

UJP

CYCLE

AMSTEL

Colofon

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Key findings

The potential for Amstel III

This publication focusses on Amstel III to summarize top-down policies and bottom-up stakeholder value chain engagement for urban upcycling. Its four chapters summarise the following findings.

Chapter one Framework

Governing bodies from the EU to the city of Amsterdam have goals to change to a circular economy:

The European Union

Reducing waste and creating methods to reuse materials.

Netherlands

Being 100% circular by 2050, and reducing materials consumption by 50% by 2030.

Amsterdam

To be a global leader in the development of the circular economy.

Chapter two Upcycling

To archive upcycling for urban areas we should integrate these methods into the construction value chain:

Negotiating

To clarify circular commitments.

Making an inventory

To map materials, quantities and qualities.

Harvesting

Saving materials for re-use and upcycling.

Distribution

Creating an efficient marketplace.

Documenting

Material passports to document materials.

Chapter three Case Study

Analysing a case study area and building shows the potential to upcycle materials for urban transformation:

Harvest potential

To harvest more than 2.500 m³ reusable materials from the case study building.

Densification potential

To build a double denser city with the use of 28% less energy.

Embodied energy potential

To save 500.000 GJ in embodied energy through re-use and upcycling.

Chapter four Drivers

Based on an analysis of current initiatives and best case studies, we advance 5 key drivers of urban upcycling:

Robotic refabrication

To treat materials fast and automatically.

Component upcycling

To upgrade material and add value.

Stakeholder synergy

To be mutualistic and win together.

Design for disassembly

To ensure future potentials for re-use.

Community engagement

To evolve people and improve behaviour.

FRAMEWORK

Circular Economy

A new model for reducing material consumption and greenhouse gas emissions.

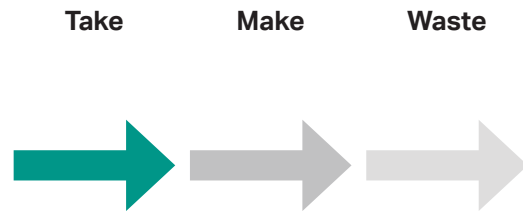


Image The linear economic model

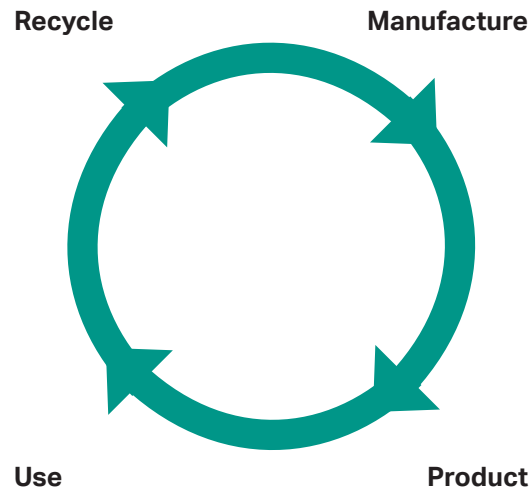


Image The circular economy model

Circular Principles

Three key principles for the circular economy.

Three key principles of Circular Economy¹

1. **Design out waste**
2. **Keep materials circulating**
3. **Regenerate natural systems**

Design out waste

In a circular economy, materials and products are continuously cycled at their highest value and for as long as possible. With a multi-stakeholder model, the circular economy seeks to unite parties within the construction value chain to design out waste and introduce new processes to the built environment.

Regenerate natural systems

A circular economy could be seen as an alternative to our current unsustainable status quo: reducing our environmental footprint and, at the same time, boosting the competitiveness and livability of our cities.⁴

Keep products and materials in use

Handling materials in a circular way means retaining their integrity and ensuring material reuse at a high value. 'Old' materials can be sold after initial uses turning disassembly into a novel business opportunity. In both existing and new buildings, there is a great challenge in preserving the value and use of materials. Design for Disassembly can be leveraged for new construction projects to ensure that building products can have a life after their original usage.

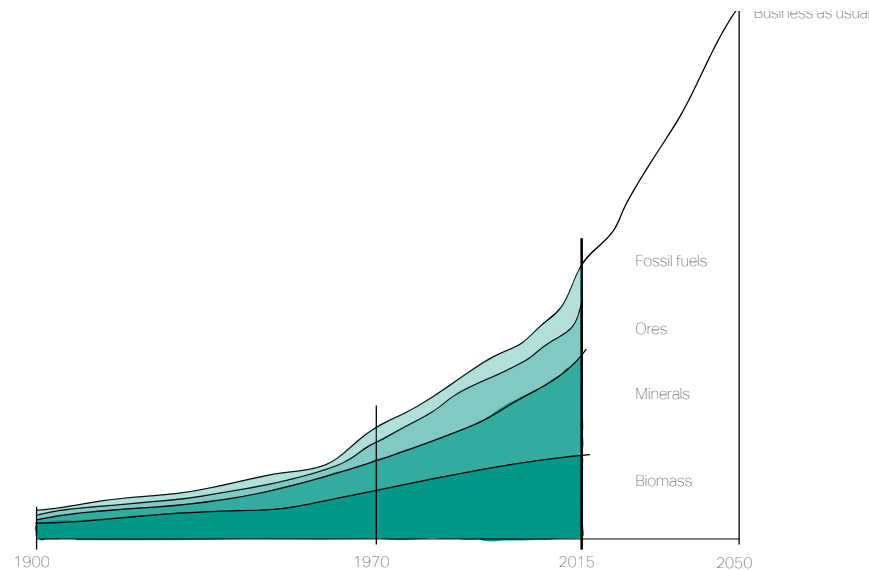
Raw materials

Our use of materials is exploding and is fast becoming unsustainable.



Global use of materials have almost tripled, from 26.7 billion tonnes in 1970 to 84.4 billion tonnes in 2015.² Today 67% of global greenhouse gas emissions are related to material management.³

Framework



Circularity gap report, Circle Economy

Depleting stocks

Material stocks are depleting, a new economic model is needed.

If we continue creating waste and polluting our material stock with business as usual we will not be able to sustain our current lifestyle. Design and construction must transition to a more sustainable model.

Materials are depleting

The built environment has a large impact on earth's climate and material stocks. The current linear economic approach can be described as take-make-waste and does not contribute to a more sustainable world. Almost all the materials in the building sector are unearthed as raw materials, manufactured into products and used once for building before demolition and downcycling degrades their value. When a building is at the end of its life, large amounts of materials and products end up as landfill. Value and embodied energy is lost and the production of new materials strains the environment and contribute greatly to greenhouse gas emissions.

Economic transition is needed

In order to make a positive change in the built environment, a transition is needed toward a different approach. This transition will have to break with our current economic models, where the take-make-waste remains widely used. Instead, we must keep materials cycling at high value and seek ways to reduce greenhouse gas emissions. This is possible. Resource-efficiency development could reduce our natural resource use by 28% and still support economic growth.⁴

Framework



Political Frameworks

Circular Economy becoming integral to advancing sustainable transformation.

Since the 2011 publication "Roadmap To A Resource Efficient Europe" the circular economy has received growing attention at the European, Netherlands and Amsterdam levels.

The European Union

The EU will strengthen economic resilience and independence by reducing waste and creating methods to reuse materials. This entails reducing the usage and import of materials. Creating new jobs. Stimulate research & innovation. Long-term thinking of costs. In construction, this entails stimulating design for disassembly, additive manufacturing and collaborative consumption to work towards circular buildings.

The Netherlands

The Netherlands will be 100% circular by 2050. The country is pushing to change regulations to boost circularity start-ups. It will share and expand knowledge platforms and promote circular economic growth, while also stimulating circular behaviour for citizens. In construction, the Netherlands will minimize material use and CO₂ output by maximizing building lifecycles, and working only with renewable raw materials or secondary materials.

City of Amsterdam

The City of Amsterdam will be a global leader in the development of circular economy. It will do so by bringing stakeholders together through specific project locations and implementing strategies to improve circularity.

The city will seek to become a platform for circular initiatives to help facilitate resource and material storage, and stimulate high-value re-use and material passports.

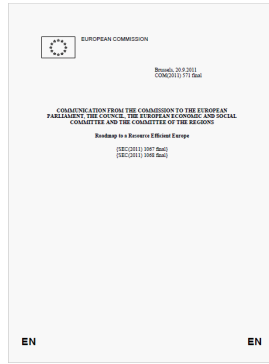
Amstel

Within the Amstel development, the City of Amsterdam will explore how to use circular economy to create sustainable transformation of the area. The City will bring stakeholders together at specific project locations to stimulate the deconstruction of buildings, in ways that allow to use materials in suitable buildings for the mixed urban area. Next steps include bringing stakeholders in the area together and making them aware of the circular approach, while negotiating circular restrictions to new buildings.

The European Union

The Netherlands

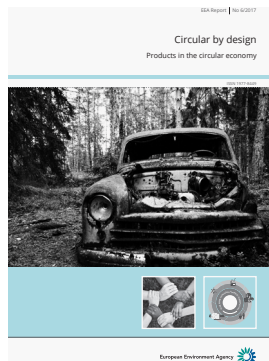




Title Roadmap to a resource efficient Europe^a
Year 2011
Author European Commission



Title Living well within the limits of our planet^b
Year 2016
Author European Commission



Title Circular by design^c
Year 2017
Author European Environment Agency

The European Union

Using a circular economy to economic resilience and global position

Vision: In 2050 the European economy is competitive, inclusive and provides a high standard of living with much lower environmental impacts. Europe will be a sustainable world leader in knowledge.

Principles

The European Commission has put the circular economy transition into its top ten priorities.⁵ The Commission encourages long-term innovative thinking in business, finance and politics, to advance new sustainable practices and breakthroughs in innovation around the circular economy. Knowledge sharing across countries is integral to this. Knowledge should be shared through innovative projects, where the European Circular Economy Stakeholder Platform connects stakeholders with public and private background to exchange approaches and build efficient partnerships. The real costs of resources use should be reflected in market prices, taxes. Within this vision of the circular economy, all resources should be sustainably managed, in a way that Europe is independent of the import of raw materials and reduce the generation of waste. Therefore, all raw materials should be reused in the future. These efforts seek to both reduce materials dependencies and create new jobs.

Construction

The EU highlights change by developing old ways of design and building to new models, such as design for disassembly, using prefab building elements with a higher reuse potential, saving new materials with additive manufacturing (3D printing), and recovering old ones via collaborative consumption.

The Netherlands



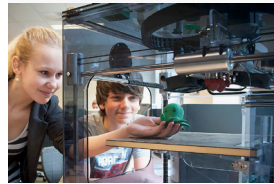
Amsterdam

The Hague
Rotterdam

Utrecht




A Circular Economy
in the Netherlands
by 2050



Title A Circular Economy in the Netherlands by 2050^d
Year 2016
Author European Commission

The Netherlands

A 7.3 bn. potential prompts the Netherlands to be fully circular by 2050.

Vision: The Netherlands has the ambition to be the circular hotspot of the world, with a goal is to reuse raw materials efficiently by 2050 without harmful emissions to ensure that the Netherlands will be completely circular with a future-proof and sustainable economy⁶. The in-between step is to aim for a reduction of 50% of raw materials used by 2030.

Principles

The Netherlands want to reach this goal by promoting resource efficient industrialization and innovation and using cleaner technologies. The Netherlands Organisation for Applied Scientific Research (TNO) has calculated the circular potential for the country to amount to 7.3 billion euro per year.⁷ Within the construction sector, the implementation of material reuse has the potential to create a value of 85 million euro per year⁸.

Four policy options are formulated by the Netherlands Environmental Assessment Agency (PBL):

1. Market and environmental pricing
2. Stimulating laws and regulations
3. Innovation policy
4. Government as a network partner.

Construction

The Environment Act offers new opportunities to realize circular ambitions at a local level. It forms a vision on how to get the ambition realized, together with stakeholders. Among these stakeholders, knowledge must be extended and spread. A change is needed in regulations to boost the reuse of materials, and new buildings should be made more flexible in order to extend the lifecycle of materials and products. Damage to the environment must be internalized to correctly reflect in the price of raw materials. To work towards a circular economy in the construction sector the Netherlands seeks to minimize the use of new construction materials and CO2 output by maximizing building lifecycles.

Amsterdam

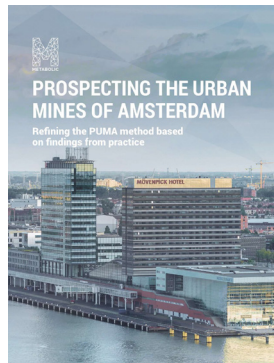
Havenstad

City Center

Amstel



Title Circulair Amsterdam^e
Year 2016
Author Circle Economy



Title Prospecting the urban mines of Amsterdam^f
Year 2016
Author Metabolic



Title Amsterdam Circular, Evaluation^g
Year 2018
Author Circle Economy

City of Amsterdam

With knowledge exchange working to a more sustainable Amsterdam with less material

Vision: Amsterdam wants to stay frontrunner in the circular economy. With this vision Amsterdam hopes to attract companies and start-ups, using the city as a living lab for the circular economy.

Principles

To achieve systemic change, the City of Amsterdam have set out a number of projects for working towards a circular economy, namely: the Circular Innovation Programme; the Waste Implementation Plan, the Circular Land Issue map, and the Learning by Doing and Amsterdam Circular Vision and Roadmap. With these initiatives, the municipality seeks to build and share knowledge and have initiated projects within three key value chains:

- Construction Chain
- Biomass & Food
- Consumer goods

The learning by doing method is about sharing the knowledge amongst all involved parties as the municipality, private companies and knowledge institutions. It has the aim of the municipality to prove in practice that a circular economy is profitable in all aspects.

Construction

The focus for the construction sector is on reducing material consumption and closing recycling loops. The transition is based on four strategies for improving circularity in the construction chain within Amsterdam, which are:

1. Smart Design
2. Dismantling & Separation
3. High-value recycling
4. Marketplace & Resource bank.

Developers and designers are encouraged to work with these four strategies to adapt circular approaches into building projects. The private sector will be challenged to work towards developing circular construction projects, as the City of Amsterdam recently launched its first Roadmap for how to increase circularity in tenders.

Strategies

For implementing a circular economy.



EXPLANATION

Smart Design

New technologies can improve high-value reuse or transformation. This can lead to less waste, less materials used and fewer transport costs.

IMPLEMENTATION

This strategy can be implemented on tender criteria to challenge both existing companies and innovative start-ups.



Dismantling and Separation

Require a DBFMO-D (demolition) plan for buildings. Avoid cross contamination of materials. Material passports should be used to give insight into the composition of buildings.

Demolition companies can start with a better plan. Initiators of projects can start thinking of what to do at end of a building's life.



High-value recycling

New ways should be found to recycle construction waste at high value. Deconstruction companies should promote and sell re-used materials.

Implemented on the purchase of materials so it can be profitable. New companies that produce high-value recycled materials have a chance to develop.



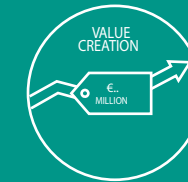
Marketplace and Resource bank

With a (digital) platform parties can exchange materials and resources. Facilitating this platform will push towards the re-use of materials.

The municipality can provide tools to the start-ups in this field to upscale their business.

Indicators

For measuring effects of the circular economy.



EXPLANATION

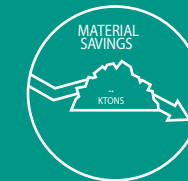
Added value in Euro

The circular strategies enable added value to multiple sectors in Amsterdam.



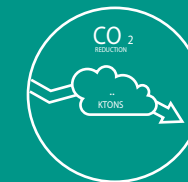
Jobs Growth in FTE

The realisation of jobs is representing the social aspect of an increase in circularity. It is estimated on the increase of added value, salaries and demand for skilled workforces.



Material savings

Looking at the use of materials in the area and that are imported and exported, expressed in Domestic Material Consumption (DMC). It takes all environmental impact factors.



CO₂-reduction

Expressed in Global Warming Potential (GWP), which expresses the avoided CO₂-emissions in the coming years with an increase in circularity, over a period of 100 years.

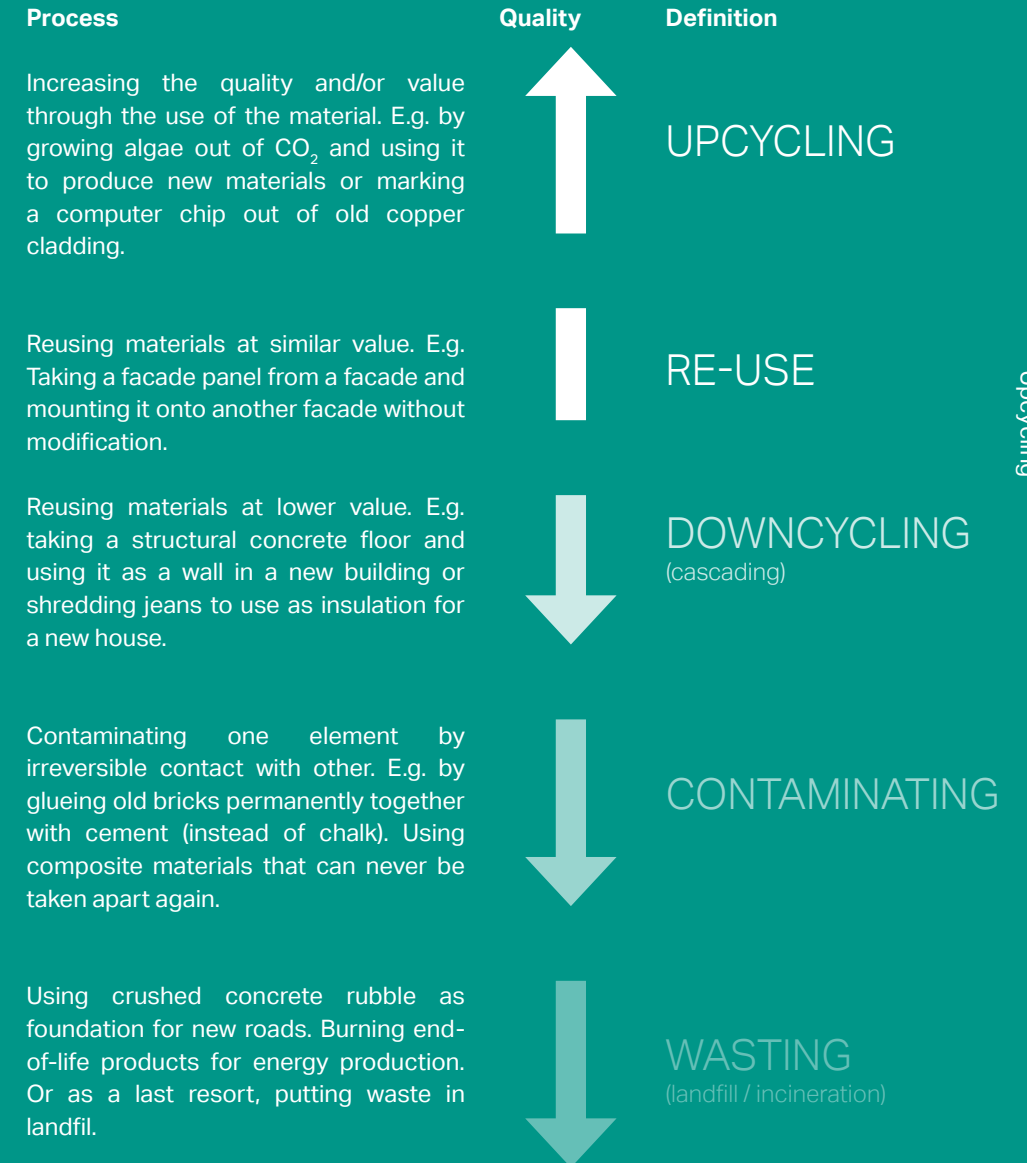
UPCY

CLING

Definitions

Upcycling, Re-use, Downcycling, Contaminating, Wasting

Upcycling



Upcycling

Definitions

Circular cheat sheet

Understanding the definitions and impacts of materials, energy and the environment is key to enabling urban upcycling at scale.

Embodied energy

The energy that is needed to produce products or buildings we call embodied energy. We use it to determine the effectiveness of recycling. Different materials need different amounts of energy to produce, so have different amounts of embodied energy.



Environmental stress

Problems with waste lead to problems with our climate. Man-made climate change is amongst the largest challenges today, and environmental stresses become an important metric for evaluating problems with waste, re-use, and up-cycling.



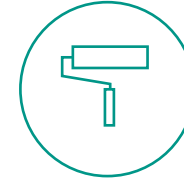
Incineration

Incineration is the combustion of waste materials. It is often promoted as recycling process, because it produces some energy, but is in fact one of the best examples of failing circularity. It is the least preferred end-of-life process in the material cycle.



Greenwashing

Sometimes the promotion of something environmentally friendly overshadows the real environmental profit. Pretending to do something sustainable, but in reality do much more harm than good. A green vertical garden on very unsustainable buildings is the most obvious example.



Landfill

Today most construction waste ends up in landfills or as crushed road fill. In the perspective of circular economy this needs to change. We need new strategies for re-using and upcycling materials and better ways of managing our waste. In the case of landfill we strongly advise keeping materials separated to enable future upcycling and re-use.



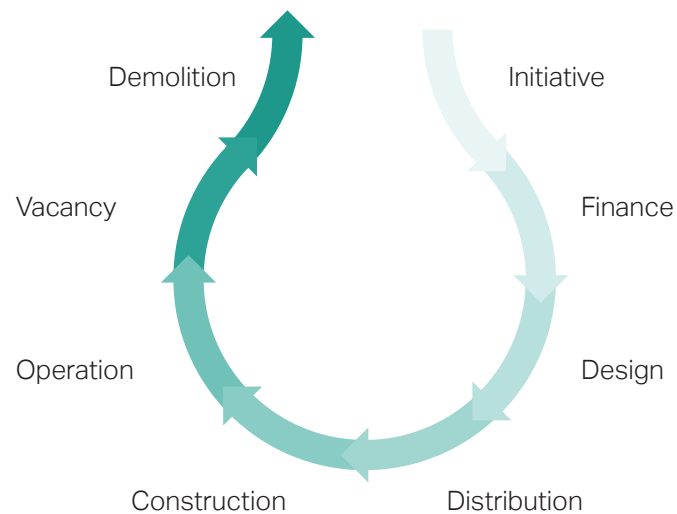


Image The diagram shows how the different phases follow each other, until the final phase has been reached: demolition.

The construction chain

Understanding business as usual to create structural change

The construction chain as we know it now is a finite process. Usually this process ends when the building is not meeting its requirements anymore and is demolished. This section explains how the chain works and how to extend it.

Every construction process starts with an initiative. In many cases an initiative arises from the need of a (new) building or function, simply because that specific building or function is lacking, or because the existing building does not meet its requirements any longer.

When the initiative has been defined, a financial plan is needed to fund the project. In some cases the initiating party takes the responsibility for funding the initiative. In other cases external financiers are also involved. If there are enough parties to support the initiative financially, the design process can be started. Together with engineers and advisors, architects create a design.

When the design is approved by the client and the municipality, a contractor can take on the job and start bringing all needed materials to the site. This process is called distribution. In the meantime, construction can start. All materials and elements are brought together on site and assembled. When construction is finished, the building is ready for operation and maintenance until it no longer serves its purpose.

By then, it will inevitably sit empty. In many cases, this will result in demolition of the building. When it has been demolished, the plot is freed up for a new initiative and the construction process can start over again. For many years, this linear process has repeated itself over and over and in most cases continue to do so today.



Image The total demolition entailed a 50.000 m² building that released roughly 45.000 tons of rubble. About 25% of this rubble is reused on site for construction means. The total process takes 9 months and will be finished at the end of 2018.

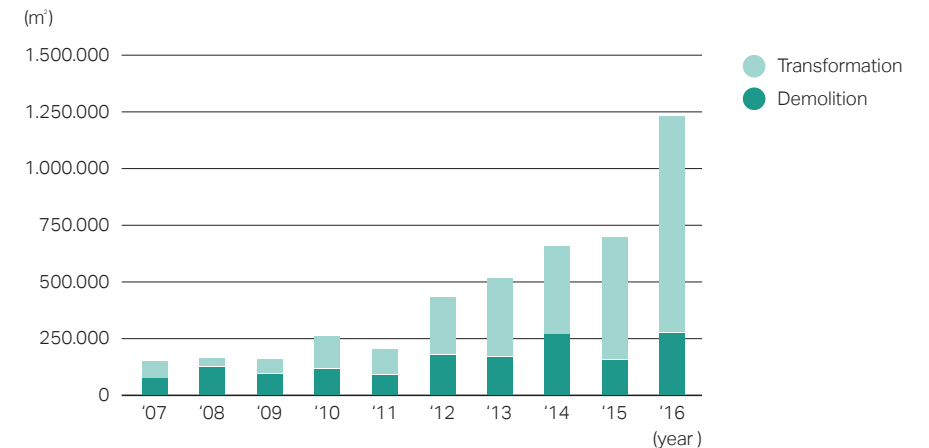
Demolition

An insight into the vacant office market

When we look at the office market, we actually see a gradual increase in demolition projects over the course of the last decade. This decrease is caused by the increasing demolition and transformation of office buildings.

In 2016 more than 250.000 m² of office space was demolished. The result of a demolition job is lots of rubble. In some cases part of the rubble is reused on site for new building purposes, but in many cases the rubble is downcycled and used as filler for roads.⁹

One of the largest demolition companies in the Netherlands is currently demolishing a former office building of the ABN-AMRO bank after it had been vacant for 12 years. The total demolition entailed a 50.000 m² building that released roughly 45.000 tons of rubble. About 25% of this rubble is reused on site for construction means. The total process takes 9 months and will be finished at the end of 2018.





1. Negotiating



2. Inventory



3. Harvesting



4. Distribution



5. Documenting

Methods

From negotiation tools to material passports

There are many methods to consider to advance upcycling. These methods vary from negotiating to documenting materials by means of material passports. They are used before, during or after construction projects.

This section will highlight some methods that one should be aware of when thinking about upcycling. In particular, 5 methods will be discussed:

1. negotiating
2. inventory
3. harvesting
4. distribution
5. documenting

There might be more methods that engage with upcycling, but in our opinion these five are unmissable. Each description will be accompanied by an explanatory scheme and an interview with a stakeholder that is actively engaging in that specific method.

Interview with Owen Zachariasse

Delta Development Group

"The best scenario is when stakeholders are on one side of the table and the problem is on the other side."



Owen Zachariasse works as consultant at Delta Development. As a developer Delta Development has grown from project pioneers in sustainable development to specialists in Cradle to Cradle optimized real estate.

"However, Cradle to Cradle is not our main driver", Owen explains. "Our desired outcome is broad based value creation. For us it is also important to maximize value creation in the local community. Secondly, we look at what's valuable for the ecosystem. Incorporating public space in their developments as much as possible is also important. The tenants of a building should be in charge of what happens to the public surroundings. They will notice a decrease in quality, not the people at the municipality looking at the numbers."

Upon being asked what distinguishes Delta Development from other real estate developers, Owen replies: "Bizarrely, not much. We add a new element to real estate development which enables us to approach the building from a unique perspective. We use a lot of the same tools and tactics. I believe firmly that if you want to get to a place where you have an accepted agreement between

two people, you have the fundamentals correct. That is real estate development. People understanding the outlines of the deal."

So what is important when entering a negotiation? "Meet the client on their home turf and make your plans as understanding as possible. Then, when you reach an understanding, you can present the designs. After the "fantastic, I love that" moment, which is the critical part of the process, then you start discussing the costs. All of this is important for successful negotiation."

Owen firmly believes in negotiating from a principle standpoint, instead of from a position standpoint. When stakeholders try to align their principles, they have a better chance of getting to an understanding. He continues: "The underlying principles are not being discussed many times and that is leading to everyone hitting a wall. The best scenario is when stakeholders are on one side of the table and the problem is on the other side. And a common source of information is a good way to look at these principles."

Negotiating

Methods



Before, during and sometimes after a construction process, negotiations take place that can allow for the introduction and clarification of circular commitments.

Negotiating parties, such as municipalities, developers, architects and builders, might well have their own goals they want to see achieved in the project and certain compromises often need to be made to reach an understanding.

In a situation where an architect wants to design a building, consisting of upcycled materials, he will probably need to convince his client that this is a good idea. Measures such as costs, total value, environmental impact, and increased flexibility of the resulting building are all elements that can play their part in these negotiations. In such cases, it can be very helpful to know how upcycling can be translated into realistic measures for creating short, medium, and long term value.

In cases where developers seek to develop a plot in an urban area, they will likely need to negotiate with the municipality on many

matters. The municipality sets rules for building height and density, for example, and energy efficiency requirements, but might be able to relax some of these rules, if the developer is willing to make other concessions.

In a scenario where the municipality already has an idea for that specific area and wants to create a circular example out of that area, it is likely that the municipality will make a deal with the developer: the developer can build higher and denser, but needs to invest in circular measures. For example: the building needs to contain a certain percentage of upcycled materials or the public space around the plot needs to be upgraded with circular measures.

These examples show that each stakeholder has their own set of measures to use during a negotiation. It can therefore be very useful to know what these measures are in advance and how they can be leveraged to advance circular design and construction.

Interview with Merlijn Blok

Metabolic

"There might be a lot of value inside buildings. Having an indication of this value, the material types and logistics helps in opening up the conversation around future reuse."



Metabolic is a consulting and venture building company that uses systems thinking to tackle global sustainability challenges. Their work is strongly guided by the principles of system thinking, collaborating, practicality and empowering others.

With regards to a circular built environment, Metabolic is engaging in making material inventories. Merlijn explains: "By providing insights into the amount of materials inside buildings that are up for demolition or transformation, we want to try and predict the built environment better. We want to measure the circular built environment in an integral manner and visualize the impact. In addition, we want to start and engage in a conversation. There might be a lot of value inside buildings that are up for demolition, so let's see if we can do something with it." He continues: "Per region we try to create an overview of what projects will take place during a certain period. The timelines of construction projects, transformation projects and demolition projects are then all 'connected' to see if matches in supply and demand can be made."

So how do you come up with these insights? "In collaboration with SGS Search we use building specifications,

cost estimates and other bottom-up studies as a reference to roughly calculate what the amount of building materials in a certain building type is. This comprises information on roughly 500 building elements and 50 materials, which allow us to give indications on how much square meters or kilograms of a component or material is inside a building." He emphasizes: "It is important to note, that we do not claim to portray the real numbers. We haven't actually been inside the building. We create a model of what it could potentially be to start the conversation about the actual opportunities for urban mining.

Metabolic is all about collaborating and working together with government institutions for example. "We are also trying to find out what the annual material streams are for entire regions. What is the impact and value of these streams? Knowing this gives us the possibility to create a better match between supply and demand, so that we can reduce the impact of the built environment in general."

Inventory

Methods



For designers and builders wishing to work with reused and upcycled materials, it is necessary to know what materials or components are available. This is why inventories are made.

Making in an inventory means getting an overview of the amount of materials and components that can be harvested from a certain building on or near a site. The quality and value of these items are also evaluated. Two known methods for making an inventory will be described here.

The first method is based on the use of key figures and formulas. Depending on the parameters, the quantities of the different types of materials can be determined. This method can be applied fairly easily, if the right information (such as?) is available.

The second method is more precise and hands-on. It requires a person going on site and into buildings to measure and/or count components that might prove interesting. It will inevitably be quite labour-intensive and time consuming.

There isn't necessarily a 'best' method, since the desired outcome can vary. If the goal is to acquire a rough number of the amount of concrete within an office area, the first method would be preferable.

However, if the goal is to find out the exact amount of windows in a certain building in that area, rough numbers are not enough. In that case, an on-site inventory needs to be made in order to get exact numbers.

For architects and builders who want to engage in upcycled materials, it is important to know the measurements and quality of the materials that are to be reused. It is therefore important to also take pictures of the harvestable materials and items and determine the assembly of these components.

Interview with Sanne Verhoeve

Superuse Studios

"In 10 to 20 years we expect reuse to be part of every tender, of every building design."



The founders of Superuse Studios were one of the first to create an online marketplace for redundant and second hand materials. They called it Harvestmap. All materials, ranging from small quantities to continuous flows of (industrial) leftovers are represented. The goal of the marketplace is to bring supply and demand together and increase the reuse of redundant materials.

Sanne explains: "We prefer to harvest materials when we already know how the material will be reused. The reason we do this, is because there is a large volume of supply of rest materials available, that is constantly changing. Thanks to our network, we are up to date on the ongoing demolition projects and other sources for reused materials."

So what is important when harvesting materials? "There are quite a few things you should take into account, but it is not always possible (and necessary) to apply them all. Focus on large amounts, to make it logistically more feasible; focus on financially valuable materials. This is necessary to still make a revenue after all the consulting, disassembling and transportation has been done; try to use materials that can be customized, to make

reusing them easy; if possible, try to reuse materials within the same organization. Many times there are possibilities for internal storage and reuse."

There is one precondition: "With regard to limiting the CO₂-emission, we take into account the fact that the ecological gain of reusing can be greater for materials where the production process has a large CO₂-emission (such as for steel) than for materials based on renewable raw materials (such as sustainable wood for example). For this reason, for example, it can be ecologically justified to transport steel from a greater distance than wood."

So what's up next? "In 10 to 20 years we expect reuse to be part of every tender, of every building design, and that dismantling and pre-demolition take place prior to any demolition project. We also believe that material passports will support and enable the reuse of materials. Lastly, we think that suppliers of building materials will rent out building parts instead of selling them, keeping manufacturers responsible for their own products during the waste phase. This way the (raw) materials will return to the manufacturer."

Harvesting

Methods



Harvesting describes the process of salvaging components and materials from buildings. Instead of demolishing a building entirely, the reusable materials are carefully removed and separated.

To do this in an effective way, material knowledge and knowledge on the assembly of these materials is necessary. How are they connected to other building parts? Will they break if taken apart? This information help determine the potential reusability and therefore also the value of harvestable materials.

Harvesting the materials can be done in different ways. Some harvesting projects require machinery, but others can be done by hand with simple tools. The choice of tool depends on the building and materials. Interior parts of a building, such as windows and doors, cabinets, installations and ducts, furniture, cables and lighting etc. can be harvested by people without the need for heavy machinery. However, if heavy structural elements need to be extracted, machines are necessary for lifting, turning and placing. In this case, professional companies such as demolition companies can be hired to do the job.

Instead of only taking on traditional demolition jobs, we see that some demolition companies are starting to get involved in harvesting jobs. Demolition is not always what the client wants and some cases have shown that harvesting a building instead of demolishing it is financially more interesting because of the re-sell value of harvested materials.

Interview with Michel Baars

New Horizon

"We are not a demolition company that needs to get rid of their waste, we are a supplier that supplies products."



They harvest reusable materials from buildings at the right moments: during renovation, transformation or demolition processes. The circular economy is no hype for them, they truly believe it is the new economic model.

What distinguishes New Horizon from other demolition (or harvest) companies, is their market approach and distribution method. "There is a market where there is a demand for products. We deliver our harvested materials to distributors and manufacturers and approach the distribution process from their perspective. That's why we incorporate our distribution system within their existing systems. We are not a demolition company that needs to get rid of their waste, we are a supplier that supplies products."

If the harvested materials are reused for construction purposes anyway, why not storing them temporarily? Michel replies: "There are a few reasons why not to do this. If I want to store my product, that means my product has to be picked up from the harvest site and brought to the storage site. But then, it also has to be picked up again from the storage site and be brought to its final destination. In the

meantime I have to pay for transport, a storage place, insurance etc.. I don't want that." He continues: "Also, in many cases, too many actions are required to make the material suitable for immediate reuse. A window frame has to undergo 6 steps before it can be reused properly. That's too labour intensive."

So what happens to these materials after they have been distributed? "Our partners from the Urban Mining Collective create new products out of our materials. We set a standard based on the best practices of that moment. We trust each other on that we all have the same goal. We want to be innovative." The Urban Mining Collective is already quite a large group of companies. "Yes, and we are still growing. We want to add designers and builders to the group and discuss circular design processes."

I also heard that you want to bring a new circular product on to the market every month, is that right? "Yes, so I guess we have to hurry!"

Distribution

Methods



Bringing the materials that come from a harvest location to the construction site requires a logistical plan.

In some cases, materials or items might be needed on short notice. In other cases, they might not have a place to go yet, in these cases, if the materials come in great numbers, a lot of storage area is needed. If the materials are large and heavy, the necessary machines to handle them must also be available. All these factors need to be considered when deciding what to do following a material harvest.

There are three ways to handle these harvests:

1. The harvested materials are brought to a (temporary) storage place. This can be a location nearby the harvest location, or nearby the location where they are to be reused. The last option is usually preferable to save on extra transport cost (and time).

2. The harvest is distributed to a manufacturer who will re-sell the materials. For example, a manufacturer of wooden window frames buys the harvested window frames and repairs and refurbishes them. In some cases, this can be done easily, resulting in a fairly new product ready to be sold again.

3. If the harvested materials do not have a destination yet, they can also be sent off to an (online) marketplace. Here they can be sold when someone is interested. Marketplaces for building materials buy the materials and re-sell them to any interested buyer either online or in a store.

Interview with Pablo van den Bosch Madaster

"There is a physical reality and a digital reality. The physical reality is always too late."



It is Madaster's mission to eliminate waste by providing materials with an identity. The Madaster Platform is designed as a public, online library of materials in the built environment and facilitates registration, organisation, storage and exchange of data.

Building owners, contractors, developers or architects. Anyone can use the platform and store the information online. Madaster analyzes the information and connects extra information from other databases to that building file, such as material certificates, quality and material price: "We have information on hundreds of thousands of materials."

Why do this? "The supply chain in the building sector is long and traditional. Products usually last a long time, so the need for renewing is little." Therefore it is important to document what materials there are now and in what state: "Documenting is cheap, because it's so easy. All the big contractors use our platform."

"We also want to prevent information on materials falls in the hands of commercial enterprises. Therefore, we carefully focus on privacy, security and continuity." "As owner, you have to allow other people

to look into your own information. You decide what information you want to make visible."

Pablo believes that digitalizing is necessary to make a large transition possible and, on long term, to prevent the raw materials from depleting: "There is a physical reality and a digital reality. The physical reality is always too late." During demolition jobs, most of the times it is not clear what the material quality or value is. It is therefore harder to decide what to do with the material, than when this information is available.

Madaster believes in cooperating with other stakeholders: "We want to cooperate with everyone and go global to realize the transformation of the economy. We are vision driven, not business driven. We are transparent."

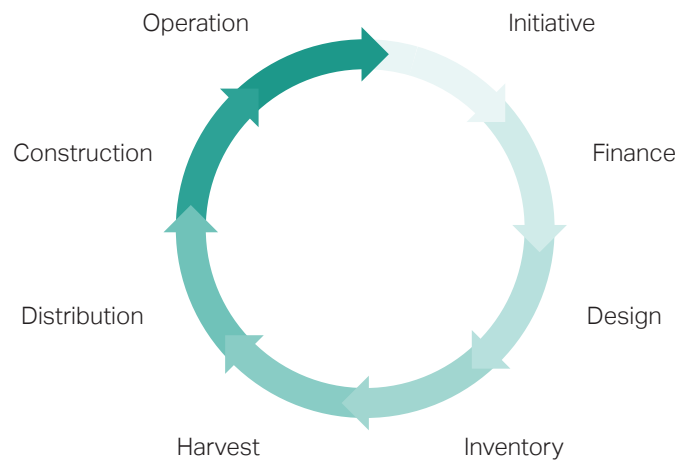
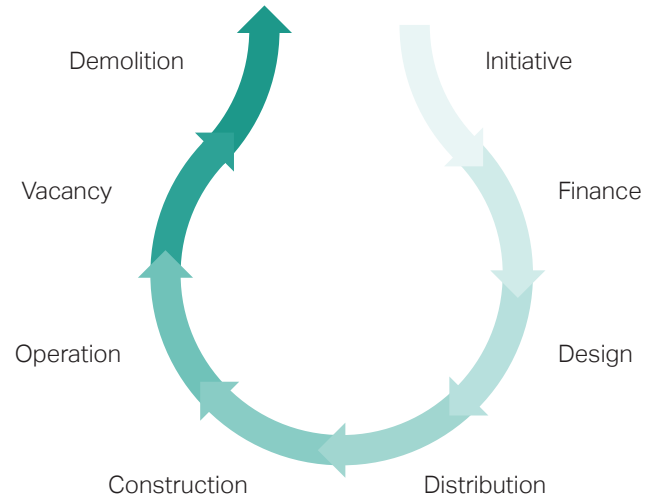
Documenting Methods



In order to make sure that materials are not 'lost,' they can be given a passport. This material passport contains information on the material such as its type, age, how it's assembled etc. All the information combined can give the material an estimated value,

The reason for creating these passports is reducing the overall loss of materials. During demolition jobs the materials are usually demolished and thrown on piles, after which the materials are called 'waste.' Within the circular economy, one of the main goals is to create less waste. It is therefore important that these materials do not end up in some kind of waste pile. If they have an identity, a passport, they can be tracked.

The information stored in this material passport can help building owners, architects, builders, developers and other stakeholders decide what to do with the materials that are stored in a building, once the building is up for demolition or transformation.



A new construction chain

From linear to circular

Knowing more about the construction value chain and the methods for working with circularity and upcycling allows us to rethink the building cycle. How can the linear process be turned into a circular one?

If we wish to efficiently use the methods explained above, we need to rethink the construction chain. Some of these methods need to be added in the existing chain in the form of a phase. Some existing phases need to be replaced or removed.

Starting with the inventory phase, this phase should be inserted after the design phase. During the design, the architect decides the concept and outlines of the design. However, if he wants to know what materials he can use, he needs to know what is available. Therefore, the method of inventory is used. In reality, this phase will probably run parallel to the design phase.

Image The conventional, linear building process can be turned into a circular one by adding in the phases of inventory and harvesting, and taking out the phase of vacancy and demolition.

Next is the harvesting phase. When it has been decided which materials and components will be reused for the design, they need to be harvested. In some cases, the materials might already be harvested from a building and stored in a warehouse or demolition site. In other cases, the material still needs to be harvested from the donor building.

Lastly, the phases of vacancy and demolition need to be removed from the existing chain, since demolition has actually been replaced by harvesting. These changes allow for a circular building process, where waste is eliminated from the chain and buildings parts are given a longer lease on life.

	initiative	finance	design	inventory	harvest	distribution	construction	operation
municipalities	●	●	●					
owners	●							●
developpers	●	●						
investors	●	●						
owner-users	●	●						
banks		●						
architects			●	●				
designers			●	●				
engineers			●				●	
climate advisors			●				●	
material scouts			●	●				
material experts			●	●	●			
harvest experts					●			
demolition companies				●	●	●	●	
distribution companies						●		
transportation companies						●		
suppliers						●		
managers			●	●	●	●	●	
contractors							●	
subcontractors							●	
tenants								●
end-users								●

Image This table outlines in which phase the different stakeholders are active. Some stakeholders can appear in multiple phases, some in only one.

Stakeholder analysis

From developers to architects

Now that we know the chain, we need to know the players. This section aims to explain what stakeholders are around and in which phase of the building cycle they are active.

Many stakeholders can take the initiative to start a building process: municipalities, developers and investors, but also private clients such as so-called owner-users. Municipalities can initiate an urban planning project, wherein developers are asked to develop specific plots or redevelop buildings.

The financing is usually done by different kinds of investors. However, the municipality and banks can also take on the role of additional financier. In large projects, there usually is more than one financier.

After financing has been settled, the design can take off. In most cases, architects take on this job, but they get help from additional designers and engineers, as well as experts on climate installations and materials. During this phase, designers can also start 'scouting' for harvestable materials. Scouting for materials is already part of the inventory phase. Experts such as demolition companies can be involved also to decide on what materials are suitable for upcycling.

Materials are harvested by experts, such as demolition companies. Increasingly some demolition companies have started to take this role of disassembling instead of demolition more seriously.

During distribution, demolition companies, transportation companies and suppliers work together on bringing the harvested materials to the material bank or construction site. In some cases, this process can be managed by a specific stakeholder.

When the material arrives at the construction site, contractors and subcontractors can do their job. Demolition companies can still be involved as an advisor, because of their knowledge of (dis)assembly.

When construction is finished, the end-users, such as tenants can start using the building. The building owner usually is responsible for maintaining the building.

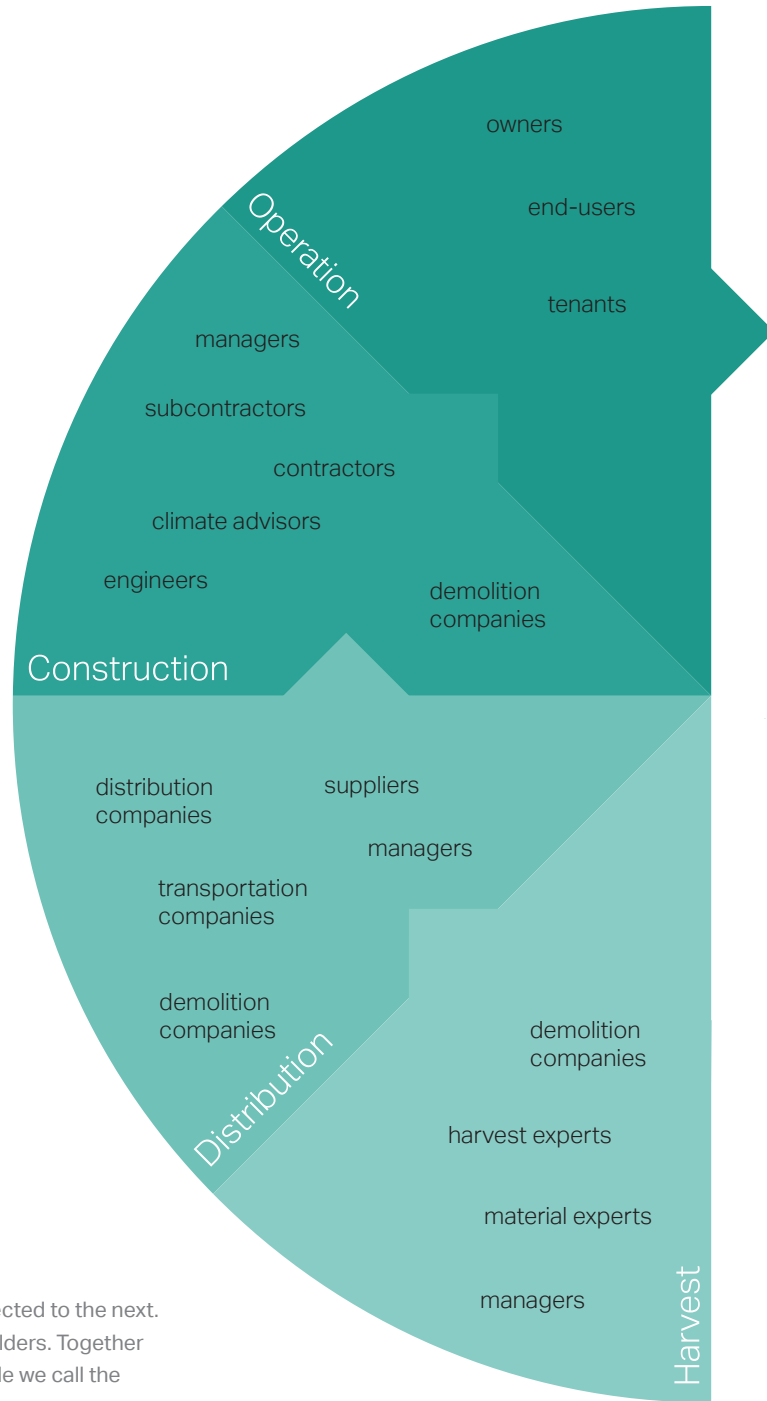
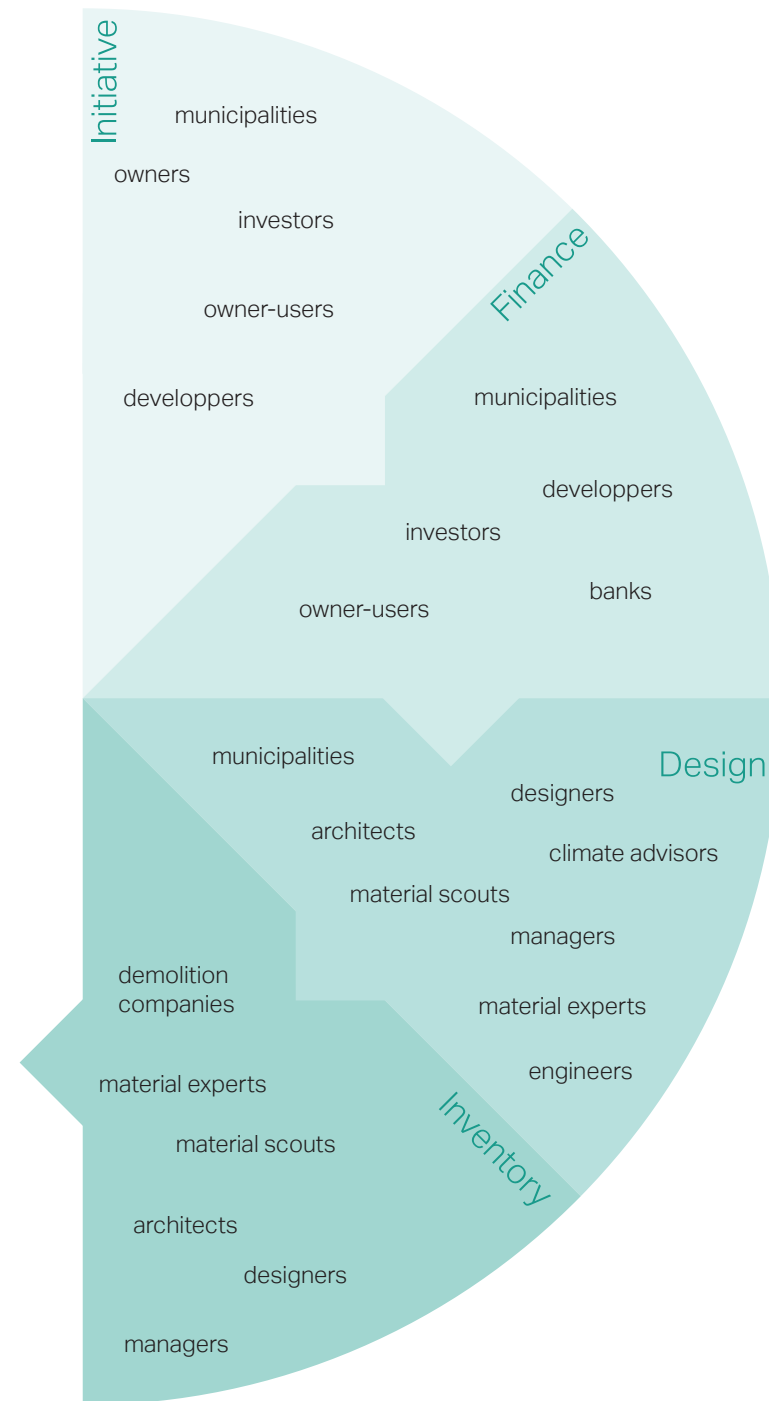


Image Each phase is connected to the next. The same goes for stakeholders. Together they form a continuous cycle we call the building chain.



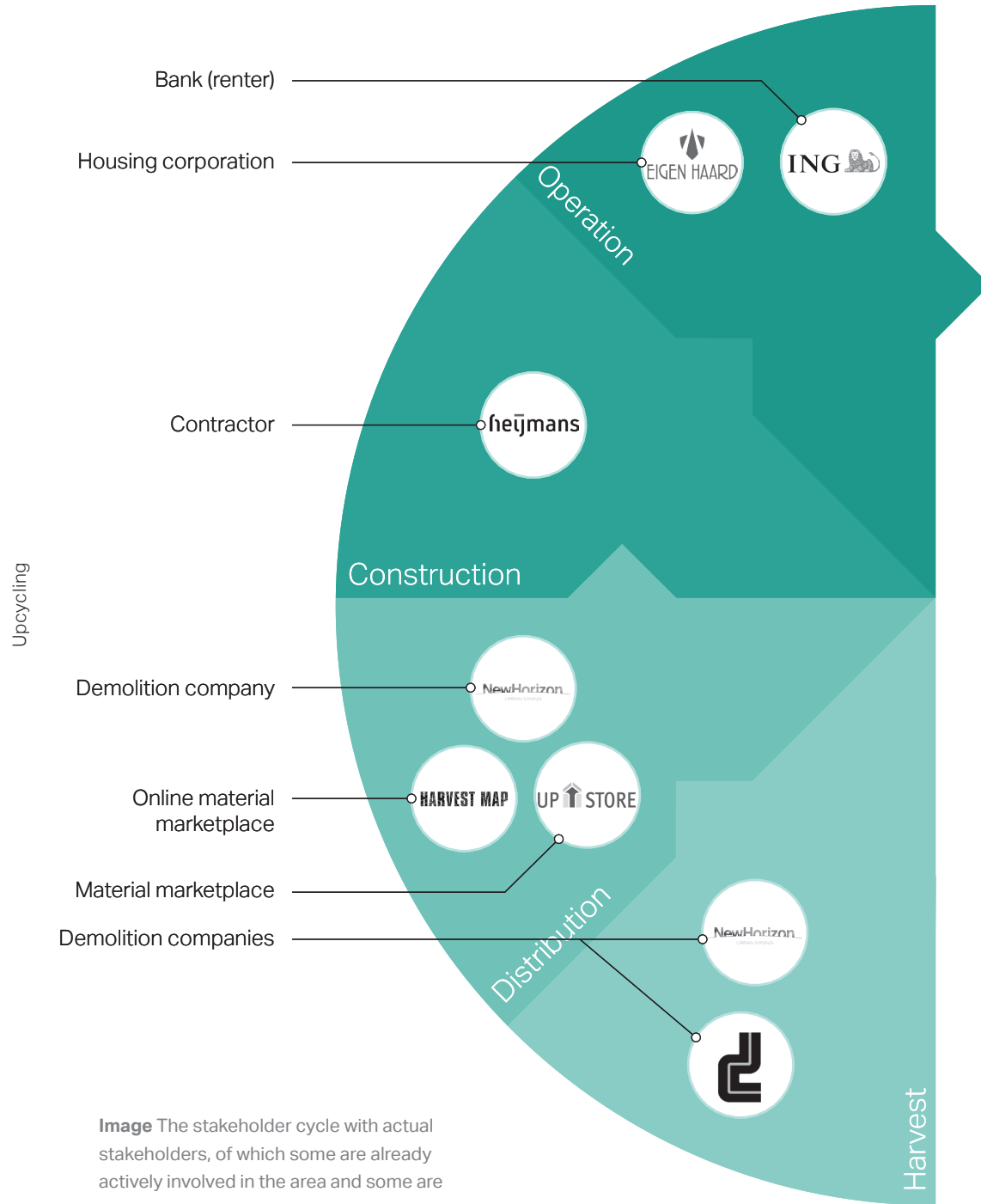
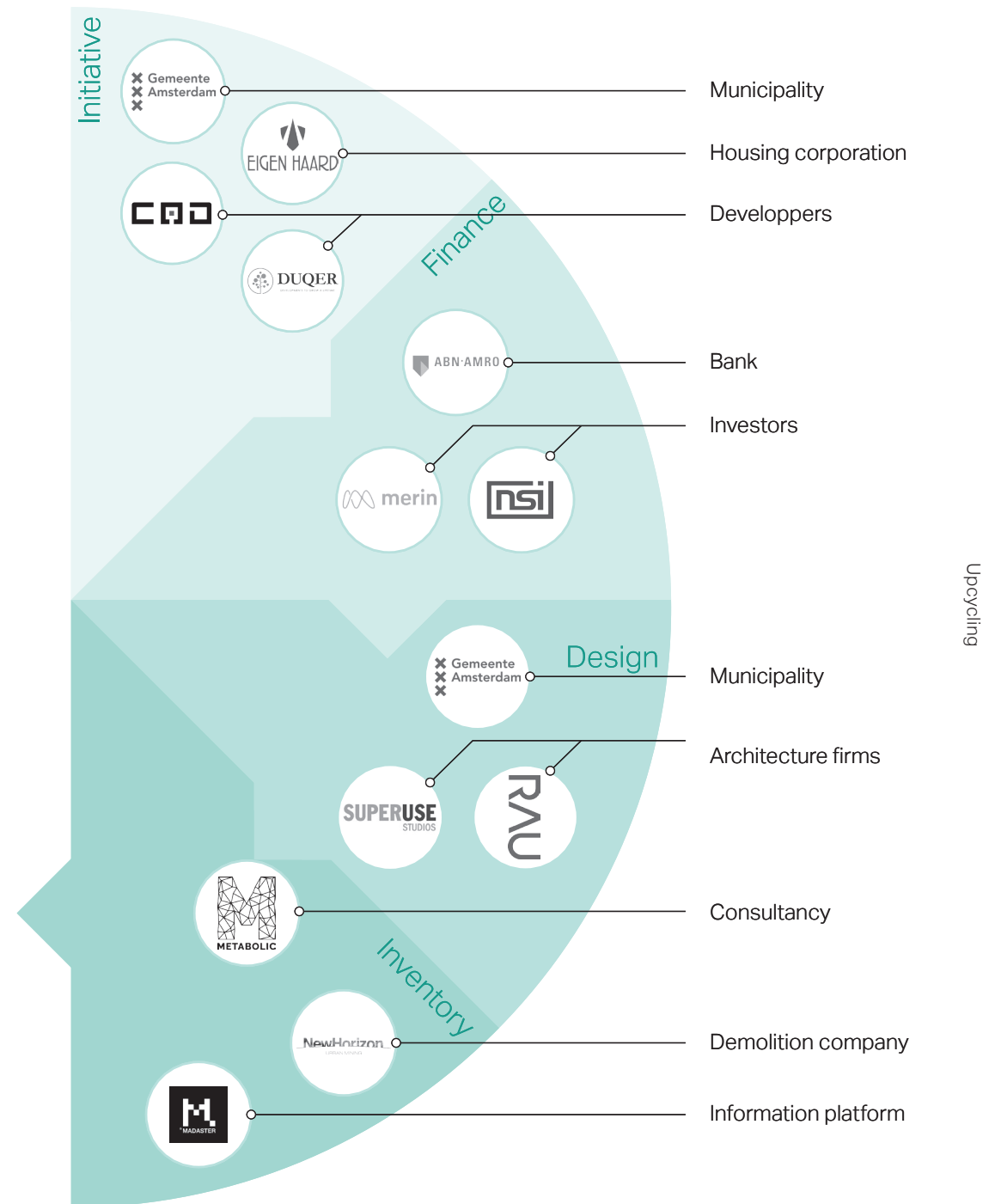


Image The stakeholder cycle with actual stakeholders, of which some are already actively involved in the area and some are not.



CASE

STUDY



Amsterdam

Case study

This Section explores the material potential of Amstel III when the current buildings are demolished. This is done through a case study on building level and these results are reflected on the scale of the whole of Amstel III. The chapter is concluded by the exploration of potential stakeholders in the area.

As Amsterdam want to stay as frontrunner and push the circular economy approach the city has several test cases of development areas. Buiksloterham was the first to be developed and is already in a further stadium, where the City can reflect on their actions. De Ceuvel is realised to restore the polluted site in ten years, and multiple other initiatives are realised. Two other, bigger, development areas are Havenstad and Amstelstad. In the coming years, the City is in need of at least 70.000 new houses. Most of these will be developed in the two areas, where the city aims for the new approach of the circular building.

Havenstad is positioned at the north-west of the city centre. Its former function was the harbour of Amsterdam before this was placed further outside the city.

In Amstel the focus lies on Amstel III, the third business district within the Amstelstad neighbourhood, developed in the 1980's and offers nowadays space to many service companies. The area is enclosed by the metro-line to the east and the A2 highway to the west. The south side ends at the AMS hospital and the north side give access to the mayor event space in Amsterdam, including the Johan Cruijff Arena and the Ziggo Dome.



Amstel III Identity

“Not being anywhere, being somewhere”

The transformation of the Amstel III area is defined by the municipality through a spatial vision. This vision will guide the developments of the buildings to work towards a vivid area where people want to live and work.¹⁰

Three Ambitions for Amstel III

The municipality aims to give the area a creative innovative identity by attracting new residents, small offices, and start-ups, ideally in the circular economy sector. Three overall ambitions guide the development:

- Inviting new citizens
- Connecting slow transport
- Healthy & sustainable green areas

Inviting new citizens

Following the vision of the municipality of Amsterdam, the area of Amstel III will transform from mainly an office area to a mixed-use urban district. Therefore, this location is inviting new citizens to live in the area, being supported by the needed facilities. Nowadays there is a lot of vacancy in the area (15% of the offices) and to manage this vacancy the municipality wants to develop an economically strong, multifunctional and vivid area. Therefore it's needed to invite a new population, in the first phase mainly consisting of students and young professionals.

Connecting slow transport

The area is well connected with train and car to Schiphol, the city centre and other big cities. The metro will make a 24/7 connection to the city centre. In residential areas, the vision is to make slow transport more important at the neighbourhood level. A hierarchy is needed in streets to make it livable.

Healthy & Sustainable green areas

Within a vivid district, the aim is to get people moving, sports facilities outdoors and indoors will support this goal. With the area being well connected to green parks in the surrounding and city gardening it will be a healthy and sustainable city district.

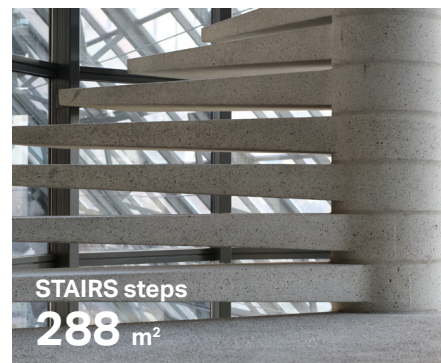
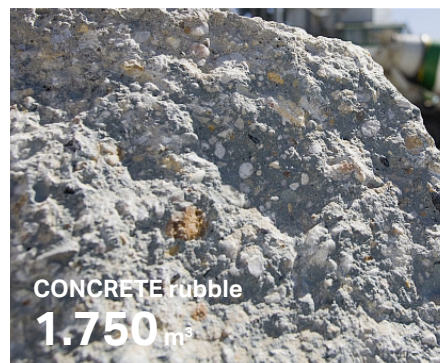
Adding program

To be sure to reach those goals set by the municipality program needs to be added to the area. This includes the following:

- 45% Houses
- 45% offices
- 10% service

Of which the houses will be:

- 40% social housing
- 40% mid-range housing
- 20% high end housing



Hullenbergweg 1-3

Building case study

To show the potential for the Amstel III area we took one building, the Hullenbergweg 1-3, and took it apart to see what materials are inside. This gives an indication of the materials that can be harvested from it when it gets demolished.

The Hullenbergweg 1-3 is one of the many office buildings in the Amstel III area. It was constructed in 1988 with a concrete structure. The facade is clad with granite panels in a standard dimension. The windows are built with a curtainwall system and the back of the building features a large glass atrium. Based on the old drawings, site visits and a three dimensional modelling we analysed the building and split it into the different materials.

Harvesting

The materials that come from the building in two groups. The first group is the amount of raw material that can be harvested. This includes concrete, double glazing, polystyrene, granite etc. The second group is based on products. In case of the Hullenbergweg there are three high-quality staircases, including 288 steps, and 4 elevators that have a high potential for re-use. The next pages display the amounts of materials that have potential for re-use.



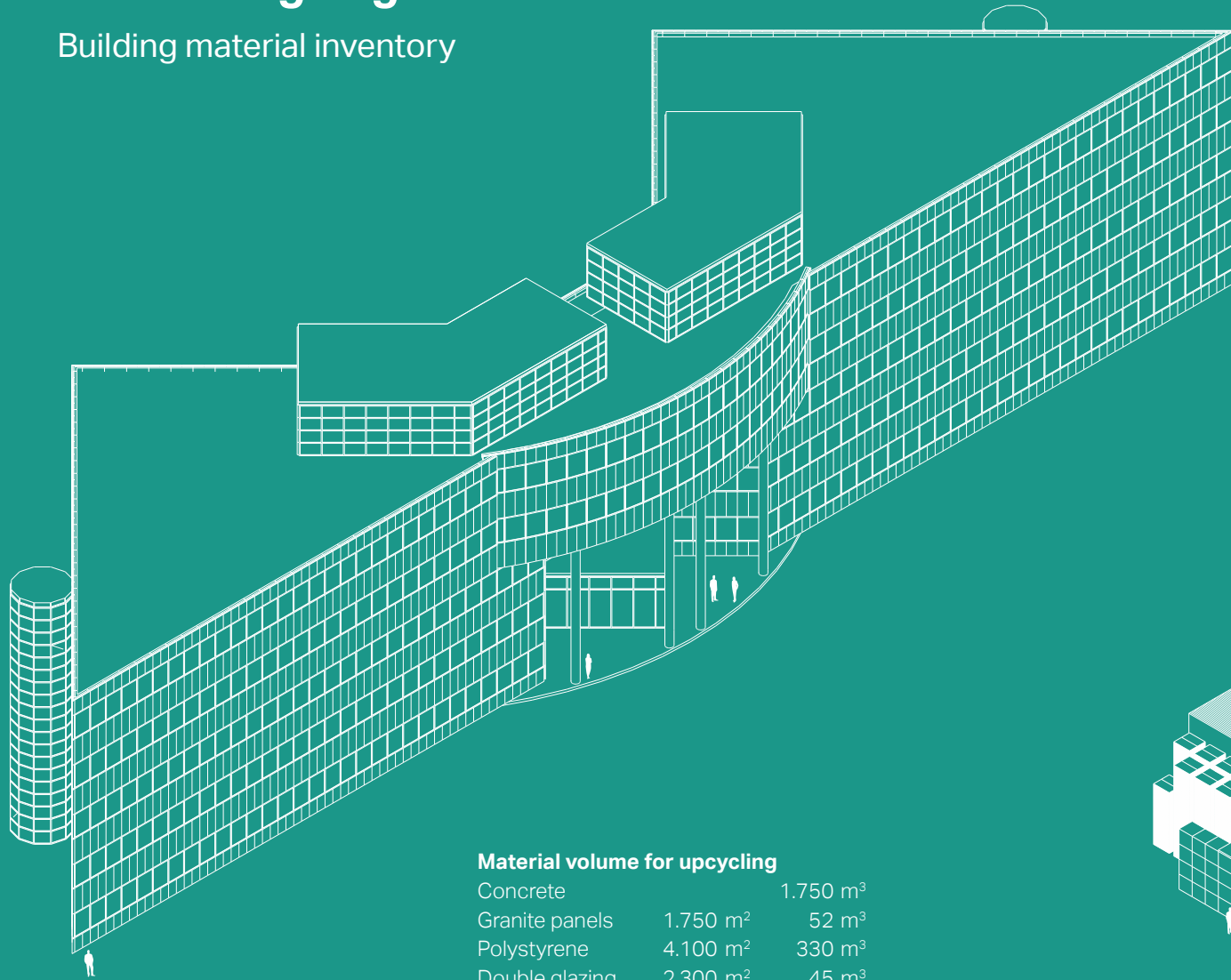
Hullenbergweg 1-3

Material Glossary



Hullenbergweg 1-3

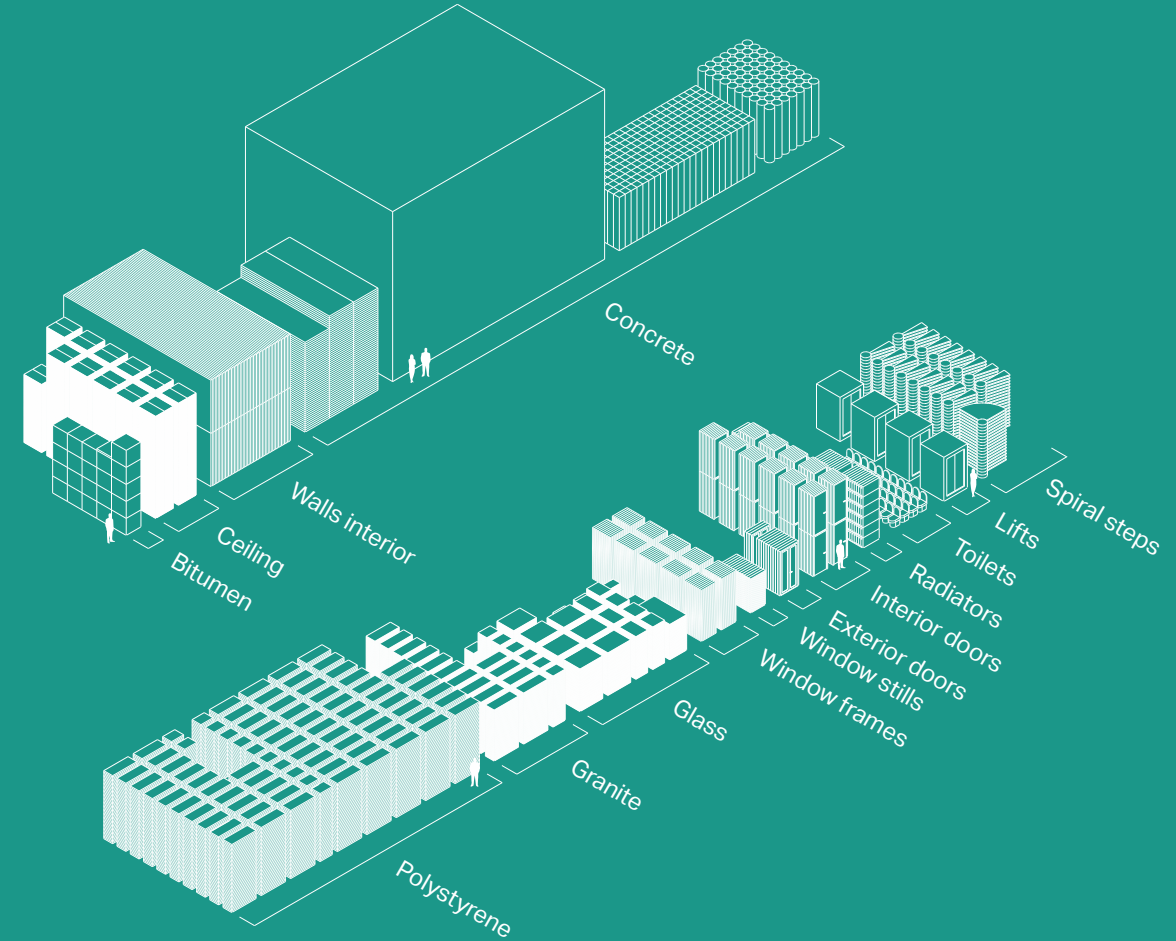
Building material inventory

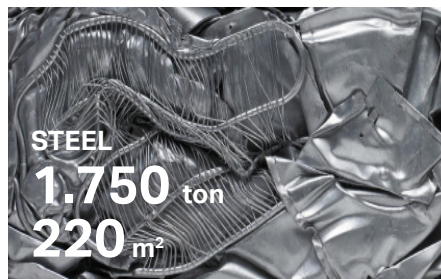
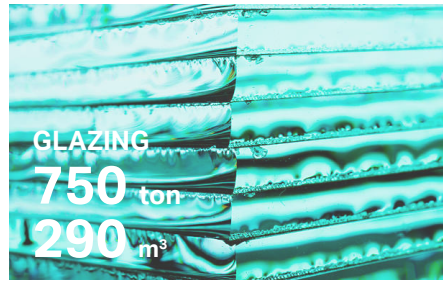


The Hullenbergweg building dissected into its different parts. Both images are in relative scale to each other

Material volume for upcycling

Concrete		1.750 m ³
Granite panels	1.750 m ²	52 m ³
Polystyrene	4.100 m ²	330 m ³
Double glazing	2.300 m ²	45 m ³
Bitumen	1.100 m ²	21 m ³
Ceiling	6.300 m ²	125 m ³
Walls interior	3.650 m ²	365 m ³
Window frames	6.900 m	50 m ³
Lifts		4 pc
Toilets		41 pc
Doors exterior		13 pc
Doors interior		228 pc
Radiators		240 pc
Spiral steps		288 pc





AMSTEL III

Materials ready for upcycling

To show the potential for the whole area of Amstel III we combined our data from the Hullenbergweg 1-3 with the data from Metabolic¹¹. This gives an indication of the possibilities in re-use in Amstel III.

Currently there are 26 buildings in Amstel III that will be redeveloped in the future or are being redeveloped at this moment. Some of these buildings will be demolished, others will be transformed. In both cases, they can be potential harvest locations. They have been marked green on the map. When calculating the materials in the area we only took the raw materials into account. The data of Metabolic allowed us to also give an indication of the amounts of steel, gravel and brick walls in the area.



● Potential harvest locations

Material passports

In the development of Amstel III the introduction of material passports could give insight into the stock of materials. The data from these passports gives the material harvesters, architects and constructors the possibility to develop their projects in with the available stock of materials. Reducing production costs, transportation costs and CO₂-emissions.



Current density

Left map shows the Floor Space Index (FSI) number of Amstel III area, which means the GFA per site area. The office zone in the east are denser and the average FSI of this area is 1.3.

Potential density

Plots of low density here are assumed to be expanded to a higher density (twice as the original but not more than 2.7) due to transformation.



The FSI in Amstel III

Case study

Circular area development

It is challenging to analyze the opportunities for circular economy at in a region, because the opportunities usually be confined within a single project. The following case study for the Amstel III area shows how we proposed to concretize a upcycling vision of a region where the demand for materials is visible.

Developing plan model

According to data from the municipality, the average FSI (Floor Space Index) of Amstel III is 1.3. For the convenience of calculation, we assumed that plots of low density here should be expanded to a higher density (twice as the original but not more than 2.7), which is similar to the situation of some residential projects that have already begun in Amstel III.

Demanding for materials

The material-estimation of demand for the transformation is based on a calculation model of uniform high-rise building with aluminum window frame¹². Based on the assumption for the scenario estimates materials needed in the Amstel III area for the intended transformation.

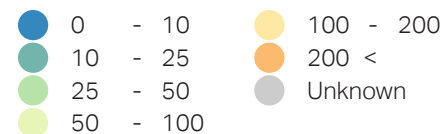


Buildings without re-use

This map shows the embodied energy needed to densify the Amstel III area to the assumed scenario in traditional demolition and construction way. This is in line with the ambitions of the municipality for this neighborhood.

Buildings with re-use.

This map shows the same assumed transformation as the map above but with the reduction of the embodied energy of the harvested materials from the current structures.



Embodied energy in TJ(10^{12} J).

Case study

Energy reduction of 28% as a result of upcycling

When the harvested materials from the Amstel III area are re-used, there is a potential for saving energy. If all materials harvested from Amstel III are re-used, their embodied energy can be subtracted from the total energy needed for the area. This means there is a potential energy reduction of 28.1%.

Material sources

Rather than build with completely new materials, there are options for us to reuse materials by harvesting from the original site. Since we estimated the material stock for the office and business buildings in this area, we can estimate the total amounts of material we have for the whole area.

Potential of energy reduction

Since the energy consumption cause by building use can be control to a certain extent by building standards and regulations, it is reasonable to focus on the embodied energy of construction materials. To get a overview of how much embodied energy we could save by reusing the materials, we used a embodied energy list for each material per kilo¹³ and set up a model to estimate the total weight of each materials in buildings of Amstel III area.

Estimation of energy reduction

For estimation we chose 26 building from our harvesting site. Combining our own building case study result with the estimation from Metabolic, we got the total amounts of each main construction materials in these buildings. When looking into the developing scenario, these materials are available for reusing. For new building types, different materials meet the needs of new construction to varying degrees. For example, demolition materials can offer nearly 100% bricks for new buildings but for concrete this number goes down to around 30%. As a result, we summed up the ideal embodied energy in totally new built buildings (516.7TJ, $1\text{TJ}=10^{12}\text{J}$) and buildings with re-used materials (371.5TJ), which means we can save 28.1% embodied energy in ideal situation.

Practical challenges

Different ways of recycling or reusing can be applied to add specific characteristics to the area, which can effect the energy consumption. Possibilities for storage and transportation which can lead to different cost are also important factors which can determined the result.

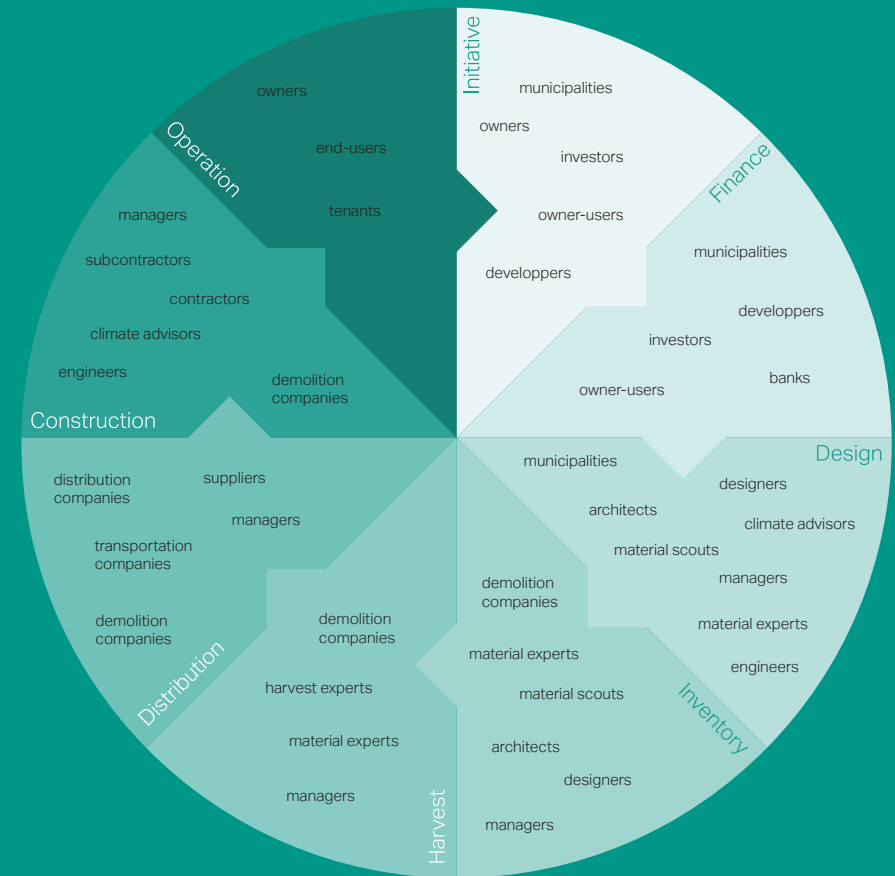
Stakeholder engagement

The Amstel III ecosystem

In addition to mapping out the area, it is also interesting to map out the different stakeholders in the area. Who are actively engaging in the Amstel III area and why? What are their goals? This chapter will explore a potential scenario that could, or maybe should, take place in order to upscale urban upcycling in the Amstel III area.

As chapter two outlined before, there are many different types of stakeholders in the area. It is interesting to replace these general stakeholders with actual stakeholders from the area and create a scenario. This scenario is fictional of course, yet potentially realistic.

Case study



Case study

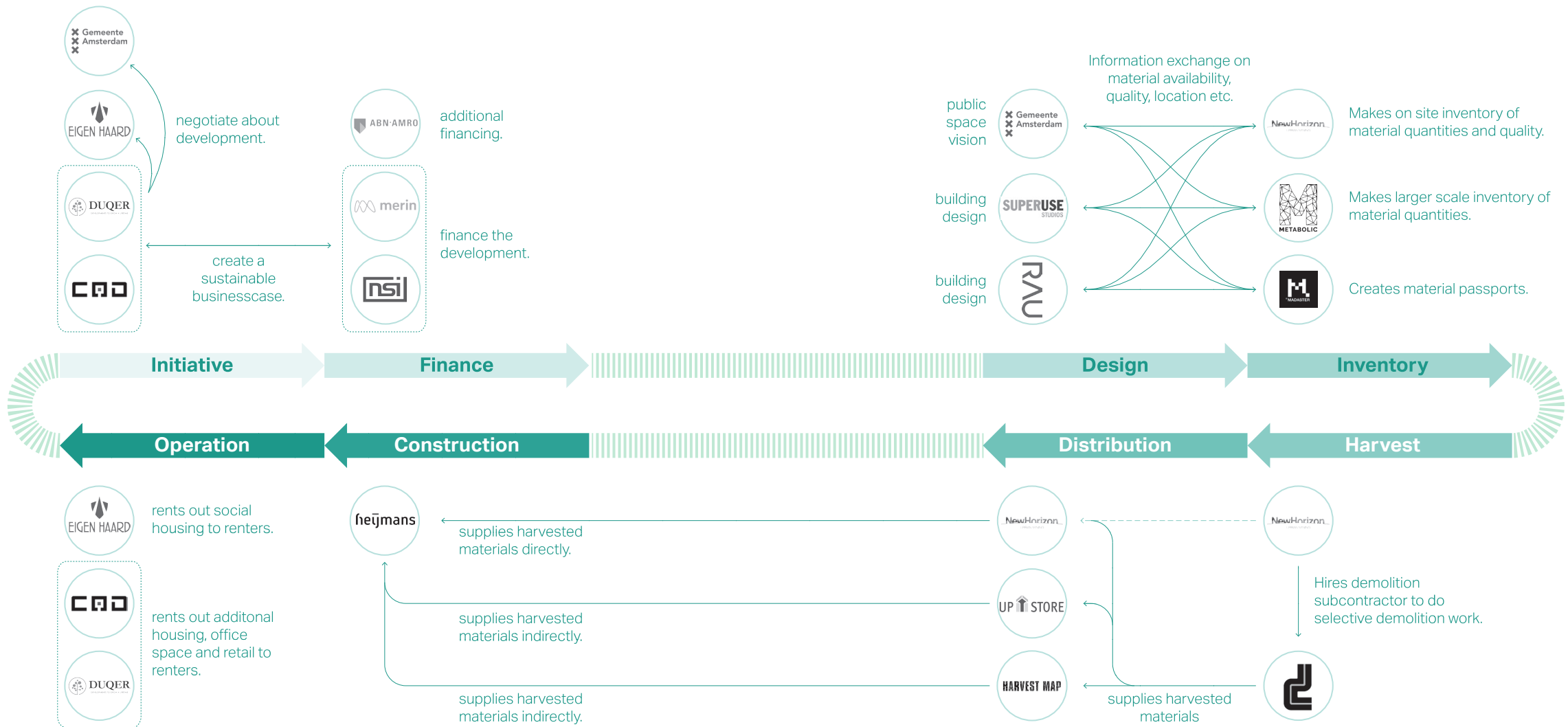
Image The different types of stakeholders and how they form an ecosystem together.

Stakeholder engagement

Connecting the dots

When the stakeholders have been mapped out, we can connect them. This scheme shows a fictional scenario, where stakeholders engage with each other during the different phases.

Case study



Case study

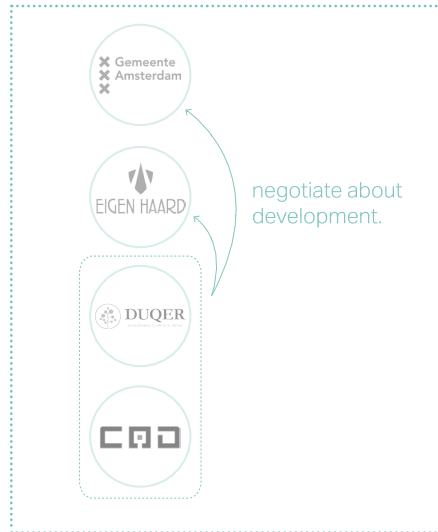
Stakeholder engagement

Phased engagement plan

Case study

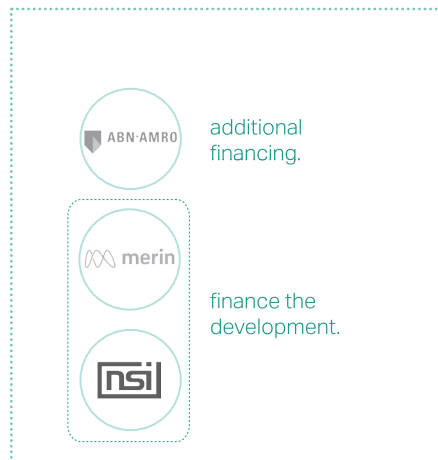
Initiative

Developers, the municipality and a housing corporation negotiate on the segmentation of the developing project. The municipality wants a minimum of 40% of social housing in the area. However, this is not financially interesting for developers. They want density and high quality apartments to gain high revenues. However, the zoning plan allows for a low density. The outcome of the negotiation might be that 20% of the developed dwellings will be social housing, but the municipality will allow a higher density. Also, the developers must invest in the public space around the project.



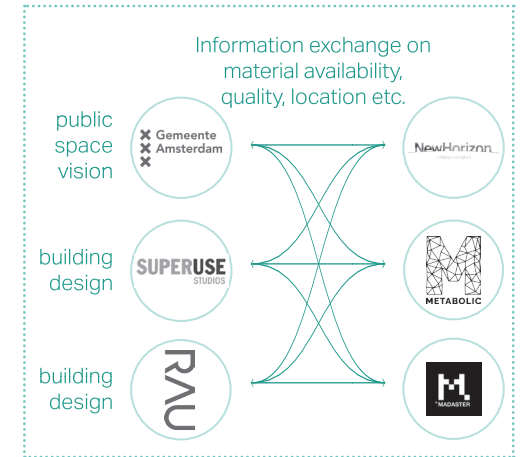
Finance

Institutional funds will finance the development entirely or partly. If needed, a bank can supply additional funding. These institutional funds have already invested in office buildings within the area. A new, high quality development can create value for the entire area, which is interesting for investors.



Design

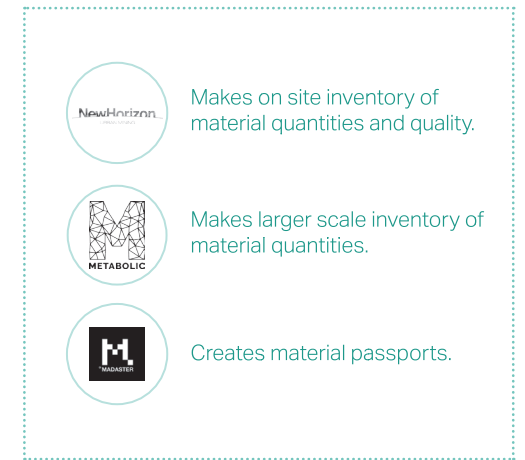
Architecture firms come up with designs for the development within the vision of the municipality and the wishes of the developers. Ideally, they incorporate information on locally harvestable materials acquired from partner stakeholders within their designs, as to lower the need for new building materials.



Case study

Inventory

The partner stakeholders that are responsible for acquiring this information do this on three levels: they make inventories on large scale and on site, and they create material passports. All this information is allowing the used materials to be reused in the future and to make sure no value is lost over time.



Stakeholder engagement

Phased engagement plan

Case study

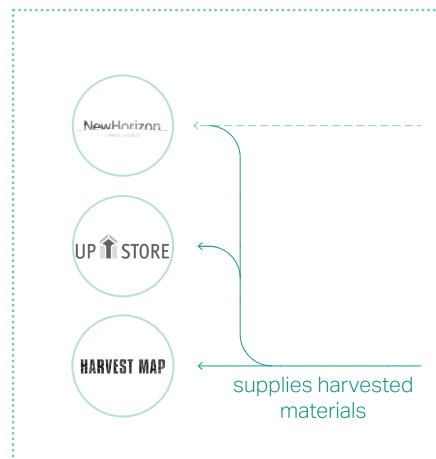
Harvest

In case the development requires an old building to be demolished, a harvest process should be started. With the information on the inventory a plan can be made. One party takes on this job and hires demolition crews to disassemble specific parts of the building. One crew is responsible for all the concrete, while another is responsible for all the bitumen roofing.



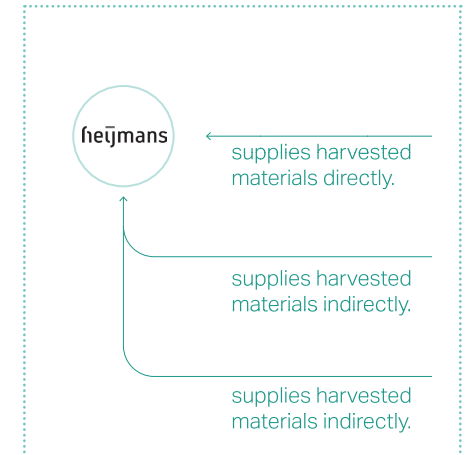
Distribution

Once all materials are harvested, they can be distributed to their destination. Ideally, all materials are reused on site for the construction of the new development. They can be stored on site until needed. However, not every material might be needed. In that case, the materials are distributed to the marketplaces or manufacturers.



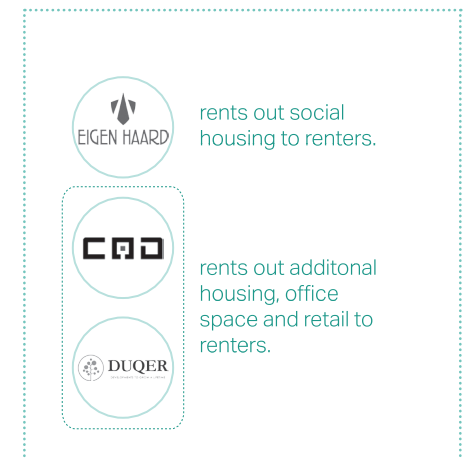
Construction

In the best case, the materials are reused on site. The contractor receives the materials at the right time in the construction process, to lower the need (and time) for storing materials. Logistically this is challenging, because some materials are needed at a later stage than others. Planning is key here.

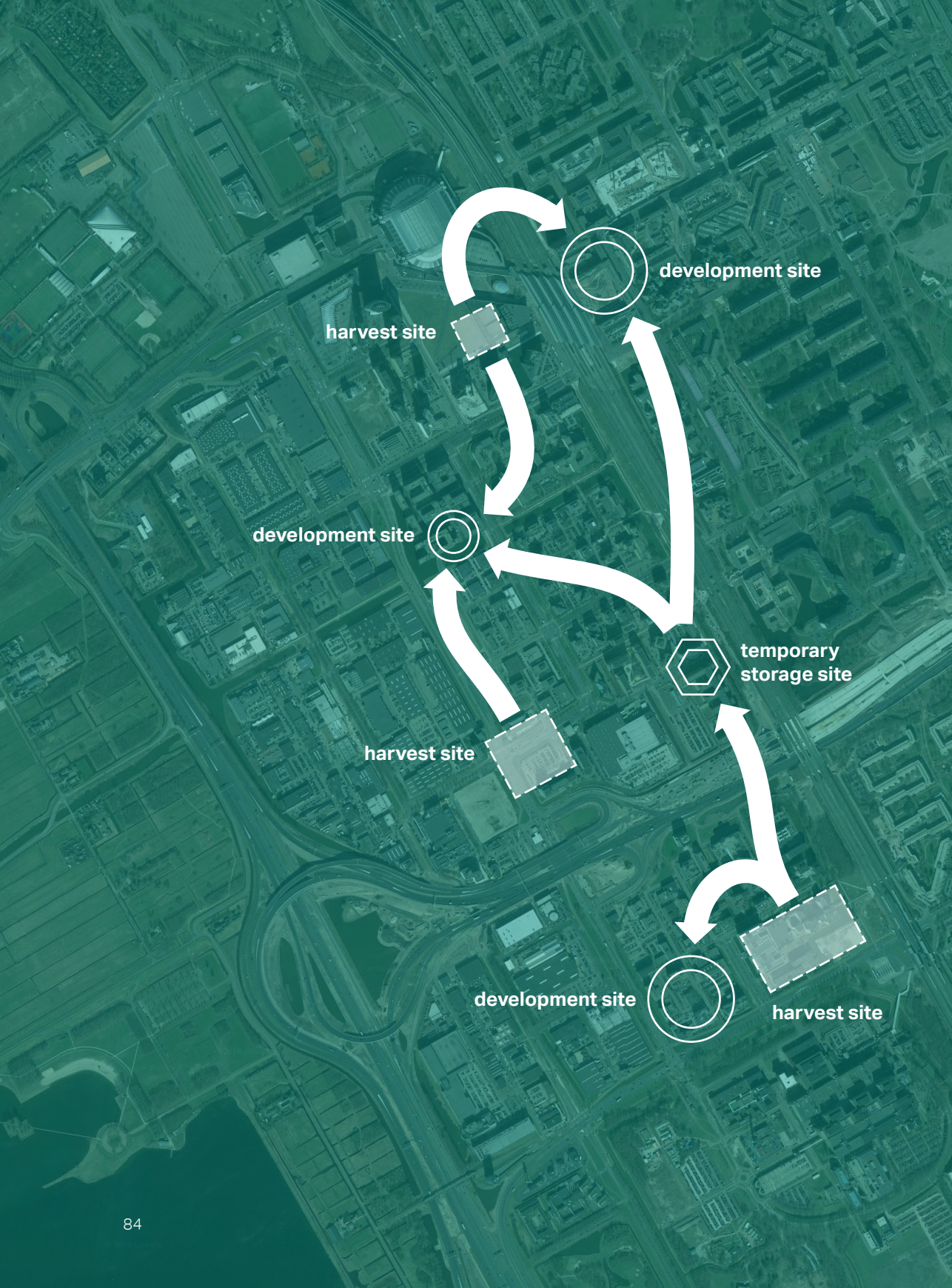


Operation

When construction is done, the building can start to be used. The housing corporation finds renters to rent out the apartments. The developers also find, or already have renters.



Case study



Engagement map

A potential scenario

There are many initiatives in the Amstel III area waiting to be developed. What if we could create a scenario where these initiatives, such as new construction developments and demolition jobs, could be connected to each other?

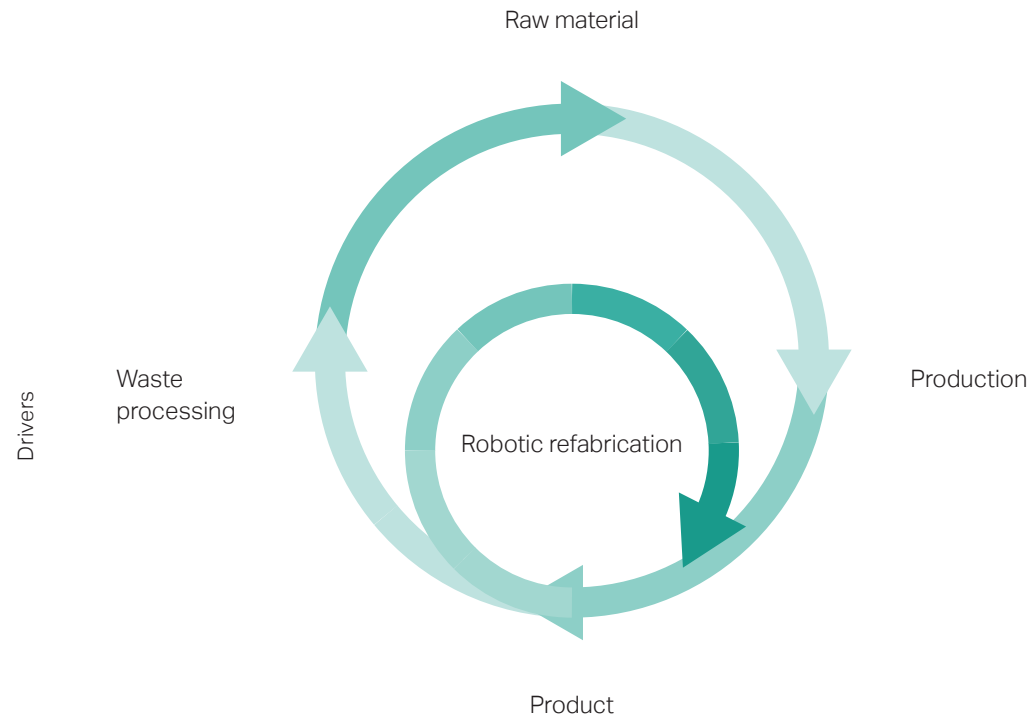
In an ideal situation where multiple developments are running at the same time, many harvest and construction processes will run simultaneously. Some developments might require materials or items from a certain harvest site, while other developments require materials from multiple harvest sites. Potentially, a great match between supply and demand can be made here.

However, this requires a great amount of design planning and logistical planning on forehand. All processes, from designing, to making an inventory, to harvesting to constructing, need to be planned as a whole. If this is possible, a huge impact can be made.

DRIVERS VEERS

Robotic refabrication

Driving statement



Robots are promising to be a solution to the fact that waste comes in such a variety of shapes, sizes, qualities, etc. The great advantage is that robots can adapt their method fast and automatically.

Fabrication today is an efficient factory business. The production of materials and products happens in fabrication chains that are simple because the supply of raw materials is constant and the materials are always the same. The big difference with refabricating recycled materials is this process should constantly work with different materials.

Most materials that are being recycled today are materials that can be made into a raw material, so they can enter the fabrication cycle again, like paper or most metals. Cars are being recycled for 97,0% today in The Netherlands, because their materials are easy to melt into raw materials again.

The challenge of recycling is much bigger for materials that can not be made into a raw material, or require a large amount of added energy to become a raw material again.

In a circular economy, production should not be a cycle of materials to products to materials, but production should also be smart and robust enough to work with available parts or elements of materials.

Reusing bricks, for instance could potentially lower the environmental stress, because it would lower the CO₂ emissions of firing the bricks. The bricks should then be processed and cleaned as whole bricks. If the bricks are crushed, processed and fired into new bricks than the total environmental stress will be the same. The cleaning and processing of bricks is very intensive so it would be necessary to do this in a robust factory process. Robots could learn how to adapt to different pieces of bricks. Robots could sort the bricks or place them in a specific way that the odd shape would be corrected.



Project Circular Experience
Location Amsterdam
Year 2017
Client ABN AMRO
Architect Studio RAP
Photo Studio RAP

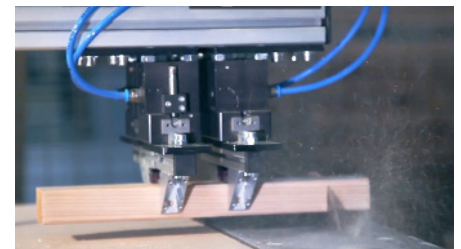
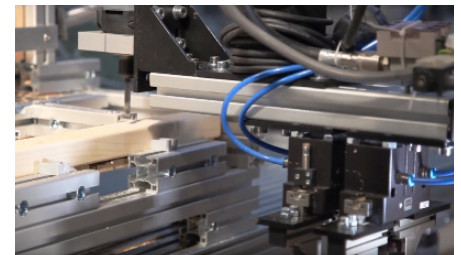
Robotic refabrication

Case study

All waste management robots from Zenrobotics and BHS, both show great examples of dealing with the sorting in the recycling industry. The combination of image recognition and robots make this process very powerful. The adaptability of the multiple axis robot strengthens the intelligence of the machine learning algorithms.

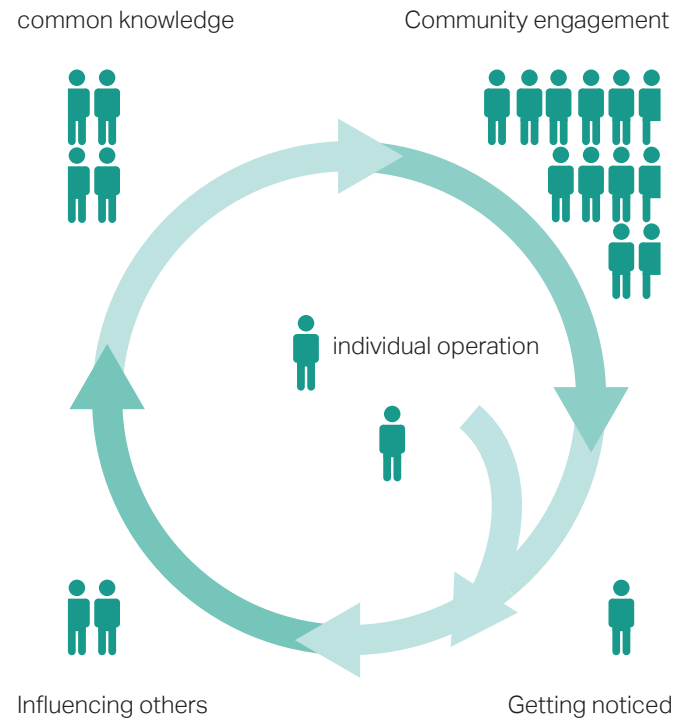
The production process for the curved wall in the Circular Pavilion also shows a similar process. This one is not so complex in the waste that it handles, but it shows a more complex way of assembly. The manufacturing process worked with two types of wood in two types of sizes. All individual wooden strips are shortened to the right size. The robot picks up the wood, drills the holes, shortens them, adds the dowels and then places them on a unique position.

Most processes in the building industry are designed simple, because they have to be understood and produced by people. And human labour is getting more expensive every day. This makes complexity very rare in these methods of assembly. The addition of robots to take over these tasks will give a chance to new craftsmanship and complexity.



Community engagement

Driving statement



Drivers

With community engagement the end-users (of the buildings) will be involved into the circular economy. Mostly circular economy and a building in general is implemented around the users without actively involving them.

Therefore the users don't feel attached to it in a way it was made and thus will they act to the needs of the building usage. There needs to be a way to stimulate people to go towards a circular economy, informed by their surroundings (a circular building). Without citizens to enhance the processes of a circular economy, it can never be adapted in society. People should learn and be surrounded by the options for circular economy. So with community engagement involved in the design, we could enhance the users to learn from the approach and see the relevance to the solution of circular economy.

By actively displaying techniques and possibilities in a hands-on approach, a whole community can get involved in the circular processes. This could be seen in a way where people can interact with the building, in groups or individually. With the interaction they could learn about the subject.

Also seeing other people work with circular projects could activate the visitors/users to do the same, in this way it can be made socially permitted to work with a circular economy. In a circular Living Lab people rent spaces for their small company or start-up, the requirements are to build up the space completely circular. If other people visit these places they could be motivated to work in the same way, or telling others about it.

Drivers



Project The People Pavilion
Location Eindhoven
Year 2017
Client Dutch Design Week
Architect Bureau SLA, Overtreders W
Photo Overtreders W

Community engagement

Case Study

The people pavilion.

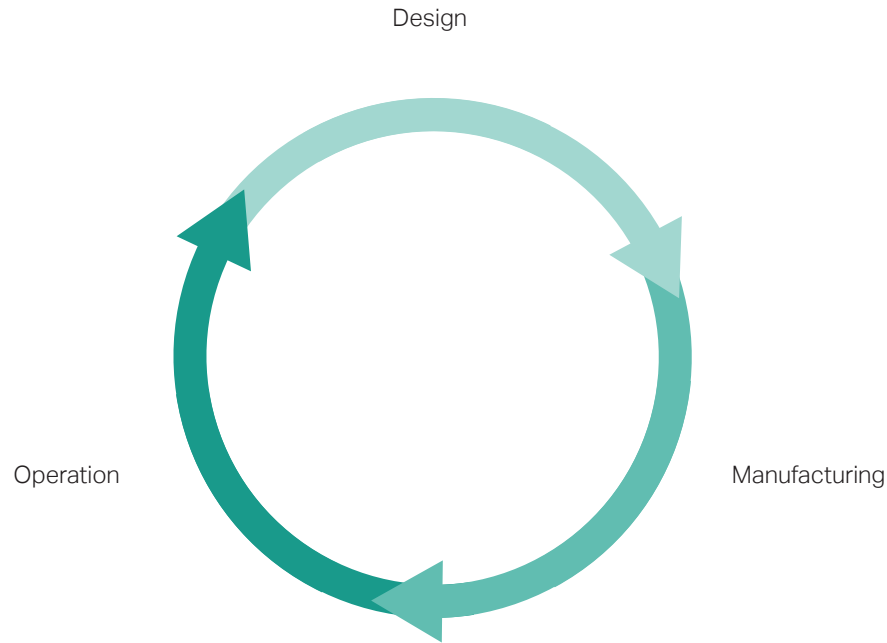
A great example of making a product without damaging or wasting any materials and showing every single joint in an educational and clear manner is the Peoples Pavilion at the Dutch Design Week of 2017. For this project the creators 'borrowed' the materials from all different companies to give it back afterwards. For the facade system, they involved the citizens of Eindhoven to collect their plastic waste so it could be turned into a facade system. In this way, the citizens could contribute to the pavilion at a circular approach and also get emotionally attached to it, because it was their waste hanging at the facade. With a project like this a community could be involved in the process to get them consciousness about the circular economy needs.

By bureau SLA, Overtreders W, Arup

Hof van Cartesius

With this example of Hof van Cartesius you notice that small start-ups can work with each other to realise a circular construction. People can rent a space in this courtyard, the only requirement is that everything is able to be reused. With this idea the owner, Charlotte Ernst, stimulate and motivates people to work with circular principles. The community together will therefore motivate outsiders to do the same. In this case ,the thought of circular economy can be carried out towards others by word of mouth. Where in the end a whole big group will have the combined goals to work toward a circular economy.

By Charlotte Ernst, RHAW Architecture



Design for disassembly

Driving statement

Design for disassembly means that buildings are intentionally designed for material recovery. This means all pieces of the building can be taken apart after the building has reached the end of its lifecycle. Products in the building can then be directly re-used in another building. Alternatively, the materials can be recycled without downcycling as the materials are not contaminated.

Contamination of materials

Too often materials are glued together in a way that they can no longer be separated again. This contamination of raw materials is downcycling and usually results in the product becoming landfill after its initial use. Design for disassembly is tackling exactly this problem, but on a building scale. Great focus lies on keeping the materials separate by using reversible mechanical connections instead of chemical connections with glue.

All buildings are temporary

Design for disassembly can already be found in stage design and temporary exhibition buildings. For example, in the Circle Pavilion at the 2017 Dutch design week in Eindhoven. The materials used to construct the pavilion were borrowed and after disassembly all materials were returned in their original state to their original owners. Of course design for

disassembly makes sense for temporary buildings. But we need to realize that all buildings are temporary. We need to stop building them like they are permanent. After 50-100 years they will most probably be taken down. We need a strategy to handle the materials that come free when that happens. Design for disassembly allows those precious materials to be re-used instead of being incinerated or landfilled. This material reuse results in significant energy savings and the reduction of CO₂ emissions.

Adaptability

The adoption of design for disassembly means looking differently at the materials we use and the way these materials are joined together. One of these changes is the building-wide adoption of reversible connection. This opens the door for the next step in adaptable buildings. The clear benefit is that the building can be altered in layout and function during its years of operation allowing it to change with the requirements of the market. This means an office building could easily become a residential building without excessive demolition costs and the creation of waste. In a circular economy the elements can be sold again for re-use or the parts can be sold as raw elements for recycling.

Design for disassembly

Case Study

Circle House project consists of 60 general housing units in Lisbjerg outside Aarhus, which is expected to be completed in 2020. In addition to serving as housing, Circle House is a scalable demonstration project that can give the building industry new knowledge about circular construction. Circle House consists of a range of building systems that can be assembled, disassembled and reassembled into other buildings while keeping their economic and aesthetic values intact.

The objective is that 90% of the materials being used for the buildings, can be reused without losing significant value. A wide range of materials can be used in the project, the key is the approach of the principles of design for disassembly and circularity. As it is the system that is crucial, great architectural freedom is achieved for material selection in circular construction. The project will be built in the new residential area 'Lisbjerg Bakke', located in the north of Aarhus, currently undergoing a sustainable development plan. The residential typologies are a mix of 2 and 3 story terraced houses and 5-story tower blocks. The super structure of the 3 different typologies is built from the same 6 concrete elements, optimized for a quick construction, disassembly and reuse.

In order to transform the building industry to a circular building practice the entire value chain of the industry needs to be engaged. The Circle House project involves more than 30 Danish companies across the entire industry. The Circle House project aims to develop, propagate and anchor knowledge about circular construction in the industry. As an example of this the architectural development of the project was made in as a so called 'collaboration studio', a joint team consisting of four companies with sustainability as their foundation, Vandkunsten, Lendager Group and 3XN Architects with the professional facilitation and coordination by GXN Innovation.



Project Circle House
Location Copenhagen
Year 2018
Owner Lejerbo
Architects Lendager Group, Vandkunsten, 3XN architects
Photo Helene Høyer Mikkelsen

Component upcycling

Driving statement

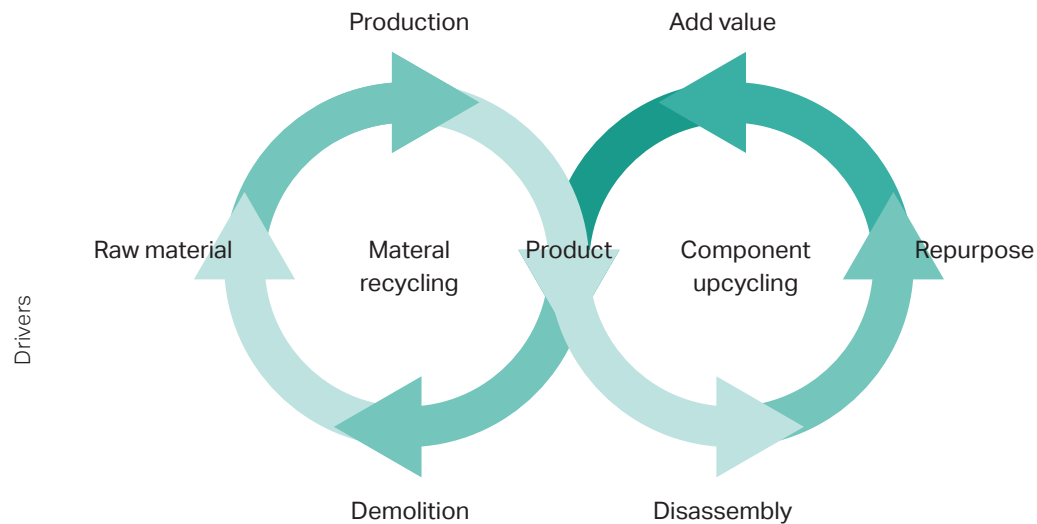
Component upcycling is a way of adding value to 'demolishing waste'. In some cases, recycling processes can achieve these aims; however, energy and water savings can be made by avoiding reprocessing materials to a virgin state.

waste management tool. Upcycling is a way designers can directly reduce the volume of demolishing waste entering the waste stream; and more broadly, material volumes in the global construction market

Component: In current demolition and waste-handling practice, components found suitable for preservation at demolition will typically be those that still contain functional and technical value and therefore possess possible sales value.

Upcycling: is a term sometimes used to define recycling with a non-diminishing use outcome and is typically used when the term recycling is taken to include reprocessing to a material with reduced performance requirements ,i.e. downcycled¹⁴. Furthermore, the primary aim of component upcycling is to refashion and integrate discarded components and materials into a new range of diverse products with open-loop cycles¹⁵. As a result, the value of the components or materials keep equal or higher as in the original embodiment.

There are clear distinctions between recycling, upcycling and remanufacturing; however, there is a relative absence of research exploring the 'system benefits' of upcycling as an effective design and



Drivers

Drivers



Component Upcycling

Case study

By means of 1:1 mock-up prototypes, The Nordic Built Component Reuse project explores new practices for reuse of dismantled building components and materials at all product stages - sourcing, rehabilitation, design integration, construction and marketing - resulting in visions of new ways to organize, tender and trade reused building components.

Project aims

It is the premise and aim of this project that future construction practice must enable resource-preserving strategies, including:

1. Repurposing building waste from demolishing, dismantling, and refurbishment.
2. Reversible construction principles known as Design for Disassembly (DfD).

Methods

1:1 work has formed the core work and led to data, discussions, exhibitions, lectures, and publications. The transformational journey from 'waste materials' at hand to valuable new components was investigated through an array of methods. First, we investigated the current market status through interviews with industry experts. Based on specific properties

and availability of large material groups, the team then used the Sfc-system to categorize waste components and map their potential applications. Then the team selected and applied Design for Disassembly principles and iterative, architectural design methods to develop multiple novel architectural concepts for facades and interior wall systems. from scrap materials groups of brick, concrete, soft flooring, steel, and wood.

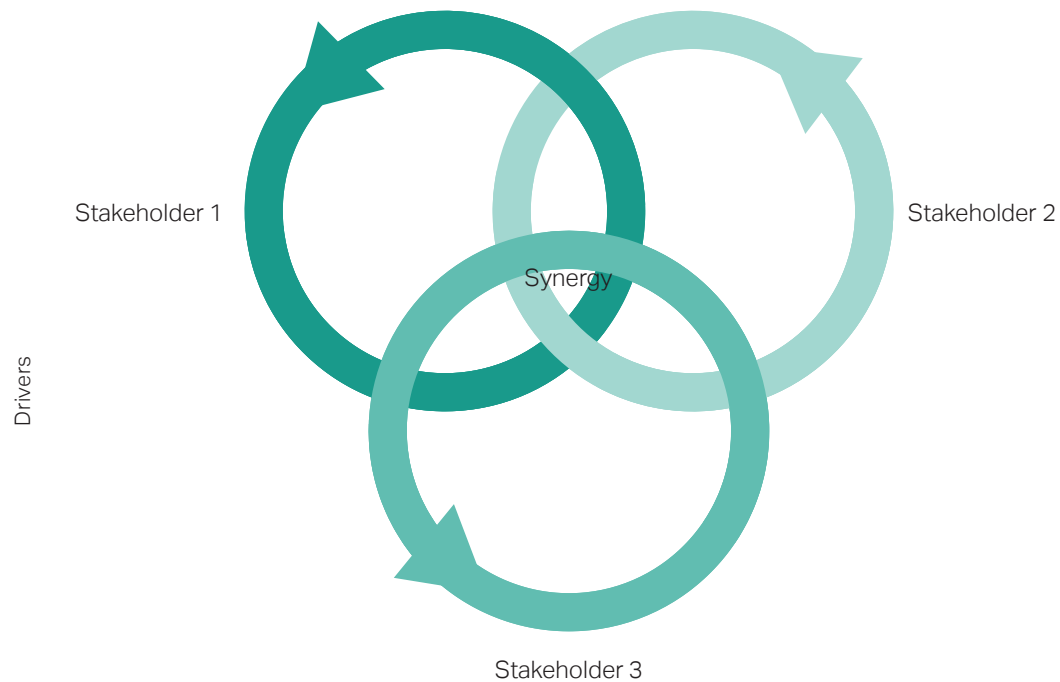
Results

The physical results of the project are the 20 full-scale prototypes made from five groups of transformed materials and components.

Theoretical results were made through double sets of comparable LCAs as well as extensive workflow charts conducted for key prototypes. All but the concrete concepts had strong LCAs. Prototypes have been broadly assessed for cultural and commercial value. In the commercial assessment of concepts ease of construction was compared with the cultural value for Genbyg customers.

Stakeholder synergy

Driver statement



Synergy is the interaction between two or more organizations, to produce a combined effect that is greater than the sum of their separate effects. A well known form of synergy is mutualism. Two stakeholders perform services for each other that they can't carry alone.

In the built environment we see an increase in stakeholders that want to participate in the circular economy. Builders, demolition companies, architects. Many are willing to rethink the building process as it is. However, they do not and can not do it alone.

A beautiful example of how stakeholders are collaborating in a mutual fashion, is the Urban Mining Collective. This collective of companies, of which most are active in the built environment, is trying out new solutions to minimize building waste. Where a demolition company has to get rid of large amounts of concrete waste, a cement and concrete factory has to buy new cement constantly. What if this supply and demand can be connected somehow?

That is what New Horizon and Rutte Groep did. They developed a machine called the 'Smart Liberator,' with which they can "free" cement out of old concrete. The old cement, now called "freement," is reusable and therefore fully circular. They have

calculated that if this innovation would be used worldwide, the total amount of CO₂-emissions would be reduced by 9%.

These types of synergy, where a waste stream becomes a resource again, turn out to be environmentally as well as financially interesting. Therefore they have potential to be upscaled and have a great impact. We need these types of synergies if we want to really transform our current economy. We need to think circular and team up with stakeholders that can help. Synergize!



Project Smart Liberator
Location Amsterdam
Year 2018
Owner Rutte Groep
Photo Bram Petraeus

Stakeholder synergy

Case study

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Acknowledgments

Two months ago Kasper Jensen entered our lives as visiting professor at our faculty. Immediately he planted the idea of writing a book on upcycling in our minds. We had two months. What did we know...

During this period we got the chance to learn from and about the “real deal.” Step out the doors of our faculty and meet true stakeholders in the field. Hear their stories and learn from them. We want to thank you Kasper, for letting us be part of this experience, taking us to Copenhagen and showing us the city and its architectural beauties. But mostly, we want to thank you for your continuous drive and enthusiasm. It has brought us where we are now.

We also want to thank Susan Jayne Caruth and Kåre Poulsen for their support on behalf of 3XN architects and GXN innovation during the start and finish of this project. Both of you have provided us with valuable knowledge.

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Lastly, we want to thank Max Veeger. Max, you are the best. Without you and your microphone, the skype sessions would have been the worst. Thank you for organizing everything and allowing Kasper and us to do our thing.

It has been a great experience writing this book together for and with all of you. We hope you enjoy it!

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| P. 106 | Bram Petraeus |

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