



# CHANGING TENDERS TO CONSTRUCT CIRCULAR (ROADS)

**Hein Oude Hesselink**

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University of Twente

Supervisors:

University of Twente

dr. A.M. von Raesfeld Meijer

prof.dr.ir. A.G. Dorée

Van Gelder:

ir. M.J. Ypma

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**Student**

H.L (Hein) Oude Hesselink

**Institutions**

University of Twente

Van Gelder

Department: integral

**Supervisors**

*Van Gelder*

ir. M.J. Ypma

*University of Twente*

dr. A.M. von Raesfeld Meijer

prof. dr. ir. A.G. Dorée

The real challenge is not climate change but mind change  
- Thomas Rau

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## **Preface**

This thesis is the final part of the Master in Business Administration with specialisation Marketing and Business Information at the University of Twente. The assignment and problem statement started at Van Gelder. The title of this thesis is changing tenders to construct circular roads.

I am looking back to an interesting period which broadened my view and interests. I thank my supervisors from the University of Twente dr. A.M. von Raesfeld Meijer and prof. dr. ir. A.G. Dorée for their time, reading, and helpful input to make this Master thesis possible. Next, I thank Mink Jaap Ypma from Van Gelder for our meetings, talking about the topic and giving me helpful input. Furthermore, I thank all my colleagues, fellow students and my family that made my Master thesis possible.

Hein Oude Hesselink

*Almere, 11 August 2018*

## Management summary

In the last few years circular economy is receiving increasing attention worldwide, which is necessary because of the overconsumption of raw materials. In the circular economy the human consumption has to change from a linear towards a circular way of consuming. In 2015 the European Union developed the Circular Economy Strategy. Based on this documentation the Netherlands developed its own strategy: The Netherlands Circular by 2050. This is a government wide program and has as goal to develop products, services and systems which operate circular. For the road construction sector this is also applicable. Rijkswaterstaat, provinces and local governments have developed their own plan of operating circular, therefore the Dutch tender system should also make it a goal to request circular products. For the road (asphalt) sector it is currently unclear how this will be achieved due to tendering. Based on the problem statement the central research question is: How will tenders be defined in order to achieve the goal of constructing circular roads by 2050?

It is important to realize that the circular transition is an interaction between different facets that is split up into niche, regime, and landscape (Rotmans, Kemp et al. 2000, Elzen, Geels et al. 2004, Geels 2011). Collaboration has to occur to share knowledge. Second, using waste as a resource should be considered as the new standard because it can be cheaper for the tenderer, and third: operating circularly can give competitive advantages.

There are eight general factors of the circular economy: prioritize regenerative resources, preserve and extend what is already made, use waste as a resource, create and rethink (new) business models, design for the future, innovation, collaborate to create a joint venture and transparency. These factor will be investigated by interviews. These eight criteria create a reflective model where the expected criteria of the circular road constructing can be reflect in comparison to the general key criteria of the circular economy.

Twelve professionals were interviewed, who are all familiar with the circular economy and road construction and who are working either for Rijkswaterstaat or the provinces or local government. The interviews have taken place in June and July of 2018. The results of the interviews were analysed based on the eight general factors of the circular economy, the model of Rotmans Kept et al (2000). The conclusion is that, at the moment of writing, it is too early to conclude how circular road constructing will be valued and measured by tendering. This is because purchasers are in the starting phase of the circular transition by defining terms, testing products and developing policies. It is plausible to conclude that the MKI will be an important measurement method for now and in the future. The MKI will be based on the measurement module of DuboCalc. However there are other parties who are currently using and testing other methods of measuring circularity in the road construction, it remains to be seen how this will develop. It is plausible to conclude that the MKI will be used for several years before it will be turned into a hard criteria. And circular solutions are the standard in the road construction sector.

Collaboration or knowledge sharing between tenderer and purchaser also have to change to stimulate the circular process in the industry. Circularity is not only project or product focused but has to be focused on the whole process to operate circularly. Design, build, maintain and reuse. To stimulate circularity, knowledge sharing between tenderers and purchasers is necessary.

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## List of acronyms

<b>ARW (2016):</b>	Dutch guideline for tendering and regulation (ARW 2018). Based on the Aanbestedingswet 2012.
<b>BPKV:</b>	Best Price-Quality Ratio. Is a way of measuring the quality and the price of the product. The BPKV consist of the criteria which the purchases have set up for a tender (BPKV 2018).
<b>Dubocalc:</b>	Calculator for translating the environmental impact of a product into an MKI value. The environmental impact of the product is measured from the mining till demolishing. Dubocalc is based on the CO2 output of product and process (Rijksoverheid 2018).
<b>EcoChain:</b>	Module to calculate and measure the environmental impact of a product in CO2. EcoChain is only developed by a private business (Ecochain 2018)
<b>EMVI; (EMAT)</b>	Economically Most Advantageous Tender, was the name of the BPKV in the past. Nowadays it is called BPKV with the motivation it should be more related to the quality of the product instead of only the price (EMVI 2018)
<b>LCA:</b>	Life-cycle assessment. Is a technique to assess environmental impacts associated with all the stages of a products life from raw material extraction through materials processing, manufacture, distribution, use, repair, and maintenance (LCA 2018).
<b>MKI:</b>	Milieu Cost Indicator, gives a value to the milieu effect of material from the mining process till demolishing. Can be measured in impact based on CO2 and scarcity of the product. Will be valuable in euros (MKI 2018).
<b>RAW:</b>	Rational and automation, ground, water and road construction. It is administrative, juridical and technical conditions (Pianoo 2018).

## Introduction

*In the introduction of this research you can find the aim of this research and the research question with sub-questions. Also can be found the case description offered by the company. This chapter describes why the research is developed, and gives some further explanation of the definition circular economy which is leading in this research. By analysing the definition of the circular economy, current situation in the road construction sector, case description (of Van Gelder), problem statement, research goal and question, scope of research and discussing the structure of the research provides a well-founded structure for further research. There is chosen for this approach, because it describes and discusses important definitions and reflects how and why this research is conducted.*

## Circular economy

Circular economy refers to an economy which is restorative and regenerative by design, according to the Ellen MacArthur Foundation(2013). Relying on system-wide innovation, it aims to redefine products and services to minimize waste while minimizing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital (MacArthur 2013). The model of the circular economy of the Ellen MacArthur foundation can be found in Appendix 1. This model implicates the economy which is transforming from a linear waste model to a circular model. Also, the model displays left-sided biological materials en right-sided technical materials which can be considered as less sustainable. The European Commission (2015) adds to this definition that the value of products and materials should be maintained as long as possible (Commission 2015).

To explain 'as long as possible' Lansink and de Vries-in't Veld (2010) develops the ladder of Lansink model to rate the degree of circularity. The model can be found in Appendix 2.

The whole Dutch economy should be circular by 2050: an **economy without waste**. Targets of being circular in 2050 are a government-wide program and so also applicable to the road constructing industry. The next step should now be made, as stated in the report of 'The Netherlands circular by 2050' (Dijksma 2016). The Dutch government, together with social partners has big ambitions and wants to take an intermediate step is developed for 2030: achieving 50% less use of primary raw materials (Dijksma 2016).

The report is interpreted by Rijkswaterstaat, the biggest purchasing institution of road constructing. Rijkswaterstaat has as target to be circular in 2030, so when the whole Dutch economy has to reach an intermediate step, the civil engineering should already be operating circular. Which means that road construction should take place without waste by 2030 (Rijkswaterstaat 2017).

## Situation

The situation description gives answer how the tender procedure is currently managed in the road construction sector. It is important to realize how it is currently organized to understand the problem statement and research question. The tender procedure of road construction is regulated by Tender Regulations Operating's (ARW). The ARW is a law and has as a purpose: fair competition among tenderers (Torvatn and de Boer 2017). It is a standard procedure for tenderer and purchaser. Execution of the ARW procedures depends on the type of project ('rebuy') and value of the project (based on the amount if national or European tendering is applicable).

Product-related information is translated into criteria which are included in the Rational and automation, ground, water and road construction (RAW) or Best Price-Quality Ratio (BPKV). Previously this was the Economic Most Advantageous Registration (EMVI). The BPKV is introduced to better manage quality and stimulate innovation. The main goal is to create added value for the purchaser. In comparison to each other, the BPKV relies less on price but more on 'quality' (Wamelink and Heintz 2007, Rijkswaterstaat 2017).

The BPKV criteria exist of selection criteria and award criteria. Selection criteria are only focused on the characteristics of the company: grounds for exclusion (bankruptcy), suitability requirements and possibly further selection criteria (based on ranking). Award criteria are mainly



focused on characteristics of the registration. These criteria are focused on price, LCA, quality, and sustainability of the product (road), this can be quantitatively and qualitatively graded. The Milieu, Cost, Indicator (MKI-value) can be a part of the BPKV and made it possible to rate the sustainability asphalt. The RAW is only based on criteria and does not take into account the discount factor of the MKI. The lower the MKI-value, the higher the environmental CO<sub>2</sub> impact of the product. Dubocalc and EcoChain are calculating modules of the environmental impact of asphalt based on CO<sub>2</sub> (MKI). Dubocalc is a measurement module developed by Rijkswaterstaat and EcoChain by a private business (Rijkswaterstaat 2017). The criteria in the tender and weighted factors for the BPKV can be freely determined by the purchaser.

According to the government-wide program, the complete civil engineering should be operating circular in 2030. How Rijkswaterstaat, provinces and local governments want to establish this is currently unclear. Current tenders are not focused on circular operating and circular products. This research investigates how the tenders will be defined to realize circular roads by 2050.

## **Case description Van Gelder**

Van Gelder is the commissioned business and investigated case in this research. In 1916 Van Gelder was developed by D.Kroeze. It is a multifunctional company specialized in laying cables, pipes, assembly work and constructing roads. Nowadays Van Gelder Group is split up into five departments: Construct, Cable, Pipe and Assembly and Railway and Telecom. The road construction part is split up into three departments, east, west and integral projects. Over 900 employees are working on national projects. The sustainability policy results in the following targets and projects: reducing the CO<sub>2</sub> output with 20% by 2020, use of green energy, a sustainable vehicle fleet and FSC® certification for the construct department (Gelder 2018).

Van Gelder Group realized several innovative projects based on sustainability principles. Examples of this are the Road of the future and the 'Wassende weg' which ensures clean air and sound reduction. Also, it develops innovative sun collectors which light up houses in Rotterdam. In 2005 Van Gelder developed a circular way of constructing roads. R-ZOAB asphalt is based on 50% reused asphalt (Gelder 2018). Another product, Circufalt, used even more reused material: 98%. The problem for Van Gelder is that they do not know how the market will interact on constructing circular roads in the (near) future. The problem that Van Gelder sees is that tenders have to change, otherwise in most of the cases circular asphalt is not competitive enough. Van Gelder is curious if and how the tender will perform in the future to request circular asphalt. It is sure that tenders request are going to change to but how it is going to change is unclear for Van Gelder (Gelder 2018).

## Problem statement

Best Price Quality-Ratio(BPKV) and RAW are a way of making criteria in the public procurement measurable and valuable. By making the public procurement measurable it is possible to compare the offers among different tenders. Sustainability and circular constructing roads are a form of value in the BPKV or criteria in the RAW. In 80% of the situations, the BPKV will be used, but the weighing of the criteria are underestimated(Wamelink, 2017). Nowadays most of the tenders do not have circular construction as (main) goal but want to find a cheap and good solution for constructing a road. A government-wide program of the Dutch government taken over by Rijkswaterstaat, provinces and local governments is that road constructing should be circular by 2050. How this target will be achieved by the tender procedure is unclear. The road constructing sector and especially Van Gelder would like to know which instruments, criteria and factors are important for the purchasers of constructing circular roads by 2030.

The gap between constructing circular roads by 2050 and how to achieve this target regulated by tender will be investigated in this research.

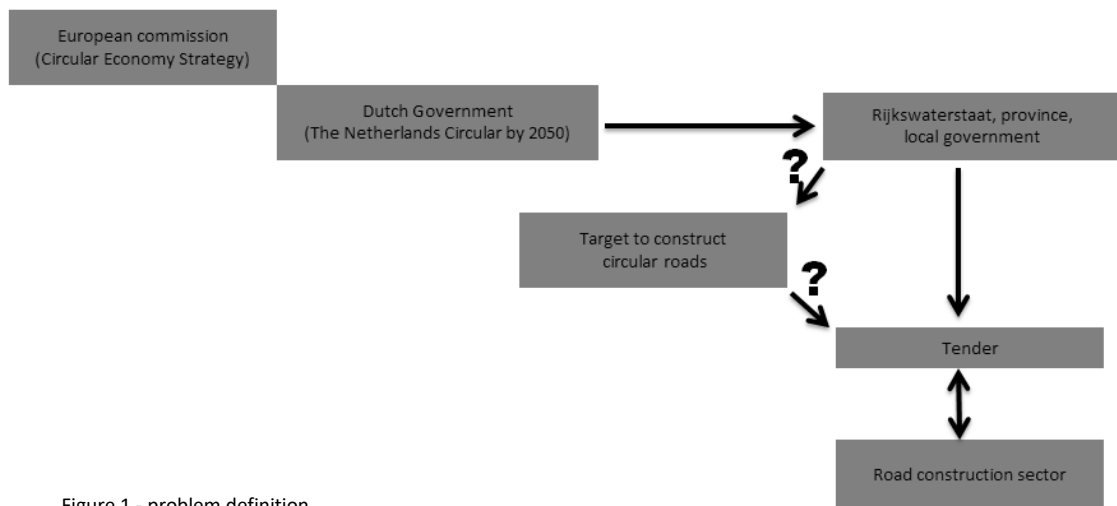


Figure 1 - problem definition

## Research goal & question

The main aim of this research is to provide strategic information for the road constructing sector, how tendering will most likely change due to the government-wide program of being circular by 2050. This research will be conducted by analyzing literature and interviews which will be held with experts in the sector. More information about how the research will be conducted can be found in the chapter methodology.

Based on the problem statement the central research question is:

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How will tenders be defined in order to achieve the goal of constructing circular roads by 2050?

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To give a substantiated and structured conclusion to the main question, the following sub-questions are conducted.

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- What will be used in the tenders to construct circular roads?
  - What is the relation between public procurement and innovation?
  - How will the circular economy be measured and valued in the road construction sector?
  - How does the road construction sector perform in comparison to the general key elements of the circular economy?
- What extent and in what period is the introduction of criteria based on constructing circular in tenders feasible?
- Which actions will purchasers (Rijkswaterstaat, provinces, and local government) perform to construct circular roads by 2050?

## Scope of research

### *Data gathering*

Data is gathered by interviewing professionals, also called experts, in the sector who are either working for Rijkswaterstaat or the province or local government and have an interface with circularity and public procurement in the road constructing sector. This choice is also made because this target group has an influence on tenders and have knowledge of both topics (circular economy and road constructing, with as intermediate variable public procurement)

### *Application*

The application of this research is for road construction companies in the Netherlands and especially for Van Gelder because they encountered the problem and are the commissioning business for this research. The conclusion of the research gives strategic management information how tenders will change due to the target of being circular by 2050.

## Structure

The remainder of this paper is organized as follows. The sub question are based from a general analyses towards more specific information which is applicable to answer the main question. Firstly transition of the circular economy is analysed this is done to develop which levels and organisations are involved in the circular transition in the road construction. This analyses is mostly based on the theories of Rotmans, Kemp et al. (2000), Elzen, Geels et al. (2004). This chapters makes clear which how the different levels of playing field are interacting and changing due the transition. Innovation is important according to the transition theory, this is also an actor of the circular economy which is important to operate circular. To assess circularity in the road construction sector is currently not possible, because there is not a reflection model. In the chapter: key elements of the circular economy are this elements analysed and discussed. After this chapter it is clear which levels are important and which are the key elements are of the circular economy. Subsequently is made an analyses of the public procurement procedure and how innovation will be realized due to the public procurement procedure. Finally is the MKI value in the chapter sustainable road is analysed to give an overview how sustainable asphalt is and how this currently is measured. From all the literature is made a general conclusion wherefrom further research based on interviews is determined. All chapters are a succession of each other, from level of playing field and innovation towards a product specific valuing method (MKI). Wherefrom the interview structure is setup with as last the results and conclusion.

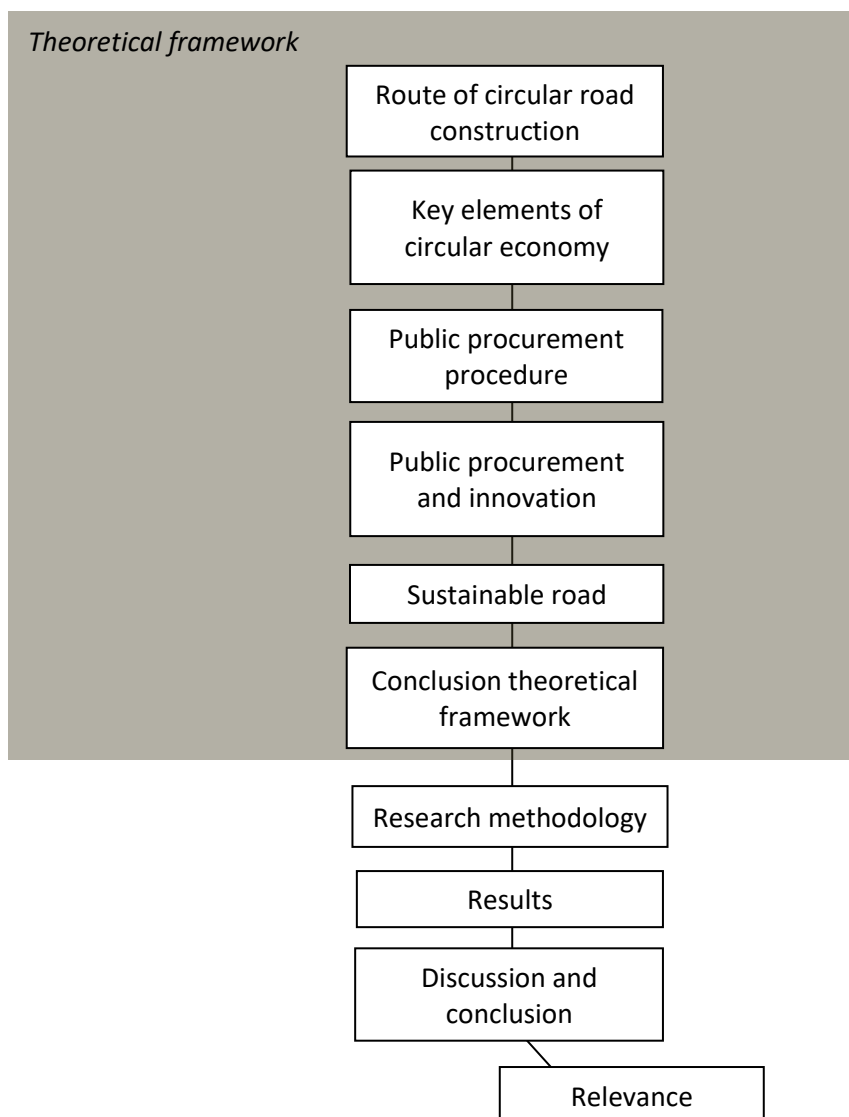


Figure 2 – structure of research

## Theoretical framework

*The theoretical framework gives more information on several topics related towards the research question, based on literature. First route of circular road construction is analysed wherein several levels of playing field are analysed in the road construction sector, followed by the circular economy principles, which is necessary to assess circularity in the road construction sector. As last are the three topics public procurement procedure, public procurement and innovation and sustainable road analyzed. Public procurement (and innovation) are involved due the special innovation development due the public procurement procedure.*

## Route of circular road construction

Circular economy defined by MacArthur foundation (2017) refers to an economy which is restorative and regenerative by design. Relying on system-wide innovation, it aims to redefine products and services to be designed without waste while minimizing negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital (MacArthur 2013). The European Commission (2015) adds to this definition that the value of products and materials should be maintained as long as possible (Commission 2015).

According to Murray, Skene et al. (2017), Hofman stated in 1848 already that in a circular economy, there is no waste. The circular economy is an interdisciplinary exploration of the concept and applications. The circular economy is not a new phenomenon according to Pauliuk (2018) *“the circular economy is not a new concept. It blends the principles of multiple schools of thought.”* Murray, Skene et al. (2017) *“a real factory uses its waste”*. *“Waste is food”* according to McDonough and Braungart (2010). Waste can be considered as raw material for new products.

Stahel and Reday-Mulvey (1981) noted about the circular economy that it will have not only benefits to the environment, but it will also create jobs, waste prevention, economic competitiveness and resource savings. Some parties in the industry adopt this and are already developing circular products. An advantage of this can be the reuse of raw materials which will ensure lower cost (Milios 2017). More often the circular product is not market competitive. The only possibility to make the circular product competitive is by focussing on the moral aspect and by mass production (Geng and Doberstein 2010). Another aspect of the circular economy is the efficient use of raw materials: by doing this the cost of raw materials will be lower.

Several researchers have shown that scarcity of raw materials will lead to problems in the economy (Yuan, Bi et al. 2006, Lieder and Rashid 2016). This will lead to problems in the production process. It is important that companies act on this, so products that will be scarce in the near future will be replaced by circular products (MacArthur 2013).

Barriers to the circular economy are currently the policies in most of the situations. According to Geng and Doberstein (2008), there is no unified platform and term for the circular economy. The fragmented regulation system often works against such innovations. Science and technology are key components of a circular economy (Geng and Doberstein 2008). New academic achievements in environmental science and environmental technologies, such as those which have contributed to the fields of eco-design, cleaner production and life cycle assessment, will help revolutionize the related fields of biotechnology, information technology and materials science (Geng and Doberstein 2008). New business models will ensure longer earnings, by lease or maintenance contracts (Stahel 2016).

The transition towards a sustainable economy is a challenging process according to Genovese, Acquaye et al. (2017), as a wide spectrum of constraints emerge, including political, human, cultural technological limitations and economic structures (MacArthur 2013). The transition can be analyzed from two sides: bottom-up and top-down. The two-sided way means that the transition can be activated, if that is necessary from product level and development or by policy (Genovese, Acquaye et al. 2017).

Yuan, Bi et al. (2006) explains the Chinese Government uses a top-down structure. In the past decade, they had already issued several laws that are very supportive of the circular economy (Geng and Doberstein 2010). For example, the law 'Cleaner Production Promotion Law,' concerning the development of circular economy, is part of China's growing demand for strict management of solid waste (Yuan, Bi et al. 2006). Nowadays it turns out that China is one of the most important innovators in the field of the circular economy (Murray, Skene et al. 2017).

The theory of Rotmans, Kemp et al. (2000), Elzen, Geels et al. (2004) is a sociotechnical transition theory. It can help to analyse the aspect towards a circular economy in the road constructing sector. The theory defines the levels niche, regime and landscape are central points of transition system management and process. Figure 3 gives an overview of the different levels of the theory.

Where every niche is the process of innovations. A niche is a learning curve from where innovations consecutively will be developed. It is an innovation and experimentation level and part of the market. This level of the total market is less subject to market and regulation influences. This part of the total actors supports the product innovation (Geels 2011).

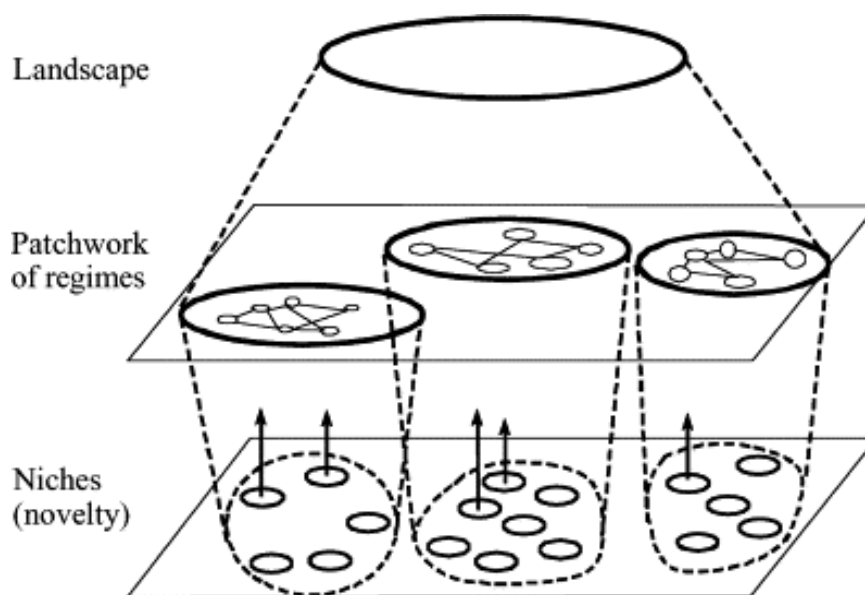


Figure 3 – transition theory of Rotmans, Kemp et al. (2000)

A regime can be seen as the regulations and request of the market according to Geels (2011). It is an explanation of the formation of the technical trajectories. Geels (2011) states radical changes of regime shift are rare because it is the standards of the market based on influences of governments' regulations, society, and industry. The landscape are all big social changes in the field of political, cultural, natural characteristics and worldviews, which are difficult to influence and difficult to change (Rotmans, Kemp et al. 2000, Elzen, Geels et al. 2004, Geels 2011). Due the changing regimes influences the landscape is going to change and due the changing landscape regimes are changing.

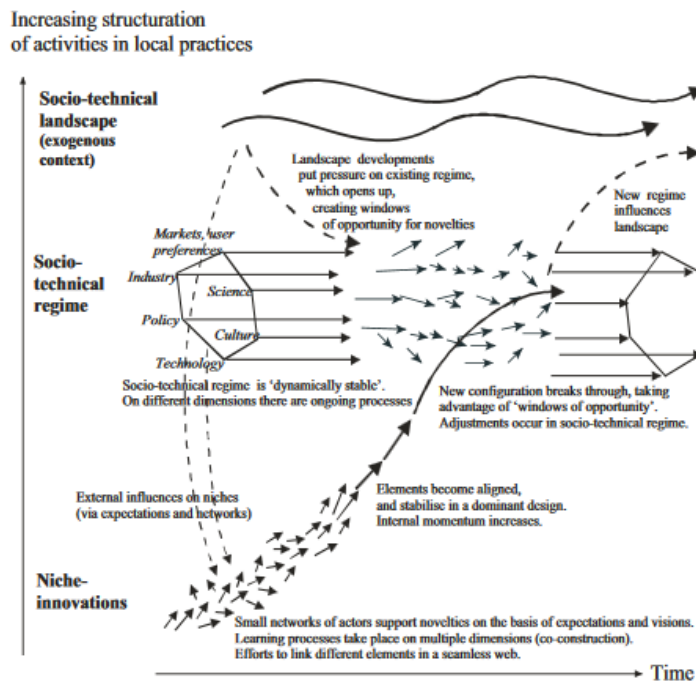


Figure 4 – multi-level perspective on transitions of Geels (2002)

Figure 4 the multi-level perspective of Geels (2011) scenarios should show socio-technical attention towards the different types of actors, strategies, resources and goals of the organization (Elzen, Geels et al. 2004). The interaction between parties is important, to stimulate the transition from niche towards the regime. Rotmans, Kemp et al. (2000) state that linkage and interactivensness are a part of the theory. Transition implies a cycle of the process of vision-building, taking action, evaluating the response to this and subsequently taking new action (Elzen, Geels et al. 2004). Elzen, Geels et al. (2004) state that niches are important for learning and radical alternativensness towards a transition. Smith, Stirling et al. (2005) add that too many niches never break through towards a transition and progress will never be made.

Focus (vision building), network, transition policy and motivation will lead towards innovation according to Rotmans, Kemp et al. (2000). Elzen, Geels et al. (2004) state that successful breakthroughs depend upon on-going processes in regimes and landscapes. After a development is successfully introduced by a niche, it should be adopted by the regime to introduce to a broader market (Elzen, Geels et al. 2004). Older products, which are established by a transition, will also be improved by new transitions. Utterback (1994) states that transition can be seen as a consecutive process, where new targets will be consecutively established.

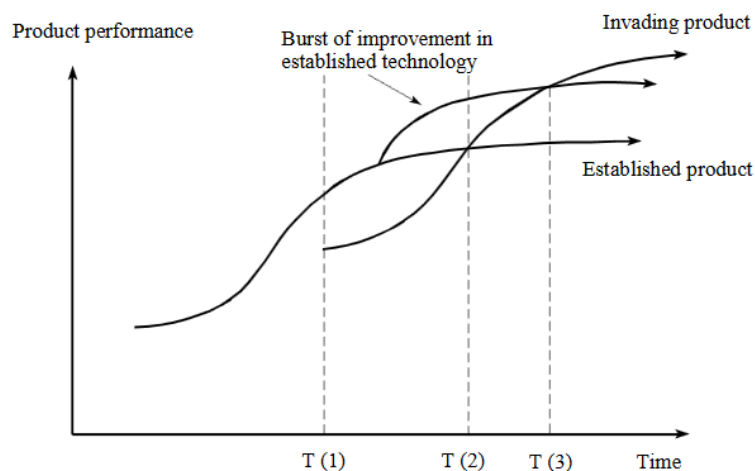


Figure 5 – Competition among products of Rotmans, Kemp et al. (2000)



The time when a transition takes place depends, according to Elzen, Geels et al. (2004), on several factors: infrastructure, conventional technologies, material conditions and physical plant. The knowledge part of the transition is an important factor: high expertise level, education and well-functioning research systems lead to quick transitions. For organizations, it is important that they are well lead by authority and control, rules, and procedures (Elzen, Geels et al. 2004). Rotmans, Kemp et al. (2000) state that transitions are gradual changes that take a long time, at least one generation. Long-term transitions look like a well-defined line, but in short periods it is small steps which lead together to an improved process and product (figure 5). When companies do not adopt a new successful innovative product they will lose market share. A new technical regime will overtake the market share of the old technical regime as shown in figure 6 - market transition route of Rotmans, Kemp et al.(2000).

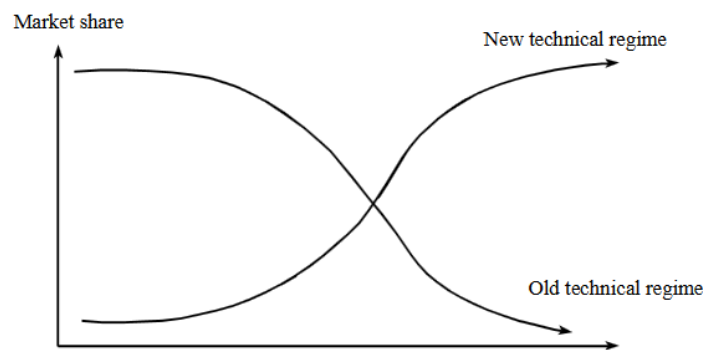


Figure 6 – market transition route of Rotmans, Kemp et al. (2000)

Yuan, Bi et al. (2006) explains that according to the circular transition that in practice there is a three-layer approach to implement the circular economy for a company. This three-layer approach exists for cleaner production, industrial ecology, and ecological modernization. Ghisellini, Cialani et al. (2016) disagree with this because it relies on the industry and their environment and mostly on the 'key elements' of a circular economy. Lieder and Rashid (2016) conclude that joint support of all stakeholders is necessary in order to successfully implement the Circular Economy concept at a large scale. Based on a top-down, as well as a bottom-up approach, where the market can offer a product towards the purchaser (bottom-up) and where the purchasers determine which kind of product it wants (top-down) (Elzen, Geels et al. 2004). Working top-down as well as bottom-up can trigger towards a circular economy.

## Key elements of circular economy

In 2017 the British Standards published the first policy and legislation of the circular economy principles. These six principles are analyzed and collaborate with the seven key elements of Ramkumar (2017) and the five principles of the Ellen MacArthur (2013) foundation. Principles that correspond were merged to one key element. The conclusion is the eight principles of the circular economy. This can be found in the model of Appendix 3. The eight key elements of the circular economy are explained, analyzed and criticized below. The eight key elements of the circular will be used to reflect circularity in the current road construction sector later in this research. Per key element is used literature to discussed the specific element.

Key elements of circular economy discussed by literature	
Key element	Description
<b><i>Prioritize regenerative resources</i></b>	Natural energy consumption is not endless. For example, earth products; oil, earth gas, and coal, will exhaust due time. Also, these kind of energy sources are polluting the earth with their CO <sub>2</sub> impact says Herzog, Lipman et al. (2001). It is important to use renewable energy sources, with minimal CO <sub>2</sub> output. Herzog, Lipman et al. (2001) defined renewable energy sources as biomass, wind, water and sun energy. A disadvantage of biomass energy is the high CO <sub>2</sub> output, so it is better to use lower output sources (Martín and Davis 2016). Martín and Davis (2016) defined that important criteria for the choice of energy source depends on the space, place, sources and cost efficiency. The right use of material and production can save 6% – 11% of the raw materials. Also, the use of biobased products is higher, graded by the different foundations who are active in the field of the circular economy (MacArthur 2013).
<b><i>Preserve and extend what is already made</i></b>	Preserve and extend what is already made has as main goal to upgrade products to meet the performance requirements after the lifespan (MacArthur 2013). <i>“for the ideal circular design.... easy to disassemble and upgradeable components (MacArthur 2013).”</i> Appendix 1 shows the circular economy model of the Ellen MacArthur (2013), which shows how the product should return to the economy. Also, the ladder of Lansink and de Vries-in't Veld (2010) is a reflection of how and when the product returns to the economy. The higher products will be reused on the ladder the better this is for the environment. Planing (2015) states that re-manufacturing and upgrading products should be a novel way of creating and capture value.
<b><i>Use waste as a resource</i></b>	Waste is food according to McDonough and Braungart (2010). Waste should be reused as new raw material for a product. How long waste is considered as waste, is difficult to determine. Situations will occur where waste will be seen as a raw material and this has consequences for many industries. The prices for the raw recycled material will increase, raising the new production cost (MacArthur 2013). The research of Reike, Vermeulen et al. (2017) used the nine R model; refuse, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover from using waste as a resource.

<b><i>Create and rethink (new) business models</i></b>	Stewardship is the new term for the owner of a product. People are no longer the owner but a faithful user of a product according to the Ellen Macarthur Foundation (2013) and Stahel (2016). Stahel (2016) states that based on the lease, rent and long-term contracts, the economy changes from the perspective of owner to user. Planing (2015) defined that rethinking is not the new business model, but the upgrade of existing business models. The vision of Planing (2015) wherein re-manufacturing and upgrading can also lead to new business models, wherein the manufacturer will be long-term the owner of the product.
<b><i>Design for the future</i></b>	Yuan, Bi et al. (2006) state that the right material should be used during the design period, based on the lifetime of the product. By using smart technologies the lifecycle of the product can be extended (Planing 2015). Important factors are using the right raw materials for the right situation. "Design to recycle." Companies are also encouraged to design more environmentally friendly products and adopt cleaner technology in their manufacturing processes according to Yuan, Bi et al. (2006).
<b><i>Innovation</i></b>	Innovation is an important criteria to be circular. By innovating, a company can produce according to the last possibilities of the circular economy. By incorporating digital technologies into products, products will be smarter, but also the production process can be improved and become less damaging for the environment (MacArthur 2013). According to the Ellen Macarthur (2013) foundation, the circular economy could create tremendous opportunities for industrial renewal, regeneration, and innovation.
<b><i>Collaborate to create joint value</i></b>	By collaborating the company can create value for their customer, said the Ellen MacArthur(2013) foundation. By providing a collaboration, both companies can provide improved circular products, services and/or redesign their entire business model. This creates another value proposition for the customers (Pauliuk 2018).
<b><i>Transparency</i></b>	By being open and transparent about obstacles during the transition, circular innovation can be stimulated. Data and obstacles should be shared with the whole industry (Geng and Doberstein 2010).

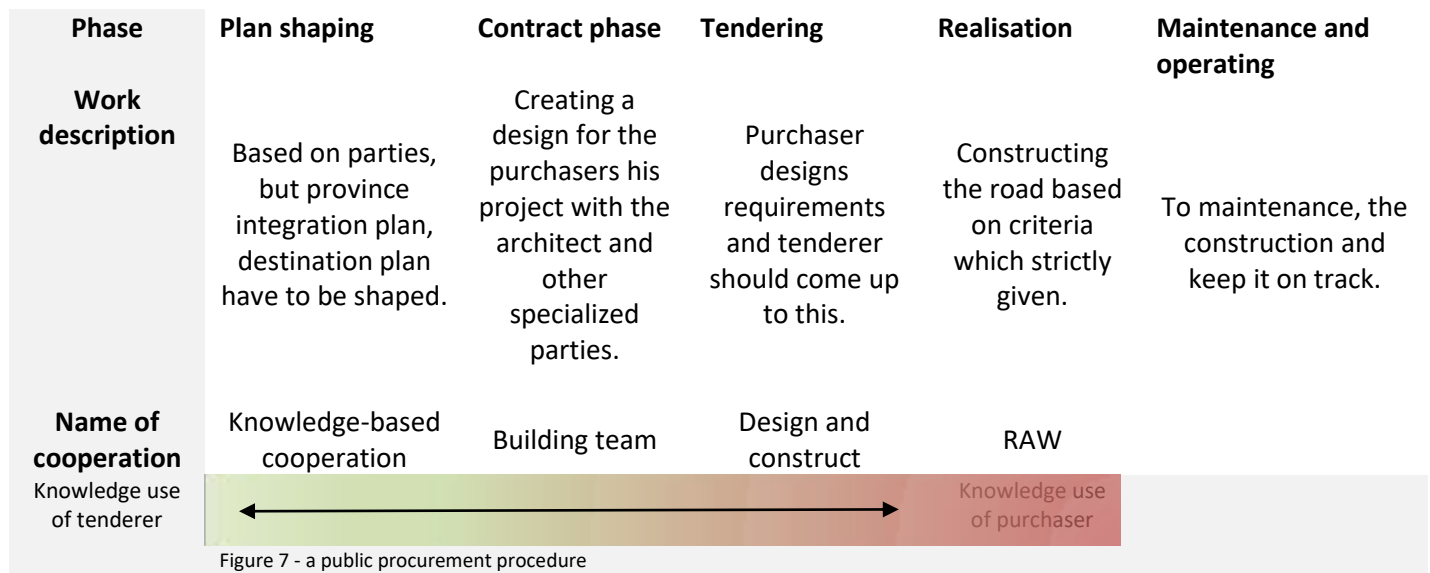
Table 1 – Key elements of the circular economy discussed by literature

## Public procurement procedure

Cooperation and a long-term relationship are difficult in sectors that have to deal with public procurement. To stimulate innovation, cooperation is even important, and connect in an early stage of the design process (Chesbrough and Rosenbloom 2002). Also, for the road construction collaboration should be important, because they often involve big, long-term, complex technical projects, state Lenferink, Tillema et al. (2013). When tenderer and purchaser work together in a tender procedure depends on the level of playing field.

The phase of cooperation can be organized into stages. In figure 8 an overview is given of the process where the tenderer joins the process, with an explanation of the specific process. The five stages are plan shaping, contract phase, tendering, realization, and management and maintenance (Pianoo 2018) (Wamelink and Heintz 2007). In these phases, the management of knowledge is a central point and strategy. If the tenderer joins in at an early stage, knowledge, insights, and capacity of the tenderer can be used. If the tenderer joins at a later stage, knowledge of purchaser will be more used (Trionfetti 2001, Wamelink and Heintz 2007).

### Level of playing field



By collaboration, EU regulations should take in mind; tenderers should get the same possibility to win the tenderer. For purchasers, the goal is to communicate and be transparent to all the tenderers. To prevent unfair competition more tenderers are involved in the procedure. It is still remarkable that in the two first stages of the process, there is no contract form involved (Wamelink and Heintz 2007).

Aschhoff and Sofka (2009) defined in the proposition of tendering two possibilities of requesting: 1) the needs and requirements of the client can be formulated (problem statement) and 2) what should be constructed should be formulated (solution-based) (Aschhoff and Sofka 2009). By tendering based on the problem statement there is more space for innovation and the solution can be freely interpreted. Important for the second criteria is that purchaser and tenderer cooperate in a later stage to find a good solution for the problem and because the solution is freely interpretable the two parties should offer better quality because the fact that the solution is better based on the problem (G.B.J. Hofmeijer 2017).

## Public procurement and innovation

Public procurement and innovation are an often discussed and debated topic in literature. Public procurement is the term used for public purchasing for any acquisition made by public organizations (Aschhoff and Sofka 2009, Murray, Skene et al. 2017, Torvatn and de Boer 2017). In most developed countries public procurement is the basis of the purchasing strategy of (semi) related government organizations (Torvatn and de Boer 2017). Innovation, according to Garcia and Calantone (2002), is a workable definition of the evolution of the product's productive system in the view of evolution. Innovation is according to Alam and Kumar (2013) a process to develop new goods or service. The EU member states define innovation as an implementation of new or significantly improved goods or services. Wherein public procurement is a buying strategy which is emphasized to meet different goals. (EU 2017). Challenges for countries in Europe, according to the research of the EU, are *"to support the 2020 strategy for smart, sustainable and inclusive growth"* (Bolton 2016)

Yearly a massive amount is spent on public procurement. A study by Loader(2015) concluded that on average 12,8% of the total Gross Domestic Product (GDP) in OECD countries is spent by public procurement. The World Trade Organization's Agreement on public procurement estimated the amount around 1.3 trillion Dollar. According to the EU, it spends averagely around 14% of the GDP on the purchase of works, services, and supplies by public procurement by European countries (EU 2017). A study done by Matthews (2005) is estimated that 20 percent of the GDP is spent by public procurement. While Thai (2008) gives a range between which percentage the institutions spend on public procurement, this is between 10 and 30 percent of the GDP. Based on general data and related to the case of road constructing, the Dutch government, for example, spends around 2,5 to 3 billion euro on constructing and maintaining the Dutch road system. For 2018, the budget has been set on 2,6 billion euro (Rijksoverheid, 2018). However, there is a difference between the percentages and amounts. The overall conclusion can be drawn that the amount of money that is spent on public procurement is massive.

Overview of advantages and disadvantages of public procurement	
Advantage of public procurement	Disadvantages of public procurement
Transparent, equitable and cost-effective way of purchasing	Contains more guidelines
Instrument of public policy	Raises barriers of innovation
Between the borders of criteria are a lot of possibilities of innovative products	Lack of interaction with procuring organizations
Due to the procurement procedure interaction will take place	Specific and prescriptive
Competitive procedures	No space for innovation
Stimulate innovation <ul style="list-style-type: none"> <li>- capacity building</li> <li>- government can function as an experimental user</li> </ul>	disturbing relationship-based approaches as co-creation

Table 2 – advantages and disadvantages of public procurement

An interesting feature of public procurement is that the procedure contains more guidelines than private purchases (Torvatn and de Boer 2017). Bovis (2012) noticed it is even strictly regulated by law. In Europe, by EU directives and also on a national level, it is obtained by rules and procedures. The rules and regulations regarding to public purchasing are extremely important for the use of public money, as well as for the business of numerous private companies (Bovis 2012, Torvatn and de Boer 2017). Bolton (2016) explains that the purpose of the regulations of public procurement are to entities, goods and services in a fair, transparent, equitable and cost-effective way. Thai (2005)

says public procurement can be seen as an instrument of public policy which is also economically important. Public purchasing is not only economically important but also used consciously as an instrument of public policy.

Public procurement raises barriers against innovation. Research of Uyarra, Edler et al. (2014) states that the most important barrier experienced by companies who have to deal with public procurement are 'lack of interaction with procuring organizations'. The second important factor is specifications that are too specific and prescriptive (Uyarra, Edler et al. 2014), which lead to specific product specification and no space for innovation according to Torvatn and de Boer (2017). Also, mentioned by Torvatn and de Boer (2017): public procurement is often criticized for hindering and disturbing relationship-based approaches as co-creation. Arnold (2004) makes it clear that innovation policy is to prove effectiveness within the system. Between the borders of criteria are a lot of possibilities of innovative products (Arnold 2004). Also, a benefit of public procurement is that due to the procurement procedure interaction will take place between parties. This communication can establish new criteria for the next tender where innovation is included. Another benefit of the public procurement claimed by Stentoft Arlbjørn and Vagn Freytag (2012) and innovation is that directives are regulated by transparency and by emphasizing competitive procedures.

According to Uyarra and Flanagan (2010) and Edquist and Zabala-Iturriagagoitia (2012), public procurement will stimulate innovation. This is because public procurement will provide capacity building: the public sector will spend more by paying for the premium cost or bear some efficiency losses. Also in some cases, the government can function as an experimental user. Flanagan (1954) and Edquist and Zabala-Iturriagagoitia (2012) describe the barriers of public procurement as weaknesses of the systems, not as a barrier. Between the regulations of procurement can be implemented new innovative products said Flanagan (1954) and Edquist and Zabala-Iturriagagoitia (2012). The step which is made in the field of innovation is negatively related to cost, and product adaptive of the market. Other researchers have described that the effect of purchasing directives solely can create innovative products by public procurement (Aschhoff and Sofka 2009).

Cooperation and long-term relationships are important to stimulate innovation, according to several studies (Spekman 1988, Wamelink and Heintz 2007). Caldwell, Walker et al. (2005) by public procurement due to purchasing directives it is difficult to have a long-term relationship and establish co-creation in the sector with their suppliers. They have to be aware of the law regulations and extremely cautious of contravening competitive legislation. By influencing the public purchaser on their capabilities and knowledge can be dangerous. Keeping on the right side of the law when engaging is tricky (Torvatn and de Boer 2017). Principles of the EU directives of public procurement are transparency, equal treatment and non-discrimination (Torvatn and de Boer 2017). In the research of Torvatn and de Boer (2017) aspects are defined, for instance inflexibility, that occur because of the procurement criteria and processes. Another aspect is the fact that due to the high development cost and the low, competitive pricing the company goes not bankrupt (Torvatn and de Boer 2017). According to Bolton (2016) a way of innovative procurement should be to look at not only the purchase price, but also the life-cycle price. This way, price will be a more holistically aspect, according to Bolton (2016).

Another aspect should be that public purchaser should be more aware of the quality of the product by new processes, materials, and technologies (Bolton 2016), and to stimulate the innovation part of the public procurement the relationship should be based on a good reputation, trust, and motivation by both parties (Uyarra and Flanagan 2010). Erridge and Greer (2002) concluded that procurement is more than just a one buy situation: it is actually a partnership. The procurement procedure should not be seen as winners and losers game, but as a relationship success depends on (Erridge and Greer 2002). Lenferink, Tillema et al. (2013) state it is all about the coordination, cooperation and competition in the whole process. In the opinion of Lenferink, Tillema et al. (2013) cooperation and competition are two related factors, which will be explained further in this research. Innovation and the circular economy are related positively according to Yuan, Bi et al.

(2006). In most of the cases, to make circular products possible, innovation is necessary. Innovation and cooperation are also key elements of the circular economy model.

Boes and Doree (2008) describe in their research that in the Netherlands in 1999 the Innovative procurement (IP) programme was implemented to stimulate innovation in the constructing sector. But this study also showed that in most of the cases, the public procurement goal is actually only based on the lowest price instead of quality. Nevertheless last decade there significant changes were made in the public sector. Based on the international trend of rethinking construction, the national governments are frontrunners for local governments (Boes and Doree 2008). However, it is a difficult discussion point in the literature. In 2005 the competitive dialogue (CD) procedure is introduced by the European government in 2005. The CD procedure has as its main purpose to co-operate among government institutions and the private sector (Lenferink, Tillema et al. 2013) The benefit of CD, according to Lenferink (2013), is that it gives private parties the possibility to gain a better understanding of the public needs and proposed contracts. This results in more creative and innovative products on better grounded and constructible bids. Blomqvist (2002) states that cooperation may lead to increased project quality based on the shared risk and better information management due to the communication channels, and cooperation will in the future establish new joint product development (Blomqvist 2002)

Cooperation does not have only benefits. Too much cooperation will establish some drawbacks. Lenferink, Tillema et al. (2013) mention examples like non-commitment in endless rounds of negotiation, decreased democratic legitimacy of planning processes, and distortions of the level playing field. The main goal of the public procurement procedure is transparency between purchasers; government (related) institutions and the private sector (EU 2017). Transparency is important in this sector especially due to the construction fraud(better known as 'Bouwfraude') in 2001 (Jansen, Dielissen-Breukers et al. 2002). That is why cooperation can even be considered risky because it is balancing act of stimulating innovation and the European regulation of public procurement. Due to this regulation private tender teams are not always allowed to cooperate (Lenferink, Tillema et al. 2013). Caldwell, Walker et al. (2005) state that new innovative practice is a new form of partnership and risk sharing between the public and the private sector.



## Sustainable road

*To understand and review the sustainability and also circularity of a road, in this paragraph road structure and mixtures of asphalt are analyzed followed by an analysis of the sustainability of the road. The information about sustainability can be used later in the research to define a well sustained conclusion of the interviewees their opinion about sustainability and circularity of asphalt.*

A road is constructed of several layers. It starts on the sand ground where a sub-foundation will be established. On the sub-foundation the foundation of the road will be realized. The thickness of the road depends on the users of the road (heavy trucks or cars), how often the road will be used, and the ground layer (clay or sand) (Bossche 2014). An overview of the 'standard' road layers can be found in Appendix 4. The road exists of asphalt, which is, according to Speight (2015), a black cementing agent and the name given to the collective high-boiling constituents of petroleum. It is also a mixture of raw materials with the purpose to be a stable structure for vehicles (Hofman 2018). The asphalt mixture exists of gravel, bitumen, and sand. There are over a hundred compositions of asphalt mixtures. Every road is developed based on the necessary principles (Hofman 2018). These principles depend on the wishes and requirements of the customers. Most of the time asphalt in roads exists of two or three layers: the underlay, middle, and top layers. The foundation of the road is made of stones, which can be obtained of different granulate types and has the purpose to be a solid underground for the road (Wang and Ma 2017).

The sub-foundation has as main purpose to protect the road against influences from under like freezing weather. Sub-foundations can be made of sand or mixtures of recycled granulate and sand (Bossche 2014, Wang and Ma 2017).

The underlay of the road depends on the natural environment. This can be a broad range of sand types (Bossche 2014). The sustainability of road construction and the process can be measured in the MKI. Both can be a part of the BPKV, depending on the purchasers. The MKI also gives a good indication of how the circular aspect of road constructing can be valued in the future. Therefore the MKI is further explained and analyzed.

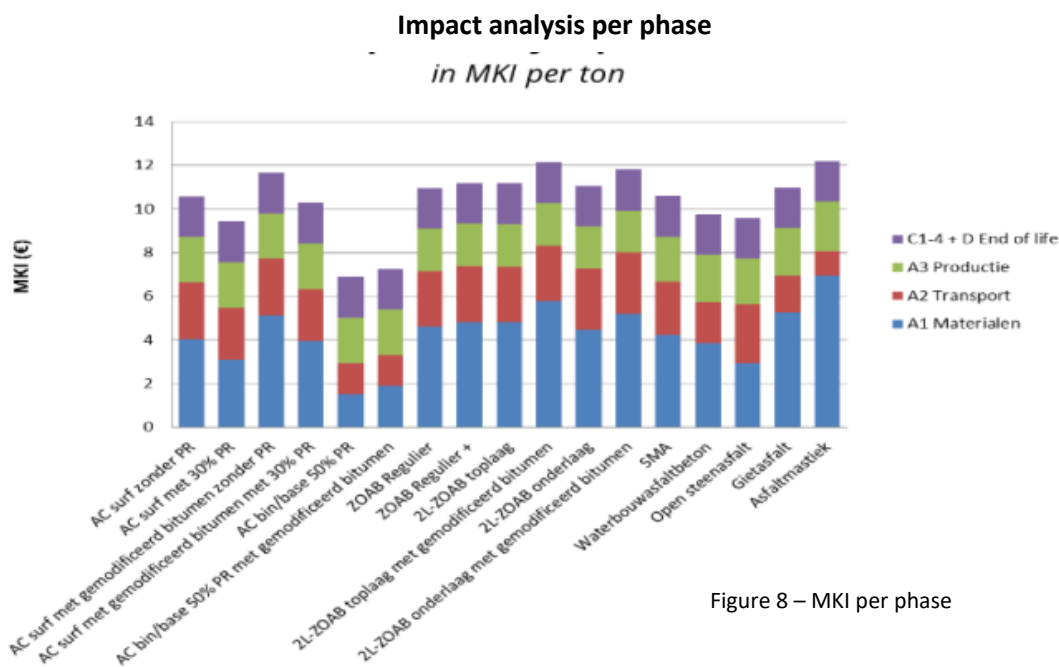


Figure 8 – MKI per phase

In figure 8 the 17 mixtures of asphalt are analysed. Based on every stages is summed up what the impact is for the environment based on the MKI in euros. Concluded can be that materials has the biggest impact on the MKI value. In some situations involves asphalt more than 50% of the MKI value in euros.

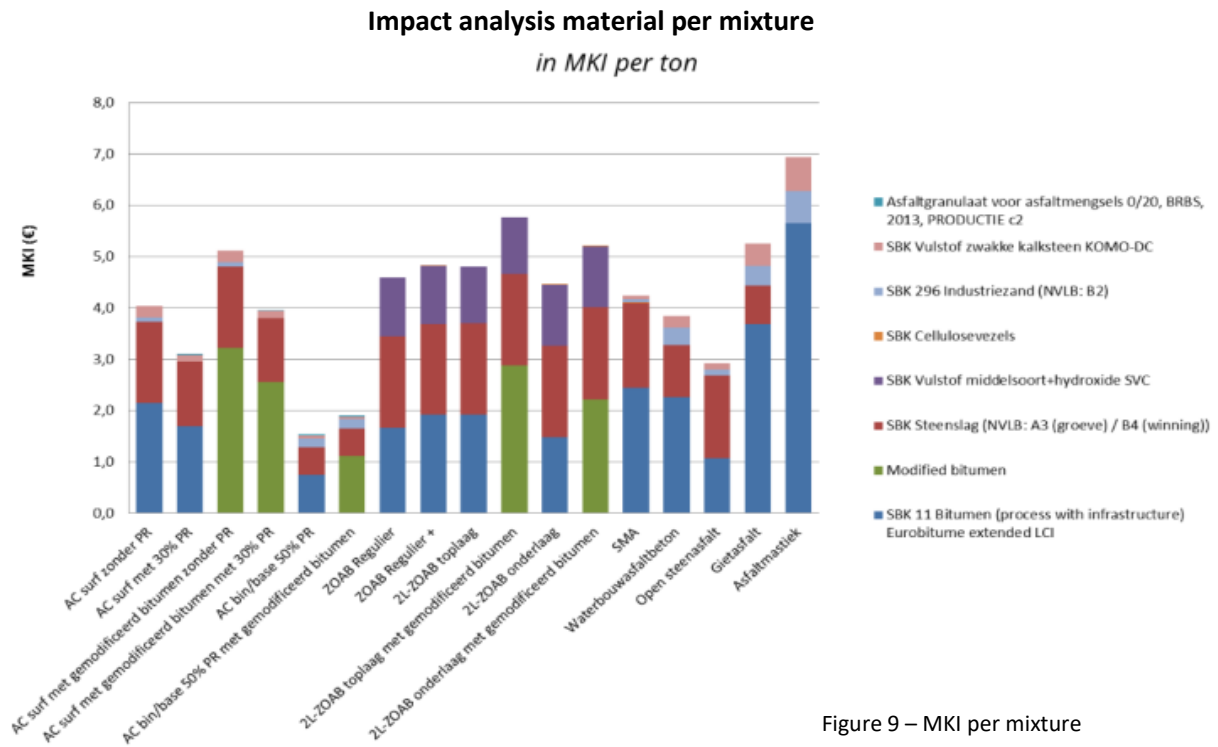


Figure 9 – MKI per mixture

Based on figure 8, figure 9 is used. Figure 9 shows that the material has the biggest impact on the MKI indicator therefore the material; asphalt - is more detailed analysed. The Bitumen part of Asphalt has the biggest impact into the MKI indicator. This is split in Bitumen and Modified Bitumen.

## Conclusion theoretical framework

To make the transition possible towards a circular road construction sector there is change needed on different levels of playing field. Not only in the road construction sector, but also by government. The circular transition is an interaction between different levels of playing field which is split up into niche, regime, and landscape. Wherein the niche is the power or start of the circular transition, which has to involve or overtake the regime and landscape. It is a cycle of interaction which is so called interactiviness. Change has to occur on multiple levels and by different organizations to make innovation possible. Innovation is a process of interaction whereby new products, services and processes constantly will be updated.

Constructing circular roads can not only be seen as a government-wide goal. It also has economic advantages for constructors (tenderers in this situation). Circular operating can be cheaper and save raw materials and it can also improve a company's image. To change the current business model to a circular business model, it is not always necessary to use a top-down approach. By stimulating the market, a bottom-top approach is also one of the possibilities. If the companies use its resources in the right manner, they can influence the decision makers to choose their sustainable product. Competition advantages can be created by a bottom-top approach, where the company functions as an advisor with a new product, instead of using policy as the only motivator. The circular economy requires system and product innovation. Innovation is a process to develop a new improved good, system or service; in this research the process from a linear to a circular economy.

Innovation and collaboration is important to operate circular, it is also a part of the circular key criteria. Innovation is just one key criteria. To make it possible to answer the sub-question "how does the road construction sector perform in comparison to the general key elements of the circular economy." It was necessary to develop the general factors of the circular economy. This criteria are discussed and analyzed by literature so on this are the best criteria of the circular economy. There are eight general factors of the circular economy are: prioritize regenerative resources, preserve and extend what is already made, use waste as a resource, create and rethink (new) business models, design for the future, innovation, collaborate to create a joint venture and transparency. Whether they are also applicable to the road constructing sector and how important are considered, will be investigated by interviews. These eight criteria create a reflective model where the expected criteria of the circular road constructing can be assessed in comparison to the general key criteria of the circular economy. A reflection model between literature and practice due interviews.

What is the relation between public procurement and innovation? The relation between public procurement and innovation is difficult. It is two sides which exist of advantages and disadvantages. So far attempts have been made to stimulate innovation through public procurement. Results of this were in the first place that public procurement is often a barrier to innovation, due to the lack of interaction with procuring organizations. The second barrier is the specific product specification where there is no space for innovative solutions. Positive results of public procurement are that the public sector will spend more by paying for the premium cost; the government will function as a tester. MKI calculation functions as a discount factor on the total BPKV price, where sustainability, LCA, and CO<sub>2</sub> output function as a positive influence which also is related to circularity.

Collaboration is an important aspect of establishing a circular economy. By sharing knowledge; systems, products and services can continue improving. However, cooperation is difficult in tender procedures because there is no space for knowledge sharing between tenderer and purchaser. The level of the playing field determines if the knowledge will be used from the purchaser, tenderer or both. The earlier the cooperation will happen, the more the knowledge of the tenderer is used. Collaboration and with that knowledge sharing is an important aspect towards a circular economy, because by learning from each other, products can be improved and better

maintained towards the circular circle. So for Rijkswaterstaat, provinces and local government it is useful to collaborate at an earlier stage. For tenderers it is even more interesting to collaborate at an early stage because it can create competitive advantages through knowledge sharing. The negative side of early collaboration is that 'knowledge-based collaboration' and 'building teams' will take place with more than one tenderer because of the transparency regulations. By sharing information, the other party can use this and the competitive advantage will disappear.

It can be concluded that first of all: collaboration has to occur to share knowledge. Secondly, using waste as a resource should be considered as the new standard because it can be cheaper for the tenderer, and thirdly: operating circular can give competitive advantages. However the theoretical framework gives a lot information about circular transition which is necessary to operate circular, missing is information how this will be established by tenders. Therefore empirical research is conducted.

## Research methodology

The main purpose of this study is to provide an answer to the question: “How will tenders be defined in order to achieve the goal of constructing circular roads by 2050?” Therefore the aim is to find information based on data gathered by a qualitative research approach. The interviews are semi-structured, which is the most reliable interviewee technique in this case because it allows participants to openly give their opinions based on their life experiences (Butterfield, Borgen et al. 2005). Due to the fact that the qualitative interviews are semi-structured, it is possible to compare the interview data between respondents (Butterfield, Borgen et al. 2005, Galletta 2013). The interview questions are based on the theoretical framework.

Twelve professionals were interviewed, who are all familiar with the circular economy and road construction and who are working either for Rijkswaterstaat or the provinces or local government. The interviews have taken place in June and July of 2018. Interviews are conducted at the location of the interviewee, as this positively influences the interviewee’s openness and comfort level, as well as the reliability of the gathered data (Galletta 2013).

The semi-structured interviews had the following global structure: introduction about the research, introduction of the interviewee, research questions, retake research question (evaluating and checking), thanking and personal conversation. Considering the semi-structured style, the interviews can differ in structure. In general the main questions were the same for interviewees. In Appendix 5 can be found a global setup of the interviews.

Afterwards, the data was processed anonymously, using ATLAS.IT software. Based on the analysis of this data, the different research questions were answered and the reflective model of the key criteria of the circular economy is valued. The interviews had as purpose to give answer to the main question and the following sub-questions:

- What will be used in the tenders to construct circular roads?
  - How will the circular economy be measured and valued in the road construction sector?
  - How does the road construction sector perform in comparison to the general key elements of the circular economy?
- What extent and in what period is the introduction of criteria based on constructing circular in tenders feasible?
- Which actions will purchasers (Rijkswaterstaat, provinces, and local government) perform to construct circular roads by 2050?

Based on the research question the results are split up into: characteristics of the circular economy in the road constructing sector, measurability and value of the circular economy and circular in the road constructing in comparison to the key elements of the circular economy.

Number	Interviewee(s)	Organisation	Length
R1	1	Local Government	36:28
R2	1	Local Government	32:59
R3	1	Local Government	45:02
R4	1	Local Government	48:24
R5	1	Province	43:26
R6	2	Province	55:02
R7	1	Province	40:46
R8	1	Province	37:00
R9	1	Rijkswaterstaat	1:44:54
R10	1	Rijkswaterstaat	32:59
R11	1	Rijkswaterstaat	38:45

Table 3 – interview overview

## Trustworthiness and authenticity of research

*Trustworthiness and authenticity is an alternative of analysing reliability and validity used by quantitative researchers. Guba and Lincoln (1994) specify terms and ways of establishing and assessing the quality of qualitative research which is used to analyse the trustworthiness and authenticity of this research. For this research is chosen to analyse validity and reliability according to the theory of Guba and Lincoln (1994), because this research is conducted by a qualitative method (interviews) and therefore this theory gives a better well-defined overview of criteria which are applied. Trustworthiness exist according to Guba and Lincoln (1994) up of the four criteria: credibility, transferability, dependability, confirmability which will be explained in the text. Authenticity exist of the criteria fairness, ontological authenticity, educative authenticity, catalytic authenticity and tactical authenticity.*

### Trustworthiness

Credibility, also called member validation which means if the interviewee is related to the specific topic. And how real are the findings with reality, is part of the credibility. The LinkedIn profiles of the interviewees are checked, to make sure that their function are actually related to the research (question). The interviewees were proceeded anonymous to prevent the interviewee does not give openly their opinion during the interview. However the interviewees were proceeded anonymously function title is used by reviewing this research by supervisors. However this job title is used by the review of supervisors this is currently marked black, because to ensure the anonymity of the interviewee. As start of the interview is always held a debriefing session to inform the interviewee also is asked to the interviewee to give a brief description about themselves and their job. For the interviews, some factors are taken into account to increase the comfort of the interviewee, for example, interviews have been held at the location of the interviewee which allows the interviewee to give open and reliable answers (Butterfield, Borgen et al. 2005, Galletta 2013). Also some of the interview transcripts are reviewed by the interviewee. Provision of background data is also part of the transferability criteria. Transferability means if the research can be generalized to other contexts or settings (Guba and Lincoln 1994). To test the research transferability it is supervised and checked by professionals of the industry who are working for Van Gelder. To ensure that the opinions and assumptions are correct interpreted. Dependability, means the quality of the collected data. By overlapping method data is double checked. For the semi-structured interview, the technique to re-ask questions was used: this means that after the interviewee answered a question, the same question in another context is asked again. Also called triangulation is used by asking the same research question among different interviewees. There is assessed an opinion double by interviewee but also among different interviews. And in some cases, the colleague of the interviewee is interviewed by doing this the data can be multiple times checked. Triangulation is also part of the confirmability criteria, but also the admission of the researcher beliefs and assumptions should be taken into account (Guba and Lincoln 1994). The assumption of the researcher can be discussed during this study because the research their business background and not a technical background, however this can lead to loss of information is made is also possible to review the whole situation open minded.

## Authenticity

The wider political impact of the research will be explained by the authenticity criteria (Guba and Lincoln 1994). For the interviews are only professional who are familiar with the road construction sector and circular economy interviewed. Missing are project managers, EMVI/BPKV coordinators and engineers, the fairness of the research can be discussed because the opinion of this group of people is missing. Only the “boosters” of the circular economy are interviewed there is a possibility that their opinion is not in line with reality. To understand the situation of the interviewee often is asked about more information, or if the interviewees can explain their opinion. Which is part of the ontological authenticity to understand the social environment of the interviewee. Ontological and educative authenticity is not direct applicable for this research, because they are more applicable for social studies. This study will be openly published and shared which implicates tactical authenticity of the study (Guba and Lincoln 1994).

## Data analysis

The qualitative data is processed in several steps. Firstly the data is recorded with a mobile phone. Directly after the interviews, the recorded data is written down by computer. This text document is analyzed by software (Atlas.TI) where the text document can be put into different codes. This process is called open coding. The goal of this is to reduce, interpret en to reconstruct rare data (van Staa and Evers 2010). During the coding process, it was considered that codes should be interpretative or descriptive by nature. The codes were defined towards criteria, processes, actions or products. Not for all the data analyses is used open coding for the key elements of the circular economy model is used manual analysing. For every specific key element is analysed the transcripts of the interviewees if some references are applicable toward the specific key element of the circular economy. Table 4 shows an example of the open coding from the transcript into code – Sharing knowledge (Market <-> Purchaser) The first part of the table implicates the answer of the interviewee the second part is the code of the interviewee (respondent 1, 2, 3, 4 and so on).

<b>Code: Sharing knowledge (Market&lt;-&gt; Purchaser)</b>	<b>Respondent</b>
“Important for the circular economy in the road constructing sector is that parties of the market and purchasers are going to collaborate. Not directly collaboration, but sharing knowledge and experiences with each other. Private parties can and will innovate much quicker than <u>we</u> do - government-related organizations.”	R3
“Our knowledge is too minimal in comparison to the market. The market has a lot more knowledge in comparison to us.”	R5
“The market can offer new innovative products.”	R11
“We as purchaser should advise market parties, and offer the problem. It is up to the market to find a solution for it. We have to keep each other up-to-date and motivated to challenge each other.”	R5 - R8
“Sharing knowledge is possible with ‘Bouwteams’ and market consultations. This way knowledge can be shared between both parties in an early stage of the process.”	R9
“Sharing knowledge is important for the circular economy”	R10
“.... By challenging the market to come with circular solutions and sharing information”	R6

Table 4 – coding interview



The codes were processed anonymously, this was necessary to guarantee the trustworthiness of the research so interviewees can openly give their opinion. The coding process made it possible to translate data into graphs.

Twelve participants in eleven interview session have been interviewed. The data is presented according to four categories: overview of the circular economy in the road construction sector, characteristics of the circular economy in the road constructing sector, measurability and valuably of the circular economy and circular in the road constructing in comparison to the key elements of the circular economy. This structure of data presenting gives the possibility to answer the main research question.

## Results

### Overview map of the circular economy aspects in the road construction sector by interviewee

Figure 10 gives a structured overview of important aspects of the circular economy. There is chosen to use this overview map, because it give an central overview of all the information which is gathered by the interview. It is a global overview of references by interviewees. Based on the information which is gathered by the semi-structured interviews. This overview shows the different actors of the circular economy in the road constructing sector mentioned by interviewees. How bigger the circle is how more often is referred by interviewees. Some actors are related to each other others are indirect related based on this are the lines drawn.

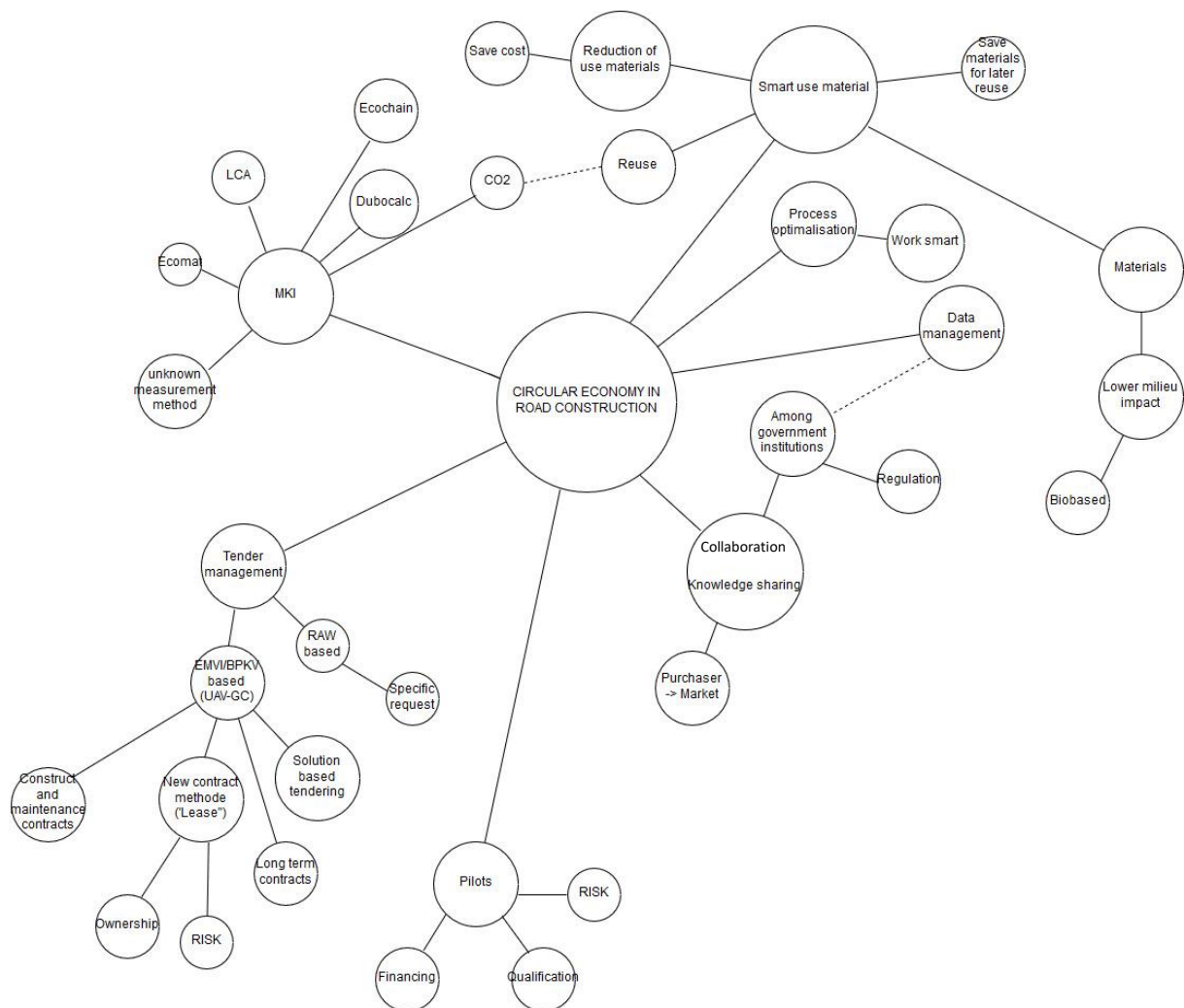
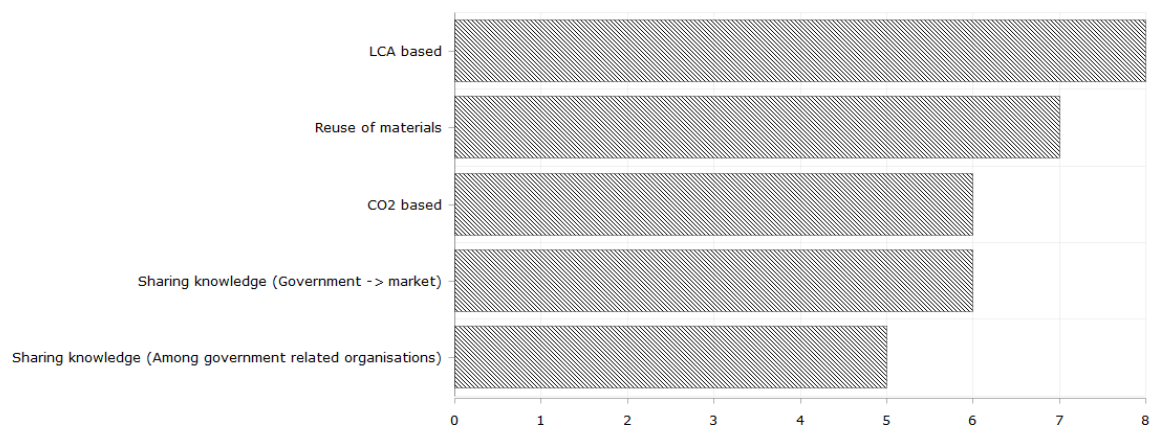


Figure 10 – overview of circular economy in road construction

Circular economy in the road construction has several main relations according to the interviewees. Knowledge sharing, smart use of material, MKI and tender management are the most referred to and well substantiated by interviewee therefore they are in the first line with the main topic. For example MKI can be based Ecochain, Dubocalc, Ecomat and some interviewees referred to an unknown measurement method. The MKI is LCA based valuing method and therefore this is also included. Tender management is based on the BPKV or RAW and this are again related on several topics who are mentioned by interviewees. Smart use of material is referred often by interviewees, because this is an easy method which can be easily be executed by constructor and purchaser. It has for both parties advantages. Purchaser can be valued more sustainable and constructor will saving cost. Collaboration is also important according the interviewees, because this made innovation possible towards a more sustainable road construction sector. Collaboration can be seen as knowledge sharing between government related organizations, companies and between both (companies and government related organizations). However this research is conducted to conclude how tenders will be defined often is mentioned by interviewees that the procedure is not necessary to change but the standards of the industry have to change. By operating, acting and designing smart can be delivered a circular product which has advantages for both parties.

## Characteristics of circular economy in the road construction sector



Graph 1 – characteristics of circular economy in road construction

Graph 1 shows the findings of the interviews and frequencies referred to the specific characteristic of the circular economy in the road constructing sector. When looking for the aspect concerning the characteristic of the circular economy in the road constructing sector, the mention of LCA based, reuse of materials and sharing of knowledge is remarkable. Often is referred to this specific characteristic by interviewees. There are used five characteristics, because towards this characteristics is mostly referred by interviewees, other were not interested to include in the research, or are not often enough mentioned by interviewees.

### **LCA based**

One of the characteristics of circular economy in the road constructing sector is LCA based. This is mentioned by R2, R8, and R9 is important according to the interviewees because:

*“LCA will be important in the future because it gives an overview of impact and lifespan, CO2 output and actually the whole environmental impact of the chain.” R2, R8, and R9*

That importance of LCA is clear due to the interviewees. Some named Dubocalc, Ecochain or Dubomat as the possibility to measure the LCA in the road construction sector.

*R5, R8, and R6: “A possibility for measuring the LCA is Dubocalc – MKI”.*

### **Reuse of material**

Reuse of material is important according to the interviewees. R4 and R3 also mentioned that they want to improve the quality of the reused material. Also, interviewees mentioned in general that they want the reuse to take place quicker, smarter and better. It should be a process from recycling towards the reuse of material. This process of reuse is not only interesting for purchaser but also for the tenderer mentioned by R9 and R6.

*R4 and R3: “100% reuse of materials is never possible, but we want to increase the reuse of the materials, for the top layers of the road as well.”*

*R9 and R6: “Reuse is also becoming more and more attractive. Sustainable asphalt is by definition also cheaper. It has not only benefits for the purchaser but also for the contractor”*

Reuse of materials is not only focused on the aspect of replacing old asphalt. For the future and by design it is important to take into account that it should be possible for asphalt to be 100% reused over the upcoming years. Nowadays most of the asphalt will already be reused but in the future, but the quality should be increased so old asphalt can be 100% reused in all the layers of the road.

*R9 and R6: “By data management asphalt can be better reused in the future.”*

*R7: “100% reuse of asphalt is the goal for the future.”*

### **CO2 based**

CO2 is often referred to by interviewees. Actually, the CO2 is part of the MKI(LCA) but due the fact that interviewees referred often individually to CO2 is it separately involved as a code. It is for example mentioned by R3, R5, R7 R8 and R9, mostly according to the measurement possibility of being circular.

*R3 and R8: “CO2 will be important in the future to operate circular and measure it.”*

*R5 and R7: “CO2 reduction...”*

*R9: “CO2 gives the possibility to measure sustainability.”*

### Sharing knowledge (Government <-> Market)

R3, R5, R11, R9, R10 and R6 mentioned something concerning the code sharing knowledge (government <-> market). Specifically interviewees mentioned the following:

*R3: "Important for the circular economy in the road constructing sector is that parties of the market and purchasers are going to collaborate. Not directly collaboration, but sharing knowledge and experiences with each other. Private parties can and will innovate much quicker than we do - government-related organizations. – Be objective"*

R3 already noticed that private parties can realize innovation quicker as government-related organizations. R5, R8, and R9 also confirm this.

*R5 "Our knowledge is too minimal in comparison to the market. The market has a lot more knowledge.."*

In reaction to which role the purchaser should take into the circular transition to the market, interviewees respond with:

*R5 and R8: "We as purchasers should advise market parties, and explain the problem. It is up to the market to find a solution for it. We have to keep each other up-to-date and motivated to challenge each other."*

*R9: "Sharing knowledge is possible with 'Bouwteams' and market consultations. So knowledge can be shared between both parties at an early stage of the process."*

All these characteristics suggest the importance of a chain approach. A part of the interviewees agreed that the circular economy in the road constructing sector should not only be based on product 'creation'. The chain approach should be used, where everything works smart and collaborating at a specific level.

### Sharing knowledge (Among government-related organizations)

R4 and R5 noticed that it is important to share knowledge between institutions. This should be with contractors but also among government organizations. Most of the non Rijkswaterstaat participant mentioned that they gather data and knowledge by Rijkswaterstaat.

R6 and R7 motivated this with: *“Sharing knowledge is important among governments’ institutions (purchasers) because one party does not have enough market share and knowledge to realize direct innovation. - Also, knowledge and data sharing can avoid expensive pilots.”*

Interviewees said that they collect a lot of data from Rijkswaterstaat due to the power of Rijkswaterstaat:

R7 and R4: *“Rijkswaterstaat has a lot of knowledge of the circular economy. They have even more power to collect and create data according to the topic. Therefrom Rijkswaterstaat has an example function for us.”*

Code – characteristics of circular economy in the road construction sector	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11
LCA based		x	x	x	x	x		x	x		x
Reuse of materials	x	x		x			x	x	x		x
CO2 based		x	x		x		x	x	x		
Sharing knowledge (Government <-> Market)			x	x	x	x				x	x
Sharing knowledge (Among government-related organizations)				x	x		x		x		x

Table 6 – characteristics of the circular economy

## Measuring the circular economy in the road construction sector

In order to measure the circular economy (8 codes are used, see table 7 for overview codes) the interviewees all answered that they are developing and testing new methods for them to measure the circular economy by tendering. Mostly the interviewees said that it is too early to conclude which is the right measurement (model) method to measure the circular economy in the road construction sector. Concluding how measuring circularity in the road construction due to tenders in the sector will be applied, is difficult and makes it impossible to draw a conclusion. This is a developing process with a range of possibilities is, which just started. R1, R2, R11, R7, R8, R9 mentioned that they just started with developing the possibilities of measuring circular into the tender procedure. Moreover, R8 and R9 said this about it:

*“Currently we are developing how we want to make circular possible in the tender process. This is an on-going process where we have some barriers.” R8 and R9*

If circularity is really feasible and measurable, R4, R9 and R11 put it into the discussion if the goal of been circular will be reached by this methods.

R4 and R9: *“If it is possible to measure something (CO2 for example), will this reach the target we had in mind? - We have to take this into consideration.” (underlined only mentioned by R4)*

R11: *“Making circularity measurable is not interesting, because not everything is measurable. And especially with innovation, this is difficult.”*

R1, R2, R3, R5, R7, R8, R9, R10 and R11 are using the MKI value often in their tender or will use the MKI value in the future to challenge the tenderer to offer a circular product. If the interviewee uses the MKI value than R4, R7, R8, R9, and R10 use Dubocalc as calculation model. Other calculation methods for the MKI which some interviewees used are Ecochain, Ladder of Lansink, and data of NIBE. Interviewees mentioned that they use not only one measurement method for circularity, but are experimenting with more methodologies.

Code – characteristics of circular economy in the road construction sector	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11
MKI	x	x	x		x		x	x	x	x	x
Dubocalc				x			x	x	x	x	
The standard											
Ecochain	x										
Scarcity					x	x			x	x	
Ladder of Lansink				x							x
CO2	x										x
Data of NIBE		x	x								
Not known											x

Table 7 – MKI overview

## Valuing the circular economy in the road constructing sector

Respectively nine interviewees indicated that the MKI will be used for measuring and valuing circular solutions. A part of the interviewees also mentioned that a circular solution will be the standard in the future. They mentioned as well that a circular product and process will be a standard hard requirement in the tender in the future (R3, R7, R8, R9, R10, and R6). Standard hard requirement - means if the tenderer does not offer a circular product the purchaser will not accept the tender.

*"It is just a matter of time for a circular product and process to become the standard to participate as tenderer." R9*

However, R3, R7, and R8 mentioned that circular solutions will be the standard in the future, because of to challenge the contractors. R10 and R7 are already a step further and expect that circular solutions, when no longer a challenge, will have to be the standard. It is not even plausible that the value of the MKI in the EMVI/BPKV procedure will increase to establish circular solutions.

*"If something is not a challenge anymore it needs to be the standard criteria" R7 and R10*

Interviewees also refer to the fact that constructors said that the MKI value is not high enough to make circular innovation possible. Interviewees R10 and R3 mentioned that circular solutions should not only be offered based on the MKI, and R10 and R2 said that circular solutions do not always have a negative impact on the costs of a product.

*"Circular solutions should not always be a value-driven offer by the contractor, but a solution which solves the problem." R10 and R3*

This is mentioned about the cost of the circular solutions:

*"By offering 'circular' asphalt it is not a given that the costs will be higher.... It can even ensure cost advantages to the contractor." R10*

The MKI is an important method which is often referred to by interviewees. There are also barriers and disadvantageous of the MKI according to the interviewees: MKI can be uncreative, not all the products are included, MKI (value) is not per definition circular, MKI is only applicable by large projects, a new company cannot use Dubocalc, because their mixture is not included.



## Transition in the road construction sector over time

The main category of code “Circular transition process” has as the main goal to analyze where the government related institutions stand towards the circular transition.

Interviewees often mention where the organizations stand in the circular transition. R1, R2, R3, R4, R5, R7, R8 R10 and R11 mentioned all that they are currently developing possibilities of circularity. R11 is open about it and mentioned that they are still defining the definition of the circular economy for their organization, measuring is even a step further.

*R1 “Currently we are starting with the circular economy in our organization.”*

*R11 “... we are defining the definition of the circular economy in our organization. How we want to measure and make circularity possible is for us currently unclear.” – “Currently we are in the middle of the process of developing how we want to deal with the circular economy in the infra part.”*

*R10: “Currently we are looking at how we want to develop the circular economy within the organization. After that, we want to look how we can implement and measure it, with as main goal to reduce the use of raw materials.”*

While R1, R3, R4, R5, and R11 are starting with the circular economy, interviewee R7 and R8 mentioned that they are testing principles of the circular economy on several projects. This means they are already a step further. Based on the experiences they are gathering data to develop a policy.

*R7 “Currently we are applying the circular principles in different projects. We want to apply circularity to the maximum by these projects. It is a learning curve for us, so we can apply it in long-term.”*

*R8 “... on different levels we are preparing on the circular approach of networking.” – “We are testing different types of measurement to get the best ‘circular project’.”*

Currently, all the interviewees mentioned that they are in the start phase to introduce the circular economy in their organization and projects. The interviewees are developing their policy and measurement methods. Based on this information it is too early to conclude which criteria, value method and measurement method will make circularity aspects possible in the road construction sector.

### Circular in the road constructing in comparison to the key elements of the circular economy.

The eight key elements of the circular economy in the part weighted against the opinion of interviewees. It is interesting to reflect how the road construction sector regards this model because based on this information, a structured analysis can be made of how the road construction sector will improve their business from a linear business towards a circular business model.

**Model 4 shows the overall fit of the circular economy in the road construction reflected on the current view of the interviewee.**

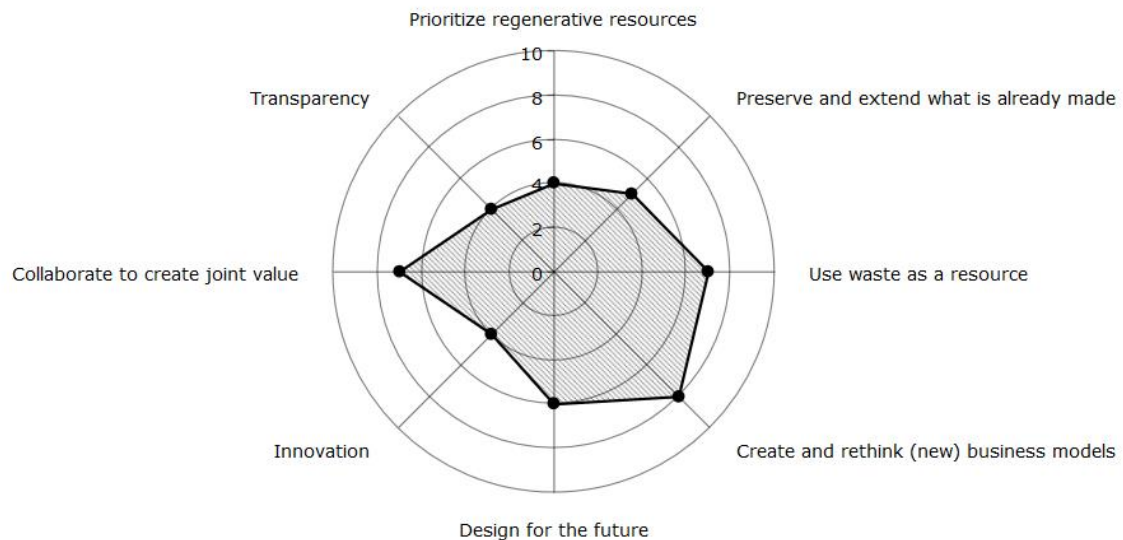


Figure 11 – key elements analyses of road construction spin

Key elements	Description
<b>Prioritize regenerative resources</b>	<p>CO2 has already a big impact in the road construction industry. It is often covered by the MKI and CO2 ladder in the tender. A point of discussion is the discount value of the MKI towards the value of the tender. In the current situation, according to interviewee R1 and R4, it is still possible to win the tender based on the lowest price in comparison to the best product.</p> <p>R1 <i>"The virtual discount of the MKI is still not high enough in comparison to the tender value. Therefore it is still happening that lowest price bidders win."</i></p> <p>However, R11 and R10 disagree with this:</p> <p>R11 and R10 <i>"In the current situation the MKI value gives enough possibilities to offer circular products."</i></p> <p>And R3 found it a complicated situation. R3 <i>"The MKI value is not the only reason to stimulate innovation, it is also a reason for us to stimulate innovation and tenderers to work more sustainable."</i></p> <p>Therefore it is possible to change the system and replace and prioritize regenerative resources. However reducing resources and raw materials should be an important aspect according to interviewees R2, R11, R7, R8, and R9.</p> <p>R7 <i>"By reducing the amount of materials we use,, we can achieve a lot of circular goals."</i></p> <p>When asked about their opinion towards more biobased products, interviewees mentioned that the bitumen can be replaced by biobased bitumen, but this is in comparison a minimal difference. Not often is referred to this (biobased) part of the circular economy, defined by the Ellen MacArthur Foundation.</p> <p>R10 <i>"In the future, we want asphalt which exists of mostly biobased products."</i></p> <p>However, the sector is working hard to improve their system towards a more sustainable sector where CO2 will be measured, valued and checked. Currently this is often not be applied by for instance MKI. Therefore the element 'prioritising regenerative resources' scores low with a 4 on a scale of 1 to 10. Small steps can be made to improve this key element of the circular economy in the road construction sector. By using the MKI value more often in tendering, the MKI will add more leverage to increase the creative process by tenders, asking other (hard) criteria from the tender and also pay attention to biobased products.</p>
<b>Preserve and extend what is already made</b>	<p>By smarter and better use of data and knowledge, roads should have a longer lifespan. R9 and R4 mentioned during the interview that data using data will be important:</p> <p>R9 <i>"....we have to use data analysis. We should look into the safety of roads, maintenance, and situations which influence the quality of the asphalt."</i></p> <p>R4 <i>"By analyzing data, we made the quality and state of the road better measurable."</i></p>

	<p>Currently, processes are being developed and especially the data part of it is starting. Therefore the key element of the preserve and extend what is already made scores currently a 5 out of 10.</p>
<b>Use waste as a resource</b>	<p>Most of the asphalt will be reused for new asphalt. Currently, a big part of the asphalt will be reused but according to R7 is it a challenge to increase this to 100%.</p> <p>R1 said that the reuse of the material will also be expensive because;</p> <p>R1 <i>"labour is currently too expensive for higher reuse percentages. Raw materials will decrease in the future where higher percentage of reuse will be interesting"</i></p> <p>R9 has a completely different opinion with regards to this subjects and said that a high percentage of reuse is already interesting.</p> <p>R9: <i>"Reuse of asphalt is per definition interesting for tenderers because it saves cost."</i></p> <p>The challenge in reuse is according to interviewee R11 and R4</p> <p>R11 <i>"Right now we downcycling asphalt too much, we have to find solutions for this."</i></p> <p>According to R4 <i>"The reuse of the product depends on the quality and design. Especially because when recycling, it is difficult to define all the substances."</i></p> <p>Another challenge, according to R8 and R6, will be to reuse the asphalt again in the top layer of the road. Currently, most of the asphalt will be reused in the other layers, but not in the top layer of the asphalt. In general, materials will in most of the cases be reused, but there are some possibilities for improvement. The industry scores a 7 on a scale of 10.</p>
<b>Create and rethink (new) business models</b>	<p>Interviewees mentioned "roads of the future" which means the a to b principle wherein the responsibility of the transport from a to b is for the tenderer for several years. How this will be fulfilled is for the tenderer self. R5, R11, and R9 refer to this:</p> <p>R9 <i>"...we will be the functional user of the road/infra. <u>Where transport from a to b and circularity is a central requirement. - It is not even important how the tenderer will carry it out.</u>"</i> (R5, R11, mentioned also last part; underlined)</p> <p>Often the interviewees mention a changing tender setup, where they will ask specific criteria but which are not specified in detail. This has as the main goal that tenderers can offer new, innovative and high-quality asphalt mixtures. - R6, R3, R7, R9 mentioned this.</p> <p>R3 <i>"We are specific in requesting criteria of circularity, but absolutely not specifically by determining solutions. It is up to the market to fulfill the requirements of their solution. The requirements (criteria) will be increased, to challenge the market time after time."</i></p> <p>Towards the principle from a to b is a long journey, but applying business models as DBM and DBFM (Design Build (Finance) Maintenance) will become more interesting</p>

	<p>according to interviewee R6 and R10. For now, a till b is a long journey, but DB(F)M contracts are applied already. Therefore create and rethink (new) business models scores an 8.</p>
<b>Design for the future</b>	<p>Design for the future is often mentioned by interviewees; especially that circular road constructing should start by design and be established due to the processes. R4, R11, and R6 mentioned that circularity in the road construction sector can only be accomplished by a chain approach.</p> <p>R4 and R6 <i>"... it is essential to work together in the whole process, as a chain approach...this starts with design"</i></p> <p>The design already should be started with the circular aspect.</p> <p>R2 <i>"It is important to start into the design with the circular aspect in mind. From that point products can be reused in the future and can be improved."</i></p> <p>Most of the interviewees mentioned that they want to reuse the materials right now. R2 and R4 mentioned as well that when making the design, the reuse of materials in the future should already be determined</p> <p>R11 and R7 <i>"Currently we apply the circular aspect in several projects that already started."</i> But the general design aspect for the future is missing.</p> <p>Currently, the circular aspect enters later into the project than the design. This can and should be improved to create higher quality and smarter products. Design for the future scores a 6 out of 10. Because, currently the circular aspect does not start already by design, but after design most of the project will be 'upgraded' with a circular aspect.</p>
<b>Innovation</b>	<p>Innovation is complicated in the road construction sector R1, R4 is mentioned;</p> <p>R1 <i>"By asking too much innovation by one party, it can lead to unfair competitive advantages. It is required to get enough tenderers for a project to get an open market competition."</i></p> <p>R3 <i>"It is difficult to make innovation possible due tenderer procedures. So start with a pilot"</i></p> <p>The solution is according to R3, R5, R8, R9 and R6 difficult, but to start with a pilot. It is important for innovative products which are being tested in a pilot to have a clear vision and make it measurable. Do not start a pilot without a clear goal and possibility to make the product market worthy and to produce it in standardized mass production. (R3, R5, R8, and R9)</p> <p>R3 and R5 confirm <i>"We are open to pilots, but only with a clear goal."</i></p> <p>And R9 and R8 have a solution towards innovation and quality. R8 and R9 <i>"By using data the quality of the (test/new) asphalt can be measured."</i></p> <p>New products will be offered by start-ups and already established companies. R4 mentioned <i>"Start-ups often introduce new products, which will be adopted by big reformed business"</i> – <i>"This is an interaction between market parties, wherein reformed business mostly can demonstrate the quality of a product"</i></p>

	<p>The biggest challenge is demonstrating the quality of new innovations, because it is new and nobody has experience with the asphalt mixture. From there, the question is raised how to deal with risks, according to R3, R7, R9, and R10. Pilots are the best way of testing risks, according to R3 and R10. In the future the risk of a pilot should change from the government carrying the risk, to the tenderer carrying the risk, state R7, R9, and R10. Innovation is a difficult process in the road construction sector, where new product development takes a while. From a niche product towards a standardized mass production asphalt can take several years. It can be stated that pilots are happening and new innovations will be introduced, therefore innovation in the road construction scores a 4 on a scale of 10.</p>
<b>Collaborate to create joint value</b>	<p>According to interviewee R3, R4, R5, and R9 knowledge sharing is important to stimulate circular development in the road construction sector. Knowledge sharing can happen between market and government institution and among government institutions. Sharing knowledge can be seen as collaboration to create joint value in the road construction sector. As motivation R5 mentions the following:</p> <p><i>R5 “Our knowledge is too minimal in comparison to the market. The market has a lot more knowledge in comparison to us.”</i></p> <p>Often the interviewees mention that level of the playing field is changing due the circular aspect. Firstly, the tenderer (market parties) often have more knowledge than the government related organization and secondly, interviewees R11 and R9 mentioned that they use market consultations to gather information before the whole process started. R9 mentioned that this will be an upcoming facet and will be used often to gather important information about solutions.</p> <p><i>R6 and R9: “Sharing knowledge is possible with ‘Bouwteams’ and market consultations. This way knowledge can be shared between both parties in an early stage.”</i></p> <p>Also, it is plausible that the level of the playing field will change which is already mentioned earlier by ‘Create and rethink (new) business models’. It will change from separated build and maintenance contracts, towards contracts which contains build and maintenance (DBM and DBFM - R10 and R6). Changing contracts have a positive influence on circularity. Therefore it scores a 7 on a scale of 1 to 10, but there are still possibilities to change the current system towards a system where market consultations and DBM and DBFM will be applied more.</p>
<b>Transparency</b>	<p>Being transparent and open is important for the road construction sector, especially due to events in the past. R1, R2, R3 and R11 mentioned the ‘bouwfraude’. This can be interpreted as an obstacle for tenderers, but transparency and knowledge sharing is according to interviewees an open way of making innovation possible mentioned R3, R4, R5, R11, and R9.</p> <p>Reflecting the key elements of the circular economy, transparency is an undervalued key element. A policy is missing towards what is possible and what is missing from data, knowledge, and problems where the industry and government-related organizations are dealing with. Therefore it scores a 4 on a scale of 1 to 10. For the future, to make the circular economy possible it is important to develop a further policy for sharing knowledge and data.</p>

Table 8 – key elements of circular economy in road construction

## Discussion and conclusion

This chapter entails the discussion and conclusion of this research. The discussion outlines the sub question which are not answered yet and the main research question. The different theoretical and empirical findings are compared, analyzed and discussed. Afterwards, a conclusion is formed, to answer the research question. Finally, implications for further research are discussed.

Actions which purchasers (Rijkswaterstaat, provinces, and local government) perform to construct circular roads by 2050 are broad. The literature shows that often a top-down approach is used for applying the circular economy. Governments stimulate applying circular solutions by enforcing rules and policies. This research shows that the industry is actually ready to offer circular products, but the government related organisations are not ready to request, value and measure circular solutions in the road construction industry. And without the possibility of offering circular solutions there will never be a circular solution offered, because the sector is bound to rules and guidelines. A gap between literature and the actual situation in the road construction sector. Also due to the fact that tenderers not always or often request a circular product it does not produce economic competitiveness by competitor advantages. However, the literature describes that it creates jobs, prevents waste, and saves resources which is in line with the findings of this research.

How will the circular economy be measured and valued in the road construction sector? It is plausible, that the MKI(LCA) will be leading when it comes to the circular economy in the road construction sector. This will be based mainly on Dubocalc. However, some organizations mentioned that this way of sustainability measurement is not applicable to their organization (because of the size of the project and missing data). It is likely that this measurement module will be improved upon for this kind of projects. In RAW tenders the circular aspect will be comprised into criteria. Currently offering circular roads will be a possibility, however in the future it will be a hard criteria. For the lowest price bid without circular aspect, there is no place in the future. A challenge will be whether all the principles (which are currently unclear for the industry) of the circular road construction sector will always be included in tenders. A danger will be that excellent circular solutions will not always be valued because of the standardized processes. For example: an investment can be made by a specific tender in the production process or product which is not in the MKI - Dubocalc software. Another fact is that, for purchasers in the road construction sector, the 'refuse' part is difficult due to law regulations. If purchaser want to accept and perform the circular economy in their projects regulation can be a drawback. However literature suggest that public procurement can be an advantage for innovation.

How does the road construction sector perform in comparison to the general key elements of the circular economy? Based on the key elements of the circular economy the road construction sector scores low. The factors 'prioritize regenerative resources', 'preserve and extend what is already made' 'innovation' and 'transparency' score the lowest. 'Prioritizing regenerative resources' is scoring low due to the fact that the government related organizations are not using the sustainable resources they have available. 'Preserve and extend what is already made' is new for the sector: they are always thinking about the process of construction and not about the long term. When it comes to transparency, a national global sharing platform is missing, which would ensure innovation is developing quicker. Innovation is scoring low due the fact that the road construction sector is conservative and products will only be applied if quality is proven. All these elements should be built upon towards an improved circular business model in the road construction sector. The other key elements did not score significantly low and are therefore less interesting.

An aspect that some interviewees are missing, is the process aspect of the circular economy where design and type of contractor are also included; they are only focused on product or project level and the reuse of materials and not the reuse and sustainability of the products for the future.

Others mentioned this as the most important part of being circular. Another thing missing in the industry is collaborating and a knowledge sharing platform which is accessible for everyone. Literature shows that for innovation and transition towards a circular economy interactiveness, cooperation and especially knowledge sharing through the whole chain is important. Currently this is not happening and there is a big gap between literature and what is happening in the road construction sector towards a circular economy.

In what period is the introduction of criteria based on constructing circular in tenders feasible? To make the circular transition possible in time, acceleration is necessary otherwise the targets of 2030 and 2050 will never be achieved. For the process of testing and quality warranty, twelve years is not that long. Accessible data and knowledge sharing should be an aspect before defining concepts and policy plans, otherwise, well-substantiated motivation will be missing for policy executors. The following characteristics will be important: systematic working, designing for the future, reuse of materials now and for the future and being ready for innovation. The circular economy in the road construction sector should accelerate and be more successful in changing from a project or product approach to a system thinking approach. Also, an unambiguous approach, government-wide will probably give better results, where the purchasers and tenderer understand each other better. Currently, the purchaser has often no idea how to perform circularly and due to this doubt the tenderer has no idea what to offer. It is also plausible that the level of the playing field will change in the future to construct circularly in the road construction sector. Currently, it is mostly based on supply and demand, but it will change to offering rethink, in which tender parties are already involved in the design phase. DBM and DBFM contracts will also be more attractive due the design phase is involved.

How will tenders be defined in order to achieve the goal of constructing circular roads by 2050?

The road construction sector is currently early in the developed phase. This conclusion is defined based on the section "Transition in the road construction sector over time." The reason for this is the fact that most of the parties who are interviewed in this research are in the start-up phase of the circular transition. They are defining the meaning of the circular economy, are shaping policy or are testing circular possibilities. For the interviewees, it is far too early to draw a conclusion on how the circular economy will be made measurable and even valuable by tendering. If that is going to happen. Also the model of the sociotechnical theory of Rotmans, Kemp et al. (2000) shows that a transition is an interaction between different stakeholders defined on procedures and rules.

The circular transition will be developed step by step due the several levels according to the model of Elzen, Geels et al. (2004). This is currently also happening in the road construction sector. The first step is made, but due to challenges of the purchaser, further development is actually missing. New innovative products which are more sustainable can be considered as niche, the regime is the current regulation and the landscape is the government, tender request, and policy. However, this research was conducted to give structured answers towards how the niche market will involve into the landscape by tendering. It is currently too early to conclude how this will be achieved. This is because a general policy and approach are missing. More interaction between parties is needed and also necessary to change from a niche market towards the landscape. It can be concluded that transition probably will be established the same as in the model, because most of the factors are present. However, currently it is too early.

Currently these regulations, rules and innovations (Niche and Regime) are not developed enough so that they will change the landscape directly. This is an on-going process which just started as can read earlier in the conclusion. Tenders will be defined based on the MKI value and later on this will probably translated into hard criteria. This made circular solutions the standard in the road construction sector. By this can be answered the research question.



For companies in the road construction sector: the MKI value will be leading the next couple of years to construct circularly and this will in time change into hard criteria. Reducing the CO2 impact and chain approach with their sub-contractors and suppliers will be important to reduce cost and innovate quickly with as few resources as possible.

## **Relevance**

The academic relevance of this study is the investigated gap in literature between innovation and tendering, and innovation in the road construction sector. This research shows there is a difference between innovation and tendering, and innovation in the road construction sector. Also the transition theory which is described in this research differs from other industries compared to the road construction sector. Actually there are factors missing which made the transition theory possible. The fact is that this research presents solutions towards how public procurement in the road constructing sector and the target of being circular by 2050 will be achieved by tendering. Several studies have been performed on how civil engineering has to deal with sustainability (Ortiz, Castells et al. 2009, Azis, Memon et al. 2012, Alam and Kumar 2013). Besides, there have been studies on how public procurement can be more sustainable but based on the tender (criteria) and circularity, there was a gap in the literature. Sustainability is a more holistic term based on environmental impact where circularity is specified on the reuse (closed loop) and durability of materials in the future to lessen the environmental impact (Geissdoerfer, Savaget et al. 2017).

The practical relevance of this study is how the road constructing sector and especially Van Gelder can deal with changing tenders focused on circularity.

## **Limitations of research**

This study is based on data which is gathered by eleven respondents who are employees of Rijkswaterstaat, provinces or local governments. A bigger group of respondents can improve the strength of the research, but due to the fact that finding participants was difficult, this was not possible. Furthermore, this study is executed in the Netherlands. In other countries the same study can produce different results. Further research can be applied based on the criteria that are formulated in this research. A recommendation is that in several years the same research can be conducted again to evaluate how the circular transition develops in the road construction.

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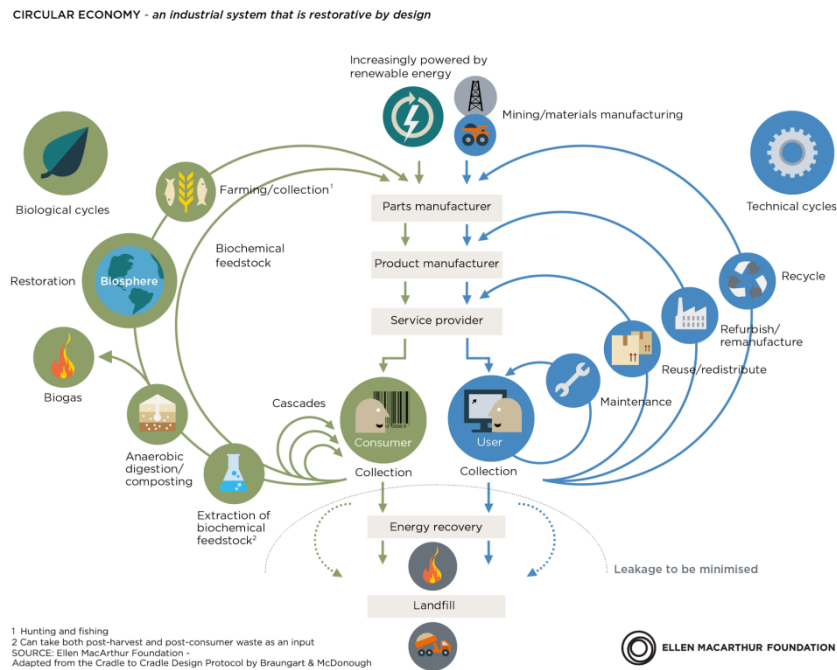
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# Appendices

## Appendix 1 – Circular economy



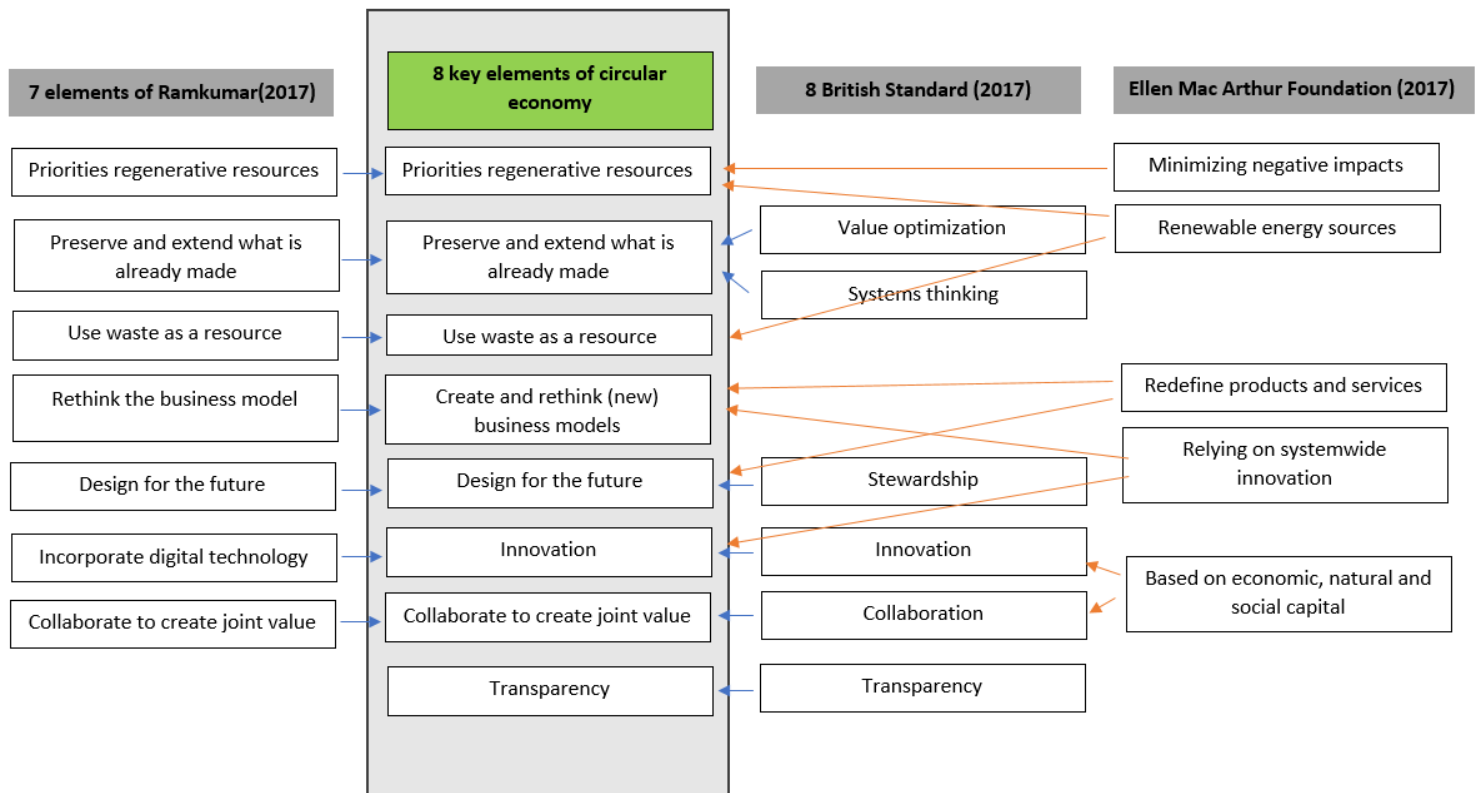
(MacArthur 2013)

## Appendix 2 – Lansink's ladder



(Lansink and de Vries-in't Veld 2010)

### Appendix 3 – Key elements of circular economy



### Appendix 4 – Asphalt





## Appendix 5 – Global structure interview

Function:

Time:

- Hoe komt u tijdens uw werkzaamheden in aanraking met de circulaire economie?
- Wat is belangrijk om circulair te zijn?
- Hoe gaan jullie circulariteit waarderen?
- Zijn er momenteel al projecten 'circulair' gerealiseerd?
- Wat doet u qua aanbesteding op gebied van voorschriften?
- Wat is de reactie op het 'circulair' aanbesteden van marktpartijen?
- Wat stimuleert circulariteit?
- Wat werkt circulariteit tegen?
- Denkt u dat circulariteit omvat kan worden in contracten/tenders?
- Maar als aannemers die de laagste prijs er neer gooien winnen standaard, hoe denken jullie dat nu op te lossen?
- Waarom zal een aannemer een circulair product aanbieden, want wie de laagste prijs aanbied wint toch de tender/aanbesteding? Hoe denkt u hierover?
- Hoe ziet u de ultieme circulaire weg?
- Hoe ziet u de circulaire weg van de toekomst?
- Wat is daarin nu jullie functie om circulaire wegebouw mogelijk te maken?