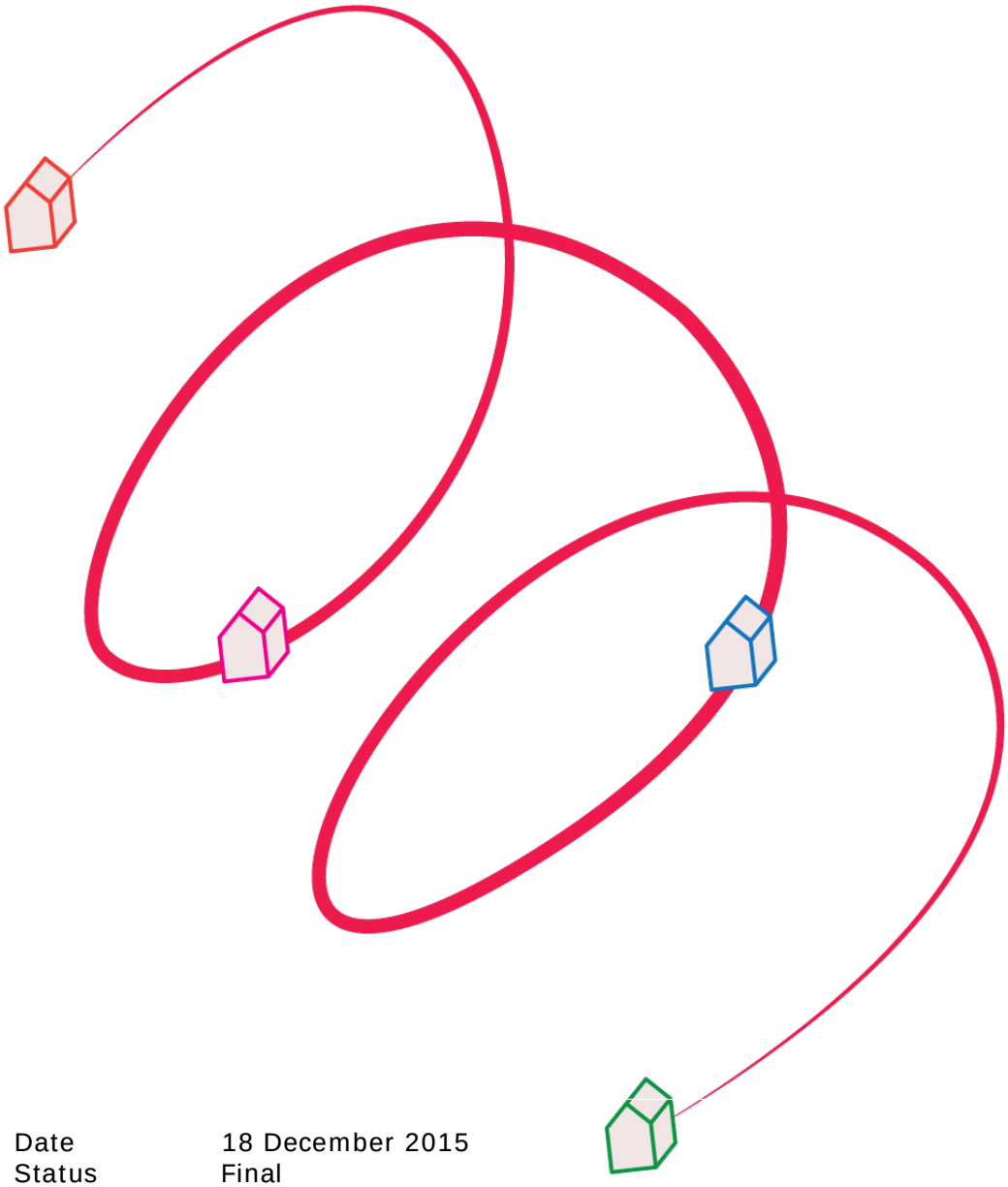
Rijkswaterstaat
Ministry of Infrastructure and the Environment

Circular economy in the Dutch construction sector

A perspective for the market and government



Date 18 December 2015
Status Final

Colofon

Published by	Rijkswaterstaat – Water, Verkeer en Leefomgeving[1] National Institute for Public Health and the Environment (RIVM)[2]
Information	RIVM report number 2016-0024
Telephone number	+31 88 797 29 48 (Rijkswaterstaat) +31 30 274 91 11 (RIVM)
Executed by	Evert Schut[1], Machiel Crielaard[1], Miranda Mesman[2]
Date	18 December 2015
Status	Final

Synopsis

Exploration of Circular Economy in the construction sector
A perspective for the market and government

The construction sector wishes, together with the government, to develop a vision on the high-quality use and reuse of materials in a circular economy. It is important that this vision receives wide government support and applies for an extended period of time. There is also the need to pre-finance the demolition of structures and the reuse of materials and construction elements, as is already the case for cars and refrigerators. This will make it attractive to optimally reuse materials. Therefore, it is important to consider during the design and reuse how elements of a building can be reused in multiple cycles.

This was shown by an exploratory project carried out by the National Institute for Public Health and the Environment (RIVM) and Rijkswaterstaat for the Ministry of Infrastructure and the Environment (IenM), together with stakeholders in the construction sector.
In the Netherlands, a large proportion of all construction and demolition waste is recycled into foundation material for roads, new residential areas and industrial estates. However, buildings are hardly ever made from recycled products. This could change, because the market for foundation materials is slowly becoming saturated, which could be an incentive to reuse materials in other ways.

The challenge is to design buildings in such a way that all of the materials in them are suitable for high-quality reuse. However, the long life of building structures - 50 to 100 years - makes it difficult to determine how the materials will be dealt with in several decades' time. Experience of new design and assessment methods can be gained through innovative learning projects. In addition, stakeholders want to have a clear method to assess the 'environmental performance' of a building over multiple life cycles. In the Netherlands, the environmental performance of a building is already measured as standard over a single cycle.

The circular economy arises if relevant companies and organisations in the construction sector work together. The government is, as a commissioning party, of course a participant and can therefore provide targeted help to speed up this process and remove any legislative bottlenecks.

Publiekssamenvatting

Beleidsverkenning Circulaire economie in de bouw
Een perspectief voor de markt en overheid

De bouwwereld wil samen met de overheid een visie ontwikkelen hoe materialen hoogwaardig kunnen worden gebruikt en hergebruikt in een circulaire economie. Het is daarbij belangrijk dat die visie overheidsbreed wordt gedragen en voor een langere periode geldt. Een andere behoefte is om sloop en hergebruik van materialen en bouwonderdelen van te voren mee te financieren, zoals dat bij auto's en koelkasten ook gebeurt. Daarmee wordt het aantrekkelijk om materialen optimaal her te gebruiken. Hiervoor is het belangrijk om bij ontwerp en hergebruik te bedenken hoe onderdelen van een gebouw voor meerdere cycli gebruikt kunnen worden.

Dit blijkt uit een beleidsverkenning die het RIVM en Rijkswaterstaat voor het ministerie van Infrastructuur en Milieu (IenM) hebben gemaakt, in samenwerking met stakeholders in de bouw.
In Nederland wordt bouw- en sloopafval op grote schaal gerecycled tot funderingsmateriaal voor wegen, nieuwbouwwijken en bedrijventerreinen. Gebouwen worden echter nog nauwelijks gemaakt met gerecyclede producten. Daar kan verandering in komen omdat de markt voor funderingsmaterialen langzaam verzadigd raakt en zo een stimulans ontstaat om materiaal op andere manieren te hergebruiken.

De uitdaging is om gebouwen te ontwerpen waarin alle materialen hoogwaardig kunnen worden hergebruikt. De lange levensduur van bouwconstructies - 50 tot 100 jaar – maakt het echter lastig om te bepalen hoe over enkele decennia met materiaal wordt omgegaan. Via innovatieve projecten, die als doel hebben om te leren van opgedane ervaringen, kunnen nieuwe ontwerp- en beoordelingsmethoden worden uitgeprobeerd. Daarnaast willen stakeholders graag beschikken over een duidelijke methode om te beoordelen wat de 'milieuprestatie' van een gebouw is bij meerdere levenscycli. In Nederland wordt de milieuprestatie van een gebouw over één cyclus al standaard gemeten.

De circulaire economie ontstaat als relevante bedrijven en organisaties in de bouw met elkaar samenwerken. De overheid is hieraan als opdrachtgever in de bouw vanzelfsprekend deelnemer en kan daarom gericht helpen om de samenwerking te versnellen en eventuele knelpunten in de wetgeving weg te nemen.

Table of contents

Summary

This report explores the relevance of the concept of the 'circular economy' for the Netherlands' construction sector, and also the reverse, what the construction sector could contribute to the circular economy in general. In various 'Green Deals' and other societal initiatives, the circular economy is the main theme, or at least an important side issue. The Ministry of Infrastructure and the Environment (IenM), the commissioning party for this survey, wants to know in particular what the role of the Dutch government should be in the efforts to make the economy in the construction sector circular. As the basis for this report, the frontrunners and sector organisations in the area of circular economy as related to the construction sector were asked to help the government to answer this question.

The construction sector uses large volumes of material: more than half of all the materials used in the Netherlands are used in the construction sector. Large waste flows are created by the construction, renovation and demolition of buildings; these flows are many times greater than the volume of household waste. Fortunately, this material - at least in the Netherlands – is has been recycled on a large scale for years. After recycling, the majority of the recycled demolition waste is used as a foundation material for infrastructure (ground works, road base and hydraulic engineering). Hardly any new residential area, business park or road is constructed without the use of recycled aggregate. This recycled aggregate consists of demolition waste from concrete and brick that was used decades ago to build houses, offices, hospitals, schools and business premises. In the Netherlands such material is welcome, because there are hardly any natural road base resources available (crushed rock from quarries) in the country. However, an oversupply of this material is a risk for the near future. When renovating roads, the road base material can be reused as road base more or less problem free and no new aggregate is required. Moreover, because more or less all of this material is used in civil engineering, no more than approximately 3 to 4% of all new construction materials for residential and non-residential buildings consist of secondary materials. In part, this is also the result of the fact that raw materials used in construction are rarely scarce.

For the construction sector, scarcity is generally not the main reason for introducing the principles of circular economy. In the recent past it was the scale of the waste flows, currently the concerns about the major environmental impact of construction materials that drives the frontrunners in their efforts to introduce a circular economy. For instance, on the global scale, concrete and steel production account for approximately 17% of all the CO_2 emissions related to human activity.

Therefore, the conclusion is that the recycling and reuse of construction and demolition waste in the Netherlands is highly advanced, but this does not mean that the country's construction sector actually has a circular economy.

Circular construction starts with a design that takes into account all of the phases in the lifecycle of a structure and continues in the following cycle. The following lifecycles of construction elements, products and materials form part of that design process. The architect must know how the demolition contractor works, the recycler must know what technical requirements the circular constructor places on the materials that he uses, so that the recycling technology can be adapted to suit. The contractor must ensure that important information concerning the materials that he uses is available to the owner / manager of the structure and the manager must ensure that the demolition contractor - sometimes more than a hundred years later - can also have access to the information. As a result, while circular construction is at first a design- and technological challenge, it quickly progresses to cooperation, knowledge sharing and transparency. New business models undoubtedly - already - arise from the intensive practical cooperation. The business models that are often dominant in circular economy thinking (lease concepts) seem to be less relevant for the construction sector, mainly because of the long life of built structures. Many expect a more industrialised method of building with far-reaching chain integration of the companies concerned and new roles for others.

Most of the principles of circular thinking have been applied to the construction sector, in theory and to some extent also in practice. Several manufacturers have successfully launched circular products onto the market (examples: paving bricks, carpet tiles and even complete ‘built in a day’ housing projects). However, there are still many challenges in every area before the construction sector actually adopts the circular approach.

In view of this, the overarching advice of stakeholders is: ***get started!*** Start with pilot projects, share learning experiences and work to jointly improve knowledge. The term ‘Living Labs’ is often used in this respect. Government organisations are by far the most important commissioning parties in construction and can make a major contribution by including circular aspects in projects by, among other things, including them in (sustainable) procurement.

Moreover, the government can contribute by assisting the further development of environmental assessment instruments and integral cost instruments. For instance, the environmental LCA (Life Cycle Assessment) can become a Multi-Cycle Assessment (MCA) and Life Cycle Costing (LCC) Multi Cycle Costing (MCC). Such methodology requires new calculation tools, databases etc. Companies do not expect the government to do all the work, but they do wish for initiatives to facilitate cooperation and, as a commissioning party, to be actively involved in this development. The question is whether in a circular economy the government can keep the same distance to the market as is currently often customary. After all, as the commissioning party, the government is part of the loop and as such is co-responsible for the cooperation between the links in the chain.

The stakeholders have also been asked what they expect will be the most important impediments to closing the loop. For many such impediments are related to the stagnation that the construction sector has faced in recent years. On the one hand, many office buildings and business estates are vacant, while on the other, there is a shortage of affordable, modern, energy-efficient homes. Urban renewal ('Agenda Stad', 2015) is a theme that is enormously popular with many municipalities and their inhabitants. At the same time, the legacy of the financial crisis is that there are no funds available to effectively solve the problems of vacant buildings. The reflex is to initiate new-build projects on greenfield sites instead of redevelopment existing areas ('infill'). The chance to create green, smart cities using the existing buildings as the source of raw material is overlooked. It is extremely clear that a successful circular economy will only gain momentum if these financial impediments are solved coherently.

A striking flaw in the construction sector is that everything is financed, with the exception of demolition and recycling. Structures are built to last an indefinite period of time and when the time comes to replace them, the community or the new investor pay the price. Building on a greenfield is simply cheaper. As a result ever more buildings are left vacant. This puts a brake on urban renewal and leaves a source of potential building materials unused. The advice the stakeholders give to the government is: develop a clear vision for solving the financial impediments that impede urban renewal, allowing the sector to confidently address the - circular - renewal of the construction sector. There are sufficient ideas that address this; consider for instance the introduction of a disposal levy for buildings, similar to the one on cars and refrigerators. At a later stage of this survey, the major banking institutes were consulted. According to the banking sector, there is sufficient finance to invest in sustainable new construction projects. With respect to investment, those involved are waiting for a signal from the government that renewal is actually commonly supported. For instance, banks would like to extend their – fiscally advantageous – 'green investment' portfolio to the construction sector, but they require permission from the government to do so. This possibly offers the government an attractive perspective: the circular economy would get a considerable boost at a relatively low cost.

In addition, it offers a positive perspective for the new construction of energy and CO_2 neutral buildings. The results from the stakeholder consultation suggest that the circular economy could mean an important boost for the construction sector. The government will fulfil an important role here as a commissioning party, facilitator and in particular also as the policy maker for urban renewal. And here, it is well advised that the building-related ministries, together with the commercial sector, develop a vision for this renewal. How this should be done exactly is a question to put to the key governmental advisory bodies.

1 Introduction

The economic crisis that started in 2007 has had repercussions for the construction sector. In the first place, the architects had a difficult time and then major new-build projects were halted, postponed or cancelled. In part as a result, building companies and their suppliers went bankrupt. Municipalities saw investments in land purchases evaporate and increasingly more buildings in commercial estates and business parks became vacant.

In 2015 there seems to be a slow recovery taking place, but the construction world has not yet developed a clear vision for the future. However, during the crisis, various initiatives were developed to give the construction sector a boost. The concept of 'Circular Economy' (CE) plays a more or lesser prominent role in various initiatives. But what is circular economy actually and what does it mean for construction? Can CE indeed make an important contribution to the modernisation of the construction sector? Can it contribute to persistent problems including vacant buildings and the clogged-up financing system in construction? And if yes, what is the role of the government, or governmental authorities? At the Ministry of Infrastructure and the Environment (IenM), circular economy is an important policy topic, together with the underlying philosophy of the programme 'VANG' (*Van Afval Naar Grondstof* - from waste to raw material).

The construction sector still produces a large proportion of all types of waste (more than 25 million tonnes in 2012, more than three times as much as all the household waste (Compendium voor de Leefomgeving). In the Netherlands, the majority of this building and demolition waste (more than 95%) is currently already recycled. The performance of the Dutch recycling industry is an example for the rest of the world. But is this also the high-quality materials reuse that deserves the qualification of 'circular'? Is our current way of working truly future proof? When the Netherlands chairs the EU in 2016, circular economy will be put on the agenda. Should we recommend other countries to follow our example with how we currently practice recycling or should we think another step ahead?

The Ministry of Infrastructure and the Environment (IenM), together with the Ministries of Economic Affairs and Interior and Kingdom Relations (BZK), is responsible for the '*Groene Groei*' (Green Development) policy, the key sustainability objective of the current government. Circular economy is an integral part of this green development policy. The Ministry of IenM requested Rijkswaterstaat (RWS) and RIVM to conduct a preliminary survey of policy options for a circular economy in the construction sector, based on a stakeholders consultation.

To this end, in the spring of 2015, various sessions were organised with circular frontrunners in the construction sector: raw material miners, suppliers, producers, contractors, architects, engineering bureaus, commissioning parties, demolition and recycling companies and various

advisers in circular economy. The objective here was to investigate how construction could become more circular and what role the government could fulfil. This report sketches out the significance of the circular economy for the construction sector and gives the results of the consultation held with stakeholders. Based on this, advice was then formulated for the (national) government.

2 What do we know about material flows in construction?

In the introduction, reference is made to the scope of the waste flow resulting from the construction and demolition of structures: approximately 25 million tonnes per year, approximately three times as much as the waste produced by households. The amount of material that is used in construction is even a factor greater. However, there are no exact data, probably because the largest material flow in construction - earthworks - is not structurally mapped out. Of all the building- and demolition waste, in the Netherlands the majority is already recycled (95%, Spijker, Van der Grinten, 2014).

Therefore, the first impression that many people have is that the construction sector in the Netherlands is already almost ‘circular’. However, this is not the case (see Figure 1). The main reason is that a large portion of most materials used in buildings (the residential and non-residential building sector) after demolition and recycling is used in in civil engineering, often as a road base material or as filler material to raise the level of industrial estates. In civil engineering in the Netherlands, the use of secondary raw materials is an every-day phenomenon: more than 50% of the materials used (excluding earth-moving) consists of recycled materials, which are functionally used (and as such replace primary raw materials). The Netherlands takes the lead in the world with respect to this form of recycling. Moreover, these materials used in civil engineering are almost 100% reused for the same type of function at the end of its life. For the Netherlands, this form of recycling and reuse has been a fortunate development. It is often necessary to build on ‘weak’ soil (peat, for instance), that requires a good foundation. However, the Netherlands has hardly any suitable material to do so (such as quarry stone) and the secondary substitutes (recycled aggregate) fulfil this function just as well, if not better.

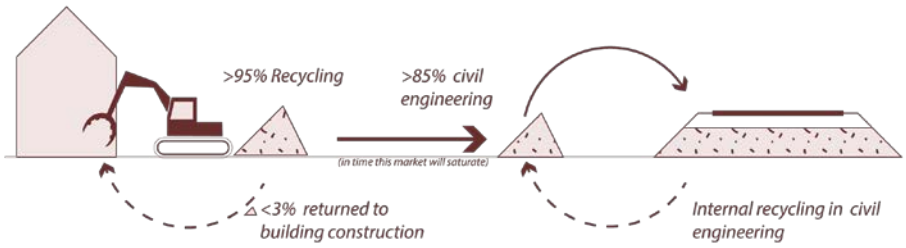


Figure 1. The demolition of buildings often provides recycled aggregate, which is then used in civil engineering (GWW) as foundation material. After first being used in a road, this road base aggregate can again be used in other road building projects. In due time, after many years of continual input of recycled aggregate and recycling within the civil engineering sector, the demand for new recycled aggregate decreases. The sector becomes 'saturated' with recycled aggregate. Only a limited percentage of the material from the building sector is actually reused in making new buildings (B&U), more sustainable methods of demolition and recycling could valorise these materials, allowing this material to be reused in the construction of new buildings.

However, in the building/ construction sector hardly any secondary material is used, no more than 3 to 4%. Primary materials are used for the remainder. For about 20 years, the waste problem of the manufacturers of these materials has been solved by the recycling sector and civil engineering. For this reason, the construction sector as a whole, in spite of the great recycling results, can hardly be called circular. Added to this is the fact that there is a gradual saturation of secondary materials in civil works. The demand is further reduced because fewer residential areas and industrial estates are being built on greenfield sites, and the Provinces, district water boards and Rijkswaterstaat are shifting away from the building of new infrastructure towards maintenance of existing assets. Large-scale maintenance of infrastructure generates a wide range of materials, but much of this can be reused in foundations. It has been predicted before (Hofstra et al. 2006 p. 77) that this would lead to new surpluses of building and demolition waste. The predicted surpluses are still not too apparent, now in 2015. According to sector representatives, this mainly results from the fact that since the start of the economic crisis not much has been demolished, which is probably related to the fact that in this period not very much has been built either. The question – which we cannot yet answer in this report – is when the long expected surplus of recycled aggregates will arise. What the report will address is the question of what needs to happen to effectively use this source of secondary materials.

'Although there is a high degree of certainty regarding the estimated need for recycled aggregate in road construction, the main conclusion should be that not all of the recycled aggregates will be able to be sold as road base material. Therefore, there is a convincing need to find other markets than the road construction sector.' (Hofstra et al. 2006 p. 77)

3 What is circular economy and what does it mean for the construction sector?

The definition of Circular Economy (CE) according to the Ellen MacArthur Foundation, the international think tank that is commonly recognised as being an authoritative source for circular concepts (see):

“The circular economy is an economic and industrial system that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles.”

This definition indicates that material flows fulfil an important role in the body of thought concerning circular economy. But it is also about a new way of thinking about economic principles including ‘value’ and about business models that give shape to the desired value creation. The Ellen MacArthur foundation - but in the Netherlands also TNO (Bastein, 2013) and the RLi (RLi, 2015) - calculated that the circular economy offers opportunities because, among other things, there are less raw material extraction and waste processing costs. Here it is assumed that other revenue models will be needed to realise this. It is not the possession of a product but its functional use that is of importance. Many companies that operate from a circular perspective use a lease construction where the product becomes a service. Some advocates of CE even consider such a revenue model to be the guiding principle whereby material chains becoming circular is a logical consequence. In this report, we chose to place the material cycle in the centre of attention, and to perceive the desirability of new business models as a possible – but not necessary - consequence of this material cycle.

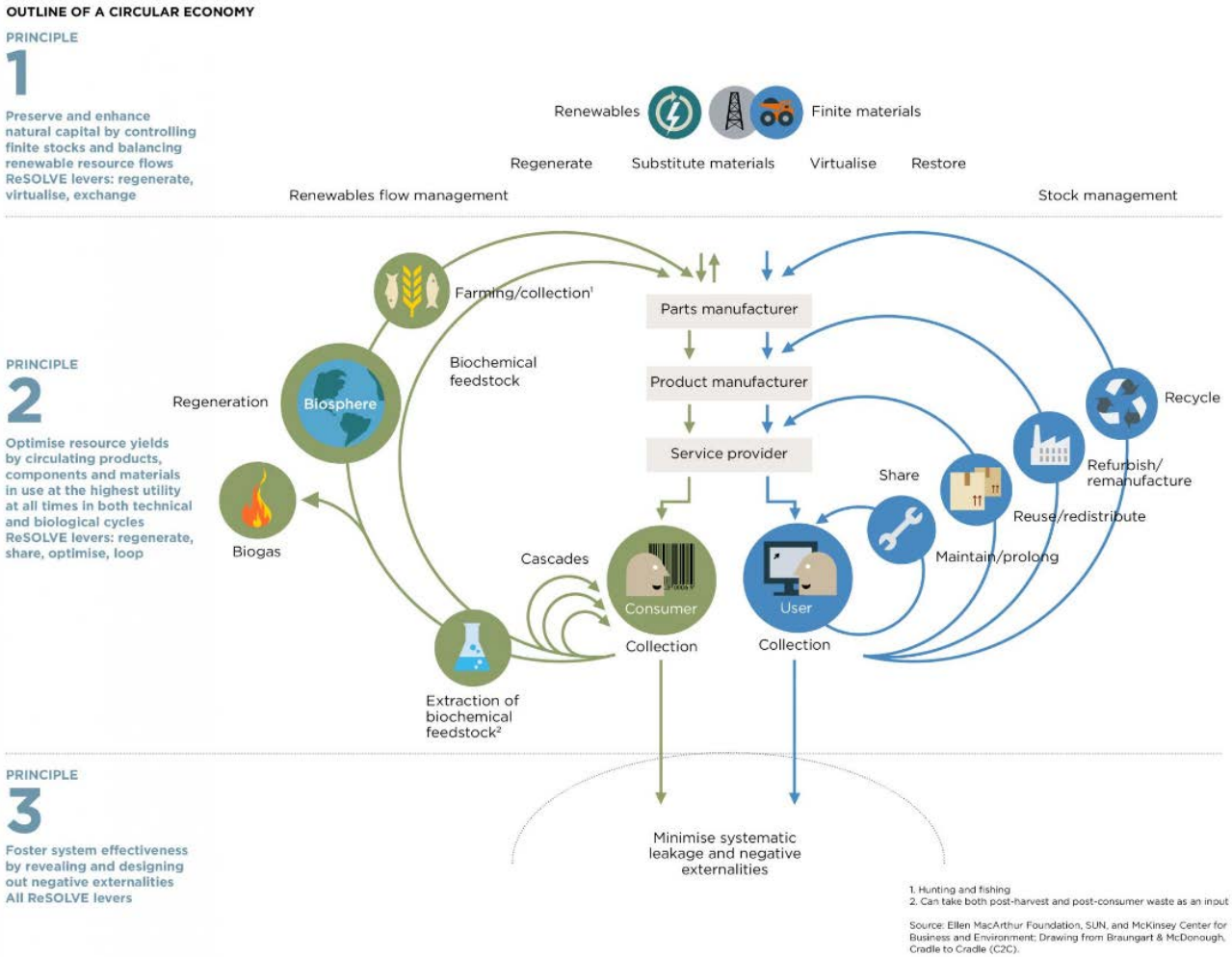


Figure 2. The three principles of the circular economy shown for the technical (blue) and biological (green) cycles, taken over from the Ellen MacArthur Foundation. Many building materials are in the technical cycle, however, wood is found in the biological cycle.

The definition and elaboration of the Ellen MacArthur Foundation have been used as the principle guiding the stakeholder dialogue (see Figure 2). In the circular economy model, economic growth and development are disconnected from the use of raw materials (including fossil fuels). The Ellen MacArthur Foundation (2012) mentions four important principles for 'technical materials' (all non-biological materials in a circular economy (see **Error! Reference source not found.**).

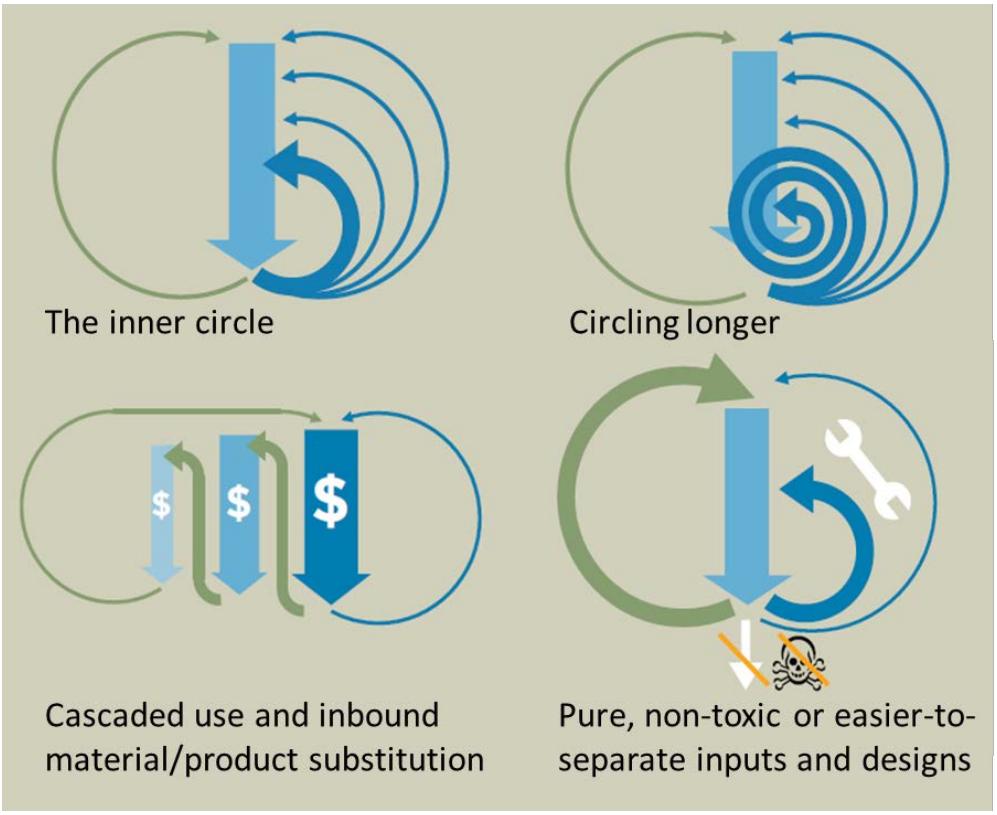


Figure 3. Taken over and modified from the Ellen MacArthur Foundation (2012). The technical cycle (in blue) in the circular economy can be extended by keeping the shortest possible cycle (top left), allowing the cycle to run as long as possible (top right), reusing materials at the highest possible value level (bottom left) and ensuring that material flows are clean and easy to sort (bottom right).

3.1 Closing material chain loops

The construction sector has a potentially enormous supply of stored materials in the form of buildings, structures and infrastructure. The chapter on material flows sketches out what has happened to this up to now when the stock is demolished. It also indicates that this practice cannot yet be called circular, in spite of the high percentage of reuse in the Netherlands. The design of new buildings and infrastructure determines the waste flows that will be released in 30 to 100 years' time. In a circular design, all of these waste materials can be reused as high-quality materials for similar functions. It is preferable that parts of buildings can be reused as products or building elements. The materials

that were used to build with in the past have not been consciously designed for high-quality reuse.
Structures are also not designed in a way that allows the materials to be simply sorted when the structures are demolished. The major challenge therefore is to use the materials that are present in the existing building stock in the best way possible in a circular design. There are various reasons why this is a major challenge:

- In practice, it is not always possible to get clean and nicely sorted materials from demolished structures. Bricks, for instance, come free in parts of demolished wall, held together by cement, plaster walls are difficult to separate from the wooden beams to which they have been attached and window panes end up in the skip together with the window frames, furniture and fittings.
- Waste materials have also been reused in the existing building stock. Here no account has been taken of reuse in multiple cycles. Little research has been done into the multi-cyclic use of such materials. Concrete, for instance, has been made for almost 30 years from increasing amounts of blast-furnace and fly ash cement. The environmental performance of such cement is considerably better than the Portland cement that was originally made of limestone, but it is unclear whether multi-cyclic reuse could become a problem.
- At the material level, it is also often necessary to separate the raw materials. Concrete recycling will only become truly interesting if gravel, sand and cement (stone) can be reused to make new concrete.
- Recycling technology often still focuses on processing significant waste flows into relatively simple products (such as aggregate for road building). If manufacturers have to meet the (higher) product requirements of a circular product, this often requires new technology that has not yet been developed.
- It is impossible to regenerate the same products from some materials because the production process is irreversible. Here it is about retaining the optimum value in the recycling cascade, with at the bottom recycling.

3.2 Scarcity and resource efficiency

Companies in the construction sector are increasingly aware of the increasing need to close material chain loops. Not because of enormous scarcity, but to limit the environmental impact. The large-scale demand for building materials has determined that in the construction sector materials have been chosen that are freely available. By far the most building materials are sourced locally or regionally.

In the Dutch situation, many raw materials used in construction, including sand, gravel and clay, are not only abundantly available, but the material is also obtained as a side effect of other societal objectives. For instance with the execution of the water safety programme Ruimte voor de Rivier - space for the river. As a result, the supply of sand and gravel has been so great in the past years when compared to the demand, that the most important source – the Grensmaas Project – has been postponed for several years. Nowadays, scarcity in the construction sector when compared to other sectors is hardly a motive for the sector to introduce circular economy.

The raw materials that are currently used in construction put pressure on the living environment, the mining or quarrying of raw materials results in pressure on the ecosystems and a large proportion of the carbon footprint of materials is found in the production of building materials from the resources (steel and cement production, for instance, are jointly responsible for approximately 15-20% of the global human generated CO_2 emissions, Yellishettya et al., 2010, Chen et al., 2010). The energy that is required to produce such basic materials for construction usually has a fossil origin and is as such also rather scarce. Incidentally, there are some interesting exceptions. Asphalt, for instance, is made from gravel, sand and bitumen. Bitumen is a residual product of the oil industry. Now that oil is threatening to become scarcer, it is often refined to a higher degree by oil companies, allowing more products to be made from it. As a result, bitumen is slowly becoming increasingly scarce and in particular more expensive. For this reason, the asphalt sector is looking for alternatives, among other things by increasing the percentage of reuse and by exploring the possibilities of bio-based bitumen.

3.3 Producer responsibility

The reason why producers and suppliers are increasingly becoming involved in CE is that they see that the environmental impact of their product can be limited by using secondary materials. This favourably influences the image of their product and the added value can be translated into a higher price with possibly a greater sales market. Of course, this is only true if the customer is willing to pay for this more sustainable product, but then again, the product could then have a higher residual value at the end of its life.

The current generation of building materials has often been designed to a have a long life, but the producer is not responsible for its demolition or recycling. Society increasingly demands the producers to take a responsible approach when dealing with materials and the environment. Waste represents a loss of value and preventing waste can create value in various respects. Currently, the costs of demolition and recycling are often paid by society and producers are insufficiently stimulated to make circular products (buildings). For that reason, producers should want to extend their product responsibility to the following lifecycles of the product. An important aspect here is to look into the composition of the product and the materials. Producers with foresight are already doing this. After all, if the producer is made responsible for the further lifecycles of the product, then designing for effective reuse will often be cheaper than destining the product for low-quality reuse. In addition, the stock of vacant buildings and industrial estates will sooner or later end up as waste at these producers to be processed into new products. The majority of the materials in this waste have not been designed for reuse. However, to be able to make high-quality use of these materials, new demolition and recycling technology is required.

Producers can try to independently develop circular concepts in order at a certain moment to build up a market advantage. For some products this is actually possible (floor covering in office buildings is such an example), but often multiple parties are required to close chain loops. This is also the most important reason why the circular school of

thought arrives at Green Deals and other chain initiatives, where the starting point is cooperation.

3.4 Principles of circular design

The principles of circular design have been clearly formulated by the Ellen MacArthur Foundation. Use is frequently made of the three (sometimes five or even seven) “R” principles:

- Reduce
- Reuse
- Recycle

In construction-oriented literature, such principles are often targeted on construction:

Low-material design

The principle is that using less material also leads to less use of raw materials and causes less waste and environmental effects. This is not always self-evidently the case. For instance, if a low-material-use building is clearly less energy efficient than a building in which more material has been used. A subject that deserves to be addressed separately with respect to low-material-use design is the prevention of waste creation on the construction site. The amount of construction waste is much less than the amount of demolition waste. This is partly because demolition waste that is generated in smaller renovation projects is in practice attributed to the construction waste flow. The most effective way to limit this on site waste production, is to use industrially prefabricated building elements. This still hardly happens in renovation projects even though the ability of suppliers to deliver more to specification is possibly greater than is assumed. In addition, it is possible to accurately sort the created waste flows at the construction site and/or in a sorting installation to allow for the high-quality reuse of building materials.

Modular design

Different parts of a structure have different technical and/or economic lives. In principle, the skeleton of a building can last for a long time; a technical life of fifty or even a hundred years is the rule rather than the exception. The roof and the exterior walls also have a long life. Sometimes they require replacement or renovation sooner than the skeleton. Consider here the insulation of cavities and replacement of windows by double - and later triple glazing. The energy system mostly has a life of approximately fifteen years, the floor covering about ten years. In modular design, an optimum life is assumed for parts of a building and possibilities are investigated to rapidly and efficiently replace building sections as ‘modules’.

Adaptive design

This modular design-related concept assumes that a building during the life of the longest remaining section, for instance the foundation and the skeleton, can fulfil multiple functions. If a building is adaptively designed, it can be amended to the requirements of the time. The layout, fittings and technology used (systems, ICT, etc.) can change radically. For many vacant buildings it is assumed that it will not be

profitable to adapt them to new functions. At some time, demolition is inevitable, while the materials used could last for very much longer. Incidentally, there is tension between adaptive and low-material-use design. A large space can, for instance, be effectively supported using a relatively large number of small (light-weight) columns that as a result use less material, but then the space is less suitable for adaptation to other applications.

Design for deconstruction
When connecting various building elements together, currently, hardly any account is taken of the possibility of taking these elements apart at a later date and reusing them as building elements elsewhere. In the main, brute force is required to demolish a structure, making it impossible to remove building elements from it in a way that leaves them undamaged and suitable for reuse. The idea of 'Legolising the construction' (Prof. Hennes de Ridder from TU Delft) is in line with this: if it would be possible to build buildings like you build with LEGO, then the reuse of building elements would be much simpler and also more profitable.

Design for recycling/ Cradle to Cradle
Design for recycling is a seasoned principle, where the design takes account of the recyclability of materials. Design for recycling is often also an established part of the 'Ecodesign' concept. The related 'Cradle to Cradle' concept goes beyond that. This concept is not just about reuse being possible but also about it being possible to continue it in the long term. The term 'upcycling' indicates that the material use should be at least of the same quality as in the original product. In addition, in 'Cradle to Cradle' the principle is that the material must not be contaminated with hazardous substances. Not only is the presence of hazardous substances less desirable in the societal sense, it also limits reusability in the long term.
In circular economy thinking it is not necessary for every raw material to be reused for exactly the same application, as long as it remains within the economic system in the long term. 'Cradle to Cradle' has been used many times in construction projects. Not only the recyclability of the material is important; the materials must also be able to be effectively separated from other materials when the structure is demolished. In practice, design for recycling has everything to do with design for deconstruction.

Recycle for (circular) design
This is a new concept that indicates that demolition and recycling companies will also align their processes more to the demand of producers that employ circular design. A secondary building material that can only be used for one cycle is not a circular building material. The result is that the recycling industry will have to make substantial technological improvements to be able to deliver the required quality. These technological developments are currently being made. In among others several EU Horizon 2020 innovation projects, in which Dutch universities and companies are involved. An example is the recycling of brick. There is a high demand for bricks originating from certain old buildings because of their aesthetic properties. The economic value is even sufficient to make the labour-intensive process required to

separate the brick from the mortar profitable. With the existing technology, it is impossible to make new bricks from old ones. In effective chain collaboration, the recycler also provides feedback to the designer. For bricks, for instance, a click system is possible.

This would make it very easy to reuse bricks. A technology that could enable the recycling of bricks laid using mortar is currently being developed with the involvement of Dutch companies and universities. Something similar applies to concrete. It is currently very possible to replace a proportion of the gravel in new concrete with concrete aggregate. However, the effective reuse of concrete will only become truly interesting if all raw materials could be reused at a high quality level for a circular design. Such technology is currently under development by multiple groups and is expected to be operational within a couple of years.

Materials passport
To be able to reuse a building product or material many years after it was initially used in a building as a product, element or material, it is essential that sufficient information is available about its composition. Sometimes, this information is obtained through investigation and detection methods that form a part of the recycling process; current recycling technology is based on this. However, to be able to take things a step further, more information is often necessary. The idea of the materials passport is to allow this information to travel with the product itself through time (see Figure 4). The development of the materials passport is still in its infancy. A promising development is the BIM (Building Information Model) 3D design tool, which already contains an extensive database of materials. The addition of specific circular information that is relevant for the following link in the chain is already being investigated. The greatest challenge is possibly how to store and keep such information accessible so that it can be usefully employed during the demolition - 50 to 100 years later.

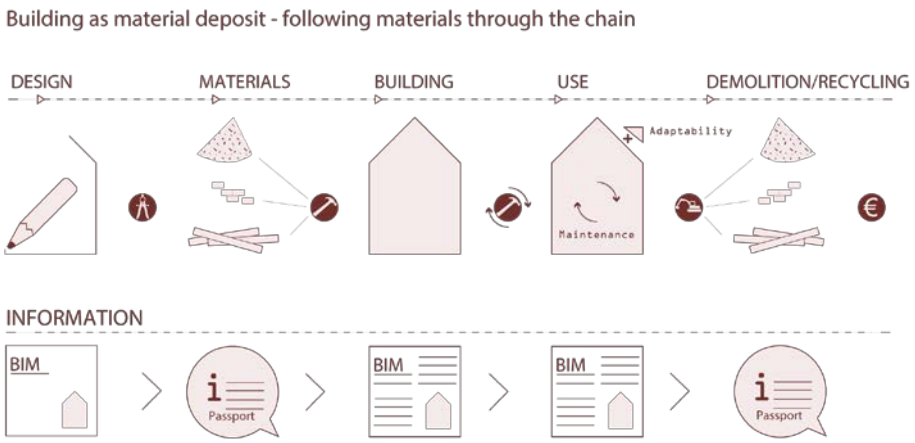


Figure 4. A materials passport linked to materials forwards information about the composition of the material (or product) to the following link in the chain. Using BIM, this can be forwarded through the design, the construction, the management and in the end to the demolition contractor. BIM data storage could in the long run replace the current municipal archives.

Preferred order in CE

The circular economy is about retaining optimal value in the physical environment. This can be done at various levels:

- Product reuse: the same product, the same function
- Repair: amended product, the same function
- Remanufacture: part of the product used for the same function
- Recycle (material reuse): in a recycling process the original materials are reclaimed to be reused in a next lifecycle. If they can be used for the same (type of) product and function, this is called high-quality reuse (or 'upcycling'). If the reuse options are more limited, mostly for a simpler product, this is called low-quality reuse (or 'down cycling').

In the circular literature, a preferred order is often given to this: the shorter the cycle, the closer the reuse is to the original product, the better. This is because it causes less waste and fewer raw materials are used. However, this hierarchy requires some refining: shorter cycles extend the life and as a result the environmental impact of a product, but if the materials are still difficult to extract at the end of this long life for re-use in the next cycle, this should not be called circular. In other words: a short cycle is only better than a long one if in the end the cycle at the material level can be a closed (high-quality) loop.

3.5 Circularity in existing buildings and infrastructure

Circular economy starts with a circular product design. However, a characteristic of the construction sector is that the products can have a very long life, for example a sluice. The Colosseum and Pantheon are 2000 years old and are still usable as buildings. This long life is not only due to a good design, but also due to good management and maintenance. For a building that functionally and aesthetically meets the

requirements of the time or can be easily adapted, extending its life will be the most useful strategy. For a structure that cannot be adapted in a cost-effective way, demolition and reconstruction of a more modern structure will be a better option.

3.6 From circular design to cooperation and other economic revenue models

The list of design principles presented above is by no means complete. The objective is to only give an impression of the questions a designer in the construction sector has to take into account to create a circular design. This designer quickly discovers that he cannot do this alone. Up-to-date knowledge of demolition processes is, for instance, indispensable to be able to use 'design for deconstruction' principles. Due to innovations, like those in the demolition sector, improvements can be implemented in extracting building elements and materials. For instance in the speed of demolition, the simplicity, the costs, reduction of annoyance, etc. The same applies to the recycling industry that develops new technology ensuring that the original raw materials in materials and products can recycled more effectively. At the same time, the innovative recycler must listen well to its customer: what are the new developments in designing construction products and which circular requirements does he place on the materials he uses? This will change the traditional relationships in the construction sector. Cooperation between the design disciplines requires a greater degree of transparency to be able to realise the joint objectives. For many companies this will be an impulse to consider new business models and it might lead to the greater integration of material chains. This can possibly also be an incentive for other revenue models. A recent example is the initiative of a contractor to act as a 'chain director' in streamlining the process of selective demolition to the production of secondary materials. This provides a guarantee to the building owner of the highest quality processing of the object to be demolished into new materials.

3.7 Circular Policy and Regulations

The European parliament is pursuing a transition to the circular economy and resource efficiency in the construction sector (EC, COM (2014) 445). Among other things, objectives have been formulated for the circular design of products;

- Chain approach in construction;
- Developing financial incentives and revenue models;
- The simplification of methods and indicators.

In addition, various research and pilot projects have started, including 'Resource efficient buildings', which is investigating whether a European framework with indicators for the environmental performance of buildings can be developed.

The Dutch policy follows the EU track in the form of a policy programme 'From Waste to Raw Material' (*Van Afval Naar Grondstof - VANG*) that intends to promote the transition to a circular economy (Ministry of IenM). To do so it is necessary to use sustainable resources, to efficiently use resources, to use eco-design principles, to increase the life span of products and to optimally reuse residual material flows. (VANG Implementation Programme). In achieving these goals the Netherlands encourages the making of 'Green Deals' as an instrument to ensure bottom up initiatives from stakeholders. In recent years, the

following Green Deals, among others, have started in the area of construction:

- Circular City *(Cirkelstad)*
- Circular buildings
- Bio-based building
- Sustainable approach to ground work, road and hydraulic engineering
- Sustainable concrete
- The RACE coalition

The central government aims to align with societal developments, reinforce good ideas, remove policy and regulatory impediments and ensure that the chains form closed loops.

The Buildings Decree regulates the measurement of environmental performance of materials. In the Netherlands, there is an obligation to provide information about the environmental performance of building materials that are covered by the Buildings Decree. The objective of this obligation is, in the long term, to regulate the minimal environmental performance of materials. Until 2020, the priority of the sustainability policy lies in ensuring that new buildings are increasingly energy efficient. For instance, there is a new approach in the Buildings Decree: BENG, which stands for 'almost energy neutral building' *(Bijna ENergieneutraal Gebouw)*. It will now be gradually introduced and be legally in force in 2021. However, for an energy neutral house, the environmental performance of the materials will be the determining factor. In the environmental performance of building materials, the emphasis lies on the climatic effects. There is no requirement in the Buildings Decree concerning the degree of circularity.

In addition, with the Soil Quality Decree (BBK) from 2007 and its predecessor, the Building Materials Decree (1998 – not to be confused with the Buildings Decree), the Netherlands has laid the foundation to minimise the leaching of hazardous substances in building materials to the environment. This is an important principle of the circular concept that has been rather effectively implemented in the Netherlands and in several other countries in the EU.

This system ensures the material/ environmental performance in the initial life phase of an application and also creates preconditions for a following application in the long term. However, there is no usable instrument and/or parameter to assess the expected physical properties and environmental performance over more than one life cycle. In spite of this, the Soil Quality Decree represents an important step forward and an essential precondition for circular thinking. The role that the Netherlands has as the frontrunner in the recycling of building materials is, to an important degree, a result of these regulations. At the time, these regulations came into being due to the intensive cooperation between the government and the suppliers and recycling companies in the construction sector. In several other countries, it is still obligatory to draw up an (costly) environmental impact report for every construction project where recycled building materials are used. Such regulations can form a serious impediment for the use of recycled materials.

3.8 Innovation in construction

In the construction sector, there are various initiatives to which Circular Economy can align. For instance, the Ministry of BZK together with a wide group of partners has drawn up an action agenda for innovation in the construction sector (Bouwteam, 2012). One of the aspects that is considered to be important is the innovation in construction. To achieve this innovation, a route map has been drawn up for an innovation agreement (Bouwteam, 2014); this also addresses motives or incentives for innovations.
From the societal perspective, these are the following aspects:

1. Sustainable real estate development
2. Structural vacancy of real estate
3. Aging population and changing housing demand
4. Consumer-oriented focus
5. Reduction of failure costs
6. Coordination problems and cooperation

To centrally direct the innovations, three themes have been formulated that provide direction:

1. Focus on the user
2. Making materials and energy consumption sustainable
3. The continuing adaptability of buildings

The report '*Gebouwen met toekomstwaarde'* (Buildings with future value) (Brink Groep, CPI 2014) introduces an integral assessment method for adaptive building. This report, under the direction of the Brink Groep and the CPI, was created on the order of VNO-NCW, MKB-Nederland, Bouwend Nederland, BNA, DGBC, FME-CWM, Metaalunie, NL Ingenieurs, NVTB, Slim Bouwen and Uneto-VNI.
These reports and agendas do not give the circular economy high priority, but - as will be shown in the next section of this report - there are many aspects that correspond with circular thinking.

4 Stakeholder consultation

4.1 Background

The Dutch government cannot realise the transition to circular economy in construction on its own. On the contrary: circular economy can only come into being through intensive cooperation between all links in the chain (or the cycle). Without societal initiative, the government cannot achieve much. This does not detract from the fact that the government probably has an important role to play, for instance in removing regulatory impediments. Therefore, in the spring of 2015, two stakeholder meetings were organised with the construction sector. The focus was on CE frontrunners and Green Deal representatives. In addition, trade associations, think tanks, knowledge centres and policy-determining government organisations were invited. Afterwards, several separate discussions were held with parties that where underrepresented in the stakeholder meetings (including the RACE coalition, contractors and banks, see appendix A).

4.2 Approach of the consultations

A large number of proposals arose from the consultation with stakeholders, in which government involvement is desirable. The subjects are summarised below. The consultation consisted of two meetings. During the first meeting, a number of themes concerning CE in construction were discussed via various workshops that addressed the following questions:

- How can we design circular building material?
- How can we arrive at a circular designed building / infrastructure?
- What requirements do we place on secondary materials in circular construction?
- What can we achieve with bio-based construction?
- In what ways do we finance circular added value?
- In what way will we carry out environmental assessments of building materials/constructions in circular construction?
- How do we create circular information, data storage and transparency?

The theme of the second meeting was impediments and what could be done to prevent them. The ideas that ensued were formulated in the following manner:

- The ‘reincarnation analysis’
- Circular procurement as a standard
- A disposal levy on new buildings, whereby the revenues are used to pay for the higher standards required for circular demolition (or rather ‘deconstruction’) and high quality re-use of materials and products
- Learning to work together in a circular construction value chain through financial instruments and rules
- Formulating circular characteristics for building materials and working with a focus on the total environmental load.

- Sharing and clarifying circular knowledge as a part of the construction information system.

The results of these workshops have been worked out in various themes in this chapter and reflect a cross section of the ideas of the participants.

4.3 Circular Design

Ensure that it is clear to all stakeholders which requirements a circular design must meet.

The principles of circular design of buildings are known by the frontrunners and are already applied in some innovative building projects. A well-known example in the Netherlands is the town hall of Brummen. Most principles of circular design are also endorsed. However, there are several points of discussion, some of which are briefly addressed here:

Preferred order of circularity
According to the stakeholders, the strict application of this principle (explained on Page 14) for the construction sector is not a good idea. Due to the long life, it is very difficult to design construction elements in a way that product reuse is still functional after tens of years. A central heating boiler, for instance, installed fifteen years ago, might be able to operate in the technical sense for a couple of years in another building. However, it is absolutely no longer suitable for today's energy performance requirements, let alone the requirements that will exist in five years' time. Reuse at the product level is, due to the long lifecycles and technological developments, less important than reuse at the material level.

Use of secondary materials in a circular design
The central government has designated VANG (from waste to raw material) as a policy spearhead. Many stakeholders support this. This is because the Netherlands already reuses a high percentage, in particular where building and demolition waste is concerned. However, there is still a difference between the current forms of reuse and circular use of materials. After all: waste materials that can only be reused once and that eventually must be dumped in a landfill or incinerated only make a temporary contribution to the circular economy, but they do frustrate the use of circular materials. The products/structures from which waste materials are released were not designed at the time with an eye on high-quality reuse. On the other hand, there is an enormous stock of construction material available in the existing buildings for which society, according to the stakeholders, bears a joint responsibility to reuse at the highest quality possible.

A topical example can clarify the discussion on secondary materials: Bitumen is used as a binding agent in asphalt. Bitumen is a residual material from the oil production process. Because the oil refinery process has become more efficient, less bitumen remains and bitumen prices rise. As a result of this economic scarcity, asphalt producing companies are increasing research efforts in using secondary sources for

bitumen. For instance, recycling technology is available to extract a type of bitumen from old roofing material and to use it for new asphalt. As a result, a waste flow that could previously not be recycled can now be reused as an asphalt binder. However, the question is whether the product can be called circular: at present this type of bitumen seems to make the asphalt more sensitive to weather influences and as a result the asphalt has a shorter lifespan. Moreover, it is still unclear whether the material can be reused again to make asphalt after this one lifecycle. Asphalt made using normal bitumen can be entirely reused for new asphalt, although not yet fully as (the more demanding) top layer. As such it is already approaching the point of becoming a circular product. If the roofing material can be recycled in a way that meets the circular design principles both options could help towards reducing dependence on fossil resources.

Therefore, the question is whether you should promote reuse if the application is not circular. According to the stakeholders, the solution for this dilemma should be sought in making clear which requirements a circular material (for a certain product or group of products) must meet, so that the demolition and recycling industry can direct their technology development towards achieving these requirements. This would work better if the commissioning parties in construction were also to use such requirements. Then these requirements will apply to both primary and secondary materials, in a comparable way as the requirements for the Soil Quality Decree (see previous chapter under policy).

For all of the stakeholders it is desirable for the government to have a clear view on what circular design entails and what consequences it has for society.

4.4 From LCA to MCA

Ensure, together with other parties from the construction sector, that the 'scope' of Life Cycle Analyses (LCA) is extended to Multi Cycle environmental Analyses (MCA).

- Life Cycle assessment (LCA) is often used to assess the environmental performance of materials or products. LCA takes account of all the environmental consequences of using a product, from cradle to grave. This makes it possible to compare the environmental score of materials and products in a certain application. The manner in which such research is done has been increasingly internationally standardised in the past 30 years. In the Netherlands, the construction sector uses, for instance, standard environmental data from the National Environmental Database (Nationale Milieudatabase - NMD) for the construction sector, which is managed by the foundation for building quality (Stichting Bouwkwaliteit - SBK). User-friendly calculation methods have also been created that require little time or money, for instance in the tendering process for construction contracts. In the current LCA method, the environmental impacts at the end of life phase (waste creation) are included. What does not yet happen is an analysis of the possibilities for:
- Continuing to use the materials in the long term, cycle after cycle,
- The high-quality reuse of the components of a product.

The example of bitumen from old roofing material can once more be used to clarify this: Because a waste material that is otherwise difficult to process is reused, this solution scores well in both a Life Cycle Cost analysis (LCC) and a Life Cycle assessment (LCA). If the following lifecycle is included in the analysis of this product, it is possible that the product will score considerably lower. By developing a Multi-Cycle Cost Analysis method that is supported by all parties, all suppliers in the market know what their aim should be to be able to deliver a circular product.

The advice to the government is - together with the commercial sector - to invest in research into the characteristics that make a material circular. And to make this measurable. Also strive to extend and update the Life Cycle assessment method to include the circularity aspect. This should make it possible to measure the environmental impact over multiple cycles. Using this knowledge, a producer can design a material or product ensuring the optimum retention of value for a following cycle. This will probably also require new parameters and/or test methods. These parameters would then be included in the MCA method.

This modification of the LCA methodology requires an objective assessment instrument to measure environmental impact over multiple cycles. It must be an understandable system that can be widely used. It is important for this method to then be embedded in the relevant regulations, for instance the measurement of the environmental performance required by the Buildings Decree.

4.5 Circular procurement

Make circularity an integral part of sustainable procurement.

Stakeholders would like the government to create integral sustainability policy and to translate this into clear procurement criteria and methods. Circular procurement should not become an alternative to sustainable procurement but should be part of it. In particular, the objective should be to do far better justice to circularity in the design. Because circular criteria are still under development, little experience has been gained with them. Therefore, it makes sense to link the development of procurement criteria to ‘living labs’ that work to continually improve circular design. In these ‘living labs’, the risks are shared between the government and the commercial sector. The government can ask something in return: knowledge sharing. Through these ‘living labs’, the government can arrive at policy and regulations in collaboration with market and knowledge organisations. The procurement criteria should align with the development of MCA (Multi Cycle Assessment) mentioned above. The role of government is to collaborate with frontrunners in the market in such development, but make well-considered choices for the rest of the construction sector. Making circularity measurable gives the procurement process a clear tool, in particular in performance-based types of contract. In addition, the best available technology is required it is important that circularity can be measured.

4.6 Risk sharing in innovative projects

Together with construction companies invest in innovative projects by creating enough room in budgets in government tenders. Ensure that the risk is also shared for the innovative aspects.

As a commissioning party, invest in a good working relationship between the commissioning party and the contractor. The state-wide ambition to innovate has led to the public innovation procurement programme Inkoop Innovatie Urgent (Innovation Procurement Urgent). This concerns the government aiming to spend 2.5% of its procurement budget on innovations. A result is the Innovatiegericht inkopen (Innovation-oriented procurement) of Rijkswaterstaat. Stakeholders report that this ambition has not yet become very apparent in actual Rijkswaterstaat projects. Stakeholders are curious about the results and how this will relate to striving for a circular economy. Their advice is to employ this 2.5% innovation budget only after entering into a contract with a party. But make clear in advance what is possible with respect to research and innovation with this budget. In particular contractors ask the government in very concrete terms, whether it is prepared to share the risks of innovative projects or parts of projects.
In a circular economy, the government itself is part of the material cycle. Often, the government is also the owner of the materials in building structures. In view of the long life of these structures and the general interest of its maintenance (consider dikes and roads), it can also be expected that the government will continue to be the owner. Collaboration between all links in the chain/cycle is the foundation of the circular economy. This also has consequences for the relationship between the government and the market parties. The consequences have not been mapped out yet, but are associated with responsibilities in which the government as the policy maker and regulator might play a role.

4.7 Financial/ economic instruments to reinforce the circular economy

Develop in the short term, together with stakeholders, new instruments that eliminate structural impediments when solving the problem of vacant buildings and at the same time provide a substantial incentive to circular building.

Financial/ economic instruments (for instance a CO_2 tax) focusing on the promotion of the use of CO_2-low construction materials, products and structures could be an important incentive for the circular economy. However, stakeholders agree that such a tax can only be effective at the European or global level. The same applies to taxing the use of (primary) resources. A resource tax can be an attractive way to make tax systems more sustainable. But the majority of the levies would come from the use of bulk resources and hardly any from scarce resources. Scarce resources are by the nature of their scarcity not available in large quantities, so if a taxing system is based on a levy per amount of material used it will have the greatest effect on the – not so scarce – bulk resources and very little effect the scarcest resources.

Although carbon taxing could be most effective instrument for resource efficiency, stakeholders feel that there is no reason to wait for

international developments. During the consultation, various new and innovative ideas arose that have a more direct influence on circular and sustainable construction.

In the Netherlands there is a municipal property tax called the WOZ (Dutch Valuation of Immovable Property Act) tax. A financial impulse for increasing sustainability can be achieved through a differentiated tariff in the WOZ Tax. This differentiation could be based on the environmental performance of a building, including its value as a future resource for new buildings. The owner or user of a building that performs well with respect to sustainability will pay less WOZ Tax; those with a poorly performing building will pay more. This creates an incentive both for sustainable renovation of existing buildings and for new construction projects. Of course, such a tax would have to be based on a reliable measurement of the sustainability indicators involved. It is currently already mandatory to provide an energy label for a house. This could be extended to include sustainable material use.

Another option is to include the residual value of a building in a valuation (for a mortgage). It will be easier to get a mortgage for buildings with a longer life or for those that can be easily adapted than buildings that will lose their value more rapidly. The central government could play a role here through the requirements set in the National Mortgage Guarantee Scheme (Nationale Hypotheek Garantie).

The Dutch Green Building Council (DGBC) will start the development of a Sustainable House Label (Duurzaam Woninglabel). Various market parties said that they wanted to contribute to this development. Bouwfonds, BouwInvest, CBRE, Triodos, Vesteda, VolkerWessels and VORM participate in this initiative. The scope here is to base the label on existing instruments for identifying categories and aspects of sustainability. The use of such a label would depend on who is customer and what is at stake. The required accuracy of the label as well as the costs involved will be taken into consideration.

There is a fundamental shortcoming in the current financing of buildings. A bank issues a loan (mortgage) to buy a building, including the land on which it is built. However, the costs of demolition and recycling at the end of its life are not part of the financing. The result is that it is cheaper to leave a building vacant and as municipality or project developer to choose to develop a greenfield site. The costs of demolition and recycling are not included in the current financial model in construction. They are now often a societal cost, with the cost item often ending up as an ‘unforeseen’ item on the municipal balance. The question is whether the government can allow this to happen or should intervene.

There is currently no clear financing model for the demolition and recycling part of the building cycle. Demolition companies would prefer to deconstruct a building rather than demolish it, focusing on the optimum reuse of materials and products, but are not commissioned to do so. The same applies for recycling companies who would prefer to produce a material that can be sold to the building industry as a high

quality resource for new buildings. The economic value of the demolition waste is insufficient to cover all the cost of high-quality demolition and recycling. To an important degree, this is the result of the way in which the building was designed. The demolition and recycling phase of buildings that are now due for demolition was hardly taken into account when the buildings were designed. Therefore, the high-quality reuse of the materials they contain is a challenge.

To avoid this problem in the future, an option is to introduce a disposal levy for buildings. This concerns (jointly) putting money aside in the construction chain for high quality deconstruction/ recycling of the building in due time. By doing so, the costs have already been pre-financed and when a building becomes economically unusable, its demolition (or rather deconstruction) can rapidly be arranged. Moreover, this gives an incentive to design buildings for optimum reuse. Such a system is already successful for several product categories in the Netherlands (cars and household appliances for instance). Charging a low level of VAT on secondary resources or a higher level of VAT on primary resources can help this further.

Institutes in the construction sector that receive government funding or fiscal advantages can be asked to help. For instance, housing corporations can help with the renovation of vacant office buildings in accordance with circular principles. A vacant building caused by an imbalance between what the market is building and what the market demands should be prevented. This is possible by having the market invest in adaptable construction and requiring users to adapt. This gives the user more influence on their living and working environment.

A choice between renovation and demolition should be considered from a broad scope of social perspectives including for instance demographic development and the need for climate neutral living- and working space. In some cases, renovation is an option, in other cases it is better to demolish. The vacant buildings can then serve as a trial site for intelligent demolition and provide an answer to the following questions:

- How can we optimally extract resources from this stock?
- And which questions should be asked during the design phase to make deconstruction a realistic option to demolition?

The participants in the stakeholder consultation are aware that these ideas must be part of an integral approach to urban renewal. Although cities/municipalities should take the lead in this, it is essential that central government plays an active and supportive role to make this fundamental change possible.

The ideas developed during the consultation towards repairing the financial flaws in the construction sector are of course no more than a preliminary exercise. However, the stakeholders agree that these flaws should be addressed if the circular economy in the construction sector is to become a success, and an active participation of the Dutch government could make all the difference. The government has taken the lead before in relation to important societal choices with large consequences for construction (spatial planning for instance). With the arrival of circular construction – in relation to the urban renewal as

desired on many sides – once again an active participation of the government is desired.

'A clear vision on (circular) building in relation to vacant buildings and the financing of construction was considered to have the highest priority by the majority of the stakeholders.'

4.8 Knowledge development

Work together on knowledge development and knowledge sharing concerning the circular economy.

Knowledge is important to further develop CE, in both material chains and in the more general sense. How do you actually build in a circular way, what requirements does it place on all aspects of the material cycles, on designers, commissioning parties, users, etc.?
The proposal is to build up this knowledge and to disseminate it through 'trial sites' or 'Living Labs'. Make clear which knowledge is required for the circular economy and then share this knowledge with the market. The manner in which this knowledge is shared is also important. Furthermore, these living labs serve to test policy and regulations and if necessary to make changes to them.
Universities have various chairs that cover aspects of sustainable building. There is no chair that specifically focuses on circular building. Such a chair would make it possible to carry out more in-depth research into the various aspects of circular building - among others, those mentioned in this report.

4.9 Information sharing in chains: transparency in construction

Help the construction sector by making essential information accessible that is required to make construction circular and guarantee this for a longer time.

Little information is shared between producing and processing companies. This is primarily a task for the companies that participate in the circular economy themselves. The government, as commissioning party, is a however a link in the construction chain (or cycle) and quite often long-time owner of the materials used in construction. As the commissioning party, the government is rarely aware of the materials that are used and of the stocks of material under its control, let alone does it have a clear view of how efficient use of these resources could be addressed.

Mainly, the government – as a user – is the link between the suppliers and producers on the one hand and demolition and recycling companies on the other. Because information about materials must be kept as long as the materials are in use, this is a clear task for the government as the commissioning party in construction. The government can indirectly stimulate the development of transparency and knowledge sharing throughout the building cycle. This also applies, for instance, to the further development of the necessary instruments. Consider here the BIM design tool that is increasingly used: Building Information Model. Work together on specifying the circular requirements for secondary materials, allowing these materials to also become marketable. Also work together on the design of materials and place quality requirements

on secondary materials in the chain, allowing the optimal alignment of production and processing. A frequently recurring subject in the circular body of thought is the 'Materials Passport' (see previous chapter). Because with respect to construction, the government is often the longest owner of building products/materials, it is obvious that it should take a directing role. How this should be done is still unclear. In view of the complexity, it is probably a subject to further develop in the tripartite of government, companies and research institutes.

Sharing knowledge in the construction sector is a sensitive topic. In the past, knowledge shared between companies in the construction sector was occasionally misused to make price agreements and by doing so obstruct free trade within Europe. To prevent this, regulations and legislation have been developed in the Netherlands, but also at the EU level. The question is whether sharing the knowledge required to arrive at the circular economy could be in conflict with the European trade legislation. If so, this could turn out to be a major impediment for circular economy.

4.10 Operate as a single government

Provide a new and circular vision for the transformation of the construction sector and prevent this topic from being fragmented over multiple ministries. Ensure wide societal participation when developing this view.

In view of the scope of the structural impediments in the construction sector and their complexity, the government is the only party that can and should take control. Here the support of all of the relevant stakeholders in the construction sector is indispensable. In general stakeholders agree to support a government that is committed to searching together for ways of realising circularity and improving sustainability in the construction sector.

5 Analysis of the stakeholder consultation

There are a number of central themes that run through the recommendations discussed in the previous chapter. In the analysis below, the questions that arise are explained in terms of the role of the (central) government.

5.1 Market or government?

The stakeholder consultation shows that there is significant support from the frontrunners for realising a circular economy in the construction sector. Of course this is a select group of people who are strong advocates of innovation in construction. However, representatives from the most important sector trade associations were present and also proved to be supporters of the circular economy. There is awareness that it concerns a gradual transition. With respect to how this should be realised, the various insights differ. There are two principally different directions:

- The government (or government bodies) is, as the largest commissioning party, the driving force behind realising a circular economy in the building sector with sustainable (or circular) procurement as its most important instrument.
- The construction sector is mostly self-organising, but can use some assistance from the government in providing financial incentives and legal instruments such as a disposal levy for the demolition of buildings and infrastructure.

Analysis

The popularity of circular procurement is striking in view of the recent criticism from the commercial sector concerning the poor operation of sustainable procurement. This criticism mainly came from contractors who were relatively underrepresented in the stakeholder consultations. Procurement instruments prove to function well for private commissioning parties. The BREEAM[1] sustainability certificate for buildings is valued, with the comment that in particular the aspect of circular/sustainable material use could be improved.

Stakeholders ask of the government to have an inclusive view of the future of construction and circular building in particular. There is a common interest where societal challenges interface with the revenue model of companies. Consider here the solving of scarcity and waste problems. Various commercial sectors are faced with scarcity and this is normally the driving force behind producer responsibility; by taking back the product, it is possible to recover scarce materials. This responsibility can only be realised by collaboration in the chains. Therefore, circularity is in the interest of entire chains and not only of the government.
In the construction sector, scarcity is a marginal problem and in general, the life of buildings and constructions span many decades. These sector characteristics ensure that the pressure for producer responsibility in the construction sector is less than in other sectors. In addition, more than other sectors, the construction sector is fragmented and the chains are

[1] Building Research Establishment Environmental Assessment Methodology

less organised than many other sectors. Moreover, the flaws in the financing of construction are a reason to look for solutions that involve a large diversity in parties (see the next item as well). It is very desirable that the government plays the role of the facilitator, if not director in this process, because the role is 'too big' for any of the individual stakeholders.

Another role for government is to be active in Europe, to provide insight there in the development of circular economy in the Netherlands. In particular as the development of policy, regulations and technical standards have direct consequences for national policy.
It is obvious that a decision to choose either the government or the market should not yet be made, but to choose for collaboration between government and market. And not only market parties: other stakeholders (in particular cities and their inhabitants) also play an important role here. Because the government as the commissioning party in construction is itself part of the desired circular economy, circular procurement is a necessary consequence of the circular market development. There is no fixed recipe that can be followed for the circular economy. A government that dictates from its ivory tower how the other stakeholders must become circular will certainly be counterproductive. Developing together and learning from each other's mistakes will bear the most fruit.

The experience of Green Deals, in which the government is directly involved, also shows this. Participants in Green Deal Concrete are actively looking for contact with their commissioning parties in construction to discuss sustainable procurement instruments. This is because the current instruments have not yet had the desired impact on the market. Having specialists from various links in the concrete chain working together makes it possible to investigate what is technically feasible. The challenge here is to remove unnecessary impediments and to amend the procurement criteria using the knowledge gained. This is a time-consuming approach, but the insights gained can in time lead to agreements for the entire sector. The Green Deal Concrete is therefore striving to reach a 'Chain Agreement': a national agreement with the entire sector to reduce CO_2 production per volume of material and to use a percentage of high-quality, recycled old concrete in new concrete. This requires the necessary investments to be made by the sector, but these are considerably lower than most other ways to realise CO_2 reduction targets. There is as yet no answer to the question of who will pay the bill. To investigate this once more requires working together with the government. In addition, the chain must also work together in the same way at the policy level to achieve major breakthroughs. On a smaller level of scale in building projects, it is also essential that the chain should work together to achieve circular economy.

5.2 Is circular construction also about solving the problem of vacant buildings?

During the stakeholder consultation, it appeared that many cannot consider circularity in construction separately from the problems the construction sector is currently facing: vacant offices and industrial estates that to a major degree contributed to the economic crisis in the Netherlands.

Analysis
The Netherlands is struggling with a high degree of vacant office buildings (17%, Compendium voor de Leefomgeving, 2015) and industrial estates. Investing in real estate and as such in construction proved profitable for investors. However, there was no consideration of whether this profitability was guaranteed over the longer term. The vacant offices are still on the balance sheet of banks and pension funds as valuable possessions and cause stagnation in financial transactions. Therefore, this has put the construction sector on hold. The costs associated with these vacant buildings were shifted to the government as a result of the emergency support given to the banks. This means that eventually these costs will be transferred to the general public.

In the past decades, municipalities often decided to develop new districts and industrial estates on greenfield sites, even though space could have been created in old industrial estates and vacant office parks. The discussions with stakeholders showed that this was partially due to the 'flaw' in the financing of construction. The costs of demolition and redevelopment of industrial estates and office parks were not part of their financing. If a municipality wants to redevelop such a site, it must pay the costs itself. In addition, the sale of land formed an important source of income for municipalities.
The consequence is that older industrial estates increasingly have to cope with the problem of vacant buildings. Hardly anyone still wants to invest in improving these areas. In addition, there are various municipalities that speculated on more growth and invested heavily in new projects based on optimum land sales. These municipalities are now left with unsellable land and face financial problems in part as a result. Due to the financial-economic stagnation, relatively few buildings are being demolished, as a result of which little material is reaching the recycling sector and therefore it hardly invests in new (circular) technology. The same applies to the producers of building materials: there is not much to build therefore the sector is having a difficult time. There is hardly any room for investment.

The awareness of the interrelationship of these problems is growing in the construction sector and might explain in part the enthusiasm for the idea of the circular economy. The idea includes the potential to build in a more well-considered way, taking the long term into account. For companies that survived the crisis, their long-term existence is more important than the profit margin.

Truly innovative ideas focus on the wish in the construction sector to collaborate more effectively and to exchange knowledge and experience, to build in a more intelligent way with fewer risks and failure costs. The construction sector indicates that it wants to create societal value and

bear co-responsibility, but requires financial capacity that is capable of offering sufficient long-term security.

The ideas concerning a sustainable and circular financial model for construction are still in their infancy. However, the present models implicitly assume that solving the problems of vacant buildings forms part of the solution for a circular economy in construction. The innovators would like to take the initiative, and are willing to take responsibility, but need the government for aspects including:

- The possibility for the sector to generate money flows (the principle of the disposal levy);
- The willingness to share risks together with commissioning parties in the area of technical, financial and organisational innovations;
- Economic incentives that translate the societal added value of sustainable/ circular buildings into economic added value (the idea of differentiated WOZ Tax);
- Active involvement of the government in elaborating this. Not as a dictatorial legislator, but as a professional and relatively independent party in the building sector.

A financial model for the lifecycle costs can be found in Figure 5. This graph shows the cumulative costs in the various phases of the life of a building. The costs of both the materials and for demolition and recycling are rather small when compared to other cost factors. Even so, with respect to the environmental effects of an energy neutral building that is circular, it mainly concerns material-related aspects.
This insight offers opportunities for new circular models for construction. By investing more in design and (industry-based) technology of materials and building products, the (high) costs of the construction process itself can be reduced with the total result being more quality at a lower cost. If the model is filled with realistic figures gained from practice, it can also be used to calculate the possible effect of stimulating measures (including a disposal levy), and could say what size this levy should be.

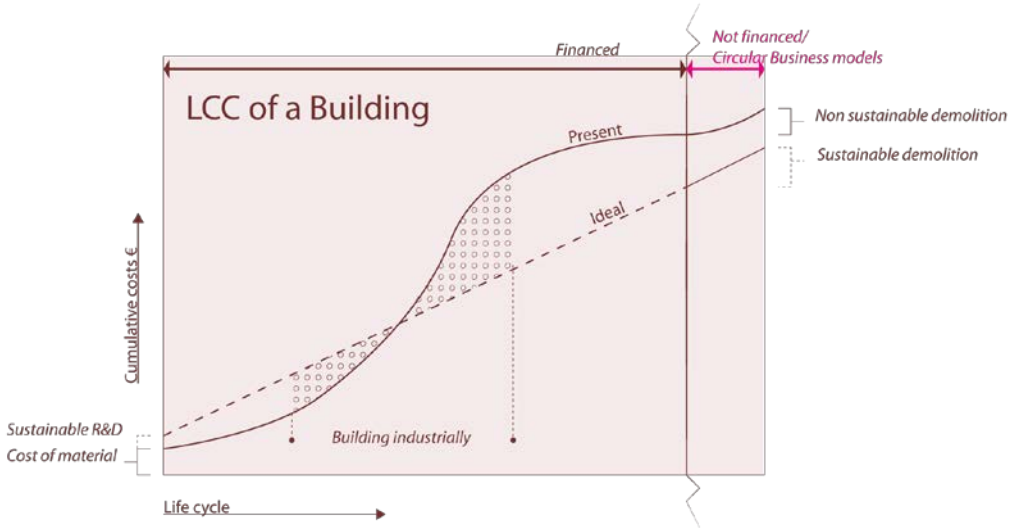


Figure 5. This graph represents the life-cycle costs of a building. The sustainable demolition of existing buildings must lead to the reuse of the materials they contain in the new structures for the B&U sector. The building materials are currently often used for a lower quality application in civil engineering. Sustainable demolition supplies materials for new construction and here the material costs are slightly higher as a result of making these materials more sustainable. However, by taking an industrial approach to construction, these costs can be saved at a later stage. This makes the future lifecycle costs for new construction lower (which is the aim) than the current costs. It is up to the market to search for revenue models here.

5.3 Demolition or renovation?

Should construction become circular by using existing (vacant) buildings for new purposes or is it better to demolish them and create functionally circular and sustainable new areas? The current tendency in construction mainly focuses on renovation. For some this is a good example of circular building. Others consider it a major threat for the circular economy in the construction sector.

Analysis

As part of the Dutch Climate agreement, the existing buildings will be made more energy efficient. In the 'Stroomversnelling' project, single family from the fifties, sixties and seventies are insulated and equipped with solar panels in order to meet the strict energy standard of 2015, which makes them almost energy neutral. This immediately benefits the environment and extends the life of these houses. However, in the long term it is still questionable whether this is a good investment. The material used in these houses is sometimes of a lower quality and the layout is mainly based on social ideas from the period in which they were built. As such they often are not in line with today's themes, including the aging population and the desire to continue to live at home for as long as possible. If the functional and qualitative residual life of the buildings is limited, in the longer term this would not be a useful societal investment. Demolishing the old buildings and building modern

energy-generating houses would be a better societal investment. Advocates of renovation take the position that renovation is better for the environment than demolition and recycling because less material is wasted. When deciding between demolition or renovation, there is no objective assessment instrument currently available that can clarify the choice. Such an instrument would be useful to be able to transform the problems of vacant buildings and stagnation in the building sector into an active new construction policy. However, a condition is that when demolishing and renovating these buildings, the materials are used in a circular way with the minimum of CO_2 emissions.

An approach where the energy performance of buildings and the environmental performance of the materials are part of an integral comparative assessments would be useful in the Netherlands. European policy uses the idea of 'resource efficiency', in which the most optimal use of both materials and energy resources are assessed as a whole. Such a method could also be useful in the Netherlands as the basis for an assessment instrument to compare renovation to demolition and rebuilding, although the usability, the energy efficiency of the built object and the complete lifecycle should also be investigated in addition to resource efficiency.

5.4 Bio-based building?

Many parties propagate bio-based construction as an opportunity to limit CO_2 emissions. The principle of bio-based building is not new; wood has been an important building material from time immemorial. It is true that wood is used to a lesser degree in the Netherlands than, for instance, in the Scandinavian countries, but this has everything to do with the availability of this building material.

Analysis

Because the construction sector - more than any other sector - requires large amounts of material, it is obvious to mainly use materials that are abundantly available. Rock formations can only be found in the south of Limburg, the rest of the country is made of sand/gravel, clay and peat. Clearly, these are the building materials that are preferred in the Netherlands. The construction sector is rarely faced with scarcity, because the use of scarce raw materials would make building much too expensive. Wood is an exception: it is relatively light and can be transported over somewhat greater distances without incurring excessive costs. Because of its light but also strong properties, and nowadays also because of its favourable CO_2 profile, wood is the only 'bio-based' material that is used on a large scale in construction.

In principle, it would be possible to use other bio-based materials. Several principles are important here:

- Bio-based applications should not get in the way of the circular use of materials; for instance, what impact does adding bio-fibres to concrete have on its reusability?
- It will mainly concern specific applications; the possibilities of replacing a bulk material are limited. To give an example: many kilometres of road shoulder are required to supply sufficient bio-based material to be able to lay a kilometre of asphalt road created from bio-based bitumen.

- The bio-based application should not compete with food production or nature development/ biodiversity.
- In environmental assessments of (primary) bio-based building materials, the use of artificial fertiliser and crop protection products should also be considered.
- When using bio-based materials, the preference may be to use them in high-quality applications rather than in bulk materials.

This year, a Netherlands Technical Agreement (Nederlandse Technische Afspraak - NTA 8080-1:2015) was published that specifies sustainability criteria for biomass and an associated assessment method. This method examines the entire chain, from biomass production or the collection of residual waste flows, trade, processing and the use of biomass in a product (bio-based material) or application (energy). Such aspects can be included when formulating circular design and assessment criteria for bio-based building materials. Based on this, the bio-based industry can design targeted products.

5.5 Reuse or circular design?

A frequently recurring discussion concerns whether attention must be focused more on the reuse of building material waste or more on the circular design of building products. In other words, is it about solving the current waste problems or about preventing a material and waste problem from occurring in the future?

Analysis

Only focusing on maximising reuse is not very useful, because there is already more than 95% reuse in construction. However, only a limited proportion is circular in the sense that the material can be reused, cycle after cycle, for the same (type of) function. This proportion is not exactly known. It is known that no more than approximately 3% of all building materials used to construct buildings originate from a recycled material.

For its own structures, Rijkswaterstaat estimated that approximately 70% could be called circular. This often differs per material flow: a large proportion of all steel is recycled and reused as steel, approximately 50% of asphalt is recycled in new asphalt, but the recycling of the surface layer is still in its infancy, concrete is mostly recycled, but mainly used as road foundation material, and only approximately 3% is reused in concrete, see also Figure 6.

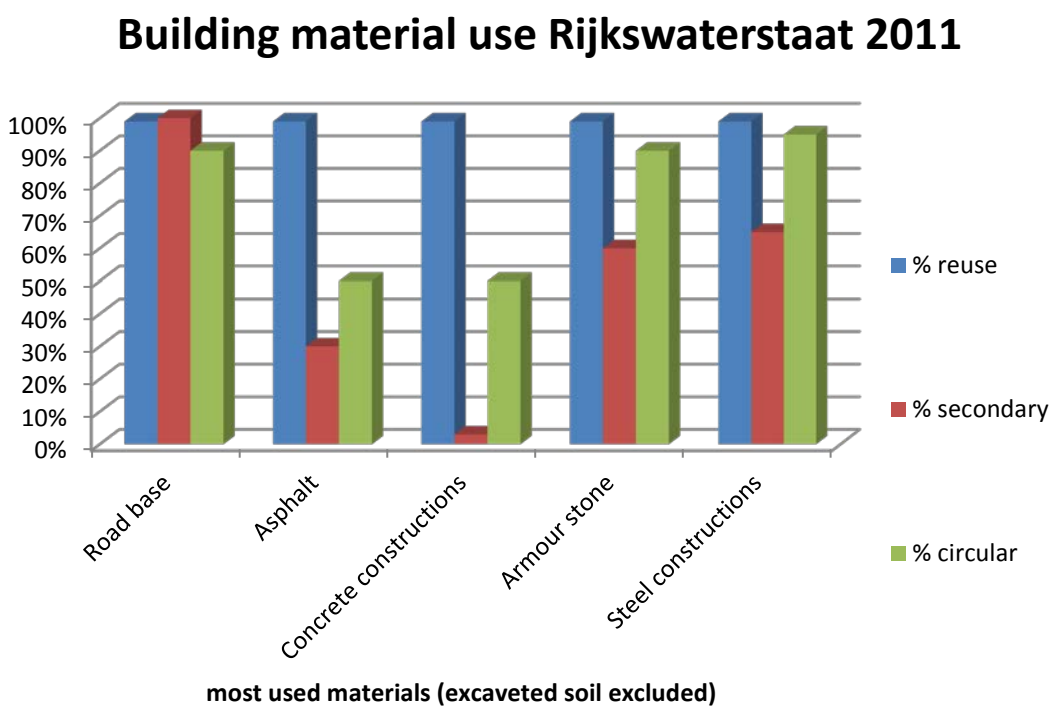


Figure 6. Building material use by Rijkswaterstaat in 2011. Based on the Movares 2013 figures; Carbon Footprint Rijkswaterstaat with estimates of percentages reuse (in the event of demolition), and secondary or circular (in new projects).

New technology makes it possible to use all of these materials in a more circular way, as long as there are sufficient economic incentives to do so. However, it is important to consider that the materials, from which the waste that arises now originates, were mainly created 50 years ago and these were not designed with high-quality recycling in mind. New technology can help in recycling waste materials so that they can be reused for new products in a circularly responsible way. But there are technological limits.

It is essential to design for the future in such a way that materials are actually circular and can be reused, cycle after cycle (in essence: 'design for recycling'). Therefore, the answer to whether one should focus on reuse or on circular design is: on both. A circular design places requirements on the materials used. If these requirements are clear, the recycling industry can focus on developing new technology to meet these requirements ('Recycle for design'). Waste materials that cannot be reused cycle after cycle will still pose a problem in the coming 50 years that will continue to demand attention. However, it will be a problem that gets smaller.

Instead of a choice between the reuse of waste materials and the use of primary raw materials, it would be useful to design using 'circular' building materials. Both primary and secondary raw materials qualify for

this, on condition that high-quality reuse is possible, cycle after cycle. Such criteria are hardly available or not yet available. It is obvious that there will be a need for unambiguous criteria that in the longer term could be harmonised at the European level. This concerns for a part the multi cycle sustainability criteria (MCA) as mentioned in the previous chapter. At least as important are the technical requirements of the specific (circular) product in which the secondary materials are used.

5.6 Create added societal value with new business models or limit to closing the loop in the chain?

What belongs to the circular body of thought and what does not? The idea to create added societal value through the circular economy is part of the philosophy. However, it is not a delineated term and because of this also impacts other societal objectives. Some consider an initiative only circular if it will realise a large number of societal objectives. Others limit themselves to the essentials: the closing of material chain loops. This second group prefers to see that the added sustainability-related societal values remain an aspect of sustainability. The circular economy offers a way to improved sustainability.

Moreover, the CE literature often assumes that CE leads to other revenue models in which the concept of ‘use instead of possession’ plays a central role. Here, lease constructions are often seen as the motor behind the transition towards a circular economy. After the lease period, producers take their product back and assume responsibility for the waste associated with it. Here it is in their own interest to ensure that these waste materials can be reused for a new product. Therefore, circular design is economically advantageous.
Due to the long life of building structures, such a lease concept is uninteresting for them, the term ‘immovable property’ (in Dutch ‘vastgoed’) says enough. There is no guarantee that the construction company will still exist at the end of the life of a building. Taking the building back after a longer time also poses a financial risk, there is simply too much uncertainty about prices and methods of building that will prevail in 50 years’ time. Even so, there are sufficient elements in a building that have a shorter life for which leasing could be an option.
The lease concept for building elements is sometimes obstructed by the Dutch approach to ownership rights. If an object is ‘permanently attached’ to a building, this object is the possession of the building owner. For building systems (e.g. air conditioning systems, central heating systems), this would mean that leasing them would pose a degree of risk. Certainly if the party that takes out the lease is a subtenant of a building. If the owner of the building goes bankrupt, the leased objects could be claimed by a creditor.

Analysis
The pitfall of the circular economy concept is that it is sometimes undefinable and therefore not measurable. This is in part due to the fact that the theme is popular, there’s something in it for everyone. Therefore, there is a great need for objective assessment criteria (see the other points of discussion as well) that can be used to make a clear delineation. Here it is important to make a distinction between circular economy at the material level and the sustainability objectives related to CE. These societal objectives are often broader than circular economy

and it would be better if they were classified differently. In the discussion regarding urban renewal (healthy, green, cool, smart cities) the creation of added value by linking multiple objectives into joint projects is essential. Here, the notion that the existing buildings - including those that are vacant and aging- can be a source of renewal is interesting. In such discussions, ideas about circular construction must therefore play a central role. However, much more collaboration between the links in the construction chain (cycle) is required to be able to actually make circular construction products. For instance, specifying quality requirements between producers and processing companies. It is possible that this collaboration will lead to chain integration and new roles for companies in the construction sector. As explained above, a lease model that is linked to the responsibility of the producer is less interesting for the construction sector due to the long life of buildings. However, for certain elements and infrastructure, a lease model might offer opportunities and attention will probably have to be given to the legal aspects.

An integrated manner of thinking also already exists: the model of the American Stewart Brand makes a distinction in six different parts of a building, each with a different lifespan (Site, Structure, Skin, Services, Space plan, Stuff, see Figure 7) (Brand, 1994). Some parts are easy to adapt and others have a longer life. Installation systems (e.g. heating) are replaced once every 15 to 20 years, here a lease model, including a maintenance contract, is an option. The shell of the building exists for a long time and is not easy to change. Here it is important that the shell intrinsically allows the building to be configured in several ways, so that when the building becomes outdated, simple modifications can give it a new use.

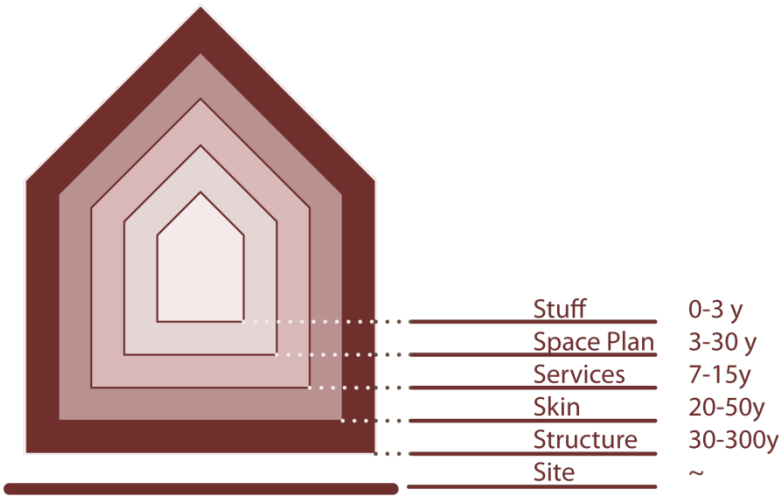


Figure 7. The philosophy of Stewart Brand states that there are six different dynamics that characterise a building.

It seems that various new revenue models are developing in parallel. For instance, some subcontractors move more in the direction of being a producer and material supplier and are also occupied in recycling. Others limit themselves to a directing role outside of the material chain.

In addition, a project developer can be the owner for the entire lifecycle of a building. For the government, this currently has no consequences. On this point, the advice is: let the market parties deal with it and do not attempt to direct it in a particular direction (with, for instance, circular procurement).

5.7 Assessment instruments for circularity: MCA and MCC

The development of assessment instruments for circularity is one of the subjects that stakeholders agree about. Nowadays, environmental and cost analyses take the entire lifecycle of products or structures into account (LCA and LCC). However, neither of these techniques take the next lifecycles into account. There is a need for assessment instruments that are able to predict such effects over multiple lifecycles (to some extent). Instead of using an LCA (Life Cycle assessment), we use an MCA (Multi Cycle assessment).

Analysis

There is support for the development of circular assessment instruments, but the question is who should develop them. Such instruments must exist if the government, as the commissioning party, wants procurement to be circular. However, the underlying knowledge must come from the material chains and the designers. The role of the government in this is to contribute ideas and to listen, and where necessary translate the instruments into circular requirements in procurement processes. An instrument must be developed to gain insight into the environmental impact over multiple cycles (MCA) and here the government should take a leading role. Instruments related to the LCA – including the Environmental Performance of Buildings and the National Environmental Database – should be included in this Multi-Cycle approach.

In addition to the environmental performance analysis, it would also be useful to extend the cost analysis from LCC (Life Cycle Costing) to MCC (Multi Cycle Costing). The central government, as the largest commissioning party in the construction sector and manager of a very large building stock, could take the lead by including such an instrument in Asset Management (optimisation of management and maintenance of infrastructure).

The international dimension has hardly been addressed. Even so, in particular in the area of technical requirements, circular criteria and LCA instruments, important discussions are being held in Brussels and the rest of the world. It is therefore important that when developing an MCA, the developments in the European Union are also taken into account including the regulations that it is developing.

A first indicator

In the EU research programme LIFE, Granta Design and the Ellen MacArthur Foundation developed an initial indicator for circularity, the Material Circularity Indicator (MCI), which in part uses existing LCA modules and builds on from there. This indicator shows how much material in a product circulates in the chain. The MCI must be combined with an assessment of other properties of the material and the impact of the product to arrive at a complete assessment (see Figure 8).

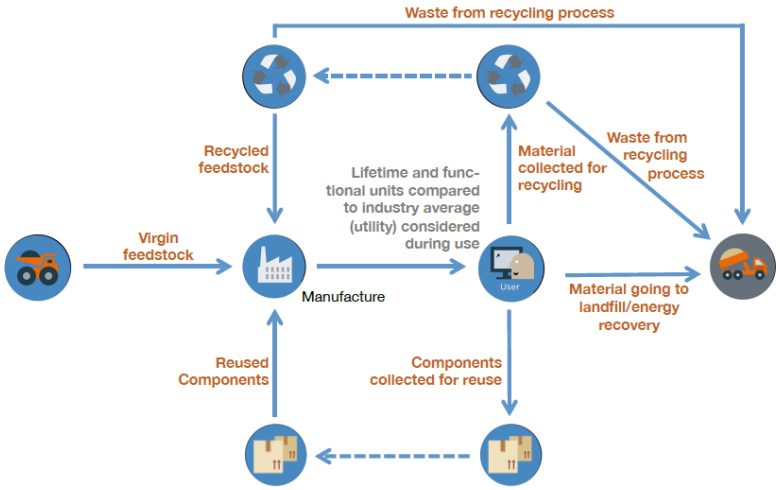


Figure 8. The Ellen MacArthur Foundation developed a Material Circularity Indicator that can be used to assess the circularity of material in a product (Granta Design & Ellen MacArthur Foundation, 2015)

6 Synthesis and policy advice

6.1 To be put on the agenda: development of a vision and the organisation of the construction sector

The Stakeholder meetings expressed a strong wish to arrive at a (more) circular economy for the construction sector. The sector can do much itself to realise this goal. However, there are a number of fundamental societal obstacles that governments must address.

Not only the circular economy frontrunners but also representatives of sector organisations argue for a widely supported societal vision for the modernization of the construction sector. This from the perspective of urban renewal in which these societal bottlenecks are addressed and in which CE will have a place in the construction sector. Stakeholders explicitly request that the government ensures that there is intensive collaboration between the policy-making departments involved. Due to the important relationship between CE and urban renewal, the request is also made for close collaboration with cities that actively pursue renewal.

This survey can serve as the basis. The themes and directions in which to search for solutions given here should each be further substantiated and should lead to concrete ambitions and implementation programmes:

- Explore the possibilities to solve structural problems related to vacant buildings and the related financing issues in the construction sector. In view of the history of financial flaws, a long-term perspective must be found.
- From an integral societal perspective, develop a decision-tree model that can be used to decide between demolition/rebuilding and renovation (or using vacant offices for other functions).
- Explore the possibilities of employing the proposed (or other) financial instruments:
  - A social cost-benefit analysis for the introduction of a disposal levee for buildings;
  - An social cost-benefit analysis for a differentiated circular property tax based on the WOZ
  - A legal exploration of the aspects of these (and related) instruments.
- Develop a vision on the gradual development of CE as a solution for existing waste problems in the construction sector to position CE as a way to prevent raw material and waste problems in the future.

When doing so, ask advice from a number of important advisory bodies, including:

- The Council for the Environment and Infrastructure *(Raad voor de Leefomgeving en Infrastructuur)*;
- The Bouwberaad;
- The Social and Economic Council (SER);
- A round-table conference with Parliament.

6.2 Arrange professional preconditions to make CE in the construction sector possible

- For the government as the commissioning party: provide freedom to experiment and to learn in 'Living Lab' building projects. The knowledge obtained in such educational projects can form the basis for the further development of circular design criteria, assessment instruments and new methods for sustainable and circular procurement.
- Together with the construction sector, develop instruments for circular aspects of construction that can be effectively tested. Integrate these instruments into existing instruments including LCA (life Cycle environmental Assessment) and LCC (Life Cycle Cost analysis) and BIM (Building Information Model *(Bouw Informatie Model)*. Add aspects that provide a better model for comparative assessment for bio-based building. Incorporate these instruments in the Buildings Decree.
- As commissioning party (in both construction and civil engineering) together with the market parties and knowledge institutes, take the lead in the development of material passports. Ensure that more insight is gained into the use of materials and the stock of materials under the control of the government (for instance at Rijkswaterstaat, Ministry of Defence, Rijksvastgoedbedrijf).
- Ensure that there is active involvement in the development of policy, regulations and technical standards within the EU.
- Promote the establishment of a chair in CE that specifically focuses on the (entire) construction sector (including demolition and recycling) at one of the (technical) universities.

6.3 Make use of the 'energetic society' by challenging market parties

Market parties in the construction sector would be pleased if the government would provide a vision, but at the same time, they must also change much themselves. The role of the government in this change is a facilitating one, for instance:

- Give a good example as the commissioning party and together with companies develop functional requirements for circular building:
  - When doing so, use instruments like the 2.5% of the central government's budget for innovation-oriented procurement.
  - Ensure that the risks associated with innovative projects are shared
  - In government projects, ask for information about the materials used in buildings and how these can be easily dismantled and removed from a structure.
- Align policy and regulations to the wishes of society regarding circularity:
  - Look for possibilities to involve residents/users more in the design of buildings and infrastructure.
  - Explore the options that are available to adapt the ownership legislation in the Netherlands in such a way that the ownership of buildings can be divided into components. Things that users attach permanently to the building should not by definition become the property of the building owner. Explore what this means for - for instance - the attachment of

installation systems (e.g. central heating systems), the installation of residential accommodation in leased building shells.

- As the government, monitor how the market is progressing in the area of circularity and sharing the associated knowledge. An evaluation should clarify whether the steps that are taken are effective.
  – Ensure that knowledge development is accompanied by ‘open access’ development principles and that it is shared widely. Also ensure that knowledge institutes participate in this;
  – Establish a knowledge agenda for circular and sustainable building in collaboration with the market.

Glossary

AVV	*Algemeen Verbindend Verklaring* - Order declaring a collective agreement binding
BIM	*Bouw informatie model*- Building Information Model
BREEAM	Building Research Establishment Environmental Assessment Methodology
B&U	*Burgerlijke en Utiliteitsbouw* - Residential and non-residential building
CE	Circular Economy
DGBC	Dutch Green Building Council
Ecodesign	European directive which places requirements on the ecological design of energy-related products, including consumer electronics, white goods (both professional and domestic) and lighting.
LCA	Life Cycle Assessment/ Analysis, a method used to calculate the environmental impact of a product or activity, from the mining of raw materials to produce the product to the waste phase of the product
LCC	Life Cycle Costing, a method used to make an inventory of the financial costs of a product or service, which allows the investment costs, management and maintenance costs, and 'demolition costs' to be compared.
LEED	Leadership in Energy & Environmental Design.
NMD	*Nationale Milieudatabase*- National Environmental Database
MCI	Material Circularity Indicator
OZB	*Onroerendezaakbelasting* - Property tax
RACE	*Realisatie. Acceleratie Circulaire Economie* - Realisation of the acceleration of circular economy
Resource efficiency	Use the natural raw materials in a sustainable way, while minimising the impact on the environment.
RVB	*Rijksvastgoedbedrijf* - Central Government Real Estate Agency
SBK	*Stichting Bouwkwaliteit* - Foundation for Building Quality
WOZ	*Wet waardering onroerende zaken* - Valuation of Immovable Property Act

Literature

Agenda Stad (2015) http://agendastad.nl/

Brand, S. (1994). How Buildings Learn: What Happens After They're Built, Viking Press: New York

Bastein, T., Roelofs, E., Rietveld, E., Hoogendoorn, A., (2013). Kansen voor de Circulaire economie in Nederland (No. TNO 2013 R 10864). TNO. http://repository.tudelft.nl/view/tno/uuid%3Af6b77035-282f-4813-82fd-a365e02f87e5/

Bouwteam o.l.v. Joop van Oosten (2012). De bouw in actie(s)! Investerings- en innovatieagenda voor de woning- en utiliteitsbouw. https://www.rijksoverheid.nl/documenten/rapporten/2012/05/24/actieagenda-bouw-rapportage

Bouwteam (2014). Routekaart Innovatieakkoord bouw, eindverslag van het Actieteam Innovatie. http://www.actieagendabouw.nl/wp-content/uploads/Actieagenda-Bouw-Innovatieakkoord.pdf

Brink Groep, CPI (2014). Gebouwen met toekomstwaarde! Het bepalen van de toekomstwaarde van gebouwen vanuit het perspectief van adaptief vermogen, financieel rendement en duurzaamheid. http://slimbouwen.nl/fileadmin/user_upload/news/nieuwsberichten/rapport_adaptief_vermogen/20140630%20Eindrapport%20bepalingsmethode_DEF.PDF

Chen, C., Habert, G., Bouzidi, Y., Jullien, A. (2010). Environmental impact of cement production: detail of the different processes and cement plant variability evaluation. Journal of Cleaner Production, Volume 18, Issue 5, March 2010, Pages 478–485. doi:10.1016/j.jclepro.2009.12.014

Compendium voor de Leefomgeving (2015). Vrijgekomen en verwerking van afval per doelgroep, 1990-2012; geraadpleegd op 10-09-2015, http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl0206-Vrijkomen-en-verwerking-van-afval-per-doelgroep.html?i=1-4

Compendium voor de Leefomgeving (2015). Leegstand van kantoren in Nederland, 1991-2015; geraadpleegd op 11-09-2015. http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl2152-Leegstand-kantoren.html?i=36-177

Ellen MacArthur Foundation, http://www.ellenmacarthurfoundation.org/

Ellen MacArthur Foundation (2012). Towards the circular economy Vol 1. Economic and business rationale for an accelerated transition. http://www.ellenmacarthurfoundation.org/books-and-reports#!/Towards-the-Circular-Economy-vol-1/p/32770373/category=0

Ellen MacArthur Foundation (2015). Growth within: a circular economy vision for a competitive Europe. http://www.ellenmacarthurfoundation.org/books-and-reports

Ellen MacArthur Foundation, Granta Design (2015). Circularity Indicators. An approach to measuring Circularity. Methodology. http://www.ellenmacarthurfoundation.org/circular-economy/metrics

Maurits Hekking et al. (2015). Brief aan de kamer over Duurzaam Inkopen. http://degroenezaak.com/wp-content/uploads/2015/01/TK-Brief-Coalitie-Duurzaam-Inkopen-27-jan.pdf

PIANo (2015) Thema Maatschappelijk Verantwoord Inkopen. https://www.pianoo.nl/themas/maatschappelijk-verantwoord-inkopen-duurzaam-inkopen, geraadpleegd november 2011

RLi (2015). Circulaire Economie – Van wens naar uitvoering, Den Haag: RLi. http://www.rli.nl/publicaties/2015/advies/circulaire-economie-van-wens-naar-uitvoering

Spijker, J. Van der Grinten, E. (2014). Einde-afval bij afvalwater en bouwstoffen: Mogelijkheden om hergebruik te stimuleren binnen de circulaire economie, Bilthoven, RIVM. http://www.rivm.nl/dsresource?objectid=rivmp:251893&type=org&disposition=inline

Yellishettya, M., Ranjitha, P.G., Tharumarajahb, A. (2010). Iron ore and steel production trends and material flows in the world: Is this really sustainable? Resources, Conservation and Recycling, Volume 54, Issue 12, October 2010, Pages 1084–1094. doi:10.1016/j.resconrec.2010.03.003

Appendix A Overview of the participants of the consultations

Participant	Organisation/Company
Peter Broere	BRBS Recycling
Agnes Schuurmans	Rockwool
Aldert Hanemaaijer	Planbureau voor de Leefomgeving
Alexander Pastoors	BNA
Arthur ten Wolde	IMSA Amsterdam
Bart van den Broek	Staalfederatie
Bas Slager	Repurpose
Bram Adema	Corporate Facility Partners
Cora Jongenotter	VORM
Debra de Leest	Interface
Dorina Putman	ASN Bank
Eric de Munck	Vereniging van Nederlandse Houtondernemingen
Erik Verhallen	RWS
Floris Schuit	
Frank Koster	Termo Komfort
Geanne van Arkel	Interface
Gerard Schroder	Schroder Vastgoed
Gerard Wyfker	Koninklijke Metaalunie
Gerwin Schweitzer	RWS
Gustaaf Boissevain	Rijksvastgoedbedrijf
Guus Mulder	TNO
Hans Spiegeler	Ministerie van IenM
Harry Roos	Bouwend Nederland
Helen Visser	Bouwend Nederland
Irene ten Dam	Economic Board Utrecht
Jack van der Palen	Architectengroep Archiview
Jan Hoeflaken	RWS
Jan Paul van Soest	JPVS
Jan-Henk Welink	TU Delft
Jasper van Rooijen	BZK
Job Spijker	RIVM
Kees Boot	Buro Boot
Kees Faes	Search bv
Lars van der Meulen	Volker Wessels
Margot de Cleen	RWS
Mari van Dreumel	Ministerie van IenM
Marie van der Poel	VOBN
Michiel Haas	Nibe
Murk de Roos	Ministerie van IenM
Nick Govers	Search bv
Peter Fraanje	NVTB
Peter van Mullekom	MWH
Piet van Luijk	Ministerie van Binnenlandse Zaken
Pieter Zwart	FGH Bank

Participant	Organisation/Company
Remco Kerkhoven	VOBN
Remko Zuidema	BRIQS Foundation
Ruud Geerlings	Scheuten
Selina Roskam	RVO
Stefan van Uffelen	MVO Nederland
Suzanne Vos-Effting	TNO
Thies van der Wal	VBI Ontwikkeling bv
Thijs van Spaandonk	Transition LAB
Tim van Dorsten	Duurzaam gebouwd
Ton Bastein	TNO
Ton Pielkenrood	BFBN
Wietse Walinga	Duurzaam gebouwd
Willem Jan Barendregt	Dekker grondstof voor ontwikkeling

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Colofon

Published by	Rijkswaterstaat - Water, Verkeer en Leefomgeving [1] National Institute for Public Health and the Environment (RIVM)[2]
Information	RIVM report number 2016-0024
Telefoon	+31 88 797 29 48 (Rijkswaterstaat) +31 30 274 91 11 (RIVM)
Uitgevoerd door	Evert Schut[1], Machiel Crielaard[1], Miranda Mesman[2]
Date	18 December 2015
Status	Final