itself can be based on characteristics of the beam:

- Bearing strength of the beam (€ per N/m²)
- Providing structure of a building

The other part of the revenues is based on the value increase of the raw materials. It is believed that due to the increase in world population, the prices of raw materials will rise. In a circular economy, products are seen as an investment opportunity, which is believed to grow significantly in the future.

Cost structure
The main challenge in designing a business model is to quantify uncertainties which not yet have occurred in a linear business model. The following costs have to be added to conventional business models in the construction industry as concluded in the previous chapter:

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Maintenance</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Renewing cost</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reuse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Recycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Remanufacture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Withdraw</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed amount / end of contract period</td>
<td></td>
</tr>
<tr>
<td>Potential</td>
<td>Substitution risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Allocation risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Complexity risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td>Economical</td>
<td>Future price fluctuations</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>General risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Energy price risk premium</td>
<td>X% / year</td>
</tr>
<tr>
<td>Organizational</td>
<td>Transport</td>
<td>Fixed amount / end of contract period</td>
</tr>
<tr>
<td></td>
<td>Management</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>Monitoring</td>
<td>X% / year</td>
</tr>
<tr>
<td></td>
<td>(dis)Assembly</td>
<td>Fixed amount / end of contract period</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
<td>Fixed amount / end of contract period</td>
</tr>
</tbody>
</table>

Table 18 list of additional costs for a building product provider in a circular economy (own table)

All these costs are illustrated in the figure below. The first cost is production cost. In the production cost all the costs are added for the chain partner to operate and to produce the product. The yellow icons are the things that the product provider provides to the customer: the service, the maintenance and the monitoring of the service. The chain partner remains responsible for the product; and therefore maintenance is included. Optionally, this could be done by an external party. The following cost is the one that is apparent in a circular economy: disassembly. Especially the way in which this is organized is quite unknown. This issue has already been comprehensively discussed in this research. Once a building has been disassembled, transport cost has to be made. The material has to be transferred to a new customer, storage or returned in the biological cycle. In all cases, cost have to be made (in this model referred to as renewing cost, storage cost and withdrawal cost). Next to all these cost, there are external factors added in the model referred to as risk premiums. A few of these risks, such as substitution risk are hard to quantify, but important to add in the business model (see ‘incorporated risks and premiums’).
This section will add numbers to the ‘variables’ mentioned by means of a case study. The aim of the case study is to determine to what extent the designed business model is able to determine the (financial) viability of providing the service ‘structure’ in a circular economy. The product used for providing the performance is a steel beam. The product is chosen since it is believed that steel structure products are well suited for a circular economy. First, a steel beam is not subject to fashion; it is solely needed for the structure of a building and this has been the case ever since they are used. Next, a steel beam could be reused/recycled, since it can be easily disassembled if the right construction methods are used. Third, it is a highly resource intensive product; not many materials are added. Fourth, the construction sector is the biggest consumer of steel, which makes owning steel more and more interesting for the future. Fifth, the world steel production has risen in the past decennia (figure 35). Sixth, the average technical lifespan of the steel structure of an office block is 110 year, far exceeding the product life of an office (Cooper et al., 2014). This means that a steel beam is still technical capable of being reused when a 10 or 20 year contract expires.

Background information
First, some background information is given about historical steel prices and steel production. Next, the variables are quantified by means of assumptions, followed by a simple discounted cash flow model in order to determine the (financial) viability.
Figure 36 shows the steel prices of the last years. It is shown that despite the increasing steel production the prices are dropping. Steel was quoted at 140 on Friday August 14. Steel averaged 432.92 from 2008 until 2015, reaching an all-time high of 1265 in June of 2008 and a record low of 125 in July of 2013.

There is a big drop in prices in 2008 because of the world credit crisis. The second big drop is in January 2015. This is mainly because China’s steel demand slumped. Contrary to these developments, the circular economy principles assume that the increase in world population will cause a rise in resource prices on the long run.

Case study introduction
To avoid, or more accurately, to correct for the distortion caused by rising prices in a euro denominated variable, it has to be adjusted to inflation. In the case study an inflation percentage of 2.1% per year is chosen, based on the average inflation rate in the past 2 decades. Furthermore it is (randomly) assumed that contracts are made for 10 years. After the 10 year contract it is assumed that the steel beam is sold to another chain partner in the circular economy. To make this case study as simple as possible, finance cost are left out of the example.

A customer demands the performance ‘structure’ for a new building. The case will be limited to the performance of one single beam. It is assumed that the following product is sufficient in providing the performance for the customer:

- Material: Steel
- Description: HEB300
- Quality: SJ235JRG2
- Size: 6m
- Value in 2015: € 966,-
- Product service system: Lease
- First contract period: 10yr
- Lease percentage: 10%
- Product index (growth in resource prices): 4%
- CPI: 2.1%

Selling price
The selling price at year 10 is difficult to quantify. Products can be seen as an investment opportunity, as it provides a certain cash flow for a certain period in time on the one hand and it is believed it increases in value on the other hand. If a valuation example is examined on, for example, an office building, the value of the building at a certain point in time is calculated with a gross initial yield. The gross initial yield (GIY) is the annualized rents of a property expressed as a percentage of the property value. It is calculated by dividing the first year of rent by the value of the real estate; the lower the GIY, the higher the investment. The GIY is determined by several market factors such as risk profiles, types of real estate and locations.
The question is what GIY can be attributed to a steel beam. At this point in time, this is difficult if not impossible to say. For this case study the selling price of the beam at year 10 is the current market value accumulated with the product index.

**Lease percentage**

The lease amount is set at 10% of the value of the beam for the term of 10 years. If all the lease payments are added up and corrected to inflation an amount of €1007 is paid for the performance the beam delivers. This exceeds the market value of the beam at this point in time, which is set at €966. However, the customers is not lumbered with the products after the contract period. Furthermore, one does not have to care for maintenance or other additional cost or storage cost, which could influence the willingness to pay for a higher price.

**Adding the variables**

This section will try to quantify and explain the variables.

- **Maintenance cost**
  It is assumed that a beam does not need any maintenance during the time it is providing its performance.
  
  - Maintenance cost: 0% of value of beam / per year

- **Renewing cost**
  This will be a fixed amount at the end of the contract period. In this research four different scenarios are made: reuse, recycle, remanufacture and withdrawal. Withdrawal cost are added to the conventional scenarios, since products have to be returned to the biological cycle if it is not functionally valuable anymore. It is important that this cost is to be added in the business model. Since this example has a 10 year time frame, only reuse costs are added to the calculation.
  
  - Reuse cost: 10% of value of beam / end of contract period
  - Remanufacture cost: 0% of value of beam / end of contract period
  - Withdrawal cost: 0% of value of beam / end of contract period
  - Recycle cost: 0% of value of beam / end of contract period

- **Risk premium substitution cost**
  As seen in the steel calculation example, the global steel prices are dropping. This contradicts the circular economy principles. It assumes a constant growth of resource prices in the future. However, the technology is constantly developing and chain partners have to find an answer to this important question: will the performance the product delivers still be conventional by the time the contract expires? The premium has to be added in the business model; however the height of premium could differ significantly per sector. It is well believed that the construction sector is a conservative sector, so in this field the premium does not have to be as high as in other sectors, especially for structure components.
  
  - Risk premium substitution cost: 2% of value of beam / year

- **Allocation premium**
  One market is more ‘safe’ or ‘profitable’ than the other. Therefore it is believed that in some cases an allocation premium is needed. Since this example is about a consumer good (steel beam) and not about a raw material this premium is left out. Since the steel beam is designed and made for the construction sector, there is not much room to choose where to allocate the beam.
  
  - Allocation premium: 0% of value of beam / year

- **Complexity premium**
  Since this example is about a consumer good (steel beam) and not about a raw material this premium is left out.
  
  - Complexity premium 0% of value of beam / year

- **Other risk premiums**
- Future Price fluctuations 1% of value of beam / end of contract period
- General risk premium 2% of value of beam / end of contract period
- Energy risk premium 1% of value of beam / end of contract period

- Transport

As seen in the previous paragraphs, no cost are added for reuse. The cost made for reusing a beam are transport cost, disassembly cost and assembly cost. The average transport cost, based on a 5,000 kg truck are €1,46 per kilometer of transport (Stichting PNR, 2011). With a weight of 716kg for a beam of 6 meters, this mean:

- Transport cost €0,21 per km of transport / end of contract period

- (dis)Assembly

Once a contract expires, the structure has to be dismantled and assembled in a different place.

- Assembly cost 15% of value of beam / start of contract period
- Disassembly cost 15% of value of beam / end of contract period

- Storage

If there is no place to reallocate the products to and they are still to be used, the beams have to be stored in a heated environment. The average rental price per square meter of industrial buildings was €44,- in mid-2015 (DTZ, 2015). Of course multiple beams can be stacked as well. It is assumed that a 6 meter beam can be stored on 2m2, which means approximately €15,- per meter of HEB300.

- Storage cost €15,- per meter of beam / end of contract period

- Management & monitoring

In order to make sure if the performance of the product lives up to the expectations, the performance need to be monitored in a regular way. Also this variable can differ significantly per product. One can imagine that the performance a steel beam delivers is more constant than, for instance, a heating system. Next to that, cost are made to establish and maintain customer relationships.

- Management cost 2% of the value of the beam / year
- Monitoring cost .4% of the value of the beam / year

These figures are all added in a spreadsheet. The spreadsheet can be found in the appendix. An internal rate of return of 4.4% has been found. This means that with all the added costs and risk premiums, a positive result emerged. As said, a great part of these cost are estimated and assumed, so questions can be raised about the reliability of the outcomes.
Different scenarios
This section will determine what happens to the internal rate of return when variables are changed. The figures of the previous two paragraphs are set as the default situation. Subsequently, one variable is to be changed in two ways, referred to as new (1) and new (2).

## Incomes

<table>
<thead>
<tr>
<th></th>
<th>Default</th>
<th>New (1)</th>
<th>New (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>lease</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>10%</td>
<td>8%</td>
<td>12%</td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>4,4%</td>
<td>1,7%</td>
<td>7,0%</td>
</tr>
<tr>
<td><strong>Product index</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>4%</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>4,4%</td>
<td>0,1%</td>
<td>8,1%</td>
</tr>
</tbody>
</table>

## Costs

<table>
<thead>
<tr>
<th></th>
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## Risk premiums

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Concluding remarks
The result of the previous chapter are summarized in the following chart. Roughly three categories can be made. There are two variables which are not much of an influence to the overall result:

- Transport
- Monitoring

Then 8 variables can be identified of which the influence on the total results are about the same when they are changed:

- Reuse cost
- (dis)Assembly
- Storage
- Management
- Substitution
- Future price fluctuations
- Energy Prices
- General

Additionally, there are two variables of which a change in number the influence is the highest:

- Lease percentage
- Product index

This distribution of these variables can be for a great deal accounted to the type of cost. For instance, it emerges that a change in yearly cost causes a higher shift in outcome than a change in one-off cost, such as storage or transport.

A sensitivity analysis showed that there are two variables which have the biggest influences on the outcomes: the product index and the lease percentage. The conclusion that can be drawn from this case study is unequivocal: the key issue is axiom of the growth in resource prices. There is a limit to the height of the lease price; therefore the growth in resource prices, based on scarcity and under the set conditions of this study, will determine the financial viability of the business model. This the key to the success of the transition from a linear economy to a circular economy.

Figure 38 Results (own image)
5.3 CONCLUSION

The question to be answered in this chapter is:

*In what way should the financial aspects of a business model be designed in a circular economy and to what extent could this model be viable in reality?*

The business model is designed for a random chain partner in the construction industry. The design of the business model is illustrated on page 52. It basically adds all the addition cost in a circular economy, as defined in previous chapters.

Next, it was applied to the business model of a building product provider of a steel beam. As a product service system the ‘lease’ alternative is chosen. All the cost are for a large extent determined by means of assumptions. This is at the same time also the weakness of the model. Due to the large amount of assumptions, it is hard to conclude whether or not the model is profitable. But it can be stated that under the right circumstances profit can certainly be made. The opposite is also true, if circumstances are not favorable, it is highly unsure if required internal rate of returns can be achieved.

After running analyses with changing variables, it is showed that capital gain due to a rise in resource prices (product index) is essential in enabling profitable lease construction for building products. This is because the following to arguments: there are only two sorts of income that must outweigh the expenses: capital gain and lease income. A drop in capital gain can logically only be compensated by a rise in lease income, which could make this solution unprofitable when compared to a ‘traditional’ linear situation. Furthermore the variable ‘product index’ shows to influence the internal rate of return to a great extent (see figure 37). This shows that the profitability of a lease construction for building products is dependent upon resource prices, making these lease solutions volatile.
Part Three
6 Conclusion

The main question of this research is: To what extent is a) the implementation of the circular economy theory in the construction industry of influence of the business models of building product providers and b) how should the financial aspects of a business model be designed in order to operate successful within the boundary conditions of the circular economy theory.

This research critically examined the circular economy concept as posed by the Ellen MacArthur foundation. A six step approach was made in order to answer the main question.

1) Examine the circular economy concept
2) Examine the construction industry and its characteristics
3) Design boundary conditions of the circular economy
4) Project these boundary conditions to conventional business models
5) Design a new business model
6) Apply the business model in a case study

Despite the growing popularity, the theory itself should not be accepted without any criticism. Due to incompleteness of literature and theory it is for instance not possible to give one generally used definition of circular economy. Therefore a new definition of circular economy has to be established. After reviewing a lot of literature and conducting various discussions the following definition is made:

‘a circular economy is an economic system with cyclical material loops based on a financial incentive.’

Wherein ‘economic system’ refers to a combination of more than one interrelated parts or components that show how people deal with scarcity, ‘cyclical material loops’ refers to a loop that makes it possible for materials to keep cycling in these loops, and where ‘a financial incentive refers to a prospect on financial merits.

The construction industry is characterized by its project-based nature, delivering unique products (buildings). Due to the uniqueness of its products, each and every project in the industry is also different from one-another, with a different composition of stakeholders in each project. Also there is not a lot of thought given to end-of-life situations, probably because of the long time span surrounding the buildings, and the different components within the building have different lifetimes. Furthermore the industry is capital-intensive and relies a lot on manual labor in order to realize its products.

The built environment nowadays is responsible for using 40 to 50% of the natural resources, 30% of the primary energy demand in OECD-countries, 40% of the emissions of greenhouse gases and 10 to 30% of the waste flow in the European Union (Schoolderman et al., 2014; OECD, 2008; Uhlein & Eder, 2009; APRICOD, 2006). These figures stresses the urgency of resource efficiency in the construction industry. However, the characteristics of the construction industry makes the implementation of circular economy significantly more difficult and contradicts circular economy principles, such as minding a product’s holistic life cycle.

During this research, boundary conditions have been set up and actors involved in a circular economy have been identified. It has been found important to divide the boundary conditions into ‘hard’ and ‘soft’ conditions in order to stress the difference between a ‘sustainable’ and a ‘circular’ economy. The ‘hard’ conditions need to be fulfilled to meet the requirements of a circular economy. The ‘soft’ conditions need to be fulfilled to create a more sustainable economy.

It can be concluded that the implementation of circular economy principles cause a significant shift in business models of building product providers. The implementation will cause a shift for building product providers from short-term to long-term governance, adding new risks and costs. Furthermore, the responsibility for the performance cause the chain partner to implement maintenance, management, transport and (dis)assembly in the business model. In short, the application of the boundary conditions to the conventional business models and markets have resulted in 13 additional issues that have to be incorporated in the design of a new business model. By implementing these issues, businesses need to broaden their range of tasks. These issues are implemented in the business model as costs and risk premiums and can roughly be divided into four different categories: product, organizational, economical and potential.
The business model is illustrated in figure 35, incorporating all these risks and costs. The main focus of this business model is the sale of performances instead of products. This means that this business model provide customers with the service the products deliver.

Case study
Next, it was applied to the business model of a building product provider of a steel beam. As a product service system the ‘lease’ alternative is chosen. All the cost are for a large extent determined by means of assumptions. This is at the same time also the weakness of the model. Due to the large amount of assumptions, it is hard to conclude whether or not the model is profitable. But it can be stated that under the right circumstances profit can certainly be made. The opposite is also true, if circumstances are not are not favorable, it is highly unsure if required internal rate of returns can be achieved.

Product index
After running analyses with changing variables, it is showed that capital gain due to a rise in resource prices (product index) is essential in enabling a profitable lease construction for building products. This is because the following two arguments: there are only two sorts of income that must outweigh the expenses: capital gain and lease income. A drop in capital gain can logically only be compensated by a rise in lease income, which could make this solution unprofitable when compared to a ‘traditional’ linear situation. Furthermore the variable ‘product index’ shows to influence the internal rate of return to a great extent (see figure 37). This shows that the profitability of a lease construction for building products is dependent upon resource prices, making these lease solutions volatile.

Substitution
With the transition from product-based business models to performance-based business models, some risks and insecurities have been identified. An important risk premium is highlighted: substitution risk premium. Especially in the built environment, this risk becomes really apparent. As already stressed during this thesis, the construction sector is about long life cycles. With retaining ownerships amongst building product providers, chain partners make long term investments, based on predictions about one’s products. Usage periods of materials are assumed.

During long periods the usage period of products are depending on regulations. Numerous examples can be mentioned of functionally good products of which are not capable of meeting regulations. Furthermore it could happen that during such a long period, new insight about products are found, of which affects the usage period as well. Next to that, it could happen that the conventional building products today are not the standard building products of tomorrow. It is important that chain partners incorporate these risk in order to prevent business failure.

In the end it can be concluded that there are many uncertainties involved in the designed business model of which more research is needed before businesses can adopt the model. However, the model shows, in contrary to current literature, concrete effects of implementing circular economy principles in practice. It is believed that this is a good starting point for further research.
7 Reflection & Recommendations

The objective of this research was to design the financial section of a business model in which building product providers can operate within the set boundary conditions of the circular economy. The cost and revenue streams of a business model have been designed and assessed by means of a case study.

The thesis is largely the result of the author trying to model the circular economy principles in practice. Due to a lack of scientific research or profound reports, there is not a solid ground theory to work with. Therefore the author first (re)defined the definition of a circular economy (together with co-student Robert van den Brink) and defined boundary conditions of this circular economy. With all these formed definitions, a business model is designed. A large part that has been written might be controversial or at least provide fodder for discussion.

This chapter will reflect on these findings in two ways. First, a look is given to the research of co-student Robert van den Brink (forthcoming). This section will combine the findings and discussion of this research with research done by Van den Brink (forthcoming). Both this research and the research done by Van den Brink (forthcoming) started out from the same viewpoint, which becomes apparent through the co-authoring of chapter 1 and chapter 2 of this research. After this mutual starting point, this research focused upon the design of the financial section of a business model for building product providers, whereas Van den Brink (forthcoming) focused on the organizational forms of an advanced services construction industry. Connecting the findings and discussion of both researches therefore yields an overview of different possible advanced services business models and the financial pre-conditions under which they might work. This offers a more complete picture and addresses one of the big subjects found in this research, namely the financial implications.

The second part will discuss feedback of market parties on this research. Two experts were asked to give a brief opinion about the design, content and results of the research. Finally, some remarks are given about the generalizability of the case study.

Findings done by Van den Brink (forthcoming)

After the mutual first chapters, Van den Brink sets out to develop different business models to use in a circular construction industry. These business model prototypes were developed following an extensive literature review and focused solely on advanced circular services solutions. This was done for two reasons: first this type of business model is as of yet unknown in the construction industry. Second, this type of business model can be expected to deliver radical environmental gain. With the development of these business model prototypes the first part of the research question is answered (How to organize the service provider in such a way that its role adheres to the definition and principles of the circular economy).

![Figure 39 Focus of the two different research projects, this research focuses on the lease of products within the construction industry whereas Van den Brink (forthcoming) focuses on different business model prototypes for advanced services delivery in the construction industry (Van den Brink, forthcoming)](image-url)
Afterwards these models were laid out in front of several practitioners in order to answer the second part of the research question (How does this organization relate to current supply side stakeholders in the construction process). With this it was found that the developed business model prototypes are not seen as directly applicable in the construction industry, on the long term however they were seen as probable. Several explanations can be given why the developed prototypes are not directly applicable to the construction industry:

1. For the advanced service model prototypes to work, innovation has to take place in multiple places within the construction process. These innovations are not always seen as likely to occur in a short timeframe.
2. The respondents in Van den Brink’s research perceive financial uncertainty around the business model prototypes.
3. There is legal uncertainty surrounding the materials and products that are inserted in a construction project. Building regulations for instance tend to be progressive and/or changing over time, this could influence usability of products that are currently present in one building to be re-used again at the end-of-loop situation.

After Van den Brink’s research it remains unclear what party (or parties) could perform the role of the service provider in the developed business model prototypes. The respondents showed a different attitude towards performing this role, and the author feels that the sample is too small to make conclusive remarks at this point.

Given the fact that the developed business model prototypes are not likely to be implemented in the short-term, the implementation of the circular economy would likely be restrained to basic-, to intermediate services business models. Evidence of which can already be found in the current construction industry, as can be seen from some of the examples introduced in Van den Brink’s research. This will most likely limit the environmental gain by implementing the circular economy in the construction industry to an incremental level (at least for the foreseeable future).

Discussion of Van den Brink’s (forthcoming) findings in connection with this research
This research shows that the financial uncertainties of implementing circular economy in practice can be brought down to two factors. First, the profitability of lease-solutions depends heavily upon resource prices. Second, the financial value of materials inserted in a construction project depends on their usability at the end-of-loop situation (point 2 by Van den Brink), which brings us to the third explanation of Van den Brink (forthcoming) why the developed business model prototypes are not directly applicable to the construction industry. Van den Brink (forthcoming) stated that there are legal uncertainties surrounding products that could influence the reusability of products. In this research this is mentioned and added as a ‘substitution risk premium’ in the business model. The arguments for this premium follows the same reasoning as presented in Van den Brink’s (forthcoming) study.
It is interesting to see that similar conclusions have been drawn after each did their own part.

It is important to note that Van den Brink (forthcoming) recognizes that the second part of his research, which deals with the question how supply side actors relate to the developed business model prototypes, is limited as it only considers a small sample size. The author stresses that more extensive research is needed at this point.

Experts
Two experts were asked to provide a brief reflection on this thesis. One was director of the NVTB, a Dutch organization that represents the common interests of producers and suppliers of building materials in the construction industry. The second expert is a general manager of Tata Steel Construction Centre NL; part of Tata Steel Group. Tata Steel is one of the biggest steel suppliers in the world. Questions that have been asked were of reflecting nature, asking about their opinions on the outcome and results, the design of the study, the topic itself and the case study.

The respondents acknowledged the importance of research on the topic. Both respondents were already involved in the circular economy. The employee of Tata Steel acknowledged that the company is interested in leasing steel structure components over selling. However for Tata Steel the focus of implementing circular economy principles is not at the construction industry, but at the automobile industry, due to the long term relationships with the industry. Tata Steel furthermore acknowledged the difficult issues on the organizational level. The respondent stresses the complexity of the ownership structure in a building, confirming the findings in chapter two of this thesis. It is unclear what happens if a customer is not able to pay its lease; it is not easy to retrieve structure components, especially in relation with other building product providers. This issue has been tried to cover by
adding ‘complexity risk premiums’ in the designed business model. Next to that, the company finds it difficult to find a lease construction for a product with such a long life span (>100 years). Finally, also Tata Steel sees that the resource prices are dropping, significantly removing the financial advantage of retaining ownership over the product and with that acknowledging one of the important conclusions in the previous chapter.

The respondent was also asked to provide feedback to the list of costs that has been added to the business model. According to the respondent the list is highly relevant and he was not able to identify any overlooked aspects. However, criticized the ease of the conclusions; more conclusions can be drawn if more sensitivities and break points were calculated. The designed business model was found interesting and realistic, whereby the respondent acknowledged the present reuse of beams in the construction industry in the Netherlands.

The director of the NVTB found the topic and the design of the study very interesting. The director thinks that leasing products can be financially interesting, since it provides a business with a continuous revenue stream over a long period of time. Next to income from the products, a company enlarges business activities with the monitoring and management of the product and therefore spreading risks. On the other hand, the director also acknowledge (as the findings in chapter three) the high upfront investments involved with this structure and furthermore states that this step is hard to overcome.

As an interesting note the respondent mentioned that disassembly are rarely causing extra costs if products are well-designed. Next to that, the director found the results interesting and praised the ‘out-of-the-box’ thinking. On the other hand the respondent thinks the case study should have had a different subject. He believed that the case should have raised value if it was more from the client’s point of view. It is believed that the study has become more useful if it has been done about already existing circular economy building product examples, such as a circular façade. Furthermore the respondent criticized the lack of market experts in the report. More involvement of those parties could have given this report more depth. This is also mentioned by the manager from Tata Steel; he claimed that the case study could have been more comprehensive if market parties were involved earlier one.

The whole period of writing was one big learning process, giving new insights on the topic every day. This thesis focusses on the suppliers, and more specifically referring to the supplier of a steel beam in the case study or, within terms of this thesis, the building product provider. This research tried to determine whether or not the implementation of circular economy could be financially viable. In hindsight, more work is required in the field, specifically trying to identify the viability of the designed business model.

In the problem description of this thesis, it has been written that the implementation of the circular economy principles in practice cause financial, legal, social, mental and operational challenges (Kok et al, 2005). This thesis identified several costs that have to be incorporated in the financial section business model. More research is needed on all the other challenges, specified for all the other actors in the construction process as well. Co-student Robert van den Brink already did a part of this research, focussing on the organizational aspect as seen in the previous section.

Case study
The case study specifically focusses on the providers of steel beams. This product is partly chosen because the construction sector is the biggest consumer of steel and is also accountable for the highest carbon footprint. The challenges and opportunities are mapped for this specific product, but more research is needed on other building products. It is unsure if the same conclusions apply to other building products as well. If, for instance, a different structure product is examined such as wood, different payback periods, different resources, and different technical and economic life spans can be identified. Next to that, wood has different characteristics and is highly influenced by building regulations regarding bearing capacities. These issues should all be incorporated in the business model and if it more profound examined, it could result into a completely different conclusions.

Concluding, more research is needed about the legal, social and mental challenges. Next to that, more market parties should have been involved in this thesis. Despite that, the two respondents all think the findings are interesting and realistic. It is hoped that this research, together with the thesis of Robert van den Brink, can contribute to the discussion about circular economy.
8 Literature


9 Appendix

9.1 APPENDIX A: PERSPECTIVES ON A CIRCULAR CONSTRUCTION PROCESS

Under influence of the circular economy the way in which buildings are realised will change, this becomes clear when looking at the description and definition of circular economy in chapter 1, and by looking at examples of products in other markets that already claim to be circular (MVO Nederland, 2014, p. 37; Deckmyn, Leijssens, Stouthuysen, & Verhulst, 2014, p. 11). As of yet there is however no precedent of what the construction process is going to look like under the influence of the circular economy. This section will therefore discuss current construction processes and their (in)applicability with circular economy theory, this will be done through examining three different aspects that will be subject to change under the influence of circular economy implementation; ownership, business finance, and building components (i.e. the products). For these exercises the earlier established definitions and preconditions of a circular economy (chapter 1) are used, if any other assumptions are made these will be noted separately with each exercise. The result of these exercises will be an overview of the possibilities of implementation of circular economy in the construction industry.

A1 Ownership in a circular construction economy

In order to get a grasp of what the effect of implementation of the circular economy in the construction industry might have on ownership, this study will comprise a short research into what happens with ownership in this situation. For the exercise below first a ‘standard’ construction process is depicted and explained. Afterwards a possible circular construction process is depicted and explained.

The exercise

Current construction processes generally go through several stages, these stages can be identified as: initiative, design, construct, and use. Where the initiative stage serves to define the need for a certain building or service, the design phase focuses on designing the need as it were. After the design has been made the process moves into the next phase, which is called the construction phase. In this phase construction of the design takes place, after construction is finished the use phase commences (Wamelink, 2010, pp. 5,6). The construction process as described above seems neat and clear-cut, but it becomes more complicated when the phases are coupled to the actors that are needed in order to execute the different phases, these will be discussed below.

Roles and their responsibilities

When the aforementioned phases are coupled to the stakeholders in the process, it immediately becomes clear that the construction process is a complex one (Figure A1 shows this relationship throughout the project time span based on Wamelink (2010)). During the initiative phase it is mostly up to the client to show the initiative to start a new project and think about the question what he or she needs.

Once the design phase is entered, architects and advisors usually become involved to try and design a solution for the need that was established in the initiative phase. Although the amount of stakeholders involved in this phase usually is quite small, there is no limit to the amount of advisors that can be consulted here and in complex projects it might be that there are already a lot of different actors involved in this stage.

After the design phase is finished and the construction phase starts, other actors make their way into the process. The most important new stakeholder in the project at this stage is the contractor who is (usually) responsible for executing the design. The contractor usually is not able to construct the entire project on its own, and therefore enlists the help of sub-contractors and possibly its own advisors. The architect, earlier advisors, and client may also still be involved in this stage.

Hereafter the use-phase commences and the client starts using the commissioned project, or it sells the project to a third party, and then could possibly rent it back or not. Another important actor in this phase is the facility manager, who is responsible for taking care of the project during the use-phase.

As can be seen from the short description above, the construction process revolves around an intricate play of different stakeholders during different phases of the project. This makes for complexity, especially since the way in which the above stakeholders cooperate is different in each project, making each project a ‘one-off’ and unique. What also becomes apparent is that on the supply side there are a lot of changes throughout the process when it comes to which parties are present in the project. There is not one single actor on the supply side that is present throughout the entire construction process. On the ownership side however, changes are relatively rare and if
they occur, these changes were probably foreseen at the start of the project. It can therefore be argued that the ownership side of the process is more long-term oriented (with exception of the project developer), and the supply side more short-term oriented.

Figure A1 Ownership and supplying parties in a linear construction process (Own image).

Implementation of the circular economy

When the circular economy is implemented in the process above, there appear some radical changes to both the ownership and supplying side, as the thought behind circular economy theory is that each supplier remains the owner of their own product, and thereby incentivises them to realize more sustainable products (Ellen MacArthur Foundation, 2013, pp. 22-34). The ownership of the object under this influence therefore changes from the traditional parties towards the supplying parties, annihilating the traditional division between the two.

Furthermore, as every actor should remain responsible for their own product, this would mean that parties that are involved from the very beginning should remain the owner of their service throughout the project timeline. Therefore the architect and the specialists in the initiative phase would remain ownership of their service throughout the projects timeline (figure A2). This process would entail that all the actors from previous phases would be added up to the actors that are present in later phases to form the ‘owner’ of the constructed object. In figure three this has not been depicted in such a way in order to keep the figure clear, but it also raises the question whether the abovementioned changes won’t complicate the construction process even further.

Figure A2 Ownership and supplying parties in a circular construction process (Own image).

Perhaps it would therefore be more logical to have only one owner of the constructed object for which other parties provide their services, however the problem then becomes that the incentive to make a sustainable product is only valid for the sole owner, all the other actors won’t experience a change from the ‘normal’ process.

Concluding remarks

When circular economy theory is brought to the ‘standard’ construction process, the division between ownership and supplying party changes and becomes blurry. It can be argued that in this line of thought ‘traditional’ ownership disappears and shifts towards the supply side parties. This complicates the process as supplying parties, contrary to the traditional ownership parties are subject to change throughout the process and there would therefore be a lot of different parties involved that can call themselves owners. It also affects the time scope of the involved parties, where supplying parties usually have a relatively short-term involvement and ownership
Business financing in a circular construction economy

Under the influence of the circular economy, the context when it comes to business financing will change for a supplier. The changed situation is probably best described by an example; if there would be a supplier S that deals with a ‘regular’ construction project he/she would simply leave the bill for his services and (hopefully) get paid. Within a circular context, the supplier would remain the owner of his delivered goods that come with his services. Instead of leaving the bill, the supplier would instead get continuous payments for the use of his services (MVO Nederland, 2014, p. 54).

As businesses are financed mostly by debt, these periodic payments could create problems, as financing is usually project based and it might be costly to delay re-payments on this debt as a result of periodic income. Getting a loan to finance the firm’s business could therefore become more complicated in an already complicated financing climate (Van Odijk & Van Bovene, 2014). As the economic basis to provide financing changes, financing should also evolve. First thoughts about a possible change in financing consider for example stock financing. Instead of financing the project, the financier finances the stock of materials a supplier uses (MVO Nederland, 2014, p. 54). But even after that the question remains, one that is very similar to the mass-produced circular products, whom will take building materials that are lodged within a building as collateral (Deckmyn, Leijssens, Stouthuysen, & Verhulst, 2014, pp. 48, 58)?

But what is the real impact of the above-described situation for a supplier, this question formed the basis of the exercise that is being described below. This exercise will comprise a short research into what happens when a construction company decides to lease its new products to customers instead of selling it. In order to do so, a yearly account of one of the bigger construction companies in The Netherlands is taken as a source of data in order to calculate the effects of leasing versus selling the produced dwellings. The exercise will be explained and visualised below, after which some concluding remarks will be made.

The exercise

As stated above, the basic data input for this exercise comes from one of the bigger construction companies in The Netherlands, for this exercise the focus is on the construction of dwellings. It is important to note that the company that provided the data for this exercise is involved in other activities besides realizing dwellings, other activities include infrastructure, commercial property and a relatively small amount of consulting. However this exercise is limited to the construction of dwellings in order to keep it relatively simple and therefore eliminating the need to make a lot of unnecessary assumptions, which would undermine the validity of the eventual results.

First off, tables A1 and A2 show the yearly account of the company under examination as it actually was for the year 2013. These results were thus attained with their ‘regular’ business practices. A few things stand out, like the high amount of short-term loans, and at the same time the low quantity of long-term loans, which is probably a result of the project-driven nature of a contracting company. It also explains the highest expenses category on the profit and loss account, delegated work, which is needed in order to make a project work. The other categories on both the balance sheet and the profit and loss account don’t stand out in any particular way.

Implementation of the circular economy

For the next part of the exercise, it is assumed that instead of selling the newly constructed dwellings, the company leases these to its customers. This assumption is made under influence of the circular economy where products are no longer bought by the consumer, but where the consumer merely pays for the service offered, which in this case would be living. Tables three and four show the effects of such a decision on the balance sheet and profit and loss account of the company under examination.

Further assumptions for the data below are that since roughly 27% of this company’s activities are related to the construction of dwellings, only 27% of the business income is affected, which translates to about 287 million Euros. This amount of money translates itself to about 2000 dwellings against an average construction price of 143,500.- Euros per dwelling, which is a conservative estimate. Considering the income stream it has been assumed that the buildings will remain in ownership for twenty years and that the revenue on the income stream of these dwellings is about 14%. All other categories are for the simplicity of the exercise considered equal to the original data.

What can be ascertained from the newly derived balance sheet and profit and loss account (tables A3 & A4) is that the decision to lease the constructed dwellings instead of selling them has got some implications (numbers that
have changed are shown in red, with the exact change mentioned after this number). First off all when it comes to the balance sheet, the solid assets of the company show a big growth as the constructed dwellings now have to remain on the balance sheet. As these assets now have to be financed, there is also an increase in both short- and long-term loans (in this exercise the decision was made to shelter the first 5 years of debt with short-term debt and the rest with long-term debt for liquidity reasons, which will become apparent later on in this explanation). As a result of this shift in income and debt, the liquidity and solvability of the company also alters, both show a weakening as opposed to the original setting, leaving especially the liquidity of the company below what is considered to be a healthy ratio.

Table A1 Balance sheet of a big Dutch construction company in the year 2013 (Dura Vermeer, 2014)

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<thead>
<tr>
<th></th>
<th>Debet</th>
<th>Credit</th>
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<tbody>
<tr>
<td><strong>Vaste activa</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>immaterieel</td>
<td>2,8</td>
<td></td>
</tr>
<tr>
<td>materieel</td>
<td>52,5</td>
<td></td>
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<tr>
<td>financieel</td>
<td>23,1</td>
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<tr>
<td><strong>Total</strong></td>
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<tr>
<td><strong>Vlottende activa</strong></td>
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<td></td>
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<tr>
<td>voorraden</td>
<td>91,8</td>
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<tr>
<td>onderhanden</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>vorderingen</td>
<td>175,2</td>
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<tr>
<td>liquide middelen</td>
<td>97,1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>364,1</td>
<td></td>
</tr>
<tr>
<td><strong>Kortlopende schulden</strong></td>
<td></td>
<td>295,9</td>
</tr>
<tr>
<td>Langlopende schulden</td>
<td></td>
<td>4,2</td>
</tr>
<tr>
<td>Saldo vlottend – kort</td>
<td>68,2</td>
<td></td>
</tr>
<tr>
<td>Saldo act. – lang en kort</td>
<td>146,6</td>
<td></td>
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<tr>
<td>voorzieningen</td>
<td></td>
<td>15,7</td>
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<tr>
<td><strong>Liquideiteit</strong></td>
<td>1,23</td>
<td></td>
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<tr>
<td><strong>Solvabiliteit</strong></td>
<td>1,47</td>
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</table>
The profit and loss account shows equally big changes. Especially company income shows a lower figure as income from sale is now replaced by income from a lease contract, which eventually will pay out around the same amount but over a longer period of time. This is the main cause for the net-result of the company to turn very negative, as the income does no longer offset the costs that are made. Of course it can be argued that the costs should also be significantly lower, as no or little labour is needed for the continuing of the payments of the lease contract, however labour costs do not allow for a quick and sharp response to a changing situation (in a situation where people are fully employed by the company in question), it can therefore be argued that this change won’t offset the loss of income. Even if we would deduct the costs of delegated labour for the coming years, it would not offset the loss of income (this is not shown in the table but follows the reasoning of lowering the delegated labour category by 27%, leasing would then still imply a loss of around 50 million Euros, or 6% of company income). A buy-buy-back construction might offer better results here, but keep in mind that money would still need to be reserved each year in order to buy back the assets, the construction would therefore have more or less the same implications only the other way around when it comes to the time period.

There are also some orange numbers present in table four, these refer to income and expenses that can be less accurately defined based on the data available, some remarks can however be made concerning these categories:

- Financial gains and losses from interest rates cannot be directly calculated based on data available in these tables. It can be argued however that the company will become more exposed to interest rate risk as a result of their growth in solid assets and long-term debt.

- The company result after taxes has been based on the assumption that all other activities of the company remain unchanged, this can however not be assured, and it can therefore not be said that this will be the actual result of the company moving into lease contracts, for this exercise however it remains a valid argument.

Income from reselling at a later point in time
One of the main thoughts behind CE is that the products that are being used can be reintroduced into the market with some alterations that make the product reach the standards that are needed at that point in time, eliminating waste as it were. What if the contractor from the example above would be able to reintroduce the product after a period of time at a relatively low cost? He would obviously save money as compared to having to start

Table A19 : Profit and loss account of a big Dutch construction company in the year 2013 (Dura Vermeer, 2014)
Suppliers going circular (figure A3). This would mean an opportunity to the contractor’s business, however as seen in the example above leasing puts a lot of strain on the company’s balance and profit and loss account and it can be argued whether future savings can justify this strain, or whether the company might still be around to profit from this situation after a few years as it might not be able to cope with the pressure. The savings that can be made through this model would need to be big and preferably not too far ahead in time in order to be able to justify a leasing model on the basis of savings in the future.

Table A20 Balance sheet of a big Dutch construction company in the year 2013 with circular building taken into account (Adapted from: Dura Vermeer, 2014)
### Table A21
Profit and loss account of a big Dutch construction company in the year 2013 with circular building taken into account (Adapted from: Dura Vermeer, 2014)

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<tr>
<th></th>
<th>Debet</th>
<th>Credit</th>
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<tr>
<td><strong>Bedrijfsopbrengsten</strong></td>
<td>763,3</td>
<td>(-270)</td>
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<tr>
<td><strong>Bedrijfskosten</strong></td>
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<tr>
<td>uitbested werk</td>
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<td>lonen/salarissen</td>
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<tr>
<td>sociale lasten</td>
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<tr>
<td>afschrijvingen activa</td>
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<td>overig</td>
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<td>845,5</td>
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<td>151,2</td>
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<td>0,2</td>
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<td><strong>Bedrijfsresultaat</strong></td>
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<td></td>
<td>280,3</td>
<td>(-270)</td>
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<td><strong>Financiele baten/lasten</strong></td>
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<td>rentebaten / lasten</td>
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<td>deelnemingen</td>
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<td></td>
<td>2,8</td>
<td>0,1</td>
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<td></td>
<td>2,7</td>
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<tr>
<td><strong>Resultaat ante</strong></td>
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<td></td>
<td>277,6</td>
<td>(-270)</td>
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<tr>
<td><strong>Resultaat post</strong></td>
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<tr>
<td></td>
<td>275,5</td>
<td>(-270)</td>
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<tr>
<td><strong>Nadere verdeling</strong></td>
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<tr>
<td>bedrijfsvoltooering</td>
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<tr>
<td>incidenteel</td>
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<td></td>
<td>266,9</td>
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<td></td>
<td>8,6</td>
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<td></td>
<td>275,5</td>
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**Figure A3** The chance to save money in the long run by reintroducing the product at a lower cost than constructing a new product (Own image).

**Concluding remarks**
Leasing the objects constructed instead of selling them in order to retain ownership does not make sense from a contractor’s perspective. This exercise has shown that leasing impacts both the company’s liquidity and solvability in a negative way. It also causes a lot of deadweight capital in the form of solid assets on the company’s balance sheet. From the second year onwards, the company’s result would recover for the most part, however there would still remain a loss when compared to the selling strategy, this is mostly influenced by labour costs.
A buy-buy-back model would diminish the negative results at the start of the timeline, but would replace the negative effects to later stages in the timeline. This option does therefore not offer a viable way around the problems observed above.

Also reintroducing the product with low alteration costs at a later point in time becomes therefore difficult, as the leasing model puts a lot of strain on the company. The income and/or savings from reintroducing would therefore have to be of a considerable size in order to justify the leasing model.

Building components in a circular construction industry
In order to get a grasp of what the effect of implementation of the circular economy in the construction industry might have on the relation between building components, this study will comprise a short research into what happens with building components in this situation. For the exercise below different buildings in terms of components are described and reviewed from a circular point of view. Three situations are described: a building is composed of one component, ten components and hundred components. One central question will be asked: what does the situations mean for the potential success of the implementation of the circular economy theory.

The exercise
One component: The first situation describes an imaginative building composed of one component. Since it is only one component, there is no interconnection with other components. This makes the component easy to maintain and/or replace. Furthermore, a single component building also means that the building consists of only one lifespan. There is no need to create flexible connections.

Ten components: In this situation is building is composed of ten components. Here, some extra challenges emerge opposed to the previous situation. Ten components could mean different life spans. This means that some components need to be replaced where others are functionally still working. Here, the connectivity demands extra attention. Flexible connections have to be designed. On top of that, contractors have to replace components without compromising the functional and technical lifespan of the others. Furthermore there are juridical challenges. It is unclear what happens if the failure of one component affects the functioning of the other. A different issue next to flexible is reachability. The more components there are, the complex the construction is. A component has to be ‘reached’ easily in order to maintain and/or replace it.

100 components: It is clear that in a building with 100 components the previous mentioned challenges are even bigger. It must be noted that in the current situation, this scenario is the most realistic in the construction industry. A buildings consisting of 100 components is more likely than one.

Figure A4 Potential owners of a circular building (own image)

Concluding remarks
It could be concluded that the more components there are involved in a building, the more difficult it gets to implement the circular economy principle (figure A4, and table A5). With an increasing number of components significant organizational issues arise; all these components have to be maintained at different points in time. With this, also legal issues arise. For instance, it has to be clear who is responsible for the connections. Furthermore, contractors need to have knowledge of the connections with other components, preferably about the other component itself as well to make sure the maintenance process of one component does not compromise the functionality of the other. Concluding, flexible connections have to be designed keeping in mind the reachability issue as well (table 9 shows the main differences between the current and a (possible) circular situation).
Current situation | Circular situation
--- | ---
All components form one giant part, which is called a building | All components form one giant part, which is called a building
1 (or a few) owner(s) | Multiple owners
Solid connections | Flexible connections
Connections are not that important | Connections are paramount
It is the overall result that counts | Overall result is still important, internal organization is however more important

Table A22 Comparison between a building that is being constructed according to present day convention and a building that is being constructed through a circular process (Own table).

Concluding remarks exercises
This section focused on three different short exercises that showed the practical implications of implementation of the circular economy in the construction industry. From these exercises it can be concluded that; when circular economy theory is brought to the ‘standard’ construction process, the division between ownership and supplying party changes and becomes blurry. This complicates the process as supplying parties, contrary to the traditional ownership parties are subject to change throughout the process and there would therefore be a lot of different parties involved that can call themselves owners. It also affects the time scope of the involved parties. When it comes to business financing, it can be said that leasing the objects constructed instead of selling them in order to retain ownership does not make sense from a supplier’s perspective. Leasing impacts both the company’s liquidity and solvability in a negative way. It also causes a lot of deadweight capital in the form of solid assets on the company’s balance sheet. From the second year onwards, the company’s result would recover for the most part, however there would still remain a loss when compared to the selling strategy. Other strategies like a buy-buy-back model or reintroducing a product were also found to be unlikely profitable activities. When it comes to building components (i.e. the products) a shift in demands will be needed when circular economy theory is implemented. Furthermore, the amount of individual building components plays a role in the feasibility of the circular economy in the construction industry, where the more components inherent in a building the less likely it seems that circular construction is feasible.
9.2 APPENDIX B: COMPARISON WITH GENERAL OBSTACLES FOR THE CIRCULAR ECONOMY

This section will make a comparison between the three exercises that were made and earlier research on obstacles for implementation of the circular economy. This earlier research however focuses on the implementation of the circular economy in general, it is not specifically done for the construction industry. In this way, this section will also make a comparison between the general obstacles and their relevance towards the construction industry. First off, an overview of the general obstacles that were found will be given, thereafter their connection to the three exercises will be made. This will then in turn give an overview of the obstacles that are relevant to the construction industry following the earlier made exercises.

The general obstacles for implementation of the circular economy

The obstacles that will be discussed in this section were found by Kok, Wurpel, and Ten Wolde (2013) in an attempt to create a roadmap towards the circular economy. These obstacles are considered to be general and valid for all actors that want to partake in the circular economy. It is important to stress that this list is not exhaustive, as is also acknowledged by the authors, and that the categories of the obstacles found are ‘loosely’ interpreted. All the obstacles can be found below in table B1, as clear as these obstacles are, their generality makes them abstract and hard to place in specific contexts without further context. This also means that the roadmap created by Kok, Wurpel, and Ten Wolde (2013) does not specify its steps in the depth needed to be directly applicable to certain industries, or as the authors call it: ‘a transition without a blueprint’. Tying the previously elaborated exercises to these obstacles should therefore make them operational and define the problem at hand in the construction industry, although it needs to be noted that like the list of obstacles, the exercises are also not exhaustive.

Validity of the list made by Kok et al. (2013)

Despite the arguments raised in the previous paragraph, the exercises are still tied to the roadmap made by Kok et al. (2013). It is logical to have some reservations to this comparison as a result of these arguments, however further research has shown that the list of obstacles named by Kok et al. (2013) is the most comprehensive (see table B1). In the left column the obstacles are given according to Kok et al. (2013). The column to the right compares the obstacles found by Kok et al. (2013) to obstacles mentioned by other authors. It appears that the list made by Kok et al. (2013) is the most comprehensive list. The obstacles mentioned by respectively the Ellen MacArthur Foundation (2014), Preston (2012), De Grauw (2015) and Mentink (2014) do all recur in the selection of Kok et al. (2013).

Also other research (apart from the exercises) done by Loppies (2015) identifies six main challenges when the principles of the circular economy are translated to the construction industry. Based on six interviews with experts in the field he came up with:

1. Industrial, flexible and demountable designing
2. Materials are reusable or recyclable
3. Choice of materials should be socially responsible
4. New contract forms
5. Responsibility at the right parties
6. Materials need to be retrievable

Furthermore Loppies categorizes these challenges in:

1. Circular use of materials
2. Circular design
3. Safeguarding circularity for the future

If the six challenges of Loppies (2015) are however compared to the obstacles of Kok et al. (2013) instead of Loppies’ own categories, it can be seen that the challenges show close relevance to some of the obstacles. Loppies’ first two challenges can be categorized as technological challenges, the third obstacle as societal, and challenges four, five, and six as organizational challenges. This shows that also through other research the main problems when translating the circular economy to the construction industry can be found at an organizational level, with also technological challenges. Financial issues are not present in this comparison, this was however not researched by Loppies (2015). Because of the literature review that was done in this section the list made by Kok et al. (2013) is deemed valid for a comparison against the earlier made exercises.
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<td><strong>Financial</strong></td>
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<tr>
<td>1. Higher up-front costs</td>
<td></td>
<td>Higher capital or cash required to change existing product design. Customers only evaluate purchase price instead of NPV of a product.</td>
<td>1. High up-front costs</td>
<td>1. Lack of financial examples</td>
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<tr>
<td>2. Externalities are not taken into account</td>
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<td>3. Shareholders with short term agenda dominate corporate governance</td>
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<td>4. Recycled materials are often still more expensive than virgin materials</td>
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<td><strong>Institutional</strong></td>
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<td>1. Higher capital or cash required to change existing product design. Customers only evaluate purchase price instead of NPV of a product.</td>
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<td>2. Financial government incentives support the linear economy</td>
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<td>3. Financial government incentives support the linear economy</td>
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<tr>
<td>4. Competitiveness is not effectively integrated in innovation policies</td>
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<td>5. Competition legislation inhibits collaboration between companies</td>
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<td>6. Recycling policies are ineffective to obtain high quality recycling</td>
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<td>7. Governance issues concerning responsibilities, liabilities and ownership</td>
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<tr>
<td><strong>Infrastructural</strong></td>
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<td>1. Higher capital or cash required to change existing product design. Customers only evaluate purchase price instead of NPV of a product.</td>
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<td>2. Circularity is not effectively integrated in innovation policies</td>
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<td>5. Governance issues concerning responsibilities, liabilities and ownership</td>
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<td>6. Limited application of new business models</td>
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<td>7. Lack of an information exchange system</td>
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<td>8. Confidentiality and trust issues hamper exchange of information</td>
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<td>9. Exchange of materials is limited by capacity of reverse logistics</td>
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<tr>
<td><strong>Societal</strong></td>
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<td>3. Financial government incentives support the linear economy</td>
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<td>6. Recycling policies are ineffective to obtain high quality recycling</td>
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<td>7. Governance issues concerning responsibilities, liabilities and ownership</td>
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<td><strong>Technological</strong></td>
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<td>1. Higher capital or cash required to change existing product design. Customers only evaluate purchase price instead of NPV of a product.</td>
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<td>2. Financial government incentives support the linear economy</td>
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<td>3. Financial government incentives support the linear economy</td>
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<td>4. Competitiveness is not effectively integrated in innovation policies</td>
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<td>5. Competition legislation inhibits collaboration between companies</td>
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<td>6. Recycling policies are ineffective to obtain high quality recycling</td>
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<td>Suppliers going circular</td>
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<td>19.</td>
<td>Limited attention for end-of-life phase in current product designs</td>
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<td>20.</td>
<td>Limited availability and quality or recycling material</td>
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<td>21.</td>
<td>New challenges to separate the bio- from the technocycle</td>
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<td>22.</td>
<td>Linear technologies are deeply rooted</td>
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<td>3.</td>
<td>Imperfect design at the beginning of supply chain if the profits from a better design would only occur at the end-of-use phase</td>
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<td>8.</td>
<td>The innovation challenge (technology)</td>
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<td>18.</td>
<td>Define pilots, trials and prototypes</td>
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<td>23</td>
<td>Lack of knowledge on design level</td>
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Table A23 Comparison of the list of obstacles made by Kok et al. (2013) with various other authors (own table)
Comparison between the exercises and the obstacles

In this section a comparison between the earlier made exercises and the above identified obstacles for implementation of the circular economy will be made. The comparisons will follow the same order as the one in which the exercises were introduced in this report, so first off is ownership in the circular construction industry, followed by business financing and concluded by the building components in the circular construction industry.

When comparing the ownership exercise with the above-identified obstacles, there appears to between the exercise and four different obstacles. First of all, the ownership exercise shows a connection with obstacle number two; externalities are not taken into account. This comes to the fore in the relatively short commitment of the supplying parties to the project, handing down responsibilities from one to another without remaining responsible throughout the entire project life span. There is also a link with obstacle number eleven; governance issues concerning responsibilities, liabilities and ownership. However this link is more at an organizational level than an institutional level in the construction industry, as the lines between the different supplying parties become blurry. There also appears to be a connection when it comes to the limited attention for the end-of-life phase in current product designs (obstacle nr. 11), following the same reasoning as stated above in connection with obstacle number two. Which also holds true for the last obstacle to be tied to this exercise, obstacle number 22; linear technologies are deeply rooted.

The business finance exercise shows a connection with obstacle number one; major-upfront investment costs, mainly due to the shift in income streams. Also obstacle number three; shareholders with a short term agenda dominate corporate governance holds true, albeit in a slightly different context. As the exercise does not say anything about corporate shareholders there can be no link on this point, the exercise however did show that there is some logic in shifting responsibilities to a party with a longer commitment to the project. Furthermore there is a connection with obstacles number eleven, nineteen, and 22 on the same grounds as in the ownership exercise.

The third exercise looked at building components (i.e.) the products in a circular construction industry, here too links were found between the exercise and obstacles eleven, and nineteen. In this exercise however, also obstacle number fifteen; exchange of materials is limited by capacity of reverse logistics, comes into play. This is because of the complex sum of parts a building is, it will therefore be difficult to divide all the individual components neatly and get them back to their manufacturers (owners). For this reason there is also a link with obstacles twenty and twenty-one.

<table>
<thead>
<tr>
<th>Financial</th>
<th>1. Major up-front investment costs</th>
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<tr>
<td></td>
<td>2. Externalities are not taken into account</td>
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<td></td>
<td>3. Shareholders with short term agenda dominate corporate governance</td>
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<td>4. Recycled materials are often still more expensive than virgin materials</td>
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<td>5. Higher costs for management and planning</td>
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<td>6. Unlevel playing field created by current institutions</td>
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<td>7. Financial government incentives support the linear economy</td>
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<td>8. Circularity is not effectively integrated in innovation policies</td>
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<td>Institutional</td>
<td>9. Competition legislation inhibits collaboration between companies</td>
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<td>10. Recycling policies are ineffective to obtain high quality recycling</td>
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<td></td>
<td>11. Governance issues concerning responsibilities, liabilities and ownership</td>
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<td></td>
<td>12. Limited application of new business models</td>
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<td></td>
<td>13. Lack of an information exchange system</td>
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</table>
Table A24 Overview of general obstacles to be found for actors when implementing the circular economy (source: Kok, Wurpel, and Ten Wolde (2013))

Concluding remarks comparison
When comparing the exercises with the obstacles provided by Kok, Wurpel, and Ten Wolde (2013), it becomes clear that the problems surrounding the implementation of the circular economy reside along the categories ‘financial’ and ‘technological’ with almost all of the connections to be found in these categories. The biggest match however, is made between the institutional obstacle; governance issues concerning responsibilities, liabilities, and ownership. In the context of the construction industry however it would be more fitting to talk about an organizational obstacle at the level of the individual actors amongst themselves.
9.3 APPENDIX C: WALL SOCKET EXAMPLE

This chapter will try to model the production process of a wall socket including circular economy principles. The basic materials of a wall socket are plastics, stainless steel, and copper.

- Plastics are man-made materials that come from natural resources such as oil, gas and coal. They are non-renewable resources.
- Stainless steels are made of some of the basic elements found in the earth: iron ore, chromium, silicon, nickel, carbon, nitrogen, and manganese. Properties of the final alloy are tailored by varying the amounts of these elements. Nitrogen, for instance, improves tensile properties like ductility. It also improves corrosion resistance, which makes it valuable for use in duplex stainless steels.
- Pure copper is rarely found in nature, but is usually combined with other chemicals in the form of copper ores.

The materials used for the manufacturing of wall sockets are shown in figure A5. If only the raw materials used for the construction of a wall socket are examined, 11 different materials can be identified. This means that there are 11 different actors involved in mining. A modest assumption is made that there are three different companies turning the raw materials into the parts for the socket; one for the plastics, one for the stainless steel, and one constructing the copper parts. Now there are 14 actors in the whole process, all adding their value to the raw materials.

Moving further along the process, there is one actor assembling the materials and finally finishing the socket. This actor delivers the sockets on the building site for the contractor to place the final product in its place. This makes the total amount of involved actors 15 in this example. It could be that the same actor is involved in two or more activities. But if it is assumed that every actor performs one activity, 16 different owners can be appointed.

![Figure A5 Materials wall socket(own image)](image)

The situation is illustrated in figure A5. It has to be noted that this is only a simple model, mapping the raw materials. In practice, more or less actors could be involved and the situation could be more complex or simpler per material.

According to the Cambridge dictionary the following definition for a supplier applies:

“A company, person, etc. that provides things that people want or need, especially over a long period of time.”

In this light, every actor in the building process could be called a supplier, since they all provide goods for the next actor. With the boundary condition that no goods are transferring in ownership - there are 15 different owners of just one single wall socket. They all have a certain share in the socket. This raises questions on organizational, legal and financial level. Do they all own a certain percentage of the wall socket? Or is the party that finally assembles the product and delivers it to the building site the legal owner? On financial level: which bank is willing to fund the
mining party with a collateral security of raw materials assembled in a material which has been placed in a building?

9.4 APPENDIX D: TRANSCRIPTS INTERVIEWS

Transcript Rendement

Transcriptie interview Dhr. de Klerk (Rendemint)

R=Respondent Dhr. de Klerk
I=Interviewers Ruud Stigter en Robert van den Brink

Datum: 19-05-2015
Locatie: Ridderkerk

I: (Vraag 1) Wat betekent het begrip circulaire economie voor u? Is dat bijvoorbeeld een economische theorie, duurzaamheidsstrategie of iets anders?

R: Allereerst bestaat de circulaire economie niet, daarom spreken wij bij Rendemint van ‘een circulaire economie’. Wanneer er wordt gesproken over de circulaire economie is het snel te verwarren met het concept van Ellen MacArthur, dat is ons inziens geen visie op circulaire economie. De economie is namelijk een afspraak tussen mensen, hoe we met spullen en mensen omgaan. Bij Rendemint kijken we naar de tijdlijn van de mens als soort en daarbinnen is het begrip economie alleen belangrijk in een hele korte periode. Daarom zou je een circulaire economie kunnen zien als een tijdelijke afspraak over hoe we met mensen en grondstoffen omgaan die we tot einde der tijden aanwezig zullen zijn. Als ik dan antwoord moet geven op jullie vraag is een circulaire economie voor ons dus: wat moet je doen om de mens als soort te laten overleven toegepast op de mens van nu: en die bevindt zich nu in economie die over geld gaat. Maar dat is alleen in de economie van vandaag. In de visie moet het gaan over de grote visie met de beperking van het moment. Als je denkt dat de circulaire economie puur financieel is begrijp je niet waar het over gaat.

I: Wanneer we van de algemene visie op circulaire economie naar project specifieke vragen gaan zou ik u graag de volgende vraag willen stellen; (Vraag 2) Bent u op de hoogte van de beweegredenen voor TenneT om mee te doen aan een circulair project?

R: Het initiatief is bij Draaijer en Partners vandaan gekomen. Als gevolg daarvan is het gebouw van TenneT uiteindelijk duurzamer uitgepakt dan wat zij oorspronkelijk voor ogen hadden en wilden. Voor het proces is het echter wel erg belangrijk geweest dat TenneT wel zelf mee wilde. Als een opdrachtgever namelijk niet wil, dan is het einde oefening. De gebouweigenaar had niet zo veel met deze keuze te maken, omdat het bij het kantoor van TenneT alleen ging om het inbouwpakket, de buitenkant stond er namelijk al.

I: (Vraag 3) Wat waren de beweegredenen voor leveranciers om mee te doen met een circulair bouwproject?

R: Ten eerste is TenneT aanbestedingsplichtig, dus alles is via Europese aanbesteding geregeld. De leveranciers hadden de keus om zelf mee te doen of niet.

I: Maar trok het bijvoorbeeld bepaalde partijen aan?


I: (Vraag 4) Wat waren de grootste uitdagingen in het coördineren van een circulair bouwproject?

R: Door streng te verifiëren wordt het kaf van het koren gescheiden, dat maakt zeker dat het publieke geld wordt gebruikt waarvoor het bedoeld is. We zien nu partijen die verder willen dan tot heden van ze gevraagd is. Een
partij die gediskwalificeerd is bij de aanbesteding van TenneT vroeg bijvoorbeeld naderhand zelfs om geholpen te worden om een bepaald niveau te krijgen. Het systeem hoe we er mee om gaan laat ruimte voor fraude. Het systeem is niet afdoende gecontroleerd dat die fraude niet kan plaatsvinden.

I: (Vraag 5) Waren er partijen die hun business model of wijze van werken hebben veranderd om mee te kunnen doen aan het TenneT project?

R: Nee de meesten hoeven niks te veranderen. Er waren bij de aanbesteding grofweg drie verschillende partijen die onderscheiden; de eerste partij wil wel mee in het concept maar weet niet hoe dit bewerkstelligt moet worden. De tweede partij wil wel mee doen aan de aanbesteding en doet alsof het zich aan de gestelde eisen houdt. En de derde partij zit al op een hoog niveau en doet goed mee met de gestelde eisen. Maar mag ik van jullie vragen wat jullie nou precies verstaan onder circulaire economie, waar gaat jullie onderzoek precies over?

I: Zoals eerder gezegd richten onze onderzoeken zich op het organiseren van een circulaire economie in de bouwindustrie. Daarbij kijken we vooral naar de rol van het financiële aspect binnen deze organisatie.

R: Duurzaamheid is veel belangrijker dan jullie vinden. Als de grondstoffen opraken gaan we als mensheid dood. We kunnen nog niets van andere planeten halen. Geld is een ruilmiddel, het gaat niet om het briefje, maar om het product. Je moet een handelsmiddeltje hebben, dat is nu tijdelijk geld. Dit begint nu erg te veranderen. Er zijn voorbeelden van eilanden gebruikte grondstoffen die hun eigen currency gebruiken, bitcoins zijn een voorbeeld op een ander niveau, er zijn communities die van geld af willen en weer dingen onderling ruilen. Geld wordt eindig en dit gaat niet lang meer duren. Dat kan 100 jaar zijn, maar dat is niet lang op de tijdschaal van de mens als soort. Zeventig jaar geleden in de oorlog speelde geld bijvoorbeeld bijna ook geen rol. Uiteindelijk blijft circulaire economie een verhaal over grondstoffen en mensen.

I: (Vraag 6a) Op de website van Rendemint zijn drie verschillende contractsoorten binnen PRP te zien, welke hiervan is gebruikt voor het TenneT project?

R: Dan heb je PRP verkeerd begrepen, wanneer je PRP gebruikt maakt het juist niet uit welke contractsoort je gebruikt. Een circulair product kan ik kopen, leasen of ruilen. Product maal de methode is nog steeds nul. In TenneT is er alleen maar sprake van koop, ik ben nog geen partij tegengekomen die met lease wilde werken.

I: Dus de verantwoordelijkheid voor de producten ligt bij de opdrachtgever / eigenaar?

R: Het is juridisch vastgelegd dat de leverancier het product terug moet nemen. Opdrachtgevers hebben echter de keus om het door te verkopen aan een eventuele derde partij. De opdrachtgever kan er echter niet onder uit om het circulair potentieel te benutten, maar hij heeft hierbij zelf de keus om de leverancier te ‘kiezen’. Hoe en met welke partij een leverancier met de materialen omgaan ligt alle juridisch vast.

R: Het enige wat zwak is aan deze constructie is dat als een iemand zegt ik doe het niet en een andere partij vindt dat prima dan gebeurt er niets. Dan is er sprake van contractbreuk, maar als andere partijen daar geen bezwaar tegen hebben is er niks aan de hand. Maar dat is natuurlijk altijd zo met contracten. Er is geen derde partij die de bedrijven aan de gemaakte afspraken kan houden. Daarbij moet echter wel gezegd worden dat heel veel mensen die op dit punt een bezwaar maken tegen de PRP methode, hier zelf ook geen beter antwoord op hebben.

R: Binnen PRP veranderen de contractvoorwaarden mee met de eigenaar. Het enige wat TenneT niet kan doen is om het circulair potentieel niet te benutten. Over 10 jaar moet het niveau van hergebruik opnieuw getoetst worden bijvoorbeeld, omdat er dan door de stand van de techniek misschien meer mogelijk is dan tijdens de constructie van de producten. Maar denk ook aan re-use, kan ik spullen hergebruiken in dezelfde functie?

I: (Vraag 6c) Is er een reden waarom er voor een periode van 15 jaar is gekozen?

R: Vijftien jaar is de economische afschrijvingsperiode.

I: (Vraag 7) Over een periode van vijftien jaar is voor te stellen dat bepaalde producten moeten worden gerepareerd of vervangen, hoe is dit geregeld onder een PRP contract?

R: Voor het onderhoud kan TenneT grondstoffen bijkopen onder dezelfde voorwaarden. Er vindt dan een zogenaamde mutatie plaats en dit moet worden vermeld op een mutatieformulier zodat duidelijk blijft wat er allemaal in een product zit. Dit is bij TenneT nog een vraag, maar dit moet in de toekomst ook een plicht worden. Eigenaren moeten dan bijvoorbeeld om de twee jaar verantwoorden wat er gebeurt is met de grondstoffen. Het
gaat ook hier weer om het voelen van de verantwoording. Alhewel dit in de toekomst wetgeving zou kunnen worden.

R: Kijk, 100% circulair bestaat niet, de definitie van Ellen MacArthur gaat er bijvoorbeeld van uit dat er nooit wat verloren gaat of moet worden toegevoegd. Dit is mijns inziens onhaalbaar, maar het maakt ook niet uit hoelang een product meegaat. Want uiteindelijk staat echt circular boven welke economie dan ook.

Het gaat erom dat de grondstoffen bekend zijn en dat het klopt. Om van een pak stropdassen te kunnen maken moet ik het bijvoorbeeld bewerken, bovendien is een pak vaak gemaakt van een combinatie van kunststof en bijvoorbeeld katoen. Dit zou ik uit elkaar moeten kunnen halen zonder materiaalverlies, dit kan vaak niet, en dus zijn dit soort voorbeelden niet circular.

R: (Na de vragen van het interviewprotocol) Wat PRP nu het meeste doet is aantonen dat iets niet circular is en het met hoe ver je afwijkt van circular. Dus eigenlijk aan heel veel mensen duidelijk maken dat we nog in de babyslofjes staan van circulariteit. Zolang iedereen nog gelooft dat de grondstof de grondstof is en het niet werkt. We staan echt nog in de circulaire kinderschoenen. Het gaat niet over goed of fout, het gaat over circular of niet. Niet circular is eindig en circular oneindig en we moeten zo dicht mogelijk bij het oneindige komen.

I: Hoe zit het met de kosten die vastzitten aan een circular bouwproject of product?

R: Een transitie moet kostenneutraal zijn anders gebeurt het niet. De meest duurzame oplossing blijkt het goedkoopst te zijn. Dit kan alleen als je het integraal duurzaam is, over alle factoren.

I: Hebben leveranciers hun producten aangepast om aan de gestelde eisen te kunnen voldoen?


I: In het voorbeeld van TenneT zijn zij verantwoordelijk, juridisch verantwoordelijk voor de verkoop, het terugbrengen van de producten naar de leverancier. Hoe denkt u dat TenneT dit over vijftien jaar zal doen?

R: Er gaan partijen ontstaan die puur gaan handelen in de producten, urban mining makelaar. Gaat TenneT producten verkopen straks? Ik zal ze met alle plezier adviseren om spullen te gaan verkopen. Flow2 is bijvoorbeeld een makelaar tussen producten die er al zijn en mensen die er eventueel gebruik van zouden kunnen/willen maken.

R: Ik mis in jullie verhaal het begrip social fairness, mensen en grondstoffen zijn hoofdfactoren in een circulaire economie. Social fairness gaat over mensen in de hele sector. Bijv: kan ik als overheid mij permiteren om fraude toe te laten als ik het had kunnen weten? Kijk naar de herkomst van de producten en grondstoffen. Eigenlijk zou de rekening dus ‘grondstoffen’ maal ‘social fairness’ maal de ‘inkoopmethode moeten’ zijn. Als één van de drie slecht is werkt het niet. Het gaat er daarbij om naar de hele keten als geheel te kijken. In windmolens zit een metaal dat in China zorgt voor enorme milieuvredesteunen, maar toch noemen we windmolens hier goed voor het milieu. Maar kijk bijvoorbeeld ook naar vrouwenhandel, prostitutie, dit soort zaken kan je niet wegliaten in je beschouwing en besluitvorming. Momenteel zijn we bijvoorbeeld met een aanbesteding bezig voor een dienst voor een architect, social fairness is hier een onderdeel van. Dit zijn wettelijke eisen maar ze moeten ook een self assessment invullen om deze waarden te borgen. Als iemand anders mee wil doen kan dat, maar zullen ze ze ook aan de dezelfde voorwaarden moeten voldoen. Dan kun je zeggen dat het een enorme papieren tijger is en dat is het ook, maar het wordt anders wanneer dit gepubliceerd moet worden. Er wordt vervolgens steekproefsgewijs gecontroleerd of dat er ook daadwerkelijk aan voldaan wordt. Heel veel bedrijven haken af op dit punt.

R: We zijn nu bijvoorbeeld bezig met de aanbesteding van een tunnel, social fairness zit daar inbegrepen maar dit moet als een EMVI, anders krijgen we geen inschrijvingen.

Social fairness is hierbinnen dus een van de aspecten die moet hierin benoemd worden.

R: Het gaat uiteindelijk om complete informatie, juiste informatie en transparantie.
Transcript BMA Ergonomics

Interviewer: Ruud Stigter & Robert van den Brink
Geïnterviewde: Ellen Veraart (E)
Datum: 16-9-2015
Locatie: Per Mail

R: Het thema ‘circulaire economie’ is de laatste jaren enorm populair geworden. Dit wordt gedreven door het toenemende besef dat onze wijze van produceren en consumeren eindig is. De transitie van de huidige lineaire economie naar een circulaire economie kan deze ontwikkeling tegengaan. Dit heeft echter significante gevolgen voor de bedrijfsvoering van bedrijven.

Ondanks de (enorme) hoeveelheid aan rapporten over het onderwerp is er een gebrek aan gedegen en onderbouwd wetenschappelijk onderzoek. Het is gebleken dat de terminologie diffuus wordt gebruikt; zelfs een werkbare definitie van wat ‘de circulaire economie’ eigenlijk is, lijkt te ontbreken.

De bouwsector is verantwoordelijk voor 40 tot 50% van de grondstofconsumptie, 30% van de primaire energiebehoeften in de OECD landen, 40% van de uitstoot van broeikasgassen en 10 tot 30% van de afvalstromen in de Europese Unie (Uihlein & Eder, 2009) (Schoolderman et al., 2014; OECD, 2008; Uihlein & Eder, 2009; APRICOD, 2006). Helaas ontbreekt het (op dit moment) in deze sector aan praktijkvoorbeelden van circulaire economie.

Onze onderzoek de gevolgen van de principes van de circulaire economie voor de toeleveranciers van producten in de bouw. Een sleutelprincipe van de circulaire economie is de transitie van verkoop-business modellen naar service-business modellen.

Zodoende doet het ons deugd om deze praktijkvoorbeelden wel in andere sectoren te zien, zoals bij BMA Ergonomics. Jullie zijn ons inzichtelijk, in tegenstelling tot andere bedrijven die claimen circulaire economie te zijn, al erg ver in de ontwikkeling. Vooral de manier waarop jullie omgaan met de stoelen in de gebruiks- en secondlifefase is enorm interessant.

1. R: In mijn zoektocht naar een eenduidige en werkbare definitie van een circulaire economie ben ik benieuwd naar de visie van de praktijk op het onderwerp. Kunt u in 1 zin aangeven wat een circulaire economie voor BMA betekent?

E: De circulaire economie is voor BMA een kans om haar ergonomische en duurzame bureaustoelen in Nederland te kunnen blijven produceren en verkopen.

2. R: Sinds wanneer is BMA zich gaan toeleggen op circulaire principes? Wat waren de eerste stappen die BMA heeft genomen in deze ontwikkeling?

E: Zorg voor het welzijn van mensen in hun werkomgeving en aandacht voor duurzaamheid is de basis van de bedrijfsvoering van BMA Ergonomics (BMA):

• BMA’s bedrijfsmisn is al vanaf haar oprichting in 1988 gericht op duurzaam personeelsbeleid: het bevorderen van het welzijn van de mens op het werk zodat optimale productiviteit kan worden bereikt op een verantwoorde manier voor zowel het individu als het milieu.

• BMA’s ontwerpfilosofie is vanaf het moment dat zij is gestart met productontwikkeling van de Axia® ergonomische bureaustoel in 1992 gericht op design for disassembly.


BMA’s strategie om die visie te verwezenlijken is om continu wegen te zoeken om de levensduur te verlengen en om meer controle te verkrijgen over de gekochte en verkochte materialen. Bijvoorbeeld heeft BMA als eerste partij
ter wereld in onze bedrijfstak een restwaarde gegarandeerd van ons product en ook reeds in 2007 een volledige
disassemblage lijn gebouwd.

3. R: Waarom heeft BMA besloten om zich toe te leggen op de circulaire principes? Op de website en
duurzaamheidsverslagen is te lezen dat bij BMA maatschappelijk verantwoord ondernemen erg
belangrijk is. De milieufocus ligt vooral op materiaalgebruik en hergebruik. Is dit een reden geweest om
in te zetten op circulaire principes? Ziet BMA ook een financiële incentive in deze ontwikkeling?

E: Zoals bovenstaand vermeld, hebben wij niet “ineens ingezet op circulaire principes” maar zijn wij er al in een heel
vroeg stadium, in 1992, mee begonnen. Stapje voor stapje (zoals je ook leert lopen) hebben wij daarin
doorontwikkeld door bijv. steeds meer recyclaat in te zetten voor de productie van nieuwe onderdelen,
returnstromen zelf als ketenregisseur te gaan regelen, restwaarde garantie aan klanten te geven,
levensduurverlengende diensten aan te bieden en een webshop voor second life bureaustoelen in te richten etc.

Definiëer “financiële incentive”. Ja, het biedt kansen voor ondernemingen om geld te verdienen aan de circulaire
 economie.

4. R: Wat is er precies verandert in de bedrijfsvoering van BMA? In de duurzaamheidsverslagen is er
bijvoorbeeld te lezen dat er nieuwe verkoopmodellen worden geïntroduceerd, zoals verhuur, lease en
terugkoop. Zijn dit al veelvuldig gebruikt concept?

E: Ja, naast dat het product zelf past binnen de circulaire economie doordat:

- er een groot percentage aan recyclaat wordt gebruikt voor de productie van een nieuwe stoel,
- de stoel zelf voor 99% recyclebaar is,
- we restwaardegarantie bieden aan de klant (we kopen de stoel dus terug van hem),
- we stoelen revitaliseren (doordat we de stoel zo hebben ontworpen dat alleen het defecte onderdeel
  vervangen hoeft te worden en niet de hele stoel) kunnen we levensduur van stoelen verlengen tot 20 jaar
- we proberen teruggekomen stoelen weer zo hoogwaardig als mogelijk in de keten te brengen,

Hebben we ook alternatieve vormen ontwikkeld voor de lineaire koopovereenkomst.

Alle mogelijke vormen waarbij een klant niet betaalt voor het bezit maar voor het gebruik worden door ons
aangeboden. Dit gaat grotendeels in overleg met en via onze dealers (BMA levert in Nederland via een select
dealernetwerk haar producten aan klanten).

5. R: Wat is concreet het verschil tussen de circulaire producten die BMA aangebiedt en ‘gewone’
bureaustoelen?

E: Voor ons is er geen verschil. Wij bieden alleen circulaire producten en diensten aan.

6. R: Stelling: alle door BMA aangeboden bureaustoelen worden circulair, wat heeft dit voor gevolgen voor
de bedrijfsvoering van BMA? Is dit überhaupt wel haalbaar?

E: Zie boven, dat is al het geval. Echter, als je het hebt om de lineaire verkoop van stoelen te gaan vervangen door
andere afnamemodellen zoals lease, huur etc dan zal er uiteraard veel meer door de fabrikant (BMA)
voorgefinancierd moeten worden. Dan komt er een ander rekenmodel uit.

Zie ook het rapport van de ING waar BMA aan mee heeft gewerkt. (onderstaande link kopiëren)
http://www.ing.com/Over-ons/Onze-berichten/Features/Circulaire-economie-en-de-gevolgen-voor-
bedrijfsmodellen.htm

7. R: Hoe ziet de toekomst er uit voor BMA wat betreft het aanbieden van circulaire producten? Welke
verwachting heeft BMA voor de komende 5 jaar?
E: Doordat overheden ook hebben uitgesproken dat zij circular gaan inkopen, zien wij dit segment groeien. We zien echter het aanbod aan recyclaat nodig voor de productie van nieuwe onderdelen niet stijgen. Daarnaast is het heel lastig om goede kwaliteit recyclaat te krijgen (vrij van toxische stoffen etc).

Tot slot wil ik nog dieper in gaan op het lease business model van BMA. Volgens een aantal bronnen is het aanbieden van services in plaats van het aanbieden van een product de sleutel naar het succes van een circulaire economie.

8. R: Op welke manier organiseert BMA het leasen van een bureaustoel?

E: BMA faciliteert alles zelf. Klant wordt door BMA volledig onttrokken door de eigen service dienst.

a. R: Op welke manier wordt het leasebedrag bepaald? Is dit een bedrag per maand of bijvoorbeeld ‘per zitruur’?

Het zou beide kunnen. Momenteel is dit een “borg” daarna een gebruikstarief per jaar of maand afhankelijk van de gekozen constructie. Daarbij wordt gedurende de hele looptijd de klant onttrokken en garanderen wij perfect functioneren van de stoel. Zituren zou ook kunnen maar een stoel van 5 jaar oud met 1000 zituren is niet meer waard dan een stoel van 5 jaar oud met 30000 zituren zoals bij auto’s.

Het leasen in plaats van verkopen van producten zorgt voor hoge initiële kosten voor de fabrikant. De productie wordt immers pas terugverdiend gedurende de contractperiode.

Ter voorbeeld: Rolls Royce gebruikt het ‘Power by the hour’ business model bij het exploiteren van vliegtuigmotoren. In plaats van dat klanten een vliegtuigmotor kopen, betalen ze slechts per uur dat de motor gebruikt wordt. Dit zorgt er voor dat de motoren gedurende de hele gebruiksteriode op de balans van Rolls Royce blijven staan, wat enorm veel startkapitaal vereist. Dit is opgelost met behulp van een externe financier, die in ruil voor het beschikbaar stellen van kapitaal een bepaald deel van het leasebedrag krijgt.

b. R: Op welke manier is de lease van bureaustoelen bij BMA geregeld? Is hier gekozen voor financial lease of operational lease?

Operational lease. Wij berekenen een borg bij het afleveren van elke stoel, daarna een gebruikstarief wat in de eerste jaren hoger is dan in de laatste jaren. Uiteraard ontvangt de klant de borg retour bij het weer inleveren van de stoel na afloop van het contract.
Transcript BAM

Interviewer: Ruud Stigter
Geinterviewde: Tom Blankendaal; Projectleider Corporate Social Responsibility (T)
Datum: 2-10-2015
Locatie: Runnenburg 9, Bunnik

R: Dankwoord en introductie interview

R: Is het goed als ik dit interview opneem?

T: Als je mij of BAM wilt quoten, graag eerst ter goedkeuring voorleggen aan mij en BAM om het op te nemen in je scriptie.

R: Projectleider Corporate Social Responsibility. Wat houdt dat precies in?

T: Hier vallen een aantal dingen onder. Uiteindelijk leidt het tot duurzaamheid. Maar maatschappelijk verantwoord ondernemen heeft ook minder 'volwassen' kanten. Dit zijn hele basale verplichtingen, zoals je morele verplichting, je overtreedt niet de wet, verspilt niet onnodig enzovoort. CSR of MVO draagt heel erg bij aan license to operate, hoe creëer je zo min mogelijk weerstand en uiteindelijk leidt dit tot een betere reputatie. Je hebt vier dingen: Morele verplichting, license to operatie, betere reputatie en uiteindelijk leidt dit tot duurzaamheid.

Wat betekent dit binnen BAM? We hebben drie speerpunten of thema’s. Veiligheid, CO2 reduceren en afval reduceren. Dat is eigenlijk hoe we onze meetbare targets hebben opgesteld. Deze zijn heel erg gefocust op het verbeteren van interne processen; hoe kan ik slimmer bouwen? Door minder energie te gebruiken hou ik onder aan de streep meer geld over. De slag maken van wat betekent CSR voor projecten.

R: Is het vanuit jullie dan gekomen om met Circulaire Economie mee te doen?

T: Tweeledig. Enerzijds is er een klant vraag. Zij zien de wereld als een gesloten systeem; bevolkingsgroei, stijgen consumpties etc. Dit zijn gegevens en deze klanten willen op een verantwoorde manier een tegenreactie geven. Als ik op een andere manier een gebouw neerzet, dan kan ik mijn manier iets verbeteren. Anderzijds, afval reduceren is een belangrijk speerpunt. In een circulaire economie heb je theoretisch gezien natuurlijk geen afval. Het was ook iets waar BAM zelf mee aan de slag wilden gaan. Uit het verleden had je de ladder van Lansink. Dit is uit de jaren 70 of 80. Vervolgens zagen we C2C als buzzword of theorie en de laatste 2/3 jaar zien we CE als opvolger van C2C. Binnen de CE heb je 2 stromingen. Je hebt het business model: betalen naar gebruik en het C2C te model.

R: Leuk dat je dit opmerkt. Dit komen wij ook tegen in praktijkvoorbeelden. 90% is meer C2C dan CE. Het is dan onduidelijk wat CE toevoegt aan CE. Misschien bedoel je met CE ook het gemeentehuis Brummen? Hier speelt C2C een belangrijk onderdeel, maar het ‘business model gedeelte’ is iets ondergeschoven. Kunt u uitleggen hoe dat gegaan is?

T: We hebben dit project in 2013 aan de gemeente overgedragen.

R: Was u hier toen ook al werkzaam?

T: Ja, ik ben in 2011 bij BAM terechtgekomen. Ik zal even wat meer achtergrond geven. Ik ben in Enschede begonnen met technische bedrijfskunde. Toen ben ik op zoek gegaan naar een afstudeeropdracht. Dit heb ik bij BAM gedaan. Dit klikte van beide kanten vrij goed. Toen heb ik bij BAM onderzoek gedaan naar hoeveel grondstoffen er gebruikt werden. Hoeveel bulkmaterialen verbruikt BAM eigenlijk? Daarna ben ik gaan kijken hoe ik dit kon verduurzamen en/of verminderen. Naast dat ik de kwantiteit heb bepaald, heb ik een aantal scenarioanalyses gedaan naar hoe BAM asfalt en beton kan verduurzamen. Om een voorbeeld te geven: bestaand materiaal toepassen in nieuw materiaal en betongranulaat in nieuw beton. Wat is de haalbaarheid? Verder is gekeken naar lage energieproductietechnieken. Voor beton betekent dit dat je cementvervangers in gaat zetten omdat dit de grootste milieuvervuiler is. Voor asfalt betekent dit produceren op lagere tempaturen. Asfalt wordt op 160 graden gemaakt. We zijn nu bezig met het ontwikkelen van een variant op 80 graden. Daarin zie je dat de
energiebehoefte dan extreem afneemt. Omdat je bij asfalt ook asfalt granulaat inzet heb je ook nog oude bitumen die je in kan zetten. Door oud asfalt toevoegen aan nieuw asfalt heb je minder bitumen nodig. Minder energie + hergebruik oude materialen.

Daarna ben ik bij BAM werkzaam gebleven. Nu zit ik iets meer aan de data reporting kant, zoals het maken van jaarverslagen. Daarin nemen we ook onze niet financiële gegevens op. Ik ben verantwoordelijk om alle data van de werkmaatschappij bij te sluiten tot BAM groep. Hier krijgen we ook een accountantsverklaring op. We moeten allerlei controles uitvoeren om te toetsen of dat mijn getallen goede representaties zijn van de werkelijkheid. Hoe zijn de dataverzamelingsprocessen in elkaar? Komt het getal overeen met hoe jij zegt dat je het bij elkaar haalt? Zo krijg je die verklaring. Daarnaast ben ik bezig met het ontwikkelen van een strategie. We zijn nu aan het kijken naar de strategie van 2016 – 2020 en hoe moet duurzaamheid of onze afdeling CSR hierin terugkomen. Dit is niet altijd eenvoudig. Het zijn onderwerpen waar het wiel nog niet in uitgevonden is. Je moet conceptueel denken en erg praktisch. Wat is de stip op de horizon? En dit moet weer vertaald worden naar wat er op de werkvloer gebeurt.

R: Heb je ook meegewerkt aan gemeentehuis Brummen?
T: Niet specifiek, maar aangezien het zo’n iconisch project was heb ik heb geprobeerd om zo veel mogelijk met het team mee te gaan.

R: Hoe kijkt BAM terug op dit project?
T: Als een project waar we heel veel geleerd hebben en waar niet alles is goed gegaan. We hebben geleerd om anders te denken. WE krijgen een vraag van een klant om iets voor 20 jaar te ontwerpen. Hier kan het zijn dat het gebouw nog langer moet blijven staan, maar het kan ook zo zijn dat het afgebroken moet worden. Het vraagt een hele andere mindset. In feite is de standaardenbenedering van het bouwen van iets met een oneindige levensduur. Na 20 jaar moet is uit elkaar te halen zijn en ergens anders weer op te bouwen zijn. Zodoende is er ook hout gebruikt in plaats van beton. Op de vloer liggen betonklinkers, de ideale vorm om iets modulair te bouwen. Het is wel heel erg wennen, maar het voelt niet gek.

Dit zijn dingen die we ons normaal niet af zouden vragen, maar doordat je de uitdaging krijgt om anders te gaan ontwerpen en om na 20 jaar iets demontabels te hebben, krijg je andere keuzes. Kun je een lease en takeback constructie met leveranciers afspreken? Dus we moesten met leveranciers in dialoog gaan om te vragen of ze materialen terug wilden hebben? Wat kunnen ze daar mee en wat voor waarde vertegenwoordigt het? De partij die de balken geleverd heeft gaf daar bijvoorbeeld aan dat met een kleine aanpassing de balken veel interessanter werden om terug te nemen omdat ze dan een standaardmaat kregen. Dit zorgt ervoor dat de verhandelbaarheid van het element een stuk groter wordt. Dat soort procesverbeteringen zijn door dit dialoog gekomen. Dat zijn hele leuke dingen. We gaan nu nadenken: wat doen we over 20 jaar en wat betekent dat in stapjes om terug te denken. Waar ik zelf bijvoorbeeld mee worstel is het voorbeeld van een casco en een aftub. Je ziet dat hier de levensduur van verschillende elementen heel erg anders is. Je ziet dat consumentenproducten zich er beter voor lenen om circulaire concepten op te nemen. Hier zie je al meer activiteit in wat betreft business modellen. De bouwsector loopt hier erg achter. Dit heeft volgens mij te maken met verschillende levensduur van elementen en het verschil in componenten.

De kunst is dus om verschillende levenscycli in een tijdbalk naast elkaar te zetten om te kijken: waar kan ik dingen integreren en hoe kan ik mijn circulaire gedachte hier beter in kwijt?

R: Dit is precies wat ik ook zie als uitdaging voor de bouwsector: levensduur en ook het aantal componenten en materialen dat in een gebouw zit. BMA gaat hier al heel ver in met bureaustoelen, maar een stoel is een stuk eenvoudiger dan een gebouw.

T: Ja, de complexiteit van een stoel is een stuk lager. Aan de andere kant: jouw telefoon wordt niet circulair ontworpen, maar hier wordt al wel over nagedacht over het business model. Je betaalt gedurende een bepaalde tijd een bedrag om het ding te gebruiken. Dit is natuurlijk een heel complex systeem.

R: Aan de andere kant heb je niet verhaal van de verschillende levensduren bij een telefoon.

T: Om een samenvatting te geven op jouw vraag: Brummen was een extreem leerzame opdracht om anders te gaan denken. Er moet op een andere manier gekeken worden naar het ontwerp en realisatie. We hebben echt niet alles goed gedaan; het business model is nog niet in de praktijk uitgevoerd.

R: Het circulaire spoor, kunt u hier wat over vertellen?

T: Dit heb ik zelf opgezet, samen met een aantal ketenpartijen. Ik heb gemerkt dat dit de key succes factor is. Wat je merkt is dat organisaties vanuit zichzelf redeneren. We zijn een onderzoekstrakt gestart om te kijken wat er precies voor nodig is om een circulair project van de grond te krijgen. Samen met ProRail, Royal Haskoning DHV als ontwerper, BAM als bouwer, Railpro is een materialenleveranciers en ESTO (?) is een onderhoudsclub. Zo hebben we verschillende partijen bij elkaar gezet om na te denken om te kijken we in de praktijk stapjes te zetten naar een circulair project. DE railsectors is een sector waar ontworpen wordt voor onzettende lange levensduren. Zodoende zijn er ook rigide denkpatrijzen. Dit kun je best uitdagen, dat hebben we met elkaar gedaan.

R: Kun je misschien aangeven hoe CE hierin terugkomt?

T: We hebben een analyse gemaakt van welke materialen de grootste milieu impact hebben binnen het railsysteem. Daar hebben we vijf elementen uitgekozen waar we een verdieping slag aan gaan brengen, zoals bovenleidingen, spoorstaven. Ze zijn ook heel veel fietsenstallingen aan het bijbouwen. Daar staan van die uitschuifrekken. Er is echter niet nagedacht wat er gebeurt als er eentje kapot gaat of iets dergelijks. Daarnaast hebben we gekeken naar de fundering. We zijn nu als eerste met de spoorstaven aan de slag. Wat je merkt is dat er in Nederland 1 systeem is van spoorstaven. Door regelgeving is het al heel erg moeilijk om hierin af te wijken. Wat we al wél teweeg hebben gebracht is dat zij niet meer alleen bestek werk aanleveren, maar meer vrijheid geven in de uitvraag van de opdracht. Hierin krijg je creatiever oplossingen. Dit si wat we nodig hebben om de circulaire economie een duw te geven. Doordat we met elkaar in dialoog gaan is dat misschien wel een van de belangrijkste uitkomsten.

Een zijstapje: onlangs de renovatie van de sluizen van IJmuiden. Dit was een ontwerp van Rijkswaterstaat. BAM heeft samen met VolkerWessels een ontwerp gemaakt waarbij de kosten met 100 miljoen werden verlaagd. Puur door de opdrachtgever uit te dagen met een alternatief ontwerp gaat er dus 100 miljoen af.

R: Gaven jullie een dergelijke vrijheid ook bij het gemeentehuis in Brummen? Hoe werd daarop gereageerd? Werden bepaalde materialen goedkoper of juist duurder door het circulair in de markt te zetten?

T: 3 jaar geleden waren veel partijen nog niet bekend met het concept. Door mensen en leveranciers mee te nemen in het verhaal en uit te leggen waarom je bepaalde keuzes maakt, creëer je een gezamenlijk belang. Voorbeeld: laten we afspreken dat over 20 jaar de waarde is van een materiaal. De waarde wat we terug kunnen geven is bijvoorbeeld 30% van de waarde van een element in de toekomst.

R: zijn er nog meer projecten waarin jullie CE toepassen waar ik niet van op de hoogte ben?

T: Het Rabobank gebouw in Utrecht is nu in aanbouw. Dit is de verrekijker toren. Daarbuiten staat een ouder kantoor. Dit is het spiegelgebouw, voordat de toren werd gebouw was dit het hoofdkantoor. Zij hebben gevraagd of wij dit circulair kunnen renoveren. ER was een hele hoge ambitie, maar door de snelle opleverdeadline hadden we te weinig tijd om deze ambitie goed in te vullen. Er werd wel gekeken naar de recyclebaarheid van het glas, maar dit is niet goed genoeg. Ik zie veel liever dat grote elementen circulair ingezet worden. De uitdaging voor het vastgoed blijft altijd liggen. Echt circulair zou ik dit niet willen nemen.

R: Zitten jullie hier ook bij door advies te geven of iets dergelijks?

T: Nee dat is nog te vroeg. Ze hebben drie partijen uitgenodigd om mee te denken, maar dit moet nog gebeuren.

T: ABN Amro wil op de zuidas iets circulair neer zetten. Het zit echt in de planfase. Dit komt wel op de markt.


R: We merken dat het heel vaak gaat over C2C. De business modellen daarachter zijn nog moeilijk in te vullen. daardoor kijk ik met heel veel interesse naar dit soort projecten om te kijken naar hoe ze het aan gaan pakken.

T: Wat we zelf zien is dat we van de PPS, waarin ook dergelijk business modellen in zitten. Met een investering op moment x en vervolgens moet je een soort kredietoverbrugging embedden in de prijs. Zo krijg je dat de overheid stapsgewijs een product terugbetaald. Dit lijkt me voor nieuwbouw iets gemakkelijker dan voor verbouwen. In theorie kan het voor een verbouwing net zo goed, alleen zal de investering iets lager zijn over het algemeen.

R: Ik wilde het nog een beetje gaan hebben over de toekomst. Hoe denk je dat het er over vijf jaar uit zal zijn. Zijn er dan al veel gebouwen volgens het CE principe?

T: Ik denk dat het lang gaat duren voor het de standaard is. Ik zie het wel als een kant waar we als bedrijf en als sector naartoe moeten. Ik denk dat het iets meer tijd in beslag neemt dan vijf jaar. Van nature is de bouw een conservatieve sector. Er wordt weinig geïnnoevede. Het innovatieve vermogen van de sector moet heel erg geprikkelld worden. Daarbij hebben projecten een lange doorlooptijd. We hebben een visie, ontwerp en realisatie. Hier zit wel een paar jaar tussen. Over vijf jaar moeten we wel veel meer voorbeelden hebben waarbij CE is toegepast. De drie projecten die ik net opnoem geeft wel aan dat het ook echt gaat doorpakken. Ik denk dat we over vijf jaar 50 circulaire gebouwen in Nederland hebben.

R: Als je 100 mensen vraagt wat CE is krijg je 100 verschillende antwoorden. Wij hebben geprobeerd om dit radicaal op te schrijven. Het verschil tussen CE en C2C is dat in een CE een leveranciers verantwoordelijk voor zijn producten. Dan en alleen dan heeft een leverancier er baat bij dat een product efficiënt en duurzaam is. Dat maakt CE zo’n sterke theorie. Hier zit volgens ons de sleutel. Apple heeft er nu baat bij dat een telefoon zo snel mogelijk kapot gaat. Als je dit kan doorbreken maak je echt de stap. Denk je dat er ooit een gebouw komt waarbij leveranciers verantwoordelijk blijven voor hun producten.

T: We zien inderdaad dat bedrijven teveel op de korte termijn gefocust zijn. Er is nu geen financiële prikkel om eigenaarschap op zich te nemen. Wat is nu een goede prikkel om dit juist wel te doen? Wat we zelf wel eens bedacht hebben is dat belasting op arbeid verlaagd moet worden en de belasting op arbeid verhoogd moet worden. Dit maakt het lucratief om sparaam aan maateriaal om te gaan. Alleen zo ga je een heel economisch model omgooien.

R: Walter Stahel zegt dus ook dat dit nooit gaat werken zonder dat het belastingstelsel aangepast wordt.

R: Er wordt nu gezeegd dat een product zo lang mogelijk mee moet gaan. Maar als je ervan uitgaat dat er een oneindige hoeveelheid groene energie is, maakt dit in principe niet uit hoe lang die meegaat. Als je sec gaat kijken naar de theorie maakt het de theorie maakt het niet uit. Sterker nog: hoe meer een materiaal meer door de cirkel gaat, hoe meer arbeid eraan gespendeerd wordt, hoe hoger de inkomsten, hoe hoger het BNP en dus onze welvaart. Hier zijn nog heel veel punten die nog zorgen voor sterke discussie.

R: Had je verder nog op- of aanmerkingen in het voorstel voor mijn scriptie?

T: Ik heb je opzet nog niet doorgelezen, alleen vluchtig gescand. Wat is het product dat je wilt leveren?

R: Ik wilde een business model gaan ontwerpen waarin leveranciers eigenaar blijven van hun product, maar het kan nog wel een paar kanten op.

T: De kunst is natuurlijk om je onderzoek zo goed mogelijk af te bakenen en dat andere er ook verder mee kunnen. Het aabaken is heel erg belangrijk om een nuttig en bruikbaar onderzoek af te leveren.

R: Eind- en dankwoord voor het interview.
### Case study: steel beam

#### Basic information
- **Material**: Steel
- **Description**: HEB300
- **Quality**: S235JR G2
- **Size (m)**: 6
- **Product service system**: Lease
- **First contract period (yr)**: 10
- **Value in 2015 (€)**: 966,00
- **Lease percentage**: 10%
- **Depreciation (yr)**: 0
- **IRR**: 4%

#### Costs
- **Production cost (/m)**: € 133,00
- **Maintenance (p/yr)**: 0%
- **Renewing cost (end)**: 0%
- **- reuse**: 10%
- **- remanufacture**: 10%
- **- withdrawal**: 10%
- **- recycle**: 10%
- **Transport (/km)**: € 0,21
- **(Dis)assembly**: 15%
- **Storage (/m in 2015)**: € 15,00
- **Management**: 2%
- **Monitoring**: 0,40%
- **Assumed sale at y 11**

#### Risk premiums
- **Substitution (p/yr)**: 2%
- **Allocation (p/yr)**: 0%
- **Complexity (p/yr)**: 0%
- **Future price fluc (p/yr)**: 2%
- **Energy (p/yr)**: 1%
- **General (p/yr)**: 2%
- **Total**: 7%

#### Other assumptions
- **CPI**: 2%
- **Distance (km)**: 200
### Suppliers going circular

#### Income

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#### Costs

**Investment**

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