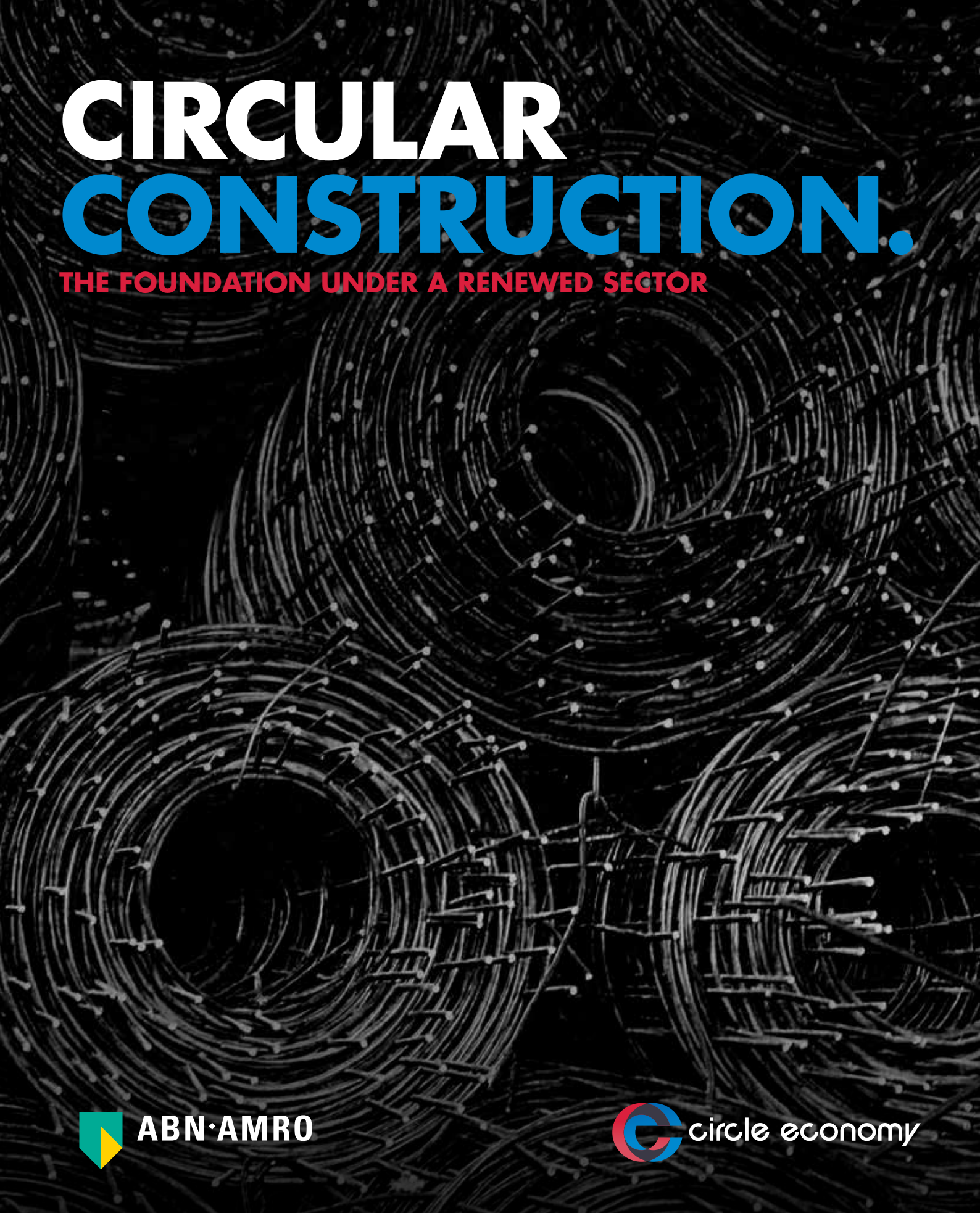
CIRCULAR CONSTRUCTION.

THE FOUNDATION UNDER A RENEWED SECTOR



ABN·AMRO

circle economy

BULLITT CENTER: COMMERCIAL SUCCESS.

One of the most sustainable buildings in the world right now is the Bullitt Center in Seattle (US). This building distinguishes itself in various ways and shows how circular building is focused on the design, the choice of materials and the use phase. The building has seven floors, an area of circa 4,600 m2 and proves that a self-sufficient office building is commercially achievable.

The drinking water and energy requirements are largely reduced and sustainably supplemented. The building thus uses a net of no water: rain is captured and filtered into drinking water. Waste water is composted in the cellar; grey waste water is biologically purified. The building also uses no energy, but produces some 230,000 kWh annually, thanks to a roof covered in solar panels.

The choice of materials and the design are also circular. As many as 350 damaging substances are excluded, including lead and fire retardants, all substances or materials that would normally have been used in the construction. The construction is of wood, steel and concrete, and built for a lifespan of 250 years. The façade has a lifespan of 50 years and can easily be replaced and modified.

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INTRODUCTION

THE CIRCULAR CONSTRUCTION AND DEMOLITION SECTOR IS SET UP RADICALLY DIFFERENTLY THAN THE CURRENT, LINEAR CHAIN. CONSTRUCTION IS AN IMPORTANT ECONOMIC ENGINE, BUT ALSO ONE OF THE LARGEST CONSUMERS OF RESOURCES AND ENERGY. SMARTER AND MORE EFFICIENT RESOURCE MANAGEMENT IS CRUCIAL IN ORDER TO CONTINUE TO MAKE PROSPERITY POSSIBLE. THE CIRCULAR ECONOMY IS A FRAMEWORK FOR MANAGING SCARCITY AND TO LET PROSPERITY FLOURISH, SAFELY WITHIN IMPORTANT LIMITS THAT PROTECT THE PLANET.

Therefore, it is interesting to investigate how we can apply the assumptions of a circular economy to the Construction and demolition sector, and thereby create opportunities for businesses. This report is intended for both entrepreneurs and investors. See it as a first impetus, an invitation to involve all the players in the sector in the realisation of the circular economy.

The first part of the report describes the current state of affairs in the sector. We then discuss the greatest bottlenecks when it comes to inefficient use of resources and the impact on the climate and biodiversity. In the third part, we give our vision of a circular future for the Dutch construction and demolition sector. Finally, with an analysis of material and energy streams, we discuss the most important opportunities for entrepreneurs. The transition to a circular construction and demolition sector offers possibilities, in both the short and long term. At the end we have listed the most important conclusions and recommendations.

CIRCULAR ECONOMY WHAT IS IT?

The circular economy is waste-free and resilient. We have used these principles in order to identify the most important characteristics of this economic model, formulated in a deliberately broad and ambitious way, as an ideal, theoretical end stage. Although they are probably difficult goals to achieve, these six points on the horizon offer a context for setting the right course:

1. All materials will - in theory - be infinitely recycled.
2. All energy is derived from renewable or otherwise sustainable sources.
3. Human activities support and strengthen the ecosystem and are natural capital.
4. Human activities contribute to a diverse society.
5. Human activities support and strengthen health and happiness.
6. Resources will be used to create more than just financial value, for example, ecological or social value.

THE FINAL GOAL IS AN ECONOMY:

- in which materials streams are efficiently managed and recycled;
- that runs entirely on the basis of renewable energy;
- without negative effects on human life or the ecosystem.

WHY IS IT IMPORTANT?

ABN AMRO has made sustainability part of its strategy. We see worldwide sustainability developments with major consequences for the businesses of our customers. Growing scarcity of important resources is one such development. Working toward a circular economy is a solution that will allow this shortage and economic prosperity to coexist.

STATE OF AFFAIRS IN THE DUTCH CONSTRUCTION AND DEMOLITION SECTOR

1

With building production valued at 72 thousand million euros, the Construction and demolition sector represents an important share (4.8% in 2013) of the added value within the Dutch economy. The sector is still recovering from the crisis of the past five years. For 2015, ABN AMRO expects growth in building production of 2%, driven by the recovery of the Dutch economy [A].

1.1. MISMATCH OF BUILDING SUPPLY: VACANT LOCATIONS KEEP INCREASING, NEW CONSTRUCTION AT A HISTORICAL LOW

THE FACTS:

- In absolute figures, the total number of buildings is still growing. But the share of 'new construction' in annual production is falling with respect to the share of 'restoration and renovation' [3].
- The market for restoration and renovation projects in housing construction has significantly increased (50%), while for utility construction, it has fallen by 25% [3].
- The number of vacant residences [1] slightly increased and was nearly 6% at the beginning of 2014. This is remarkable, since in comparison with 2000, 70% fewer residences were built.
- The rate of vacant offices has significantly increased. In 2014, this amounted to nearly 17%. In half of the cases today, this concerns structural vacancies of three years or longer. This represents an increase of circa 10% since 2010.
- In 2014, nearly 9% of retail space was vacant [2], 3% more than in 2008. Just as with offices, the share of structural vacancies has grown.

1.2. LAWS AND REGULATIONS APPLIED TO THE TRANSITION TOWARDS SUSTAINABILITY

National and international governments are formulating goals for creating a sustainable, circular society. This development also has consequences for the Dutch Construction and demolition sector, given its intensive energy consumption and environmental impact.

EXAMPLES OF POLICIES THAT INFLUENCE THE SECTOR:

- Energy savings in existing construction (More with Less) and new construction (Spring Agreement). One of the goals is energy- neutral new construction in 2020. In addition, ever-lower EPCs must be realised at a national level. In 2015, the standard will be lowered to 0.4. [8]
- The National Action Plan (in Dutch 'Landelijk Actie Plan'; LAP) sets a recycling goal of 95% for the Construction and demolition sector. This is well above the agreed-upon 70% within the EU Waste Framework Directive. The sector currently has a recycling percentage of 97% [17], but lacks clear guidelines, for both the quality of re-used materials and the use of sustainable materials. The majority of materials recycling in the sector is also low-value (downcycling).

1.3. NEW FORMS OF PROCUREMENT

Due to the increasing complexity of construction and infrastructure projects, integrated procurement is now official government policy. Integrated contracts include the costs and environmental impact for the entire lifecycle. Because contractors collaborate and are responsible for the complete lifecycle of the project, planning and prices will be optimised. They therefore also choose more responsible materials. Compared with regular contracts, this leads to potential cost savings of 10 to 20%. [14]

THE DUTCH 'LAP' SETS A RECYCLING GOAL OF

95%

1.4. MISMATCH BETWEEN DEMAND AND SUPPLY

There are difficulties in matching demand and supply at one transaction, which are mainly due to the fact that demolition sites produce only a relatively small amount of construction waste. Even though waste is available at different locations, it does not match with the required amount for new constructions, which is much greater than the supply. Waste is therefore not directly used in the construction of another building. This results in difficulties in matching the volumes of demand and supply.

1.5. LIMITED KNOW-HOW ON REUSE OPTIONS:

Before buildings are demolished, contractors want to sell or even to give away the materials for free to other companies in order to get rid of waste management costs. This creates the supply in the market. In spite of this, architects and building companies do not know the potential applications of the waste and are not willing to buy it.

1.6. TECHNOLOGICAL DEVELOPMENTS

Technological developments also contribute to becoming sustainable.
Research and experiments are conducted in the following areas:

- the use of alternative materials for cement in concrete;
- recycling techniques for concrete (recovery of high-value fractions);
- concrete separation with plasma;
- 3D printing of construction materials;
- bio-adaptive facades;
- energy-generating road sections. [11][12]

'Compared with regular contracts, this leads to a potential cost savings of 10 to 20%.'

SMART BUILDING

Furthermore, the urban environment is increasingly SMART. Thanks to automation, lighting, heating, ventilation and humidity, for example, can be monitored and adjusted in real time. This has significant advantages for the environmental performance of buildings.

ANTICIPATING WITH BIM

Building Information Modelling (BIM) [15] is a way of building virtually during an early stage of the construction process. BIM gives information not only about the functional and physical characteristics of the building, but also ensures more effective and more efficient management of the construction process. This prevents failure costs, increases the quality and strengthens lifecycle-thinking. [13]

TRACK&TRACE

The emergence of materials passports and the use of RFID labels make materials traceable through the entire chain. This gives insight for each material into its origin, supply and environmental performance.

NEGATIVE EFFECTS OF THE SECTOR (CIRCULARLY SEEN)

2

2.1. LARGE-SCALE USE OF RAW MATERIALS, STRONGLY DEPENDENT ON NATURAL RESOURCES

The greatest impact of the Dutch construction and demolition sector is caused by its dependence on fossil fuels; this amounts to 96%. In addition, the sector is more than 90% dependent on raw materials such as iron, aluminium, copper, sand, clay, limestone and wood. Collectively, that accounted for some 260 million tons in 2010. Because harvesting and processing of these materials is so complex, most of them have a high energy value. The CO2 emissions and required energy per kilogram of materials are relatively high.

ENERGY USE FOR RAW MATERIALS

In 2010, the primary energy use for materials harvesting for the Dutch Construction and demolition sector domestically and abroad amounted to 172 petajoules, or 47 thousand million kWh. That is 4.5% [17] of the total primary energy use in the Netherlands. This excludes energy use during the use phase.

GREENHOUSES GASES AND PARTICULATES

The climate impact of the sector is 9.6 million tons CO2 eq, a contribution of 5% of total national greenhouse gas emissions. The particles that are released in the harvesting and production phase for building materials account for over 70% of the total particulate emissions of the Dutch Construction and demolition sector.

The harvesting of resources has noticeable consequences for the environment.
This land use leads to:

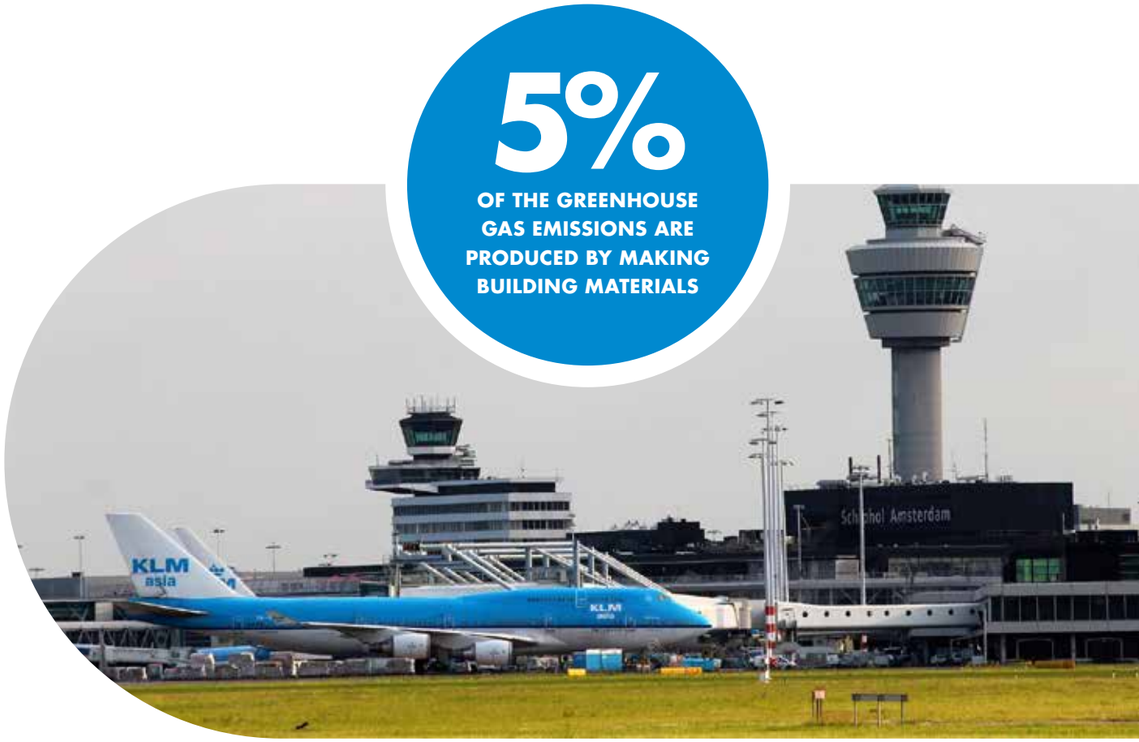
- habitat destruction and fragmentation;
- reduction of biomass;
- soil erosion and soil acidification;
- increased sedimentation and turbidity of bodies of water.

SECONDARY IMPACT

In addition, noise, dust, waste and contamination (toxins and chemicals) have significant secondary impacts. The hazardous and unhealthy labour conditions in the mines also threaten the physical and mental health of labourers. [19][20] The origin of materials can also contribute to the impact. In comparison with, for example, Germany, where steel is made from scrap using the electric arc furnace (EAF) process, China has a much higher environmental impact due to less energy-efficient steel manufacturing, less environmentally friendly energy production and transport.

TRANSPORTATION POLLUTES

The transportation of resources and building materials represents 20% of total goods transportation by road in the Netherlands. The transport of heavy building materials also contributes significantly to CO2 emissions, particulate emissions and soil acidification.



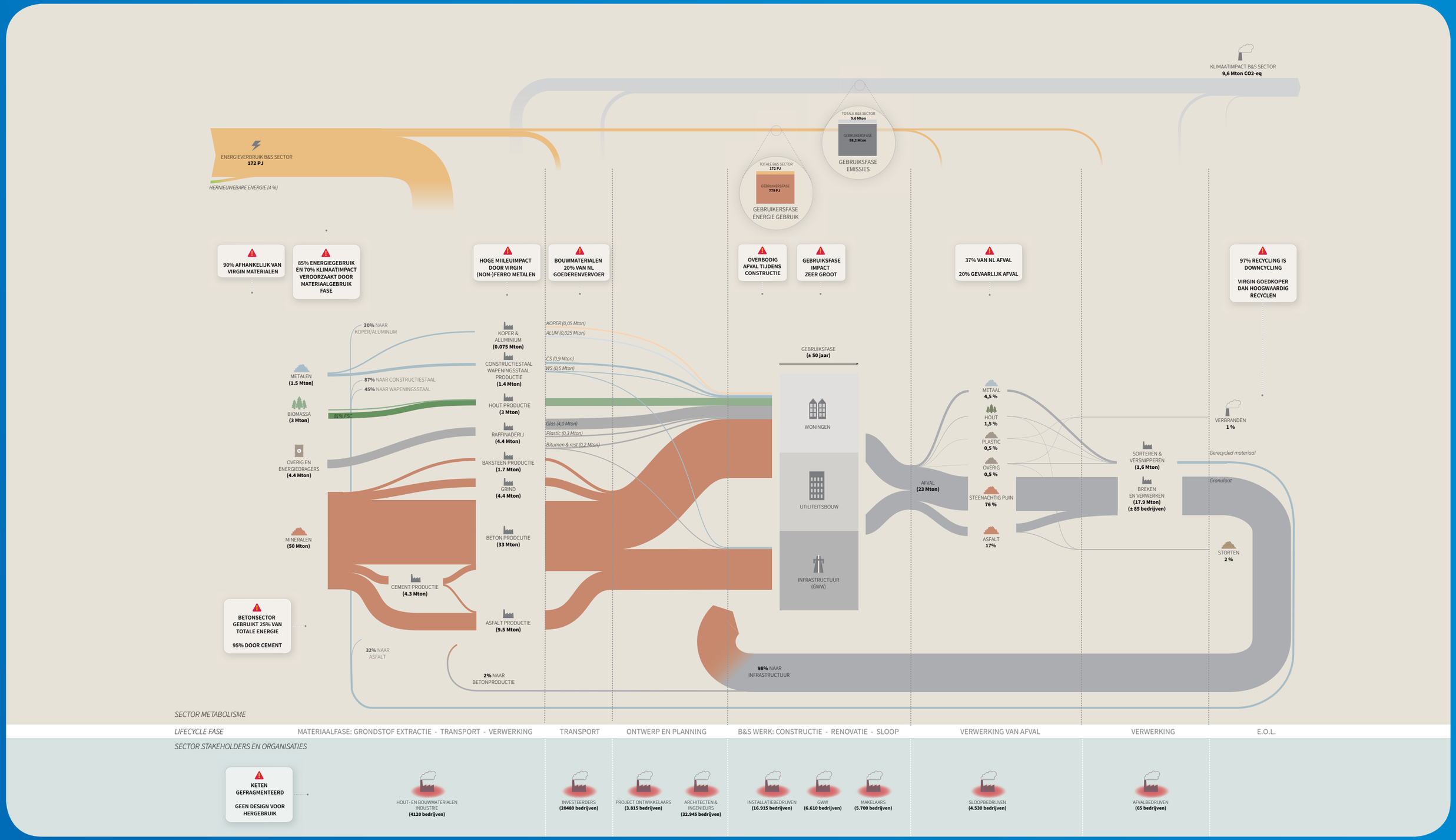
2.2. CONCRETE RESPONSIBLE FOR THE LARGEST SHARE OF THE IMPACT

Concrete, which accounts for 25% of the total energy use in the Dutch Construction and demolition sector, is the primary cause of the total energy impact that the sector has. In addition, the material is responsible for more than 35% of the total climate impact of the sector, which corresponds to 1.7% of the total climate impact for the Netherlands. [12] Cement is the biggest culprit. Its production emits 2.2 million tons CO2 eq. (95% of the total climate impact of concrete). The use of Portland cement in CEMI accounts for the largest share. The concrete sector as a whole represents 13% of the PM10 eq. particulate emissions caused by all economic activities in the Netherlands.

2.3. CURRENT FORM OF RECYCLING IS SUBOPTIMAL

The Dutch Construction and demolition sector, with 23 million tons of construction and demolition waste per year, is responsible for 37% of the total waste stream in the Netherlands. [17] Although more than 95% of this waste is re-used or gets another application, its recycling is suboptimal. More than 75% is stony rubble, of which only 2% will be re-used as a replacement for gravel in new concrete. The vast majority of the gravel ends up in roads. The processing of this fraction is very energy intensive, and the recycled waste will - in other words - be 'downcycled'. As much as 15% of all the Dutch waste that will be dumped or burned originates in the sector. Nearly 20% of this share is 'hazardous'. Figure X1 shows the current state of material flows in the Dutch construction and demolition sector.

On the next page, you can find FIGURE X1: Current state of material flows in construction and demolition]


KLIMAATIMPACT B&S SECTOR
9,6 Mton CO2-eq
ENERGIEVERBRUIK B&S SECTOR
172 PJ
HERNIEUWBARE ENERGIE (4 %)
TOTALE B&S SECTOR
9.6 Mton
GEBRUIKSFASE
98,2 Mton
GEBRUIKSFASE EMISSIES
TOTALE B&S SECTOR
172 PJ
GEBRUIKSFASE
779 PJ
GEBRUIKSFASE ENERGIE GEBRUIK
90% AFHANKELIJK VAN VIRGIN MATERIALEN
85% ENERGIEGEBRUIK EN 70% KLIMAATIMPACT VEROORZAAKT DOOR MATERIAALGEBRUIK FASE
HOGE MIILEUIMPACT DOOR VIRGIN (NON-)FERRO METALEN
BOUWMATERIALEN 20% VAN NL GOEDERENVERVOER
OVERBODIG AFVAL TIJDENS CONSTRUCTIE
GEBRUIKSFASE IMPACT ZEER GROOT
37% VAN NL AFVAL
20% GEVAARLIJK AFVAL
97% RECYCLING IS DOWNCYCLING
VIRGIN GOEDKOPER DAN HOOGWAARDIG RECYCLEN
30% NAAR KOPER/ALUMINUM
METALEN (1.5 Mton)
87% NAAR CONSTRUCTIESTAAL
45% NAAR WAPENINGSSTAAL
BIOMASSA (3 Mton)
81% FSC
OVERIG EN ENERGIEDRAGERS (4.4 Mton)
MINERALEN (50 Mton)
CEMENT PRODUCTIE (4.3 Mton)
32% NAAR ASFALT
2% NAAR BETONPRODUCTIE
BETONSECTOR GEBRUIKT 25% VAN TOTALE ENERGIE
95% DOOR CEMENT
KOPER & ALUMINIUM (0.075 Mton)
CONSTRUCTIESTAAL WAPENINGSSTAAL PRODUCTIE (1.4 Mton)
HOUT PRODUCTIE (3 Mton)
RAFFINADERIJ (4.4 Mton)
BAKSTEEN PRODUCTIE (1.7 Mton)
GRIND (4.4 Mton)
BETON PRODUCTIE (33 Mton)
ASFALT PRODUCTIE (9.5 Mton)
KOPER (0,05 Mton)
ALUM (0,025 Mton)
CS (0,9 Mton)
WS (0,5 Mton)
Glas (4,0 Mton)
Plastic (0,3 Mton)
Bitumen & rest (0,2 Mton)
GEBRUIKSFASE (± 50 jaar)
WONINGEN
UTILITEITSBOUW
INFRASTRUCTUUR (GWW)
98% NAAR INFRASTRUCTUUR
AFVAL (23 Mton)
METAAL 4,5 %
HOUT 1,5 %
PLASTIC 0,5 %
OVERIG 0,5 %
STEENACHTIG PUIN 76 %
ASFALT 17%
SORTEREN & VERSNIPPEREN (1,6 Mton)
BREKEN EN VERWERKEN (17.9 Mton) (± 85 bedrijven)
VERBRANDEN 1 %
Gerecycled materiaal
Granulaat
STORTEN 2 %
SECTOR METABOLISME
LIFECYCLE FASE
MATERIAALFASE: GRONDSTOF EXTRACTIE - TRANSPORT - VERWERKING
TRANSPORT
ONTWERP EN PLANNING
B&S WERK: CONSTRUCTIE - RENOVATIE - SLOOP
VERWERKING VAN AFVAL
VERWERKING
E.O.L.
SECTOR STAKEHOLDERS EN ORGANISATIES
KETEN GEFRAGMENTEERD
GEEN DESIGN VOOR HERGEBRUIK
HOUT- EN BOUWMATERIALEN INDUSTRIE (4120 bedrijven)
INVESTEERDERS (20480 bedrijven)
PROJECT ONTWIKKELAARS (3.815 bedrijven)
ARCHITECTEN & INGENIEURS (32.945 bedrijven)
INSTALLATIEBEDRIJVEN (16.915 bedrijven)
GWW (6.610 bedrijven)
MAKELAARS (5.700 bedrijven)
SLOOPBEDRIJVEN (4.530 bedrijven)
AFVALBEDRIJVEN (65 bedrijven)

RECYCLING IS EXPENSIVE, REQUIRES PROGRESS

Recovery of valuable materials from buildings or rubble is not economically viable due to current construction methods. In particular, metals such as copper, aluminium and steel are contaminated with concrete. In addition, raw materials and new materials are less expensive than the complex recovery processes. Just some 30% of the used aluminium and copper is currently recycled. An important factor that currently limits the recovery is the absence of guidelines or effective stimulants [18] from (inter)national government. [12]

2.4. IMPACT OF USE PHASE NEARLY FIVE TIMES GREATER THAN THE TOTAL IMPACT OF OTHER CHAIN PHASES

That the use phase has the greatest impact is immediately apparent when you systematically analyse the chain. In particular when it comes to energy use, the urban environment is responsible for 45% of the total use in the Netherlands. An important cause of the high energy costs is the average energy performance of the existing home and building supply. Of this, 86% is currently below energy label B. Water use, the production of waste water and the amount of waste itself are also the greatest during the use phase. [12][17]

'Just some 30% of the used aluminium and copper is currently recycled.'

FUTURE VISION: THE PATH TO CIRCULARITY

3

The circular construction and demolition sector is radically different from the current linear chain. Buildings and infrastructure are designed to maximise lifespan and dismantling. At the same time, they offer space for changing functions and they can be aesthetically or technologically modified. In the use phase, only renewable resources will be used.

PARK 20|20

The circular economy is the basis for the development of Park 20|20 in Hoofddorp [D] by Delta Development. All buildings on the business park are developed via the Cradle to Cradle philosophy that starts with the waste = food cycle. Delta Development, Volker Wessels and Reggeborgh sought a financier to make this concept possible. ABN AMRO has confidence in this renewed approach [E]. We have given advice and financed this new construction.

LIFECYCLE THINKING

Instead of a short-term approach, the circular construction and demolition sector are characterised by a lifecycle approach. The impact that the current production of construction materials has is significantly decreased. This is because priority is given to high-value recycling of components and resources that are recovered in the End of Life phase. By using pre-fabricated components, the waste production during the construction, renovation and deconstruction is minimised.

NEW OWNERSHIP MODEL

At the basis of a chain that is set up circularly, is a different ownership model. Resources will no longer be sold to developers, and the end result will no longer be sold to an owner. A consortium delivers, for example, housing for living or working as a service, so that the resources remain the property of the producer.

Understandibly this requires an overview of the total cost of ownership, and how it can be lowered. Good insulation, for instance, delivers savings over the entire lifespan, just like many other interventions. Management and maintenance of the construction, shell and installation techniques will be supported by smart sensors and are included in the contract. Sharing information within the chain also offers a solution, for example via BIM (Building Information Modelling) and materials passports for resources. This allows better planning of and more intelligent design of the re-use of materials.

Such a modified ownership model also requires a new way of looking at financing, with different payback times and residual values. At this time, banks finance on the basis of expected cash flow or with real estate as collateral. In the new ownership model, they would, for example, finance the resources in the property, or the 'housing' service. Furthermore, there are options for financing on the basis of lease, since (parts of) properties are re-usable.

In line with our sustainability goal and from the persepective of how to help our customers increase sustainability, ABN AMRO is exploring these topics.

3.1. OPPORTUNITIES FOR CIRCULARITY IN THE SECTOR

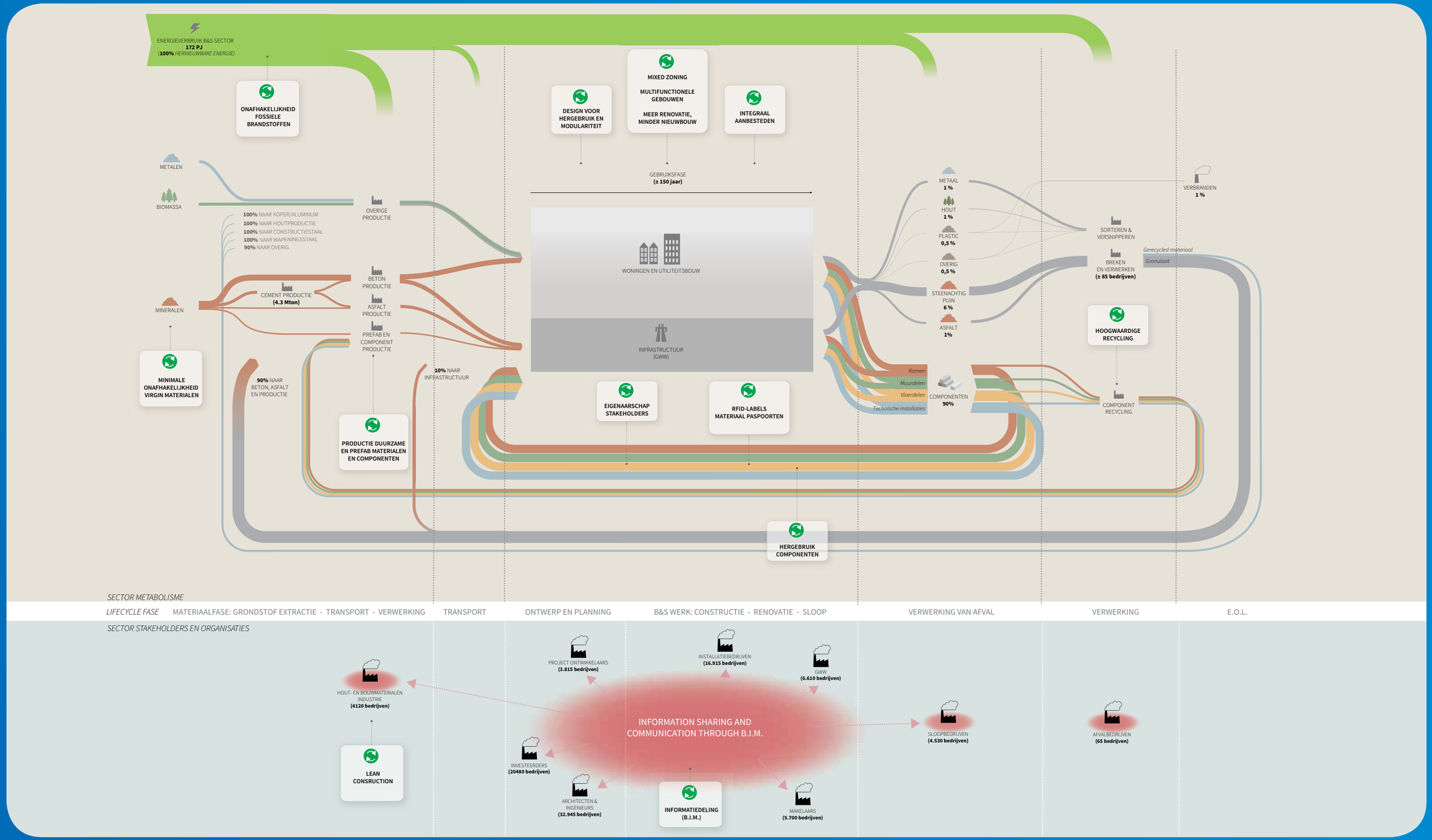
For the transition from a linear to a circular construction and demolition sector, there are three important things:

1. Reducing the impact during the use phase, for both new construction and the existing supply after renovation.
2. Optimising and re-using the existing supply of buildings and infrastructure. Vacancy is currently the greatest inefficiency in the sector.
3. Designing future buildings according to circular principles and with circular materials.

Although in this report the emphasis lies on the third opportunity (circular design), we also devote brief attention below to the first two directions. This gives a complete picture of how the construction and demolition sector can be set up more circularly. Figure X2 illustrates this future vision for circularity in the sector.

On the next page, you can find FIGURE X2: Future vision for a circular construction and demolition industry

'Designing buildings of the future according to circular principles.'


ENERGIEVERBRUIK B&S SECTOR
172 PJ
(100% HERNIEUWBARE ENERGIE)
ONAFHAKELIJKHEID FOSSIELE BRANDSTOFFEN
DESIGN VOOR HERGEBRUIK EN MODULARITEIT
MIXED ZONING
MULTIFUNCTIONELE GEBOUWEN
MEER RENOVATIE, MINDER NIEUWBOUW
INTEGRAAL AANBESTEDEN
GEBRUIKSFASE
(± 150 jaar)
METALEN
BIOMASSA
100% NAAR KOPER/ALUMINUM
100% NAAR HOUTPRODUCTIE
100% NAAR CONSTRUCTIESTAAL
100% NAAR WAPENINGSSTAAL
90% NAAR OVERIG
OVERIGE PRODUCTIE
BETON PRODUCTIE
ASFALT PRODUCTIE
PREFAB EN COMPONENT PRODUCTIE
CEMENT PRODUCTIE
(4.3 Mton)
MINERALEN
MINIMALE ONAFHAKELIJKHEID VIRGIN MATERIALEN
90% NAAR BETON, ASFALT EN PRODUCTIE
10% NAAR INFRASTRUCTUUR
PRODUCTIE DUURZAME EN PREFAB MATERIALEN EN COMPONENTEN
WONINGEN EN UTILITEITSBOUW
INFRASTRUCTUUR (GWW)
EIGENAARSCHAP STAKEHOLDERS
RFID-LABELS MATERIAAL PASPOORTEN
HERGEBRUIK COMPONENTEN
METAAL 1 %
HOUT 1 %
PLASTIC 0,5 %
OVERIG 0,5 %
STEENACHTIG PUIN 6 %
ASFALT 1%
Ramen
Muurdelen
Vloerdelen
Technische installaties
COMPONENTEN 90%
VERBRANDEN 1 %
SORTEREN & VERSNIPPEREN
BREKEN EN VERWERKEN
(± 85 bedrijven)
Gerecycled materiaal
Granulaat
HOOGWAARDIGE RECYCLING
COMPONENT RECYCLING
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(16.915 bedrijven)
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(6.610 bedrijven)
INFORMATION SHARING AND COMMUNICATION THROUGH B.I.M.
INVESTEERDERS
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ARCHITECTEN & INGENIEURS
(32.945 bedrijven)
INFORMATIEDELING
(B.I.M.)
MAKELAARS
(5.700 bedrijven)
SLOOPBEDRIJVEN
(4.530 bedrijven)
AFVALBEDRIJVEN
(65 bedrijven)

3.1.1. IMPACT REDUCTION IN THE USE PHASE

Realising buildings that minimise the impact during the use phase is an important opportunity for the sector. The greatest impact of a building in this phase comes from electricity, heating and water use.

PROFITABLE RENOVATION

Making the existing supply of homes and buildings sustainable is a significant challenge. Large-scale renovation projects, such as Power Acceleration (in Dutch: 'Stroomversnelling'), show that a solid business case can be based on the high-value renovation of existing homes. Such projects significantly lower the demand for energy, measured across the remaining lifespan. In Germany, it is even common in renovation projects to create a passive house as a standard.

POSSIBILITIES FOR NEW CONSTRUCTION

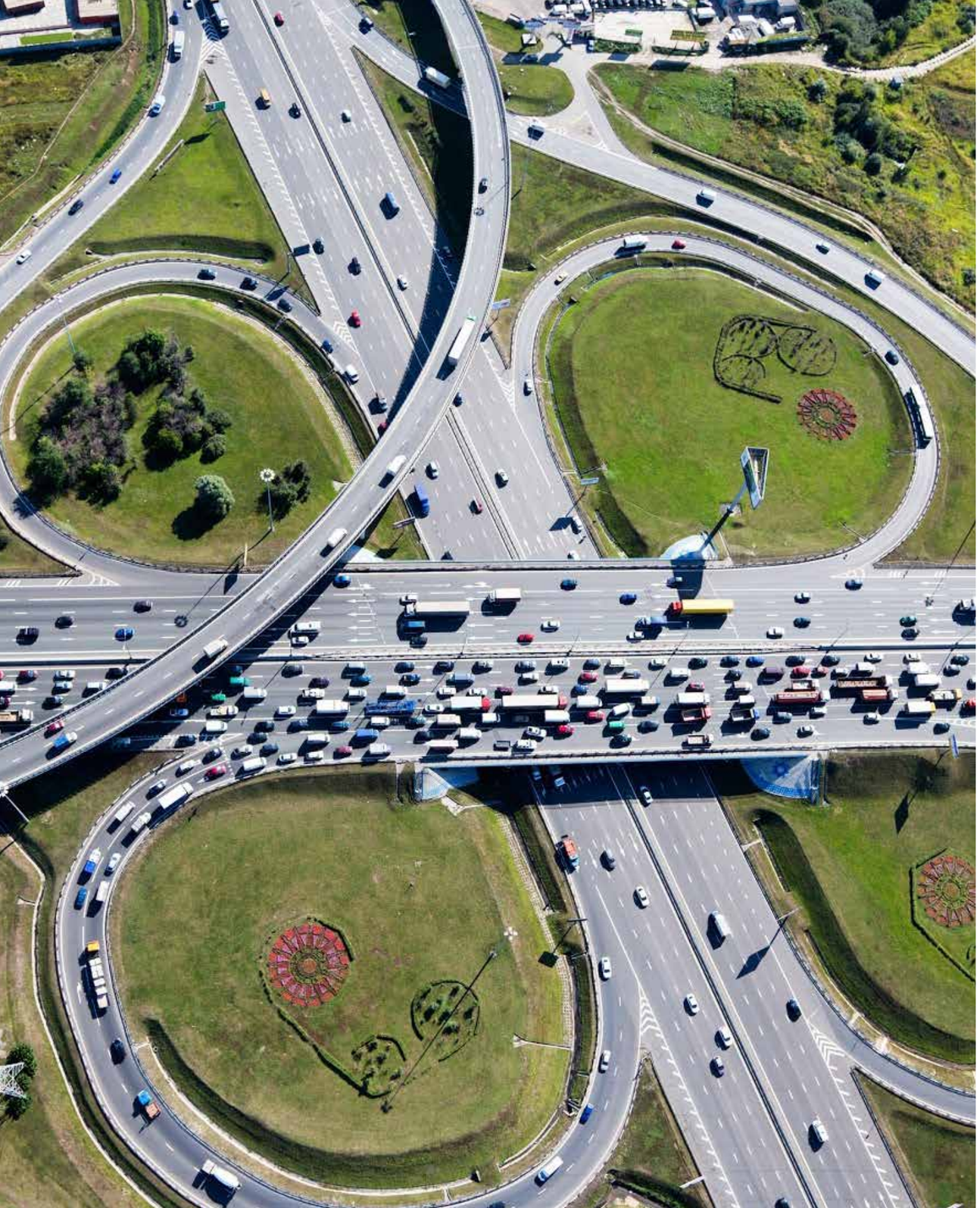
Impact reduction is also an important subject in new construction. Standards like BREAAM and LEED have become an inherent part of utility construction. Furthermore, national and European policy set increasingly higher requirements for new construction. Starting in 2020, for example, all new construction must be completely energy neutral. Technically it is possible to go much further – to energy positive (energy-producing) buildings.

IT SOLUTIONS

In addition to energy, other factors that are part of a sustainably designed building that is circular in its use are: waste management, waste- and rainwater management and environmental factors. Real time monitoring and IT solutions in the use phase are indispensable for significant impact reduction. The same applies for the design phase, so that you get insights into the energy performance of a design.

OTHER MOBILITY CHOICES

In planning, road construction and water projects, reducing the impact of the use phase is important. Mobility and logistics are important sources of inconvenience for society. Noise pollution, particulate emissions and energy use, along with the emissions that generates, are some examples of this. In a circular world, reduction of the mobility and logistics burden is important, for example, by better aligning supply and demand locally via IT solutions. It is then key to fulfil the remaining demand as sustainably as possible, by choosing differents form of mobility. Shipping by barge is a more circular option than transportation by road. [17]



3.1.2. OPTIMISE AND RE-USE EXISTING BUILDINGS AND INFRASTRUCTURE

How you do you most efficiently meet the demand for space? This is a critical subject in circular construction. It is important to give renovation and refurbishment priority above new construction, and to introduce more creative solutions for existing buildings. If the choice still falls to new construction, then supply and demand should be in close alignment.

MORE IS NOT ALWAYS BETTER

Creating more supply is not always the solution to the demand for living and working space. The same applies for infrastructure: often, constructing extra roads or bridges is not the most effective way. Traffic pressure does not appear to decrease automatically when you expand motorways; more supply even induces a hidden demand (induced demand). Because of this searching for solutions that meet the demand differently is preferable.

3.1.3. CIRCULAR CONSTRUCTION DESIGNS

This report focusses on designing and constructing buildings and infrastructure in radically different ways, and on the required re-use of materials and components. A key element is identifying and addressing the most significant bottlenecks in the construction chain:

- loss of precious, energy-intensive and high-value resources;
- low-value recycling of these resources;
- use of non-sustainable materials.

In an actual circular Construction and demolition sector, buildings and infrastructure will be designed according to circular principles. In addition, use will be made of circular, innovative construction materials. The immediate implications of this are modified ownership structures and End of Life scenarios for construction materials.

3.1.3.1. DESIGNS FOR DISASSEMBLY, RE-USE AND ADAPTABILITY

Circular design means designing a building (or infrastructure) in such a way that it is built out of components or parts that can be disassembled – think about facades, windows, doors, floors and structural elements. The necessary resources must be recyclable in a high-value way. When you disconnect the exterior, architectural characteristics from the structure, this increases the adaptability of the building.
Overview of circular design principles:

- **MODULAR BUILDINGS**
  With prefabricated components such as interior and exterior wall and ceiling panels. When suppliers make these parts exactly to order, the loss of materials at the construction site will be minimised. The assembly will also be easier, and you can integrate the components with insulation or wall coverings.

3D CANAL BUILDING

In a few places in the world, 3D printing is being applied as an innovative method of construction. This is happening in Amsterdam as well, where a 3D-printed canal building is being erected. The eventual advantages: faster construction, with local (renewable) resources [21] and waste streams (bioplastics).

• EXTENDED-LIFESPAN BUILDINGS

By using (among other things) ventilation and drainage, you project materials from wind and weather.

• ANTICIPATING BUILDINGS

A building should be able to change in function through time, or adapt itself to changing demands or needs of the user. Making assets usable multi functionally provides a more robust earnings model behind the investment. In infrastructure construction, this applies as well. You can thus set up roads multifunctionally, for example by integrating solar panels in canopies, sound screens or the road surface for generating sustainable energy.

• USING STANDARD SIZES

For example, for the spans and heights of structural components. This provides re-usability and a higher residual value for structural elements and materials.

• SEPARATING THE STRUCTURAL ELEMENTS FROM THE COVERINGS

This increases the adaptability of the structure. It is important to pay attention to the layout of the structure, so that you can change the architectural properties and and characteristics of a building when these are no longer appropriate to the times.

• INTEGRATING INSTALLATION TECHNOLOGY INTO STRUCTURES

Sometimes, this is very valuable, as with concrete activation: a heating method that can produce a high energy profit. In general, it also true that a separation between the structure itself and the installation technology offers advantages. It provides increased flexibility in management, maintenance, renovation and any needed replacement. This simplifies the integration of, for example, new technological solutions.

• USING COMPONENTS THAT CAN BE DISASSEMBLED

Permanent connections often result in an irreversible merge of materials. The opportunities for re-use of both the materials and the connections themselves thus declines significantly. It is important to use components with connections that are strong enough for one or more (dis)assembly steps. Chemical or mechanical connections should thus be avoided because they increase the complexity of the components, delay disassembly and thus limit their re-usability. There have already been several innovations seen in this area, like ClickBrick. [22] This brick needs no mortar, making it possible to disassemble facades. Click Brick also offers purchasers a return guarantee.

A LONGER LIFESPAN OF A BUILDING

A BUILDING AS A RESOURCE BANK

One of the most appealing and thoroughly developed concepts in circular construction is from architect Thomas Rau. He sees a building as a 'resource bank', where the developer of the property remains the owner of the resources. The user pays for their use. From this thought, his architectural agency, Turntoo, realised the town hall for Brummen in Gelderland.

- **BUILDINGS WITH RE-USABLE COMPONENTS, RECYCLED OR RENEWABLE RESOURCES**

  The negative impact of the Construction and demolition sector largely takes place in the materials use phase, among other things, for energy use, harvesting, production and transport – with all the ecological effects of these activities, such as damaging emissions. Therefore, reduction of the demand for construction materials deserves the highest priority.

  This can happen in various ways, for example, by replacing virgin resources with recycled ones. Furthermore, where possible, parts and construction components should be recycled and re-used. This applies for both structural and functional elements.

  Of course, a longer lifespan of a building, component or material also produces fewer negative effects in the material use phase. This requires a different design approach, where you also look at whether materials are available locally. This reduces the negative effects of transport.

HIGH-VALUE RE-USE - A BUSINESS CASE

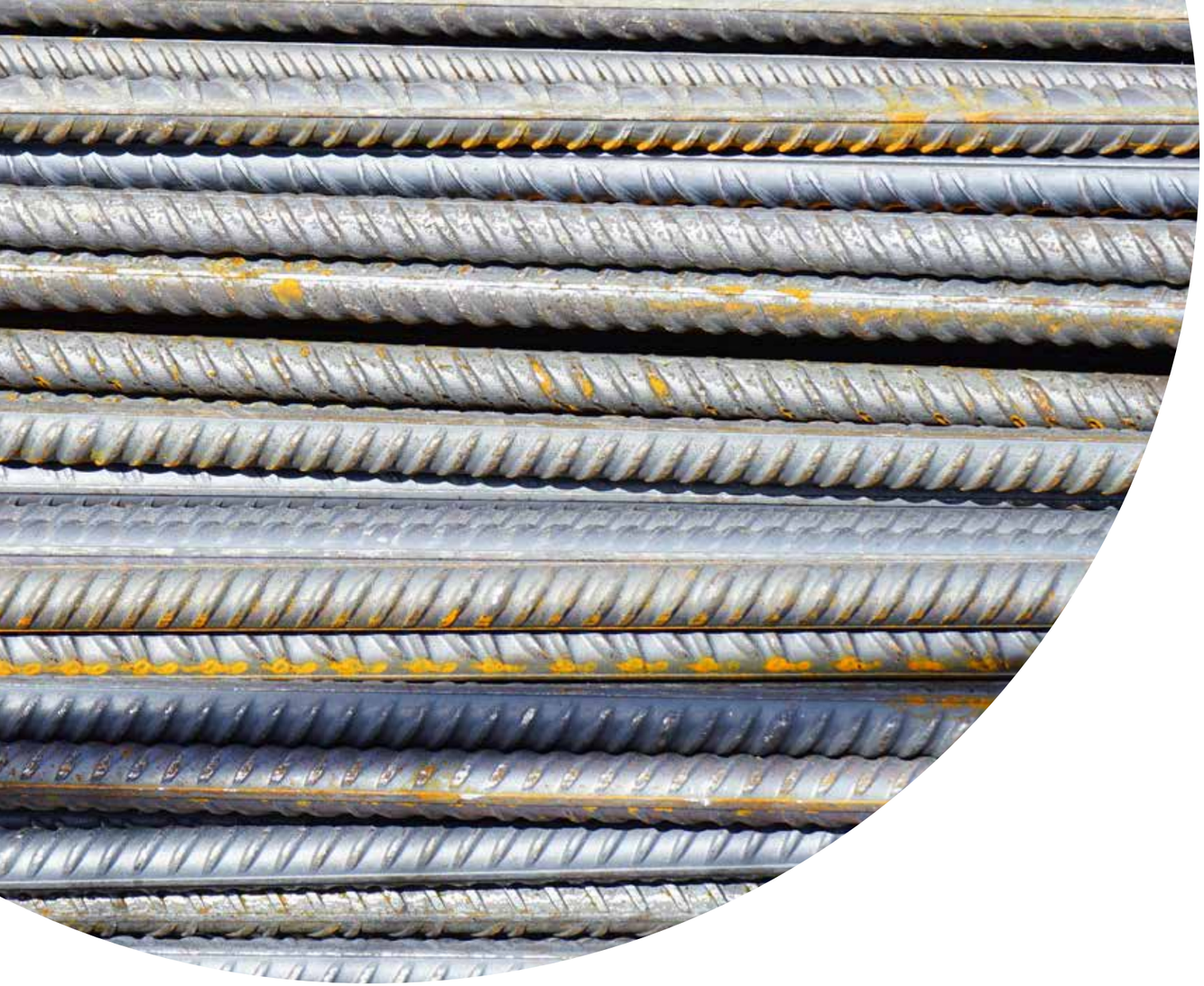
Weighing End of Life (EoL) scenarios against each other often requires a comparison of the corresonding business cases: what are the costs and benefits of high-value recycling as opposed to low-value? Circle Economy [C] developed a model that makes it easier to calculate such scenarios. This makes it increasingly interesting to investigate the different EoL scenarios for concrete. Market conditions, such as resource and energy prices, labour costs and taxes, can be quickly entered into the model. Then you calculate the effect of each scenario for profitability. With help from these kinds of tools, trade-off points become apparent, and you can identify business cases strategically.

In the graph shown on the right, the outcomes of three End of Life scenarios for concrete are illustrated. These examples represent a spectrum from low- to high-value recycling. The costs (blue) are off-set against the benefits (grey). The profit margin (dark blue) is also clear.

- **LOW-VALUE RECYCLING: PROCESSING INTO GRANULATE FOR ROAD CONSTRUCTION (OFF-SITE)**
  After a building has been dismantled and demolished, valuable materials (such as metals) are separated from each other. Sometimes, there is a local demand for material that can be used as foundations for roads. If that is not the case, then the waste must be transported to an external location for processing. This incurs extra costs, so that the margin comes out lower in comparison with a scenario in which there is a local demand for road materials.

- **HIGH-VALUE RECYCLING: INTENSIVE PROCESSING INTO MORE HIGH-VALUE GRANULATE FOR CONCRETE PRODUCTION (OFF-SITE)**
  In this scenario, the demolition waste is handled more intensively, so that more value can be pulled from it. This demands a precise dismantling process, so that other materials do not contaminate the concrete. As much as 60% of the waste will thus be designated as 'high-value'. The clean concrete can then be transported, broken and washed. After separation, a part can be sold as natural grit, which is used again as input for making new concrete.

BUSINESS CASE FOR THREE END OF LIFE SCENARIOS (IN USD PER 500 KG CONCRETE)



- **HIGH-VALUE RE-USE: CONCRETE BLOCKS**
  From a circular viewpoint, re-using concrete blocks is most beneficial. It eliminates steps that require additional energy, such as recycling, since the blocks can be re-used immediately. Because of this the regained value is much greater than when the blocks are recycled into new concrete or roads.

HENGELO SAVES MONEY AND TIME

Due to the economic crisis and stricter sustainability requirements in construction, ever-more innovative ways of building and renovating have been created. In Hengelo circa 130,000 euros and three weeks of construction time were saved by re-using concrete façade plates. In total, some 95% of the materials were applied again in the transformation of the old Expo Center into (i.a.) a new datacentre.

3.1.3.2. CIRCULAR MATERIAL CHOICES

During the complete lifecycle, circular construction materials produce as few negative effects as possible and have no damaging impact on people and the environment. Deliberate material choices are important in order to reduce the life-cycle impact, to extend the lifespan of materials and to increase their re-usability. The importance of other material choices quickly becomes clear when we look at the possible advantages:

- smarter;
- lighter;
- longer lifespan;
- no synthetic additives.

REDUCE MATERIALS MASS

For example, by using lattice or girders as structures for bridging spans, instead of massive solutions like wood or steel beams or concrete structures. An example of this is a more open, non-massive boat-like structure [25]. This is sometimes stronger than aluminium.

The Karlsruhe Institute of Technology (KIT) has developed such a material, which with the help of 3D laser lithography is precisely 'printed'. Another example is the strengthening of standard construction materials by adding nano-materials. Thus, carbon nanotubes (CNT) [26] can make concrete stronger than steel, so that the demand for steel can be decreased. In addition, this construction can be completed more quickly and is less labour intensive.

ELIMINATING TOXIC AND NON-BIODEGRADABLE MATERIALS

In many construction materials, toxic substances appear that are not biodegradable and may lead to problems for people and the environment. Acrylics, lacquers and stains often contain damaging solvents. There is a growing supply of non-damaging, organically bio-degradable paint. There are also bricks and cement available today made of sand and micro-organisms. In comparison with the production of concrete, this costs only a sixth of the energy used to make this material. In addition, it is completely biodegradable.

There are also natural alternatives for some chemical additives. The 'growth bed' (mycelium) of mushrooms appears to work well as an insulator and fire retardant. Furthermore, it is important to avoid commonly used toxic materials such as lead, zinc and copper. Traces of these contaminate surface water. The same applies for asphalt and tar-containing roofing materials. Often, these contain damaging hydrocarbons. Materials like paint, glue and fillers are in general not renewable. These should thus have renewable resources as a basis.

EXTENDING THE LIFESPAN OF MATERIALS

Steel, concrete and other construction materials have a long to very long lifespan (100-250 years). Weather and external factors can shorten this lifespan. Therefore, it is important to build in such a way that structures are protected from these and are maintained in a timely way. Application of high-value materials is also an important condition for the residual value with renovation or End of Life.

By using sensors in materials and structures, you can monitor maintenance requirements more precisely and intervene as needed. Remote sensing (observing the planet from a great height) helps to monitor the state of the roads network. There are also innovations that improve the resilience of materials. TU Delft, for example, developed a method for self-repairing concrete on the basis of bacterial spores and nutrients. Rainwater activates bacteria, which then, with the help of the available nutrients, make limestone. This can seal cracks up to 0.5 mm. [27]. The lifespan of asphalt can also be extended through the use of various innovations.

THE BIQ BUILDING IN HAMBURG

IMPROVING BUILDING PERFORMANCE

Think about materials that contribute to the thermic properties of a building, for example, a synthetic mat on the roof that retains water and 'sweat' in order to cool the building in high temperatures. [28] There are also special facades [29] in which algae produce energy and shade for the building, as in the BIQ building in Germany.

ALGAE IN THE FAÇADE PRODUCE ENERGY

In Hamburg, the first building was opened where algae provide a large part of the energy supply. This occurs according to the BIQ (Bio Intelligence Quotient) principle: 129 glass panels in the façade containing millions of microalgae that produce heat. The façade thus functions as a dynamic sun screen, an insulator and a sound screen. A bioreactor converts the harvested biomass into electricity.

WHAT DOES THIS MEAN FOR ENTREPRENEURS?

4

ABN AMRO PROMOTES CIRCULARITY

ABN AMRO commits itself in various ways to accelerating the transition to a circular economy. We do that in our own business as well. For this, we have concluded various Green Deals [B] with the government, such as the Green Deal Circular Construction and the Green Deal Circular Procurement. Green Deals preferably inspire others as well and pave the way for subsequent sustainable initiatives. They have broad consequences and impact.

We think it is important, together with our employees, suppliers and customers, to gather more knowledge about circularity, and to offer each other practical solutions. We know that not only our own business practices can contribute to a sustainable world, but that the choices that we make, for example, in our credit policy also help to achieve this goal.

In order to be a better bank in a better world, we therefore look at how we can apply the principles of circularity to:

1. our properties;
2. the investments that we make;
3. promotion of sustainability within the entire chain;
4. sustainable customer relationships.

4.1. THE CHAIN CHANGES

The current, fragmented chain of design, construction and demolition can be transformed in an alliance of parties that collaborate to deliver services. To do so, material re-use has to be the starting point, both during renovation (interior and exterior) and at the end of the lifecycle. This new chain is also based on an integrated lifecycle approach to investment decisions and design. The producer or financer remains the owner of the resources and is responsible for the residual value. The residual value of materials remains on the balance sheet and can be estimated using resource model predictions. Building in such a way that materials have a residual value instead of a negative value (disposal costs) makes investing in circular design useful. The customer pays for the performance of the building or a section of road, instead of the function. This shifts the responsibility for good maintenance and management from the customer to the owner of the materials. Investments in the adaptability (modularity) of buildings generate value in the long term because the needs of (future) users are more easily met.

FRONTRUNNERS RENEW THE SECTOR

The transition from a linear to a circular Construction and demolition sector will not take place overnight. The playing field continuously renews itself, and frontrunners are currently shaping this new sector. They will create numerous new earning possibilities. At the same time, modified regulations become a motivation for handling resources differently.

CLEAR GOALS AND PERSEVERANCE

Applying circular construction principles and materials demands clear goals and involvement of both clients and designers. In order to be able to re-use parts, components and materials after refurbishment, renovation or End of Life, a lifecycle and services approach is needed. It requires a greater investment in advance, which pays for itself during the lifespan of a building, and in the renovation, refurbishment and End of Life phase.

LIFECYCLE AND SERVICE APPROACH IS NEEDED

RE-USE IS OFTEN NOT PROFITABLE

Decreasing energy use through better insulation (or less influence of rising energy prices through investments in clean technology) reduces the energy costs in the use phase. Designing for disassembly – both of structural components and aesthetic and technical parts – increases the residual value of components and resources at the end of the lifespan.

4.2. INFORMATION BECOMES INCREASINGLY IMPORTANT

Software platforms (like BIM) that connect multiple disciplines and simplify the optimisation of the design and construction process are becoming increasingly important. In addition, information about materials and their properties is critical. By documenting details in a materials passport, you can take responsible decisions and re-use materials or components. With renovation and demolition plans that are distributed throughout the value chain, a database of potentially available materials and components can be made from these passports. With that information, architects and urban planners can make new building designs or renovation plans.

4.3. THERE ARE CERTAINLY STILL BARRIERS

At this time, there are still many legal and economic obstacles that hinder or delay the transition to a completely circular economy. There are grey areas for shifting ownership constructions, for example, when a house or property owner only buys the use right (or the living/working service declines) and does not by definition possess the physical property. For construction companies, it is not interesting to tie up their working capital in resources for long periods and only to sell or rent the use right. This demands separate financing of resources, the construction process and the use of the housing.

RE-USE IS OFTEN NOT PROFITABLE

Another barrier is the re-use of construction materials. In the current, conventional construction style, it is difficult and expensive to recover materials and components, for example when two materials are joined in such a way that they can no longer be separated. In that case, they are often contaminated in such a way that it is not profitable to re-use them as a replacement for virgin materials. Downcycling into resources is often the only option. A shift from taxing labour to taxing resources can make a big difference here.

EX'TAX: TAXING RESOURCES INSTEAD OF LABOUR

Due to high labour costs, recycling and re-use of materials is now often not profitable. The core thought behind Ex'tax is a shift in taxation: from labour to resources. This creates an important stimulant for handling resources more intelligently. According to those taking the initiative, this can, in the long term, lead to a service economy in which more appreciation exists for craftsmanship, design and creativity. You can read more about this on ex-tax.com.

BETTER INSIGHT INTO MATERIALS PROPERTIES NEEDED

At this time, there are certainly a great number of challenges to address in the recycling of structural components and materials. In order for these to be eligible for re-use, they must be (visually) inspected and, in some cases, tested. Smarter information management provides more insight into any impact on structural material properties, and into the possible causes, for example, a heavy storm. With this insight, re-use becomes more achievable because you can exclude structural damage.

RECOMMENDATIONS AND OPPORTUNITIES?

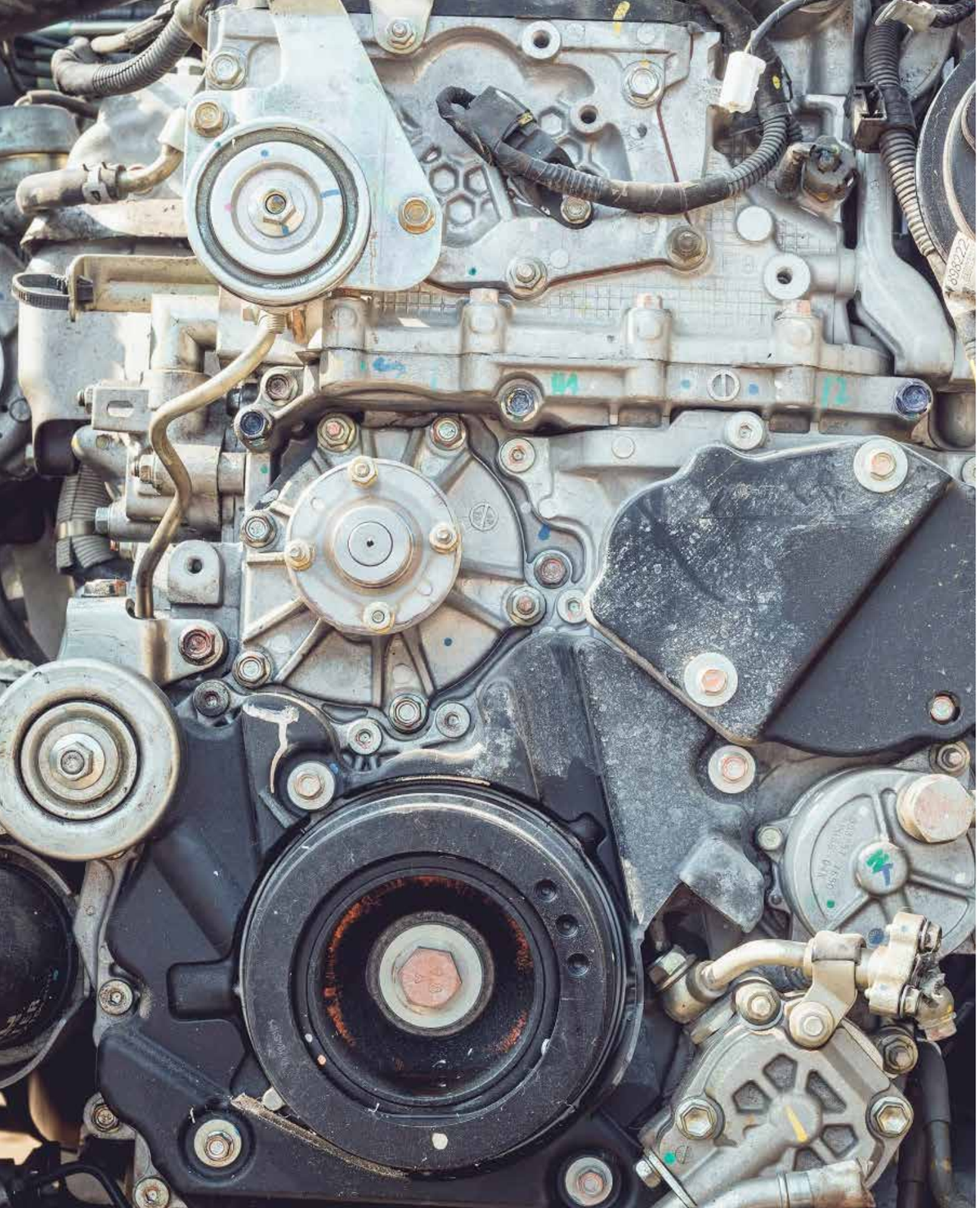
5

The circular economy is waste-free and resilient. It is an ambitious and ideal end-state to work towards. But where do you start? How do you modify your current business strategy as an entrepreneur in order to set a course for the circular world of tomorrow?
By getting started with tomorrow now, with these concrete steps and effective tips:

- Save on costs and materials by using prefab instead of in-situ construction.
- Increase your knowledge. Develop experience with circular construction materials and methods. Think about connection options without permanent assembly.
  There are new materials and concepts with which you develop connections that make the separation of re-usable components easier, for example, fittings, mounting parts, attachment tools and sealant materials.
- Explore the options and advantages of the resources passport.
- Expand your network, across the entire chain. Invest in knowledge of modelling tools and digital platforms. This increases your opportunities for collaboration.
- Specialise in specific circular construction methods, materials and installation technology.
- Switch to flexible or ''anticipating'' buildings. By making function changes and architectural style changes, you can respond more easily to changing needs of (future) users. This also lowers the renovation costs and prevents vacancy.
- Create more financial certainty for the long term, for example, by anticipating shifting ownership of materials, components and technologies.
- Offer integrated contracts that include the costs and environmental impact for the entire lifecycle.
- Work together within the chain. Make circular choices for each project and in each phase thereof: from planning and design to deconstruction and from renovation to reconstruction. This provides positive residual value instead of negative at the End of Life (EoL) of buildings and of the materials, resources and components of which they are made.
- Start a conversation with a bank that thinks about new forms of financing and circular construction.

SUMMARY

6



CIRCULAR CONSTRUCTION: NEEDED AND POSSIBLE

Construction is a powerful engine for our prosperity, but also one of the largest consumers of resources and energy. The question is then: how do you sustain that prosperity and protect the planet? A logical answer is to organise the construction and demolition sector according to the principles of the circular economy. In the ultimate stage, this is resilient and waste-free because all materials are infinitely recycled. It runs completely on renewable energy and is non-damaging for human life and the ecosystem. Circularity is a condition for sustainability, and the sector still has a long way to go to achieve it. But concrete steps are certainly possible. In addition, they provide opportunities.

VACANCY AND LACK OF CLARITY

With the recovery of the Dutch economy, a growth in building production of 2% is expected in 2015. Positive, but there are certainly links that have yet to be placed in the chain. There is a mismatch in the building supply. The (structural) vacancy of residences, offices and shops is still increasing. Although (inter)national governments set goals for a circular economy, the sector is lacking positive stimulus, especially when it comes to the quality, sustainability and re-use of materials: recycling of construction materials is largely low-value (downcycling).

A START HAS BEEN MADE

There are also favourable developments. Integrated procurement stimulates collaboration between contractors, who are collectively responsible for the complete lifecycle of projects. This lifecycle thinking leads to better planning, cost savings and responsible materials choices. In addition, technological progress produces results. Developments like SMART buildings, Building Information Modelling and materials passports provide better environmental performance, more efficient construction processes and more insight into the source of materials.

NEGATIVE IMPACT ON THE CONSTRUCTION AND DEMOLITION SECTOR

Even so, from a circular viewpoint, it is a world that has yet to be conquered for the Dutch construction and demolition sector – literally, since the dependence on fossil fuels and raw materials is still enormous, especially in the harvesting of materials. The same applies for the emissions of greenhouse gasses and particulates. The secondary impact of the sector is also great, due to waste, contamination and noise pollution, but also due to damaging emissions as a result of heavy transport. The production of concrete (in particular, cement) accounts for the greatest share of this.

LIFECYCLE THINKING AND ANOTHER OWNERSHIP MODEL

A circular construction and demolition sector is set up radically differently than the current, linear chain. For this transformation, a lifecycle approach is needed. The impact of materials harvesting decreases drastically, just like waste production during construction, renovation and demolition. In addition, the ownership model as we know it know will change. Think about the delivery of buildings for living and working as a service, where the resources remain the property of the producer. Such shifts demand new forms of financing, with different pay-back times and residual values.

CONCRETE IS THE BIGGEST POLLUTER

CONDITIONS FOR CHANGE

There are certainly opportunities for the sector to become circular, but that does require certain measures. Some of those are significant, but can be implemented now. In addition, they provide immediate results. The most important conditions for change are:

- Reducing the impact in the use phase (lower electricity, heating and water demand)
- Optimising and re-using existing buildings and infrastructure
- Designing circular construction (focused on disassembly, re-use and modification)
- Choosing circular materials (smarter, lighter, stronger, non-damaging)

OPPORTUNITIES FOR FRONTRUNNERS

At this time, the value chain in the construction and demolition sector is fragmented, from design to construction and from renovation to demolition. In order to achieve circularity, a well-oiled alliance of parties will have to offer these services collectively. With their efforts they can give shape to a new sector. All in all, circular construction offers the possibility of realising more added value at lower costs.

KNOWLEDGE IS POWER

For entrepreneurs in the sector, the importance of information continues to increase, as well as that of software platforms that connect multiple disciplines and simplify the optimisation of design, construction and renovation processes. Knowledge of and insight into the properties and source of materials and components becomes critical. The materials passport has a useful function in this.

CHALLENGES (AND SOLUTIONS)

The transition to a completely circular Construction and demolition sector definitely has some challenges. Some are legal and/or economic, due to shifting ownership constructions. The thus-far unprofitable re-use of construction materials is also a barrier. A shift of taxation on labour to taxation of resources can make a difference here. A third obstacle is the difficulty of recycling of structural components and materials. Here, smarter information management offers a solution.

THIS IS WHAT YOU CAN DO NOW

As an entrepreneur in the Construction and demolition sector, you can get started on circularity tomorrow.

- Save (materials) costs through the use of prefab, instead of in-situ construction.
- Develop experience with circular construction materials and methods.
- Explore the options and advantages of the resources passport.
- Invest in your network, work together within the chain and make circular choices.
- Specialise and increase your knowledge of modelling tools and digital platforms.
- Anticipate shifting ownership of materials, components and technologies.
- Offer integrated contracts that include the costs and environmental impact for the entire lifecycle.
- Talk to a bank that thinks about circular construction and the forms of financing that go along with it.

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7

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