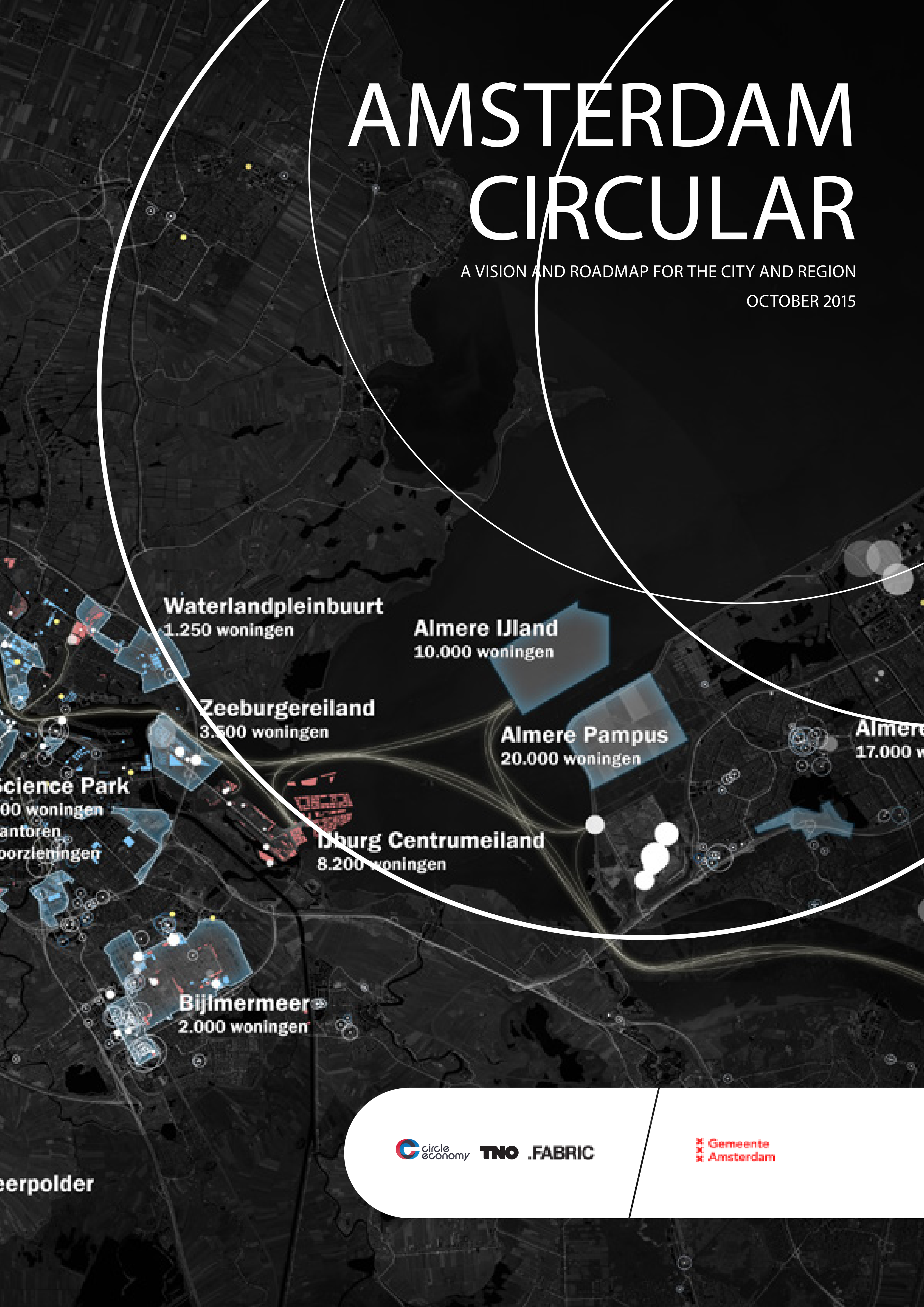

AMSTERDAM CIRCULAR

A VISION AND ROADMAP FOR THE CITY AND REGION

OCTOBER 2015

circle economy TNO .FABRIC

Gemeente Amsterdam

TASSEL

This report describes in Chapter 2 a vision and action agenda to come to a circular design of theconstruction chain in Amsterdam. In Chapter 3 follows a vision and action agenda to organic residual streams to process the volume of and opportunities for greater value retention and added value. The current design of flows in Amsterdam and the surrounding metropolitan region are described in Chapter 4. This chapter provides insight into how far Amsterdam stands from the circular economy. In Chapter 5 recommendations are made for the next steps.

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strategies
barriers
Route map
action agenda

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action agenda

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MANAGEMENT SUMMARY

High on the sustainability agenda of the municipality of Amsterdam is the circular economy as the pillar of sustainability policy. The results presented in this study ' Amsterdam circular: a vision for the city and region ' aim to give a basis for and guide the next steps which the municipality can take. The roadmap explicitly connects with and builds on the many initiatives that are already in progress.

In the study, the City Circle Scan approach consists of four phases. In phase 1, the main material- and energy flows as well as the employment in the economic sectors in the region have been analysed. In phase 2, a comprehensive analysis has been conducted of the value chains that connect multiple sectors within Amsterdam. The results of phase 1 were the starting point of this analysis. Based on macro-economic statistics it has been established in which chains the greatest impact can be achieved from a circular perspective. On the basis of the analysis and a round table discussion with representatives from the municipality and local companies the choice has been made to perform a detailed analysis for the construction chain and the organic residual flow chain. Then in phase 3 is explored how the two chains can function in an ideal circular future. This vision of the future gives a view on how the chains (and their interactions with other chains) can currently be set up differently. In phase 4 an action agenda and roadmap are drawn up for starting relevant circular projects. Barriers that could possibly form an obstacle have also been identified.

Results of the study show that Amsterdam has great potential to greatly reduce the use of materials and greenhouse gas emissions and at the same time realise economic growth and opportunities for employment. The economic activity of the Amsterdam metropolitan region amounts to 106 billion euros annually, of which 47 billion is accounted for by the city of Amsterdam (2013) (CBS, 2015). In the future vision and roadmap that have been developed for both chains and for the impact this may have on the economy and on the use of materials, below you can find a summary per chain.

Construction chain

By organising the building chain in a circular way - among other things by fulfilling the ambition to realise 70 thousand new homes by 2040 - the municipality can achieve 3% productivity growth, a value creation of 85 million euro per year. This economic growth is realised in a significant part by larger value retention due to material re-use and efficiency improvement. But this can not be realised overnight. With productivity growth, opportunities for employment are also created, which over time can add up to about 700 additional jobs out of a total of 75 thousand jobs in the Amsterdam building sector at this time. For the most part, these are jobs for low- to medium skilled personnel. The outlined improvement of the re-use of materials and the correspondingly larger value retention leads to significant material savings of 500 thousand tons. This is significant compared to the current annual import of 1.5 million tonnes of minerals. The perceived decrease in greenhouse gas emissions is of the order of half a million tonnes of CO_2 per year, this is equivalent to 2.5% of the annual CO_2 emissions of the city of Amsterdam. The above impacts are based on four strategies that specifically fullfil the circular design of the construction industry. (1) Smart design: Commit to smart design of buildings in order to make buildings more suitable for repurposing and re-use of materials. (2) Dismantling and separation: Efficient dismantling and separation of waste streams to enable high quality re-use. (3) high-quality recycling: The high quality recovery and re-use of materials and components. (4) Marketplace and resource bank The exchange of commodities between market players.

The roadmap and action agenda in the study present a large number of short and longer term actions that can contribute to transforming the chain and thus to the realisation of the impacts. On the right is a brief overview of the top 3 action points.

Organic residual flow chain

High-quality recycling of organic residual streams for the city of Amsterdam can, over a period of 5 to 7 years, lead to an added value for the economy of 150 million euros per year. This calculated ' circular scenario ' provides insight into the effects in relation to the autonomous (linear) growth in Amsterdam. In our account for a circular scenario, a palette of adopted

	1 FACILITATION OF RAW MATERIAL AND MATERIALS STORAGE	2 STIMULATING HIGH-QUALITY RE-USE	3 STIMULATING RAW MATERIAL PASSPORTS
	Matching of demand and supply of building materials and raw materials requires temporary storage. A possible role of the Government can focus on two aspects. The allocation of places for physical storage by the municipality can play a role. On the other hand, the Government can play a facilitating role in drawing up the conditions where materials have to meet to qualify for storage and re-use.	High-quality re-use of building materials can in the current early stage of development from the Government be encouraged in two ways. The Government can contribute to the development of procurement guidelines and building codes in which specific requirements have been formulated aimed at high-quality re-use. Also, the Government can play a role as launching customer for the use of recycled materials.	A raw materials passport for buildings provides an overview of used materials, processes and possibilities for re-use. The Government can encourage a (minimal version) of raw material passports is recommended or made mandatory for new construction projects. Also, the municipality could implement raw material passports for its' own property portfolio.
INVESTMENTS AND RESULTS	A follow-up analysis is needed to see how construction flows in the city will develop both where large demolition projects and where new construction take place. Such analysis complemented with available knowledge of zoning plans and structural vision forms input to assign places for the (temporary) storage of raw materials.	Developing criteria for building regulations and ensuring compliance calls for more commitment compared to the current situation. Possibly, the municipality can co-invest through the AKEF or a Fund for circular development in new processing technologies. Condition for this contribution may be that the activities are based in the city of Amsterdam so that any employment shall also be realised in the city.	The investment from the municipality would primarily consist of the provision of time for municipal officials on how the raw materials passport for buildings can be embedded in policy. For the registration of the passport, facilities are needed as currently provided by the land registry.
STAKE-HOLDERS	Municipality, Port authority, collaborative partnership Circle City, "start-up in residence", West axis partners, AEB.	Construction- and waste companies, such as BAM, Heijmans, AEB, Van Gansewinkel, Deped and Stonecycling, Circle City. Dutch Green Building Council.	Construction-, waste- and ICT companies, such as BAM, Heijmans, AEB, Van Gansewinkel, IBM, Stonecycling, Deped and Delta development group.

measures including source separation of the organic fraction of time in Amsterdam in all 430 thousand households. This separate collection makes it possible to use the organic fraction, for example, for the production of protein for animal feed, biogas and building blocks for the chemistry such as for the production of bio-plastics. Also organic waste streams from the food processing industry in the port area offers opportunities for higher quality processing and can thus contribute to additional value creation. This transition could also contribute to the local employment of 1200 jobs in the long term on a total of 10 thousand jobs in the agriculture and food processing industry at present. For example, it can be about employment for adjustment of the waste infrastructure such as underground containers, an increase in jobs at pick up services for the separate groups but also for the more complex processing of these flows. In addition to direct employment effects in the agricultural and food industry there are chances for additional economic activity in the supply industry such as engineering and logistics. The material savings mainly consists of materials that can replace higher quality processed flows. An example is the production of high-quality protein on organic waste to replace protein-import such as for example soy for animal feed. Also the production of bio-based building blocks for the chemistry such as for the production of bio-plastics would be able to replace oil-based raw materials. The material savings that can be achieved may add up to 900 thousand tons per year. Set against the current annual import of 3.9 million tonnes of biomass for the entire metropolitan region this can be characterised as significant. In connection with the material savings, the expected reduction of greenhouse gas emissions is in the order of 600 thousand tonnes of CO_2, this is equivalent to a small 3% of the annual CO_2emissions of the city of Amsterdam.

The above impacts are based on four strategies that can clearly translate the higher-quality recycling of organic residual streams. (1) Central hub for bio-refinery: A central hub for the valorisation of organic residue streams from household and industrial waste and waste streams from the industry. (2) Waste separation and return logistics: Smart waste separation and return logistics to deploy the logistics hub of Amsterdam in a smart way and to increase the value of residual flows. (3) Cascading of organic flows: To deploy organic residual streams in the smartest way possible. (4) Retrieving nutrients: Retrieve essential nutrients to close nutrient cycle.

The roadmap and action agenda in the study present a large number of short and longer term actions that can contribute to transforming the chain and thus to the realisation of the impacts. The table opposite indicates a concise overview of the top 3 action points for the processing of organic residual streams.

	1 VIRTUAL RAW MATERIALS PLATFORM	2 CIRCULAR FREE ZONE BIO-REFINERY	3 LAUNCHING CUSTOMER
	Further developing and making publicly accessible digital (commercial) platforms for organic waste, "which offer a transparent overview of the supply, the demand and the use of organic residual streams in Amsterdam (and beyond) and in addition can contribute to matching supply and demand. This may be a response to the current uncertainty in market participants about supply and demand of flows.	The municipality can initiate circular free zones. This takes away certain obstacles which currently stand in the way of the development of innovations. For example, the ban on the use of digestate rich in nutrients (especially phosphate) on agricultural land. This is currently blocking an important and essential part of the business case for anaerobic digester plants because the current market value of digestate is low).	The municipality can by means of criteria in the purchasing policy stimulate locally produced grass, wood (as in street furniture) and food (catering). The large buying power of the municipality itself can create an important and constant demand that allows local parties to further develop and professionalise.
INVESTMENTS AND RESULTS	The investment in setting up a platform is largely for the development of the IT-infrastructure and for the time it takes for the conceptual development of a platform. The municipality can be the initiator. Although there are many market participants including large IT parties that also deal with the development of such platforms.	The designation of circular free zones can be an effective way to neutralise barriers such as described in the local barrier overview. It is a measure that requires investment especially in the organisation of supervision and enforcement. The measures to be taken fall completely within the perspective of the Municipality Act.	The effects of these measures may soon be visible since there is a direct market demand for local products. This is expected to be quickly absorbed by the market.
STAKE-HOLDERS	Ams, Floow2, Harvest Map, TNO, Municipality Wageningen UR	Orgaworld, SkyNRG, Schiphol Group, KLM, Port Of Amsterdam, Sita, Awakenings, Loveland, Air	Municipality, Caterers,Local producers, Exter, Crooked doom Provalor, GRO, Holland, Taste Before You Waste, Instock, Food bank, Multi-country and Fruityourworld

1. INTRODUCTION: MUNICIPALITY AMSTERDAM AS PIONEER

The urgency of the transition to a circular economy our linear way of producing and consuming is under pressure. The world's population grows to nine billion people by 2050. Also the city of Amsterdam urbanises and grows with 10.000 inhabitants per year. The demand for raw materials rises. This demand and the finitude of various raw materials leads to scarcity and strong price fluctuations. More and more companies are therefore opting for the transition to a circular economy: it offers opportunities for innovation and (exporting) new production techniques and business models and reduces the dependency on imports. For citizens it will improve the quality of life in a circular city, new jobs can be created and it will form new business models for entrepreneurs in a circular city.

Amsterdam wants to be front-runner in circularity. The Amsterdam region has a good starting position for a circular economy. The region has many entrepreneurial and innovative businesses, citizens, start-ups, organisations and knowledge institutions that already work on the circular economy.

The city of Amsterdam works based on the following seven principles on the circular economy:

1. The circular economy knows no waste. All materials enter into an infinite technical or biological cycle.
2. All energy comes from renewable sources.
3. Raw materials are used to generate (financial or other) value.
4. Modular and flexible design of products and production chains increase adaptability of systems.
5. Move from possession of goods to (use of) services; This requires new business models for production, distribution and consumption.
6. The logistics system changes: more region-oriented service and return logistics.
7. Human activities contribute to ecosystems and ecosystem services and the reconstruction of "natural capital".

Circular economy as a pillar for Amsterdam The municipality of Amsterdam has in its sustainability agenda *(Amsterdam, 2014a)* -adopted on 11 March 2015- highly committed to the circular economy as the pillar of sustainability policy. Within the existing resource mechanism there is already space to accelerate transition, for example through the development of circular free zones. This good starting position is also confirmed in the rural Green Deal 'The Netherlands as circular hotspot'. Lately the region has experimented with some pilots in the transition to a circular economy. The municipality strongly wants to commit themselves to more efficient recovery of natural resources and materials, where the construction chain is an important area of focus. The coming period the municipality wants to commit to a real conversion. The municipality would like to stimulate economic activity, research and innovation. It is therefore important for the municipality to get a picture of the entire system. That is why the municipality ordered the Circle Economy, TNO and Fabric to do a Quick Scan Circular for the city, as indicated in the sustainability agenda.

The changing role of Governments Circular business models are being seen as promising by businesses *(Accenture, 2014)*. Therefore, the transition to a circular economy is mainly driven by companies at this time. At the moment these front runners still experience many barriers (for example, in the form of regulation) which slow down the speed of the transition. For Governments a crucial role is played in facilitating and guiding the transition to a circular economy *(EMF, 2015a)*. Especially at city- and regional level the circular economy is taking shape and groups of citizens and businesses start all kinds of circular initiatives *(RLI, 2015)*. These developments show that currently a great deal of interest and commitment exists to capitalise on the opportunities offered by the circular economy. To scale up these initiatives support from the Government is essential.

The Government of the future does not direct, but brings parties together. To play that role, the two main strategies are the removal of barriers resulting from existing policy and to actively encourage and challenge the market. One can think of, for example, the development of

inspiring goals for the circular city, adjusting the private purchase- and tender conditions, stimulating innovative research and start-ups that contribute to circular solutions and financial incentives. This last point for example, can be fulfilled by differentiating tax rates (think of waste tax), but also by investing in good infrastructure to increase exchange of raw materials. A close cooperation between Government and market offers a great opportunity to accelerate the transition to a circular economy.

Amsterdam Circle Scan: from vision to action In this document the results of the ' Amsterdam Circle Scan ' are described, an analysis of the opportunities and challenges for a circular Amsterdam. The results contribute to the further development of the municipal ambitions and agenda on the theme circular economy. The road map is a step towards the stimulation of practising the circular economy in the city. To create a circular economy, we must first understand what is not circular in our current economy. This document provides insight into the commodity flows in the city and metropolitan region. It shows where the processing of raw materials adds value to the local economy and be re-used in a smart way, and where raw materials are wasted. The report focuses on two value chains with a significant impact, contribution to the regional economy and potential to be set up circularly, namely construction materials and organic flows. For both value chains is explored what a circular future may look like. To concretise the vision, four strategies are being detailed and translated to a specific roadmap of the city and region with concrete action points. The report concludes with recommendations and next steps. A key recommendation and follow-up step involves making circularity more measurable to monitor progress. The 'circular indicators framework' applied in this study offers a good starting point.

Jump start: build on momentum the ambition to be a circular hotspot is widely supported in Amsterdam. Not only the municipality is progressive, citizens and businesses are equally enthusiastic and energetic about the transition to a circular economy. .The city is buzzing with circular initiatives. That was once again made clear during conversations held in the region to gather input for the future visions and action points in this document. With these action points we want to contribute to and build on the momentum that is becoming increasingly clear in this region. In the action agenda we have connected and built as much as possible on the many initiatives already under way. Internationally, Amsterdam is pioneer being followed by other cities in Europe and beyond.

THE CITY CIRCLE SCAN METHOD

The City Circle Scan is a method that gives direction to cities in the development of a roadmap and action agenda for the practical implementation of the circular economy in the city and region. The method consists of four phases.

MAPPING OF MATERIAL FLOWS AND ADDED VALUE

To get a better picture of how circular Amsterdam currently is, the main material- and energy flows as well as the employment in the economic sectors in the region have been analysed. Amsterdam has been analysed using data from (regional and national) statistics and sources, supplemented with interviews. The analysis provides insights on the material flows in the city, the activities and places in the region where the most important ecological impact can be achieved. In addition, the analysis provides insights where and how value can be created in the region and where opportunities lie for job growth and economic development.

EVALUATION AND SELECTION OF CHAINS

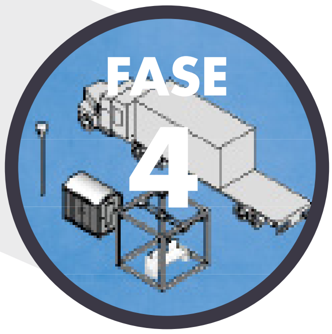
In phase 2, a comprehensive analysis has been conducted of the value chains that connect multiple sectors within Amsterdam. The results of phase 1 were the starting point of this analysis. Based on macro-economic statistics it has been established in which chains the greatest impact can be achieved from a circular perspective. The result was a list of chains that have been prioritised on the basis of the following indicators: ecological impact, economic importance and conservation of value and transition potential. These indicators are also held in the national program Realisation of Acceleration to a Circular Economy.

VISIONING

Then in phase 3 we explored how the two chains can function in an ideal circular future. This future vision gives a view on how the chains (and their interactions with other chains) can currently be set up differently. Per chain four strategies are formulated for a circular economy. The future vision is tested in feedback sessions and in interviews with various experts and stakeholders in Amsterdam. The feedback that was revealed has been used to further refine the vision of the future.

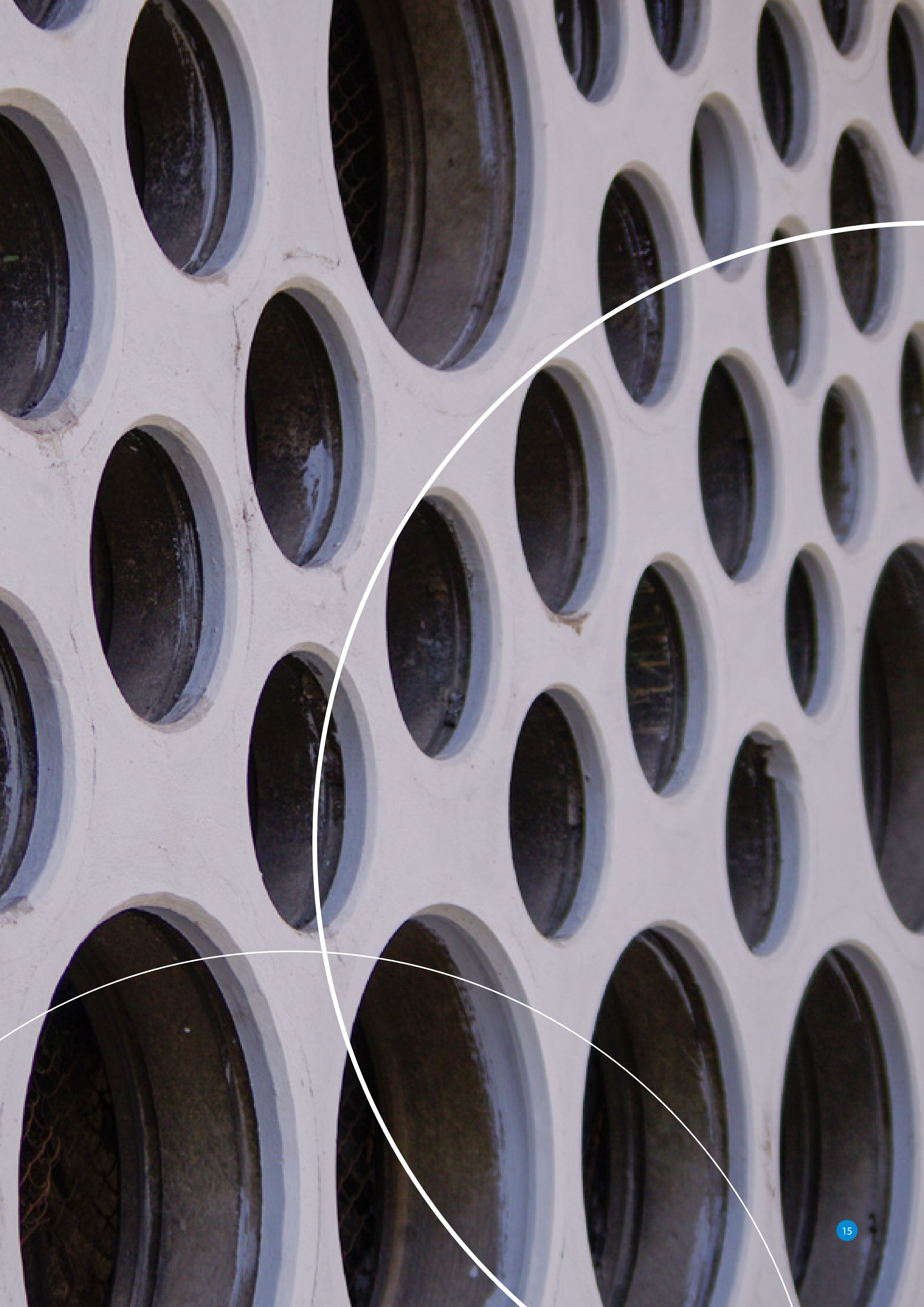
PROJECT SELECTION AND FORMULATION OF ACTION POINTS

In phase 4 an action agenda for starting relevant circular projects has been drawn up, provided with a planning and implementation strategy. All are projects in which Governments, research institutes, companies, entrepreneurs and citizens work together to make the two chains circular. Time paths for the actions and policy interventions have been formulated, that indicate which stakeholders are essential for a successful transition. The actions have also been assessed on four main effects: (1) value creation, (2) CO_2-reduction, (3) material savings, and (4) job growth.

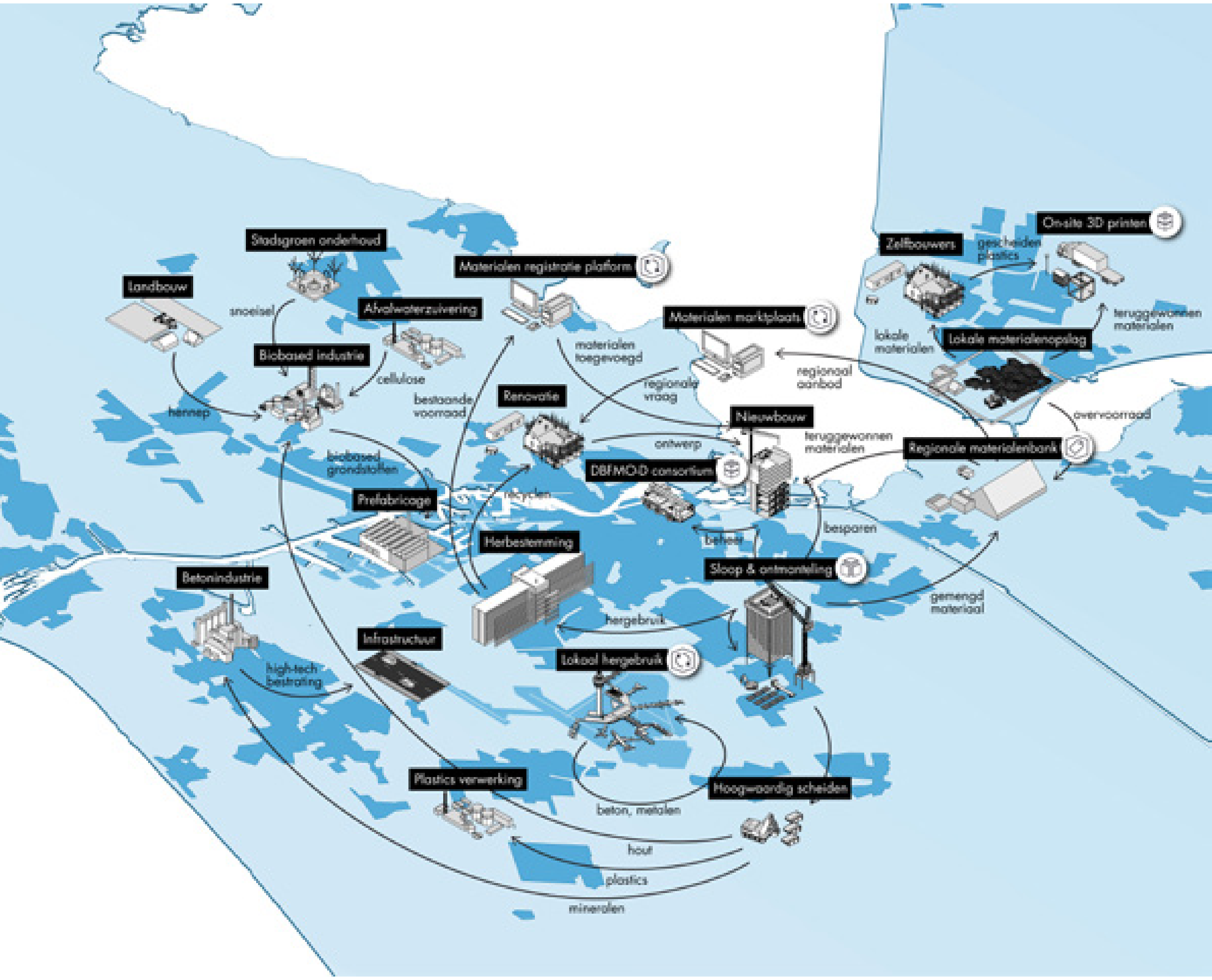


2. VISION OF A CIRCULAR CONSTRUCTION CHAIN IN

To get a picture of how the construction and renovation assignment in Amsterdam can make better, higher quality and longer lasting use of material flows, we explored a potential future of the construction industry in Amsterdam. This vision of the future partly came about based on interviews with experts and stakeholders. Their feedback was used to further refine the vision of the future. The starting point of this exploration was to retain the highest possible value in the construction chain by means of circular solutions. This chapter therefore describes four strategies that can be followed. These strategies are then placed in the context of the region (by linking with local initiatives and a selection of innovative market parties). Furthermore, the link is made with trading opportunities for the municipality. Also addressed is where the market is active and how the government can facilitate this. The roadmap describes concrete action points for the municipality and links this to time lines and to which parties can play a role in the emergence of those actions. The impacts of implementation to be realised are calculated for value creation (1), (2) CO_2-reduction, (3) material savings, and (4) job growth.



VISION OF CIRCULAR CONSTRUC-



In an ideal circular construction chain the buildings are designed in such a way that materials will have the longest possible life span through re-use or re-purposing. Introduction of a commodity passport would be a concrete measure that can help greatly in stimulating re-use because it increases transparency that gives direction to the potential reallocation and the business case. Furthermore chain cooperation and supply chain financing is especially important since it contributes to a longer term that does justice to the useful life of buildings. As a result hereof the economic, environmental and social performance improve.

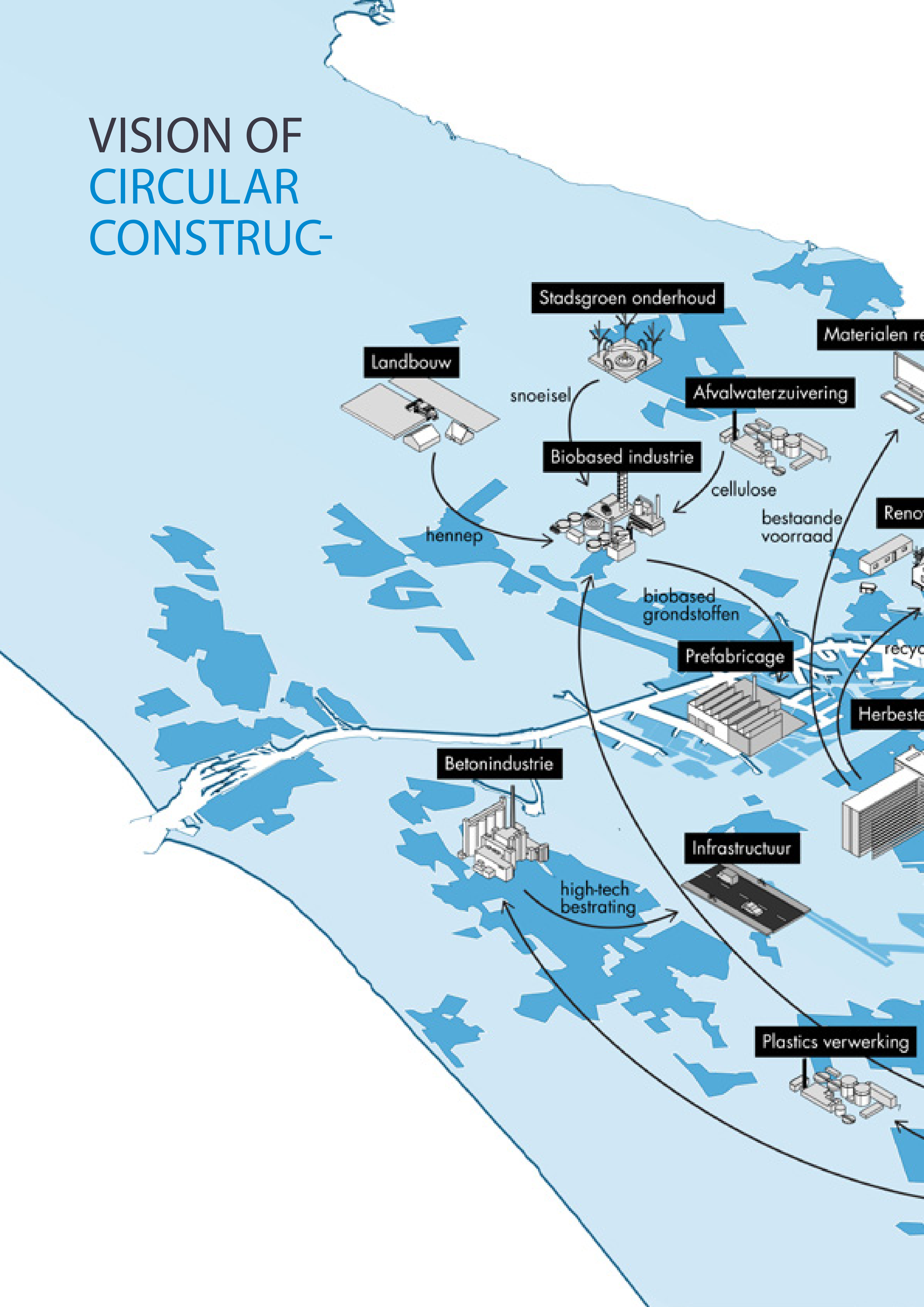
Integrated planning is essential for the realisation of a circular future. Construction and demolition of buildings in Amsterdam should be coordinated, so that the construction materials from demolished buildings may be used again in new construction projects and renovation projects. That way, the use of new materials in new construction projects will be reduced to a minimum. Bio-based construction materials can also play a role. Locally produced biomass can serve a part of this market, for example, from he production of elephant grass around Schiphol airport or on wastelands of the port. In addition, it is important that besides local sources, also national and international sources and production methods of sustainable bio-based materials are being used. New production methods, including the use of 3D printers can realise the local production of buildings. This can also increase the demand for bio-based plastic, and thus stimulate the production of bio-compositen.

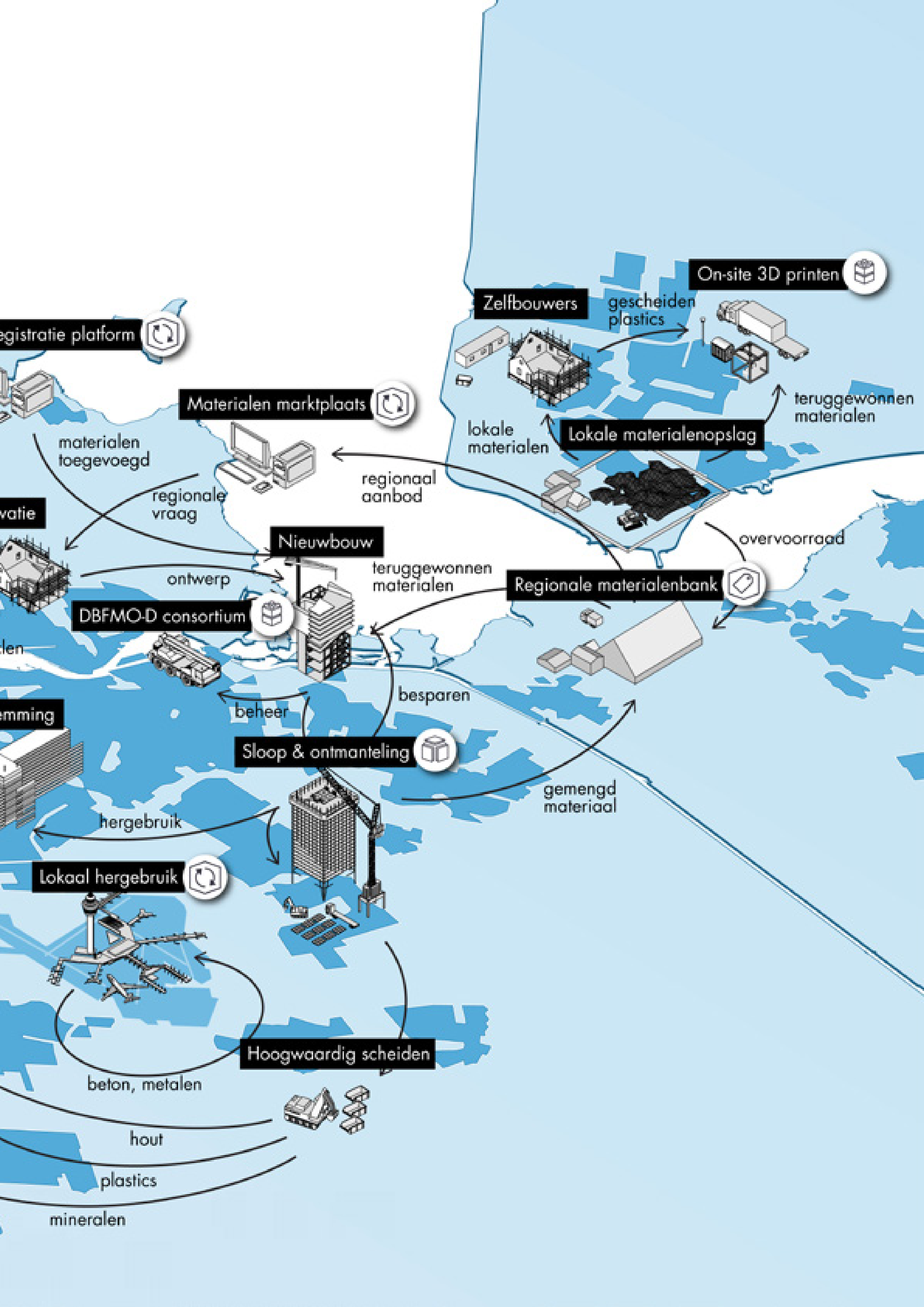
Buildings can be constructed in a modular way. The flexibility of multifunctional buildings ensures that buildings have a longer life span despite the varying demands of residents and users. This underlines the role of architects and property developers in the design of buildings that are made suitable for re-development. Modular construction can contribute to rapid and cost effective adaptation of the building function with which it can also contribute to the prevention of vacancy. Preventing vacancy is an important starting point for optimal and profitable exploitation.

In a circular Amsterdam more focus will be on smarter demolition. During the demolition of buildings re-usable products and materials are separated, while maintaining their physical characteristics and economic value. During the separation, there is a special place for storing materials that will be used directly in the construction of new buildings and renovation of existing buildings. For this a materials database is required, which is linked to an online marketplace, where buyers can easily decide on the basis of data on quality and quantity. Materials can be kept in physical storage places (for example, on waste land) that is close to demolition or new construction projects.

The described vision is processed in a visual representation (see opposite and enlarged on the next page) that depicts the flows in the city. In the next section the vision is translated into strategies and action items, with which the city through market technical, technological and administrative instruments, creates possibilities to the material cycles in the construction chain.

VISION OF CIRCULAR CONSTRUC-





egistratie platform
Materialen marktplaats
materialen
toegevoegd
regionale
vraag
regionaal
aanbod
vatie
Nieuwbouw
ontwerp
teruggewonnen
materialen
DBFMO-D consortium
len
beheer
besparen
emming
Sloop & ontmanteling
gemengd
materiaal
hergebruik
Lokaal hergebruik
Hoogwaardig scheiden
beton, metalen
hout
plastics
mineralen
Zelfbouwers
gescheiden
plastics
On-site 3D printen
teruggewonnen
materialen
lokale
materialen
Lokale materialenopslag
overvoorraad
Regionale materialenbank

STRATEGIES FOR BUILDING A CIRCULAR CHAIN

From the vision described for the construction chain a translation is made in strategies and action items which enables the municipality to close the material cycles in the construction chain.

(1) smart design
Smart design of buildings so they are better equipped when the purpose of a building changes and materials can be re-used.

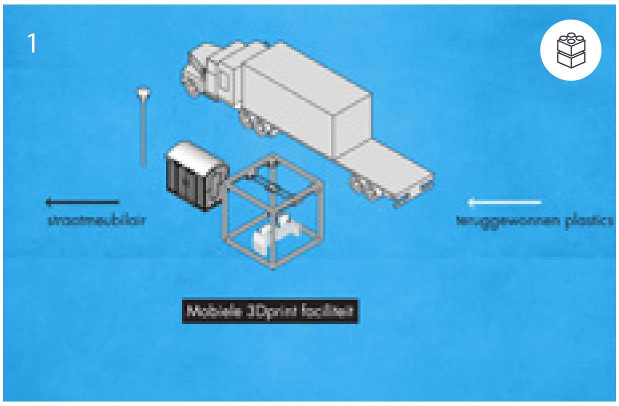
(2) Dismantling and separation
Efficient dismantling and separation of waste streams to enable high quality re-use.

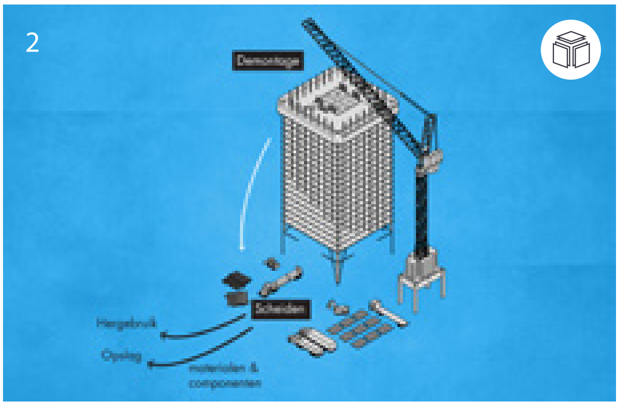
(3) high-quality recycling
The high quality recovery and re-use of materials and components.

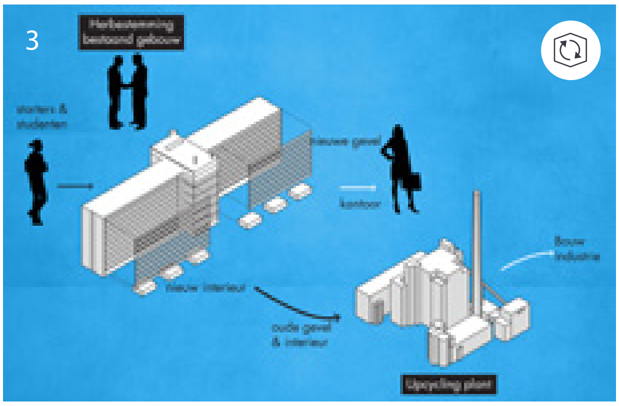
(4) Marketplace and resource bank
The exchange of commodities between market players to enable the re-use of materials in new building (high-quality).

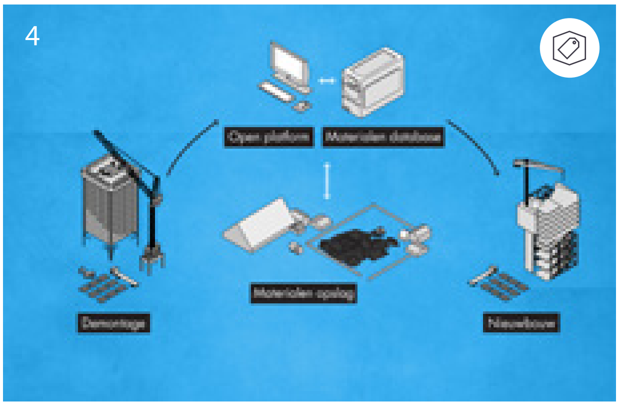
These circular strategies are explained on the basis of relevant existing activities that currently take place in Amsterdam. In addition, four strategies are displayed in a space view, see *spatial vision map*. Even though the strategies are formulated separately, they are partly intertwined with each other. Successful implementation of high-quality re-use, for example, is dependent on efficient dismantling and separation techniques.

The following section lists the four strategies translated into a concrete roadmap action agenda. The action agenda further explains where the municipality can be of influence, what other market parties can become involved and in what time frame the transitions may take place. Here a first advice is formulated on the basis of the previously described research and analysis activities and interviews with stakeholders and experts.



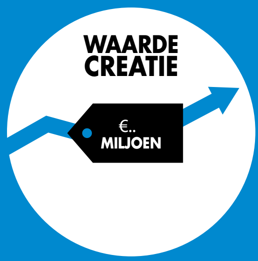






Explanation indicators The effects of the circular strategies on the environment and the economy are calculated for a construction of 70 thousand homes in Amsterdam. Here, the impact will be realised over a period of five to seven years. To achieve this, four indicators were used. (1) Net added value in millions of euros (2) net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission. These are further described below.

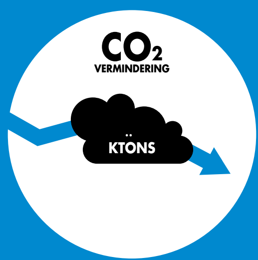
Net added value in euros The circular strategies directly enable a number of sectors in Amsterdam to realise more added value: more sales and more profit. "Net" meaning that in some cases also a decrease of added value is calculated and that via the chain analysis also the indirect effects of all other sectors are taken into account.



Net jobs growth in FTE One of the social aspects of an increase of the circularity is represented among other things by the realisation of jobs (FTE, Full Time Equivalent). Job growth is estimated on the basis of the sectoral increase of added value, of salaries in that sector and of the demand for low-, medium- and highly skilled workforce. NET jobs growth means job growth that results in a direct reduction of unemployment.

Material savings Use of materials is expressed in Domestic Material Consumption (DMC)*, which in addition to the use in an area also looks at materials that are imported and exported. Apart from CO_2-emission (which already is explicitly included) DMC makes all environmental impact factors related to the circular projects quantifiable.

CO_2-reduction The most well-known impact of economic activities, is the emission of CO_2. The impact of the modules on the emission is expressed in Global Warming Potential (GWP), a globally adopted measure that expresses the avoided CO_2-emissions in the coming years, by an increase of circularity, over a period of 100 years. To make the impact comparable with the annual emissions in the region the choice was made to convert the indicators to annual CO_2 emissions.



** Domestic Material Consumption, abbreviated as DMC, is a commonly used statistic that measures the total amount of materials that are used directly by an economy. It measures the annual amount of materials that are extracted in the geographical area including all physical import and minus the physical export.*

SMART DESIGN

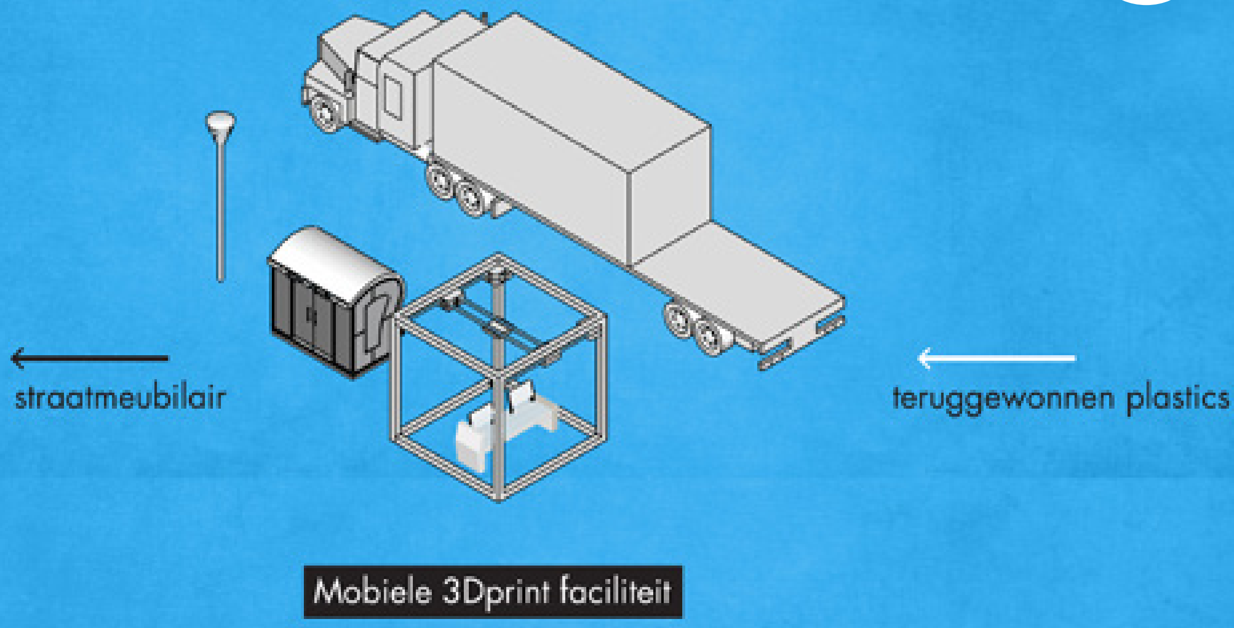
Smart design (smart design) of buildings is important in the transition to a regional construction circular chain *(EMF, 2015a).* Inhabitants move more frequently and work areas should be regularly adapted to meet changing work patterns such as mobile working and flexible working hours. In addition, it has been found that companies more often move to another building rather than renovating the current one. These factors lead to an increasing demand for flexible and customisable areas that meet the changing demands of tenants and owners. To illustrate the concept we will focus on four categories of smart design, namely modular and flexible design, 3D printing, bio-based materials and experimental space.

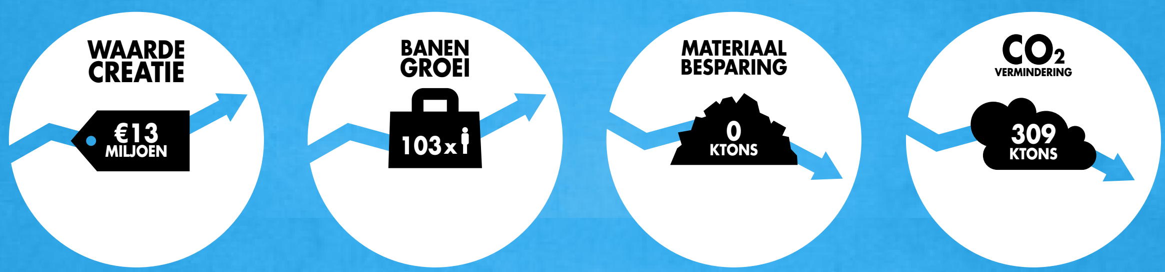
Modular and flexible design One of the aspects of smart design is a modular and flexible approach, whereby buildings can be updated to new users and other applications without sacrificing the current safety guidelines *(Schoenborn, 2012)*. These designs lead to real estate that is more functional and more durable and thus offers a better revenue model during the utilisation period. Examples of integral modular designs are Solid in Amsterdam by housing association The East, student accommodation Keetwonen in Amsterdam of TempoHousing and Park 20 | 20 that Delta Development Group realises at Schiphol.

Flexibly designed houses are often more attractive to users because they can adapt such houses to their changing lifestyle. Hubbell in Amsterdam builds modular spaces for individuals. Companies also prefer flexible offices because they do not need to move as their business situation changes. Especially start-ups and other fast-growing companies can profit from it. Rent or purchase of flexible office space can even result in a cost saving *(Cushman & Wakefield, 2013).*
3D printing New technologies, such as 3D printing, can play a pioneering role in reducing cost and material use *(EMF, 2015b).* Such technologies expect to lead to less waste and offer the possibility of new (e.g. bio-based) materials to be used. The Amsterdam firm of architects SO Architects has in collaboration with Hager and Henkel started the project "3D Print Canal House' to investigate the possibilities of 3D printing for the construction industry. The research project looks at different building materials, such as recycled construction materials and stone waste *(so, 2015).*

Bio-based materials New sustainable building materials with a biological origin can contribute to designing smarter buildings. More than 3 million tonnes of biomass and organic residual streams are released from agricultural activities in the Amsterdam metropolitan area, from which significant amounts of bio-composite materials can be produced. This would at least be sufficient to supply the materials needed for the planned housing expansion of 70.000 homes *(CBS, 2014).* An interesting example of sustainable building materials is the work of Waternet, who develop together with stakeholders such as NPSP and Cityblobbio composite components. The municipality of Almere has already begun with projects involving bio-waste which is used to generate bio-composite for the building sector. The 60.000 m^2 of buildings for the Floriade in 2022 can be built as circular as possible by the use of biomaterials. Another interesting example is the trajectory of Waternet in which waste streams such as water plants are converted into (building) products.

Experimental space Laws and regulations can be adjusted to make it possible to develop bio-based, modular buildings with flexible applications *(Acceleratio, 2015).* By modifying the building codes developers get more room to experiment and more freedom to put their clever designs into practice. The success of Park 20 | 20 is partly due to the municipality of Haarlemmermeer, that created flexible rules for the area in which innovative building designs could be tested. In IJburg the possibilities are settled to create an experimental area for new developments. These*free zones* offer a great opportunity for start-ups, that work on innovative concepts, and contribute to the ambition of making Amsterdam a start-up hub.





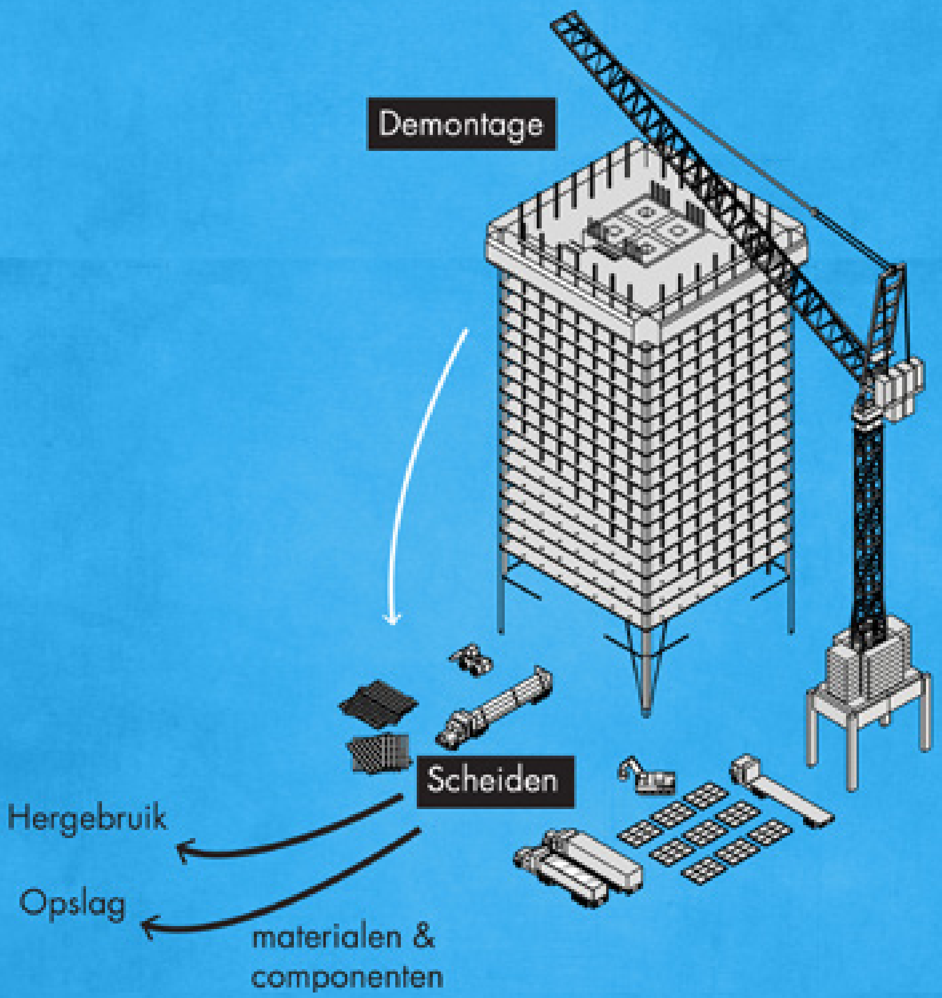
Visual display of smart design: Retrieving bio-plastics are used by a 3D printer to produce new products such as street furniture. In addition, mobile stations are used to be able to produce on site. The effects of circular strategies on the environment and the economy are passed on for a construction of 70.000 new homes in Amsterdam. It is expected to take 5 to 7 years to achieve circular design within the construction industry. The impact will also manifest itself at that time. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission.

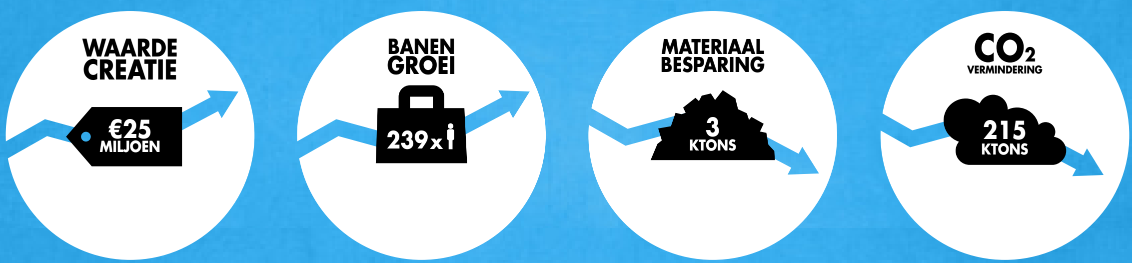
DISMANTLING AND SEPARATION

By dismantling existing buildings in more efficient ways and by separating their waste streams, materials and components of old buildings can be better re-used. An important but often ignored phase in the life cycle of a building is the end-of-life *(Acceleratio, 2015).* These days a maintainance clause is sometimes included in contracts for real estate development, however it almost never includes anything about the cost of end-of-life. Therefore destruction currently seems the cheapest option with a cost of only € 20 to € 30 per square meter *(Circle Economy, 2015).* By handling demolition of buildings in a smarter way high-quality materials can be separated to avoid them from being contaminated by other raw materials. From a circular approach it is necessary to take decommissioning already into account in the design of buildings. Efficient separation of the waste streams can facilitate high-quality recycling- and re-use of these materials. Especially in small-scale construction projects such as renovations still little attention is spent on this due to the small scale not making it financially viable. However by dismantling smarter on a regional scale, and by separating materials and components in a better way, more mono-streams of materials are made available, which makes re-use worthwhile.

Decommissioning In a circular construction sector by close cooperation the entire life span of a building is organised, in which the costs and benefits of a longer life span are divided in a fairer way among the cooperating partners. The cost and time for the approach to the end of life of buildings can be tackled in DBFMO-D (design, build, finance, maintain, operate and demolish) in which not only clauses for design, building, financing, maintainance and use of buildings are contained, but also for their demolition *(Netherlands Court of audit, 2013).* Such contracts allow the components and materials in the building to be used again. These components and materials can then be sold to compensate for the demolition costs. In Amsterdam there are companies already specialising in decommissioning- and demolition methods. Examples of these companies are VSM demolition works, Demolition Company Concurrant, Demolition Support Netherlands, Orange BV and Bentvelzen Jacobs.

Waste separation By better separation of construction- and demolition waste, materials can be retrieved in a high-quality manner so that the materials will not be contaminated. Hybrid waste management systems, which combine individual and central sorting methods, can lead to better business cases. Companies like Icova and Waltec BV offer processes and technologies to separate construction and demolition waste. New technologies, such as the Smart breaker of SmartCrusher BV, make it possible to separate concrete in sand, gravel and cement. As a result, the value of the individual materials increases, whereby better recycling is possible and high quality new concrete can be produced.





Visual representation of dismantling and separation: Buildings are separated in a smart and efficient way so that high-quality raw materials are recovered and saved. In addition, components can be re-used. The effects of circular strategies on the environment and the economy are passed on for a construction of 70.000 new homes in Amsterdam. It is expected to take 5 to 7 years to achieve circular design within the construction industry. The impact will also manifest itself at that time. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission.

HIGH QUALITY RECYCLING AND RE-USE

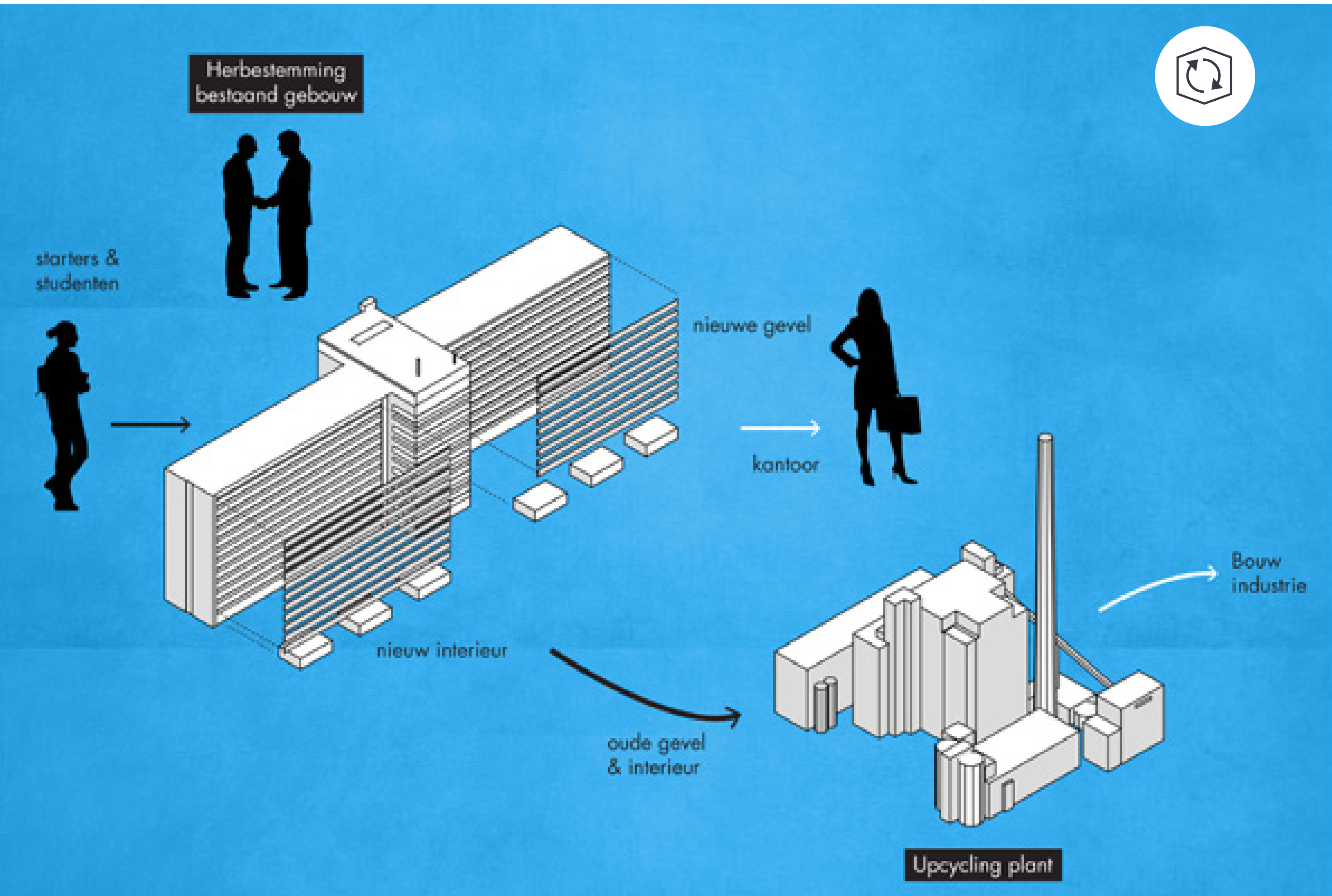
The construction chain is responsible for 40% of the total waste stream in Amsterdam *(CBS, 2014)*. Although more than 90% is recycled, the vast majority of these materials are used as gravel for roads. This is a low-value application *(Circle Economy, 2014)*. Here is a chance for high-quality re-use. Also office-spaces offer opportunities from circular perspective. At this moment, about one-fifth of the office spaces in Amsterdam is vacant, which is inefficient when you look at the (financial) resources and raw materials used *(DTZ, 2015)*. At the same time, the buildings have a large financial potential. The challenge is to better use the opportunities for high-quality re-use of components and materials in buildings and redevelopment of the buildings themselves in Amsterdam.

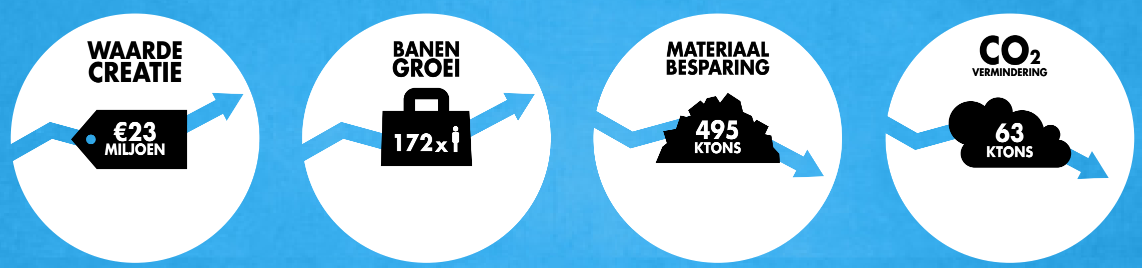
Better re-use Building- and waste materials can be reworked into new products. In Amsterdam a special installation can be built that enables high-quality recycling of building materials. In this installation different companies could process and recycle varying parts of the stream of construction waste. Amsterdam already knows a number of companies, such as Stonecycling, who work together with construction waste companies to recycle stone and ceramic waste to bricks.

Demo clean building materials Another example is AEB Amsterdam. They use the inert group-ash that is left behind when burning residual waste to produce building materials. Next year a pilot will start on demo-AEB scale in order to create clean building materials in a process in which CO_2 is permanently recorded. Currently this fraction is down cycled for the use in road construction, but in the future this can be applied in higher quality as building material for example. This is a total amount of 300 thousand tons worth of building materials in which 8 kiloton CO_2 is logged *(AEB, 2015)*.

Retrieving materials from street furniture and paving materials The city of Amsterdam is in the process of acquiring knowledge by means of procurement criteria to retrieve more materials from street furniture *(Such as in the project "The Street of the Future" in Amsterdam)*. Struyk Verwo recycles old concrete pavements to new products that for 75% consisted of recycled or re-used concrete *(Struyk Verwo, 2015)*. Such installation can bring together different companies and enable them to experiment and to extend their technologies. Almere is working on the construction of such a plant, meant to recycle materials in a high-quality manner.

Repurposing existing buildings Excessive and vacant buildings in Amsterdam have a large share in the material and energy costs in the region. It is recommended that these buildings are optimised and are given a new purpose. Major renovation projects, such as 'rapid', show that high-quality renovation of existing housing can form a solid business case. Such expansion and renovation projects lead to significantly less energy consumption during the remaining lifespan. Redevelopment projects in Amsterdam are also attractive for the inhabitants because they provide an opportunity for additional living space.





Visual representation of high quality recycling: Repurposing existing buildings for new applications. In addition, components (such as interior) are retrieved so that they can be re-used by an upcycling plant. The effects of circular strategies on the environment and the economy are passed on for a construction of 70.000 new homes in Amsterdam. It is expected to take 5 to 7 years to achieve circular design within the construction industry. The impact will also manifest itself at that time. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission.

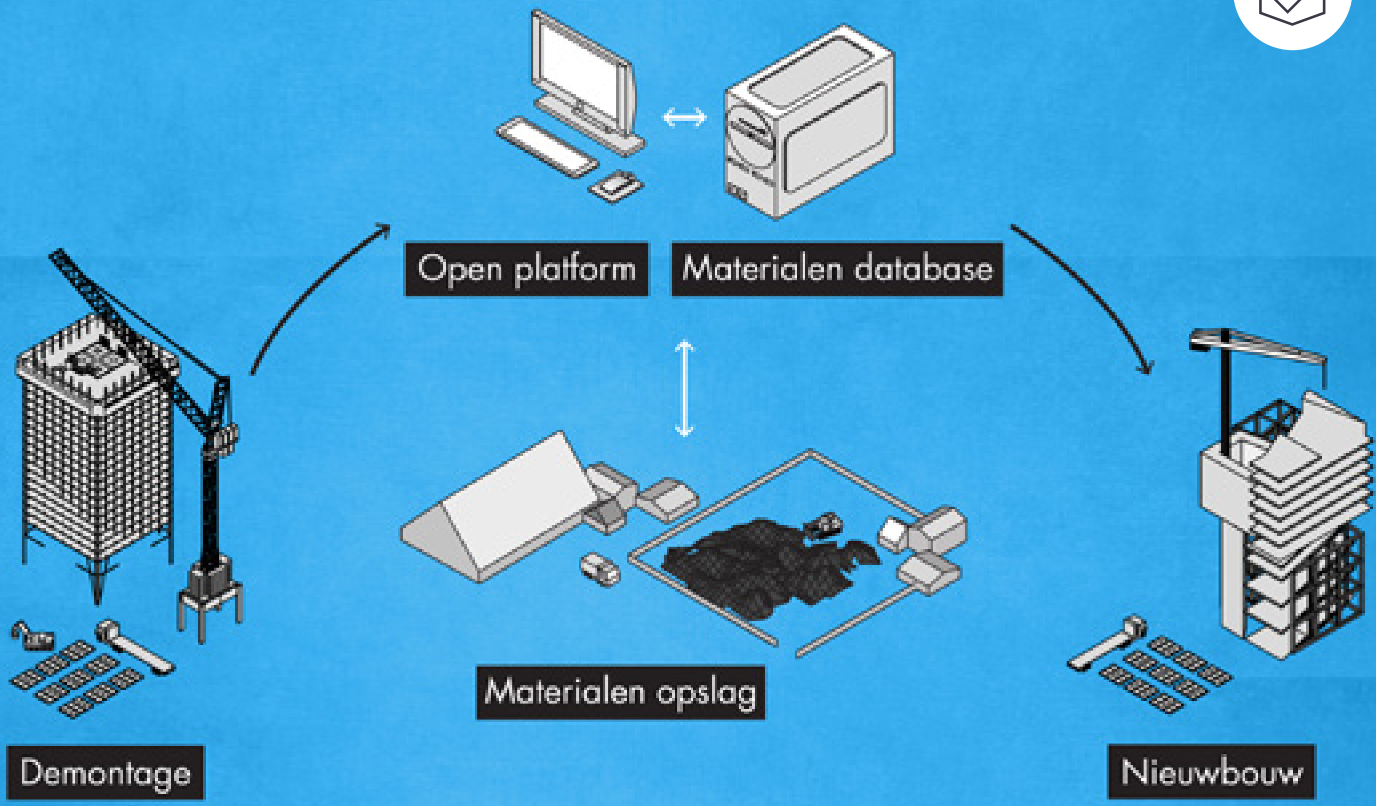
MARKETPLACE AND RESOURCE BANK

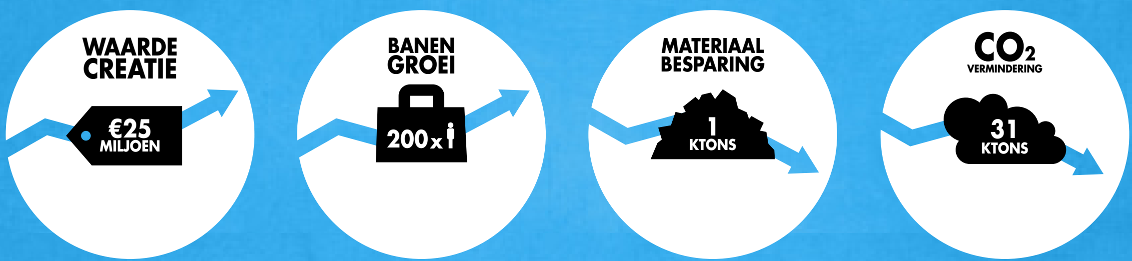
Each building in Amsterdam can be seen as a materials bank full of valuable materials, a modern take on the traditional mines *(United Nations University, 2014)*. There remains, however, even after dismantling, separation and recycling of building materials a gap between the demand for and supply of these resources. Demolition and decommissioning projects provide important opportunities for processing and direct re-use of the recovered building materials in nearby construction projects. However, it is often unclear which materials are present in existing or decommissioned buildings and of what quality these materials are. That makes high-quality re-use a major challenge. There is a need for a comprehensive online marketplace and a supporting logistics system that facilitates the exchange of building materials between the demolition, construction and recycling companies in Amsterdam. In addition, a physical location is required where these materials can be stored in the meantime, a so called 'raw material bank'.

Online Marketplace Via an online marketplace supply and demand of building materials for local construction projects can be aligned (by means of GIS data) *(Zhu, 2014).* Apart from the building information management systems and building passports the quality and quantity of the materials that have been used in a specific building and are delivered as demolition waste, can be documented and be made transparent. This provides opportunities for trade and exchange of building materials between parties and encourages re-use and high-quality recycling. In the United Kingdom the company Enviromate develops an online marketplace where construction companies can exchange and trade waste materials of construction projects. Such a system can also be used in Amsterdam. For new buildings in Park 20 | 20 at Schiphol material passports are already being developed. These can also be applied in the rest of the region.

Logistics for collection An online marketplace alone does not necessarily make the collection and transportation of construction- and demolition waste easier or cheaper. The material is indeed very diverse and extensive. Therefore there is a need for an advanced collection system and for intelligent logistics, which makes the exchange of building materials easier. Because many developing locations are located near waterways, the port of Amsterdam can be a central point in that logistical system. For the transport shipping companies can be deployed. Many logistics companies such as DHL and PostNL consider offering reverse logistics for a wide range of material flows. Reverse logistics meaning the use of logistic activities for the clearance of goods. That way the usually empty truck after delivery is being used for retrieving waste.

Commodity bank Currently there are challenges for the temporary storage of construction waste at companies mainly because this requires space and thus investment. A solution can be to arrange a centrally located physical storage of materials (commodity bank), that are also traded on the online commodity market place, where they can be stored temporarily. Vacant plots around Amsterdam, such as in the port of Amsterdam and in West port, Zaanstad and Almere, are ideal locations to temporarily store construction waste until it is traded through the online marketplace. The province of Limburg has ambitions to create such raw material bank. Designers and architects are invited to view a catalogue with materials to see if they can come up with new applications for these materials. Several companies, such as Brink Industrial, Repurpose, Turntoo and Icova, work in addition on their own raw materials bank.

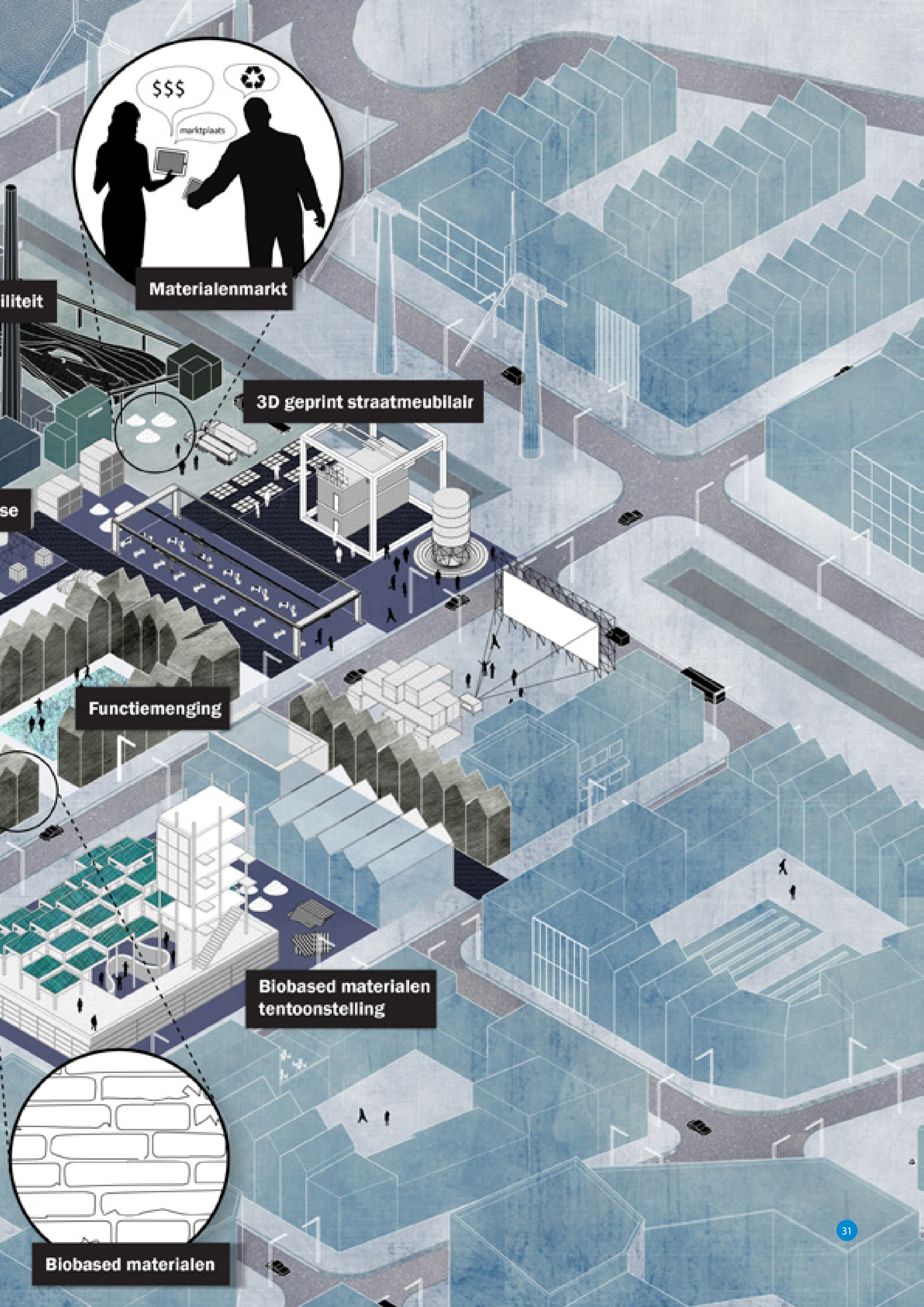




Visual representation of market place and commodity bank: Raw materials are traded between disassembly of old buildings and new construction, by means of a physical repository and online marketplace. The effects of circular strategies on the environment and the economy are passed on for a construction of 70.000 new homes in Amsterdam. It is expected to take 5 to 7 years to achieve circular design within the construction industry. The impact will also manifest itself at that time. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission.

SPATIAL VISION

The spatial vision card indicates how circular strategies for the building chain in Amsterdam can be applied and how they are interwoven in spatial context. The following strategies are described: (1) smart design, (2) dismantling and separation, (3) high-quality reuse and (4) market place and commodity bank.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BARRIERS

Many of the ways to achieve a circular economy may already be profitable but for upscaling often barriers are in the way. Policy can play an important role in the removal of these barriers. We distinguish four types of barriers:

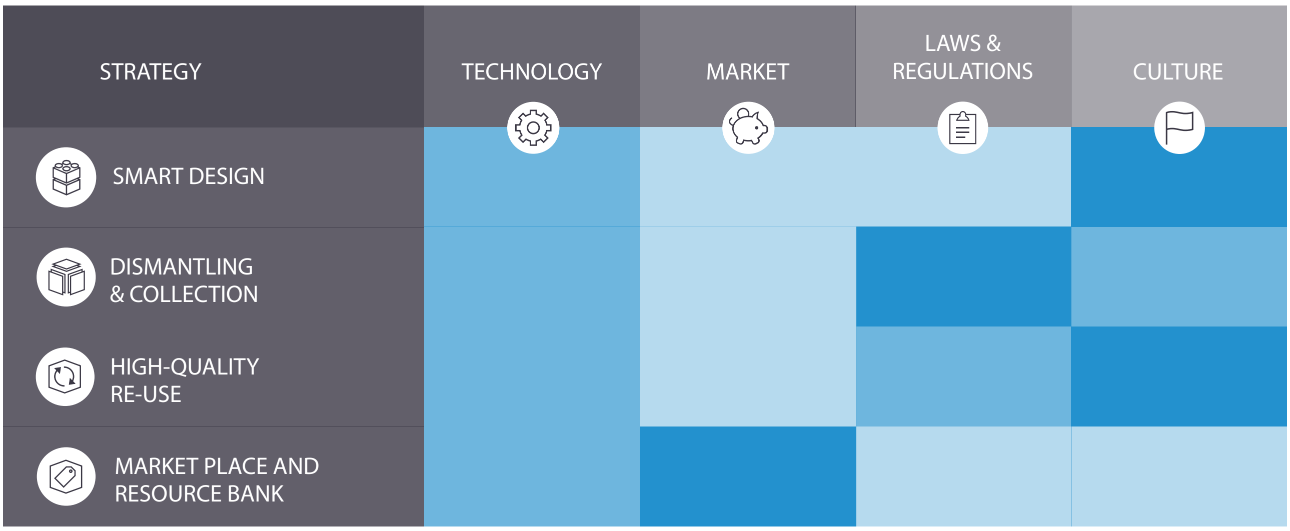
Laws and regulations Existing policy often does not lead at changing market conditions to unforeseen consequences. An example is the environmental management Act (art. 1.1) that describes definitions and possibilities of what is classified in the law as waste and what is not *(Government, 2015).*

Culture The circular economy requires close co-operation between sectors and chains. A lack of wide networks between sectors and a conservative culture- and manners can form a barrier to quickly come to a successful cooperation. Vested interests in sectors can also play a role in this.

Market The existence of 'split incentives'; the investments are at one party in the chain while the income is at another. Another market-related barrier is knowledge asymmetry between parties, for example with regard to the availability of secondary raw material flows and the quality of it. Also (the lack of) pricing of externalities including CO_2 can greatly affect the market. The last barrier that we want to mention in this category is the limited access to financing circular initiatives.

Technology Technological development has two important challenges. Upscaling a small pilot to commercial scale is often challenging. Also the interdependence and complexity of technologies that must be developed together can be a barrier.

The barriers have important implications for the extent to which-especially on the short term-some of the strategies can be implemented successfully. Sometimes governments can overcome these barriers, other times the market may break down barriers, but in many cases the solution requires cooperation, experimentation and iteration. For each of the 4 strategies described above below is indicated per barrier how big the impact is. The assessment of the severity of the barrier comes from insights obtained from the interviews and is further based on estimates of the research team. For the top 3 proposed actions, the roadmap will address the options to overcome these barriers.



This table indicates for each of the strategies how high the barrier is to get to circular economy. (Source: Insights from interviews, literature (Acceleratio, 2015; EMF, 2015) and assessment of the research team)

Strategy	Barrier	Description
		There are limited opportunities for 3D-printed buildings or components to comply with current regulations for buildings. The building Act contains no guidelines enforcing the cooperation between developers and the city, the current residents and future residents to develop a flexible design plan *(national Government, 2011).*
		Modular homes are in most cases only acceptable to social housing. These are difficult to finance because the income of the tenant is modest compared to that of tenants of more expensive type of housing *(Tempohousing, 2015).*
		Financing is difficult and it can be more expensive to implement new systems or sustainable materials. This approach requires a shift from cost-oriented thinking to a life-cycle approach *(Buildings, 2009)*
		The speed with which technological innovation in the construction sector takes place-especially the development and application of new materials-is high *(Sinopoli, 2010).* 3D printing is such an innovation that the use is still very limited in the construction sector. The challenge at upscaling is mainly to reduce the cost by economies of scale.
		Green building materials are now seen as a niche product. This is because of a lack of economies of scale: there is not yet enough demand for the technologies, which is necessary in order to be able to reduce the cost of production *(Remodelling, 2008).*
		The building/construction industry is a conservative sector in which new methods and smart design for buildings have not yet been accepted *(Barkkume, 2008).*
		The costs for dismantling and collection can be 2.5 to 3 times higher than the costs incurred for demolition. The costs for dismantling and collection form a barrier when the added value of the recovery of building materials is not appreciated *(Chini, 2002).*
		Fast and economical cost effective techniques are essential to accept dismantling and collection as the default application *(big house, 2014).*
		There is a lack of information, experience and resources to design for both decommissioning and collection.
		Many buildings are designed for a lifespan of several decades. There is no account of what happens with the building after this life.
		High taxation on labour and low tax on raw materials ensures that it is discouraged to use recycled raw materials and in addition often labour-intensive processing methods become more expensive *(national Government, 2011).*
		The building Act contains no guidelines which describe that re-use and high-quality recycling of building materials should be preferred over downcycling or burning *(national Government, 2011).*
		Recovery of valuable materials from buildings is often not economically viable by conventional building methods where materials are often combined and mixed what makes recovery difficult or impossible. *(Buildings, 2009).*
		Building constructions often have unique dimensions and are requested for specific purposes, making it difficult to use these for other purposes *(Phys, 2015).*
		In some cases, reconstruction and re-use of a building is more expensive and the impact on nature is bigger than to demolish and build new *(Tempohousing, 2015).*
		There is no transparency and alignment in the market on the supply and demand of (regained) building materials, resulting in high transaction costs. It is essential that all information in the field of building production and the assembly process remains available *(national Government, 2011).*
		There is a lack of market for reclaimed building materials *(remodeling, 2008).*

Overview of barriers in the construction sector, based on research, literature, interviews and insights from the research team.

ACTION POINTS

To create a circular construction chain the following actions as key interventions for the municipality of Amsterdam have been formulated, which in cooperation with various parties can be realised. The actions stem from the vision and the underlying strategies for the building chain linked to the previously described barriers.

SMART DESIGN

1: Assigning pilot projects in new areas New districts are ideally suited for testing new concepts such as smart design. The new developments in Centre Island in IJburg offer a chance to test other building codes. The municipality has already prepared an exploratory document entitled 'Dreams about Centre Island' *(city of Amsterdam, 2014b).* These include DIY plots (where residents have more control over the construction of their house) assigned in Centre Island in which the new building codes are tested. The municipality may in its land allocation policy make requirements on the degree of circularity. In these criteria can be recorded, for example, the minimum ceiling heights. Which makes repurposing for buildings easier.

2. Land allocation can be scored to the degree of circularity High quality recycled products, parts and materials hereby form an important selection criterion. Rebates on land prices can be given to projects that have a maximum score on circularity. This may include the use of bio-based insulation materials, construction methods with application of 3D printers, modular and flexible design for foundations and construction elements.

3. Drawing up of tender criteria for smart design principles in soil, road- and water construction The municipality can, based on the results of pilot projects with smart design in (for example) IJburg, and based on feedback from local stakeholders, define tender criteria, construction requirements and rules for future developments in Amsterdam. The goal here should be to make the longest possible lifespan of buildings, and make the value after life as large as possible by recovery of components and materials. It should take into account the lowest impact on the environment in the long term. An example of a similar set of instruments is the CO_2-performance ladder *(SKAO, 2015).* To start with the municipality can begin with the procurement of new soil, road- and water construction projects.

4. Challenge startups to develop solutions for smart design The city of Amsterdam can build on the newly launched 'Startup in residence'- programme where startups and companies seek solutions to local problems *(SIR, 2015).* Here a solution can be thought of to use simple and easier local recycled or written off materials in the city through the use of smart design. This knowledge may be used with AEB on the waste processing and design implications.

DISMANTLING AND SEPARATION

1: Establishing procurement criteria of separation at demolition projects The Bijlmerbajes in Amsterdam is tendered by the government from the second half of 2015 to 2016. The municipality can use this demolition project as a pilot for the separate collection, re-use and high-quality recycling of waste. Selection criteria can be drawn up to encourage local use of construction and demolition waste. Hereby better dismantling is stimulated and more value is created from construction and demolition waste.

2. Initiate dialogue for better dismantling and waste separation in demolition projects The municipality can enter into dialogue with stakeholders of future demolition projects where the buildings are removed in stages to maximise the recovery of building materials and components.

3. Encourage local companies in the processing and in the reverse logistics of waste The municipality can encourage local companies to be more self steering in waste collection, so that retailers can take the initiative to use their waste streams. For example, by linking these files directly to a materials map,

where local demand for waste streams can be found. This way the municipality is partially relieved in the processing of waste.

HIGH QUALITY RECYCLING AND RE-USE

1: Adjust zoning plans to allow multifunctional buildings The municipality can change areas with a construction permission in destination areas with multiple permissions, including Arena gate and Oosterdokseiland in Amsterdam. This gives more flexibility for buildings at the end of their life cycle to be given a new destination.

2. Innovation projects offer renovation and possible redevelopment projects for existing buildings The municipality can ask market participants through innovation projects to reallocate existing buildings (in creative ways). This can be started with empty school buildings, or other buildings that the city administers. To speed up this process, the municipality can create guidelines that oblige companies to renovate or find a new purpose for similar or new applications. For example, renovation is already applied to renovate projects energy neutral *(LALOG, 2014).*

3. Establishing guidelines and goals for high-quality recycling of construction waste To ensure that construction waste is being re-used in a high-quality way, the municipality can issue guidelines and goals with respect to the amount of recycled or re-used building materials in new construction projects.

4. In waste processing contracts aim for high-quality re-use At concluding waste disposal contracts, arrangements can be included around the method of processing which can be directed to high quality processing to create market demand.

MARKET PLACE AND RESOURCE BANK

1: Initiating a 'materials showroom' for construction waste The fact that a large proportion of construction projects and initiatives for urban development are located near water and that the port of Amsterdam has ambitions to become a hub for circularity is it conceivable that undeveloped areas can be used for (temporary) storage of construction waste. Here the municipality could work together with stakeholders to make temporary storage of construction waste possible. The municipality can also increase innovation in the field of logistics, and marketing materials by deploying innovation contests, or projects such as "startup in residence".

2. Facilitate the Exchange and the use of high quality building materials The municipality can facilitate the exchange of building materials between construction companies and waste companies by, for example, partly taking the initiative for setting up an online marketplace.

3. Companies encourage the use of a material passport The municipality can stimulate construction companies in future construction and development projects to register and report how many materials are used and what type of materials are used. Hereby it is possible, for example, to direct a land price discount. This information can then be made available during the demolition, at the end of the useful life of a project. Waste management companies understand which materials will become available.

ACTION POINTS TOP 3

From the interviews and discussions with stakeholders involved in the region 3 action points as shown in the table have been selected. It takes into account 4 major effects: (1) value creation, (2) CO_2-reduction, (3) material savings, and (4) job growth that have been calculated for the 4 strategies. The measures have further taken into account the barriers that have been identified for the construction chain, and the role that the municipality can fulfill. This way, the municipality can play an important

	1 FACILITATION OF RAW MATERIAL- AND MATERIAL STORAGE	2 STIMULATIN RE-US LAUNCHING CUSTO OF PROCURI
	Matching of demand and supply of building materials and raw materials that require temporary storage. Especially since the availability of volume materials is not synchronised with demand. A possible role of the government can focus on two aspects. On the one hand, there is a need for physical facilities for storage. The allocation of places for physical storage by the municipality can play a role. Given the expected volumes, locations being located near waterways are ideal because water transport replaces road transport. At the same time, the government can play a facilitating role in drawing up conditions which materials have to meet in order to qualify for storage and re-use.	High-quality re-use of building m of development be encouraged Government can contribute to the and building codes in which spec aimed at high-quality re-use. Als launching customer for the use of is tendered by the municipality in (soil-road-water engineering). Also places of raw materials and mate trading of building materials and t being worked on.
CONNECTION AT PROJECTS	Throughout the country there are several initiatives to organise physical raw materials banks. Individual companies are now starting to set up their own raw materials banks that they form together with companies in their own chain. Amsterdam can facilitate innovation by realising a wide carried material repository. The logistical challenges are in line with the manifesto and initiative to the give the logistic Westas an important role in the circular economy. *(ALB, 2015)*	There is an important role for the r In addition, there are several pa high-quality materials, such as Sto pavement. The municipality can b enable them to experiment and to this links to the ongoing project 95% of high-quality material relea addition, it is connected to Circle in the field of circular construction and, where possible, additional jobs
INVESTMENTS AND RESULTS	A follow-up analysis is needed to see how construction flows in the city will develop both where large demolition projects and where new construction take place. Such analysis complemented with available knowledge of zoning plans and structural vision forms input to assign places for the (temporary) storage of raw materials. The actual operation and organisation of these sites can be organised by both, the market participants and the municipality - in public or private. Depending on the chosen direction the precise role of the municipality is to be determined.	Developing criteria for building calls for more commitment comp the municipality can co-invest th development in new processing tec may be that the activities are base employment shall also be realised in
STAKE-HOLDERS	Municipality, Port authority, collaborative partnership Circle City, "start-up in residence", West axis partners, AEB.	Construction- and waste compan Gansewinkel, Deped and Stonecy Council.

role by directing the land allocation and the definition of locations for temporary storage of materials (action 1). Also acting as a launching customer via the purchasing policy, for example, focused on the development, but also renovation of the municipal building portfolio (action 2). Finally, looking at how the municipality can contribute to the development of a building passport and its application in the own portfolio (action point 3).

NG HIGH QUALITY- E BY BEING A OMER AND DEVELOPMENT EMENT DIRECTIVES	3 BOOSTING COMMODITY PASSPORTS AND CONTRIBUTE TO DEVELOPING OF DIRECTIVES
naterials can in the current early stage by the Government in two ways. The development of procurement guidelines ific requirements have been formulated o, the Government can play a role as recycled materials. Every year 1.5 billion the development of CIVIL ENGINEERING , in addition to contributing to physical rial storage, an online platform for the the matching of supply and demand are	A raw materials passport for buildings provides an overview of used materials, processes and possibilities for re-use. The Government can encourage a (minimal version) of raw material passports to be recommended or made mandatory for new construction projects. Also, the municipality could implement raw material passports for its' own property portfolio. Also the municipality can - in her Government role - contribute to the further development of guidelines for passports, for example, how the use of passports can be a condition in real estate development and land issue.
naterials department of the municipality. rties that innovate in using reclaimed necycling. Struyk also used old concrete ring more of these parties together and extend their technologies. Furthermore CO Green in Slotervaart where locally sed at demolition is locally re-used. In City of Amsterdam where local projects , renovation and demolition are realised are realised *(circle city, 2015).*	Some construction companies in The Netherlands are experimenting right now with raw material passports. In the immediate vicinity of Amsterdam there is, for example, the 20/20 park real estate project realised by Delta Development, Reggeborgh and VolkerWessels. In addition, there are far-reaching ideas to apply these principles in Buiksloterham.
regulations and ensuring compliance pared to the current situation. Possibly, rough the AKEF or a Fund for circular hnologies. Condition for this contribution ed in the city of Amsterdam so that any n the city.	The investment from the municipality would primarily consist of the provision of time for municipal officials on how the raw materials passport for buildings can be embedded in policy. For the registration of the passport, facilities are needed as currently provided by the land registry. Possibly the introduction of the passport also needs investment to expand these systems or to modify them.
ies, such as BAM, Heijmans, AEB, Van cling, Circle City. Dutch Green Building	Construction-, waste- and ICT companies, such as BAM, Heijmans, AEB, Van Gansewinkel, IBM, Icova and Stonecycling, Deped and Delta development group.

ROUTE MAP

CONSTRUCTION CHAIN

SHORT TERM (1 YEAR)

TOP 3

1. FACILITATION OF RAW MATERIAL AND MATERIALS STORAGE

2. STIMULATING HIGH-QUALITY RE-USE BY BEING A LAUNCHING CUSTOMER

3. BOOSTING COMM

SMART DESIGN

ASSIGNING PILOT PROJECTS IN NEW AREAS

LAND ALLOCATION SCORING TO THE DEGREE OF CIRCULARITY

DRAWING UP OF TENDER CRITERIA FOR SMART DESIGN PRINCIPLES IN CIVIL

CHALLENGE LOCAL STARTUPS TO DEVELOP SOLUTIONS IN SMART DESIGN

DISMANTLING AND COLLECTION

DETERMINE TENDER

INITIATE DIALOGUE FOR BETTER DISMANTLING AND COLLECTION IN DEMOLITION PROJECTS

ENCOURAGE LOCAL COMPANIES IN THE PROCESSING AND THE REVERSE LOGISTICS OF

HIGH-QUALITY RE-USE

ADJUST ZONING PLA
BUILDINGS WHERE P

INNOVATION PROJECTS OFFER RENOVATION AND POSSIBLE REDEVELO
FOR EXISTING BUILDINGS

ESTABLISHING GUIDELINES AND GOALS FOR HIGH-QUALITY RECYCLING OF CONSTRUCTION WASTE

DIRECT WASTE TREATMENT CONTRACTS INTO HIGH-QUALITY RECYCLING

MARKET PLACE AND FOR MATERIALS

INITIATING A 'SHOW

FACILITATE THE EXCHANGE AND THE USE OF HIGH QUALITY BUILDING MATE

COMPANIES ENCOU

ARROWS

The arrows indicate by what date an action can be deployed and on what term impact is to be expected as a result. Actual impleme depends on many factors including the speed at which the market takes action, the speed with which upscaling takes place, etc.

LONG-TERM (20 + YEARS)

DDITY PASSPORTS AND CONTRIBUTE TO DEVELOPING GUIDELINES

. ENGINEERING

CRITERIA SEPARATION AT DEMOLITION PROJECTS

ANS TO ENABLE MULTIFUNCTIONAL
OSSIBLE

OPMENT PROJECTS

ROOM' MATERIAL FOR CONSTRUCTION WASTE

ERIALS

RAGE TO USE A MATERIALS PASSPORT

ntation of the actions and expected impact

BARRIERS

Technology Mar Regulatior lture

POTENTIAL ECONOMIC AND ENVIRONMENTAL IMPACT OF A CIRCULAR CONSTRUCTION CHAIN IN AMSTERDAM COMPARED TO A LINEAR SCENARIO

The economic activity of the Amsterdam metropolitan region amounts to 106 billion euros annually, of which 47 billion is accounted for by the city of Amsterdam (2013) (CBS, 2015)*. The contribution of the construction industry to this earning is 1.7 billion euro per year. Until 2040, Amsterdam has plans to realise 70.000 new homes (Amsterdam, 2011). This new construction is partly replacing existing houses that are demolished and partly to accommodate growth. Based on the strategies that can contribute to the circular shape of construction activities in Amsterdam, a macro-economic analysis has been carried out. The results provide insight into the effects that implementation of this circular strategies can have on economic growth, employment, the saving of material use and reduction in greenhouse gas emissions.

This calculated 'circular scenario' provides insight into the effects in relation to the autonomous (linear) growth in Amsterdam. This includes direct and indirect effects of circular strategies. An example of this is that cost savings for construction materials such as cement by efficiency improvement can lead to higher spending on machines for which materials are also needed. The net effect of the efficiency improvement can therefore be lower than the direct effect. Productivity growth for the construction industry in Amsterdam shows in contrast to other sectors a shrinkage of 2.8% for the period from 2005 to 2012.

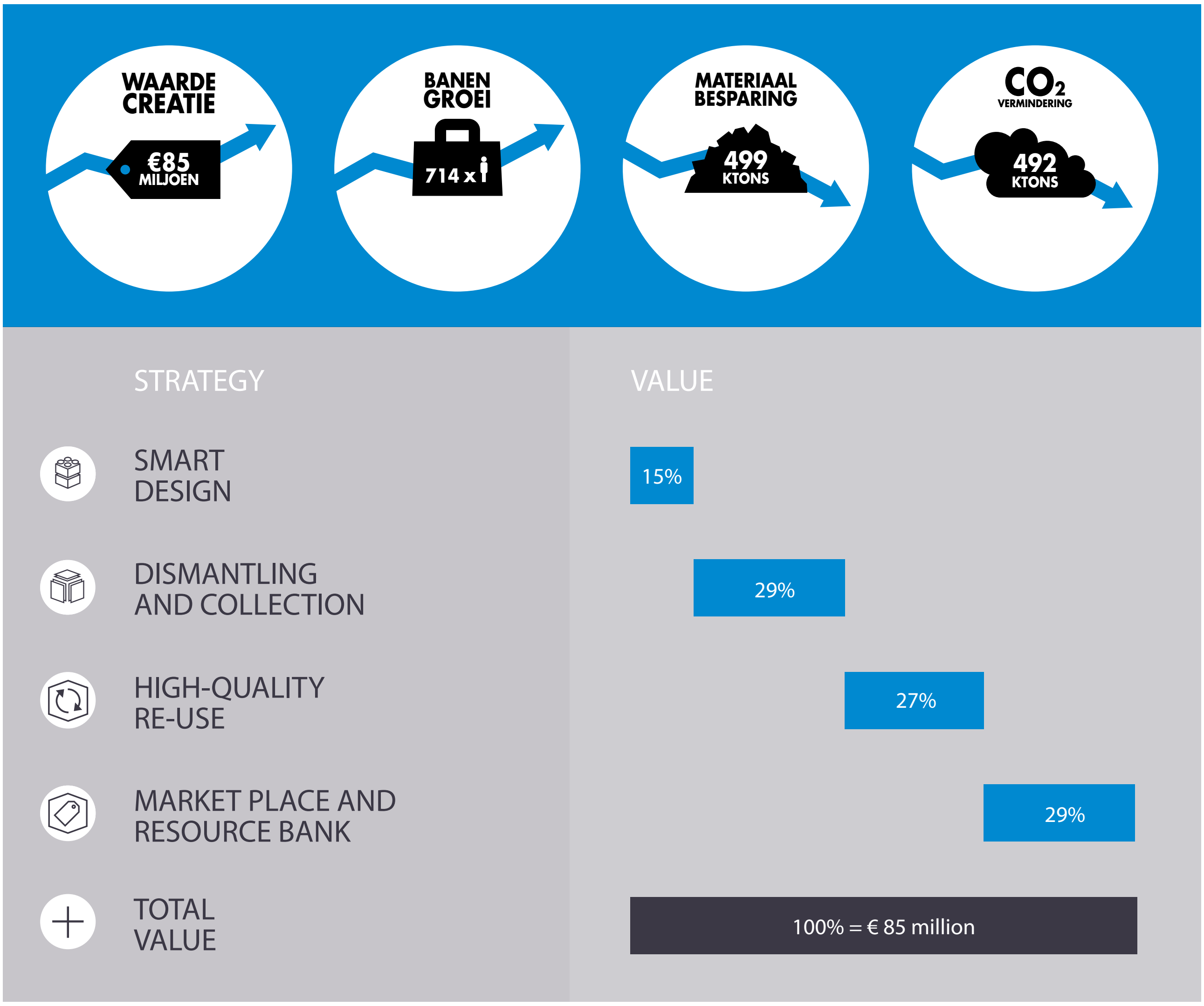
A fully circular fitted building chain can for the city of Amsterdam chain lead to an increase in productivity growth of 3%, representing a value of 85 million euro per year. Set against the decline of 2.8% for 2005-2012 this is very significant. This added value, however, can not be realised from one day to the next. Depending on the diligence with which companies adopt a circular method and on the policy creating the right conditions it is to be expected that the negative growth in a period of 5 to 7 years could be redirected to the growth of 3% per year. This economic growth is realised in a significant part by larger value retention due to material re-use and efficiency improvement.

With productivity growth opportunities are also created for employment. This occurs for example by increased demand for targeted demolition activities that require more manpower. For instance, the return logistics become more complex. Not, as currently takes place, the disposal of just a container of demolition waste but a sorting of different fractions that are transported to various reprocessing locations, to be processed or upgraded and finding their way back to new construction. For employment, this means that a total of about 700 additional jobs in the city can be realised. This is therefore a structural expansion of the number of jobs. For the most part, these are jobs for low- to medium skilled personnel. Set against the current 75 thousand jobs in the Amsterdam building sector, this approximately 1% would be a great contribution. That means that unemployment (average of 8.1% in Amsterdam) in the construction sector drops with 10%.

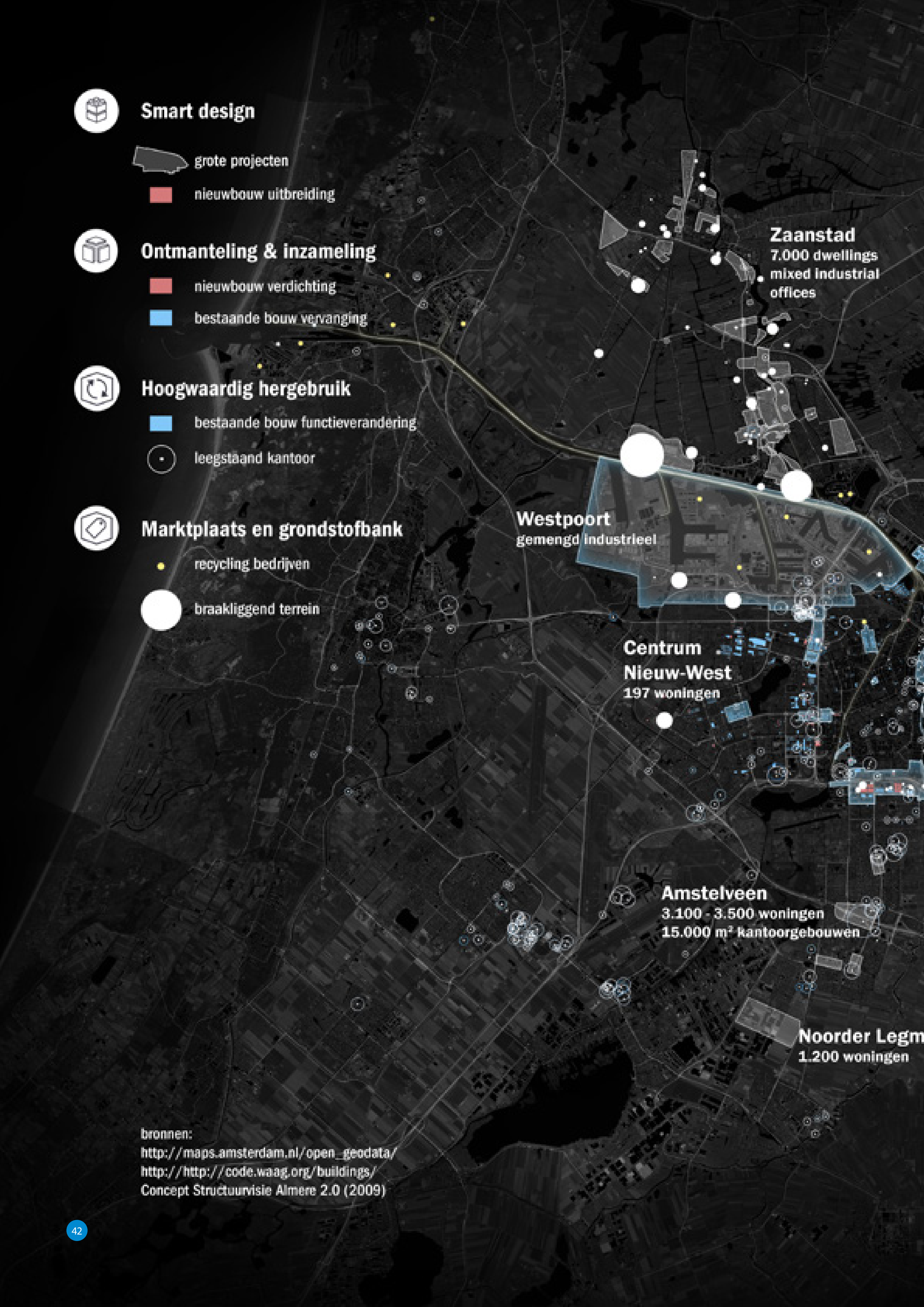
The outlined improvement of the re-use of materials and the correspondingly larger value retention leads to significant material savings of 500 thousand tons for the new building project of 70 thousand houses in Amsterdam. Set against the current annual import of 1.5 million tonnes of biomass for the entire metropolitan region this can be characterised as significant. In connection

** In this study value creation of circular initiatives will be compared with the total added value at basic prices are expressed, NOT with the Gross Regional Product. In this chapter a TNO-analysis is applied in which the assumptions used are from the following sources: (2014) Macro-level indicators to monitor the environmental impact of innovation. EMInInn (Environmental Macro-indicators of Innovation) THEME [ENV. 2011.3.1.9-3], FP7 project for the EU; O. Ivanova, M. Chahim. (2015) CBS statline.*

with the material savings, the expected reduction of greenhouse gas emissions is in the order of half a million tonnes of CO_2, this is equivalent to 2,5% of the annual CO_2 emissions of the city of Amsterdam.



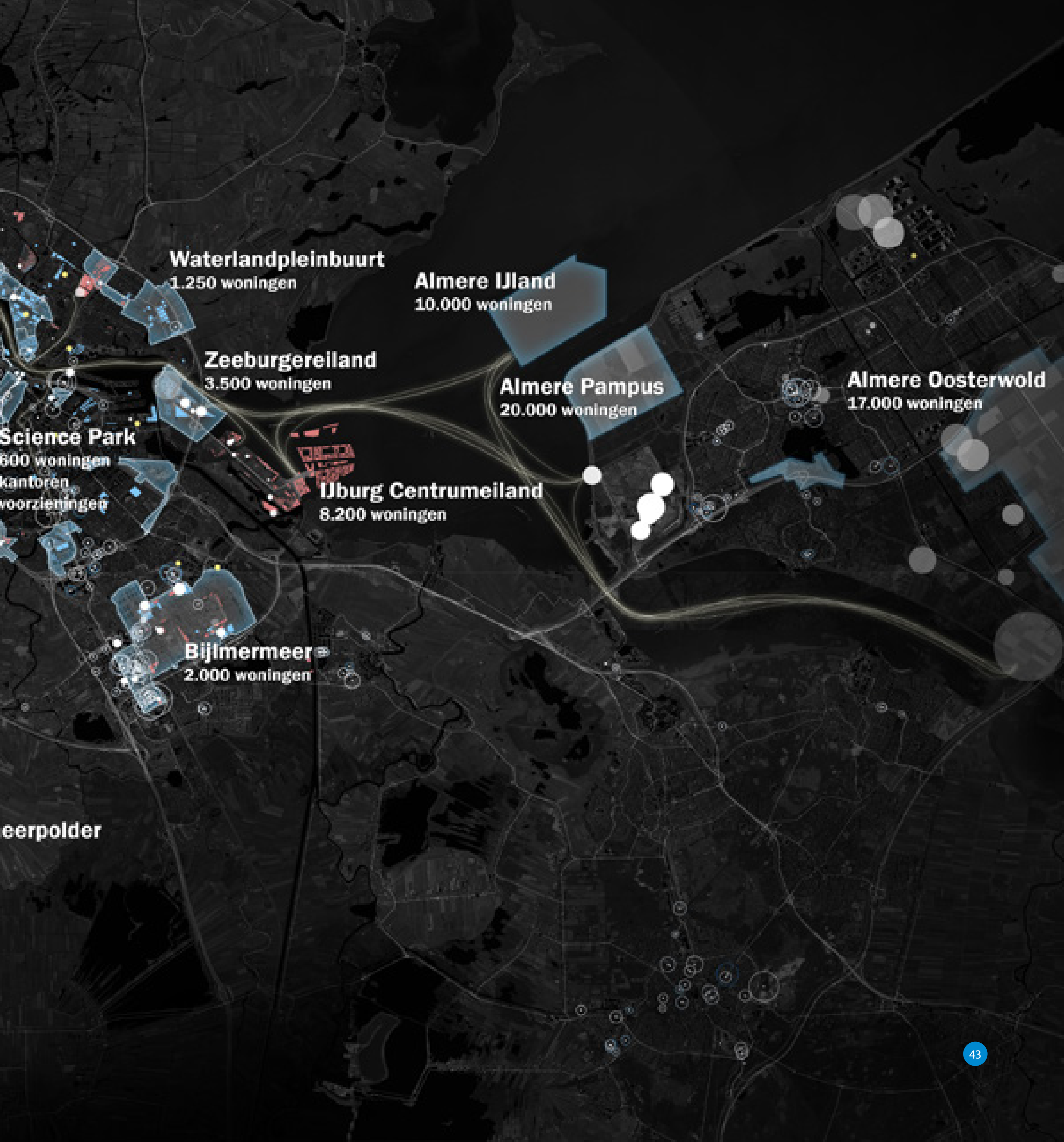
Potential economic and environmental impact of a circular construction chain in Amsterdam compared to a linear scenario are calculated for Amsterdam. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission. The values for the 4 indicators are shown in the 4 circles. In the bar chart the distribution in added value is shown.



Smart design
grote projecten
nieuwbouw uitbreiding
Ontmanteling & inzameling
nieuwbouw verdichting
bestaande bouw vervanging
Hoogwaardig hergebruik
bestaande bouw functieverandering
leegstaand kantoor
Marktplaats en grondstofbank
recycling bedrijven
braakliggend terrein
Zaanstad
7.000 dwellings
mixed industrial
offices
Westpoort
gemengd industrieel
Centrum
Nieuw-West
197 woningen
Amstelveen
3.100 - 3.500 woningen
15.000 m² kantoorgebouwen
Noorder Legm
1.200 woningen
bronnen:
http://maps.amsterdam.nl/open_geodata/
http://http://code.waag.org/buildings/
Concept Structuurvisie Almere 2.0 (2009)

SCALABILITY MAP

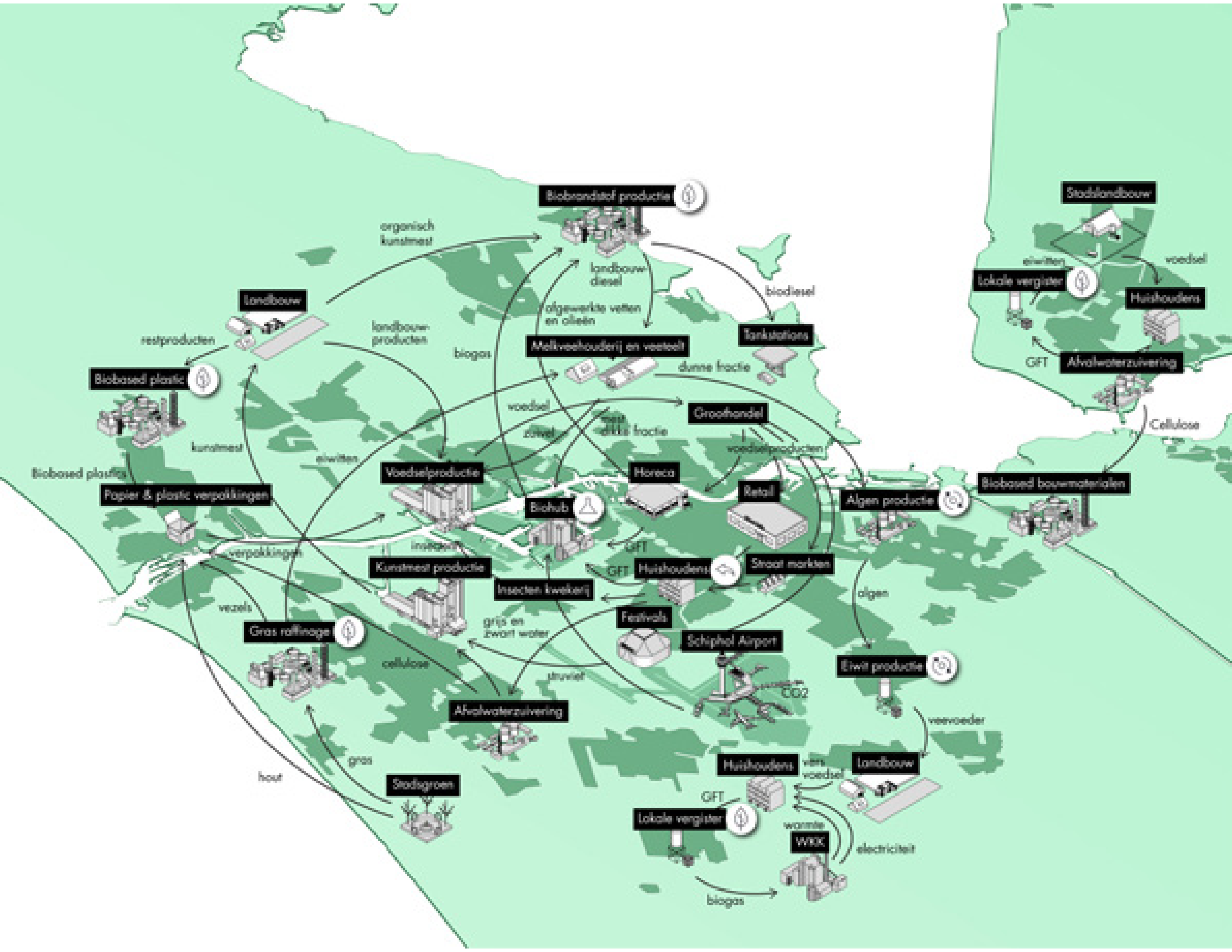
The scalability map shows where opportunities lie for the construction chain to apply the four circular construction strategies. The strategies are dismantling and separation, high-quality re-use, smart design and marketplace and commodity bank. The red areas indicate places for new construction strategies. Blue represents areas where circular strategies on existing building can be applied. The white circles represent locations that lie fallow. These locations can be interesting for storage of commodities and materials or for the development of new circular building projects.



3. VISION OF HIGH-QUALITY RECYCLING OF ORGANIC RESIDUAL STREAMS IN

In order to achieve high-quality recycling of organic residual streams in Amsterdam a circular vision has been established. The vision- and road map is supplemented and refined on the basis of conversations with experts and stakeholders. Starting point for the analysis is the realisation that there are many initiatives in the city and in the region that are focused on higher quality processing. At the same time, there is a good possibility to develop precisely in Amsterdam and the surrounding region a strong cluster that focuses on further value retention and optimised cascading of organic residual streams. This chapter therefore describes four strategies that can be followed. These strategies are then placed in the context of the region (by linking with local initiatives and a selection of innovative market parties). Furthermore, the link is made with trading opportunities for the municipality. Also addressed is where the market is active and how the government can facilitate this. The roadmap describes concrete action points for the municipality and links this to time lines and to which parties can play a role in the emergence of those actions. The impacts of implementation to be realised are calculated for (1) value creation, (2) CO_2-reduction, (3) material savings, and (4) job growth.

VISION ON ORGANIC RESIDUAL STREAMS



In the ideal circular future for organic residual streams in Amsterdam organic flows such as food and water are delivered to consumers in the highest quality. Organic residues are recovered in a high quality manner and re-used in innovative applications. The core of this circular vision is formed by integral food production, food processing and biological processes, where nutrients and water flows are efficiently directed and residual flows are valorised. That leads to a more varied chain for organic residual streams that requires less energy, nutrients, water and raw materials. It achieves a significant economic, environmental and social profit.

In a circular future consumers get easy access to local food sources. Local, cooperative farms and breeders in the vicinity of cities will ensure direct supply of fresh seasonal produce to consumers. The food chain will therefore be shorter, with more interaction between local growers and citizens and a greater sense of community. By using underutilised city-, roof- and community rooms in a smart way for urban agriculture and city gardens, consumers get much easier access to fresh food.

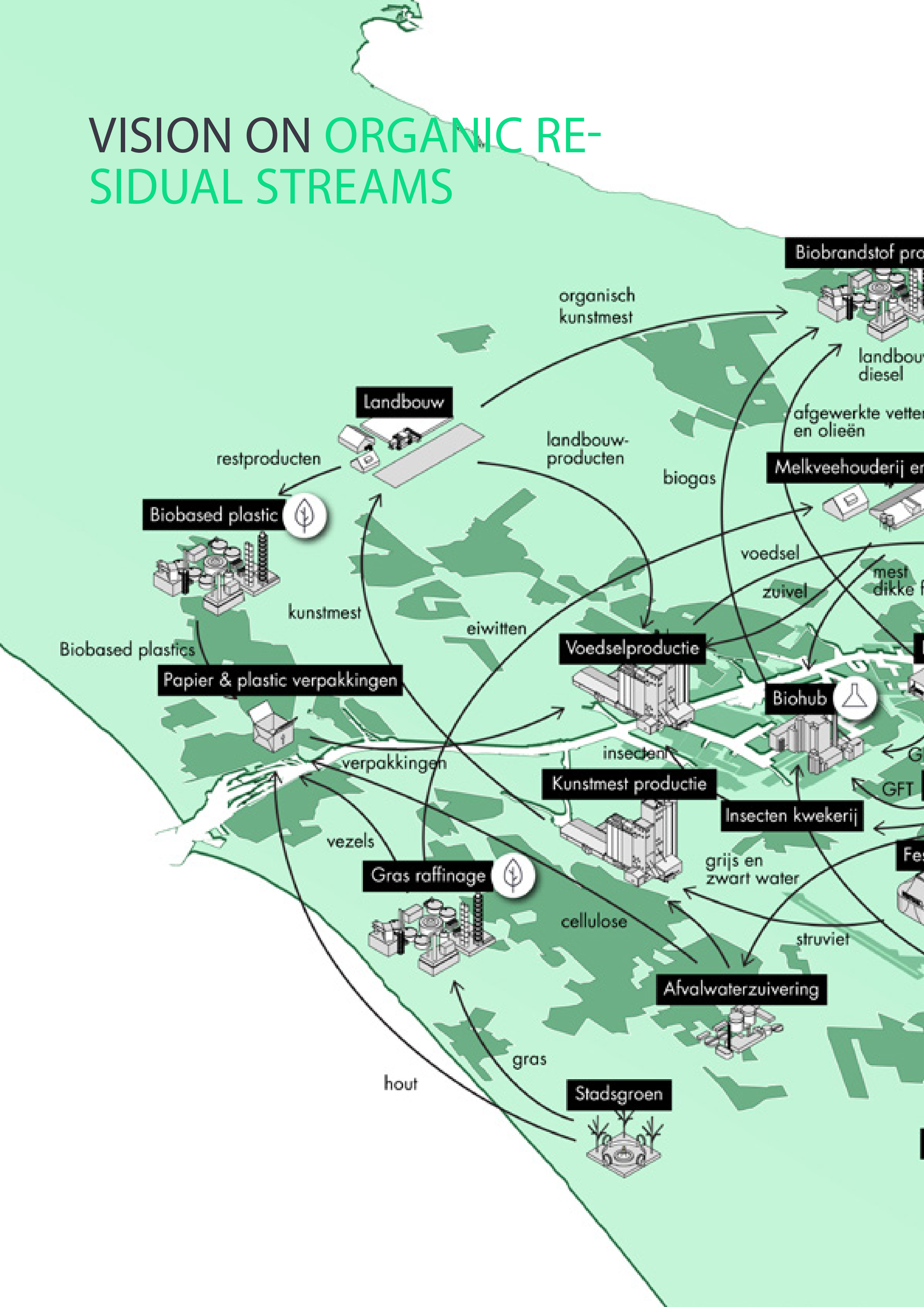
Innovative technologies for the distribution and storage of food also offer better opportunities for documentation and management of food products. Smart logistic solutions will continuously monitor the food quality and ensure that food is transported within the correct time frame from producers to retailers and restaurants. At the same time, retailers and restaurants have smarter systems that provide information about the quality and shelf-life trajectories of their food supply. Thereby they can optimise their sales before the expiry date of their food and before it needs to be discarded.

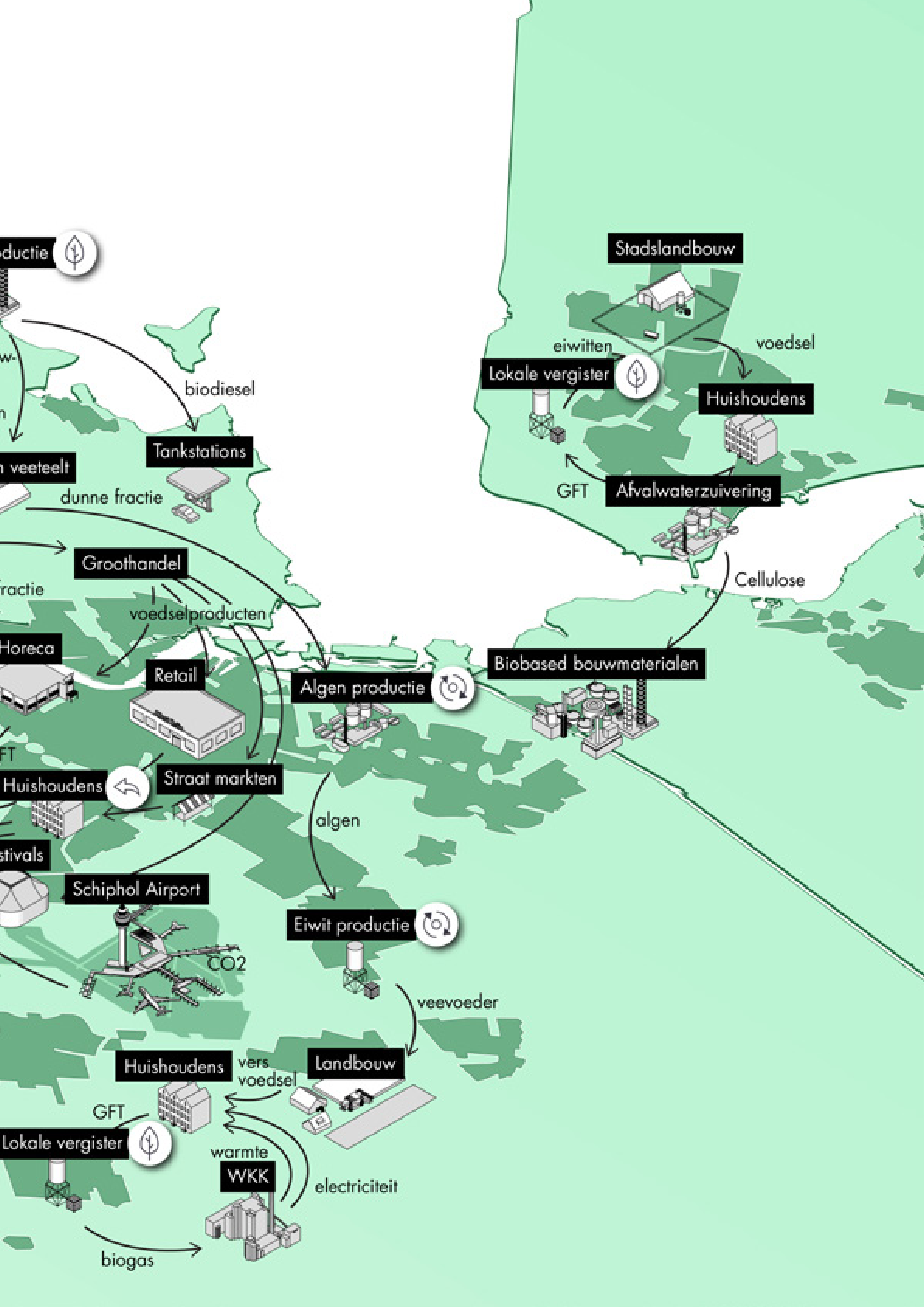
Food that can still be used, but needs to be discarded due to its shape, for marketing reasons or in connection with too wide a range, can be offered on a virtual marketplace where food producers, retailers and restaurants can buy and sell 'food waste'. This leads to a growth of innovative companies that can take advantage of this food waste stream.

Thanks to the bio-refinery by remaining organic waste streams, Amsterdam can develop into a hub for bio-refinery. Organic residual streams that can no longer re-used in a high quality manner, are being used to a maximum in the bio-refinery hub. Separating and processing of mixed and homogeneous waste streams by producers, consumers and retailers offers opportunities to win the important nutrients that can be used in the agricultural sector. Processing these secondary raw materials also provides opportunities for new packaging solutions, biochemicals, biofuels and biogas products which can be exported or be used in Amsterdam.

The described vision is processed in a visual representation (see opposite and enlarged on the next page) that depicts the chain and stakeholders in the city. In the next section the vision is translated into strategies and action items, with which the city through market technical, technological and administrative instruments, creates possibilities to close the organic residual stream in the chain.

VISION ON ORGANIC RE-SIDUAL STREAMS





ductie
Stadslandbouw
eiwitten
voedsel
Lokale vergister
Huishoudens
biodiesel
Tankstations
veeteelt
dunne fractie
GFT
Afvalwaterzuivering
Groothandel
fractie
Cellulose
voedselproducten
Horeca
Retail
Algen productie
Biobased bouwmaterialen
Huishoudens
Straat markten
algen
stivals
Schiphol Airport
Eiwit productie
CO2
veevoeder
Huishoudens
vers
voedsel
Landbouw
GFT
Lokale vergister
warmte
WKK
electriciteit
biogas

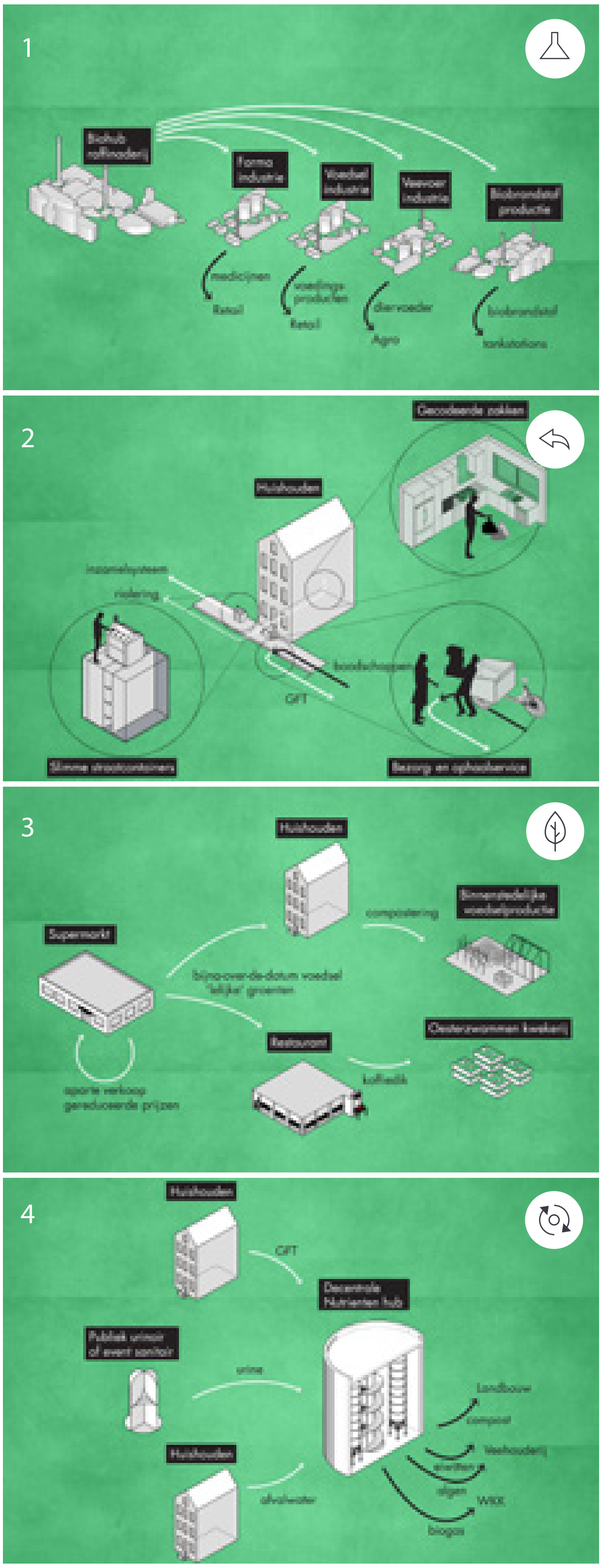
STRATEGIES FOR ORGANIC RESIDUAL STREAMS

From the described vision for high-quality recycling of organic residual streams a translation is made in strategies and action items, with which the city can, via market technical, technological, administrative instruments such as land allocation and purchasing, create the possibility to close the material cycle in the organic residue flow chain. The strategies are:

(1) central hub for bio-refinery
(2) waste separation and return logistics
(3) cascading of organic flows
(4) Retrieving nutrients

These circular strategies are explained on the basis of relevant existing activities that currently take place in the city and region. In addition, four strategies are displayed in a space view, see spatial vision map. Even though the strategies are described separately in order to distinguish action points which can accelerate the circular economy, they are partly intertwined with each other and should therefore be considered as a total package.

The following section lists the four strategies translated into a concrete roadmap and action agenda. The action agenda further explains where the municipality of Amsterdam can be of influence, what other market parties can become involved and in what time frame the transitions may take place. Here a first advice is formulated on the basis of the previously described research and analysis activities and interviews with stakeholders and experts.



The effects of circular strategies on the environment and the economy are calculated for the organic residual flow chain in Amsterdam. Here, the impact will be realised over a period of five to seven years. Four indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2emission.

Net added value in euros The circular strategies directly enable a number of sectors in Amsterdam to realise more added value: more sales and more profit. "Net" meaning that in some cases also a decrease of added value is calculated and that via the chain analysis also the indirect effects of all other sectors are taken into account.

Net jobs growth in FTE One of the social aspects of an increase of the circularity is represented among other things by the realisation of jobs (FTE, Full Time Equivalent). Job growth is estimated on the basis of the sectoral increase of added value, of salaries in that sector and of the demand for low-, medium- and highly skilled workforce. NET jobs growth means job growth that results in a direct reduction of unemployment.

Material savings Use of materials is expressed in Domestic Material Consumption (DMC)*, which in addition to the use in an area also looks at materials that are imported and exported. Apart from CO_2-emission (which already is explicitly included) DMC makes all environmental impact factors related to the circular projects quantifiable.

CO_2-reduction The most well-known impact of economic activities, is the emission of CO_2. The impact of the modules on the emission is expressed in Global Warming Potential (GWP), a globally adopted measure that expresses the avoided CO_2-emissions in the coming years, by an increase of circularity, over a period of 100 years. To make the impact comparable with the annual emissions in the region the choice was made to convert the indicators to annual CO_2emissions.

** Domestic Material Consumption, abbreviated as DMC, is a commonly used statistic that measures the total amount of materials that are used directly by an economy. It measures the annual amount of materials that are extracted in the geographical area including all physical import and minus the physical export.*

CENTRAL HUB FOR BIO-REFINERY

By means of cascading (highest possible quality use of biomass) organic residual streams optimal value can be extracted from organic residual streams *(Bio-based Economy, 2015).* These activities may be bundled into a central bio-refinery hub; a logistics hub where bulk products can be transported on a large scale, and where also local small flows can come together. The port is a node in the global trade in agricultural- and energy products because of its strategic location and logistic connections. Many processed and traded raw materials from all over the world are supplied here and a processing cluster is here for the local marketing of organic residual streams. For the realisation of a hub for the processing of organic waste and the optimal re-use of organic waste streams a certain scale is required, which can be reached in Amsterdam. *(Green raw materials, 2014)* Such a hub can produce a variety of bioproducts, such as biomaterials, building blocks for the chemical industry, food, feed, biodiesel, biogas, lubricants, paint and oil on biological basis, fertilisers, algae and bio-aromatics.

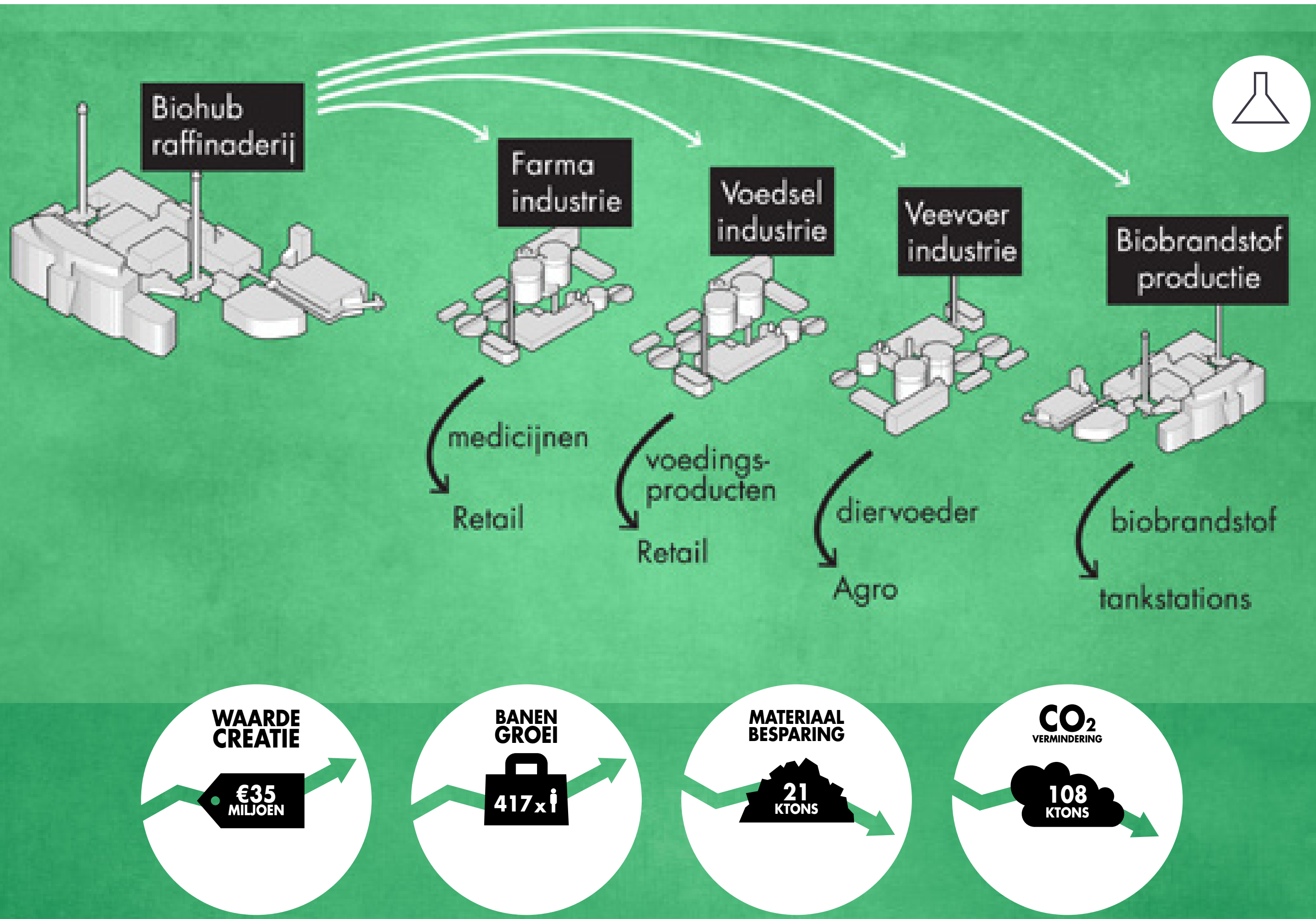
Optimised cascading of organic residual streams To enable optimised cascading of organic residual streams, it is necessary that the link is established with existing initiatives and to upscale this so the resulting volume is greater. Existing pioneering activities in the region include the Greenmills-cluster, a alliance between six companies (Noba Vetveredeling BV, Rotie BV, Biodiesel Amsterdam, Tank Storage Amsterdam BV, Chaincraft BV and Orgaworld BV) that is active in the further development of bio-refinery concepts and the optimal re-use of organic residual streams. On site organic residual streams (including finished edible fat, animal fats and supermarket waste) are processed for the production of almost 300 million litres of biodiesel and 25 million cubic metres of biogas through anaerobic digestion *(city of Amsterdam, 2015b)*, with which 5000 tonnes of fertiliser can be derived. Chaincraft develops a technology on site to distill out of organic residual stream components for the food and chemical industry *(Port of Amsterdam, 2014).*

Close cooperation between AEB Amsterdam and Waternet has resulted in a joint industrial cluster in which AEB is burning 80 thousand tonnes of dry sewage sludge per year. The 11 million cubic metres of biogas that is produced from the fermentation of sewage sludge, is burned in the CHP (combined heat and power) plants of AEB, where some of the energy and heat is delivered back to Waternet to use for their own processes and 10% is used by OrangeGas to produce green biogas *(city of Amsterdam, 2015b)*.Plans are ready to increase production to around 22 million cubic metres. AEB indicates to have plans to extract fruit and vegetable fractions from waste. These are first steps towards further marketing of these waste streams to the volume of products, such as proteins, bio-oil and hydrogen. The production of sustainable steam and CO_2 by AEB will cause further circularity.

Similar activities are planned for Schiphol Airport, where an anaerobic digester plant is planned. This facility, which in the future will be responsible for 6% of the energy supply of Schiphol *(Croes, 2015)*, is among other things provided with raw materials by grass clippings from the site around Schiphol. The rest comes from organic residues from the region, such as the nearby flower auction and greenport Aalsmeer. Another project is Bioport Holland for the production and use of biojet fuels that is carried out in a consortium of SkyNRG, the Dutch Government, KLM, Neste Oil, Schiphol Amsterdam airport and the port of Rotterdam. With its direct airplane fuel pipeline (60% of the consumption of Schiphol stems from the port of Amsterdam) the port area has both the infrastructure, utilities and raw materials to produce bio-jet fuel.

Bio-based materials The use of bio-based building material is an important chance, through the use of sustainable building materials, to reduce the impact of scarce and new renewable building materials *(Ecorys, 2014; EMF, 2015).* Locally sourced biomass can (partly) be used for the production of bio-based materials. This reduces the impact of transport movements among other things.

In Amsterdam there are several companies active in this area. For example Avantium is a pioneer with conversion technologies for the production of renewable fuels and plastics. Bio-based plastics (PEF) can serve as an alternative to PET. At this time, Port of Amsterdam, Orgaworld and AEB work together with TNO, Attero and the Association of Wast Companies, on a project to replace for example petrochemical polymers or coatings by chemical components (for example, bio-aromatics).



Visual display of bio-refinery: Organic residual streams are processed and used as raw material in for instance medication, food producers, feed and biofuel. The effects of circular strategies on the environment and the economy are calculated for the organic residual streams in Amsterdam. It is assumed that it will take 5 to 7 years to achieve a circular arrangement of the processing of organic residual streams coming from all 430.000 Amsterdam households in the long term. The impact will also manifest itself at that time. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission.

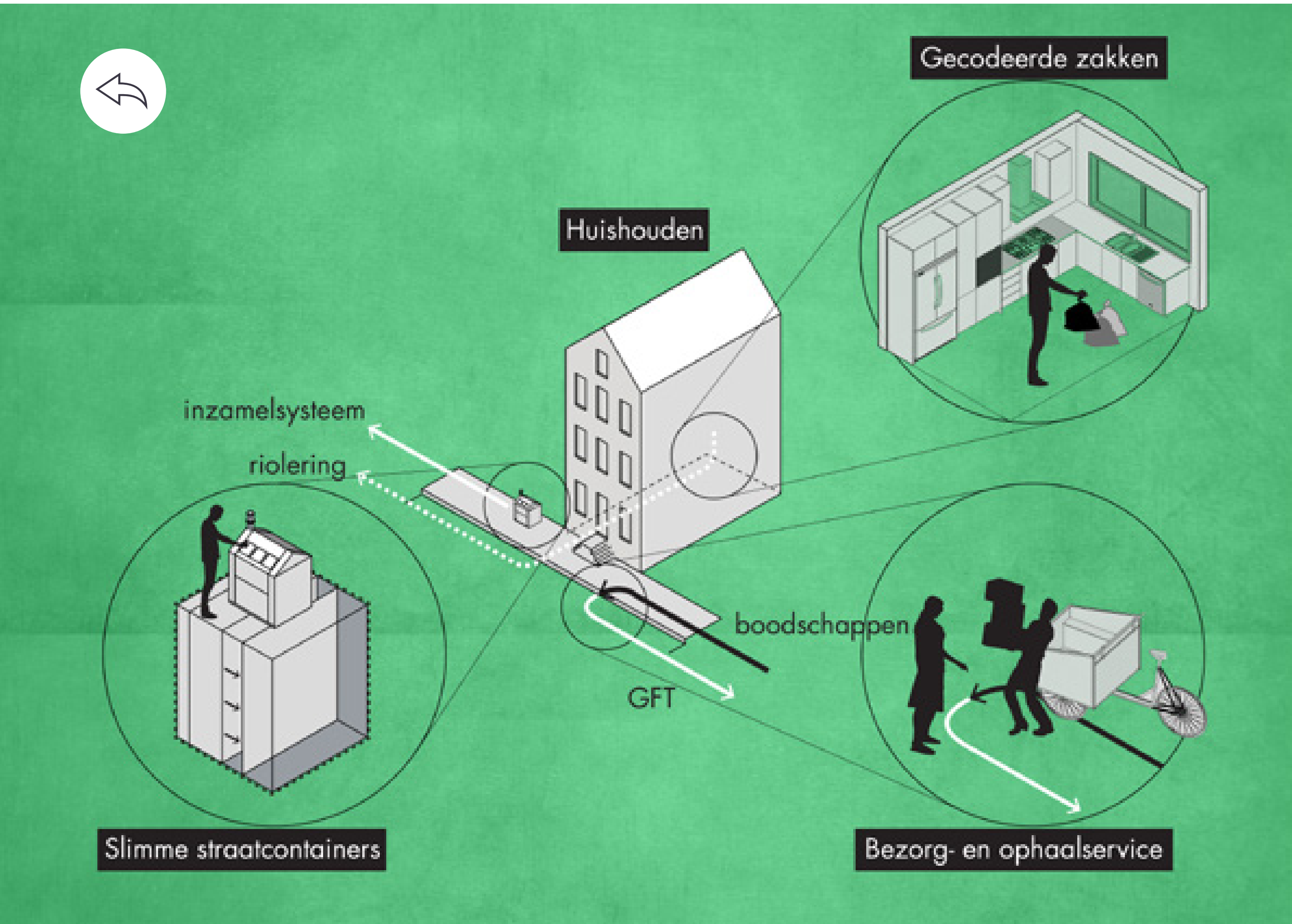
(2) WASTE SEPARATION AND RETURN

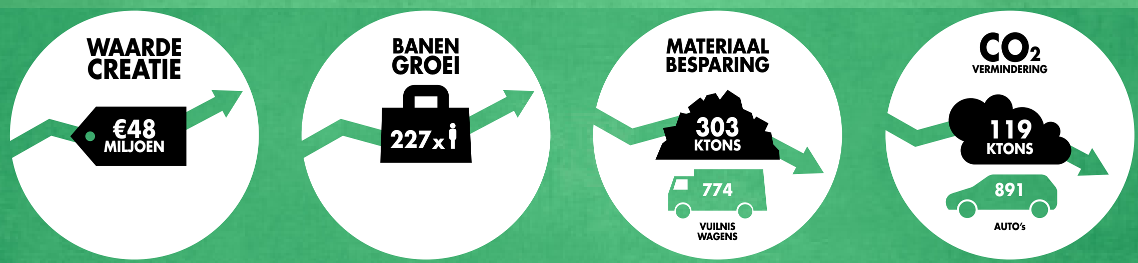
Good waste separation and smart reverse logistics is important in the optimal valorisation of organic waste streams *(Consonni, 2015).* At this time, the separation share of Amsterdam is far below the Dutch average *(CBS, 2015c).* In particular, organic waste is little separated at the source . Solutions for effective separation of domestic waste at source in densely populated urban areas require a complex technological approach, particularly for existing homes.

AEB prepares an investment decision to build a post separation installation that in addition to plastics can also extract fruit- and vegetable waste (organic waste) from the collected residual waste. The fruit- and vegetable waste will initially be used for the production of green gas what is suitable as f.i. a transportation fuel. At a later stage, this can serve as raw material for the production of biochemicals such as bio-aromates. It is expected that this technology will bew mature in about 5-10 years *(AEB, 2015).* The separation installation is an in between solution to bridge the period until source separation, by means of collection systems, has been introduced and embedded, so that post-separation is no longer needed.

Street smart containers A possible solution for existing building is to place waste separators in existing underground waste collection systems to enable separation of organic and mixed waste. The underground containers can be equipped with smart sensors for the measurement of waste streams. This allows for better processing of waste streams, more information on the composition of the waste and for better logistics around matching supply and demand. When no underground waste containers are available, separate collection can also be realised via existing systems. This can be through the use of encrypted bags for the separation of all kinds of waste. A pilot for this is taking place in Reigersbos where inhabitants receive colored bags which they can dispose of in special value containers *(city of Amsterdam, 2015c).*

Smart reverse logistics The market for meal boxes such as the BeeBox is growing fast, and recently also other large retailers like Albert Heijn have entered this market. It is expected that the market for meal boxes will grow strongly over the next few years *(Keuning, 2015).* The growing interest for reverse logistics by logistics service providers such as PostNL in combination with the meal boxes trend offers opportunities for the development of solutions for the reverse logistics of organic waste. Once food boxes are delivered, the same carriers can be used to collect organic waste. For high quality processing, organic residual streams can further be transported to the hub for bio-refinery.





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CASCADING OF ORGANIC FLOWS

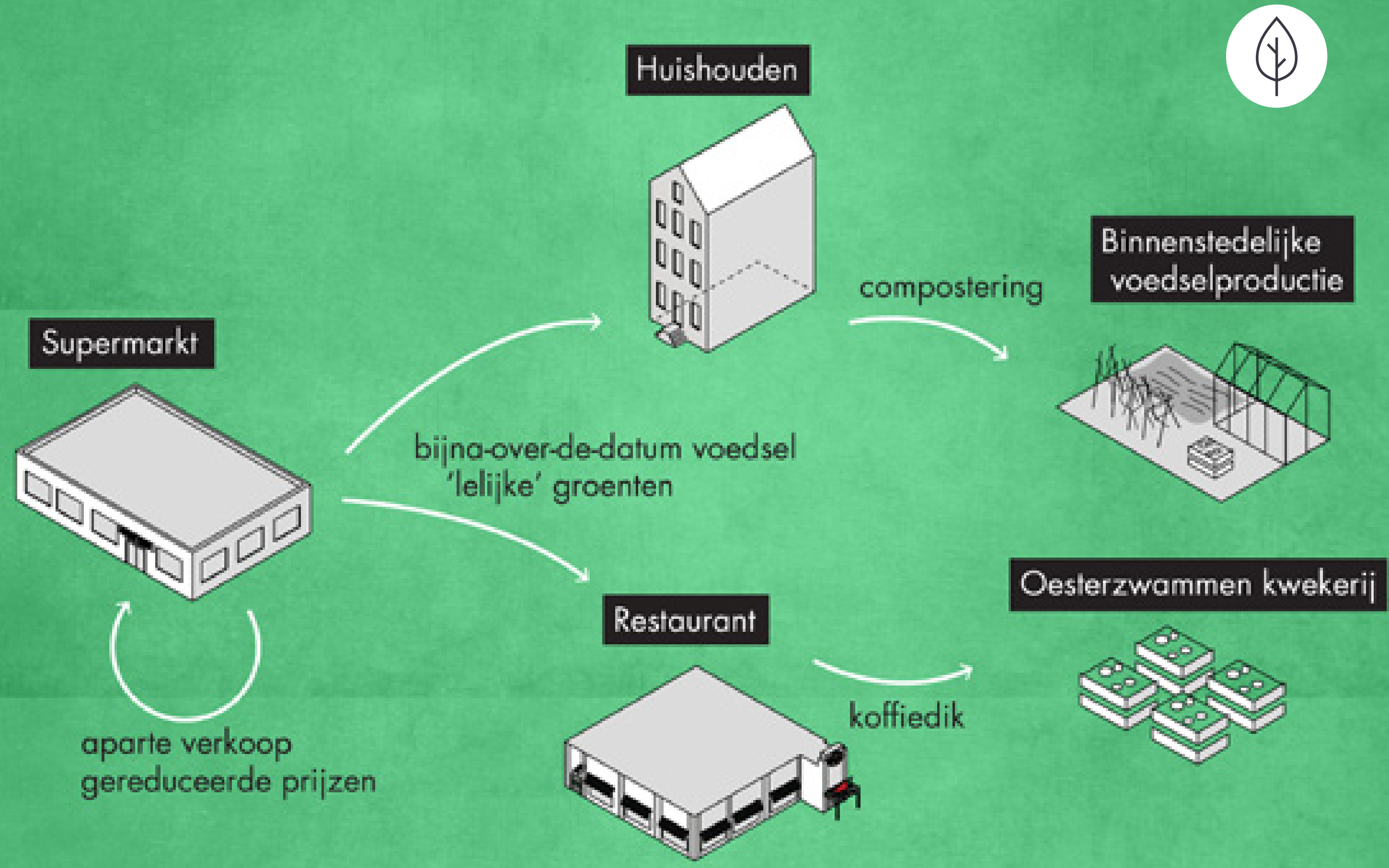
Although there are a variety of options for the recovery and re-use of organic waste for other purposes, 97% of the household organic waste in Amsterdam is burned for energy recovery and only 3% re-used or recycled for other purposes *(Circle Economy, 2014).* The combustion currently provides valuable energy and heat, but there are several methods that have the potential to create more value. There are several new technologies and business models to apply to these waste streams in a high-quality manner *(Bio-based Economy, 2015).*

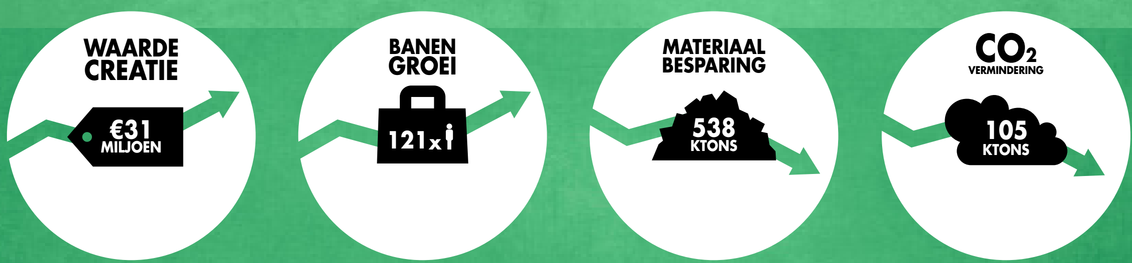
The recovery of foods In the Amsterdam metropolitan area new restaurant- and catering concepts arise for the preservation of edible food scraps from warehouses and shops. Many of these companies are well set up with permanent, well-appointed shops and a neat shopfront, such as InStock. There are also bottom-up community initiatives, such as Guerilla Kitchen. Companies like Kromkommer process edible but deformed or damaged foods, which are not suitable for sales in a shop, in soups and other food products, giving them a second life that is in line with their original purpose.

Cascading of organic residual streams Organic residual streams which cannot be directly re-used, can by means of cascading be processed in high-quality applications *(Wahab, 2015).* Additives for the food processing industry, for example bio-aromatics and reactive flavors, can, by companies like Exter, be extracted from vegetable proteins and be used as a replacement for flavourings on chemical basis. Also waste water and organic waste from a variety of municipal, industrial and agricultural sources can get a new destination in large-scale algae growth projects, and at the same time be treated *(Loftus, 2013).* GRO Holland uses discarded coffee grounds from cafes and restaurants for growing Oyster Mushrooms, which are then immediately sold or used as ingredients for foods.

Production of high-quality protein The emergence of insects as a source for both animal feed and as a food source for people has led to the growth of the production of insects. For example by companies like Protix Biosystems, based in Amsterdam, The Netherlands. This uses food waste. Also algae are rich in high-quality protein and can be processed in a wide range of products such as animal feed, fertilisers, fuels, chemicals and pharmaceuticals. Algae can be used to improve plant production and they are less sensitive to diseases. The algae acts as a natural pesticide.

Biomass in public spaces Public areas and unused spaces, for example in port areas or the berms of highways, can be used in a smart way for the production of biomass. Different grass types are suitable for the production of fiber and protein. This can be locally used as raw material for the production of cardboard or as an alternative to soy. Organisations such as Meerlanden experiment with alternative uses of public green areas. Initiatives such as Fruityourworld show that it is possible to share public spaces with others and to grow fruit there for and by local residents.





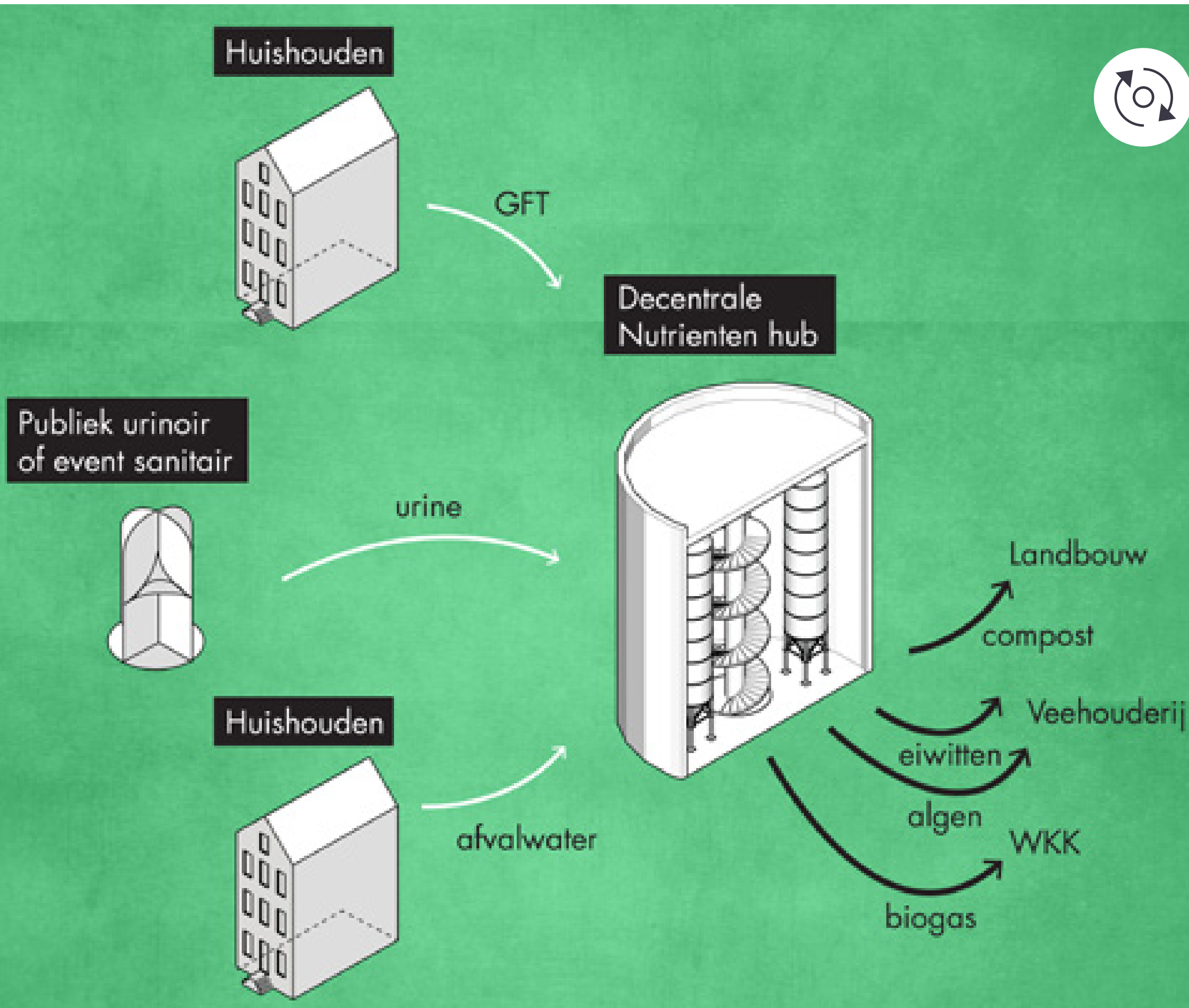
Visual display of bio-refinery: Organic residual streams are processed and used as raw material in for instance medication, food producers, feed and biofuel. The effects of circular strategies on the environment and the economy are calculated for the organic residual streams in Amsterdam. It is assumed that it will take 5 to 7 years to achieve a circular arrangement of the processing of organic residual streams coming from all 430.000 Amsterdam households in the long term. The impact will also manifest itself at that time. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission.

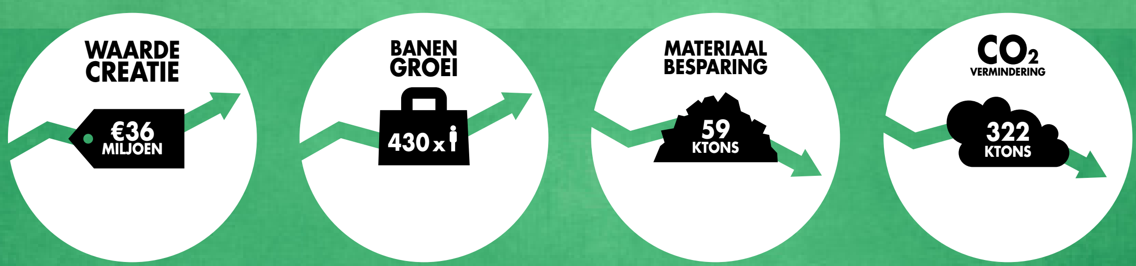
RETRIEVING NUTRIENTS

From the whole food chain - from field to fork – eventually only 5% of the nutrients placed in the soil are actually used to provide us with nutritional value *(Circle Economy, 2014a)* The remaining 95% of the nutrients are lost somewhere in the cycle. For example, crops absorb only 30 to 50% of the applied fertiliser and use almost 25% of that for the growth of the non-edible parts, which in the current model are disposed of as waste. In addition, large quantities of nutrients like minerals, fertilisers, foodstuffs or animal food in Amsterdam are imported that, at some time, end up in the environment. In addition, the sewer drainage system is a valuable resource for nutrient retrieval. Mankind produces on average 500 litres of urine and feces in a year. Because the human body does not absorb all the nutrients from the food we consume, this human waste is full of nutrients. An important opportunity to improve the nutrient cycle in Amsterdam is in the application of decentralised, local processes.

Fertiliser manufacturing Globalisation of the food production system has led to the concentration of many large-scale food processors in the Amsterdam port area, for example soy processing companies like Cargill and Ahold, Coffee Company, Starbucks, Olam international and ADM Netherlands, where coffee and cocoa are being processed. Residues of these companies can be used in the production of fertilisers; a process in which phosphates can be recycled. An example in the Amsterdam port area of a company that recycles nutrients from waste streams of Cargill is ICL Fertilizers Europe, which uses residual flows with a high phosphate content. ICL Fertilizers strives to replace 15% of the phosphate ore in 2015 and 100% in 2025 *(Langefeld, 2015).* The first tests shows promising results for the use of 'secondary' phosphates, but additional research is needed to further extend this approach.

Decentralised processing The municipality could develop local pilots in order to retrieve nutrients from the food system through anaerobic digestion plants and techniques to convert urine into valuable nutrients, such as nitrogen and phosphate. A disadvantage of these techniques is that they are often still not financially profitable *(AEB, 2015).* Decentralised management of waste water can be beneficial in areas linked to excessive water throughflow, such as densely populated urban areas. Further investment in the cascading of waste water and process technologies can provide great improvements. More energy, heat and nutrients can be recovered.





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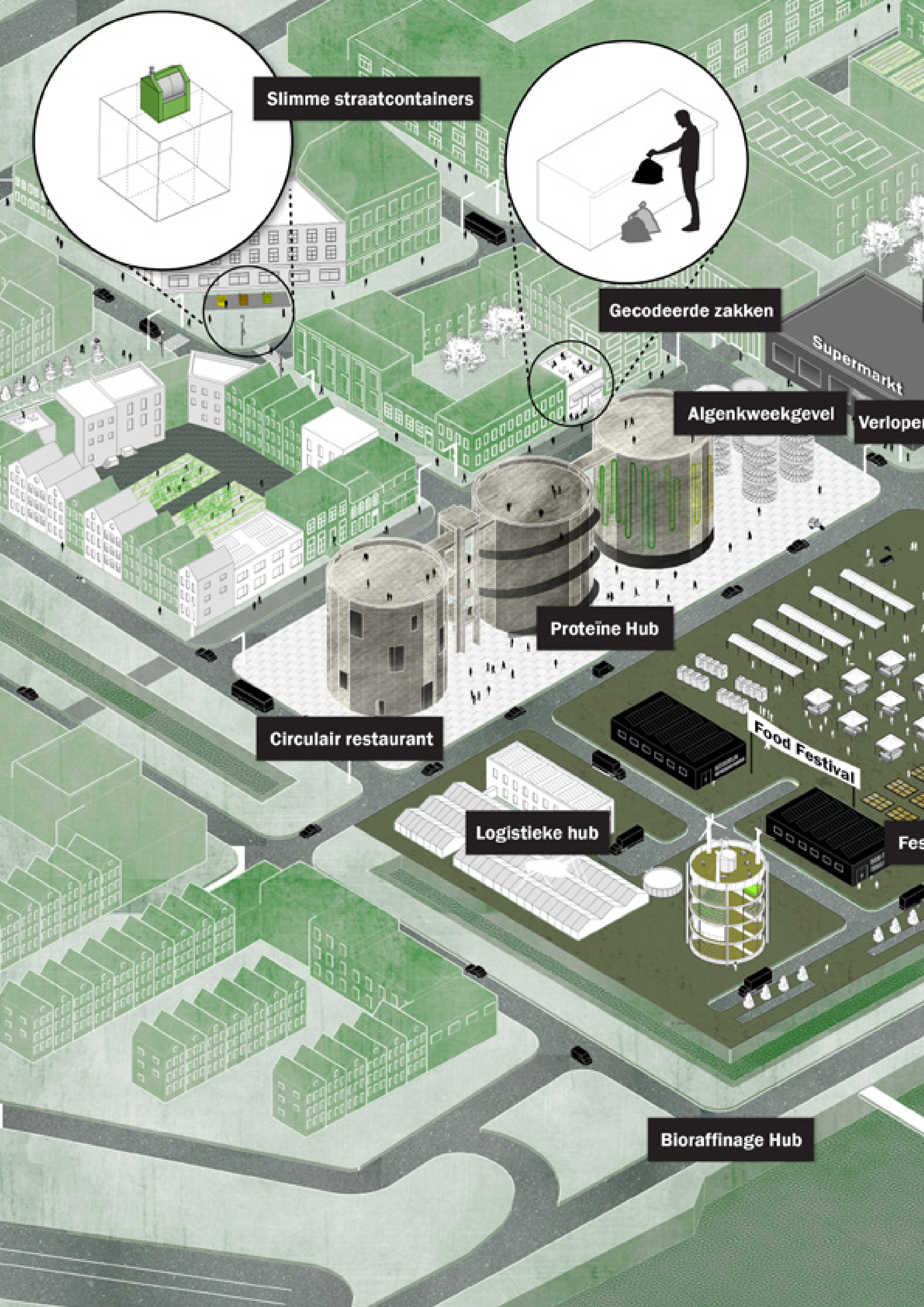
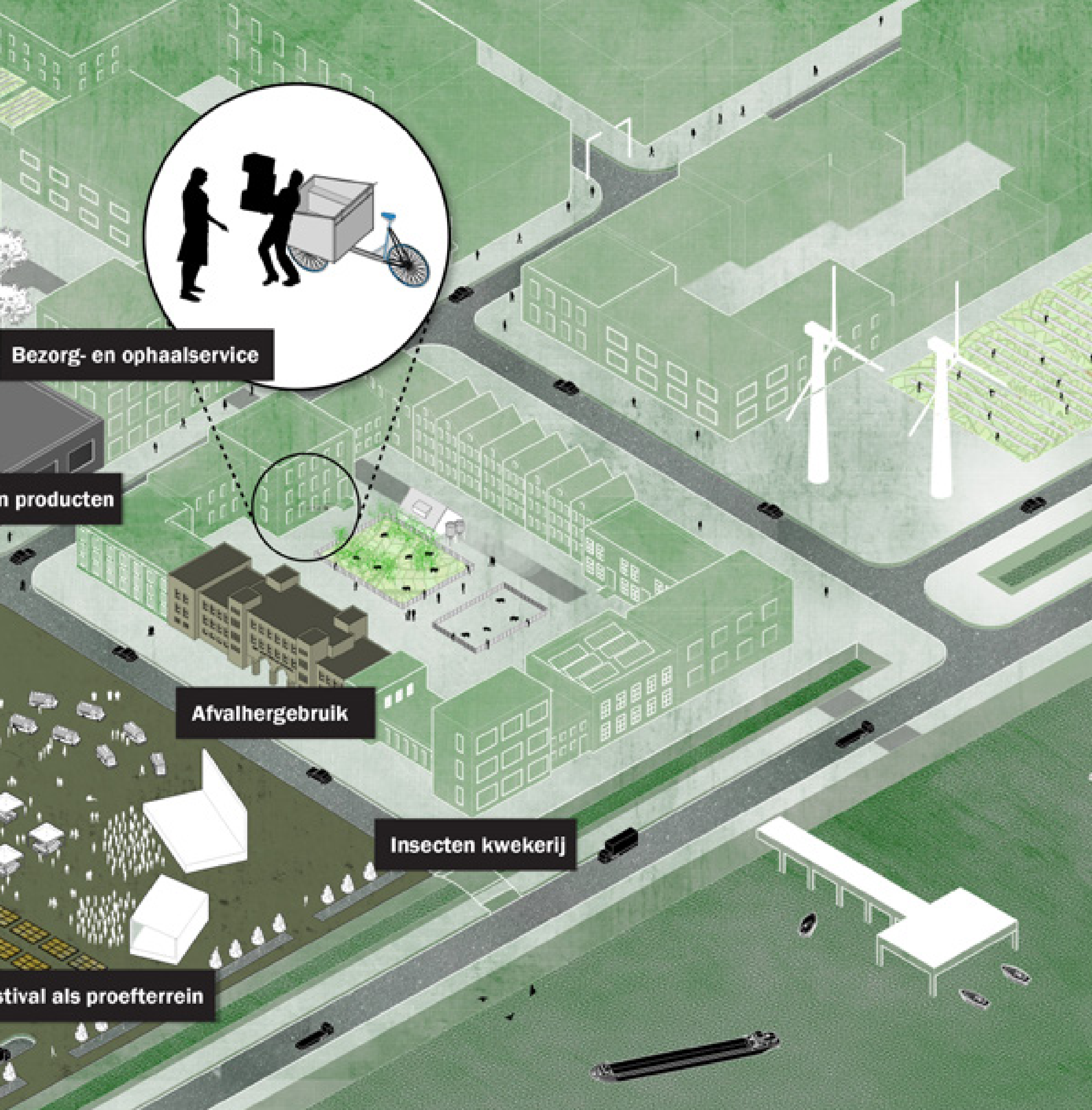


Slimme straatcontainers
Gecodeerde zakken
Supermarkt
Algenkweekgevel
Verloper
Proteïne Hub
Circulair restaurant
Food Festival
Logistieke hub
Fes
Bioraffinage Hub



SPATIAL VISION

The spatial vision card indicates how circular strategies for the organic residual streams in Amsterdam can be applied and how they are interwoven in spatial context. The following strategies are described: (1) central hub for bio-refinery, (2) waste separation and return logistics, (3) cascading of organic flows (4) recovery of nutrients.

BARRIERS

Many of the ways to achieve a circular economy may already be profitable but for upscaling often barriers are in the way. Local policy can play an important role in the removal of these barriers.

We distinguish four types of barriers:

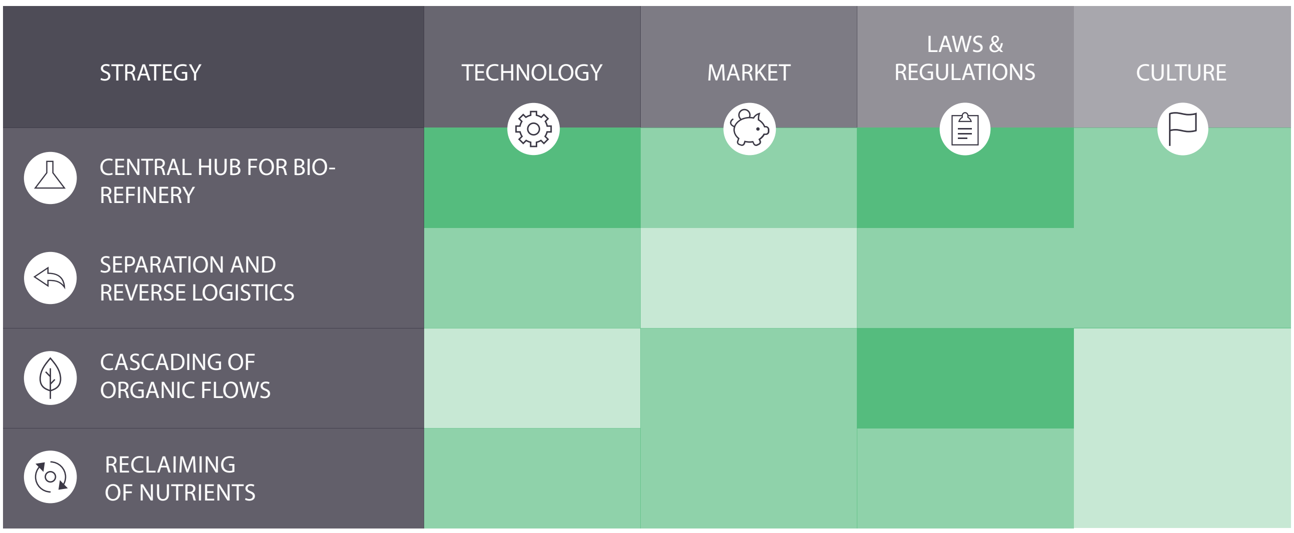
Laws and regulations Existing policy often does not lead at changing market conditions to unforeseen consequences. An example is the environmental management Act (art. 1.1) that describes definitions and possibilities of what is classified in the law as waste and what is not *(Government, 2015).*

Culture The circular economy requires close co-operation between sectors and chains. The current relationships, the culture and manners can form a barrier to quickly get to successful cooperation. Vested interests in sectors can also play a role in this.

Market The existence of 'split incentives'; the investments are at one party in the chain while the income is at another. Another market-related barrier is knowledge asymmetry between parties, for example with regard to the availability of secondary raw material flows and the quality of it. Also (the lack of) pricing of externalities including CO_2 can greatly affect the market. The last barrier that we want to mention in this category is the limited access to financing circular initiatives.

Technology Technological development has two important challenges. Upscaling a small pilot to commercial scale is often challenging. Also the interdependence and complexity of technologies that must be developed together can be a barrier.

The barriers have important implications for the extent to which-especially on the short term-some of the strategies can be implemented successfully. Sometimes governments can overcome these barriers, other times the market may break down barriers, but in many cases the solution requires cooperation, experimentation and iteration. For each of the 4 strategies described above, per barrier is indicated how big the impact is (see below). The assessment of the severity of the barrier comes from insights obtained from the interviews and is further based on estimates of the research team. For the top 3 proposed actions, the roadmap will address the options to overcome these barriers.



This table indicates for each of the strategies how high the barrier is to get to circular economy.
(Source: Insights from interviews, literature and assessment of the research team)

Strategy	Barrier	Description
		The offer of organic residual streams is very spread both geographically and in time (among other things by seasonal variation in green waste such as roadside grass) which forms an obstacle when trying to complete the business case.
		High-quality bio-refinery technologies are in an early stage of development. For upscaling additional research and development (R&D) is required. A lack of funding for this can make both the speed and the chances for success uncertain. Besides, it requires significant investments to make it commercially viable.
		Market demand for end products of bio-refinery is currently low because of, for example, ignorance of market players and a limited possibility to realise significant supply. Also there is a the lack of clear quality criteria.
		The production of high-quality protein by growing insects (larvae) on organic residual streams must comply with the current laws and regulations regarding slaughter of live animals, which raises practical and thus financial barriers.
		At the feeding of green gas into the natural gas network, too little consideration is given to the interests of import and more to the interests of the (traditional) network operators.
		Retrieved nutrients, such as phosphates (for example by addition of stuvite) from waste water may, under current laws and regulations, not be applied as fertiliser on agricultural land and can therefore not be capitalised, which makes the business case more difficult. A recent signed green deal provides an adjustment in the classification of waste under VANG and REACH. *(Sloover, 2014)*
		Digestate from anaerobic digestion according to current legislation should not be used as fertiliser on agricultural land (to replace artificial fertilisers), which complicates the profitability of digester plants.
		For waste substances a waiver on the legislation is required per waste substance and per installation. This is an intensive and lengthy process that has taken place for struvite in Amsterdam.
		European regulations concerning the 'expiry date' and related regulations concerning food hygiene, create uncertainty around the responsibility of food donations. This limits the useful re-use by, for example, food banks versus what would be possible.
		Various technological possibilities to come to higher source separation rates of organic residual streams are examined. The technological complexity (for example, the link of technological installations in households and the necessary infrastructure) of these solutions raises challenges that require both further technological development and the planning of underground installations and infrastructures.

(The above table is a summary of the most relevant and significant barriers, that apply to this chain, in order to achieve a transition towards a circular economy. This is based on research, literature, interviews and insights from the research team.)

ACTION POINTS

To create a circular organic waste stream chain, the following actions as key interventions for the municipality of Amsterdam have been formulated, which can be realised in cooperation with various parties. The actions have been formulated from the described vision and underlying strategies.

HUB FOR BIO-REFINERY

1. Expanding and designating new ' free zones ' and ' circular field labs ' In a number of industrial clusters such as the harbour area, the policy can be temporarily eased to support the development of bio-refining activities. Certain legislation that currently stands in the way of the development of bio-refinery concepts is, for example, the ban on the use of digestate, which is rich in nutrients (especially phosphate), on agricultural land. This is currently blocking an important and essential part of the business case for anaerobic digester plants because the current market value of digestate is low. This legislation also affects Waternet, which retrieves phosphate from waste water (by the precipitation of struvite crystals due to adding magnesium), but can not currently sell the reclaimed nutrients nor apply them to agricultural land. A Green Deal recently signed between the Ministry of I & M and the water boards, will however certainly lead to changes in the classification of recovered substances under VANG and REACH *(Sloover, 2014).*

2. The further development of a sustainability fund specified for the circular economy A fund financed by public and private parties with the aim of financially supporting innovative projects before the market provides starting capital, private equity and financing by banks. The circularity fund can build on experiences with the ' Amsterdam climate & energy fund ' (AKEF) Sustainability Fund, which provided financing and investments in the form of loans, guarantees and capital shares *(AKEF, 2015).* The Fund should provide a solution to the financing of early (usually on lab- or pilot scale) projects that want to upscale to commercial level.

3. The establishment of criteria for 'new bio-based products' Currently the market is being hampered by uncertainty about quality specifications. The lack of clear criteria is currently a problem for two projects around the breeding of insects using organic waste, with the aim to produce proteins that can be used as fodder in, for example, aquaculture. Growing insects now falls under the slaughter Act. These are complex regulations. The establishment of clear criteria can give clarity to this underdeveloped market.

4. To differentiate Amsterdam as an '(innovative) hub for bio-refinery' By means of a communication strategy strongly distinguish Amsterdam of other port cities in the field of circular economy and bio-refining activities. The municipality can invite leading companies to develop their activities in Amsterdam. This can build on for example Startup Amsterdam, with a focus on bio-refining, and be deployed as an innovation hub. The port of Amsterdam, together with the surrounding cities can develop a stimulus package and match-making services to companies that consider to be located in the region.

DISMANTLING AND SEPARATION

1. The renovation of existing underground waste containers The renovation of waste containers, for example in Amsterdam-West, can lead to an improvement in the share of source separated collection. The suggestion is to equip existing or newly placed containers with the possibility for separate collection of fruit and vegetable waste, in addition to the current collection of paper and glass. Currently in Amsterdam West a great replacement campaign is being rolled out that will take 3 years. This modernisation campaign can be an incentive for local SMEs, in particular for metal-and installation companies. The new requirements to the possibilities for separate collection would also be included in procurement criteria for the infrastructure of municipal waste collection.

2. Change waste points in centers for circular economy The waste points can be transformed into a hive of activity (in the area of recycling), and knowledge sharing. This is similar to the recycling platforms of the municipality of Almere, where high-quality recycling is applied locally *(Municipality of Almere, 2015).* This increases local activity in the field of circular economy. And in addition, it increases the knowledge and involvement of local residents by involving them in recycling and other activities in the field of the circular economy.

3. Street containers and waste infrastructure with smart IT systems This optimises the reverse logistics and the share of separate collection at source *(Amsterdam Connecting Trade, 2014)*. This can lead to a decrease of transport movements. By connecting information about the composition of waste in a smart way, there may be more value from the residual flows. In small-scale pilots in appropriate waste management areas and in cooperation with companies, suppliers and households the system can be tested on ease of use and (financial) feasibility.

4. Enter differentiated tax rates for different waste categories in (the so-called Diftar-system). In very densely populated residential areas in urban regions it is more difficult to separate household waste at source. By taxing more heavily on grey household waste by means of a differentiated tax system (Diftar) *(Drift, 2014)* source separation of domestic waste will be stimulated (financially).

VISION ON ORGANIC RESIDUAL STREAMS

1. Creating 'breeding grounds' to promote urban agriculture This increases local food production or biomass production. In addition, empty buildings can be used to produce food. The examples and initiatives on urban agriculture are expanding rapidly. An example in Almere is 'Agromere', which aims to put a process in motion that eventually should lead to a new residential area in which agriculture is fully integrated *(Jansma, 2015).*

2. Through purchasing policy stimulate locally produced products, biomass and nutrition At local production of biomass and food, the need for transport and the associated environmental impact are reduced *(PBL, 2014).* One of the sources for the production of local wood is green areas of the city *(City of Amsterdam, 2014a).* To increase the production of biomass in the municipal green facilities, a more holistic approach to the management of municipal green and waste materials is required. Public green spaces can be used for the planting of special species of plants (e.g. shrubs) *(Urgenda, 2015).* which are specially bred to grow quickly and produce more biomass, take in more CO_2, save more rain water and absorb more particulates.

RETRIEVING NUTRIENTS

1. The realisation of an integrated phosphate strategy The municipality can therewith enable a full circular phosphate cycle. This can be achieved by the municipality by working together with stakeholders and by encouraging industrial symbiosis and technological innovation. Through cooperation with different parties a strategy can be developed to regionally make best use of residual streams with phosphate and to place these with parties that have great demand for phosphate (from mines). The first steps are already taken, among others in projects involving AEB, ICL and Waternet.

2. The promotion of decentralised waste-water management systems This enables the local recovering of heat, energy and raw materials. Research has been done in Buiksloterham how at neighbourhood level the urban environment can be set up to allow decentralised reception of waste and water *(Amsterdam Smart City, 2015).* It should include for instance separating waste water types (grey, yellow and black water) and valorising these streams (partly) locally. The municipality can build on this.

ACTION POINTS TOP 3

From the interviews and discussions with stakeholders involved in the region, 3 action points as shown in the table have been selected. It takes into account 4 major effects: (1) value creation, (2) CO2-reduction, (3) material savings, and (4) job growth that has been calculated for the 4 strategies. The measures have further taken into account the barriers that have been identified for the organic residual flow chain, and the role that the municipality can fulfill. The municipality can, by making (open) data

	1 VIRTUAL COMMODITIES PLATFORM To further develop and make publicly accessible specific geodata with regard to demand and supply of organic residual streams in the city and region	2 CIRCULAR FR Identifying specific locatio drawing up rule
	The further development and making of publicly accessible 'digital (commercial) platforms for organic waste', which offer a transparent overview of the supply, the demand and the use of organic residual streams in Amsterdam (and beyond) and in addition can contribute to matching supply and demand. This may be a response to the current uncertainty in market participants about supply and demand of flows. The lack of understanding has been mentioned as an obstacle to planning by many of the regional stakeholders, which in turn affects the financing because of the risk with regard to security of supply. For this reason, the platform also provide insight into fluctuations in supply and demand, for example on the basis of seasonal variations in the availability of green waste. The municipality can also stimulate innovation concepts, and link small and large businesses.	The municipality can initiate circu obstacles which currently stand in th For example, the ban on the use phosphate) on agricultural land. Th essential part of the business cas the current market value of digestat
CONNECTION AT PROJECTS	The program 'Urban Pulse' run at AMS has partly planned activities around the mapping of raw material streams including organic flows and to translate these spaciously. There are also activities within the municipality around providing insight into waste streams associated with geo-data. In addition, one can affiliate with initiatives that use big data and have great potential for the circular economy *(Lacy, 2015)*. Among other things the Wageningen UR and AMS do research into the use of BIG data *(Top, 2015)*.	It is important that new projects existing pioneering activities in site, a consortium of six companie bio-refinery concepts and the op Furthermore, Waternet and AEB local initiatives including the proc biogas production.
INVESTMENTS AND RESULTS	The investment in setting up a platform is largely for the development of the IT-infrastructure and for the time it takes for the conceptual development of a platform. The municipality can be the initiator. Although there are many market participants including large IT parties that also deal with the development of such platforms. The 'out-of-pocket' development costs for a platform can be carried by private and public parties. The effects and impact on the actual volume of processing organic flows through deployment of the platform will probably cost several years before it is of significant size. On the one hand because the development takes time. In addition, buy-in and critical mass is required by market parties.	The designation of circular free zo barriers such as described in the that requires investment especiall enforcement. The measures to be ta of the Municipality Act.
STAKE-HOLDERS	Ams, Floow2, Oogstkaart (Harvest Map), TNO, Municipality, Wageningen UR	Orgaworld, SkyNRG, Schiphol Grou Sita, Awakenings, Loveland, Air

available, stimulate innovation in the city (action 1). In addition, consideration was given as to how the municipality can play an important role to settle the high barrier around laws and regulations and for bio-refining technology (action 2). Precisely because this strategy has a great potential in the circular economy. Finally, it was look at how the municipality by its own purchasing policy can increase the demand for circular products (action line 3).

EE ZONE BIO-REFINERY ns intended as circular free zones and es for further development	3 LAUNCHING CUSTOMER Purchase criteria for the use of locally produced grass, wood and food
ılar free zones. This takes away certain ne way of the development of innovations. of digestate rich in nutrients (especially is is currently blocking an important and e for anaerobic digester plants because e is low).	The municipality can by means of criteria in the purchasing policy stimulate locally produced grass, wood (as in street furniture) and food (catering). The large buying power of the municipality itself can create an important and constant demand that allows local parties to further develop and professionalise. At local production of biomass and food, the need for transport and the associated environmental impact is reduced *(PBL, 2013)*. The local production of wood can take place in the municipal green facilities of the city *(Municipality of Amsterdam, 2014a)* To increase the production of biomass in the municipal green facilities, a more holistic approach of the management of municipal green and waste materials is required. Public green spaces can be used for the planting of special species of plants (e.g. shrubs) *(Urgenda, 2015)* that are specially bred to grow rapidly. And deliver more biomass, take in more CO_2, and can absorb particulates.
build on- and are linked with already the region, including the Greenmills es active in the further development of timal re-use of organic residual flows. are involved and well informed about essing of sewage sludge treatment and	There are several companies and initiatives in Amsterdam that produce the local biomass such as food but also fibres for products. To achieve higher stakes of these local products the municipality can direct its purchasing policy here. So the municipality is signatory of the 'green deal circular purchases' *(Geet, 2013)*. Also in broad sense the theme of circular purchases for the purpose of local production and consumption is a spear point at Circle City *(circle city, 2013)*.
nes can be an effective way to neutralise local barrier overview. It is a measure in the organisation of supervision and ken fall completely within the perspective	The effects of these measures may soon be visible since there is a direct market demand for local products.
o, KLM, Amsterdam port,	Municipality, Caterers and suppliers of facility management,Local producers, Exter, Kromkommer, Provalor, GRO, Holland, Taste Before You Waste, Instock, Food bank, Meerlanden and Fruityourworld

ROUTE MAP

ORGANIC RESIDUAL FLOWS

SHORT TERM (1 YEAR)

TOP 3

1. TO FURTHER DEVELOP AND PUBLICISE GEODATA FOR THE SUPPLY AND DEMAND OF ORGANIC RESIDUAL STREAMS IN THE CITY
2. IDENTIFYING SPECIFIC LOCATIONS INTENDED AS CIRCULAR FREE ZONE UP RULES FOR FURTHER DEVELOPMENT
3. PURCHASING CRITERIA FOR THE USE OF LOCAL PRODUCED GRASS, WOOD AND FOOD

CENTRAL HUB FOR BIO-REFINERY

- EXPANDING AND DESIGNATING NEW 'FREE ZONES' AND 'CIRCULAR FIELD
- THE ONGOING DEVELOPMENT OF THE SUSTAINABILITY FUND SPECIFIED FOR THE CIRCULAR ECONOMY
- THE ESTABLISHMENT OF CRITERIA FOR 'NEW BIO-BASED PRODUCTS'.
- DIFFERENTIATE AMSTERDA

SEPARATION AND REVERSE LOGISTICS

- THE RENOVATION OF EXISTING UNDERGROUND CONTAINERS FOR WASTE
- CHANGE WASTE POINTS IN CENTERS FOR CIRCULAR ECONOMY
- EQUIP STREET CONTAINERS AND WASTE INFRASTRUCTURE WITH SMART IT SYSTEMS

CASCADING OF ORGANIC FLOWS

- CREATING ' BREEDING GROUNDS ' TO ENCOURAGE URBAN AGRICULTURE
- BY MEANS OF PURCHASING POLICY, PROMOTE LOCALLY PRODUCED PRODUCTS, BIOMASS AND

RECLAIMING OF NUTRIENTS

- THE REALISATION OF AN INTEGRATED PHOSPHATE STRATEGY
- PROMOTING DECENTRALISED WASTE- AND WATER MANAGEMENT SYSTE

ARROWS

The arrows indicate by what date an action can be deployed and on what term impact is to be expected as a result. Actual implemen depends on many factors including the speed at which the market takes action, the speed with which upscaling takes place, etc.

LONG-TERM (20 + YEARS)

ES AND DRAWING

D LABS'

AM AS AN '(INNOVATIVE) HUB FOR BIO-REFINERY'

IMPLEMENT DIFFERENTIATED TAX RATES FOR DIFFERENT WASTE CATEGORIES IN

EMS

tation of the actions and expected impact

BARRIERS

Technology Marl Regulation lture

POTENTIAL ECONOMIC- AND ENVIRONMENTAL IMPACT OF OPTIMISED PROCESSING OF ORGANIC STREAMS IN AMSTERDAM COMPARED TO A LINEAR SCENARIO

The economic activity of the Amsterdam metropolitan region amounts to 106 billion euros annually, of which 47 billion is accounted for by the city of Amsterdam (2013) (CBS, 2015)*. The contribution to this of the agricultural sector in the city of Amsterdam amounts to 248 million euros and the food sector 593 million euros. The current recycling of organic residual streams in Amsterdam gives a lot of room for optimisation. On that note, the city of Amsterdam has ambitions to increase the source separation percentage to generate more value from the organic residual group in household and industrial waste. Also organic waste streams from the food processing industry in the port area offers opportunities for higher quality processing and can thus contribute to additional value creation. Based on the strategies that can contribute to an optimised processing (cascading) of organic residual streams in Amsterdam, a macro-economic analysis has been carried out. The results provide insight into the effects that implementation of this circular strategies can have on economic growth, employment, the saving of material use and reduction in greenhouse gas emissions.

This calculated 'circular scenario' provides insight into the effects in relation to the autonomous (linear) growth in Amsterdam. This includes direct and indirect effects of circular strategies. This way a direct saving can, for example by reprocessing organic material flows to a raw material for bio-plastic, result in cost savings which enables investment from this obtained budget space in new installations for which materials are needed. In the period between 2005 and 2012, the agricultural sector and food industry in the metropolitan region show a productivity growth of 5.7% and 13.6% respectively.

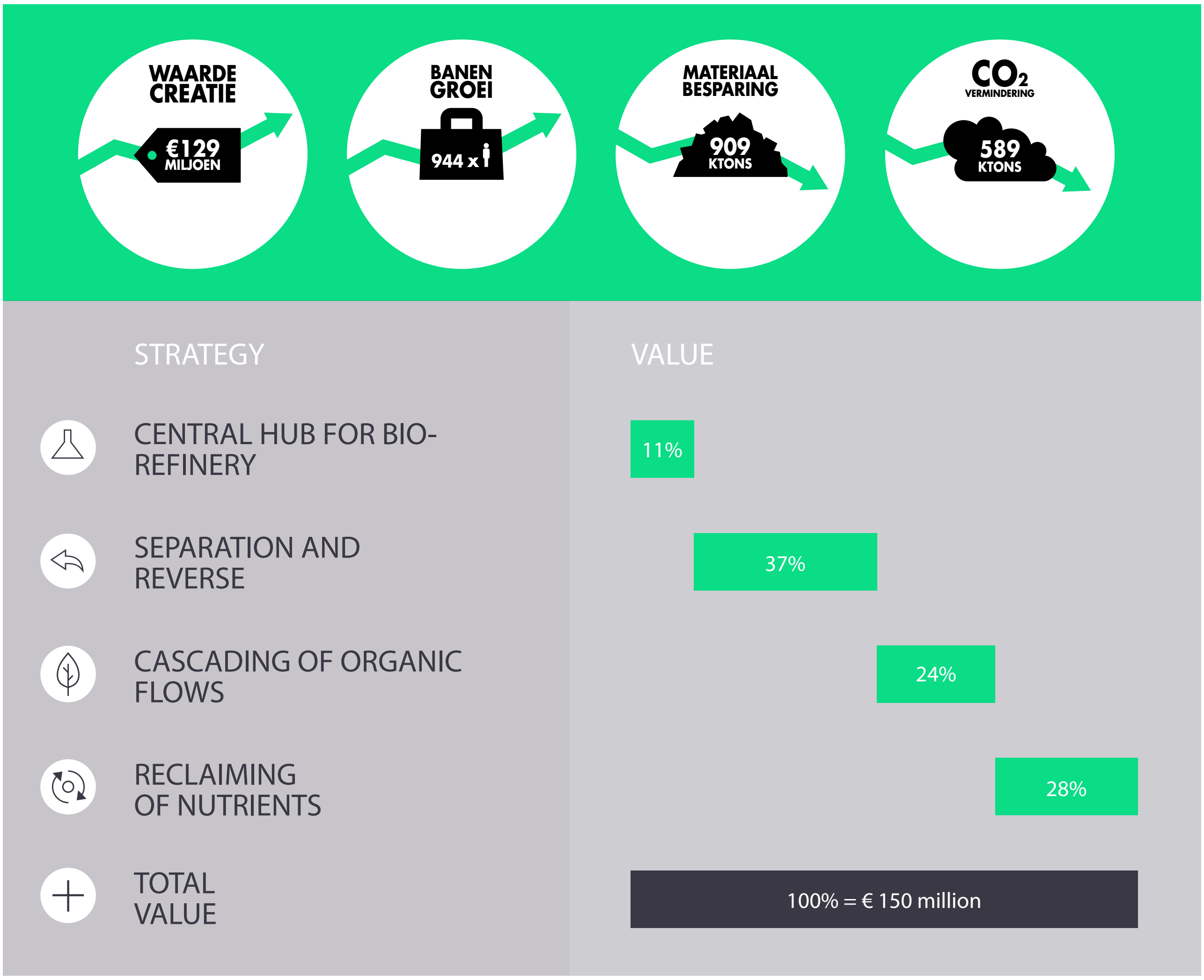
In our calculations for a circular scenario for the processing of organic residual streams, we adopted source separation of the organic fraction over time in all 430 thousand households in Amsterdam. In 2015 every inhabitant of Amsterdam generated an average of 92 kilograms of vegetable-, fruit- and garden waste (Amsterdam, 2015d). This separate collection makes it possible to use the organic fraction, for example, for the production of protein for animal feed, biogas and building blocks for the chemistry such as for the production of bio-plastics. A full circular organic residual flow chain can, for the city of Amsterdam, result in an increase in productivity growth of 14% for the agricultural sector and 7% for the food sector over a period of 5 to 7 years. This is thus on top of the autonomic growth as previously mentioned. In that case, the added value to the economy could amount to 150 million euros a year.

Also, this transition could contribute to the local employment of 1200 jobs in the long term. Set against the 10 thousand jobs in agriculture and the food industry this is a significant contribution with approximately 8%. For example, it can be about employment for adjustment of the waste infrastructure such as underground containers, an increase in jobs at pick up services for the separate groups but also for the more complex processing of these flows. It requires a complex such as Greenmills with various bio-refinery factories with private operators more labour

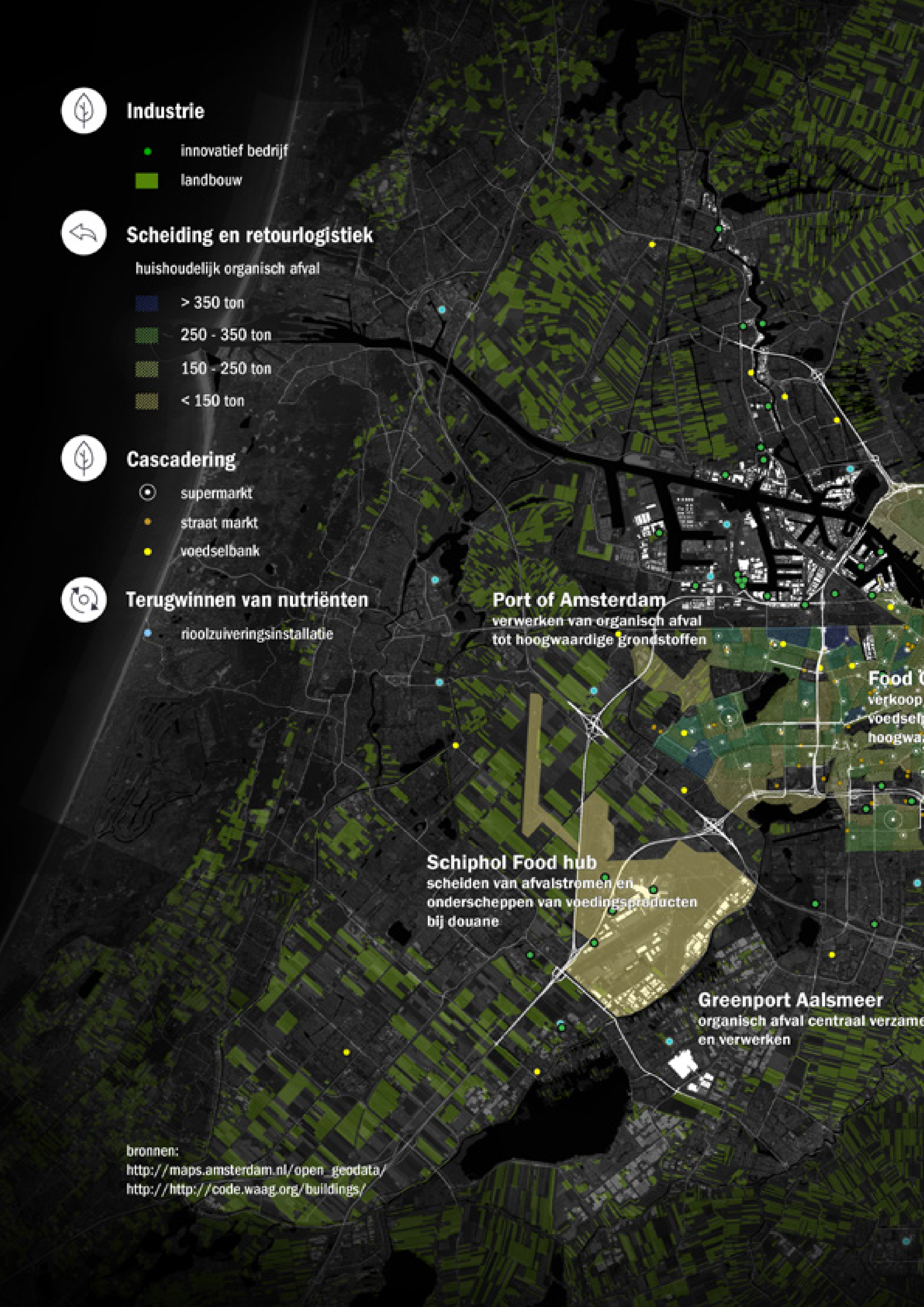
** In this study value creation of circular initiatives will be compared with the total added value at basic prices are expressed, NOT with the Gross Regional Product. In this chapter a TNO-analysis is applied in which the assumptions used are from the following sources: Chiewa, et al. (2014) Environmental impact of recycling digested food waste as a fertilizer in agriculture—A case study Resources, Conservation and Recycling; Vandermeersch, et al. (2012) Environmental sustainability assessment or food waste valorization options. Department of Sustainable Organic Chemistry and Technology; Leceta, et al. (2015) Bio-based films prepared with by-products and wastes: environmental assessment Journal of Cleaner Production.*

than when all large-scale and unsorted waste is processed. In addition to direct employment effects in the agricultural and food industry there are chances for additional economic activity in the supply industry such as engineering and logistics.

The material savings mainly consists of materials that can replace higher quality processed flows. An example is the production of high-quality protein to replace protein-import such as for example soy for animal feed. Also the production of bio-based building blocks for the chemistry such as for the production of bio-plastics would be able to replace oil-based raw materials. The material savings that can be achieved may add up to 900 thousand tons per year. Set against the current annual import of 3.9 million tonnes of biomass for the entire metropolitan region this can be characterised as significant. In connection with the material savings, the expected reduction of greenhouse gas emissions is in the order of 600 thousand tonnes of CO_2, this is equivalent to a small 3% of the annual CO_2 emissions of the city of Amsterdam.



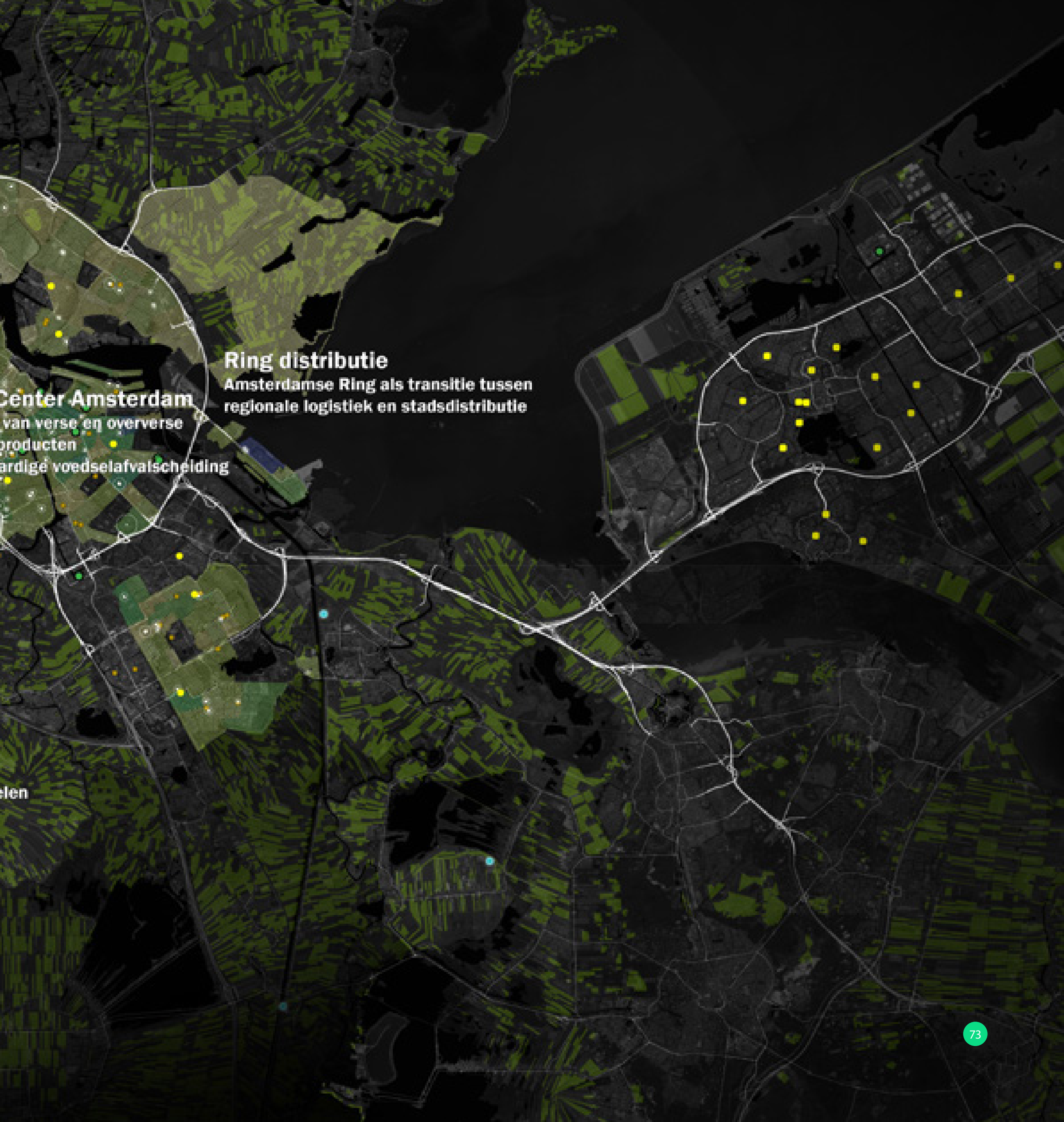
Potential economic and environmental impact of a circular construction chain in Amsterdam compared to a linear scenario are calculated for Amsterdam. Here, the impact will be realised over a period of five to seven years. 4 indicators have been used for this (1) Net added value in millions of euros (2) Net job growth in FTE (3) Material savings calculated by value retention in domestic material consumption and (4) Reduction in CO_2 emission. The values for the 4 indicators are shown in the 4 circles. In the bar chart the distribution in added value is shown.



Industrie
innovatief bedrijf
landbouw
Scheiding en retourlogistiek
huishoudelijk organisch afval
> 350 ton
250 - 350 ton
150 - 250 ton
< 150 ton
Cascadering
supermarkt
straat markt
voedselbank
Terugwinnen van nutriënten
rioolzuiveringsinstallatie
Port of Amsterdam
verwerken van organisch afval
tot hoogwaardige grondstoffen
verkoop
Schiphol Food hub
scheiden van afvalstromen en
onderscheppen van voedingsproducten
bij douane
Greenport Aalsmeer
organisch afval centraal
en verwerken
bronnen:
http://maps.amsterdam.nl/open_geodata/
http://http://code.waag.org/buildings/

SCALABILITY MAP

The scalability map shows for the organic residual flow chain where opportunities lie for four circular strategies: (1) waste separation and return logistics, (2) cascading of organic flows (3) recovery of nutrients (4) bio-refinery hub. Green markings show places where household waste is released and thus where the potential lies for separation and return logistics. Furthermore supermarkets and street markets are indicated with green and yellow points, and it reflects the potential for cascading for retail and industry. In addition, large multinationals and food processors are displayed on the map to indicate opportunities for the industry.



4. THE STATUS

To create a circular economy, we must first understand what is not circular in our current economy. This chapter provides insight into how resources move through the city, where they will be processed to add value to the local economy and where raw materials are wasted, or, ideally, all cascade back into the system and be re-used. To reach this understanding, the region was looked at in the extent of materials flows, energy consumption and employment. The progress of the various streams was examined in order to serve as a starting point for the assessment of the question on which points the achievements in the field of circularity, quality of life and economic vitality of the city can be improved. For example, on which locations is waste created? And where are the short and long term opportunities to convert these into opportunities for the city and the region? To get a more detailed picture of the 'non-circular' situation at present, we have conducted an analysis based on regional and national statistics supplemented with specific organisational dates.

CIRCULARITY MEASURED

One of the challenges in determining a strategy to create a circular economy is the measurable circularity and gaining a good understanding of the status quo. For measuring the circularity of the city, region and sectors, the 'circular indicators framework' is developed by Circle Economy and TNO. The framework describes four main indicators that provide insight in the essential aspects of circularity. The first three indicators were evaluated using quantitative data by CBS and TNO. The indicator for transition potential was investigated by means of interviews and qualitative reviews of specific companies, organisations and other stakeholders within their respective chains. This framework was also used by Circle Economy and TNO for establishing the priority chains for a national project with the Ministry of infrastructure and the environment. The four key indicators, with each specific sub-indicators, are represented on the right.

In the figure opposite is an overview presented with the results of the framework applied to the thirty sectors that CBS differentiates in the macro-economic statistics of the region. Per sector is indicated how big the 'economic added value' is to the regional economy (y-axis), the 'ecological impact' is (x-axis) and how big the potential is for value retention (size of the bubble).

ECOLOGICAL IMPACT

Metal exhaustion
Fossil exhaustion
Abiotic depletion
Acidification
Eutrophication
Global warming
Ozone layer depletion
human toxicity
Fresh-water aquatic toxicity
Maritime aquatic toxicity
Country toxicity
Photochemical Oxidation
Country competition

ECONOMIC INTEREST

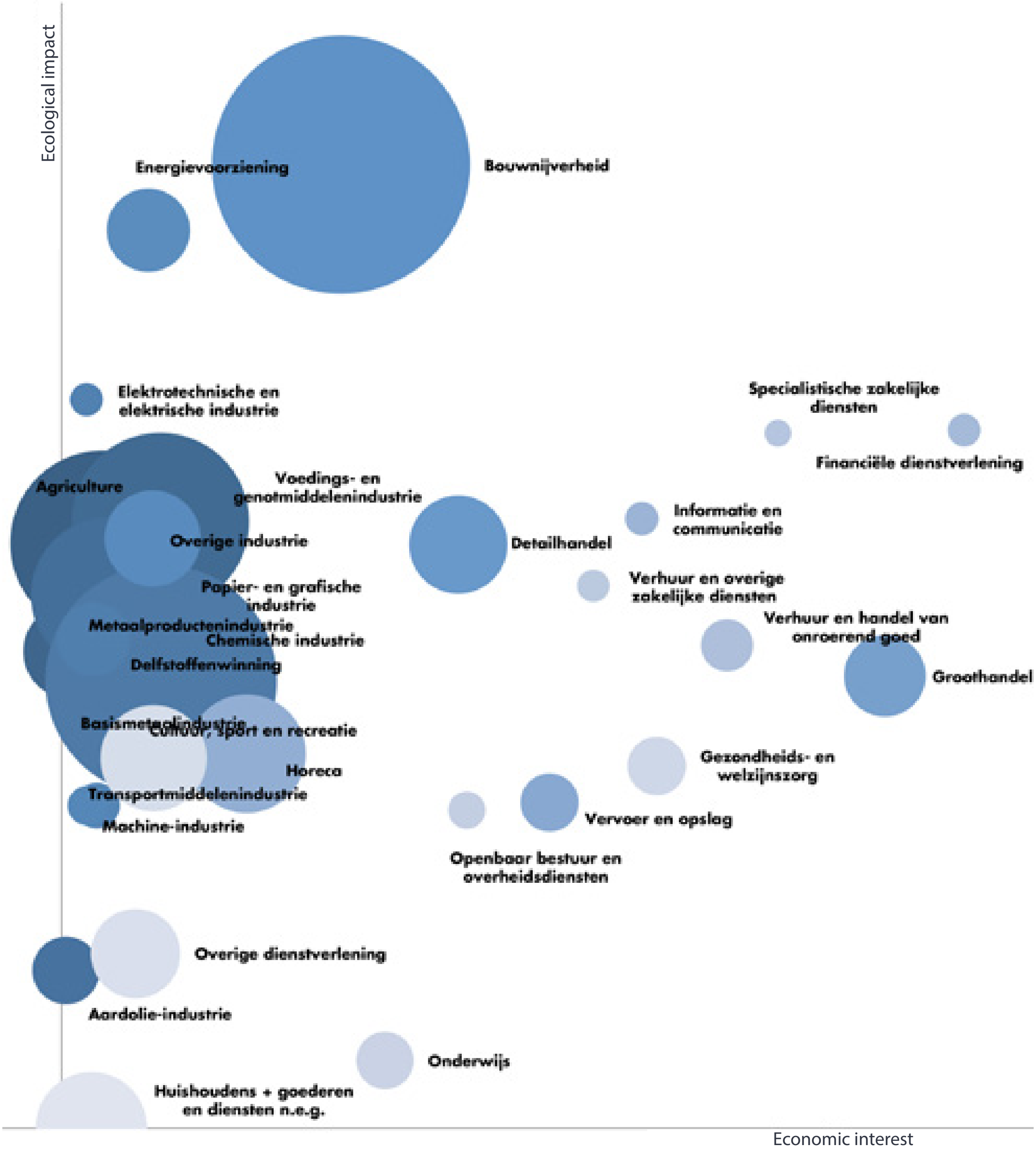
Added value

POTENTIAL FOR VALUE RETENTION

Raw material efficiency
Valuable waste generation
Dispersion factor
Recycling ratio

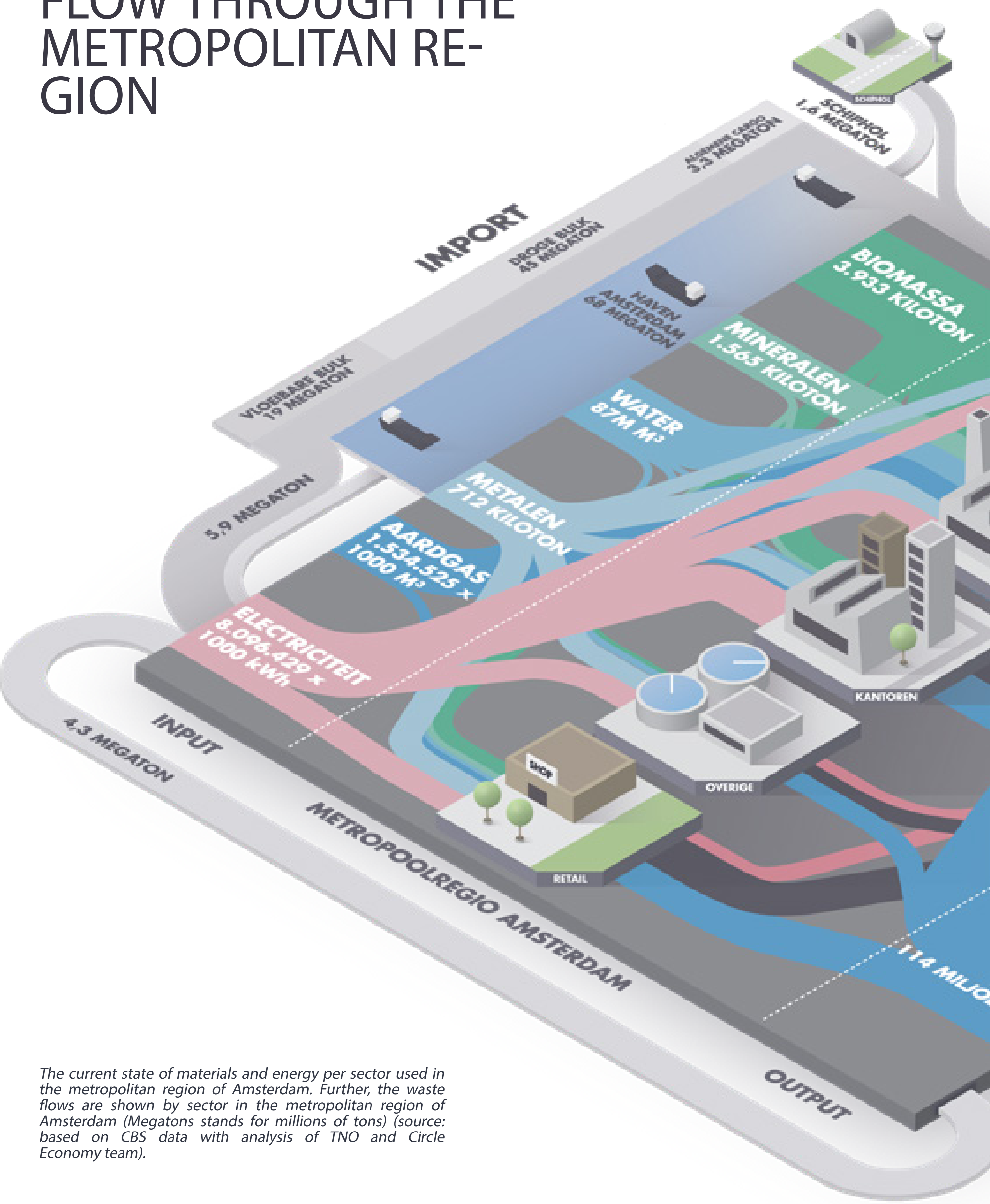
TRANSITION POTENTIAL

Transition readiness
Organisation and culture
Visibility and impact



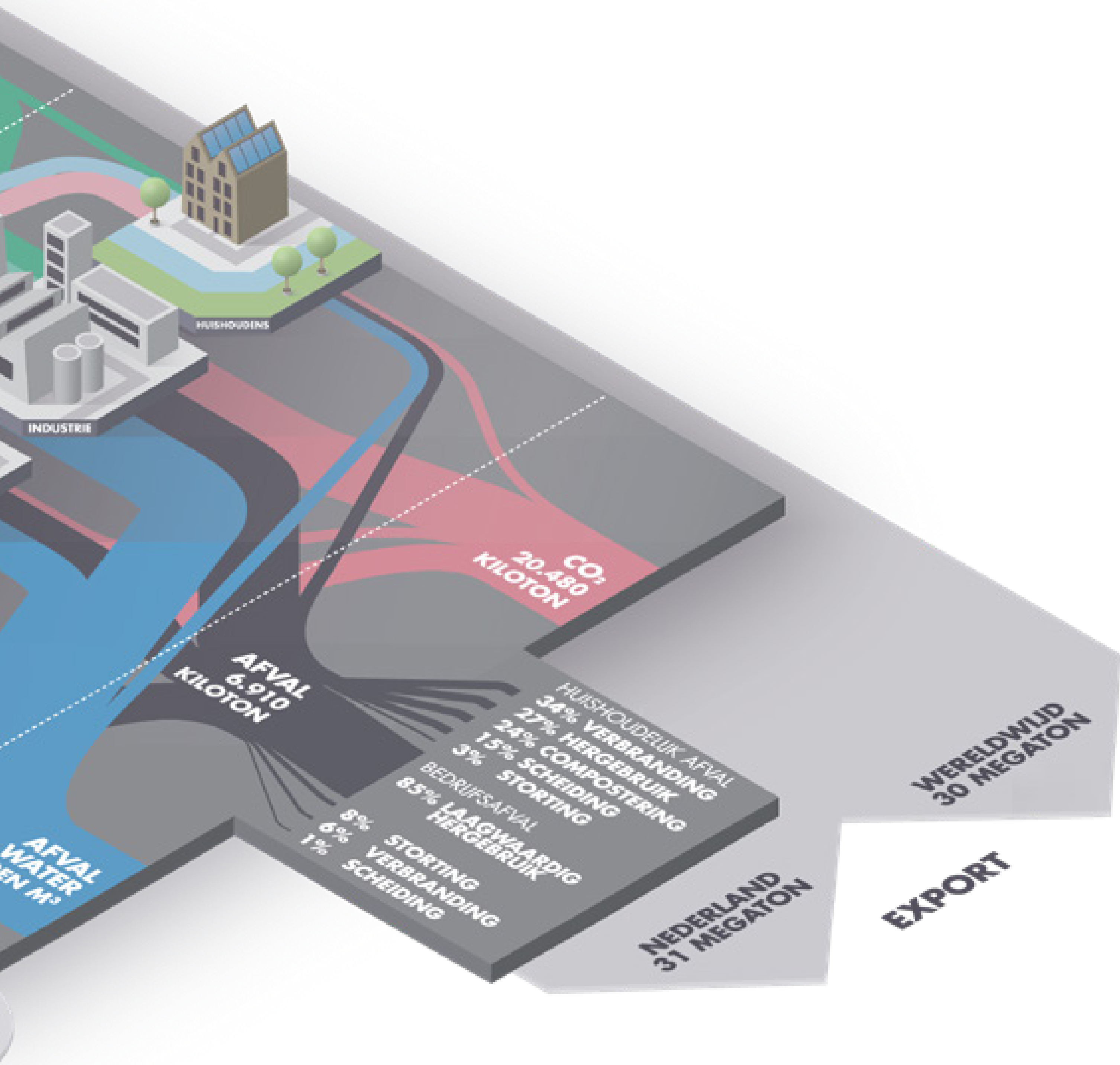
The above figure shows how the 30 sectors in the Amsterdam metropolitan area score on 'economy', 'ecology' and 'value retention', the 3 main indicators in the 'circular indicators framework'. (Source: based on CBS-data with analysis of TNO and Circle Economy team)

FLOW THROUGH THE METROPOLITAN REGION



The current state of materials and energy per sector used in the metropolitan region of Amsterdam. Further, the waste flows are shown by sector in the metropolitan region of Amsterdam (Megatons stands for millions of tons) (source: based on CBS data with analysis of TNO and Circle Economy team).

The material flows for Amsterdam are analysed and visualised in the following diagram. This figure provides insight into how resources move through the metropolitan region and city, where they will be processed to add value to the local economy and where raw materials are wasted, or, ideally, cascaded back into the system and be re-used. From this review, three important aspects appear to determine the status quo - which is largely linear oriented - but which have the potential to create a circular economy in the region.



ECONOMIC PERSPECTIVE

The import, processing and transit of materials and goods is an important economic activity in the metropolitan region The Amsterdam metropolitan area has the largest seaport and airport in Europe. Through these two ports combined, annually more than 100 million tons of goods are imported and 30 million tonnes are exported *(Port of Amsterdam, 2013).* The gross added value of the seaport amounted to EUR 3.5 billion in 2012, mainly coming from business and industry, metal industry and transport & logistics sector, and for Schiphol Airport this is 5 billion *(Ministry of I & M, 2015).* The total direct employment of the Amsterdam seaport is 34.000 jobs; for Schiphol it is 65.000 *(Port of Amsterdam, 2013).*

The food and construction sectors have a relatively low use of circular services Circular services are sectors that are focused on product design, rental, repair and recycling. The average use of circular services in the Amsterdam metropolitan area is 14%. The construction- and food chain are below the average; they make use of respectively only 12% and 13% of circular services.

LOGISTICS HUB

The Metropolitan region is highly dependent on imports of raw materials In the metropolitan region 10 million tons of material is consumed annually, of which 60% is imported from abroad, see Figure 4.1 and 4.2 for further detailing of import- and export flows in Amsterdam *(CBS, 2015b).* More than 50% of the import consists of fossil fuels, that are mainly used in the petroleum industry for the production of plastic.

The supply of materials is vulnerable to strong price fluctuations and distortions in geopolitical context The high trading volume in the MRA offers economic opportunities but at the same time makes the MRA dependant to disruptions in supply. In addition, the import of biomass from abroad has significant negative consequences for the environment, due to non-sustainable land use and agriculture in South America and other regions.

USE OF MATERIALS AND PROCESSING OF BY-PRODUCTS

Use of materials in the making and processing industry is dominated by biomass and minerals In the metropolitan area, annually more than 10 megaton of materials – of which 40% biomass and 40% fossil fuels – are consumed *(CBS, 2015b).* Biomass is mainly used by the industry (70%) and agricultural- and food sector (20%). A large part of the biomass use is allocated to the extensive food- and stimulants industry, which uses produced biomass (of the agricultural sector) as input. Minerals are mainly used in the utility industry (74%) and the industry (17%) for example in the form of coal *(CBS, 2015b).* Metals are used in the industry for more than 90%.

Large flows of organic and mineral waste originate from industrial waste Of the waste that is produced in the MRA, only a small part is collected through the municipal system for household waste, see Figure 4.3 for further detailing of household and industrial waste. *(CBS, 2015b).* About 1 of the 6 million tons is municipal solid waste, mainly consisting of minerals and organic waste (in Amsterdam 14% is household waste and 86% is industrial waste). Non-municipal waste amounts to about 5 million tons a year, and consists mostly of mineral- and organic waste. This offers opportunities for bio-refinery applications for high quality use of residual streams to be applied to both, municipal and non-municipal waste collected.

Waste in Amsterdam is to a large extent processed in a relatively low grade One third of the total waste is incinerated, with which electricity and heat are generated. Less value therefore comes from waste compared to, for example, recycling or re-use. For domestic waste the rate for 'useful re-use' is 85% – as defined by the CBS. This includes activities such as the use of granulated demolition- and construction waste for road foundations, which in a circular economy can be regarded as a low-value application of recycling. Through high-quality re-use, recycling and composting more value can be extracted from these waste streams.

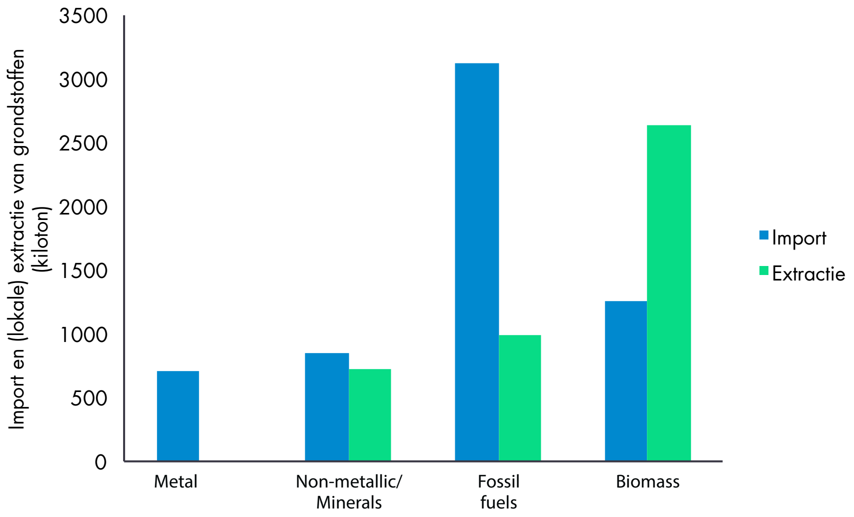


Figure 4.1: Extraction and import of materials in the metropolitan region of Amsterdam in 2014 (source: based on CBS and port of Amsterdam data with analysis of TNO and Circle Economy team)

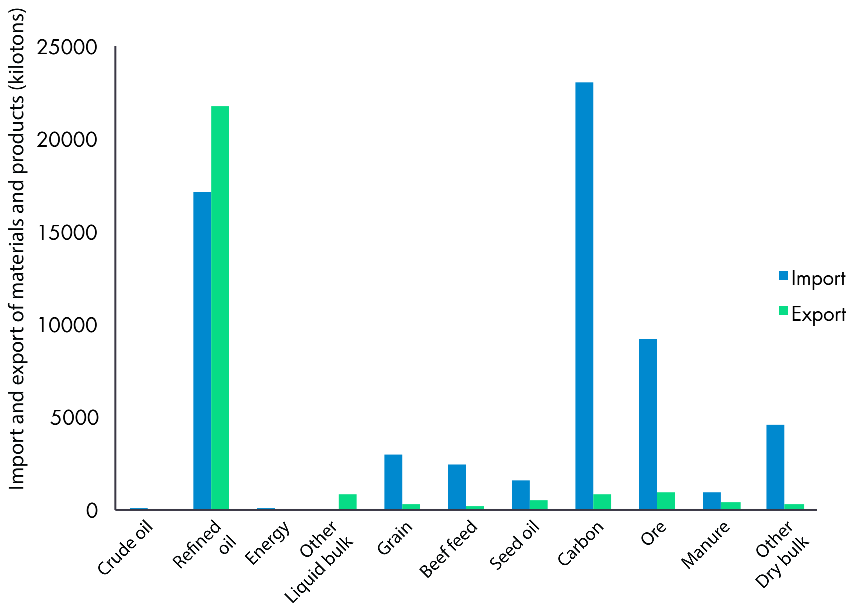


Figure 4.2: Import and export of materials in the metropolitan region of Amsterdam (source: based on CBS and port of amsterdam data with analysis of TNO and Circle Economy team)

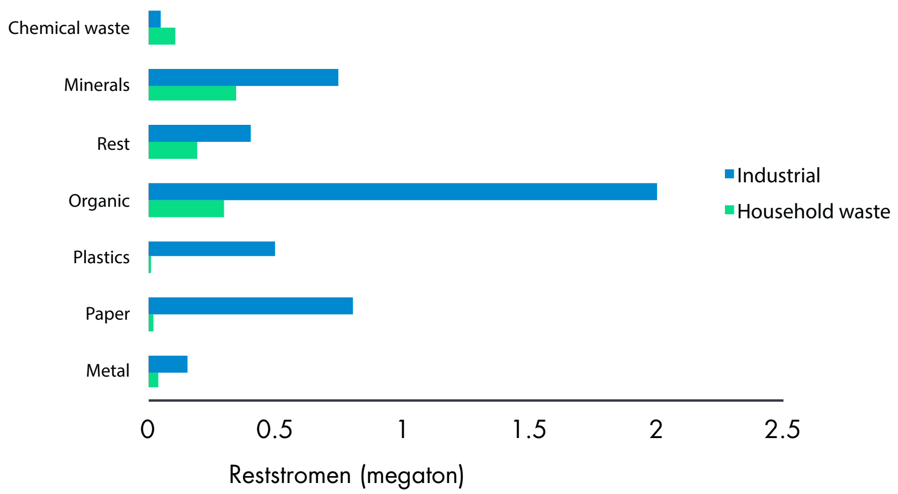


Figure 4.3: Residual streams in the metropolitan region of Amsterdam. (Source: based on CBS and AEB data with analysis of TNO and Circle Economy

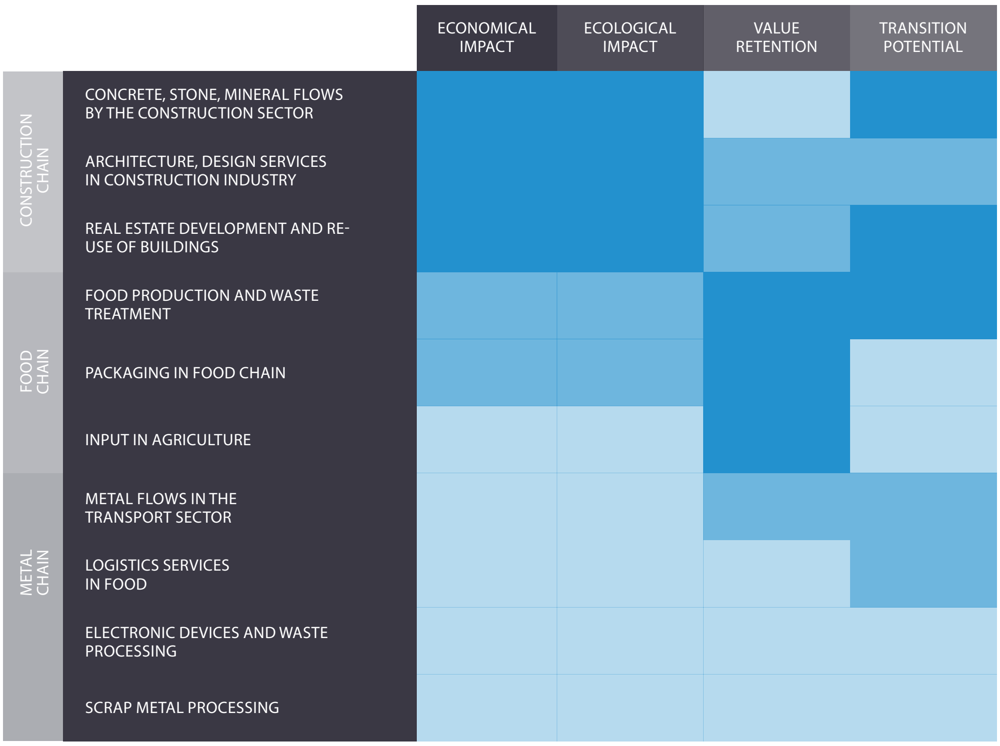
SELECTION OF

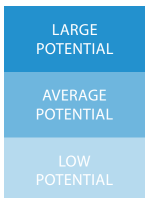
PRIORITISATION OF CONNECTING FACTORS IN A CIRCULAR ECONOMY

To come to understand the extent to which various chains contribute to the economic and ecological impact in Amsterdam a chain analysis has been conducted. This chain analysis provides insight into the connections between sectors in an economy. For example the materials (physical flows) and economic value (monetary flows) that sectors provide to one another. An example is the production of oil, the production of plastic from this oil, the use of plastic packaging material in the food chain as packaging and the waste processing of it. Exploring what chains between sectors result in large economic and ecological impact is a starting point to prioritise where possible interventions could reduce this impact. The four indicators used from the 'circular indicators framework' have been explained in the beginning of this chapter. For the economical and ecological impact and value retention, a comprehensive analysis has been conducted which linked hundreds of value chains and sectors together. The ten chains with the highest impact or the greatest potential have been selected. In addition, stakeholder interviews have been used to assess the transition potential. The ten value chains are shown in the table below in which shades of blue indicate that the impact of the potential is high. Of the ten chains, six are included in the analysis (not the metal chain).

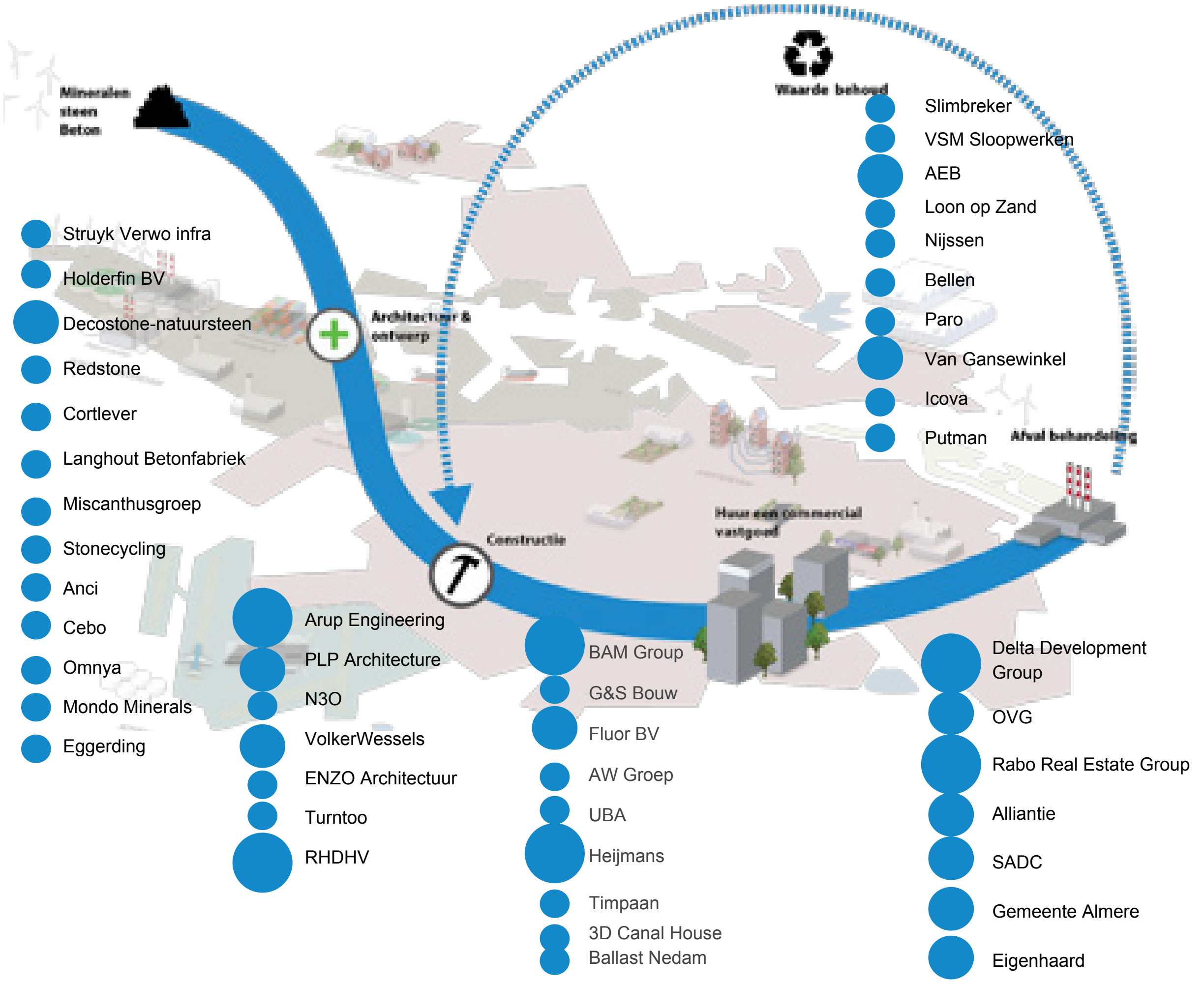
After consultation with the municipality and local stakeholders it has been decided to focus on the construction chain and on organic waste streams, as these have the highest economic- and ecological impact, and the highest value retention and transition potential.

The analysis of the value chains serves not only to achieve a transparent selection of important chains at which circular initiatives should be focused, but also provides an overview of economic sectors and actors that are associated with that particular chain. These actors can be a source of inspiration in the development of concrete projects with the actors that are factually active in the Amsterdam metropolitan area. Opposite is a representation of a - non-exhaustive and select - group of actors for the construction chain and organic residual flow chain.

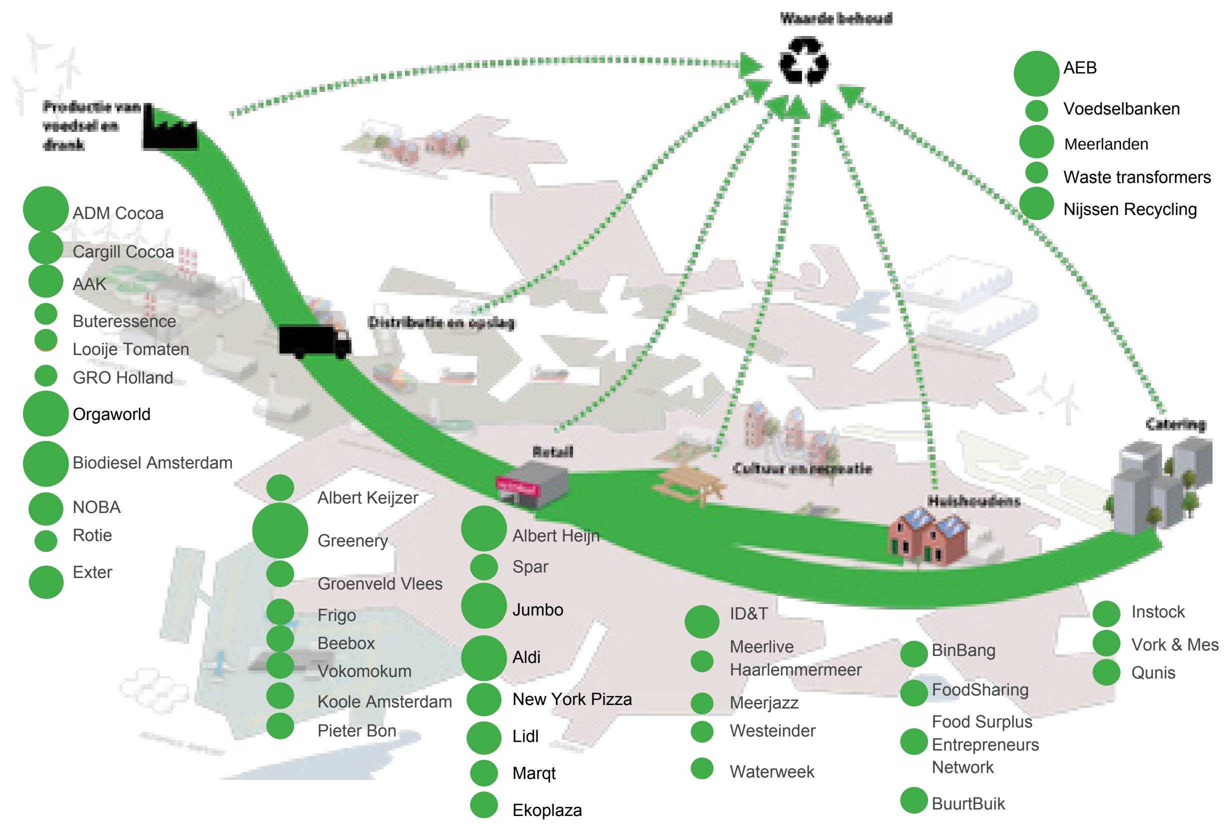




Overview of ten chains in the MRA. In an analysis developed by TNO and Circle Economy.



Overview of a select and non-exhaustive group of stakeholders in the construction chain. The size of the circle indicates the importance of the organisation. (Insights from interviews, literature and assessment of the research team).



Overview of a selective and non-exhaustive group of stakeholders in the organic residual flow chain. The size of the circle indicates the importance of the organisation. (Insights from interviews, literature and assessment of the research team).

INDICATORS CIRCULAR ECONOMY

This page represents how the city of Amsterdam, the metropolitan region and The Netherlands score on three indicators: value retention, economic impact and ecological impact. together these three indicators give an initial idea of how, on city-level, circularity could be measured. The three indicators developed in the context of the program RACE (Realisation or Acceleration towards a Circular Economy), a program initiated by the Ministry of Infrastructure and Environment. A summary of the indicators is presented on page 76. Previously TNO and Circle Economy calculated these indicators at the national level. The value retention is estimated based on the raw materials efficiency: the amount of waste that is produced to generate an added value of 1000 euros. The economic impact is measured as added value per person and the percentage of circular services in the economy: the proportion of the added value in an economy that is generated by services focused on product design, rental, repair and recycling. The ecological impact is measured by the indicators environmental costs and CO_2 emissions.

ECONOMICAL IMPACT

GROSS ADDED VALUE

Gross Added Value per person is the economic value in € per person

AMSTERDAM	MRA	NETHERLANDS
61295 €..	33616 €..	31256 €..

CIRCULAR SERVICES

Circular service is the percentage of services - related to the circular economy - compared to the Gros Added Value

AMSTERDAM	MRA	NETHERLANDS
N/A	14%	N/A

ECOLOGICAL IMPACT

ENVIRONMENTAL COSTS

Environmental costs are the costs incurred by depletion, water pollution, CO_2-emissions, toxicity and land use in €

AMSTERDAM	MRA	NETHERLANDS
N/A	52 €/kg	63 €/kg

CO_2-EMISSION

CO_2-emission is the amount of carbon dioxide released into the atmosphere in kilograms of CO_2 per person

AMSTERDAM	MRA	NETHERLANDS
5345 kg CO_2	8575 kg CO_2	9343 kg CO_2

5. RECOMMENDATIONS & NEXT STEPS

The roadmap and action agenda presented in this Quick Scan offer a starting point to give direction and concreteness to the ambition, vision and agenda on the theme circular economy. This report presents for two specific value chains – construction and organic residual streams - a roadmap and action agenda. Next steps for the municipality can focus on the further detailing of these plans. Also at stakeholders, both within the government and in the market, will need to be looked at finding support to actually take action on the proposed directions. Listed below are some next steps advised for the municipality.

- Further development and selection of indicators that provide insight in the essence of the circularity of the city of Amsterdam. This (basic set) of indicators can be used among other things to measure progress. The applied 'circular indicators framework' in this study (Chapter 4) can give direction to the next steps.

- The indicators can be applied in an interactive circularity dashboard which displays the progress of the most important indicators. The dashboard can be used internally, but can also involve inhabitants of the city more actively on the subject of circular economy. In addition, Amsterdam can (in the future) benchmark with other cities in the area on their circular performance.
- The action agenda and road map describe concrete actions to which the municipality can give directions from her commercial perspective. To come to a detailed feasibility of the proposed actions more analysis is needed. This analysis can include for example a further elaborated (social) cost- and benefit assessment for the various parties needed to come to implementation. Next steps in the investigation of opportunities for the city and region are among other things guaranteed in the program Urban Pulse led by Amsterdam Metropolitan Solutions (AMS) and Circular City.

- The need for greater transparency and a better understanding of the demand of (secondary) raw material flows in the region and beyond is mentioned by many stakeholders as a condition for a circular economy and optimal exchange between- and high-quality processing of streams. Further development of (geographical explicit) digital raw material platforms would herein have a crucial role to play. These connect supply and demand of residual streams and materials with each other.

- Linked to the previous point, there is also a need for empathically and active coordination on matching supply and demand. The municipality could explore what the possibility is to appoint chain directors who would be responsible for active matchmaking.

PROJECT TEAM

Circle Economy

Klaske Kruk, Project Manager
Marc De Wit, Project Manager
Shyaam Ramkumar, Circular Developer
Jurn de Winter, Circular Developer
Merve Güvendik, Circular Developer
Kay van 't Hof, Visual Designer

TNO

Ton Bastein, Program Manager Resource Efficiency and Circular Economy
Jacco Verstraeten-Jochemsen, Project Manager, Sustainable Cities
Elmer Rietveld, Researcher
Mara Hauck, Scientist Specialist on life-cycle assessment, Climate, Air and Sustainability.

FABRIC

Eric Frijters, Co-founder
Olv Klijn, Co-founder
Bass Driessen, Project Leader

EXPERTS CONSULTED

Hereby we express our gratitude to the following experts who shared their knowledge and specific data on the different streams in Amsterdam with us:

Sietse Agema, Strategic Advisor, Amsterdam Energie Bedrijf
Olaf Blue, Director, Delta Development
Martijn Bovee, Manager Strategic Accounts, Orgaworld
Bart Brink, Director Business Unit, RHDHV
Marc Brito, Senior Relationship Manager Public Sector, Rabobank Amsterdam
Jeremy Croes, Programme Coordinator Raw Materials & Waste Streams, Schiphol Airport
Pieter Goudwaard, CSR Advisor, Sustainable business development, Jumbo
Raymond Groot Lipman, Senior Account manager Wholesale Company, Rabobank Almere
Peter van Heerde, Account manager SME, Rabobank Schiphol
Angeline Kierkels., Director Public Sector, Multi-country
Fokke Kroesen, Environmental Manager, KLM
John Lubbers, Deputy head Economic Affairs municipality of Almere
Kees van der Lugt, Strategic advisor & innovation manager, Waternet
Ward Mass, Co-owner, Stonecycling
Dominique van Ratingen, Program manager sustainability, Amsterdam Economic Board
Jan Willem Reuchlin, Consultant Strategy & Innovation, Port of Amsterdam
Rene van Schaijk, Senior Account manager, Rabobank Amstel and fight
Wouter Schrier, Advisor on mobility and electric mobility
Jeroen Slot, Head of research, employee research and statistics, municipality of Amsterdam
Marc Spiller, Waste water treatment, Advanced Metropolitan Solutions
Sven Stremke, Principal Investigator for Energy, Advanced Metropolitan Solutions
Sabrine Strijbos, Sector Specialist Economic Sustainability and Fashion, municipality of Almere
Andre Struker, Strategic Advisor, Waternet
Philippe Vorst, Founder & Director, New York Pizza
Ad van Vught, Strategic Purchasing Manager, Exter
Bart de Wit, the Manager SMES, companies, Rabobank zaanstreek

Circle Economy is a cooperative whose mission is to globally accelerate a practical implementation of circular economy. To accelerate the worldwide transition towards a circular economy, we use two main levers:
1) Practical action, aimed at developing practical solutions;
2) Campaigns, communication and engagement, aimed at spreading our message. We focus on projects and activities that are both practical and scalable.

TNO is a non-profit organisation that applies thorough scientific principles to a wide range of disciplines. TNO is active within five key sustainability themes: industry, healthy living, energy, the environment and defence and security. TNO is one of the most internationally oriented research and technology organisations in Europe and has an unparalleled knowledge base full of information about innovation, sustainability and policy making. Maintaining and improving this knowledge bank is a high priority as we continue to develop within international knowledge networks.

FABRIC is a knowledge-intensive design studio led by Eric Frijters and Olv Klijn. The involvement of the two founders in architecture, urban planning and research led to the creation of FABRICations. Our motto is: "Think while you do." The motto expresses the thorough approach that characterises FABRIC. Our innovative solutions are rooted in a huge technical, historical and cultural knowledge. With each project, we invest in research to even further increase the available knowledge and to further improve the quality of our proposals. We want to be the best knowledge provider and the most innovative solution creator. That is why we often form partnerships with other similar knowledge-intensive companies.

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