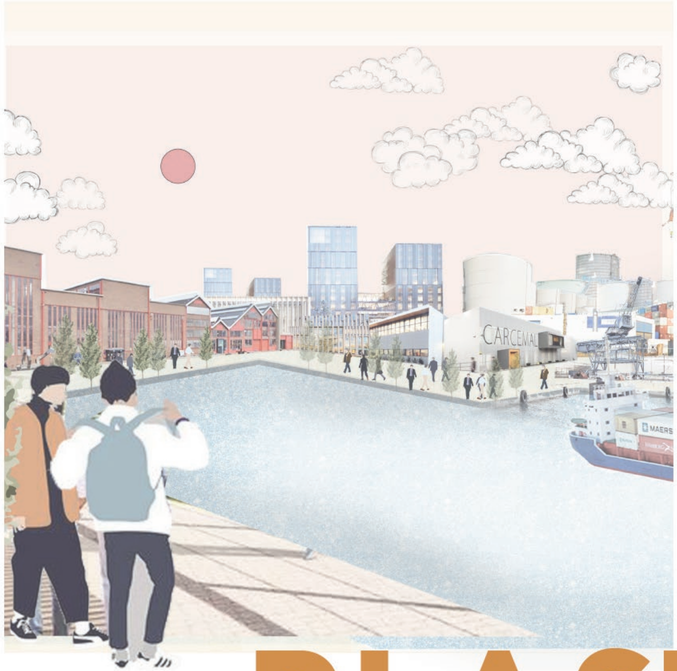
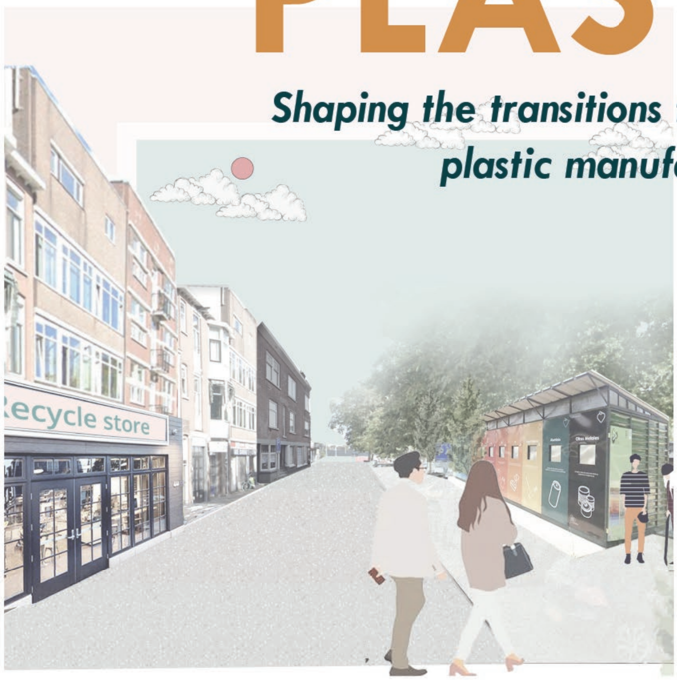
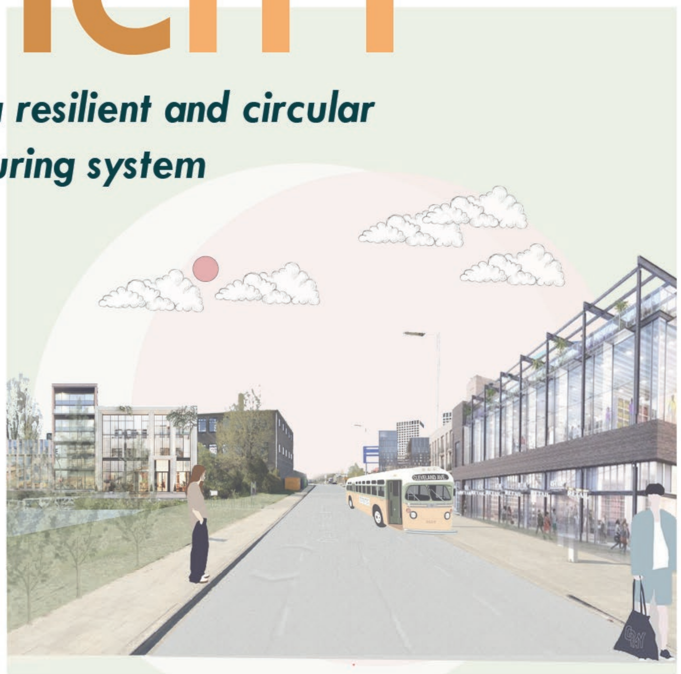


PLASTICITY

Shaping the transitions to a resilient and circular plastic manufacturing system





Xiaoge Huang, Matthijs Koch, Natalia Yu & Sophie van Hal

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MSc Urbanism Q3 2021-2022
AR2U086 Spatial Strategies for the Global Metropolis
AR2U088 Research and Design Methodology for Urbanism

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Cover image: vision and strategy collages

Plasticity

plas-tic-i-ty / plæˈstɪsəti / noun [uncountable]
technical the quality of being easily made into any shape, and of staying in that shape until someone changes it
(Longman Dictionary)

Preface

Plasticity is a proposed vision and strategy for the port of Rotterdam and the province of South Holland, to work towards a circular plastic manufacturing sector in 2050. This report has been made by Xiaoge Huang, Matthijs Koch, Sophie van Hal and Natalia Yu for the Q3 courses AR2U086 Research & Design Studio: Spatial Strategies for the Global Metropolis and AR2U088 Research and Design Methodology for Urbanism, as part of the Urbanism mastertrack at the Faculty of Architecture and the Built Environment at the TU Delft.

We would like to thank our tutors, dr. Diego Andres Sepulveda Carmona, ir. Robbert Jan van der Veen and dr. Karel Van den Berghe for their feedback during studio sessions, and dr. Marcin Dąbrowski and dr. Roberto Rocco for providing the tools and knowledge to produce this report.

Abstract

Different government bodies, from the European Union down to the Port of Rotterdam Authority have implemented the policy goal to become circular by 2050 to minimize demand and dependence on finite resources. However, a circular economy - an economic model in which materials circulate in closed loops and waste is viewed as a resource - is vastly different from the current linear system of extraction, consumption and waste. The plastics industry that is currently present in the port of Rotterdam is one such industry where large amounts of raw material is being used and large amounts of waste generated. It is still far from circular. Thus, transitions in the industry itself and in our interaction with products are necessary. The question that arises is: how can the transition to circular plastic manufacturing in the Rotterdam maritime region contribute to a more sustainable, resilient and just economy?

Theory on transition management and socio-technical systems, analyses of spatial use and networks of the plastics industry in South Holland, and research on the developments in plastic manufacturing, has led to the understanding of the current networks and flows in the plastics industry. A subsequent analysis of stakeholders, policies and design options has led to a vision and strategy for the South Holland region, on how to shape a new circular plastics economy.

In the proposed strategy of Plasticity, (1) the strength of a strategic location in the port of Rotterdam is used to expand the renewable cycle of the bioplastics industry, and (2) by actively engaging citizens in reusing and recycling plastic products on a local level in the whole region, a technical circular cycle is enhanced in the whole province. Plastic is used as an example to demonstrate the contemporary issues around dependency on fossil material in the South Holland context, but similar principles regarding integrating the biological and technical cycle, facilitating space for innovation and growth of circular models, and engaging the whole socio-technical system in the transition process can be applied to other sectors and places. This expands the applicability of this vision and strategy beyond plastic.

Keywords: circular maritime manufacturing, plastics manufacturing, circularity strategy, transition management, Port of Rotterdam

Content

1

Introduction

Circular manufacturing by 2050

Chapter content

In this chapter, the overall background of the plastic related problems in port of Rotterdam is introduced, as well as the SDG goals that point the target to achieve.

1.1 The challenge: from linear to circular

The province of South-Holland is in need of a change. Home to one of Europe's biggest ports, the region in an economic powerhouse for the Netherlands and the rest of Europe (Port of Rotterdam, 2018). However, economic and environmental issues, like job insecurities and high carbon emissions, are pressing on the future economic growth of the port. Several institutes have agreed to switch towards a circular economic model in order for the port and the surrounding maritime region to become more futureproof (provincie Zuid-Holland, 2019; Drift & Metabolic, 2018). The circular economy is described as minimizing waste by closing production loops, thus reusing materials as much as possible and protecting the value of both natural and human processes (provincie Zuid-Holland, 2019). However several industries in the port of Rotterdam are still in a linear fashion, among which the manufacturing of plastics.

What makes the plastics industry linear and why does it have to become more circular?

A linear economy is a system of 'taking, making and disposing' where finite resources are consumed and waste is seen as a products final stage (Sariatli, 2017 & Jørgensen & Pedersen, 2018). Once a product is used, it is disposed of and usually either burned or dumped. This generates a status of 'low-value' to this products, while (parts of) it could sometimes still be re-used (Port of Rotterdam, 2019).

This model of a linear economy is evident in the port region and its plastic production. The port of Rotterdam is one on the country's top plastic producers, housing around 50 chemical refineries and 70 production facilities (Lisa Data, 2019). Annually generating up to 2.5 times more plastic products than the Netherlands actually uses, the port of Rotterdam is in need for a transition towards a circular plastic production (Drift & Metabolic, 2018). The 'taking' of large quantities of raw material, the 'making' of 360 kiloton of plastic products and 'disposing' of find overall number waste to be burned. The province of South-Holland alone consumes up to 230 kiloton of plastic products and around 80% of that plastic was burned in waste facilities after-use (Drift & Metabolic, 2018). In a circular model, this number will have to drop by large amounts. This is where our main challenge lays. Our team will have to guide a large scale, deeply rooted and still mainly linear industry towards circularity.

The growing demand for plastics

Cities keep growing and the demand for plastic products will rise alongside. The global demand for plastic will continue to grow in 2050. It is expected that in 2050, 600 MMT of plastics will be need to be produced in order to meet the demand. This in comparison to the demand and production of 445 MMT in 2025 (Statista & IEA, 2022). The largest share of the type of plastic used and demand is for packaging (Plastics Europe, 2021). Usually, this type of plastic is used for single-use ends and is seen as waste at the end of the products lifespan. This is a very linear way of using plastic products and with the growing demand, will only increase over time.

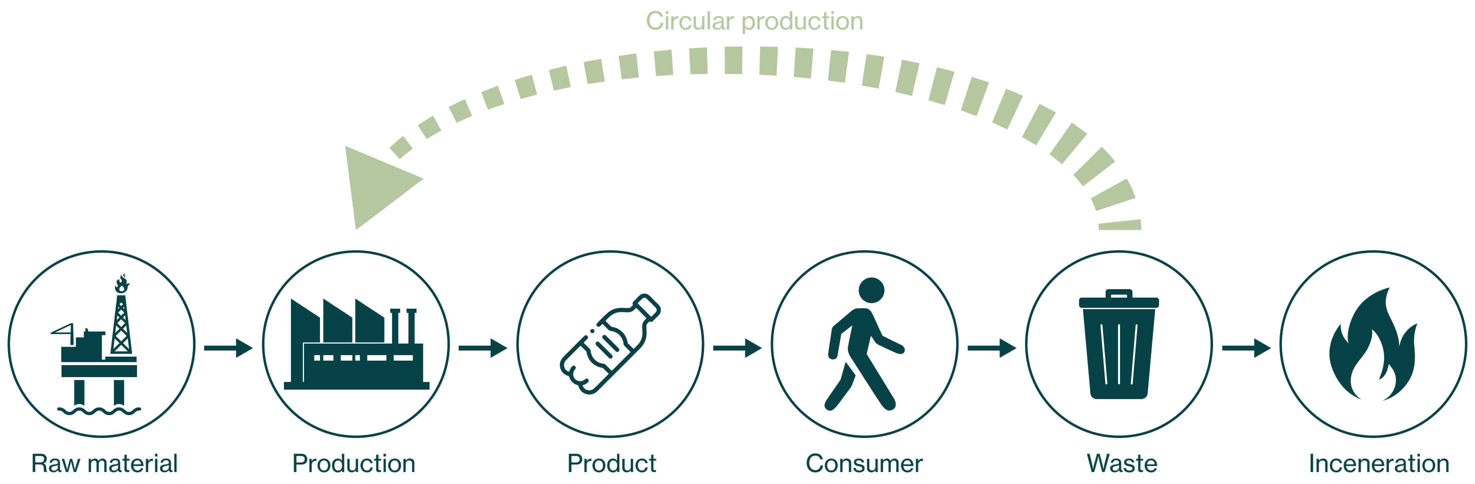


Figure 1.1, General process of plastic production

1.2 Three problems of plastic

Ubiquity

Plastic is a versatile and durable type of material. It can be molded, shaped, melted or mixed through multiple usages (Thompson, Swan, Moore, & vom Saal, 2009). Plastic packaging, for example, keeps produce fresh for longer periods of time. However, it is becoming more clear each day, that the material of plastic is highly intertwined with everyday life and consumers are becoming very dependent on it. The challenge to aim for a circular plastics production system in the port of Rotterdam thus has an extra layer of complexity added to it: plastics are everywhere. We can't solely change the production of the material, we also have to seek out the diverse range of interconnections ranging from raw material, production, down to consumer level.

Ubiquity as an opportunity

Plastic products in all forms are noticed everywhere in the port. Port activities like shipping or transport involve large numbers of plastic materials such as packaging. Another issue concerning the ubiquity of plastics is the accidental losses of plastics during transport, production or other processes (Port of Rotterdam, 2020). The challenge to change all of the networks plastic has created with other sectors is difficult to face, but necessary in order to kick start the transition to a circular plastic manufacturing industry. The deep rooted issue of ubiquity could, in turn, aid the process of shaping a circular maritime region through all sectors where plastics are involved (Drift & Metabolic, 2018).

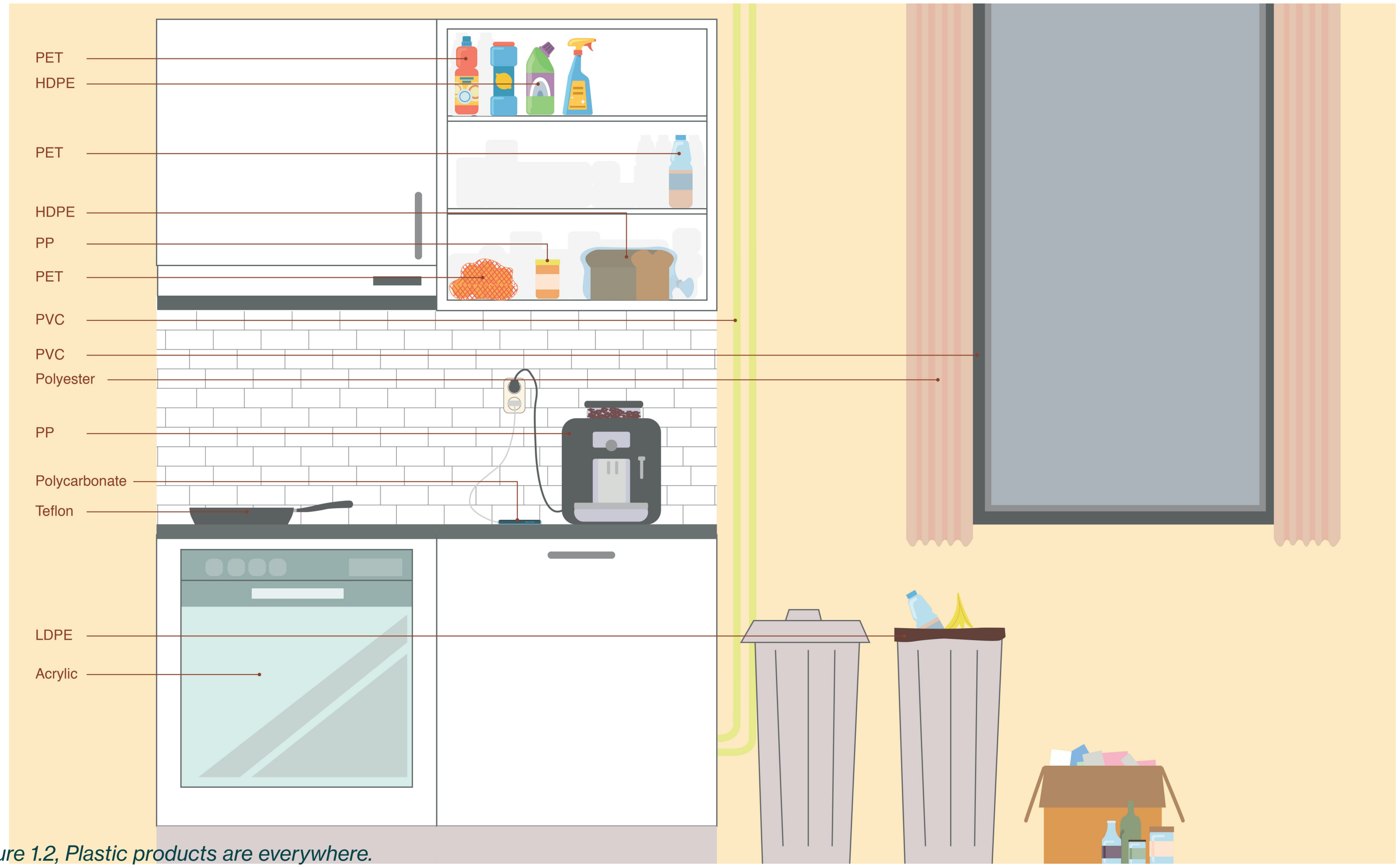


Figure 1.2, Plastic products are everywhere.

Unsustainable source

The growing need for plastics in 2050 is putting pressure on the source: crude oil (Drift & Metabolic, 2018). Crude oil is one of the main base materials for the production of plastic products. However, this raw material is finite. Speculations have shown that the world, and its current consumption pattern of oil as a raw material, has less than 50 years of oil supply left (“World Oil Statistics - Worldometer,” n.d.). This dependency on the source causes the other sectors using plastics, described in the previous part, to be heavily dependent on this unsustainable raw material as well.

International dependence

The region of South-Holland doesn’t produce crude oil. This is why the port of Rotterdam and its numerous refineries import most of the oil from countries like Russia, Iran or Norway (Port of Rotterdam, n.d.). This dependency on raw material from other countries, makes the production chain in the port of Rotterdam vulnerable for global crisises. Just recently, the war between Russia and Ukraine has proven this point to be true (Port of Rotterdam, 2022) . Insecurities around import prices and amounts will have effects in the plastic manufacturing industry as well.

In order for the port of Rotterdam to transition to a circular system, the input of finite raw material should be minimized (Drift & Metabolic, 2018). To lessen dependency on other countries and minimize the input of fossil based raw material, new ideas have to be stimulated for a new type of source material that could be produced more locally and sustainably.

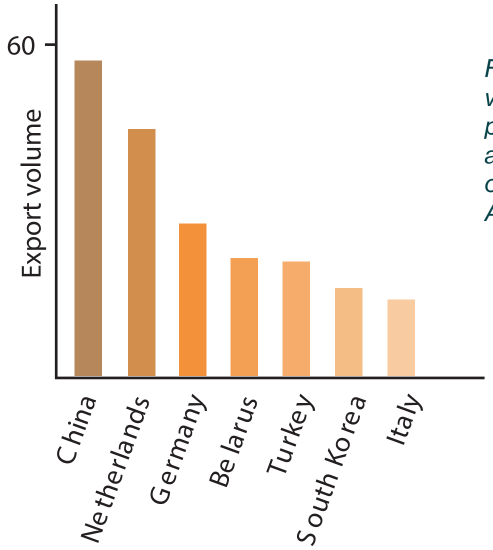


Figure 1.3, Graph of import volumes from Russia. The port of Rotterdam is second after China. (image based on statistics from Statista. Armstrong, 2022).

Pollution

Finally, the last and most concerning issue regarding the current plastic industry is the large share of polluting elements coming from the plastics industry. As stated in the previous parts, plastics are everywhere in our daily lives, not only as products but as particles in our drinking water and recently in our bodies as well. (Leslie et al., 2022). The plastic industry pollutes the environment in multiple ways, by releasing physical particles into natural systems or emitting large amounts of CO2 into the atmosphere (Plastic Soup Foundation, 2020). Microplastics floating in oceans is detrimental for wildlife and the quality of underwater ecosystems. Sea animals like fish or turtles either get trapped, ingest or hit plastic debris in waterbodies (Ritchie & Roser, 2018). The production of plastic and the processing of plastic waste has negative influences on the health and well-being of people as well. Carbon emissions deteriorate air quality and contribute to climate change.

Figure 1.4, Plastic pollution in the Schie waters, Rotterdam

A cause of this pollution has largely to do with the incorrect and mismanaging of the disposal of plastic waste. Currently, a mere 11% of all yearly produced plastics in South-Holland are eventually recycled back into the production process (Drift & Metabolic, 2018). The other percentages are either burned or put into landfills. Another problem is that, usually wealthy countries, send off their plastic waste to lower income countries (Parker, 2019). However, these low income countries often don’t have the knowledge, skills or financial capacities to manage this plastic waste properly. Thus, adding to the plastic pollution into natural water or soil systems.

1.3 Goals

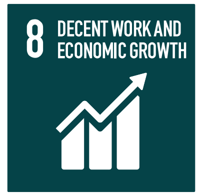
Sustainable Development Goals

The Sustainable Development Goals [SDG] set up by the United Nations are a set of goals, shaped to aid a more sustainable, fair and clean world for all (United Nations, n.d.). These SDG’s are of importance for our vision as it concerns a production industry that is not exclusive to the Netherlands, but concerns other global port regions as well. The vision should thus be in line with the global framework set up by the United Nations. This way, our vision for the port of Rotterdam can act as a global example of circular manufacturing of the plastics industry.

The SDG’s our vision will be in line with are as follows:

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Our vision will be in line with target 4.4 of SDG number 4. We aim to promote accessible education targeted to topics surrounding sustainable port development. We want to attract and encourage talent in both high-tech and practical fields. To learn form one another, foster an environment for innovative ideas and enhance collaboration between education and industry.

Ensure access to affordable, reliable, sustainable and modern energy for all
In 2050, fossil-based energy will be transformed into clean and renewable energy sources. Like target 7.2 of SDG number 7, our vision will aim to also incorporate clean energy sources throughout the transition towards a more sustainable plastic manufacturing process. We believe the transition towards cleaner energy sources is a big part of the transition towards a circular plastic manufacturing industry.



Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Our vision will, alongside introducing proper training for all, embrace the economic importance of the port of Rotterdam from the past and aim to grow further in a sustainable way. In our vision, jobs will be created as businesses, from start-ups to big companies, ranging from technical to digital skills, will be financially supported equally. Just like target 8.3, the stimulation of economic growth through entrepeneurship or innovation will be of iportance in our vision.

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
In our vision we value the element of proximity and believe it could promote discussion and participation in the to be developed, new and sustainable plastic manufacturing. Like target 9.4 of the SDG number 9, current urban and industrial forms will have to be either adapted or retrofitted with improved technologies. We believe that a large share of current spatial structures are still proper to re-use, as this is a sustainable way of making use of scarce amount of space in dense urban areas. By intervening at strategic spots throughout the region, our vision will have incremental positive effects.

Make cities and human settlements inclusive, safe, resilient and sustainable
Our vision will also tackle a social aspect of the transition towards a circular plastics manufacturing system. Growing cities equal a growing demand for plastic products. Like target 11.6 of SDG number 11, we aim to create synergies between these new housing developments and plastic recycling spaces. Our vision will not only make industrial areas more sustainable, we encourage the transformation of a healthy city as well. This way, interactions between city and port will be more comfortable and have minimized environmental effects

Ensure sustainable consumption and production patterns
Another social transition is the encouragement of a changing lifestyle. By implementing spatial interventions and encouraging education in sustainable production, people are stimulated to change their consumption patterns. In line with target 12.5 of SDG number 12, waste should be re-used as much as possible. In our vision and its establishing of a circular economy, waste is seen as a valuable product instead of having no value. Changing how people view products after-use could aid this transformation.

2

Methodology

Chapter content

In this chapter, the issues and the goals that have been introduced in the previous chapter are translated to a methodological framework.

First, the research question and sub-questions are introduced, after which the relevant concepts and methodologies are explained.

2.1 Problem Statement

The port of Rotterdam currently operates with a very linear fossil-based plastic production. Too much products are consumed and discarded than the region actually needs. The plastics industry is currently dependent on other countries in order to function properly. This dependency increases vulnerability of material flows, employment and market prices. Furthermore, the current fossil-based plastics industry is increasing environmental pollution.

What makes the issues even more complex is the ubiquity of fossil-based plastics. Plastics are everywhere. However, our vision sees this issue as an opportunity:

By transforming the linear, fossil-based plastics manufacturing industry to a more circular system, the entire region of South-Holland will become more sustainable. The new circular port of Rotterdam can thus act as a global example in new ways of plastic production and smart ways of recycling.

2.2 Research Questions

In order to give a response to the problem at hand, this report will aim to answer the following question:

How can the transition to circular plastic manufacturing in the Rotterdam maritime region contribute to a more sustainable, resilient and just economy?

Sub-questions:

- *What is the current (spatial) structure of plastics manufacturing in the Rotterdam maritime region?*
- *How sustainable and resilient is the plastics manufacturing sector currently?*
- *How can the plastics industry be made circular?*
- *What spatial interventions could facilitate a circular plastic economy in the Rotterdam maritime region?*
- *How can a just transition to circular plastics manufacturing be achieved in the plastics industry?*

2.3 Conceptual framework

On the next page in figure 2.2 the conceptual model for Plasticity is shown. The conceptual framework shows the concepts that are used to guide the analysis and vision, and how the concepts relate to one another.

The conceptual framework consists of three components.
1. A central notion is that the objective of a circular plastic industry requires a socio-technical transition (which in turn consists of several transitions).
2. Guiding the research of the transition to a circular plastics industry are three themes (circular economy, resilience and scale of cycles) each with their own concepts. As the conceptual framework shows, these concepts are interrelated.
3. Finally, the research is guided by the concept of socio-spatial justice. Socio-spatial justice is used both as a guideline, as well as an evaluation method of the design for the central goal.

These components will each be explained in the remainder of this section.

Transitions
The goal of circular manufacturing requires a transition from one state to another: from a linear system of extraction, consumption and waste, to a circular system of closed cycles and waste as a resource. An important concept used in this research to describe transitions is the X-curve from Loorbach, Frantzeskaki & Avelino (2017). This figure comprehensively shows that the old system is broken down, while the new system is built up. This transition has several identifiable phases that give structure to analysing the transition process.
It must be acknowledged that a transition from one economic model to another is not merely economic. Rather, the whole socio-technical system of institutions, technology and actors requires a transition (Loorbach et al, 2017). This is why we identify three different transitions that happen in cohesion:

- A social transition, which includes the involvement of actors and change in behaviour
- A spatial transition, which includes change in modes of production and physical networks in a new economic model
- A sustainability transition, which is one of the primary reasons of adapting the circular economy model.

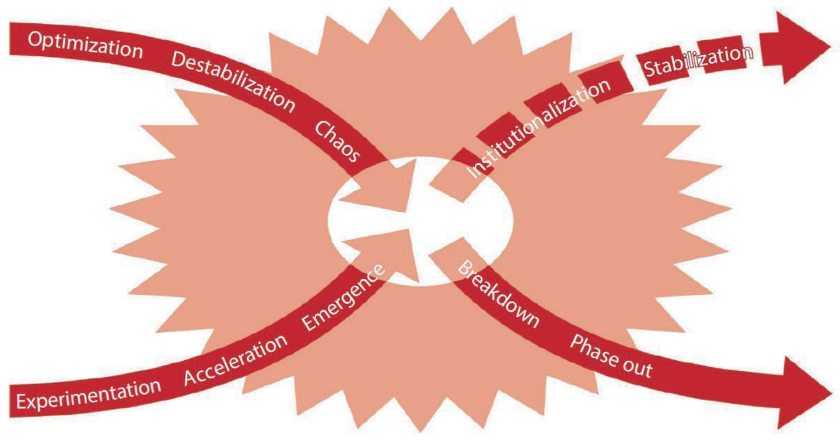


Figure 2.1, X-curve for transitions (Loorbach, Frantzeskaki & Avelino, 2017)

Circular economy
The 'circular economy' is a new buzzword in policy debates (Heurkens & Dabrowski, 2020). The concept is still in development and because contributions to the development of the concept come from different fields of study, there are many definitions of 'circular economy' (Drift & Metabolic, 2018). The circular economy is the economic model that applies the notion of circularity, which is about closing material cycles (Gemeente Rotterdam, 2019). Geldermans et al. (2018), point out that in a circular economy natural capital and resources are used in an environmentally and economically sustainable way. In a circular economy, the resource flows in a production-consumption network are optimized. This means that flows are cycled in closed loops or are connected through the spatial or temporal conditions in which the highest possible value can be retained (Geldermans et al., 2018). Unlike some companies wish proclaim, recycling of material is only a part of a circular economy.

Two main concepts from the field of circular economy studies are used in this report to operationalize the circular economy: technical cycles and biological cycles, which are both combined in the butterfly model.

<u>Butterfly model (technical and biological cycles)</u>
The butterfly model is a visualisation by the Ellen MacArthur Foundation (2012, figure 2.3) as a way to show two different models for circularity. These two circularity models are based on the work of Braungart and McDonough (2002) on the cradle to cradle concept.
The butterfly model consists of a biological cycle and a technical cycle. In the biological cycle, renewable materials can be safely returned to the biosphere at the end of their life cycle, after they

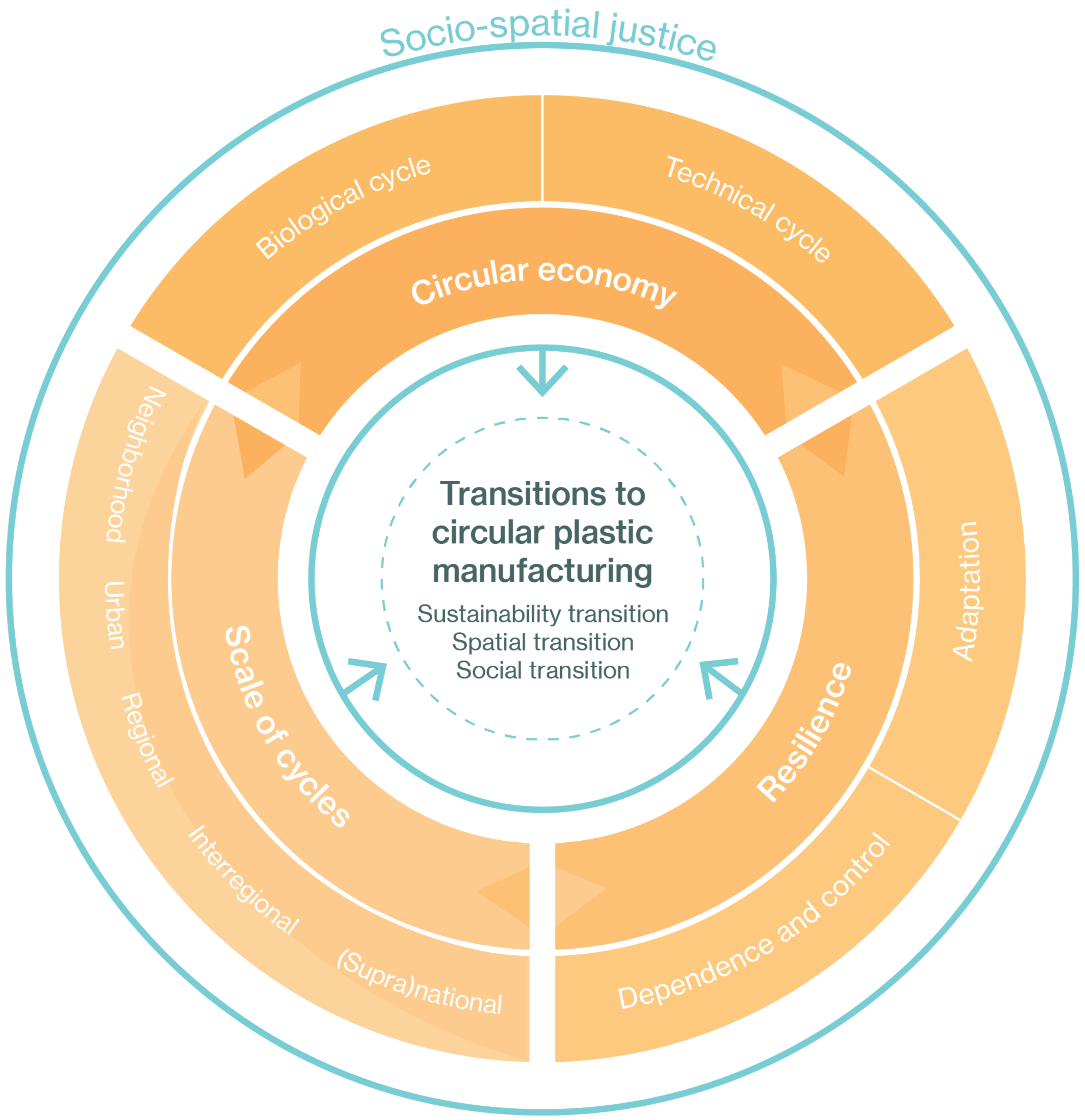


Figure 2.2, Conceptual framework

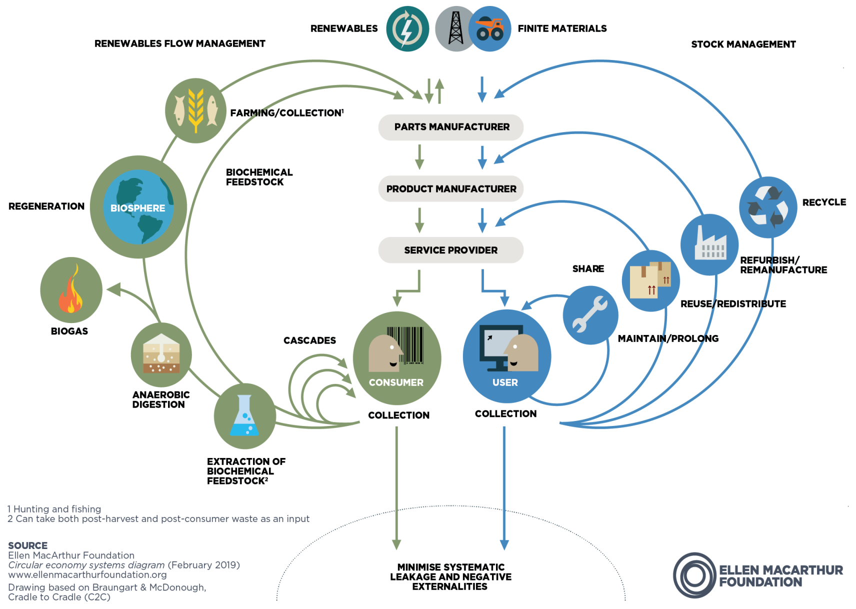


Figure 2.3, Butterfly diagram (Ellen MacArthur Foundation, 2012)

have been cascaded in their highest use. The technical cycle describes circularity for material that cannot be safely returned to the biosphere, of which conventional plastic is a clear example. In this technical cycle, products are kept in highest possible use before being recycled, through reusing, repairing and remanufacturing products or parts of products (Ellen MacArthur Foundation, 2012). The technical cycle is closely related to the R-ladder, which describes a hierarchy in resource use to minimize wast, starting with refusing, reducing and rethinking, a use phase of reusing and repairing and a recycle phase (Kishna, Rood & Prins, 2019).

So, the butterfly model contains two approaches to circularity based on the renewability of the waste. Because plastic has various applications with different functional requirements (Hahladakis & Iacovidou, 2018), particular circularity strategies may be feasible in one application, but not in the others. Thus, a combination of strategies is required. The two approaches to circularity create several possibilities for this.

Scale of cycles

The third theme that guides the research is the scale of circularity. The closing of material loops can happen on many different scales. From a very local scale - closed loops within a neighbourhood - to a global scale - where materials are transported across the globe to be reused or recycled (Drift & Metabolic, 2018).

Because closing of material cycles is a new kind of system, it will require a change in social and physical (infra)structures. Different scales of circularity require different types of infrastructure. A more local scale of circularity might have very different spatial consequences for the economy and use of space in the Rotterdam maritime region than a more global scale of circularity. The scale on which circularity will crystalize will therefore influence the shape of the new social and physical (infra)structures in the Rotterdam maritime region (Drift & Metabolic, 2018).

The ideal scale of circularity is partly determined by the type of material and economic value of a material. The scale of circularity is different for sand than for precious metals. As of now, it is not clear what the optimal scale is for circularity in the plastics industry (Drift & Metabolic, 2018).

Resilience

The concept of resilience is taken from the socio-ecological approach of sustainable transitions (Loorbach et al., 2017). “Resilience is related to the ability of a system to withstand shocks while maintaining function as well as to transform anticipating external pressures, shocks and threats.” (Loorbach et al., 2017, p. 13). Even though resilience is often used related to the desire to maintain a certain regime, its application moves beyond staying in a certain shape.

We use to concepts related to resilience: adaptation (economic and social resilience in the face of a transition), and control (resilience in the face of shocks and threats).

<u>Adaptation</u>

Currently the socio-technical system of the linear economy model is in a lock-in. Characteristic for this state is path dependency: instead of developing a new and better system, the system is in a state of optimalization. The risk of this is that it becomes inefficient (Sydow et al., 2009). Certain factors, such as the emergence of a new technology can lead to the destabilization of a regime and give rise to new regimes (Loorbach et al., 2017). Being able to adapt from the vulnerable old regime to the new regime, while maintaining function is at the core of adaptive resilience.

<u>Dependence and control</u>

In the current linear economy, there are many factors that can lead to destabilization. An event that disrupts linear supply chains can consequences throughout the production chain. Recent examples of the vulnerability this creates are the block of the Suez canal in March 2021 (Notteboom, Pallis & Rodrigue, 2021), the Covid crisis and the rise of oil and energy prices due to conflict (NOS, 2022). These shocks also expose undesired dependence on the first part of the supply chain. Whether we like it or not, the port of Rotterdam and its plastic industry are currently dependent on Russian oil.

Systems that are built for efficiency are fragile, while diverse systems with multiple connections and scales are more resilient in the face of external shocks (Ellen MacArthur Foundation, 2012). Resilience in this sense is about being able to pull different levers and keep a certain degree of control in the face of shocks.

Socio-spatial justice

Socio-spatial justice is used as a way to assess the proposed vision and strategy in this report. For this reason socio-spatial justice also guides the vision and strategy.

‘Justice’ may take on different meanings depending on social, geographical, and historical context (Harvey, 2002). Justice can both be procedural (social) and distributive (equitable distribution of burdens and benefits). Justice is based on notions of consensus and fairness, which are values that are generally held in high regard, and makes justice a good evaluation criterion (Fainstein, 2010).

The choice to use justice as an evaluation method is value laden. It reacts to the frequently used measure of economic growth in the neoliberal planning process that aims at enabling market processes (Fainstein, 2010). Often in the growth model, individuals benefit from the common good, but everyone experiences the exhaustion of resources. This means that there is an unfair distribution of burdens and benefits. Justice on the other hand is about fairness: about diversity, democracy and equity (Fainstein, 2010). The vision for this project has been made in an educational context, so while attention has been paid to democracy, real participation is not possible. Therefore the focus is slightly more towards equitable distribution of resources than about procedural justice. However, both are addressed.

2.4 Methodology

The product of this report is an evidence-based design exercise. In design, there is a constant interaction between research and design. One categorisation to describe the different relationships between research and design is the division of research for design, research through design and research about design (Frankel and Racine, 2010). Research for design is research that informs the design, research through design is a method of answering a question by means of design and research about design is a field that studies the design research. Research and design both influence each other at different stages of design research (Frankel & Racine, 2010).

Figure 2.4 shows the process of our research. The starting point of the process is the given assignment which briefed the first research for design phase. A background research with literature (both academic and non-academic) and spatial analysis led to an understanding of the problem on which the research question is based. The conceptual framework that guided the analysis is based on literature review. The analysis phase consisted of academic and non-academic literature reviews on the plastic production chain and associated flows, and spatial analyses. These spatial analyses were conducted using GIS datasets and general GIS data and documented in the form of maps. The analyses resulted in an understanding of current networks, flows and stakeholder relations which informed the vision for the future.
This vision is evidence-based, but has a research through design character as well, since different iterations were tried.

The vision is the basis of the strategy. Additional policy research, research on existing plans and strategies (which can be called research on design), and stakeholder analyses were conducted for the strategy. Spatial interventions were developed based on the general strategy and further developed with research through design.

Especially this last phase is iterative. The development of the spatial interventions by both 'research for design' and 'research through design' informed the vision and strategy, which illustrates that the design research is an iterative process.

The final design and vision is evaluated by using the literature-based conceptual framework.

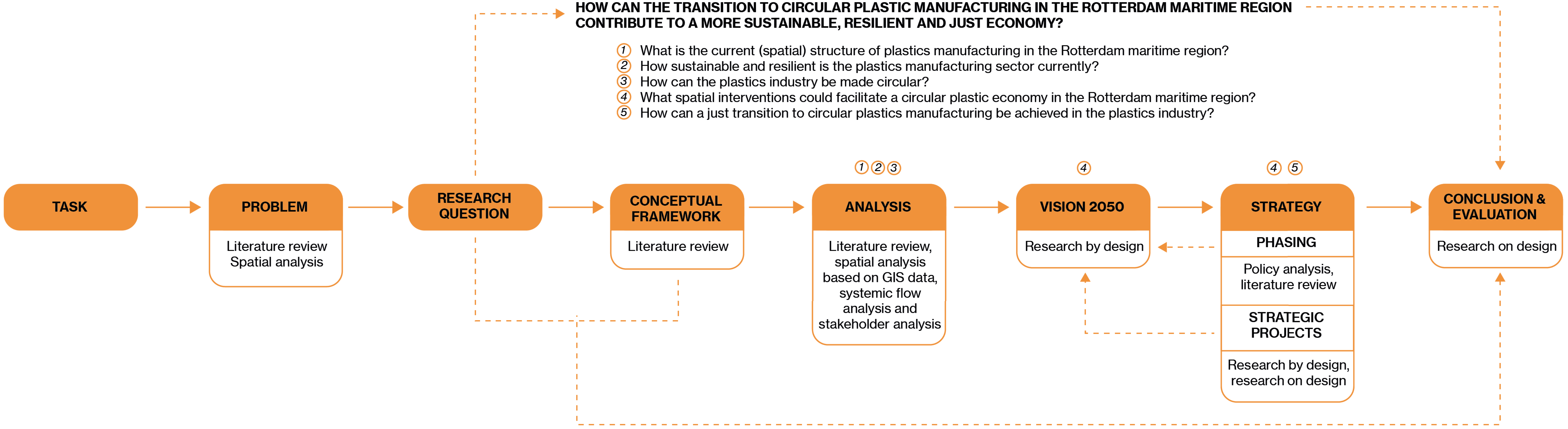


Figure 2.4, Methodology flows

3

Analysis

Plastics in South Holland

Chapter content

In this chapter, more detailed information about plastic is explained, together with the analysis of its situation in South Holland, its relatinships with the infrastructure and stakeholders. Based on that, the diagnosis stimulates the vision drafting.

3.1 The world of plastic

3.1.1 Plastic as a material

Why is plastic important in our daily lives?

Every time when we think of plastic, it is hard to avoid those different properties that pop into our mind: either transparent or opaque, hard or soft, as their forms are too diverse and flexible to leave us a single impression. On one hand, plastics are widely used for packaging as they can be light and waterproo; on the other hand, they can be applied to vehicles as well when they are attributed with good transparency and malleability. Although the manufacturing of plastic is never friendly to the environment, we still cannot live without this material in the foreseeable future.

The production process of plastic

- Traditional fossil-based production

In the normal plastic manufacturing process, crude oil is refined and polymerized to produce polymers (Fig. 3.1), which is the raw material for the formulation and moulding of final products. Traditionally, the process is supplied with fossil fuel energy, such as coal, petroleum and natural gas. After the final use, most of them (around 80%) result in landfill, and the remainings (around 20%) are incerated or mechanically recycled. Both of them lead to high potential of environmental leakage (Rosenboom, JG., Langer, R. & Traverso, G., 2022).

- Bioplastics - A promising role in the future

Bioplastics are coming into peoples' lives in recent years, which is a more sustainable substitute for fossil-based plastics. 'The term 'bio-plastics' refers to polymers which are bio-based, biodegradable, or both (BIO-PLASTICS EUROPE | "Bio-Plastics", n.d.).' (Fig. 3.2)

Bio-based polymers are (or partly) extracted from biomass: the 'organic material of biological origin (excluding material embedded in geological formations and/or fossilized) (BIO-PLASTICS EUROPE | "Bio-Plastics", n.d.).' The biomass that can be utilised at the stage are plants, algae, marine- and micro-organisms, etc. Another source for 'Bio-based' can be the organic waste in any form (BIO-PLASTICS EUROPE | "Bio-Plastics", n.d.).

Biodegradable materials are those can be break down into natural substances such as water, CO2, so as to be composted by different natural organisms. Normally, the conditions for the microorganisms in water and soil are critical for biodegradation, especially the presence of oxygen. Meanwhile, the property of biodegradation is closely linked to its chemical structure (BIO-PLASTICS EUROPE |

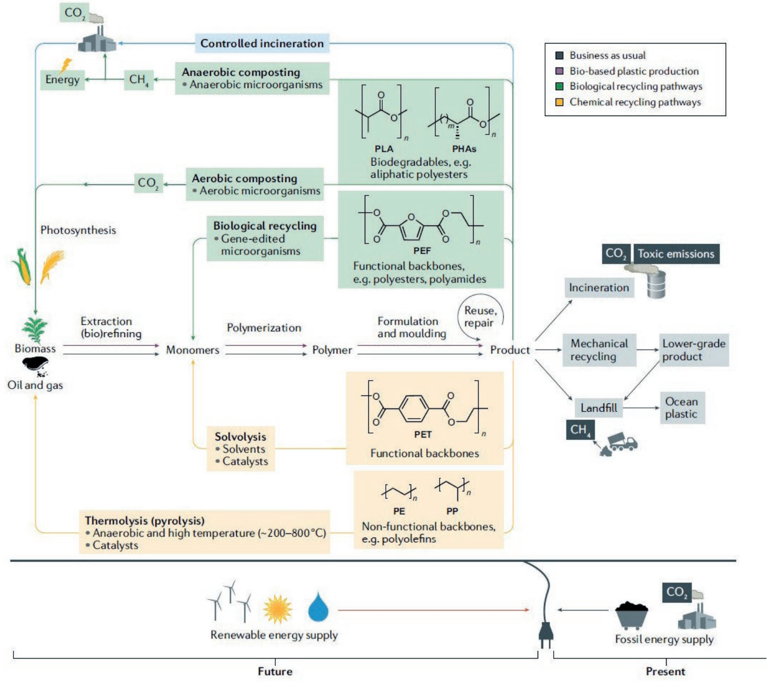


Figure 3.1, The manufacturing chain of plastic (Rosenboom, JG., Langer, R. & Traverso, G., 2022)

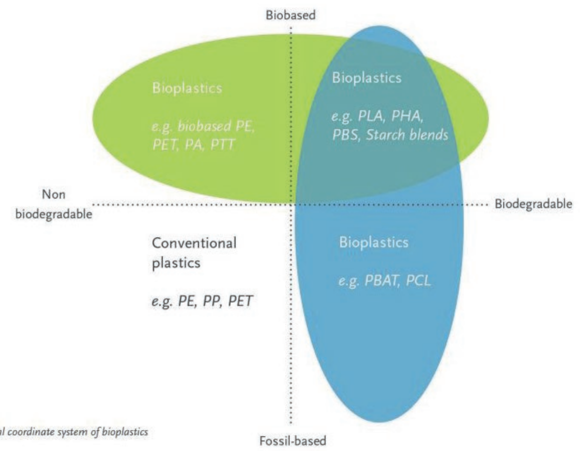


Figure 3.2, Material coordinate system of bioplastics (BIO-PLASTICS EUROPE | "Bio-Plastics", n.d.)

"Bio-Plastics", n.d.). Therefore, both the quality of the environment and the plastic material itself are important to achieve a successful bidegradation process.

In the circular bioplastic manufacturing process, the feedstock come from biomass and plastic waste. After the end of their life, the plastic products that are hard to reuse will be recycled for a new round of production (Fig. 3.5), or composted (Fig. 3.4) to serve as fertilizers. While those with relatively complete form will get into reuse and repair depending on their status. During the process, the clean and renewable energy (wind, hydrogen etc.) is applied to support a sustainable manufacturing scenario (Rosenboom, JG., Langer, R. & Traverso, G., 2022).

Figure 3.3, Polymer (Clarke, 2018)

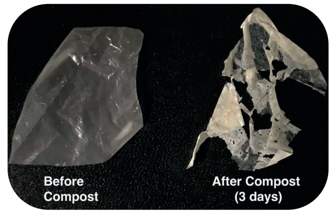


Figure 3.4, Composting (Bioplastics magazine, 2021)

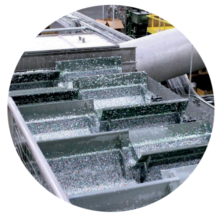


Figure 3.5, Recycle (B+B, 2020)

Different types of plastic: value and recycleability

Different kinds of plastic products show different properties based on the structure of the monomers (Fig. 3.6). For example, the plastic bags for grocery packaging are transparent, flexible but fragile, they belong to the family of Low-density Polyethylene (LDPE). In contrast to that, High-density polyethylene (HDPE) is less transparent, stiffer and long-lasting, which explains why it tends to be used for milk bottles. The difference comes from their molecular structure, although these two types of plastic are all composed by the monomer of ethylene, there is less branching in the structure of HDPE than that in LDPE, which equips HDPE with stronger intermolecular forces in the polymerization process (Yashoda, 2016).

In the world of plastic, one of the most common ways to classify the value is by evaluating the difficulty in recycling. In other words, after the end use, the harder the plastic product is to recycle, the lower value it tends to have in recycling. In that way, polystyrene (PS), polyvinyl chloride (PVC), polypropylene (PP), and low-density polyethylene (LDPE) are defined as relatively low-value plastics (Fig. 3.7), because they are hardly accepted by most recycling programs with the lack of technologies and innovations to make it a place in the loop (Gladstone, 2021).

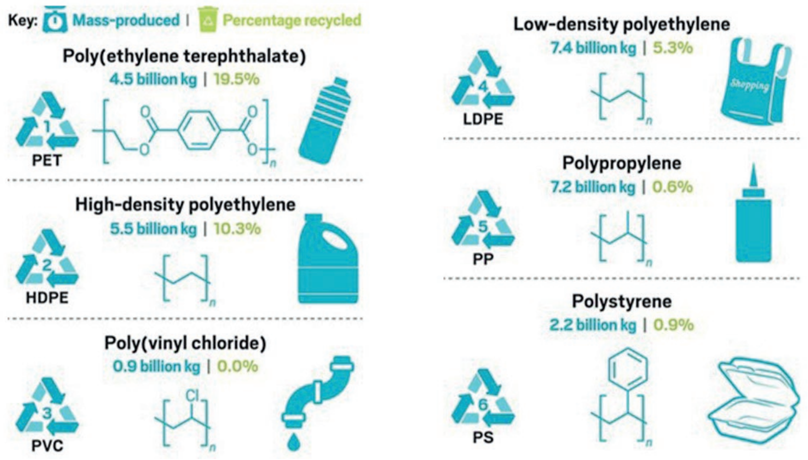


Figure 3.6, Molecular structure of plastics (Lemonick, 2018)

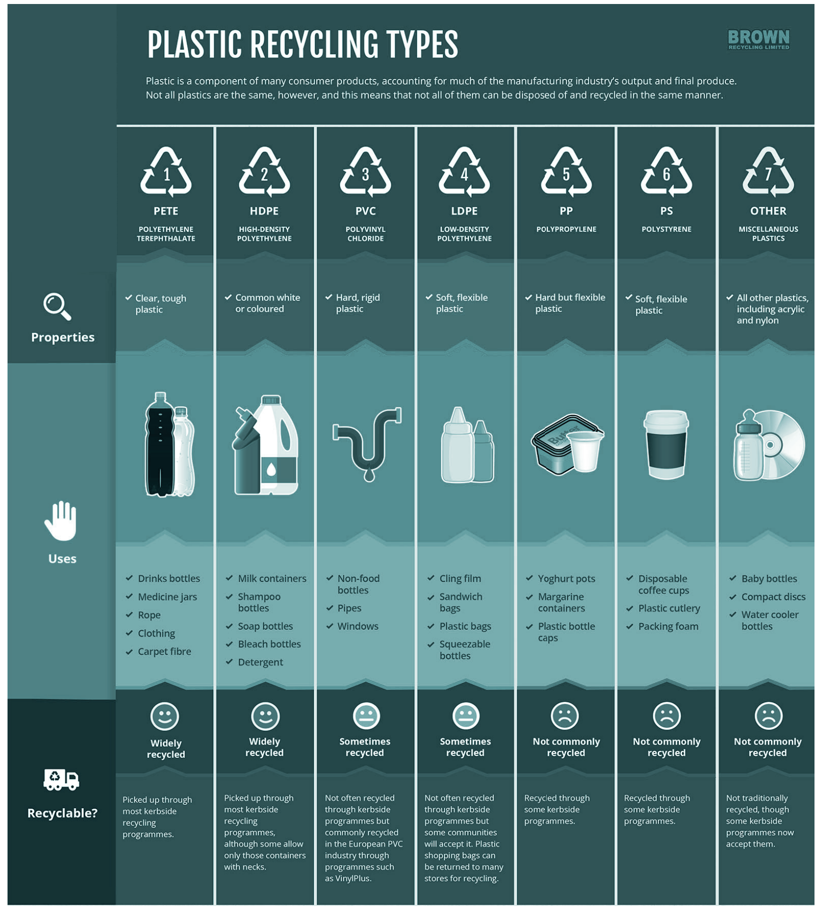


Figure 3.7, Plastic recycling types (Brown Recycling, 2022)

3.1.2 Plastic production chain

International connections

The European plastics production chain of the EU27 incorporates plastic raw materials producers, oil refiners, plastics converters, plastic recyclers and relevant machinery producers around the world. In the general plastic poduction chain, world-wide collaboration plays an important role, and the whole progress depends largely upon imports and exports (Fig. 3.8) (PLASTICSEUROPE, 2021).

The plastic production chain in Netherlands

Being one of the largest ports in the world, Port of Rotterdam is absolutely the leading role in European plastic manufacturing and processing with integral production chain, although there is a lack of resiliency at the moment.

Still, the whole story begins with the crude oil, which are either imported or extracted from marine and land. However, only a part of the refined oil then gets used for the plastics industry in the port of Rotterdam. First because only specific hydrocarbons found in crude oil that are left after refinement, particularly naphtha, are suitable for plastic production (Plastics Europe, n.d.). Secondly, while the refining of crude oil does take place on a large scale in Rotterdam, the production of plastic is not concentrated in the port of Rotterdam. There are roughly 30 companies that produce plastics in primary form in the province of South Holland (Drift & Metabolic, 2018). A few notable large companies, such as Indorama and Shin-Etsu are located in the port of Rotterdam. Several other companies that produce the raw material that can be used for the production of plastic can be found in the region, such as the Shell facilities in Moerdijk (Drift & Metabolic, 2018). These companies connect to a wider regional network. Part of the oil that is refined in Rotterdam gets transported through pipelines to Antwerp in order to be used in the petrochemical industry there (Van den Berghe et al., 2022).

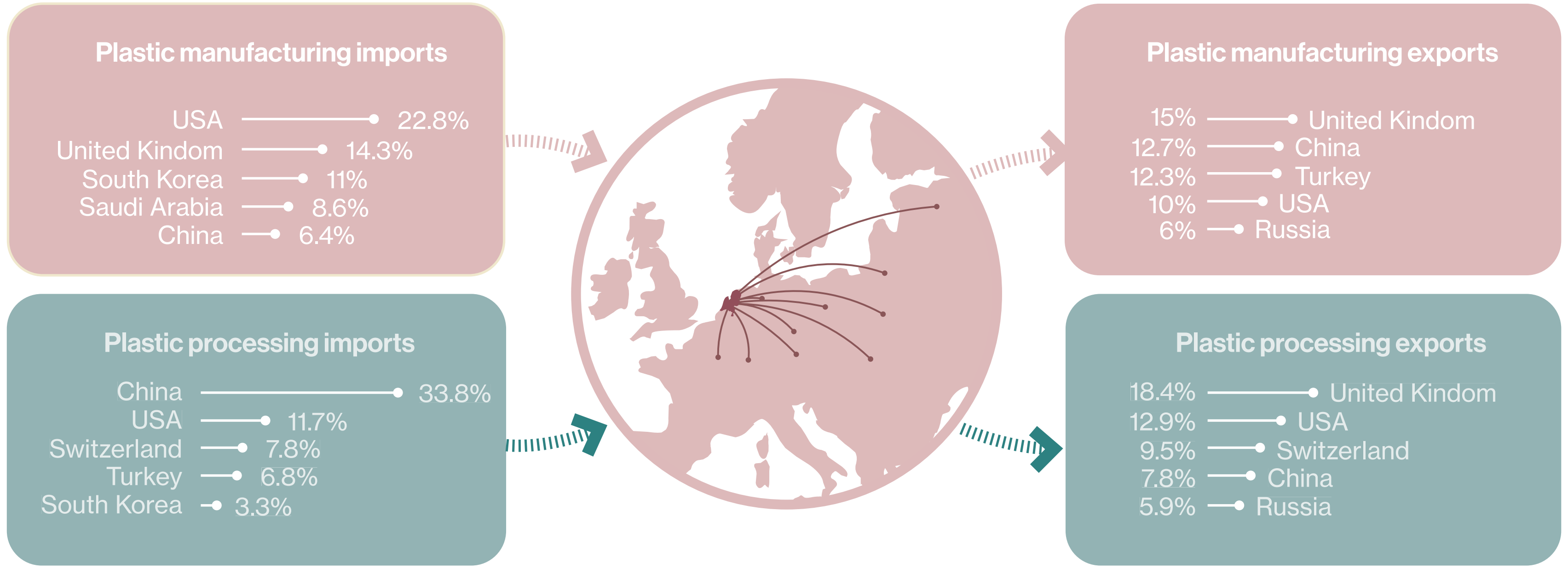


Figure 3.8, Top EU trade partners (PLASTICSEUROPE, 2021)

Meanwhile, after the primary manufacturing of plastic pallets, formulation and moulding for final production is the last step before the plastics becoming the form as what we are familiar with. The final products are transported to urban area or exported overseas. A large part of the port of Rotterdam is focussed on oil-related processes: transport, storage, refining, processing and the petrochemical industry (Van den Berghe et al., 2022) (Fig. 3.9) Despite plastics being a minor component of the complete crude oil activity in the port of Rotterdam, the plastics industry is strongly connected to the oil industry in the port of Rotterdam.

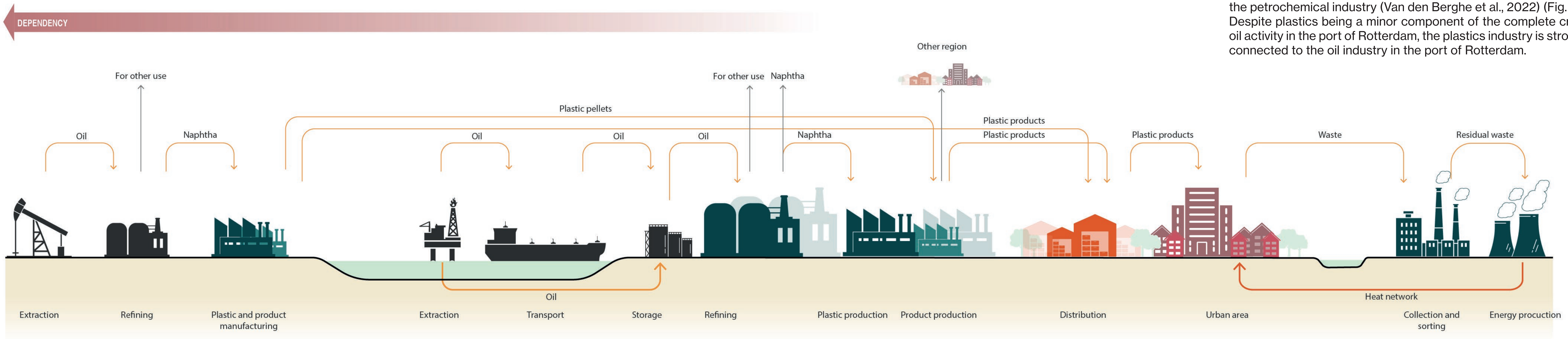


Figure 3.9, Systemic section of plastic production chain

3.1.3 Plastic in a circular economy

The possibilities and challenges for plastics in a circular economy

As is revelaed above, there is great momentum and potential in the development of circular plastic economy, including the good connection between different manufacturing phases and the innovation-oriented production of bioplstics. However, there are still efforts to be put into other phases such as the efficient sorting of plastic waste, where public participation plays a dominant role.

Overall, to further upgrade the plastic manufacturing in a circular economy, there are two paralleld pathways to keep with at the same time (Fig. 3.10). From the perspective of manufacturing with the existing finite (fossil-based) materials, reinforcing the research and application of rcycling technologies is important, including mechanical and chemical recycling or even combining them. Apart from that, the concept of R-ladder should be popularized among stakeholders (especially manufacturers and citizens) to raise their awareness of the method in sustainable plastic disposal after end-use.

As for the manufacturing with renewables (feedstocks and energy), more arable land can be used for bioplastic production based on the condition of sufficiency for food industry, with the combination of imported materials that are hard to achieve in Netherlands. Besides, greater importance should be attached to the innovative technologies for bioplastic products and clean enerygy such as hydrogen and wind energy.

Following the progress simultaneously, the production with finite materials can gradually phase out and be replaced by the renewable pathway in the end. This integral development cannot stand without the joint efforts of all the stakeholders.

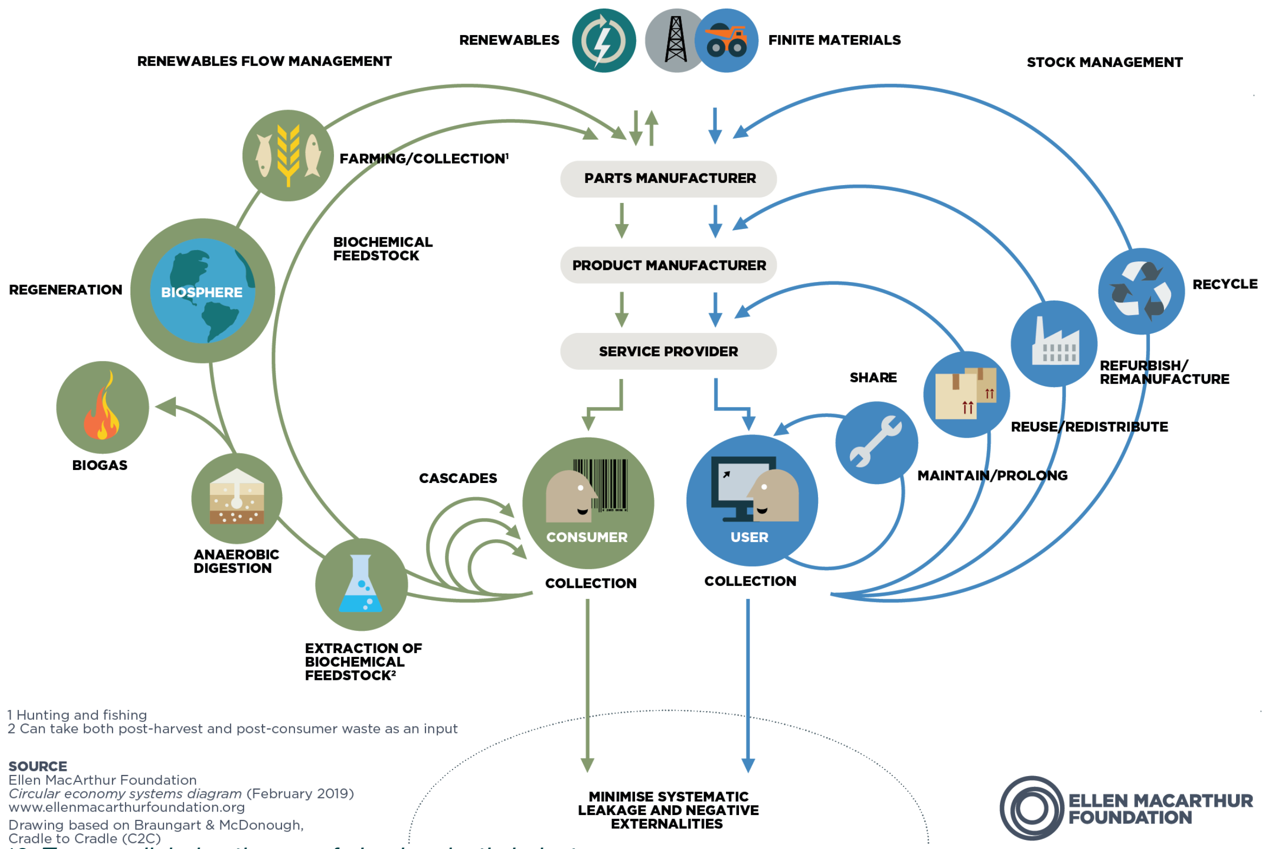


Figure 3.10, Two paralleled pathways of circular plastic industry

3.2 The current state of plastics in South Holland

3.2.1 The flows of plastic in South Holland

High demand of raw material

Fossil-based materials are the predominant resource (approximately 487 kiloton) for the production of plastics, including oil, natural gas and coal. Apart from that, around 42 kiloton of recycled plastic is input to make new products. For the bioplastics, about 46 kiloton of biomass is needed. There is roughly 942 kiloton of carbon dioxide (CO2) coming from the raw materials mentioned above (Drift & Metabolic, 2018).

The usage and after-use

In the nine categories of plastics, most of the products in society are used for packaging (approximately 39%) (PlasticsEurope 2017). Some of the plastic becomes trash after the end of their lives, while a little portion becomes other forms such as frames or electronic devices. The main waste streams include household (74%) and industrial waste (26%). Based on that, the majority of the plastic ends up in household residual waste, only a small part of the residual waste is collected and sorted for recycling within whcih a part is still incinerated. Addressing this based on plastic types, PET is reused mostly in packaging (2%), while the rest find different destinations to landfilled (1%) recycled (19%) or incinerated (77%) (Drift & Metabolic, 2018).

There are several causes lead to the separated plastics being end up with incineration. Firstly, the plastic is of low-quality for recycling with efficiency. Secondly, the defective logistics and the infrastructure for collection and separation are to blame. Thirdly, there are also economic incentives that promote the incineration, which defines how much profitability can a waste incineration plants gain from waste incineration to generate electricity. In South Holland, 32.8 GWh of electricity comes from the combustion of plastic in order to power 7,000 households per year (Drift & Metabolic, 2018).

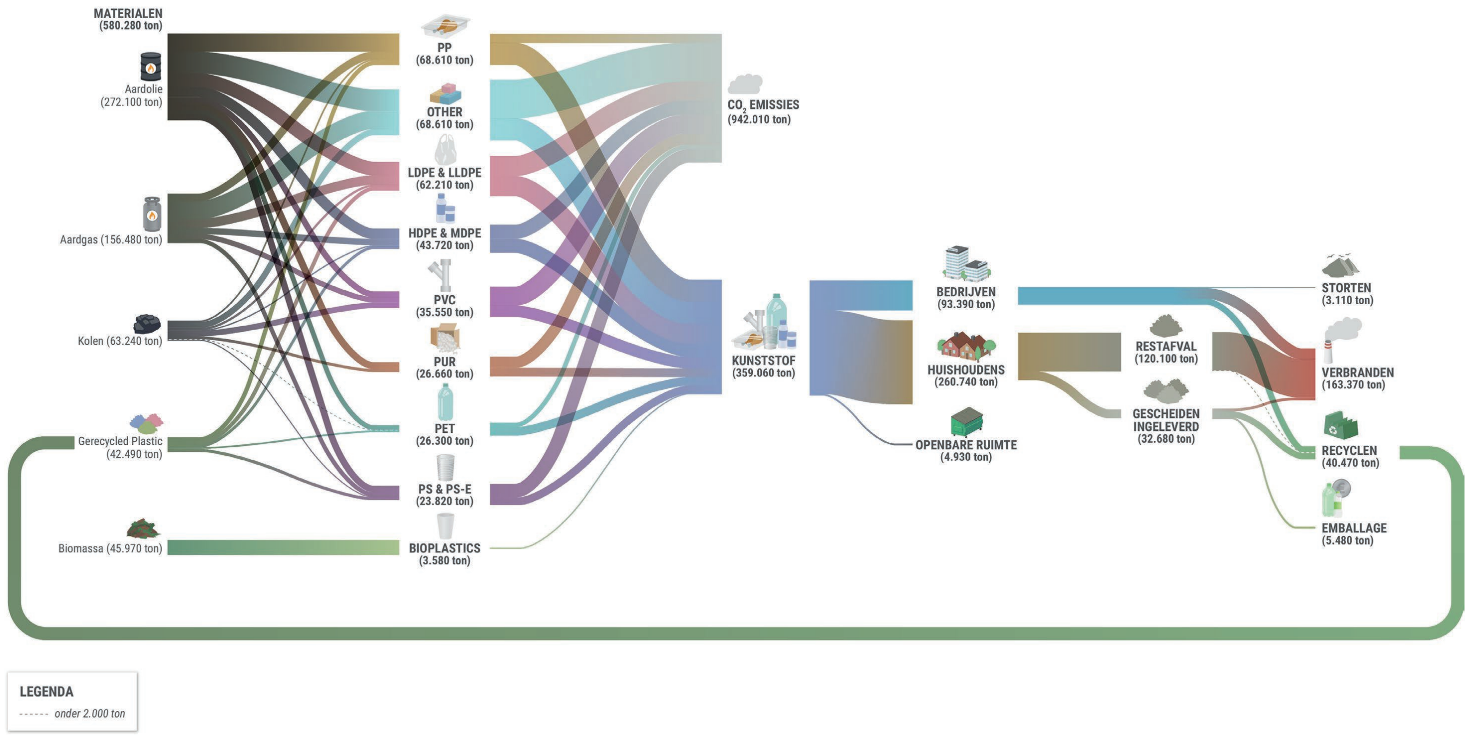


Figure 3.11, Sankey diagram for plastic flows in South-Holland Drift & Metabolic (Drift & Metabolic, 2018)

3.2.2 Plastic production in regional context

Plastics are traded globally, and Europe imports and exports large amounts of both primary and non-primary plastics every year. Primary plastics are the plastic materials themselves, such as pure polymer granulates and compounded plastics. Non-primary plastics are plastic components for later assembly, such as car interior panels, and finished products, for example tubes and bags, as well as products containing plastics, such as electronics, furniture and cars.The Europe has a trade surplus in both primary and non-primary plastics, meaning that the value of the exports for both categorie is larger than the value of the imports.The development of the plastics industry can be profitable and promote the development of the industry. But at the same time, when considering the benefits, we also need to consider the issue of sustainable materials and the waste generated by plastic products that have been imported and exported.

Figure 3.12, EU imports and exports amount

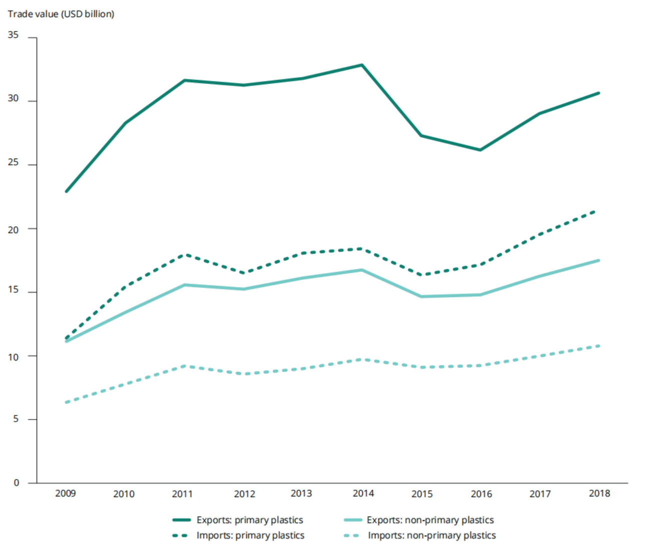


Figure 3.13, EU imports and exports of primary and non-primary plastics, 2009-2018 (EU-28)

Source:Based on data from UN Comtrade (2019a)

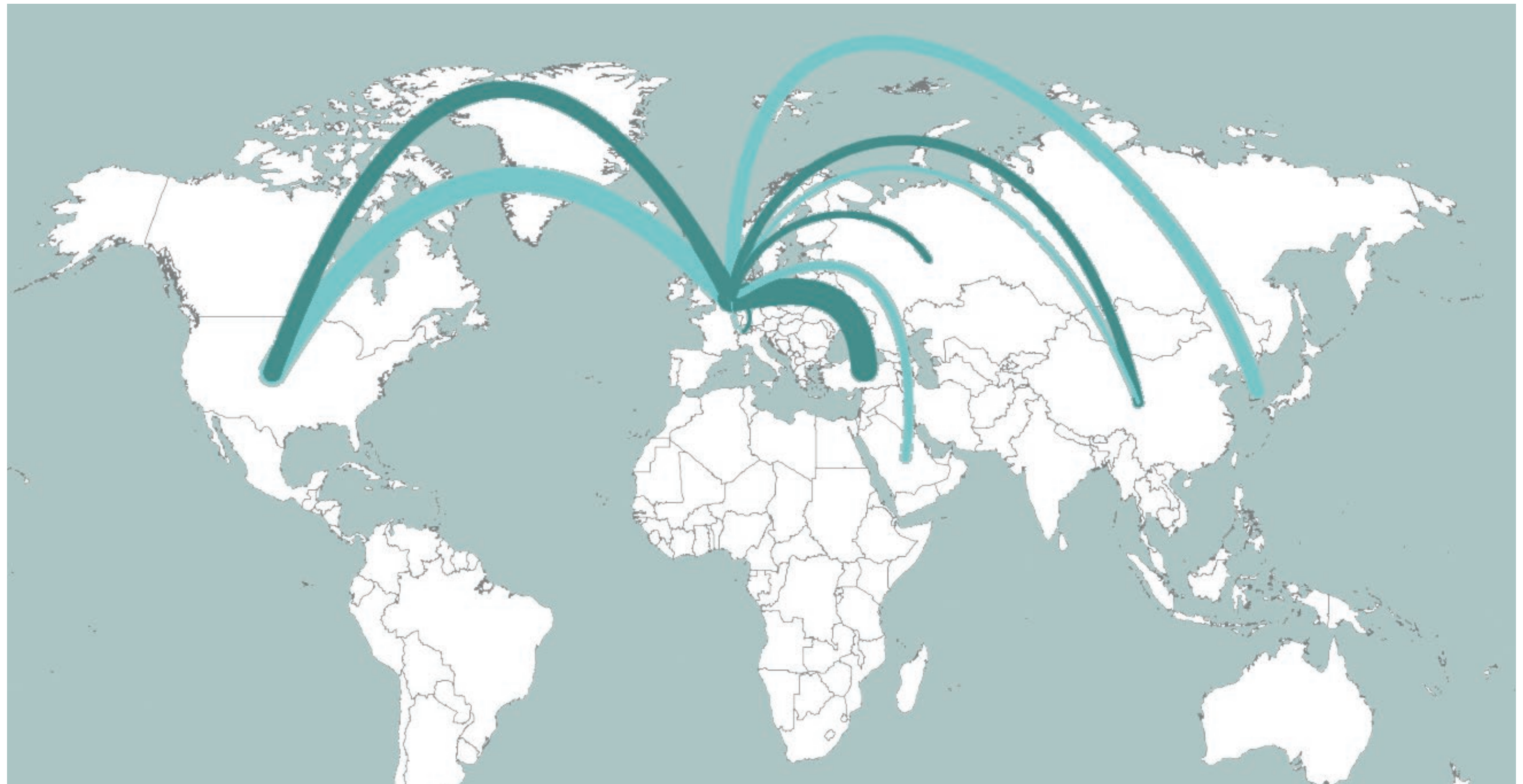


Figure 3.14, EU-28 exports and imports of primary plastics to and from the EU's five largest trade partners in 2018

3.2.3 Plastic production in South Holland

Figure 3.15, Chemical pipelines NW Europe(relate to plastic)

Source:Plastic verwaardingshub Zuid-Holland

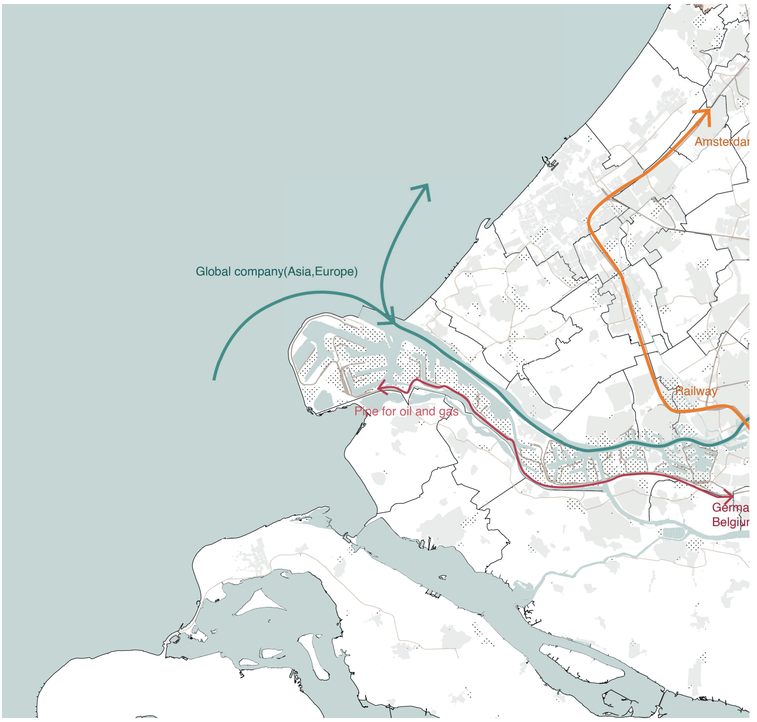


Figure 3.16, Transportation of plastic products in Rotterdam port

The government of Zuid-Holland is try connect the initiatives in the region. First to support PET chemicial recycling around PET production in Rotterdam. And then try to strengthen some material flow in the entire region. Also focus on the PS loop in the area. For the cooperation of global companies, they area trying to link up with pipeline system in the Netherlands, Belgium and Germany.Based on the current network in the chemical industry, it is interesting to think of cooperation between: Rotterdam, Antwerp, Cologne, Frankfurt, Ludwigshafen (BASF), and perhaps also Terneuzen, Moerdijk, Geleen and Duisburg.

The South Holland area already take account into the recycle chain of fossil plastic like PET, and the cooeperation with global companies. There is much opportunity for developing plastic manufactures and cooperation in the area. But they still lack of focus on bio-plastic chain and recycle part. So for the sustainable source of plastic and recycle of non-degradable plastic part still need to be developed.

The port of Rotterdam has proven to be an outstanding hub for the energy and petrochemical sectors. Its pivotal location in Europe, excellent maritime access, substantial economies of scale, wide range of service providers and excellent connections by inland waterways, pipeline, rail and road make Rotterdam the port of choice for the world's leading (petro)chemical and energy companies.Moreover, Rotterdam offers attractive cluster advantages,including shared utilities and a range of industrial clients at close hand. Many companies supply their neighbours with raw materials and semi-manufactured products. The residual products of one company can serve as raw materials for the other. Synergies like this create an extremely efficient and profitable business climate for all chemical companies in Rotterdam.

For the plastic manufactures in Rotterdam, there already are many fossil-based plastic manufactures and plastic recycle/ chemical recycle companies here. But they still lack of cooperation with global company and maker space.

Petrochemical refining and processing plastic manufacturing

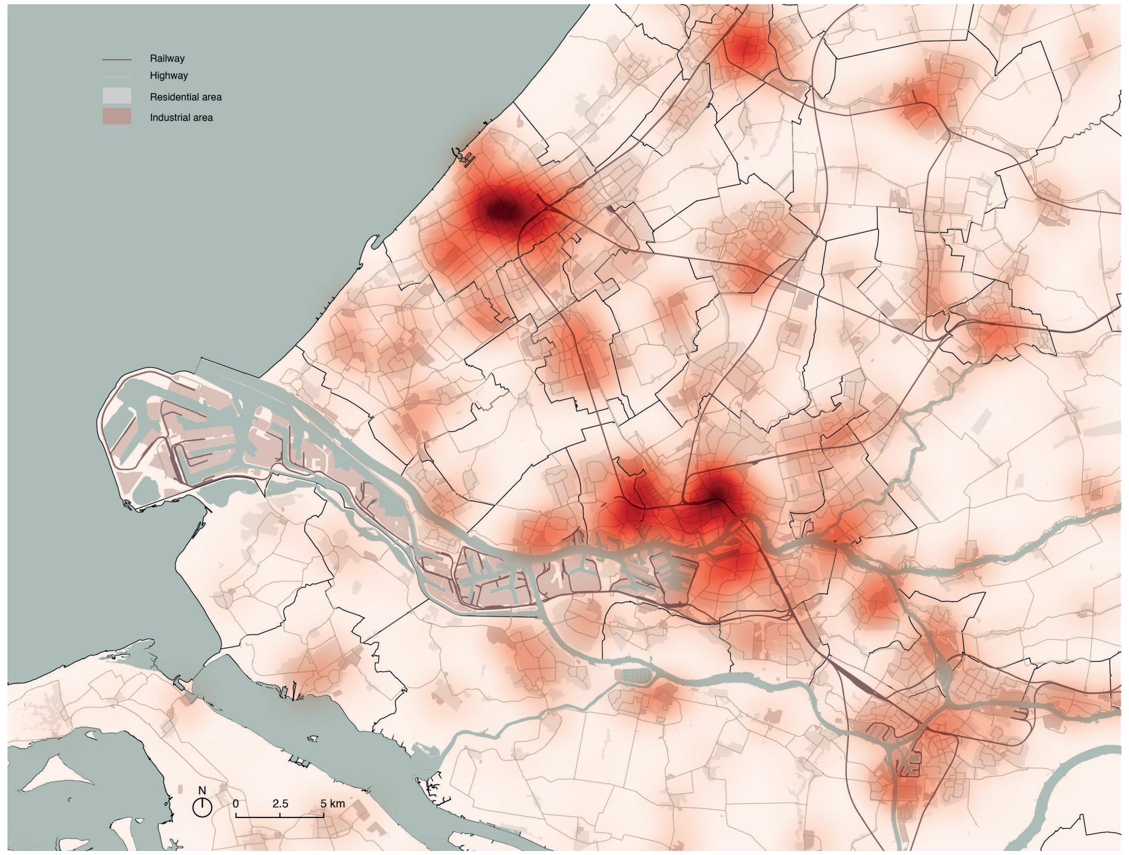


Figure 3.17, Heatmap of all manufacture

Figure 3.18, Distribution of petrochemical processing factory

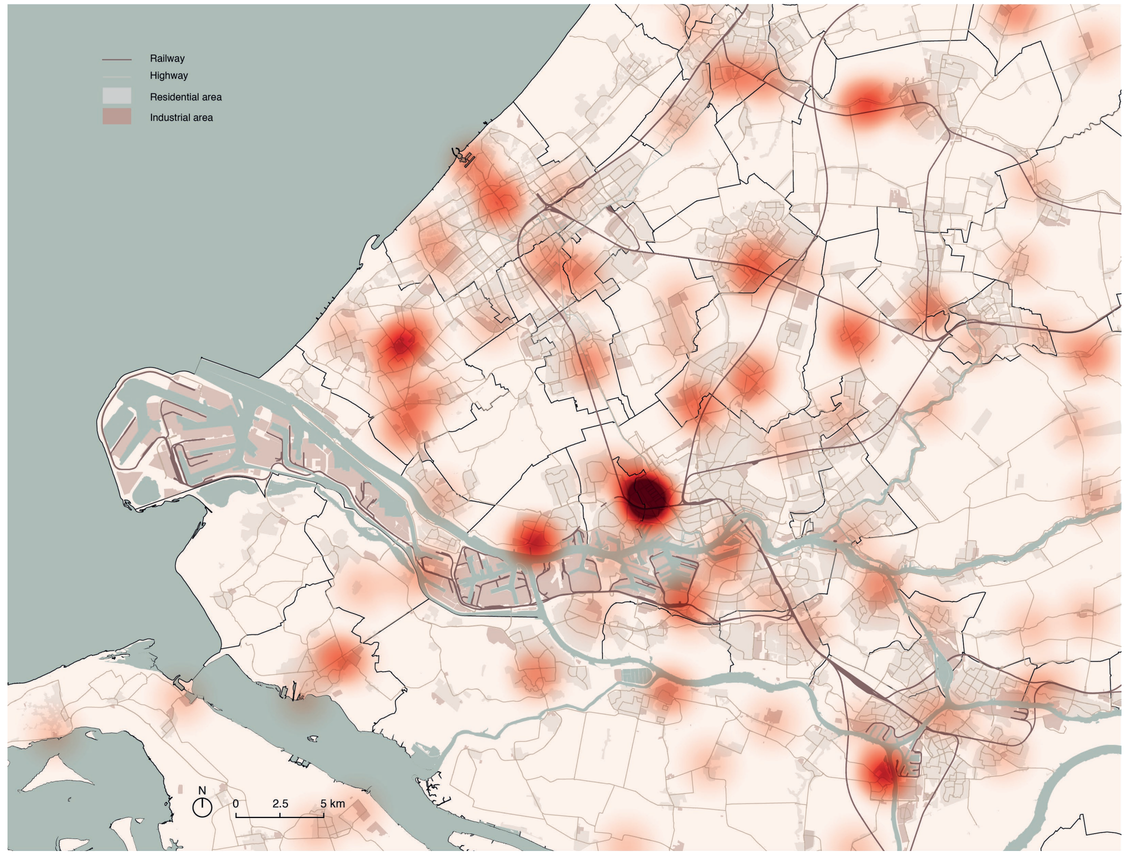


Figure 3.19, Heatmap of plastic manufacture

According to the heatmap of all manufacture, it is clear that all tyoes of manufacture area gathering in the convenient place for transportation. Manufactures are distributed according to urban centers. The main cluster of manufactures are in the edge area of Rotterdam/Den haag and Leiden(in Zuid-Holland).It can be seen that Rotterdam has the highest density of manufactures among these cities and is mostly located around the port of Rotterdam.Be more specific to the plastic manufactures, it can be seen that Rotterdam/s plastic manufacture is more concentrated. And it has great demand for port/inland traffic. Therefore, the port of Rotterdam has the basis to fully develop the plastic recycling industry and to cooperate with the surrounding areas.

The plastic-related raw material processing factory like the petrochemicial factory is closely related to fossil plastic. Such factories have a high demand for land and need to be located at a certain distance from residential areas. The port of Rotterdam is essential for large number of plastic related industries and has a rich base of plastic processing that can provide material for end-product of plastic companies.There is plenty of room for development.

3.2.4 Bio-plastic production in South Holland

Distribution of bio-plastic and fossil-plastic in Rotterdam port area

The entire port of Rotterdam contains the main types of manufactureing for oil/oil products/chemicals/biofuels/edible oils/gas/power/coal and biomass. Some of them like biomass storage and processing of biomass are related to bio-plastic. The oil refinery and chemicial processing manufactures are related to fossil plastic. The amount of bio-plastic manufacture and fossil-plastic manufacture is quite different.Fossil-plastic manufactures are much more than bio-plastic manufacture. Although the port and many manufactures are starting to take account of bio-plastic for sustainable development.The port is dependent on oil and fossil trade and lacks sufficient space to develop new source of material. So how to fully develop bio-plastics in the limited space available is an important issue.

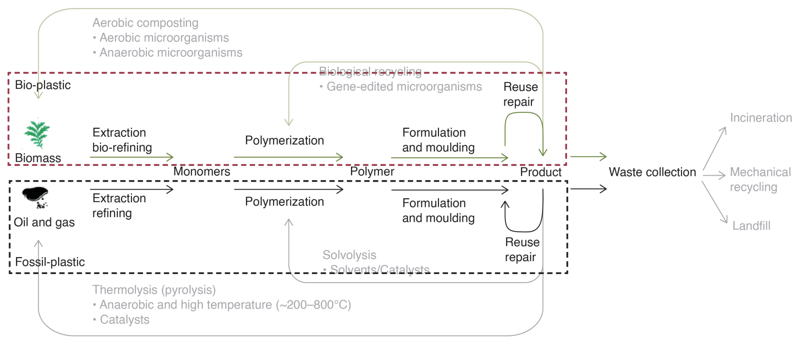


Figure 3.20, Progress for bio-plastic and fossil plastic and relationship to area

Figure 3.21, Distribution of bio-related and fossil-related plastic manufacture in port of Rotterdam

3.2.5 Disconnections of plastic chains

Disconnection of plastic manufacture

The whole area has different types of plastic manufacture(builders' ware of plastic/plastic plates/sheets/tubes and profile/plastic packaging materials).Some of them are global company with quite a lot cooperation with other countries and some are local plastic companies that search for more opportunities. The global and local companies lack of cooperation between each other. And the plastic companies in different cities also lack of cooperation with each other. The semi-finished and final product company in the port of Rotterdam lack the cooperation and the cost for input products from other area is high.

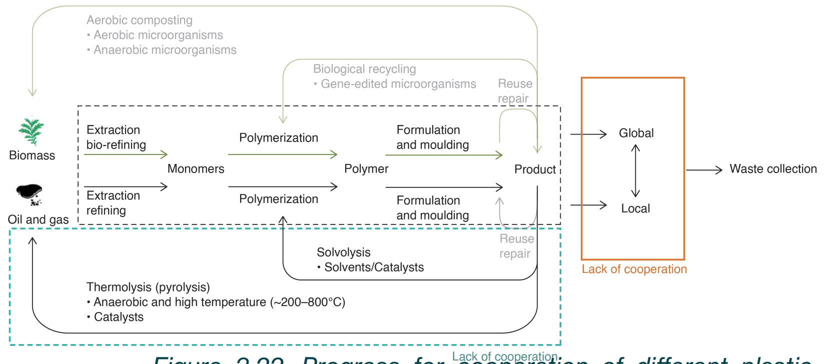


Figure 3.22, Progress for cooperation of different plastic manufacture and relationship to the area

Figure 3.23, Disconnection of plastic manufacture in port of Rotterdam

Disconnection of innovation to manufacture

The innovation area has important impact for knowledge and skills training support, The RDM campus/TUDelft campus and Leiden campus are three important campus that can support the knowledge for bio-plastic and effcient recycle of fossil plastic. For the current situation, there already some cooperation of maker companies with TUDelft and RDM campus. But they still lack of complete system for knowledge exchange and cooperation.Newly developed technologies and result on recycling waste also lack the opportunity and space to be put into use. Rotterdam port area is a suitable space for research on recycling and new sources. And there is a lack of cooperation between industrial area and innovation area.

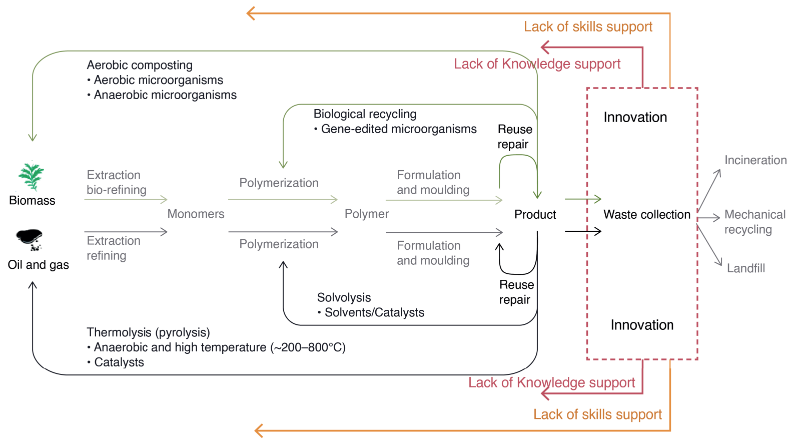


Figure 3.24, Progress for cooperation of innovation and relationship to the area

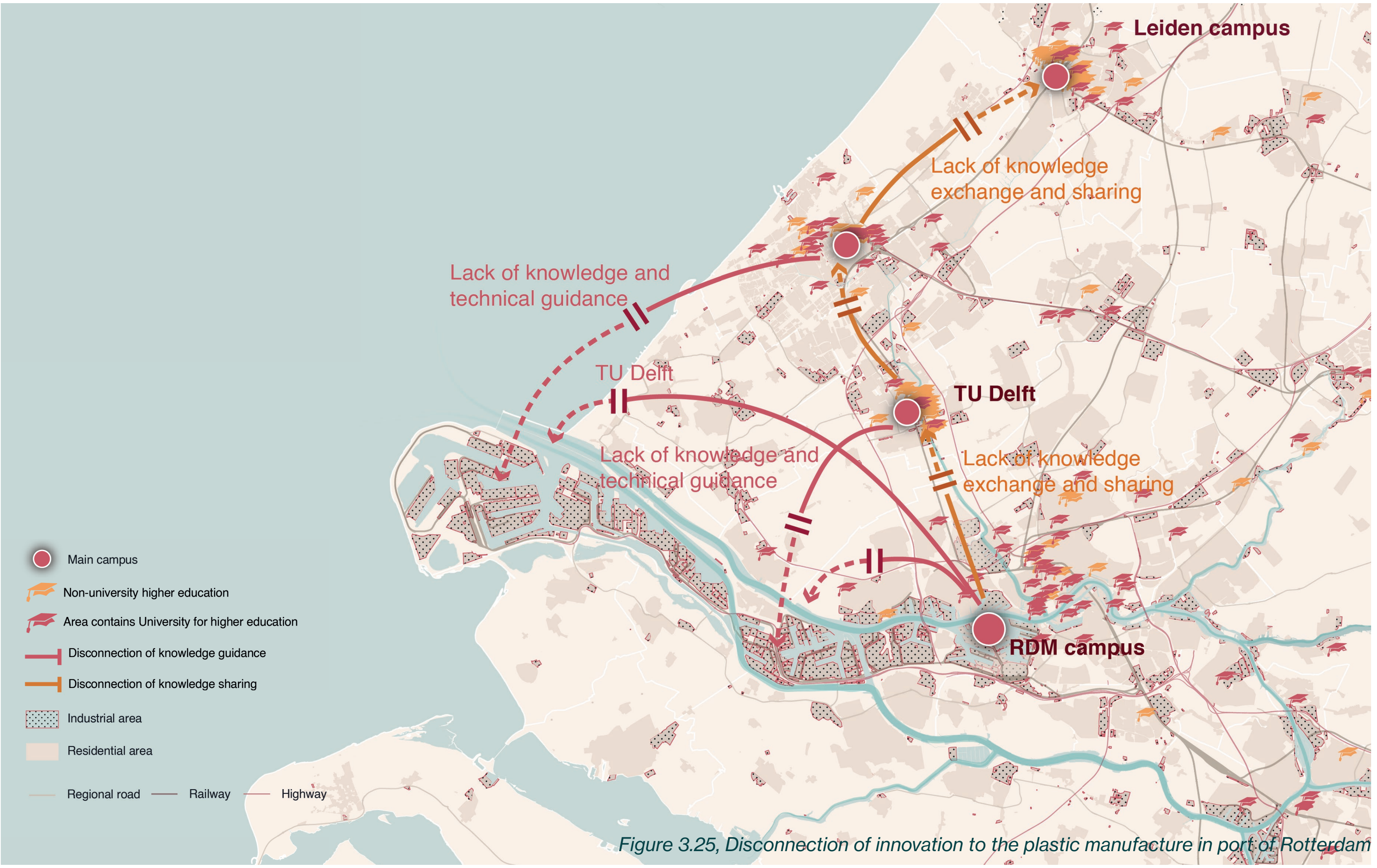


Figure 3.25, Disconnection of innovation to the plastic manufacture in port of Rotterdam

Disconnection of recycle part

There are different plastic manufactures related to the recycle progress of bio-plastic and fossil plastic in the port area. There are chemicial recycle companies/plastic waste recycle companies and little amount of bio-plastic recycle companies. There still many plastic waste used for incineration/landfill which is not sustainble for the environment. Also residents did not fully participate in the waste collection organization.The plastic product companies in the area are divided into widely recycled/sometimes recycled and not commonly recycled. There still lack of recycle companies cooperation with plastic products and bio-based plastic.

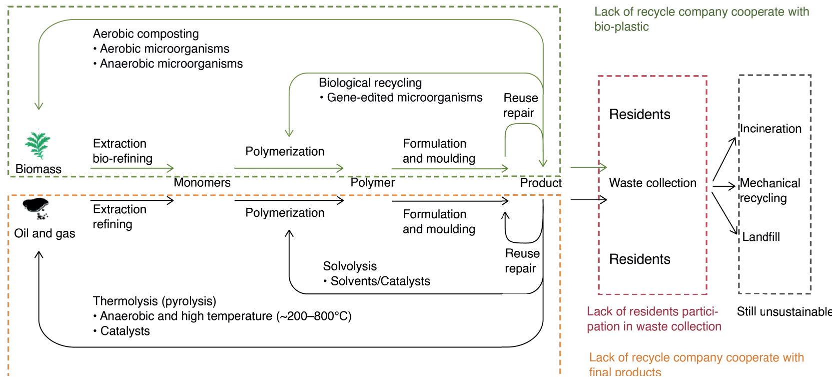


Figure 3.26, Progress for cooperation of different plastic manufacture and relationship to the area

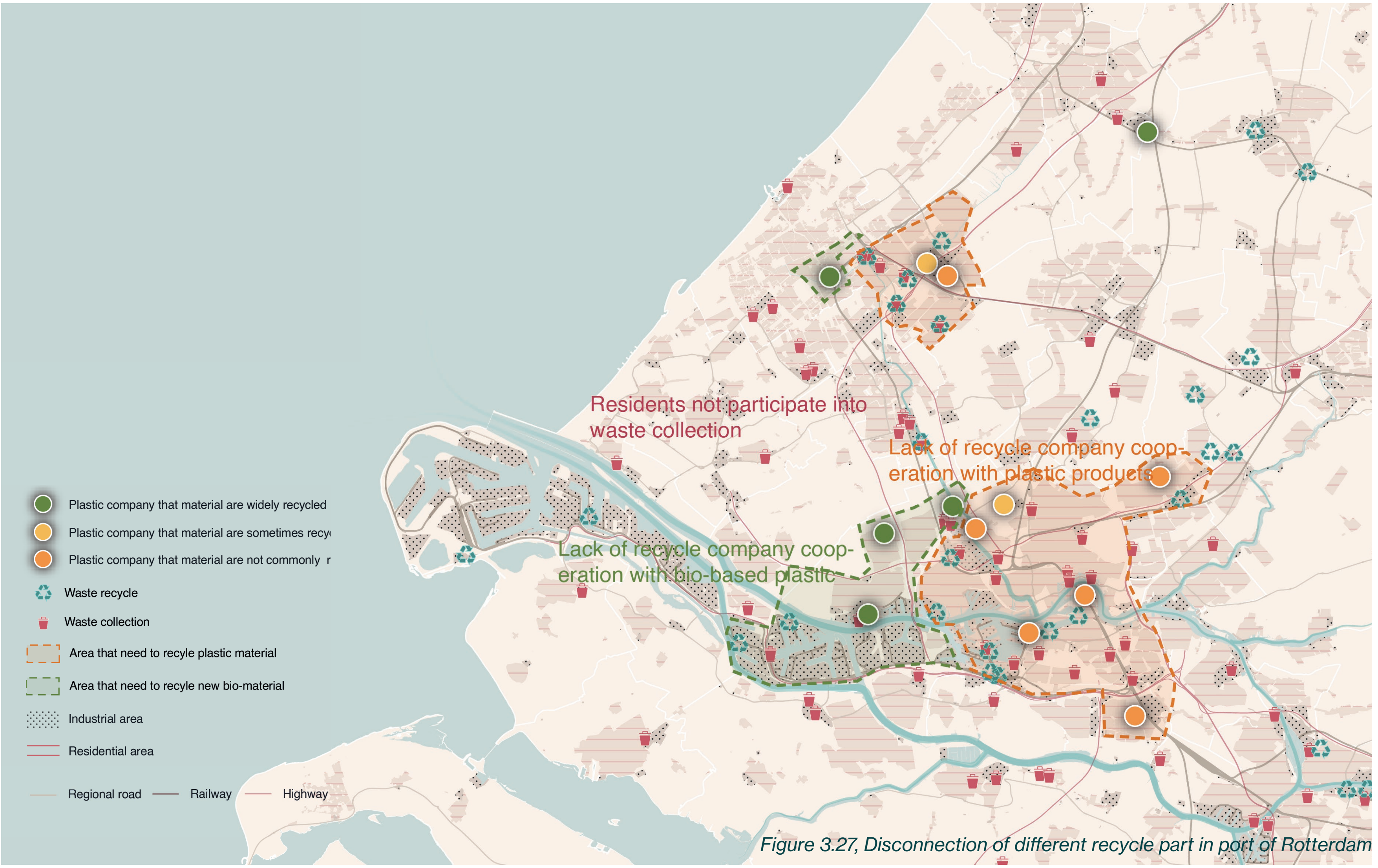


Figure 3.27, Disconnection of different recycle part in port of Rotterdam

3.3 City structure for Development Potential

Water

Figure 3.28, Water structure of Rotterdam port

The port of Rotterdam is ideally situated for inland shipping and is a start and end point for cargo flows over water. European destinations can be accessed quickly via the Maas and Rhine rivers. Links with the Main and Danube enable transport to the Black Sea.Inland shipping is strong in long-distance transport and can be combined with short-distance road transport. Inland shipping is responsible for about 50% of incoming and outgoing cargo between the port of Rotterdam and European destinations. It contributes to the transportation of materials as well as final products throughout the plastics chain.

Railway

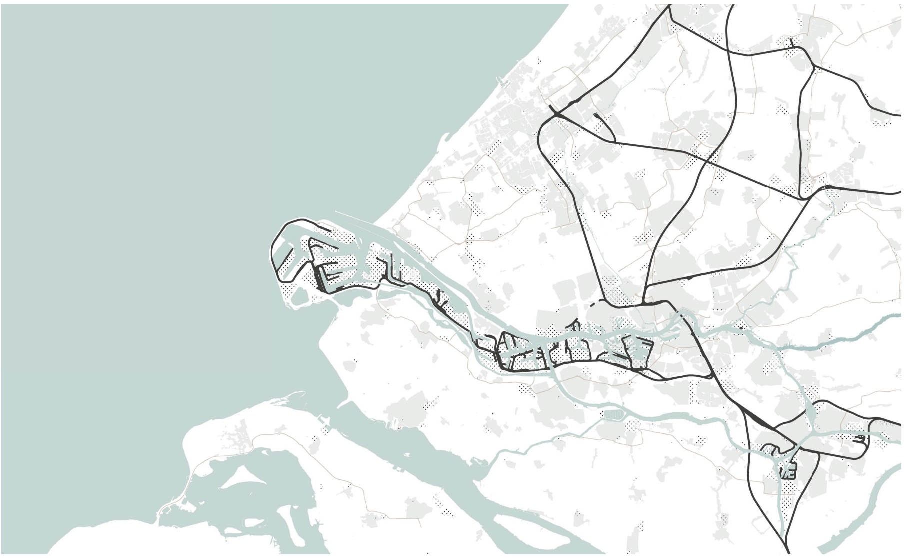


Figure 3.29, Railway structure of Rotterdam port

Every week, over 400 international container rail services run to and from the port of Rotterdam. Besides containers, the port has daily block train services for liquid and dry bulk. Transit times are short: within 3 hours, the freight passes the German border, and many destinations in Europe can be reached within 24 hours. Rotterdam offers a wide range of handling facilities for rail freight – meaning that every imaginable form of cargo can be put through the port.Rail transport throughout Rotterdam is combined with shipping to increase efficiency. And most of the containers are transported through this mixed traffic system. So the port of Rotterdam also has a great traffic advantage in terms of rail traffic and can adequately transport raw materials for plastic-related products.

Road

Figure 3.30, Road structure of Rotterdam port

Transportation by truck is a good way to quickly cover short distances to and from the port of Rotterdam. 40 percent of the trips leaving the port by truck stay in the Rotterdam region. Half are destined for the Dutch market and only 10 percent of the trips from Rotterdam cross the border.The A15 is the main traffic artery to and from the port area. This highway connects well to the national and European highway networks. Thanks to bridges, tunnels and viaducts, traffic is smoothly guided through this densely populated area.Rotterdam has a high level of overall road congestion and takes more time during peak hours. However, this is mainly due to non-motorway traffic. Rotterdam has relatively low delays on the freeways and in order to ensure accessibility to the port, Rotterdamport has been improving its overall accessibility.

City structure

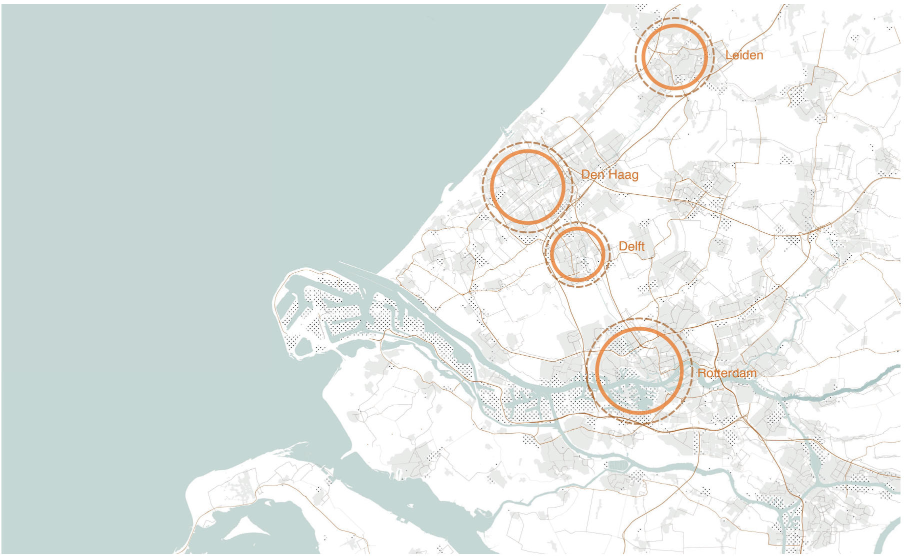


Figure 3.31, City structure of Rotterdam port

Cities with close cooperation with Rotterdam include delft, Den Haag, Leiden, etc. In addition, these cities have centralized education universities, which can provide theoretical and experimental support for the development of new sustainable bioplastics and plastic recycling throughout Rotterdam. There are also opportunities for cooperation between the cities in the development of the plastics industry and the recycling of plastics as a whole. This provides a strong urban structure to support the development of the whole plastics industry system.

3.4 Stakeholder network

In order to make the transitions to a circular plastic industry in 2050, it is important to understand which parties are currently involved in the plastics industry.

The stakeholders involved in plastic manufacturing and use have a rather specific connection to the (linear) production chain that has been discussed in previous sections. First the stakeholders in relation to this production chain are discussed, after which the other relevant stakeholders are discussed.

Manufacturing of fossil-based plastics
There are several actors involved in these early stages of production. First of all there are oil companies that extract oil. These are international companies such as BP and Shell, as well as state owned companies such as Saudi Aramco. The crude oil is then transported to Rotterdam by transportation companies and stored in the port by storage companies, affiliated to the oil refining companies. There are five oil refining companies in South Holland (Drift & Metabolic, 2018). Even though it is important to understand that these actors are involved in the process, and the process of plastic production is dependent on these international stakeholders, only a small percentage of the crude oil that comes into the port of Rotterdam is used for plastic production, so these stakeholders are not the primary stakeholders to influence in the plastic production network.

Of great importance are the companies that produce plastic. There are two phases to plastic production: the production of primary plastic in primary form (plastic pellets) and the production of plastic products from those primary materials. Especially the production of plastics in primary form from fossil fuel is a complex process. This fine chemistry requires knowledge and advanced facilities (Plastics Europe, n.d.). Both of these types of companies are found in South Holland, but there are many connections cutting across boundaries. The plastic production is not only happens in the port of Rotterdam, but also in places such as Terneuzen in the Netherlands, Antwerp in Belgium and in the German Ruhr area (Van den Berghe, 2022; VNCI, n.d.).

Manufacturing of bioplastics
The manufacturing of bioplastics brings in different stakeholders. It first of all involves farmers for the production of the raw material, who have a different relationship with plastic production than the oil extraction companies. In the bioplastics chain there are also transport and storage companies, and for the processing of plastic, biorefineries and bio-chemical companies come in at play. These companies are related to the wider biochemical industry, as there is an exchange of material amongst chemical industries, with one company new or waste products produced by other companies (Port of Rotterdam Authority, 2016)

Use phase
For the use of plastic there are several actors involved. First there are distribution and logistics companies that are involved in the process of getting plastic products to the consumer, via different warehouses and shops.

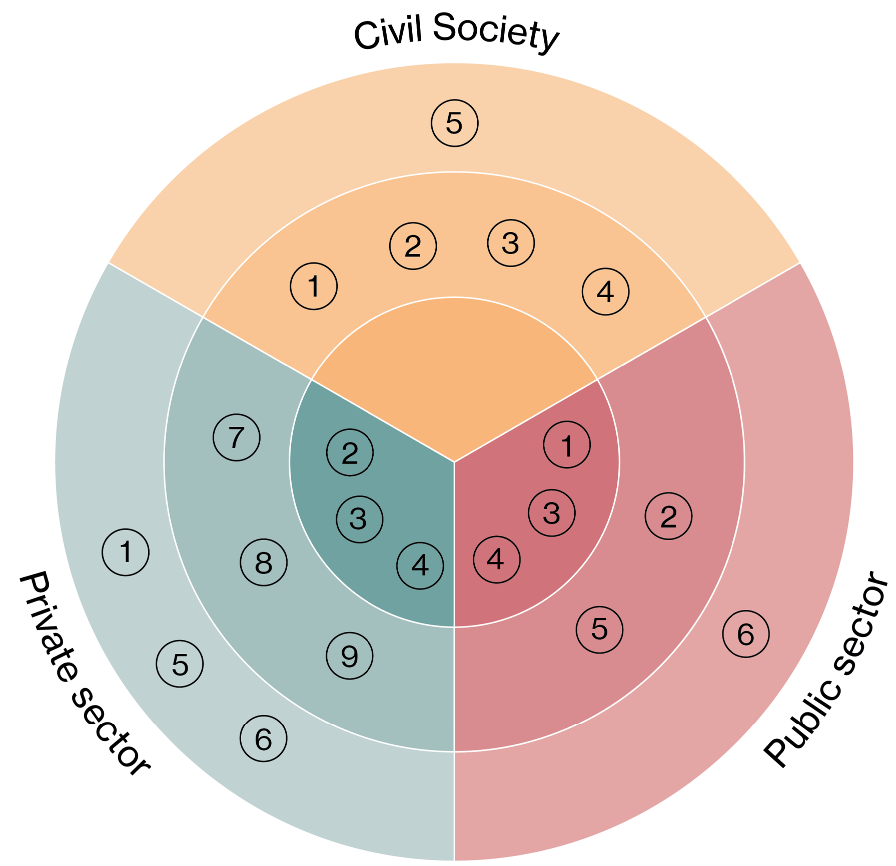
As mentioned in the problematization, plastic is everywhere. Everyone is a consumer of plastic. There are two types of consumers of plastic products: companies and residents. Companies use plastic products in their operation, packaging to high-end plastic products, such as acrylic. Residents, 'the people' interact with plastic in many ways. Their consumption sets the demand for plastic products, and they are influenced by the changes in the industry, such as a ban on plastic bags. Residents also play a role in the recycling process, by collecting their waste and delivering it to waste services.

After use
After the use phase of plastic, most of the time it is treated as waste. This brings in several actors as well. First of all, the municipality plays an important role in waste collection. The municipal government decides on the collection process of plastic for residents within its vicinity. Waste can either be collected together with the residual waste or separately. Both of these systems exist within South Holland, as municipalities have made different choices about this. The collection of municipal waste is done by waste collection companies, such as Suez, Irado and PreZero and municipal waste services. Company waste is collected and treated separately by private waste companies.
An important actor in the after use phase is the AVR, which sorts the plastic waste of the Rijnmond region (AVR, n.d.). Part of the plastic from this is recycled. Another part is incinerated together with residual waste and incinerates residual waste and a part of the plastic waste in its waste incineration facility in the Botlek. Heat from this process is used to heat houses the city of Rotterdam (AVR, n.d.).

There are several other relevant stakeholders that have not been mentioned because they are not directly part of the production chain. One influential category is the public sector. Different levels of government are involved: the Port of Rotterdam Authority leases space to manufacturers; municipalities have legislative power, most prominently in land use policy; the Province of South Holland is an important agenda-setter and connector; the national government regularly influences the industry through policy, just like the European Union.

Universities play a role in the research and development in the industry, regarding manufacturing and recycling. Schools (high schools and MBO's) are related to the industry in a more practical way, educating young people about technology, sustainability and the practical side of the plastics industry. This also brings in the category of employees, who are influenced by policies that target employment in specific industries. Special categories in work are start-ups and makers industries, which play a role in the development of new circularity initiatives and are the practical backbone for local circularity initiatives.

To conclude, the plastics industry is a divergent network, with many different stakeholders involved in the process. The actors that have been discussed so far are among the most relevant ones, but one can think of many others (e.g. water boards, societal organizations, energy companies), because the industry is so large. The issue of ubiquity makes every person and many sectors involved in the transition. The main stakeholders are mapped in an onion diagram in figure 3.32.



Civil society
1. Residents
2. Employees
3. Universities
4. Schools
5. Societal organizations

Public Sector
1. Port of Rotterdam Authority
2. Province of South Holland
3. Municipalities
 • Municipality of Rotterdam
 •Municipality of Schiedam
4. Dutch Government
5. European Union
6. Water boards

Private sector
1. Bioplastic producers
2. Fossil-based plastic producers
3. Manufacturers using plastic
4. Recycling companies
5. (re)makers
6. Start-ups / innovators
7. Oil companies (extraction, refining)
8. Logistics/distribution companies
9. Companies using plastic products

- Key stakeholders
- Secondary stakeholders
- Tertiary stakeholders

Figure 3.32, Onion diagram for the plastics industry

3.5 Diagnosis

Strength

The port of Rotterdam has proven to be the important hub for different types of manufacture especially for plastic.In Europe they have efficient maritime access,good structure of global economy and complete system for manufactures, service and infrastructures.The entire port has a complete industrial system and transportation system. Among the plastic-related industrial facilities are oil refinery manufactures, chemical industries, pipelines and utilities for the transformation and some chemical,plastic product recycle companies.The entire plastics industry has a complete system and has the equipment and facilities for each step. In the transformation of the plastics industry, we can make full use of the existing facilities and take advantage of the existing industry, transportation and cooperation conditions to develop the plastics industry system.

Weakness

Despite the abundance of infrastructures and the complete system of plastic related. The port of Rotterdam still has some weaknesses regarding the plastics industry as a whole. In a globalized economy, the plastics industry in the port of Rotterdam is still very dependent on the supply of materials from global companies and has a large output of products to global companies. At the same time, the relevant local companies have not followed the globalization wave to enrich and develop themselves and form more cooperation. To a certain extent, the globalization of industries has also limited the development of local plastic companies. And the large number of manufacturing industries gathered also raises the consideration of pollution and environment. The carbon emissions of the factories have implications for the surrounding environment and for future sustainability. The port as a whole needs to find a more sustainable solution.

Opportunity

Manufactures and infrastructures related to the recycling of fossil plastic already exist throughout the port of Rotterdam. For example, organizations and companies have started to collect plastic waste from the port and some recycling companies have recently moved to the port of Rotterdam to recycle plastic-related products. They process the plastic waste into new processable materials and some more advanced products. And the port already has a bio-plastic company working on renewable and recycle materials for plastic products, with some success and progress. And plastics-related companies throughout the port are looking for more sustainable, environmentally friendly production methods. So there are a lot of opportunities to transform the plastics industry and make the journey to a circular economy.

Threat

Digital transformation is leading to fundamental changes in society and port of Rotterdam also face in this change. Port of Rotterdam has navigate to five an overview of the most efficient connections via Rotterdam, PortXchange for every port call to be performed at the right time and the port information notice for shipping traffic.Digitalization brings a lot of convenience, such as the ability to plan the entire port traffic situation more efficiently, and the location of different types of ships of different sizes to optimize the overall efficiency. But this is also a threat for future development, because too much dependent on the entire digital system will reduce the reliance on human resources, and if one day the digital system goes wrong, it takes a lot of time to fix and respond to emergencies.

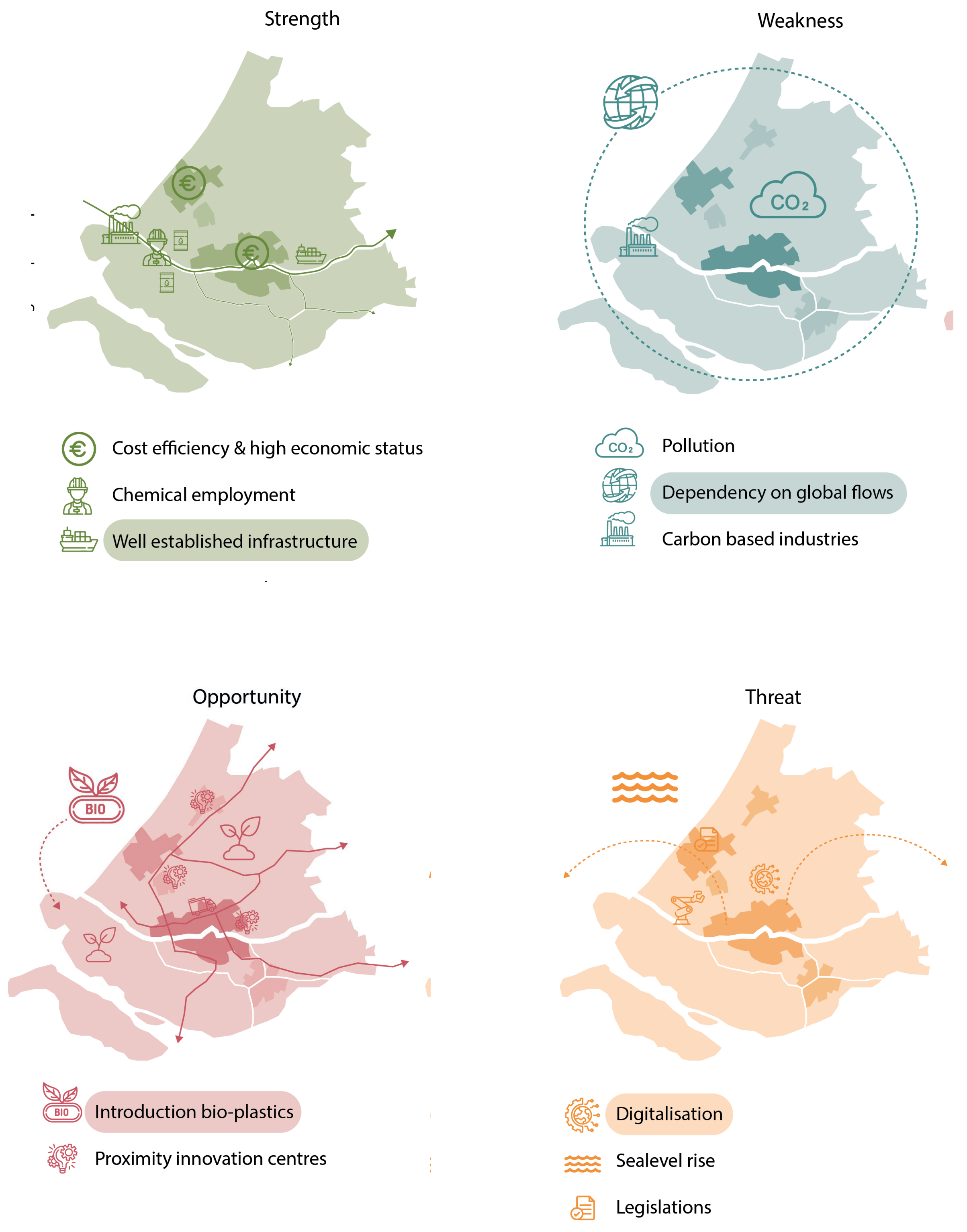


Figure 3.33, SWOT analysis based on current situation

4

Vision

Shaping of plasticity

Chapter content

This chapter mainly displays the vision of the project based on the analysis and explains it in-depth by means of different layers in industrial and social aspects.

4.1 Vision approach

From the analysis we can conclude that the current linear economy model is unsustainable and is not very resilient due to dependence on raw material. This practice needs to change. One way to do create resilience in the face of global dependency is to keep material within the region, because what is there does not need to be imported and stays within a certain area of control. Additionally, there is a need to make the production chain of new materials more sustainable, for which bioplastic offers an interesting direction. The two of these approaches are visualised in figure 4.1.

Additionally, the transition in the plastic industry is of major impact due to the ubiquity of the material. In order to make a successful transition, there is a need to include people throughout the process, as agents of change.
Lastly, there is a change in systems. In order to develop an upcoming system in the region, there is a need to facilitate different stages of development. Every circularity initiative needs to start small and needs to grow. This requires stimulation of niches and more mature companies, see figure 4.2.

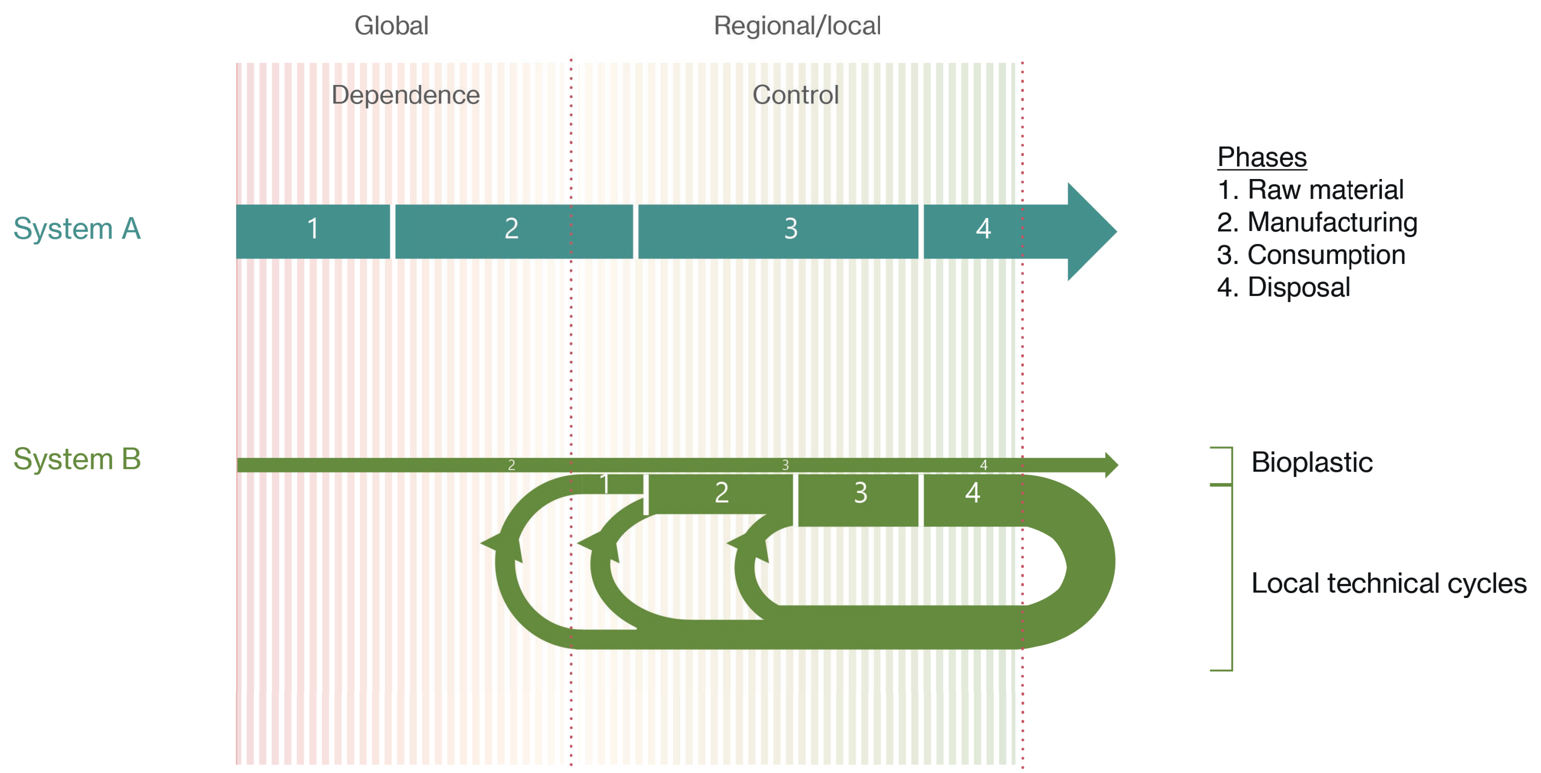


Figure 4.1, Conceptual approach to the vision

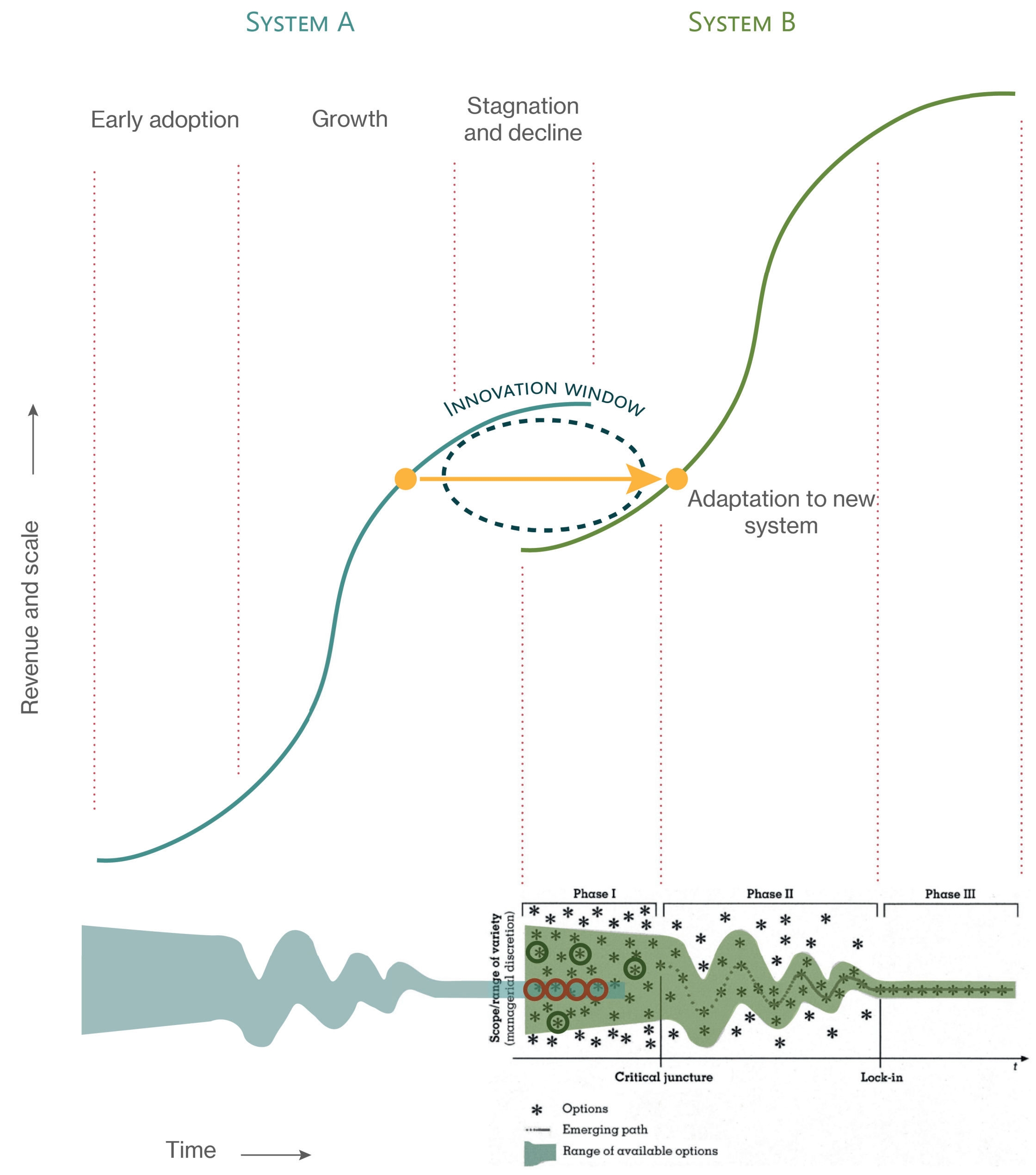


Figure 4.2, The role of facilitating different scales in a transition. Figure based on Scheel (2011), Sydow et al. (2009) and Mazouz et al. (2019)

4.2 Vision Statement

In 2050, the Rotterdam maritime region offers the spatial conditions for innovation, production and reuse, which makes the region resilient and able to adapt to new circumstances. The strength of a strategic location in the port of Rotterdam is used to expand the renewable cycle of the bioplastics industry, and by actively engaging citizens in reusing and recycling plastic products on a local level in the whole region, a technical circular cycle is enhanced in the whole province.

The transition from a globalized fossil-based port economy to a partially local circular economy is environmental, spatial and social related. These transitions are facilitated in the Rotterdam maritime region by creating environments of education and innovation, offering space for environmentally friendly production, and clever use of resource flows. By catalyzing the systemic change on a more local level, in close proximity to citizens, the transition is brought close to the people, making the people part of the systemic change.
This makes the maritime region resilient, while maintaining an important role in the supply of (plastic) products in the region.

Figure 4.3, Collage of the vision

4.3 The spatial layers of plasticity

4.3.1 The innovation layer

Transition

2022 2050

Figure 4.4, Transition map of innovation from 2022 to 2050

The current innovation center is located around RDM campus/TUDdelft and Leiden University. There are fewer innovation centers on recycle bio-based and fossil-based plastics.The different kinds of innovation center lack of cooperation with each other and lack of cooeperation with plastic manufactures.

In 2050, the system of innovation will be complete.Main campus will be the rechnology center for developing the surrounding innovation center.The amount of recycle center and bio-processing innovation center will increase according to the development of bio-plastic and new energy/recycle manufactures.

Connecting innovation centers in different regions to achieve knowledge flow and drive overall development and innovation.The Rdm campus is the closest university to the port of Rotterdam and contains both new knowledge and special skills for manufactures. It is also the center of the entire innovation system. The whole innovation system is divided into three levels, the central area of the TUDelft, Leiden University and RDM campus are connected to the area providing educational and technical resources for the development. The area along the port is the main innovation area for bioplastic development and bio-related recycling. The area where the plastics related industries are concentrated is the area where more innovation related to repair and reuse. The key nodes of the innovation system are concentrated in the high educational areas.

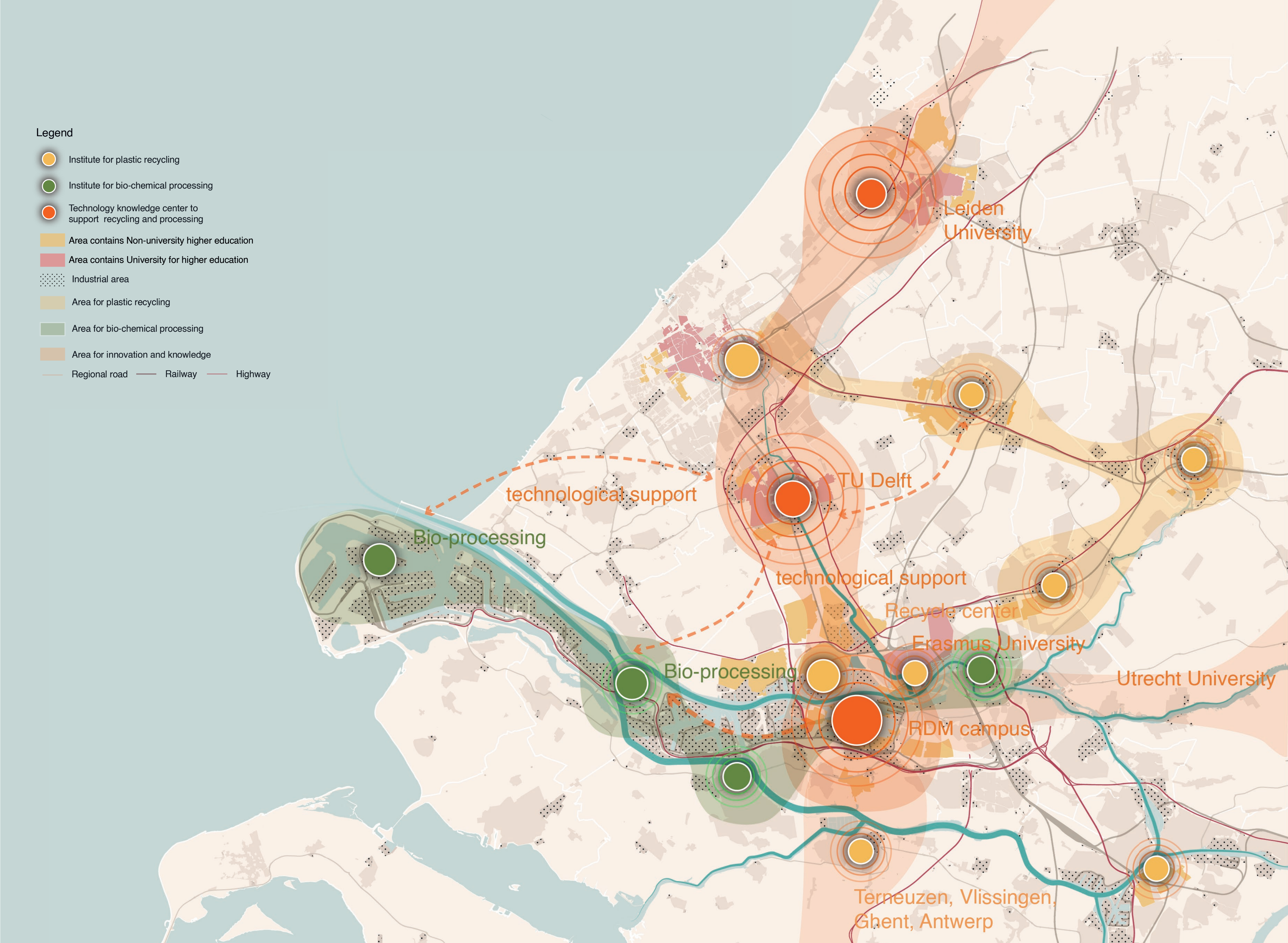


Figure 4.5, Vision map layer of innovationn

4.3.2 The biological cycle

Transition

2022 2050

Figure 4.6, Transition map of the biological cycle from 2022 to 2050

In the current situation, the recycle part in the whole port is mainly for fossil-based plastic. There are few recycling-related industries and companies for bio-plastic. Moreover, the overall waste collection is not systematic and there is no cooperation with related industries. There are few links between existing agricultural land and biomass.

In 2050, the entire port of Rotterdam will realize the transition from fossil plastic to bio-plastic. The plastics-related industries will concerntrate on bio-plastic, including raw material like biomass, processing and end product manufacturing. The original oil refineries will be converted to bio-oil and the fossil fuel will be converted to bio fuel and some more sustainable energy sources.

The entire bio-plastic system consists of the biomass material supply area and the bio-plastic processing area, the bio-plastic industry related cooperation area. The Botlek area as the main bio-plastic processing and manufacturing center, and the related material storage, and the bio-plastic industry related cooperation area. The M4H area is the main final product industry cooperation center, which leads to mutual cooperation and product flow between the tud, leidon and Hague related areas. The area around the port will be used to increase agricultural land for biomass production and to develop new material sources. Increase the use of hydrogen energy to save energy for sustainable development.

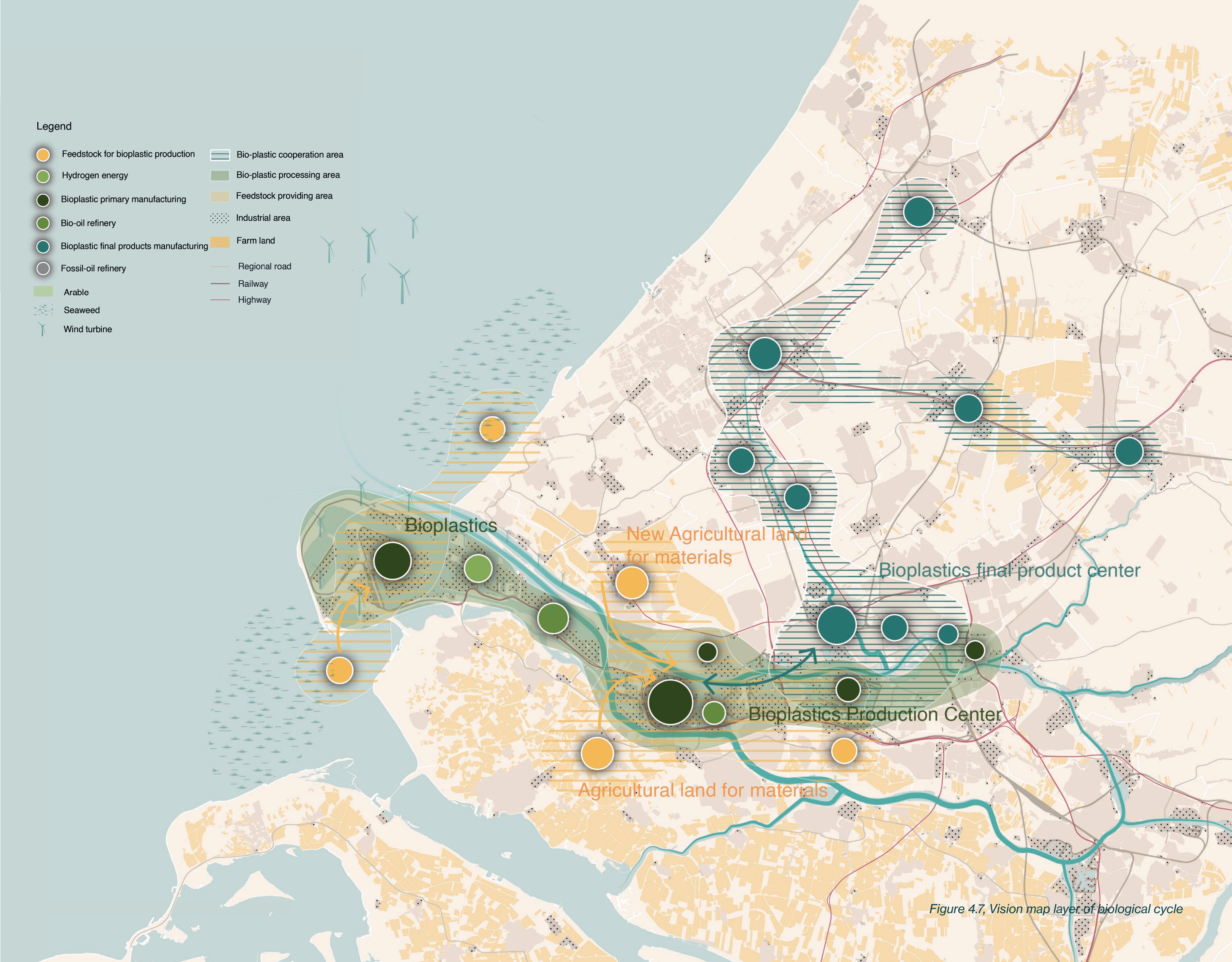


Figure 4.7, Vision map layer of biological cycle

4.3.3 The circular chain

Transition

2022 2050

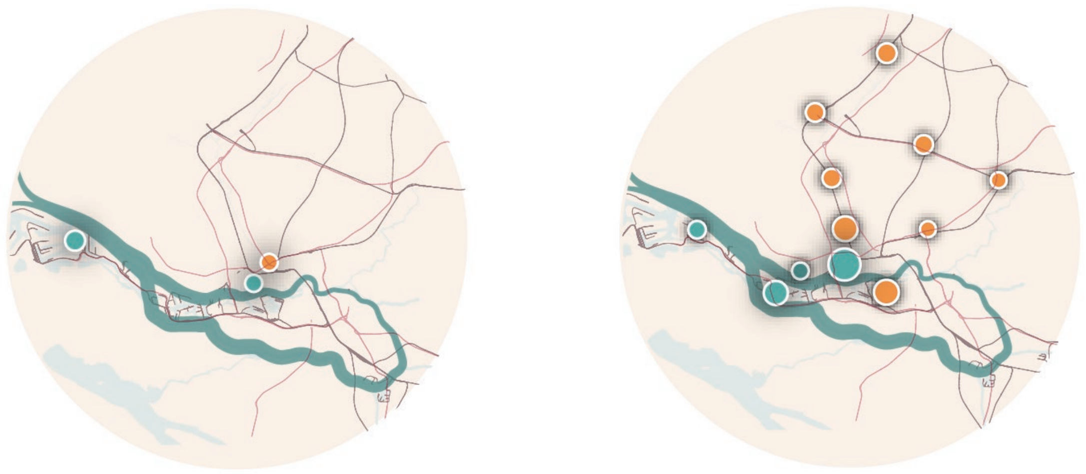


Figure 4.8, Transition map of the recycle from 2022 to 2050

In the current situation, a number of recycle, reuse and repair companies already exist on the site. part of them are integrated with manufacturing in the port industrial area and are related to bio-plastic. Most of the recycle-related companies are related to fossil plastic and are clustered in the area around M4H. These recycle companies do not cooperate with local waste collection and product companies.

In 2050, Rotterdam's plastic recycling chain will shift its focus from fossil plastic to Bio-plastic. Fossil Plastic is phasing out from the entire manufacturing genre. The port innovation center is also used as the recycling center, and the node will be used to develop the whole recycling and reuse/repair companies under r-ladder guidance.

The whole system will transfer from fossil-plastic recycle to bio-plastic rucycle, connect different part of recycle progress, add more R-ladder area according to innovation and products. The whole recycling system mainly consists of three parts:Bio-plastic recycling areas along the entire Rotterdam harbour, reuse and repair areas guided by R-Ladder and plastic waste collection areas. And these recycled areas matter to plastics companies. The recycling of chemical materials in the port area will also put in more bio-plastic recycling and generate new biomass and biological materials. The M4H area is the center part for R-ladder area and will expand along the innovation area between different cities.The cooperation between recycle/ reuse/repair and semi/final finished products companies will be enhanced.

Figure 4.9, Vision map layer of reycle

4.3.4 The social layer

Transition

2022 2050

Figure 4.10, Transition map of the social layer from 2022 to 2050

In the current situation, the main centre of residence is in the center part of Rotterdam/ Den haag/Delft and Leiden. The industrial center is concentrated in the port area of Rotterdam, and a few industrial areas are scattered around the edge of the city. Residents are not fully participating in the whole plastic recycling progress.

In 2050, with the development of urbanization and the continuous development and promotion of manufacturing industry. There will be more manufacturing centers and more residential centers. And manufacturing facilities will further reduce environmental pollution, meaning fewer restrictions on residential expansion.

Future residential centers will be located in highly urbanized areas, such as Rotterdam/Den Haag/Leiden, and the residential areas will continue to expand. At the same time, the demand for plastic manufacturing will also expand. Due to the enrichment and improvement of the entire plastic manufacture system, its demand for space and impact on the environment will be smaller. Manufacture area will also have less impact on residential areas, with fewer restrictions on residential expansion. Moreover, residents will be an important part of waste collection in the whole bio-plastic recycle closed loop.

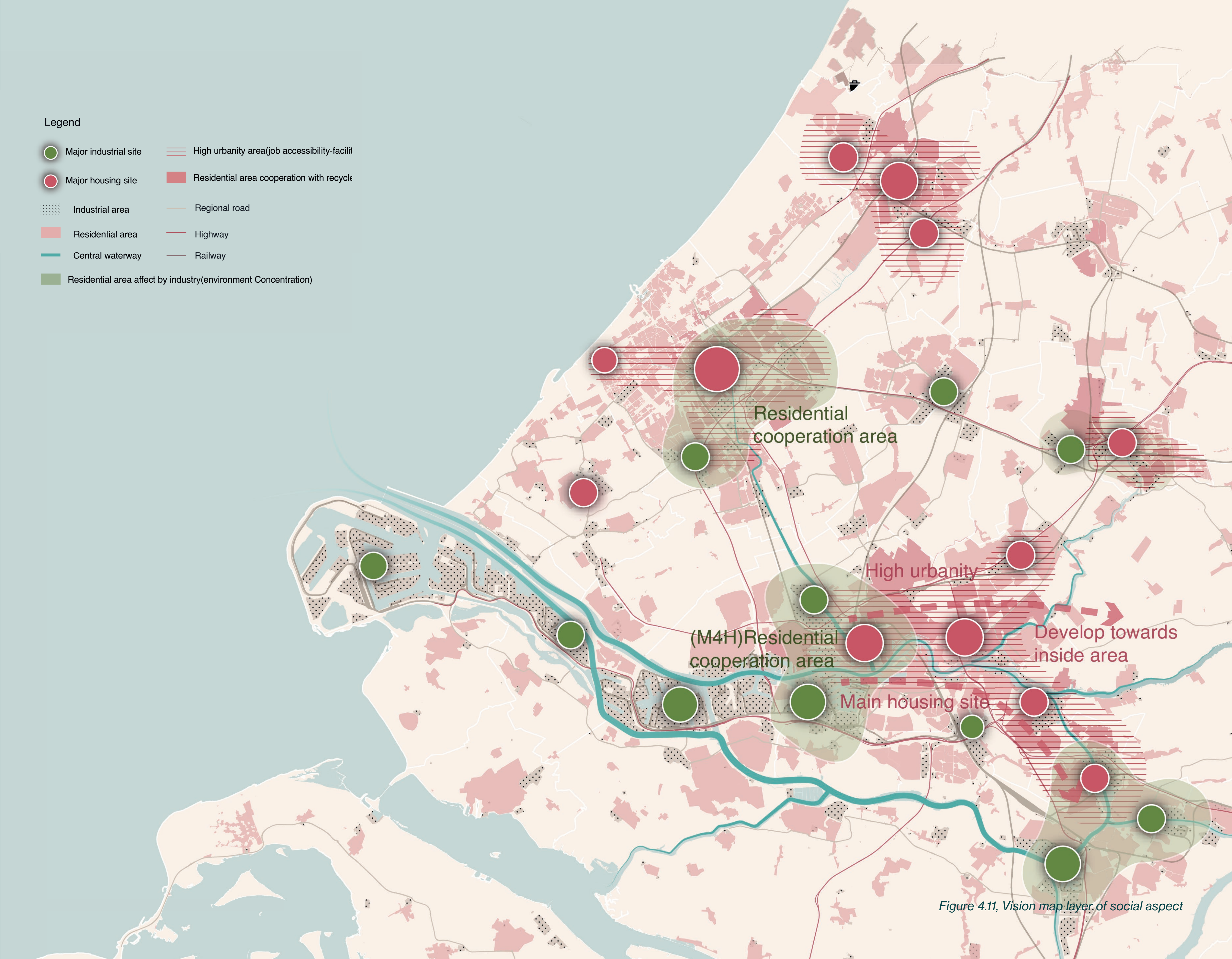


Figure 4.11, Vision map layer of social aspect

4.3.5 The layers combined

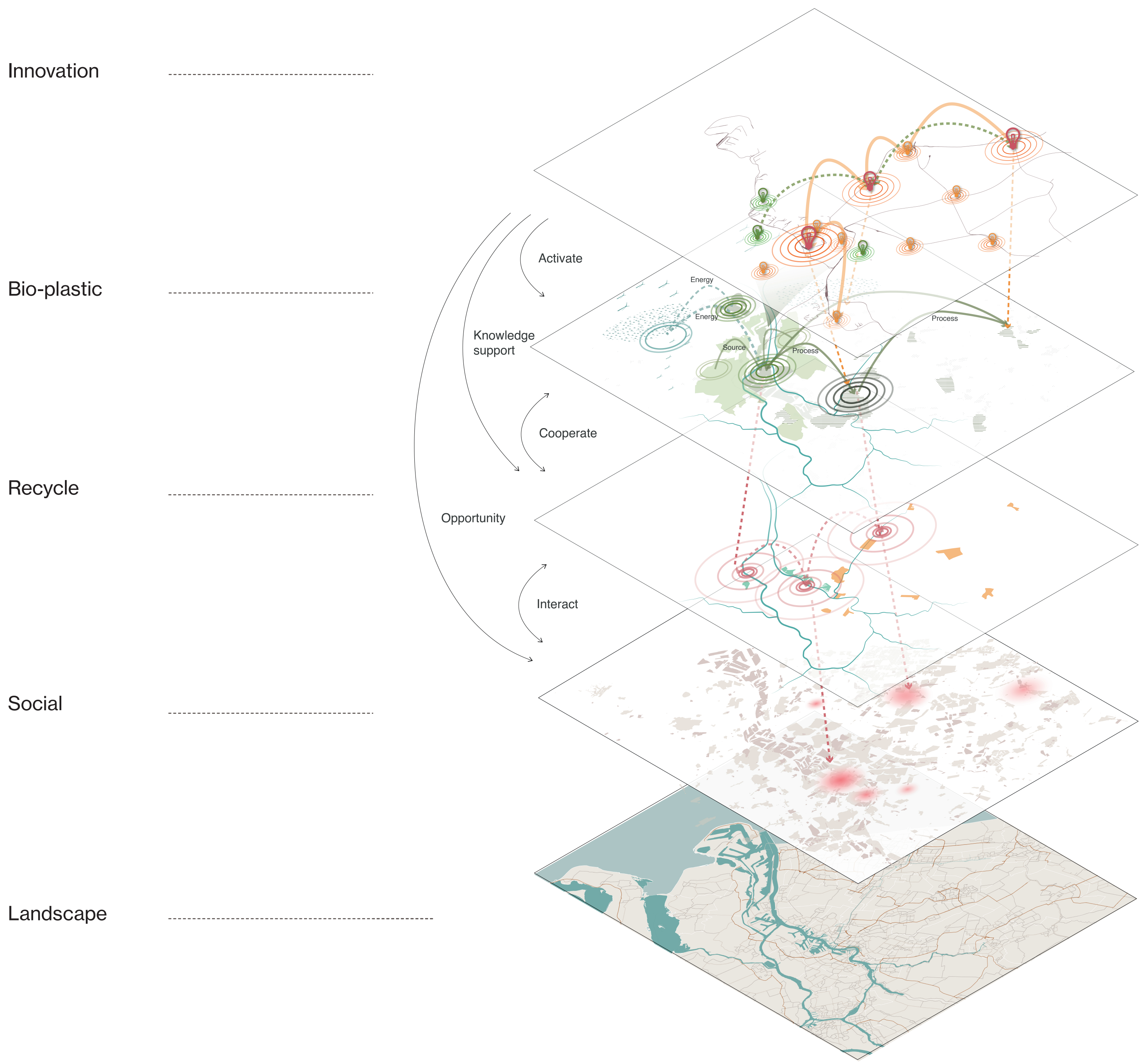


Figure 4.12, Exploded axonometric of layers

Innovation

Railway
Institute for plastic recycling
Institute for bio-chemical processing
Institute for plastic recycling & bio-chemical processing
Axis for plastic recycling
Axis for bio-chemical processing

The innovation point is used as a driving force to stimulate the development of new knowledge in related fields by recycling plastics in each region, and interconnecting them to form a knowledge flow.

Bio-plastic

Arable
Seaweed
Hydrogen energy
Bio-oil refinery
Bioplastic primary manufacturing
Bioplastic final products manufacturing
Wind turbine
Axis for bio-plastic process
Axis for bio-plastic energy source
Axis for bio-plastic material source

Connecting biomass material areas, processing to produce bio-plastic areas and bio-plastic end product areas and activated by innovation part.

Recycle

Repair & Reuse
Recycle
Waste collection

From the fossil-base plastic recycle to bio-based plastic recycle, also cooperate with the bio-plastic companies. Innovation part also help to develope the recycle companies.

Social

Industrial area
Residential area
Housing opportunity

Residents participate in the entire recycling process and discover new housing spaces.

Landscape

Regional road
Tertiary Road
Secondary Road
Water way

Combining the interactions between different areas and spatial relationships, thinking in different directions is superimposed on the site

4.3.6 Vision map

Figure 4.13, The vision map

4.4 Systemic impact

The proposed vision for Plasticity has an impact both on the systematic processes and on the space use.

We propose two main changes in the system. First, we highlight the transition to a more sustainable production method. In the current situation, the majority of plastic manufacturing is synthetic. The input material for plastic is crude oil, and energy for the production is fossil-based. This fossil based production chain has its effect on the landscape in the form of transport, storage, refining, processing the petrochemical facilities (Van den Berghe et al., 2022).

In the proposed situation, this infrastructure has been replaced by bio-based materials. This influences the type of products that are imported oil to biomaterial. The production facilities remain similar in location and size, but require facilities that support bio-based production. Additionally, to fulfil the goal of circularity, the energy system that is necessary for the production of plastic material needs to be made more sustainable. A promising direction for this is the use of hydrogen in the manufacturing process. As far as possible, hydrogen will be produced in the port, based on renewable resources (known as green hydrogen), but some import of hydrogen might be necessary (Port of Rotterdam Authority, n.d.). The spatial dimension of this transition does not necessarily change the port of Rotterdam too much. The scales of these processes are similar, and production of chemical material preferably still happens in clusters with access to water and in separate environmental zones.

A second major change is that in the vision we encourage the different steps of the R-ladder (technical circularity cycle) in our vision. This results in more material flows going backwards in the chain, in different stages of production. This reuse and recycling causes less dependency on imported raw material.
The integration of the technical cycle near the people living in the region has a clear impact on the spatial structure of the region. In order to provide for a system that utilizes the full scope of the technical cycle, from refuse to recycle, these processes need to be well integrated in the physical structure. We therefore envision a stronger integration of distribution and (re)manufacturing in the urban area.

A last major intervention is the addition of chemical recycling in the end of use phase, to use materials at a higher value than energy use. As heat can also be generated from other industrial processes or geothermal sources or example.

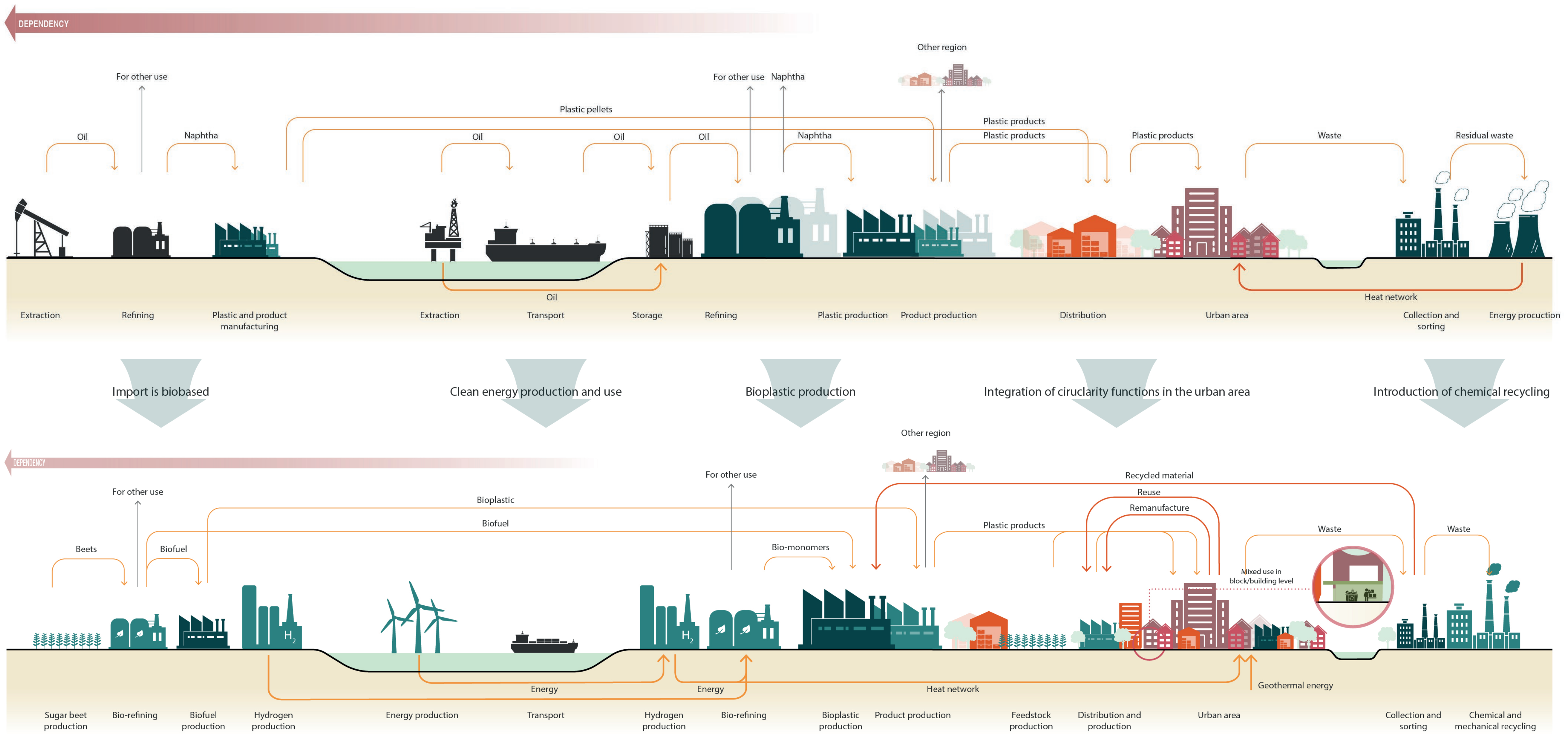


Figure 4.14, Changes in systemic section

5

Strategy

Creating the desired shape

Chapter content

In this chapter, the vision is furtherly interpreted by diving into three strategic locations, which are fucused on different aspects in plastic manufacturing. The spatial consequence from the actions is envisioned, aligning with phasing and stakeholders.

5.1 Phasing

A transition to a circular plastics industry, the desired shape of the region in 2050, does not happen overnight. It has a strong temporal dimension.

The vision for Plasticity shows two main developments in the plastic industry: a growing share of bioplastics production and increasing recirculation of plastic products and materials.
These developments require innovation to grow and be adaptable and require involvement of people to embrace and validate change. Simultaneously, the current system of linear plastic production and use is broken down.

The rough phasing for the strategy is shown in figure 5.1. Both of the main developments start small in strategic locations. Change is slow, but the first developments inspire, create new knowledge and business models, resulting in a snowball effect for future developments. More regions start to become involved, (knowledge) connections become stronger and the role of the port becomes more established throughout time, eventually leading to a state of maturity in 2050.

We have translated this development to three strategic phases:

I. Short term actions (2022-2025)
II. Systemic change (2025-2040)
III. Final stage (2040-2050)

These phases and the corresponding actions taken are given context through the X-curve comes in as a useful tool. The connections to the different stages of building up and breaking down are discussed at each stage and shown in figure 5.2 on the next page.

I. Short term actions (2022-2025)
The name of this phase already tells its purpose: in order for a transition to happen in the long run, actions in the short term are necessary.

The timespan of this phase is short, but it falls within the scope of governmental power, with clarity of the situation and structures. The actions are aimed at facilitating the systemic change that follows. The actions in this phase relate to experimentation and acceleration of the new system, in the form of developing examples and testing new systems.

On the other hand it is about breaking down the old system. Currently we already see the destabalization of the linear production stystem, as explained extensively in the problem statement. There is a societal consensus on many of these problems. The strategy of breaking down must respond to these destabalizing factors and guide the transition. This might be the hardest part of the transition, as actions in this category can be threatening the status quo, while a new situation is still uncertain. Actions must therefore be taken in careful consideration and in cooperation with stakeholders

Figure 5.1. General phasing of the vision

II. Systemic change (2025-2040)
The phase of systemic change is the most important phase for the transition. It is in this phase that the new circular system starts to catch on and become dominant.

Due to new innovations and strategic policy, bioplastics will have a substantive share of the total production at the end of this phase, fossil-based plastic will be on its return, and people will start to get different views on the value of plastic throughout this phase. Even though these views are only held by a select group at the beginning of the period, fifteen years later the socio-technical system will have changed in such a way that circularity will be broadly embraced.

This period is characterized by chaos, as two systems are simultaneously in operation, although at this point, the old system is clearly losing (Loorbach et al., 2017).

Policy in this phase makes clever use of this chaos and will seize opportunities to guide the process of breakdown to minimize harm, in collaboration with actors, both of the emerging system and the system that is in chaos.

Stimulation and regulation by government is essential in the first part of this phase, but will become less essential once the transition has caught on, as the new status quo will be integrated in practice.

III. Final stage
The final stage, roughly from 2040-2050 is when the main systemic change has occurred. The actions are about the phasing out of the old system after breakdown and the stabilization of the new system when it has institutionalized.

If actions of the systemic change have happened accordingly, this phase will see a strengthening of the circular plastics manufacturing sector. This strong position could result in the region being an exporter of knowledge on circularity.

As this stage is farthest in the future, it is the most uncertain phase. It is not possible to plan concrete actions for this period. Rather the phasing for this period shows the possible actions and consequences that can happen in this period. For this phase, it is important to keep the possibilities open. Even though a circular plastics industry is a desirable future now, a new transition may present itself, to which the region must in turn adapt.

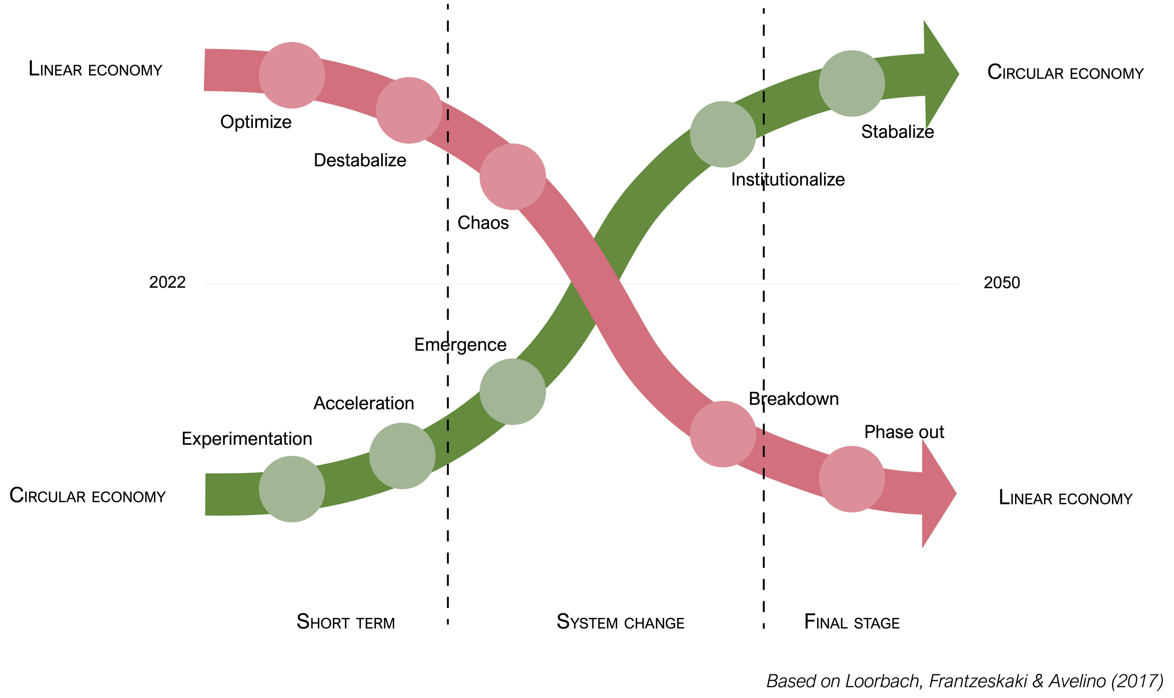


Figure 5.2. phasing in relation to the X-curve. Own work based on Loorbach et al. (2017)

5.2 Governance: activation of stakeholders

The transition to a circular economy is not only economic, but requires a full change of regime (Loorbach et al., 2017). A regime shift in a socio-technical system therefore includes society and markets - actively, not just passively.

As an alternative to primarily top-down planning and primarily market-led planning, which both fail to generate sustainable solutions at the societal level by themselves, Western governments have started to integrate these processes with a new form of governing, commonly known as governance (Loorbach, 2010).
In the form of governance, governments develop policies in interaction with a diverse set of stakeholders. Through an informal network of state, market and society (temporary) societal consensus and support are produced, which guide policy decisions (Loorbach, 2010). This form of governing is based on a broad support, which makes the governing process potentially more democratic and therefore more just.

For spatial planning especially it is important to acknowledge the collaboration between the state and other stakeholders. Except for government property and public infrastructure, the government doesn't produce space. For other developments, the state needs to influence the market to bring about change (Verheul et al., 2017).

We have seen that the plastics industry is for a large part a market affair, especially in the manufacturing phase. Local governments do play a large role in the recycling process (the end-of-life phase), but even there relations are obscured by semi-private waste collection companies and public private partnerships, such as collaborations with energy companies Eneco and Vattenfall for the heat network in Rotterdam (Gemeente Rotterdam, 2021).

So, to transform the plastics industry, the different levels of government - Port of Rotterdam Authority, Province of South Holland, Municipalities and the National government - need to work in collaboration with the plastic industry.
An additional argument for this is that if one were to approach the plastics industry with a top-down approach, one has the risk of ricocheting burdens (and benefits) to other locations. Plastic production companies are not bound by state boundaries. Simply banning production in the Netherlands would only encourage companies to change location, rather than change practice. Burdens could be relocated to other places (presumably those places that are in dire need of the income and cannot afford to ban these industries). Not only is this shift of burdens democratically and inequitably unjust, it also does not benefit the common good. If production still happens, but at a different place, resources are still depleted and pollution will continue. Thus such a top-down approach could defeat the purpose.

Therefore, in the planning strategy for Plasticity, we do not only wish to encourage changes of function, but also to make the transformations of existing structure in collaboration with stakeholders. To make a sustainability transition for the plastics industry in collaboration with manufacturers, and to create a change of practice in collaboration with the people.

In terms of spatial interventions, this creates three options:
- Keep: for desired functions;
- Reform: to make more sustainable or otherwise fitting to the vision, in collaboration with stakeholders;
- Replace: for redundant functions or functions that cannot be reformed.

Planning instruments
Governments (in this case the Province of South Holland and the Port of Rotterdam Authority, for whom this vision is produced) have several planning tools to their availability with which they can influence developments towards the desired state.

These planning tools can either be with hard or soft steering, and at a distance or in collaboration. This produces a matrix of options, that is shown in figure 5.3 on the next page. Steering elements can be grouped according to the four quadrants:
- Shaping
- Stimulating
- Regulating
- Capacity building

The two categories related to hard steering are based on direct actions by the government. Regulating policies are mostly juridical, related to policy. They are restrictive in the sense that they set limits, but loosening of limits is also a steering possibility. Stimulating instruments mainly refer to financial incentives, directly through for instance subsidies and government investment, or indirectly through tax cuts.
Soft steering is about communication and is relational. Governments create an environment that invites action. Typical examples for shaping include visions and place branding. Capacity building is about facilitating the market in the other categories, through connecting actors and building a broad base of support (Verheul et al., 2017)

In the strategy for Plasticity, the associated actors for each

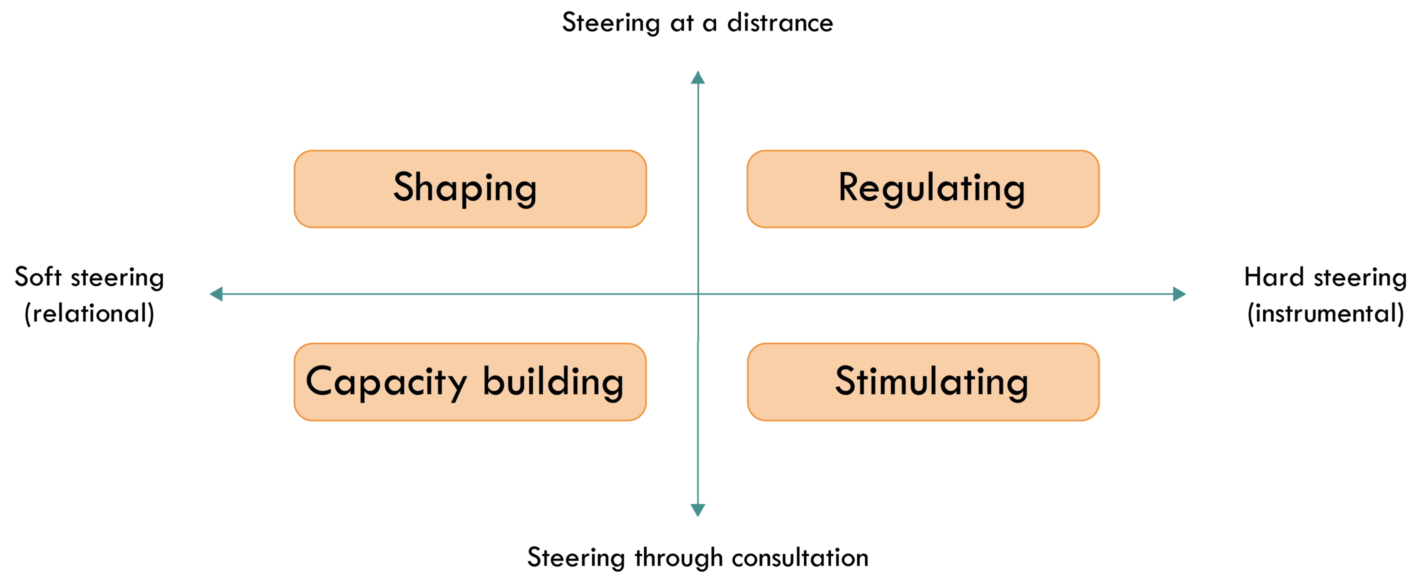


Figure 5.3. Categorization of planning instruments. Based on Verheul et al (2017)

objective strategy are identified. We use these four steering categories to describe the desired steering method for certain objectives.

As explained in the previous section, the phases for the strategy are associated with certain phases of the X-curve. In the first phase of short term actions, and the first period of the systemic change, the introduction of the circular economy is mostly based on stimulation. Emerging initiatives need to navigate the system that is built for the linear economy, so their emergence is not self-explanatory. The linear economy mostly requires regulation, as it is the existing system that needs to be guided in a breakdown.

Existing policies
Due to the complex process of governance, there are certain limits to implementing new policies. It would require many different stakeholders to shift direction. Even though the different levels of government do have regulatory power, it does not mean that every policy is possible.

First of all we are talking about political bodies that faces electoral consequences when policies go against people's will. This might make a government unwilling to implement policies, but is also directly threatening justice, when decisions are not made in a democratic way.

A certain governments (be it local or national) may also not want to be the single government that implements a regulating policy, for example for the plastic industry, if that means that industries will move to a different location where these regulations do not apply. This problem can largely be overcome with agreements on a higher scale level: a national or provincial decision will create equal treatment for the municipality level. Agreements at the EU level will even be binding several nations at once. This relationship is quite one-sided. From the local level of the Province of South Holland it is hard to influence decisions on the European level, but the decisions that have been made on this level do heavily influence the local level and the phasing of this vision. The EU level agreements are made between multiple nations that have to be facing in the same direction, these agreements are rather robust in guiding the strategy. They are also influential, setting targets for the plastics industry. This is also why they are guidelines for the phasing of Plasticity. The strategy is drawn on these existing policies that already have emerged from the complex governance structure. Actions in the strategy are primarily on the local level, showing the real life consequences and necessary steps to achieve the general policy goals.

The main policies guiding the phasing are, from long term to short term:

<u>Rijksbreed Programma Circulaire Economie (2016)</u>
This policy by the Dutch national government sets the general goals for circularity (Rijksoverheid, 2016):
- 50% reduction of raw material use by 2030
- Full circularity in 2050

<u>Transitieagenda Kunststoffen (2018)</u>
The transition agenda sets actions and goals for the period up to 2030. Goals from this include, short term actions regarding research and innovation, as well as longer term aims and expected developments, such as (Transitieteam kunststoffen, 2018):
- 15% bioplastic production in 2030
- An increase in mechanical recycling (quality and quantity)
- 10% of feedstock from chemical recycling

Plastic Pact (2019)

The Plastic Pact is a clear example of governance. It is a collaboration of government, societal organizations and private parties, who together have set four main aims for the short term, for 2025:

- All plastic packaging and single use plastic products are reusable where possible and feasible, but at least 100% recyclable;
- There is 20% less use of plastic for single use products and packaging;
- Minimum 70% of single use plastic products are recycled at high value;
- All single use plastic products and packaging contain at least 35% recycled material.

Besluit kunststofproducten voor eenmalig gebruik

The Dutch implementation of the single use plastic (SUP) ban from the EU (2019/904), which is a result of the 2015 EU action plan for a circular economy. The single use plastic ban is a European strategy to ban single use plastic products as a response to the plastic waste commonly found on European beaches.

These policies are implemented in a short timeframe

- A ban on the sale of certain single use products such as plastic plates and straws, valid from 2021
- A ban on single use cups and food packaging for on site consumption, valid from 2023
- A required fee for plastic products to go, valid from 2023
- Extended producer responsibility (EPR), valid from 2023 which makes companies producing plastic products financially responsible for collection of waste and for educating consumers

These policies guide the phasing of the strategy and have informed the actions. The actions that are needed to achieve these policies and the overall vision are shown in the tables on the following pages. The types of actions are based on objectives, actors and activation method. The phases in the tables correspond to the three phases of the strategy: I. short term actions (2022-2025), II. Systemic Change (2025-2040) and III. Final Stage (2040-2050).

A. Expand bioplastic production

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Stimulate existing biochemical clusters in the port to expand	Strategic locations: Botlek and Maasvlakte	• Port of Rotterdam Authority • National government • Province of South Holland • Bioplastic producers	• Shape • Stimulate	1. Promote the port of Rotterdam as an attractive location for bioplastic production. 2. Reserve free space in strategic locations for bio(plastic) production
I	Encourage fossil-based plastic companies to become more sustainable	National (with a high concentration of producers in Rotterdam)	• National government • EU • Fossil-based plastic producers	• Stimulate • Regulate	3. Subsidies to stimulate existing plastic producers to use bio feedstock 4. Polluter pays (Extended Producer Responsibility (EPR), valid from 2023).
II	Expand the biochemical clusters in the port	Strategic locations: Botlek and Maasvlakte	• Port of Rotterdam Authority • National government • Province of South Holland • Bioplastic producers	• Stimulate • Regulate	5. Freed up space after leases expire is only given to companies that meet to be set up sustainability criteria
II	Grow biomaterials for bioplastic production in the region	National or provincial	• National government • Province of South Holland • Farmers	• Connect • Regulate	6. Province and national governments make agreements with farmers to produce a certain percentage of crops for the chemical industry, with a sufficient food supply taken in consideration 7. Create quality norms for the bioplastic production feedstock with regard to sustainability
II	Create a solid and resilient supply chain for bio-feedstock	South Holland	• Bioplastic procucers • Port of Rotterdam Authority • National government	• Connect • Regulate	8. Connect producers and suppliers from different regions 9. Limit dependency on single sources by determining a maximum percentage of a certain source
III	Strengthen the position of the port and province as a producer of bioplastic	South Holland	• Bioplastic producers • Port of Rotterdam Authority Universities	• Shape	10. Share knowledge on production methods with other regions

B. Phase out fossil-based plastic production

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Limit further expansion of fossil-based companies	Port of Rotterdam	• Port of Rotterdam Authority • Municipality of Rotterdam • Fossil-based companies • Chemical companies	• Regulate	1. Land use policy aimed at prohibit the expansion of petro-companies within the port of Rotterdam
I	Encourage recycled material as an alternative to raw material	National	• National government • European Union • Fossil-based plastic companies • Port of Rotterdam Authority • Societal organizations	• Regulate • Shape	2. Establish quality norms for recycled plastic material 3. Establish a quote of for recycled content in plastic products
II	Discourage fossil-based plastic production	National	• National government • European Union • Fossil-based plastic companies • Port of Rotterdam Authority	• Regulate	4. Polluter pays (Extended Producer Responsibility, (EPR) valid from 2023). 5. Gradually expand EPR to more plastic-products

C. Encourage chemical recycling

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Stimulate the development of chemical recycling	National	• Universities • National government • Province of South Holland • Recycling companies	• Connect • Stimulate	1. Subsidize pilot projects for chemical recycling to bridge efficiency gaps 2. National government connects research and practice stakeholders to stimulate innovation
I	Introduce chemical recycling in the port of Rotterdam	Botlek	• Port of Rotterdam Authority • Municipality of Rotterdam • Province of South Holland • Recycling companies	• Shape • Connect	3. Reserve space for a chemical recycling facility near the existing AVR facility 4. Municipality gets in contact with potential users of this site
II	Introduce chemical recycling in the port of Rotterdam	Botlek	• Port of Rotterdam Authority • Municipality of Rotterdam • Province of South Holland • Recycling companies	• Stimulate	5. The municipality integrates chemical recycling in the municipal waste recycling system

D. Manufacturing with renewable energy

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Plan wind farms	National	• National government • Energy companies	• Shape	1. Government appoints locations for wind farms 2. Government writes out tenders for the development
I	Carbon Capture Storage	Port of Rotterdam, National	• National government • Fossil-based companies • Universities	• Stimulate • Connect	3. Connect businesses interested to universities and other research institutions that develop the technology. 4. Test Carbon Capture Storage in small scale
I	Development of a hydrogen network	Port of Rotterdam, international	• Port of Rotterdam Authority • Municipality of Rotterdam • Fossil-based companies • Chemical companies • Bio-based companies • Antwerp and Rhine region governments	• Stimulate • Connect	5. The Port of Rotterdam Authority plans a hydrogen network in collaboration with companies in the port region and international stakeholders
II	Development of a hydrogen network	Port of Rotterdam, international	• Port of Rotterdam Authority • Municipality of Rotterdam • Fossil-based companies • Chemical companies • Bio-based companies • Antwerp and Rhine region governments	• Stimulate	6. Port of Rotterdam Authority acquires space 7. Hydrogen infrastructure are built using public-private partnerships 8. Facilities for hydrogen import are built by interested companies

E. Stimulate cycles in the use phase

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Create places in urban and in peri-urban areas to integrate the technical cycle close to daily life	Urban	• Municipalities • Makers • Start-ups • Citizens	• Stimulate • Connect	1. Facilitate R-ladder initiatives in zoning plans through mixed zoning in places with critical mass. 2. Municipalities introduce rent-regulation for companies that contribute to the circular economy
II	Regulate the use of plastic waste for heat production	National	• National government	• Regulate	3. Government sets a target for 0% plastic waste incineration

F. Stimulate recycling

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Create easily accessible recycling points in strategic new building developments (pilots)	Neighbourhoods	• Municipalities • Developers • Citizens	• Regulate	1. Zoning/area plans determine a maximum radius or location of recycling points. 2. Introduce an exploratory policy that requires dedicated waste separation space in new houses
II	Make accessible recycling the norm for building (re) development	Province, National	• National government • Province of South Holland • Developers • Citizens	• Regulate	3. Governments establish a policy that determines a maximum radius to or location of recycling points to houses 4. Introduce a policy that requires dedicated waste separation space in new houses

G. Stimulate innovation

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Preserve existing spaces for innovation and spaces that have this potential	Province	• Province of South Holland • Municipalities • Start-ups • Makers	• Shape • Regulate • Stimulate	1. Express the significance of innovation spaces through branding 2. Land use policy aimed at keeping sufficient innovation and maker spaces in urban regions 3. Stimulate makers to use existing spaces through rent-control
II	Strengthen the connections to innovation environments	Province	• Province of South Holland • Municipalities • Start-ups • Makers	• Stimulate	4. Improve connectedness and attractiveness of routes in network.

H. Stimulate maker spaces

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	(Re)introduce maker spaces in urban and peri-urban areas	Province	• Province of South Holland • Municipalities • Makers • Citizens	• Shape • Regulate • Stimulate	1. Express the significance of maker spaces through branding 2. Land use policy aimed at keeping sufficient innovation and maker spaces in urban regions 3. Stimulate makers to use existing spaces through rent-control
II	Phase out makers that have an unsustainable production process	Province	• Province of South Holland • Municipalities • Makers	• Regulate • Stimulate	4. Zoning plans allowing only sustainable production use (connected to environmental zones) 5. Stimulate makers to use sustainable production processes by

I. Involve people in the transitions

Phase	Strategy	Scale	Key and primary stakeholders	Activation	Actions
I	Stimulate community initiatives to recycle waste	Neighbourhoods	• Municipalities • Citizens • Citizen groups	• Shape • Stimulate	1. Advertise circular initiatives through government and media channels 2. Give financial means, space or material for community initiatives regarding CE
I	Motivate people to work in a local circular economy	Province	• Province of South Holland • Schools • Citizens	• Shape	3. Campaigns to promote working in a circular economy / maker industry
I	Create education programmes that prepare for jobs in the circular economy	Province	• Province of South Holland • Universities • Schools • Citizens	• Connect	4. Bring companies and universities together to establish the necessary skills and knowledge to implement in education
II	Set up education that prepares for Circular Economy jobs	Province	• Province of South Holland • Universities • Schools • Citizens	• Connect • Stimulate	5. Stimulate the development of educational programmes that prepare for circular jobs, or circularity is part of the curriculum. For example by making a special certificates or quality norms for this.

5.3 Timeline

The actions that have been formulated in the last section have been translated to the timeline that is shown in figure 5.4.

The timeline is built around actions in the three phases of the transition. The main policy goals that guide the vision are highlighted in the top of the timeline. The coloured outlines of the actions correspond to the colours of the tables on the previous pages, which relate to different types of interventions.

The timeline relates to actions on four types of transitions: sustainable, economic and social transitions, and the consequential spatial transition. Of course many actions related to the other transitions are also spatial by their nature, but this has not all been translated to the spatial transition category. Instead they are discussed in more detail in the strategic areas in the following part of this chapter.

As previously mentioned, the most concrete and clear actions are in the first years. After a while, the phasing is more about showing possible consequences and desired directions.

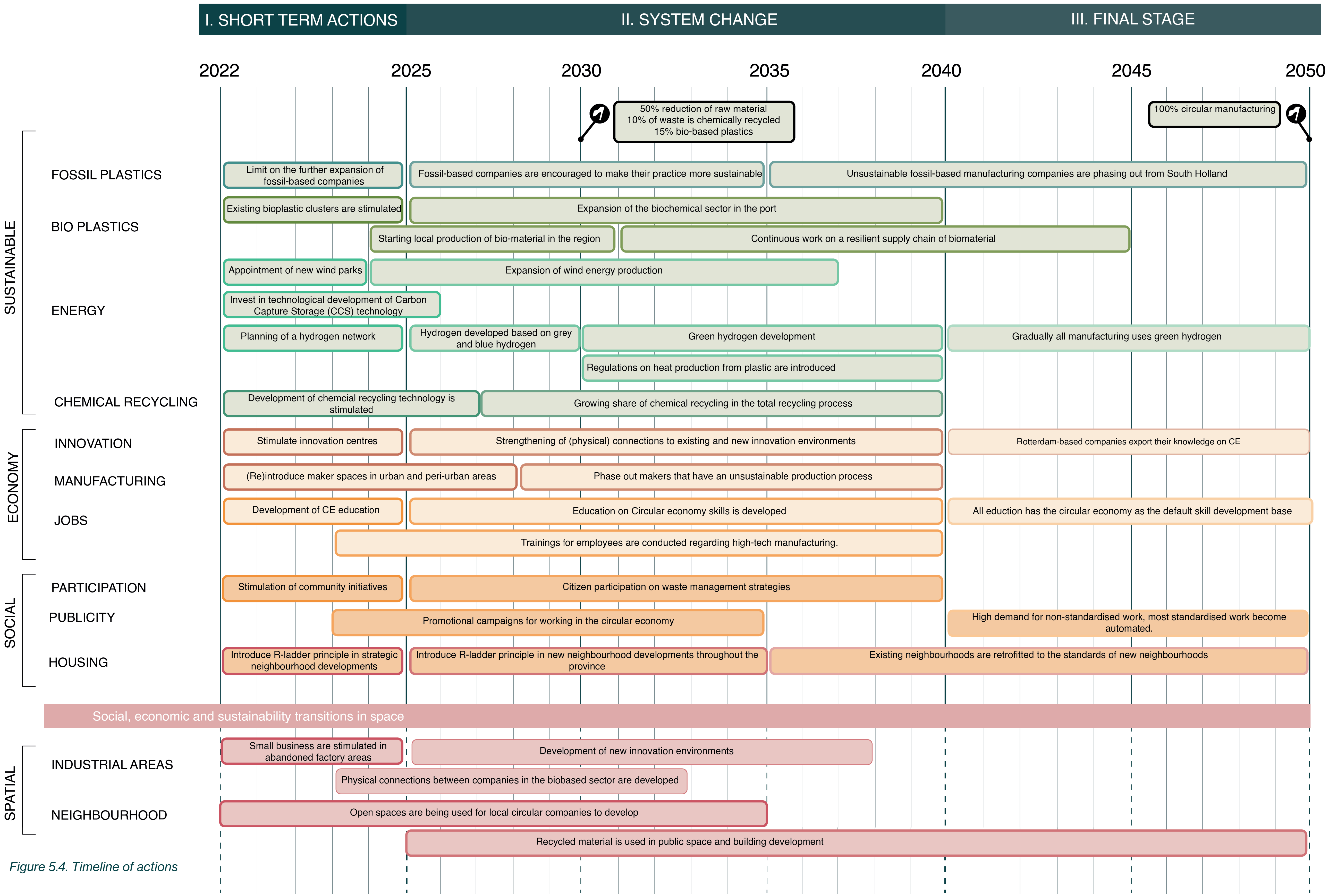


Figure 5.4. Timeline of actions

5.4 Strategic projects

Previously mainly the higher scale level of the port of Rotterdam and the province of South Holland have been discussed, but in order to bring about the desired change, actions need to be taken on a lower scale. In this section, three strategic projects on this operational scale are discussed. These strategic locations show the possible spatial consequences on a lower scale level and the involvement of stakeholders is discussed in more detail.
We view these areas as important starting points, because all these three areas have seeds planted already. The strategy of Plasticity is to make them sprout, in order to accelerate the transition.

1. Botlek
The Botlek area is the first strategic location. This is the location in South Holland that shows the highest potential for the bioplastics industry to develop and expand. Its global scale, with access to essential infrastructures for import and export of feedstock, make it an excellent manufacturing area. On top of this, the area offers opportunities for synergy, as currently the site hosts the main recycling facility of Rotterdam, a well developed (petro)chemical cluster, bio-industrial facilities, and a chemical innovation facility (Plant One).

2. Makers District
Merwe-Vierhavens (M4H) and the RDM Campus, collectively known as the Makers district, offer an excellent location between port and city.
The transition to a circular plastics industry requires new systems to be put in place, particularly for the technical cycle of reusing, repairing and recycling, but also for smaller-scale development of the bioplastics industry.
The RDM Campus offers conditions for innovation and knowledge exchange (rethink). The M4H area offers space for the makers industries (repair, remanufacture, recycle) on different scales and is well connected to the Spaanse Polder, where industries within the higher environmental category can operate and companies from M4H can grow.
The plans for M4H show circularity ambitions, but the area is only at the start of development. This means that it is possible to steer developments in the desired direction.

3. Binckhorst and Laakkwartier
Similar as for the Makers District, the Binckhorst area will be redeveloped in the near future, which makes it a great location to directly implement circularity principles. The area is connected to the Laakkwartier. The strategy for transitioning the existing built will be shown for this area.

These areas relate to the different scales on which the vision and strategy operate. The Botlek region is oriented towards a global scale, while the Makers District and Binckhorst relate to the lower scales and their corresponding functions within the strategy.

These scale relations are visualised in figure 5.5.

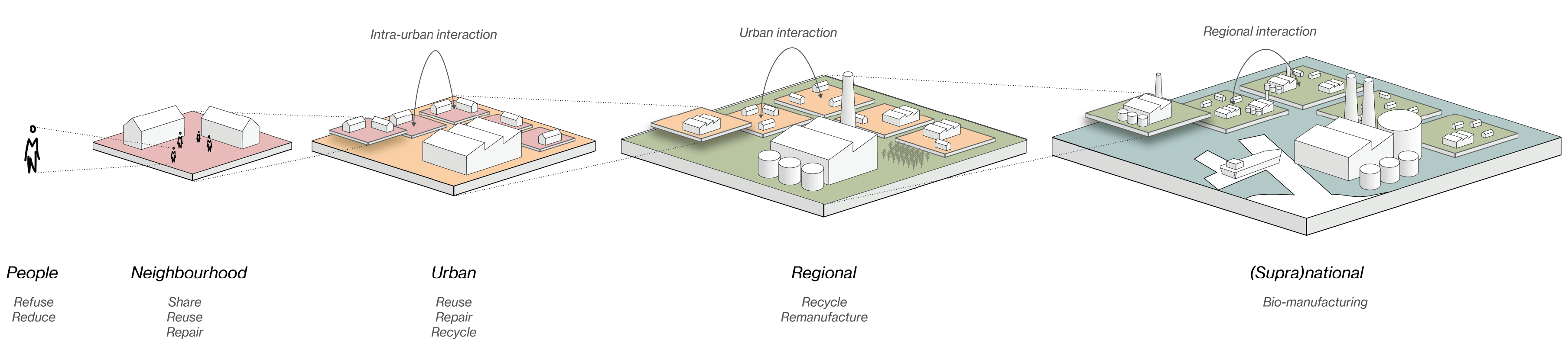


Figure 5.5. Scale relations in the strategy

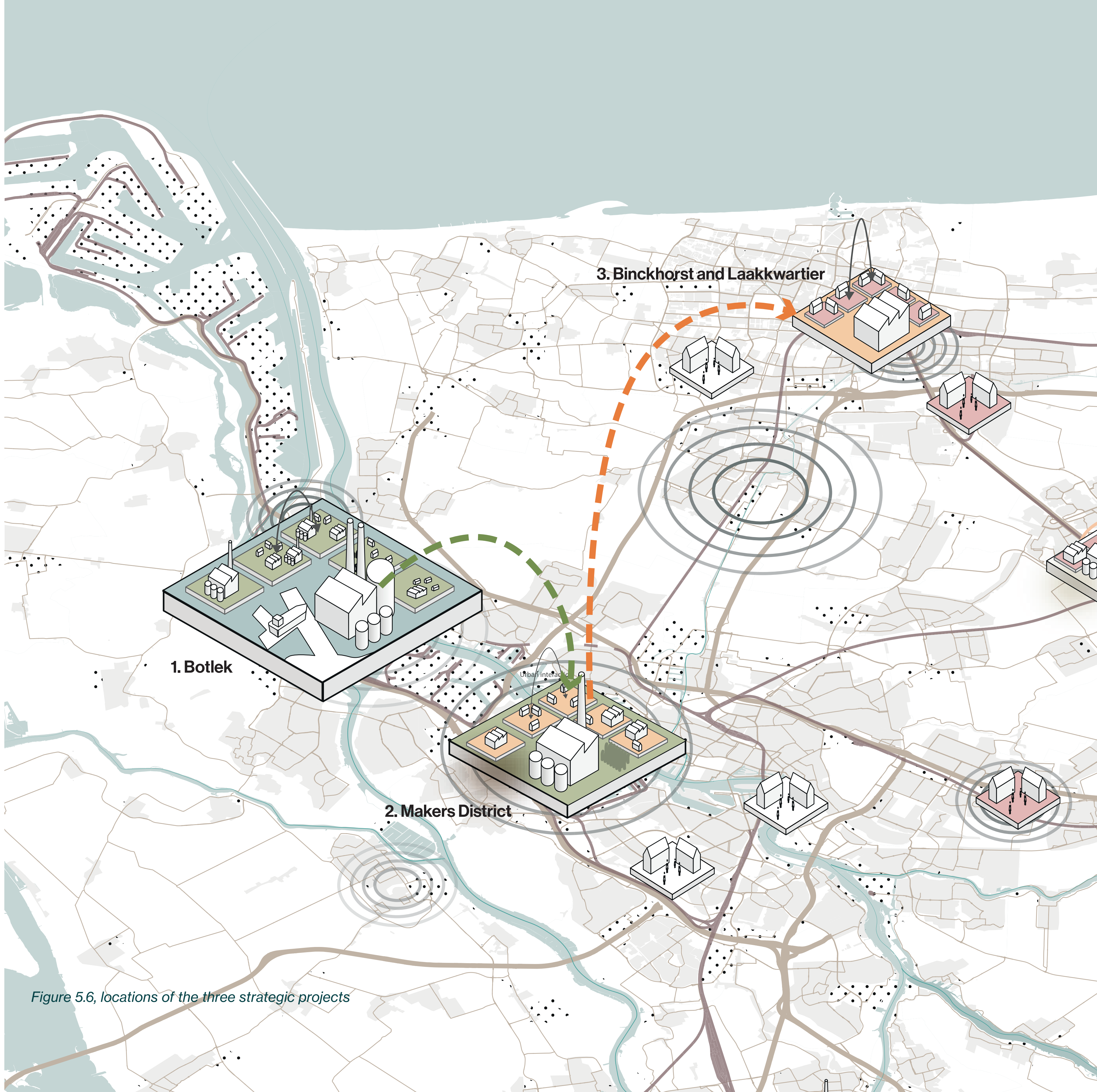


Figure 5.6, locations of the three strategic projects

5.4.1 Botlek: expanding bioplastics production

The Botlek area locates in the central part of the port. Having such a unique geographical advantage for maritime transportation, the area is targeted at providing the functions of petrochemical industry and the storage for tanks and dry bulks. The area is one of the most important sites in our vision, in respect of the expected transformation from fossil-based plastic to bio-plastic production.

The existing infrastructures and transportation systems are well-equipped in the Botlek area, which adds up to the efficiency for the chemical refining, processing and energy production factories on site. The factories are in good coorporation with each other based on shared facilities and space. Among them, there are several companies that already have strong initiatives to trasform towards a more sustainable and circular manufacturing mode, which can be the trigger to guide the transformation of the whole area.

Figure 5.7, Birdview of Botlek area (Gemeente Rotterdam, n.d.)

Stakeholders

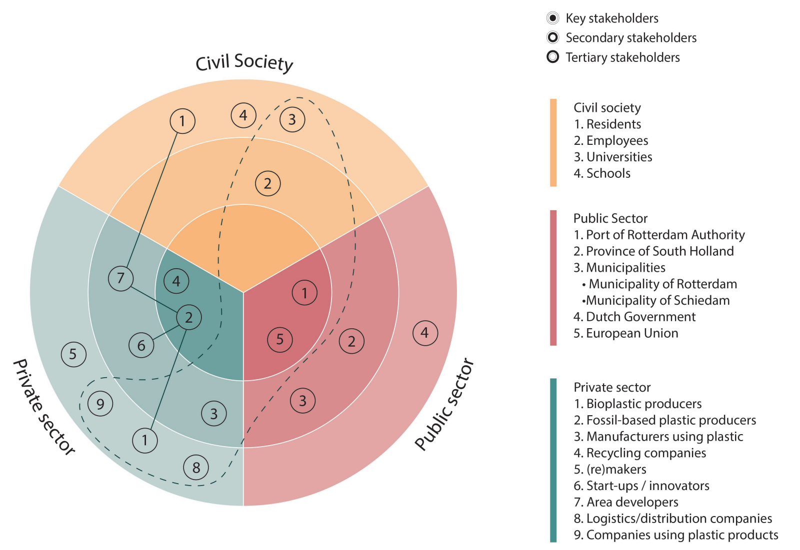


Figure 5.8, Current stakeholders of Botlek area (Port of Rotterdam, 2016)

Current situation

In the current situation of the Botlek area, the most functional zones are occupied by chemical extraction and polymerization, energy production and refineries, which plays an important role in the manufacturing of the monomers and polymers of plastics, the facilities are also applicable for bioplastics production to some degree. There are several companies that have the potential to lead the transformation progress as belows.

"Plant One Rotterdam BV" is the innovation centre for the area, which focuses on "the testing and demonstration of sustainability innovations in technology (Plant One Rotterdam BV, n.d.)". It fills the gap between laboratory experimenting and practical production.

"Esso Netherlands BV" belongs to the family of an international company "ExxonMobile", which is dedicated to become a hydrogen and biomass production plant to achieve net-zero emissions and support sustainable development around the world.

"AVR Waste" is the main waste processing site in the area, specialised in the disposal of various types of residual waste. The company contributes to achieving the national and European targets of energy and sustainability.

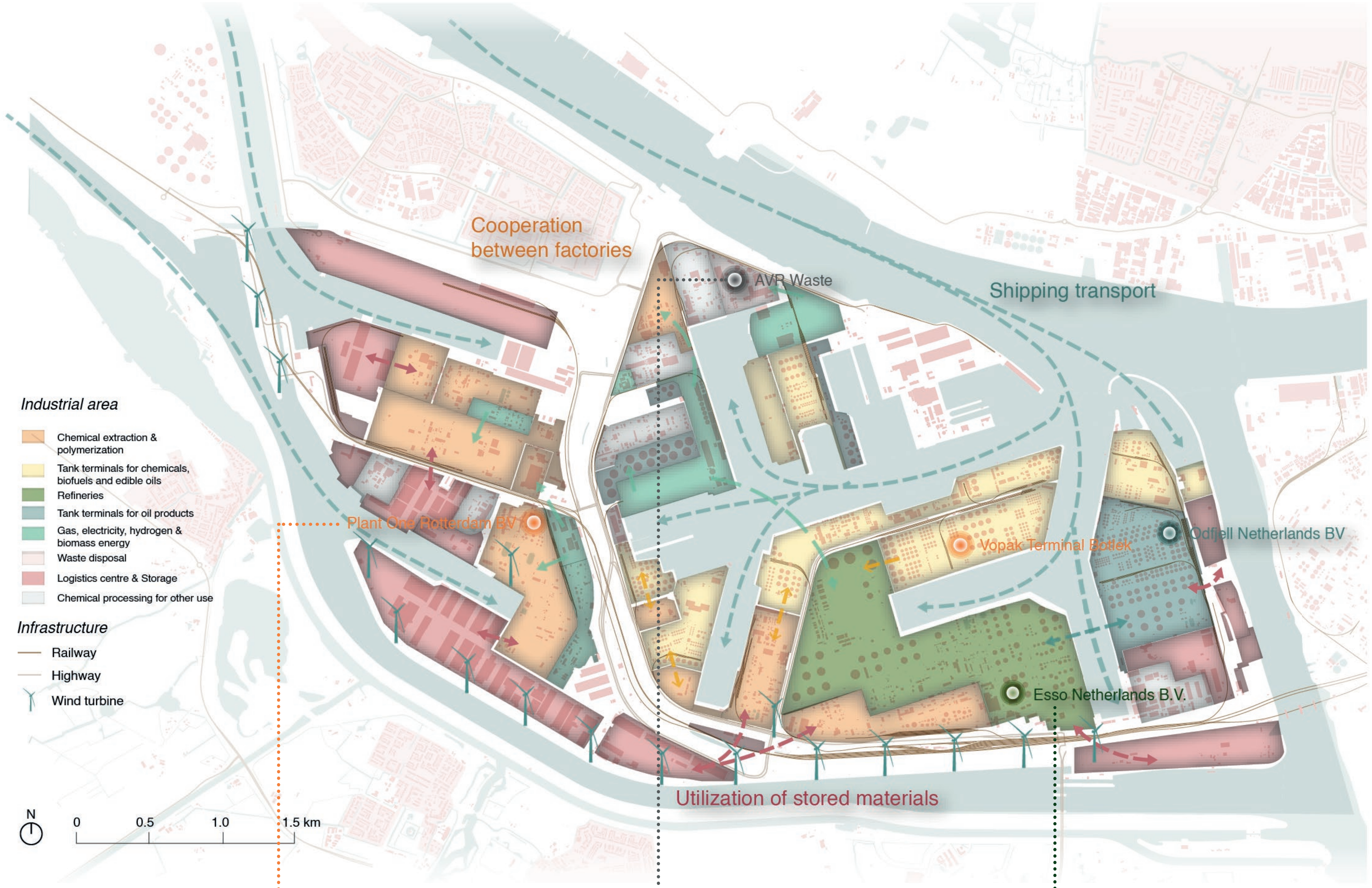


Figure 5.12, Current function of Botlek area (Port of Rotterdam, 2016)

Figure 5.9, Plant One Rotterdam BV (INNOVATIEVE IDEEEN TESTEN EN PRODYOUCEREN, n.d.)

Figure 5.10, AVR waste (Atlas News database, 2018)

Figure 5.11, Esso Netherlands BV (ExxonMobil starts construction of energy-efficient Hydrocracker at Rotterdam refinery, 2016)

Phasing

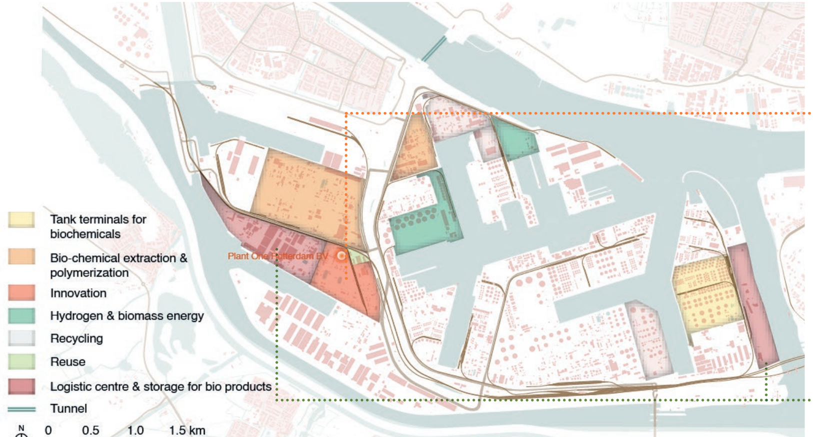


Figure 5.13, Phasing: 2030

Short term actions: 2022 - 2030

During this period, the innovation centre “Plant One” is enlarged in scale and becomes the leading role in the research on bioplastics (G1) and disseminate it to the surrounding companies, by providing knowledge and laboratory for them to get prepared for the transition from fossil-based production to bioplastic production, thus gradually put it into practice. Meanwhile, single-use plastic will be banned (B4, B5), the nearby energy plants shift their focus to hydrogen, solar and biomass related energy production (D5), the “AVR Recycling” centre is also expanded incorporating mechanical recycling and chemical recycling (C3). There are also some storage centres and tank terminals specifically prepared for bioplastic use (A2).

Figure 5.14, Phasing: 2040

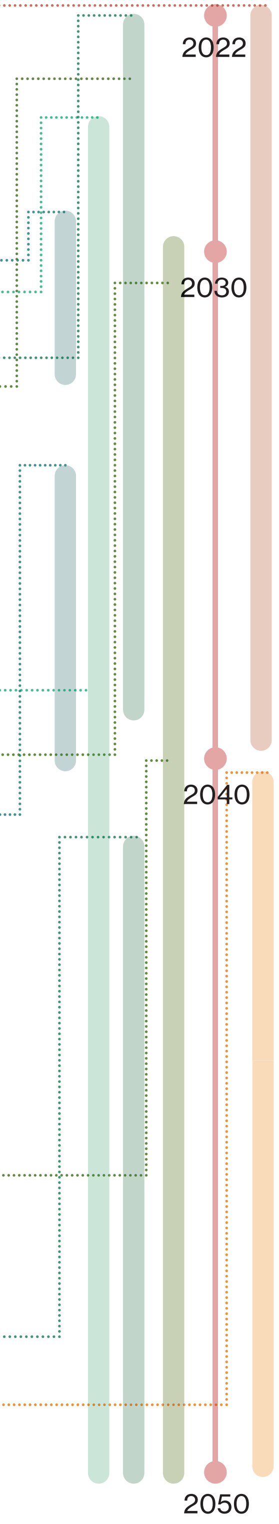
System change: 2030 - 2040

During these 15 years that are the most important period before final vision being achieved, the second promoter “Esso Netherlands BV” rises up to lead the energy production plants into transition. At the same time, more chemical extraction and polymerization companies get into the transition towards bio-chemical related ones (A3), which can be supplied with sufficient renewable energy, fossil based plastics that have bio-alternatives will be banned (B5). The whole region shows a development trend of gradual retrofit from the east and the west to the central area.

Figure 5.15, Phasing: 2050

Final stage: 2040 - 2050

In the final ten years, there is no large-scale alteration in spatial configuration, but mainly the expansion of key producers and further transition of the chemical processing companies. The central area is on track as well, following the steps of the companies in the eastern and western sides. The whole area with circular bioplastic production is successfully retrofitted with small amount of non-intervened space for the demand of edible oil and other chemical industries that use either biochemicals or chemically recycled chemicals (C5). Civil societies also play an important role in waste collection in this phase.



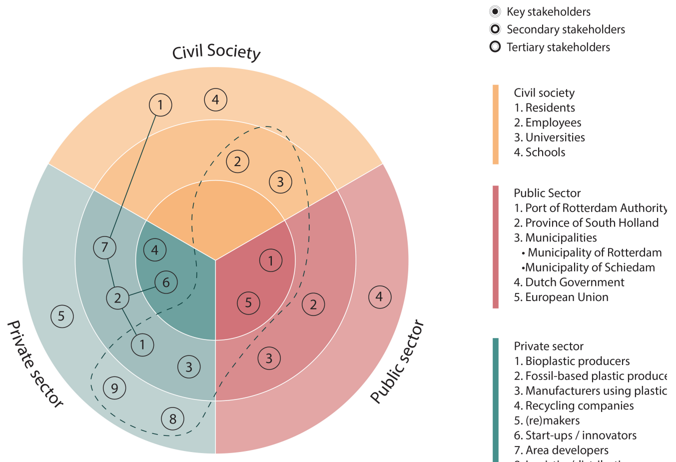


Figure 5.16, Stakeholders: 2030

Short term actions: 2022 - 2030

During this period, fossil-based plastic producers move from the key skateholders to the secondary ones, while bioplastic producers move forward to secondary stakeholders as well, because part of the fossil-based chemical processing factories perform the transition to bioplastics factories. Innovators play a key role during this process, with the research assistance from the universities outside the area.

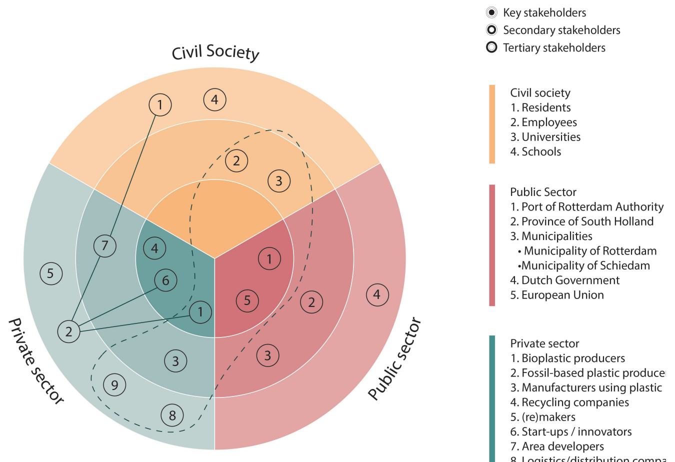


Figure 5.17, Stakeholders: 2040

System change: 2030 - 2040

The fossil-based plastic producers continue to be phased out and gradually become the tertiary stakeholders, while bioplastic producers becoming the key ones. The recycling and innovation centres keep their influence on the development during this phase.

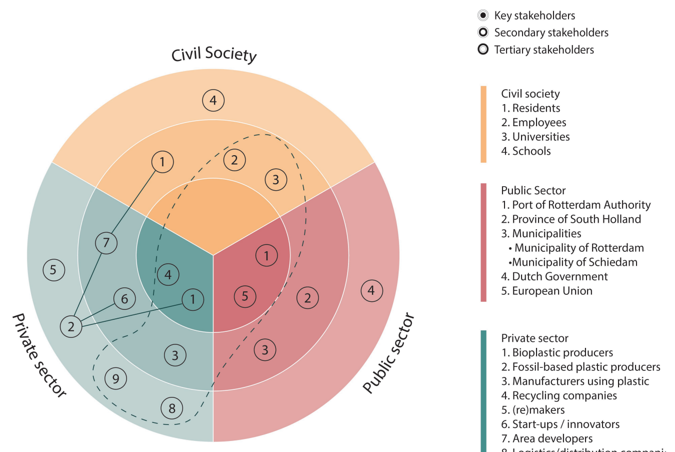


Figure 5.18, Stakeholders: 2050

Final stage: 2040 - 2050

In the final stage, the fossil-based plastic companies are phased out or transformed into bioplastic related companies, the innovators become less imortant in promoting the transition. The interrelations between different stakeholders tend towards stability. The participation of the civil society is activated in getting used to the new mode of plastic use and waste collection (I1, I5), especially for the residents in the Rozenburg area that is adjacent to the Botlek.

Vision

In the final vision of the Botlek area, almost all the previous infrastructures and facilities for fossil-based plastic production are transformed for the use of bioplstic production, which is the dominant industry of the area in 2050. There is also a backbone of hydrogen energy transportation implemented as the main energy supply for the manufacturing process instead of the use of the fossil fuel, according to the vision from the Port of Rotterdam (Port of Rotterdam, n.d.), where the Botlek area plays an important role in generating Hydrogen energy from biomass and transport the energy to other regions.

The residents in Rozenburg are active participants in plastic recycling as well. To achieve that, extra plastic waste collection points are set next to the main supermarkets and shops related to plastic products, which are easily accessible for the residents to deal with their household waste. Additionally, the innovation centre "Plant One" will collaborate with local schools for the education about bioplastics and recycling, also provide the public with the opportunity in visiting the bioplastic production chain, thus making bioplastics an integral part of everyone's life.

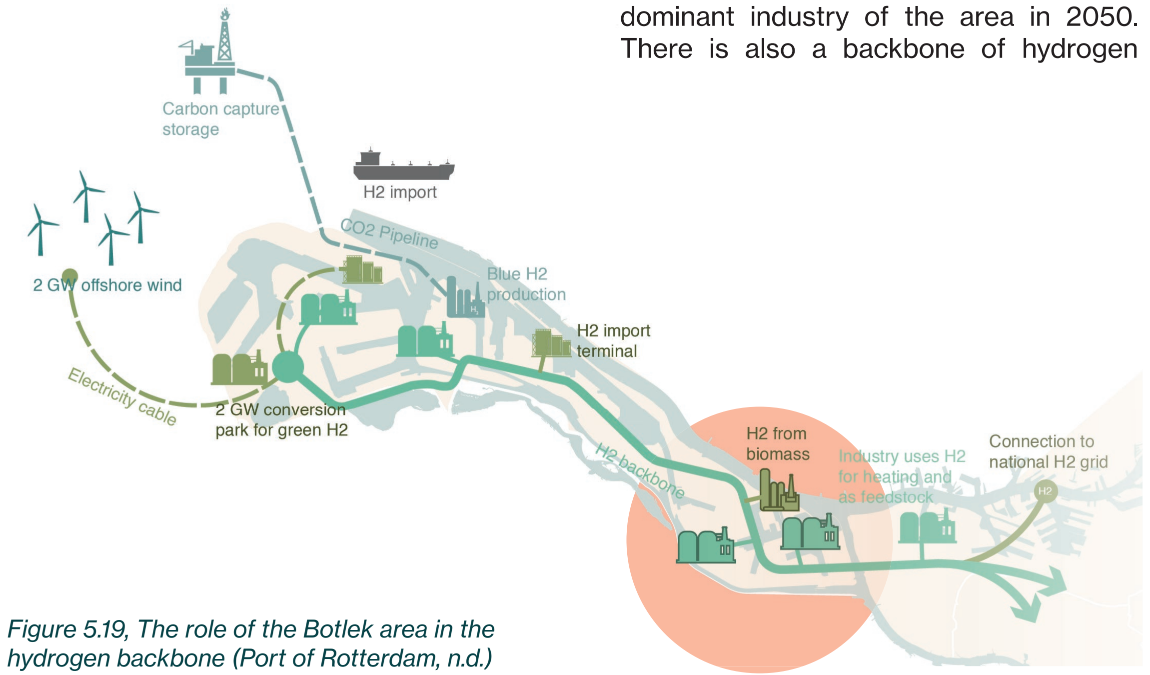


Figure 5.19, The role of the Botlek area in the hydrogen backbone (Port of Rotterdam, n.d.)

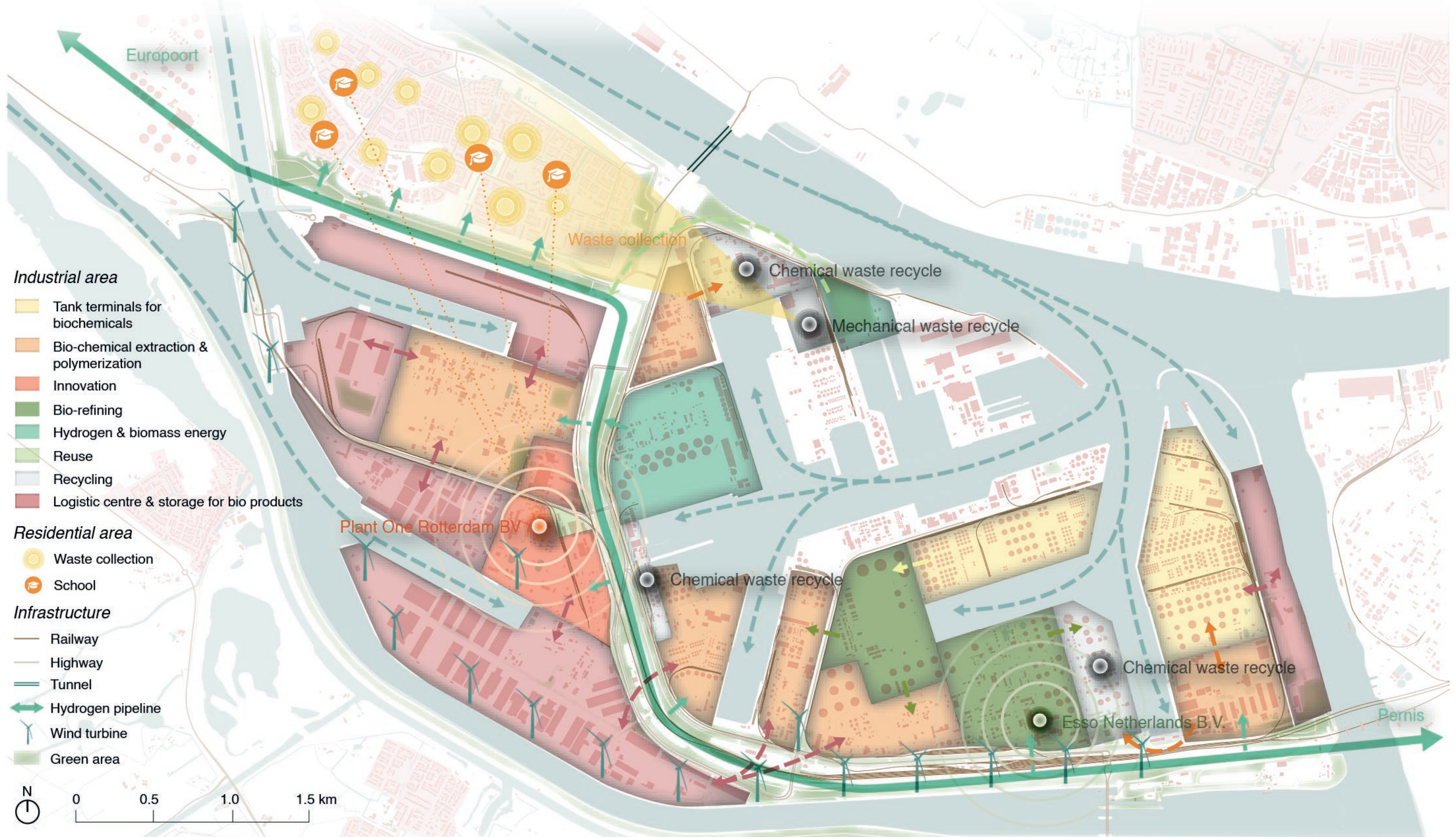


Figure 5.20, Vision map of the Botlek area in 2050

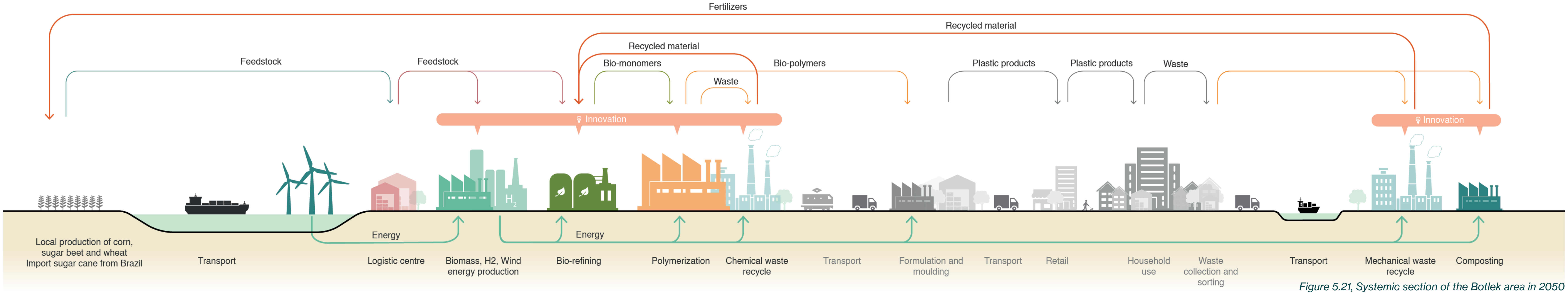


Figure 5.21, Systemic section of the Botlek area in 2050

Future situation

- Bio-plastic manufacture
- Innovation activation
- Convenient Port transportation
- Cooperation with recycle companies
- Better environment for manufacturing

Figure 5.22, Collage for the vision of the Botlek in 2050

5.4.2 Makers District

The strategic area Makers District is chosen in order to enhance innovation in the recycling of both fossil- and bio-based plastics. The proximity of both the RDM campus and the M4H maker spaces to adjacent neighbourhoods can enhance citizen participation in the collection of plastic waste and boost awareness in daily lives. The RDM campus is a space for knowledge creation and start-ups. Our vision could benefit from this by enhancing innovative ideas in new ways to recycle, reuse or refurbish fossil- and bio-based plastic products. The Spaanse polder area could act as a potential growth area for start-ups, concerning plastics recycling, to scale-up if needed.

First of all, we analysed the current situation of the M4H & RDM campus and selected the spatial element that could work in our visions favour. The M4H harbour is already home to plastics recycling companies like Urban Mining Corp and Plasticiet (M4H Rotterdam, 2021; Duurzaam 010, 2021) The area is also well connected through either railway or metro lines to the city centre and surrounding cities such as Schiedam. The blue infrastructure connects the area to the production harbours in the west.

The port and the municipality of Rotterdam are currently developing the M4H harbour. Plans for new housing, the stimulation of innovation space , culture and recreation are at the forefront of the new plans (M4H Rotterdam, 2019). The addition of new green and improved cycling connection will make the area more attractive for citizens surrounding the harbour.

Figure 5.23, Future plans for M4H (M4H Rotterdam, 2019)

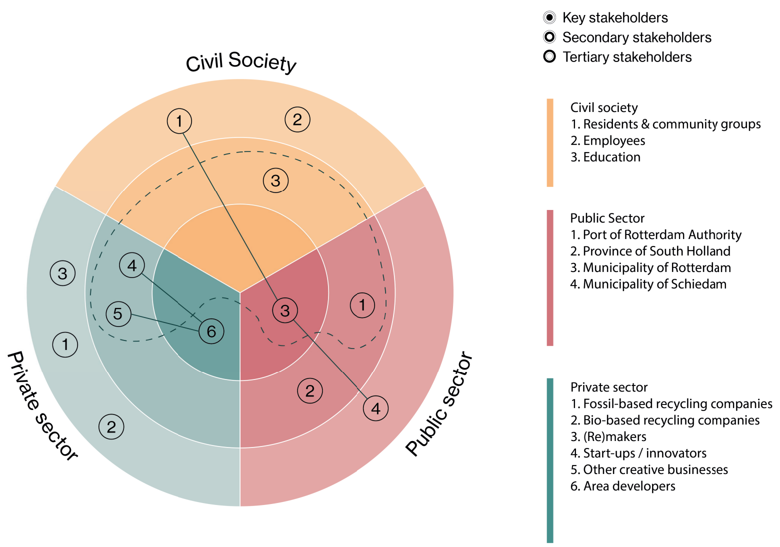


Figure 5.24, Current stakeholders in the Makers District

The stakeholders involved in the Makers District are mostly derived from the current development plans of the M4H harbours. Area developers for housing are put as key stakeholders in the current situation, but could have conflicting ideas with the creative businesses that also want space in this area.

Furthermore, the current stakeholders like the RDM campus, the Port of Rotterdam authority and start-up businesses are already collaborating in order to stimulate innovation. Our vision will keep this collaboration going.

Figure 5.28, Current situation of Makers District

Figure 5.25, RDM Campus The stimulation of education and innovation (RDM Centre of Expertise, n.d.)

Figure 5.26, Plasticiet Company that transforms plastic waste in creative and smart ways (Plasticiet, n.d.)

Figure 5.27, Spaanse Polder Industrial area with need to revamp (DZP, n.d.)

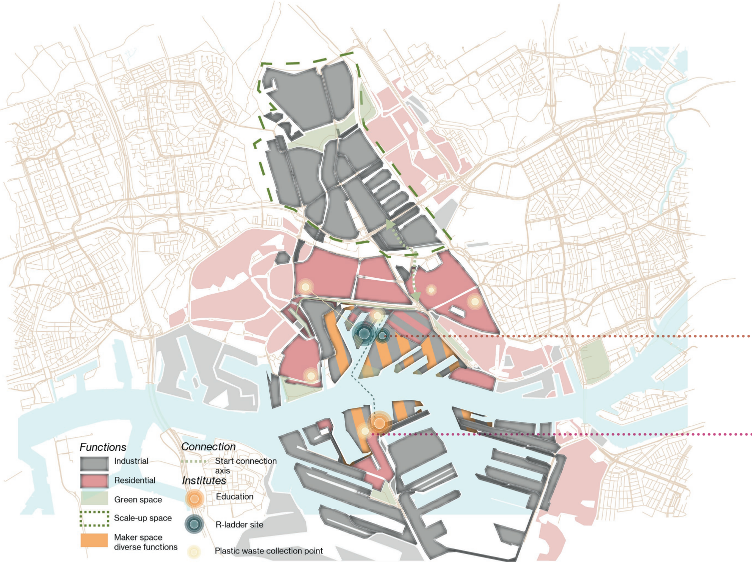


Figure 5.29, Phasing: 2030

Short term action: 2022-2025
Short term triggers to kick-start our strategy are the already exisitng future developments for the M4H area. Our vision will respond to these and aim to push forward the recycling and reusing of fossil- and biobased plastics in small-scaled facilities (H1). This will be done when leases expire of current functions (bestandje). New policies will have to be created to ensure that the housing development won't dominate the area and cause rent to rise (G1). A start is made to improve the connection between the M4H and Spaanse polder areas (G2). New specialized waste containers retrofitted into the adjacent neighbourhoods slowly respond to the introduction of bio-plastics and the phasing out of fossil-plastics (F1).

Figure 5.30, Phasing: 2040

Systematic change: 2025-2040
Once the first stage of development has passed, a new social and spatial environment will be established. Waste collection points and community programmes can be stimulated in order to create daily life habits (I1). The improvements of accessibility will attract people and encourage participation (G1 & G2). Innovation will slowly respond to the changes in the western parts of the port as fossil-based plastics are being phased out. New ways of recycling and reusing will have to be developed and new, talented start-ups could help with this process (E1).

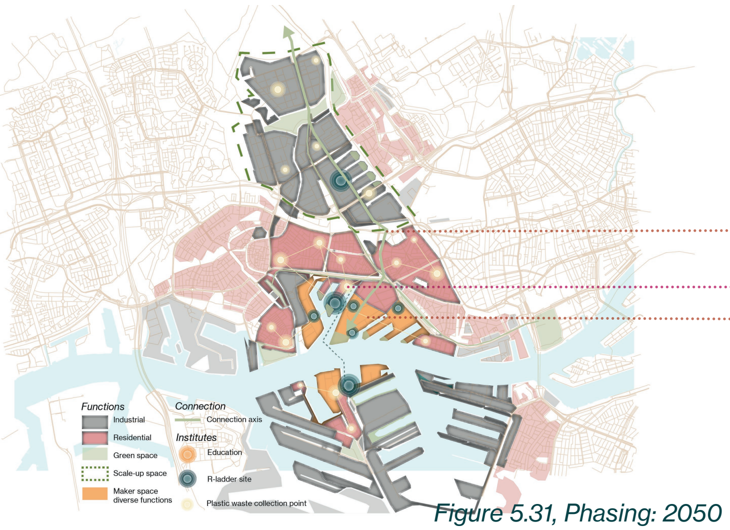
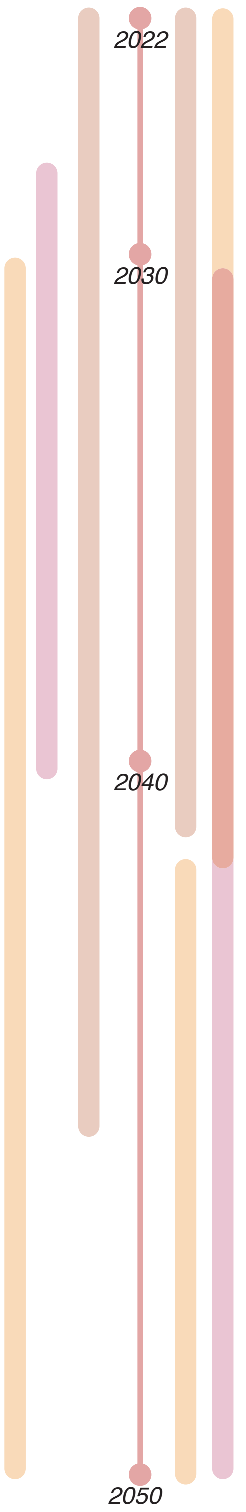


Figure 5.31, Phasing: 2050

Final stage: 2040-2050
A new connection route between the Spaanse polder and the maker district is fully developed, enhancing the already existing transportation system (G2). Start-ups from the previous phase will have grown and are in need to scale-up. The Spaanse polder could facilitate them and eventually form a creative environment as well. Waste collection points will be fitted into neighbourhoods and has become part of people's day-to-day life (E1). Networks and smart collection methods will be created in order to make this system run smoothly. The R-ladder facilities for both fossil- and bio-based plastics have become an integral part of the maker district and will keep benefitting from diverse industries (H1).



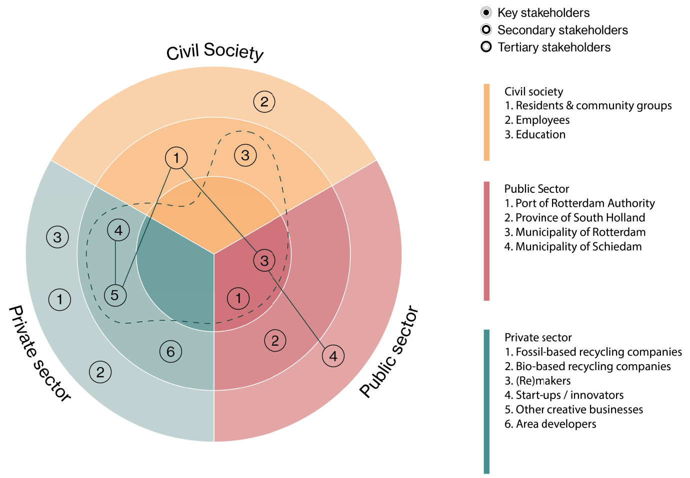


Figure 5.32, Stakeholders: 2030

Short term action: 2022-2025
Private area developers move from key to secondary stakeholders, as space for creative busnisses will be protected. This ensures that housing development will be limited so that the full potential of urban industrial spaces like M4H could be reached in the near future (G1). Citizens of adjacent neighbourhoods will be more involved in the planning process in order to make the makers district enjoyable for all (I1). The Port of rotterdam authority, just like at the RDM campus, will set out programmes to stimulate innovation (I1). Conflicts could arise when deciding who gets what amount of space.

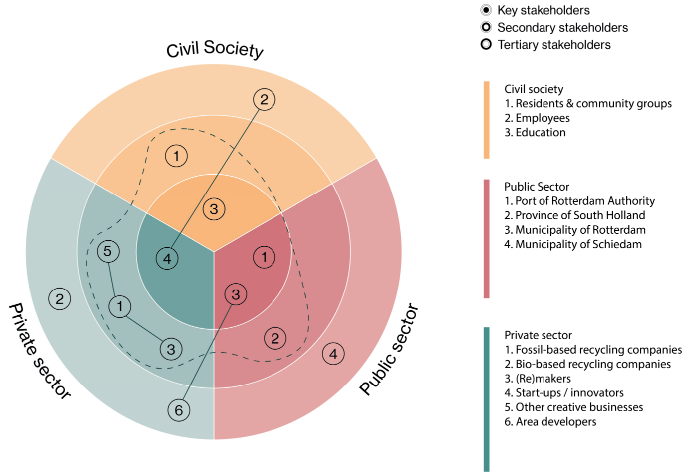


Figure 5.33, Stakeholders: 2040

Systematic change: 2025-2040
Start-up businesses and education programmes get a more prominent role in the systemic change phase. Innovation will be stimulated in order for different recycling facilities of both fossil- and bio-based plastics to run smoothly (H1). Fossil-based recycling will move up to become a more important actor in the Makers District, as these plastics types will start to phase out (H2).

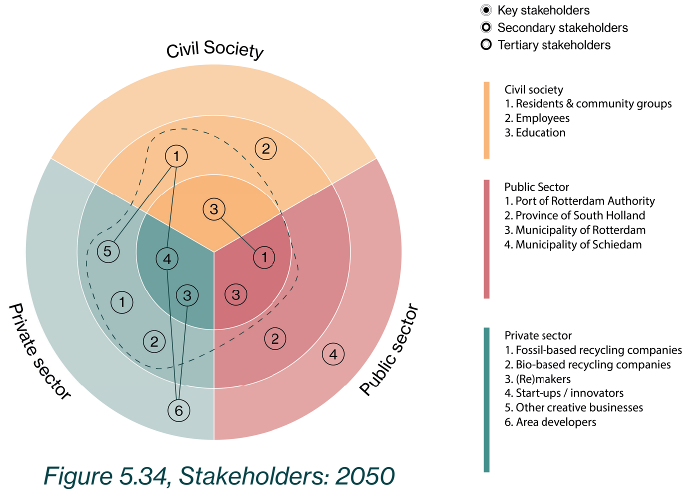


Figure 5.34, Stakeholders: 2050

Final stage: 2040-2050
Lastly, Bio-based recycling facilities will have moved up to become more important as well, as bio-based plastics will have entered the consumer cycles. R-ladder companies will become a key stakeholder in the maker district, along side other creative businesses (E1). Citizen participation is intergrated into people's everyday life and education programmes will train people for specific jobs in the R-ladder system (I2).

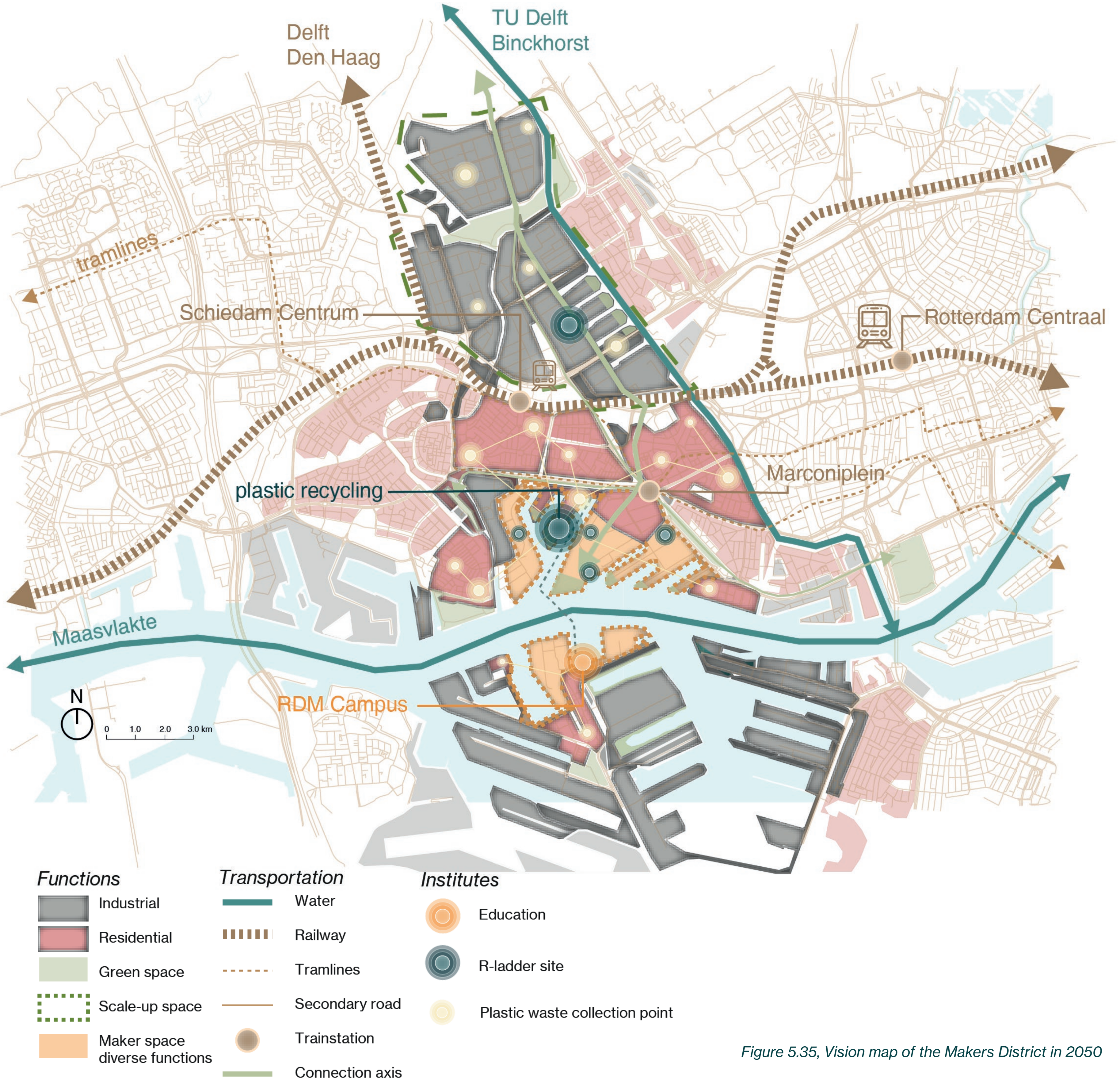


Figure 5.35, Vision map of the Makers District in 2050

The overall aim of the vision for the Makers District is to enhance the existing situation of and innovation and create an environment for creative industries to take place. The M4H harbor plan will be slightly tweaked to ensure that the housing development won't eventually take over. We aim to stimulate diversity in creative functions in combination with our overall visions' R-ladder amenities. A knowledge network will be formed in order to stimulate collaboration between new talent and the Makers District can create opportunities for ideas to become reality. The makers district will also foster a network of social participation with adjacent neighbourhoods and enhance community programmes in regards to, for example, waste cleanup. This will boost awareness and create sustainable lifestyles. The creative industries will be connecting with the Spaanse polder area through a green axis. This way, the connection is still enjoyable by people using passive modes of transport and will keep the city healthy.

For us it is important to intervene at these types of areas. According to van den Berghe (2021), a spatial paradox is happening with industrial urban zones. For a circular image of cities, industrial areas like M4H are vulnerable to developments, like housing, disguised as circular urban growth (van den Berghe, 2021). In our vision, spaces like M4H in combination with the RDM campus provide opportunities for the development of an intergated plastics recycling, re-using and refurbishing landscape.

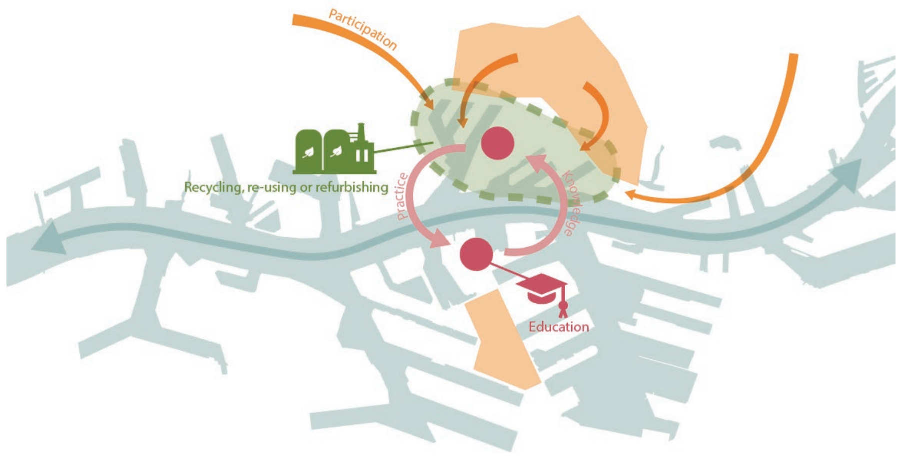


Figure 5.37, Knowledge network established in the Makers District

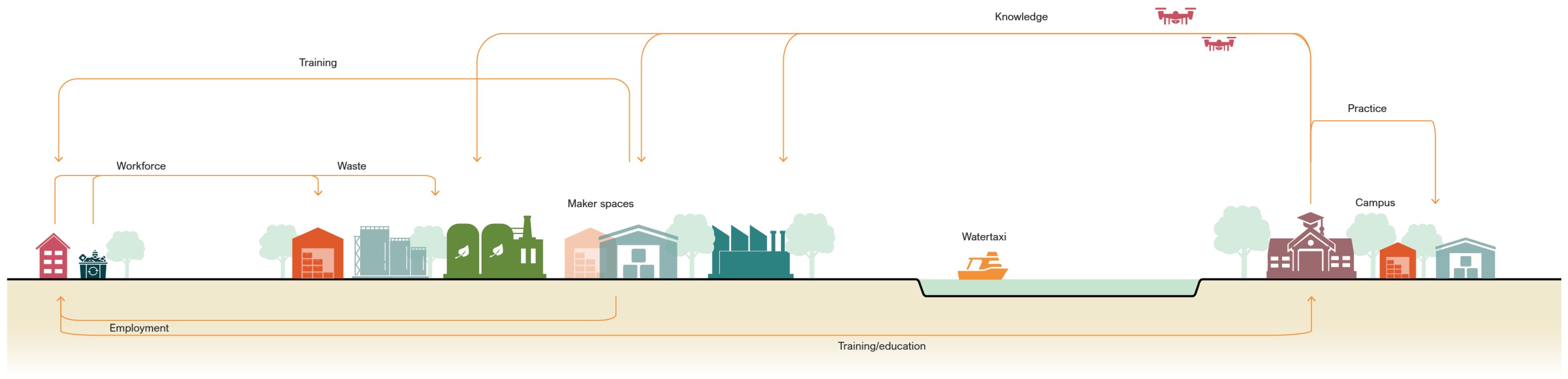
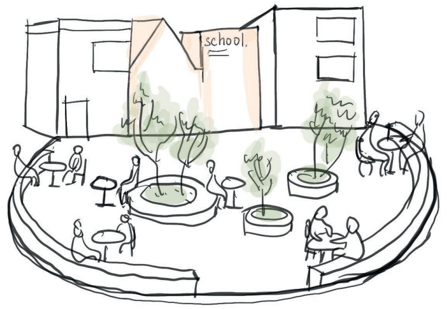


Figure 5.36, Systemic section of Makers District

Future situation



- Maker companies
- Innovation center
- Develope local companies
- Cooperation with recycle companies
- Better environment for manufacturing

Figure 5.38, Collage for the vision of the Makers District in 2050

5.4.3 Binckhorst & Laakkwartier

Our vision will not only change spaces in Rotterdam, but have an effect on adjacent cities in the region as well. Instead of fending away from these transformations, we aim to use these regional effects as a strategic move in spreading our vision for 2050.
The Binckhorst-Laakkwartier are will show our visions aim to involve the people and use community strengths as activators from a consumer base in the use of fossil-based and bio-based plastics. The Binckhorst is similar to the M4H harbor, as recent developments are made in order to create an innovative, mixed-use and mostly residential district (Den Haag, 2020). In this strategic area, the role of citizen participation will be central. The Binckhorst is an area with future highrise development, which could leave the Laakkwartier neighbourhood next to it with uncertainties. Our strategy here will be to implement proper actions to ensure the goals of our vision will be integrated into the development.

Overall the Binckhorst and Laakkwartier have good spatial proximity to areas like the Central Innovation District, the Haagse Hogeschool (higher vocational education) and many railway stations. However the Binckhorst and the Laakkwartier neighbourhood are poorly connected and are seperated by a small waterway. The Binckhorst currently has a waste collection and processing facility already, 'Afvalbrengpunt Gemeente Den Haag' and 'Renewi waste processing'. A shopping street centrally located in the Laakkwartier neighbourhood offers possibilities for the implementation of R-ladder facilities.

Figure 5.39, The Binckhorst. Currently industrial, but soon to be residential. (Gemeente Den Haag, 2022)

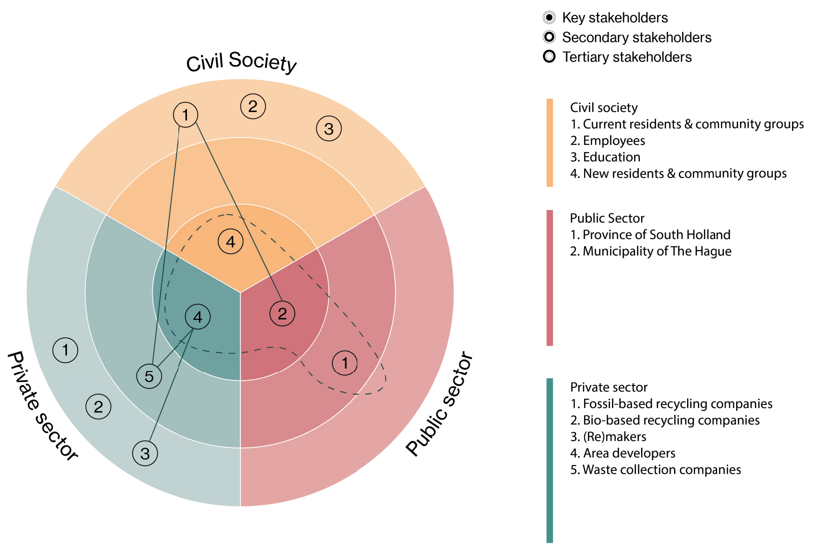


Figure 5.40, Current stakeholders in the Binckhorst and Laakkwartier

The current key actors in the Binckhorst & Laakkwartier are favored towards the new (mainly housing) development that will take place. Area developers and future residents are taken into account way more than current residents of Laakkwartier and this could lead to conflicts. Recycling, reusing or remanufacturing companies are not yet of importance in the current situation.

Re-makers could have conflicts with area developers as well. We will have to ensure that enough space is left for the creation of R-ladder amenities.

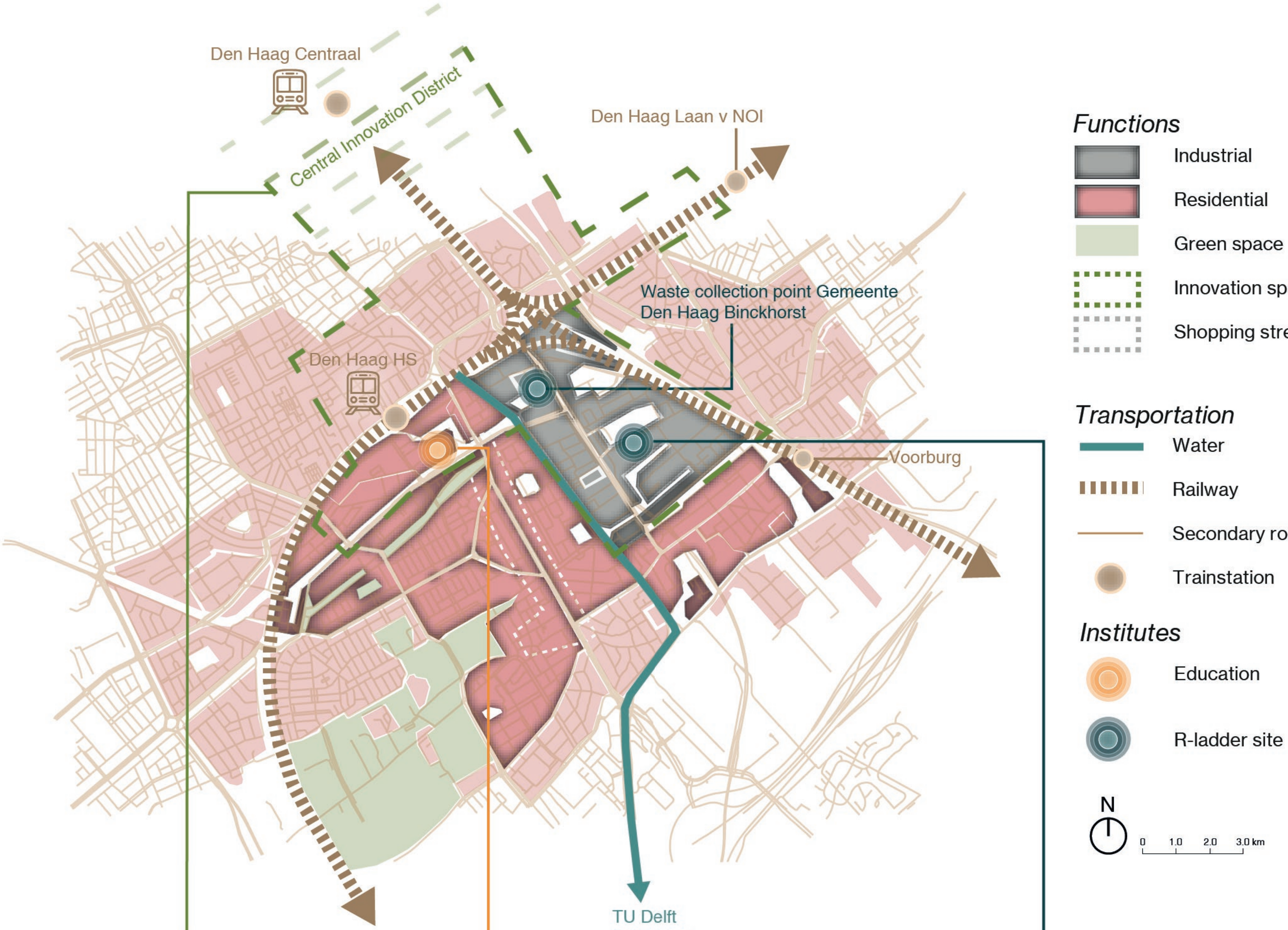


Figure 5.41, Current situation of Binckhorst & Laakkwartier

Figure 5.42, (Den Haag Central Innovation District, 2019)

Figure 5.43, Haagse Hogeschool (Haagse Tijden, n.d.)

Figure 5.44, Waste collection (Renewi, 2022)

Figure 5.45, Phasing: 2030

Short term action: 2022-2025
This strategic area needs quick interventions, as the Binckhorst developments are set to be finished in 20 years. Policies concerning residential development need to ensure not all space will become housing (G1). New housing blocks will have to be implemented with smart waste collection systems (F1). Slowly, some shops in Laakkwartier will start to empty, leaving space for start-up or pop-up R-ladder facilities (H1).

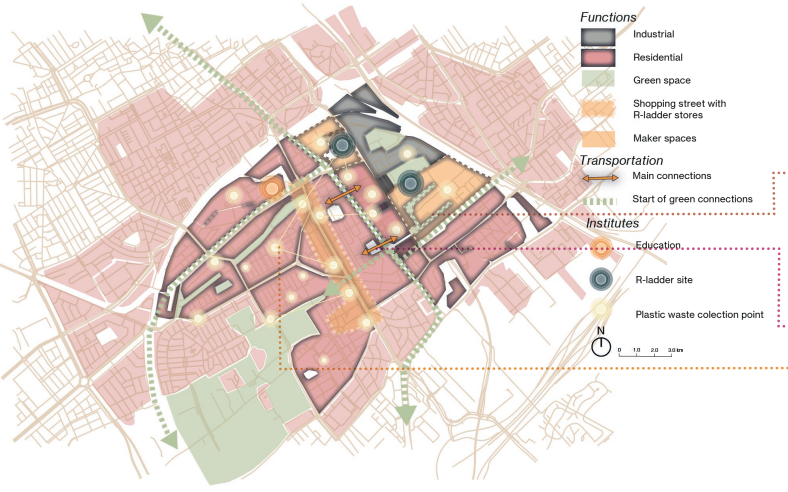


Figure 5.46, Phasing: 2040

Systematic change: 2025-2040
The Binckhorst developments are finalizing. Diverse maker spaces will be created where several recycling or repairing sites can be facilitated (H1). A network of waste collection points throughout both the Laakkwartier and the Binckhorst will stimulate citizen participation in the new system of circular plastic manufacturing (E1 & I1). New connections between the two neighbourhoods can foster a new social environment of sustainable living and consuming (G2).

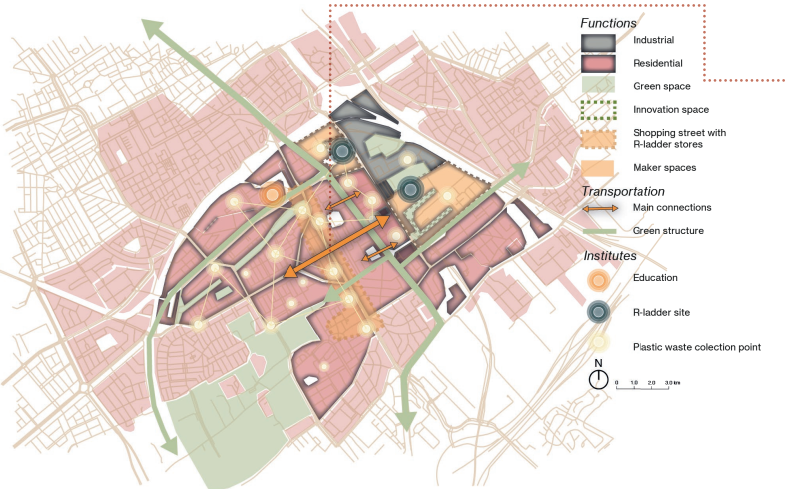
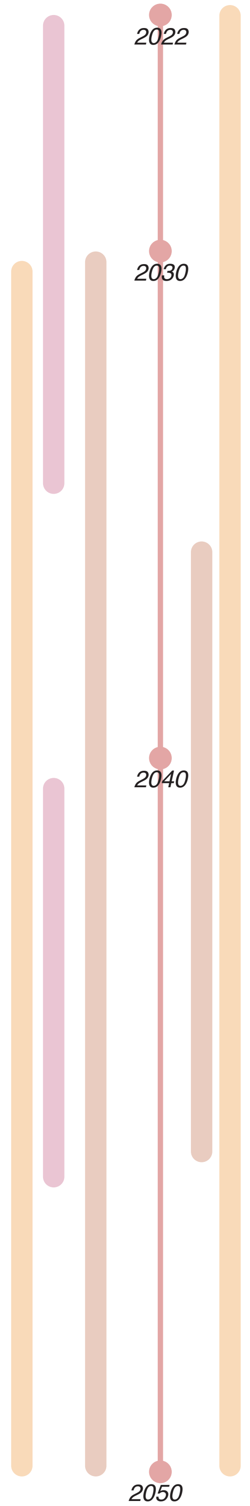


Figure 5.47, Phasing: 2050

Final stage: 2040-2050
A final and central connection axis is created (G2). The implementation of bio-plastics in everyday life is now standard. Concious waste collection and participation in creative industries strengthens social cohesion in the neighbourhoods (I1). It is important that our vision protects the identity of neighbourhoods, while giving equal opportunities for all to participate in a new circular system of plastic manufacturing and recycling (E1 & F1).



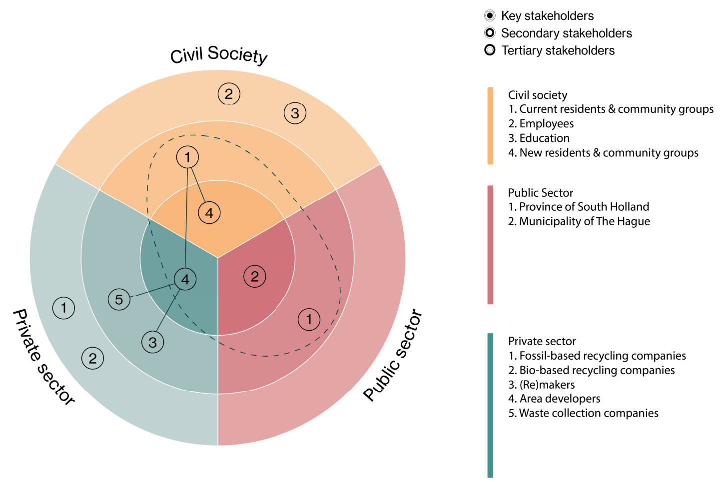


Figure 5.48, Stakeholders: 2030

Short term action: 2022-2025
Area developers are key stakeholders, as the plans for the Binckhorst are in full process. However, both current citizens and (re)makers are becoming more important for the shaping of the public spaces throughout both Laakkwartier and the Binckhorst (I1). Our vision values participation from stakeholders that can contribute to a more sustainable and innovative system.

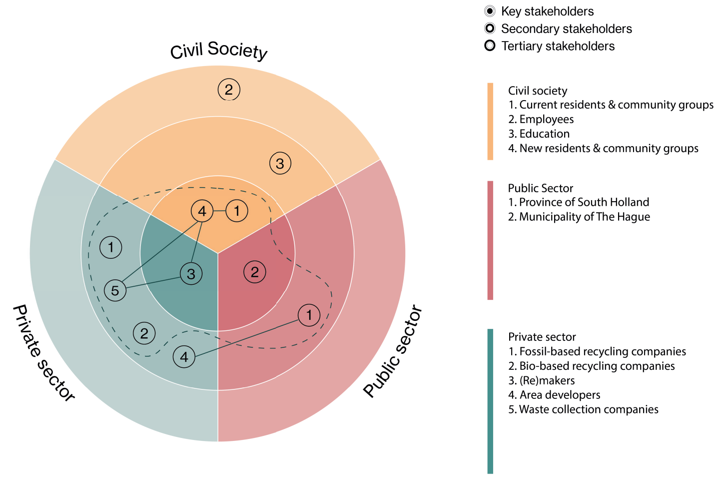


Figure 5.49, Stakeholders: 2040

Systematic change: 2025-2040
Current residents of the Laakkwartier neighbourhood have become key actors as their participation is of great importance for proper consumer behaviour change (I1 & E1). Citizens can collaborate with (re)maker industries and recycling companies (G2). This way, values are discussed and a healthy social environment regarding plastic waste is established. Private are developers are becoming less important as the Binckhorst developments are finalizing.

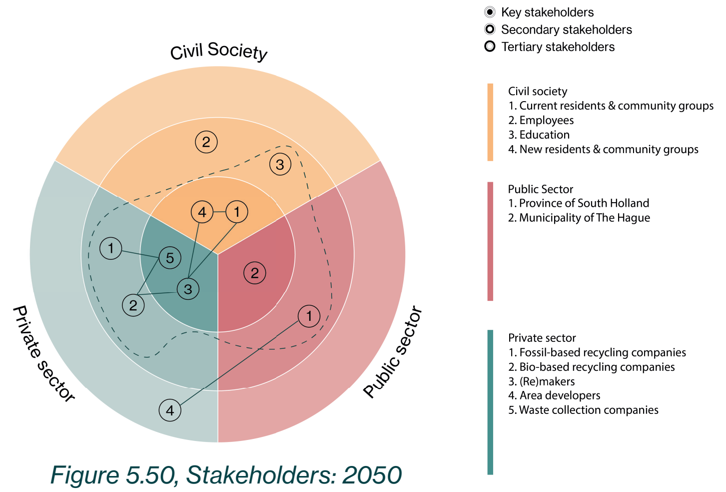


Figure 5.50, Stakeholders: 2050

Final stage: 2040-2050
An integrated waste collection system throughout neighbourhoods is established and waste collection companies, for both fossil- and bio-based plastics, have become key actors (F2) . (Re)makers maintain an important role in the third and last strategic area. Our vision encourage consumers to consiously re-use, repair or recycle their plastic products as much as possible in order to aid circularity (I1).

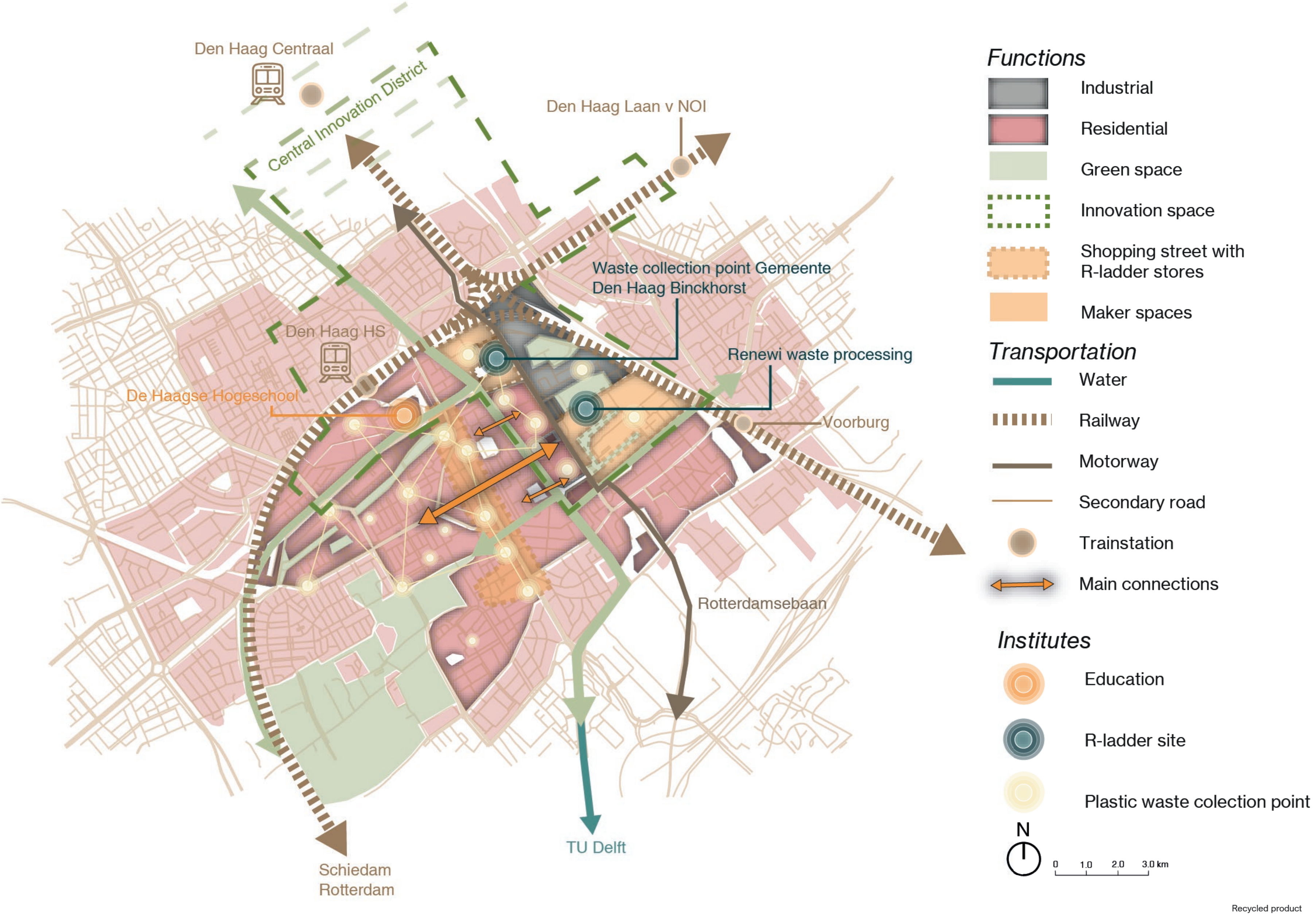


Figure 5.51, Vision map of the Makers District in 2050

The final vision for the Binckhorst and Laakkwartier shows a mix of implementing and retrofitting of the goals of our overall vision. Rapid developments of high-rise dwellings can be implemented with interventions regarding waste collection. Apartment complexes can have dedicated waste separation floors for example. This is possible as the buildings planned for the Binckhorst are still in development (Binckhorst Den Haag, 2021). The new buildings could be built using recycled plastic material and upgraded by placing solar panels or roofgardens on top (Ministerie van Infrastructuur en Waterstaat, 2020). The current neighbourhood of Laakkwartier will be retrofitted with interventions for both fossil- and bio-based plastic waste collection systems. Plastic waste containers will replace the already existing containers which makes the transformation less impactful to the current residents. The 'Rijswijkseweg' shopping street will slowly be added with R-ladder stores, like repair or reusing shops. This way, people will be encourages to first attempt to repair their plastic product, before it is labelled as waste.

In order to stimulate interaction between the newly developed Binkchorst area and the upgraded Laakkwartier neighbourhood, new physical connections will be created. Bridges can connect the two neighbourhoods and people can thus benefit from both. A cozy neighbourhood on one side, and a sustainable and innovative one on the other.

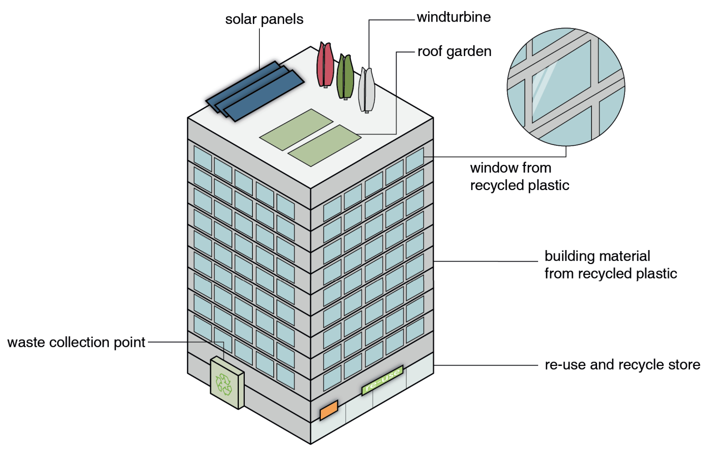


Figure 5.53, New apartment buildings, implemented with recycling and collection parts

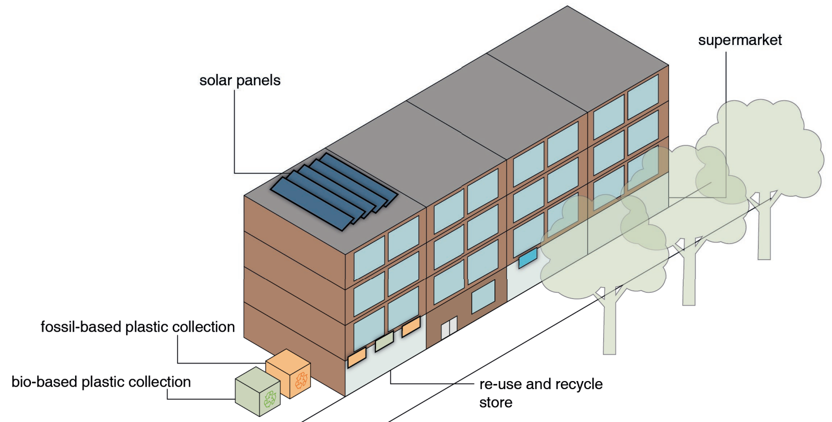


Figure 5.54, Current neighbourhoods with small, retrofitted interventions of waste collection and R-ladder facilities

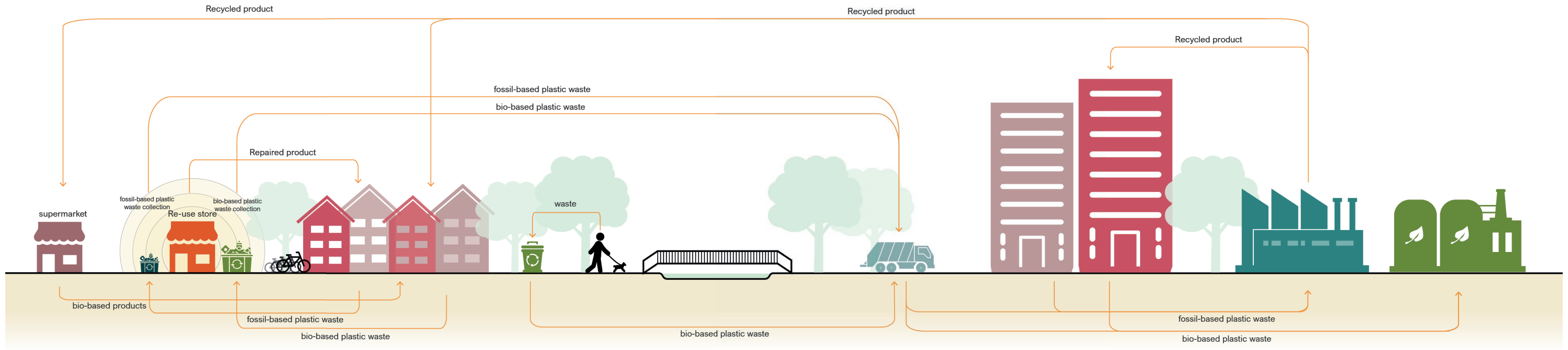


Figure 5.52, Systematic section of the Binckhorst and Laakkwartier

Future situation

- Participation in waste collection
- Recycle, reuse, repair stores
- More sustainable energy use
- Seperate waste collection
- Better inironment for living

Figure 5.55, Collage for the vision of Binckhorst & Laakkwartier in 2050

6 Conclusion and discussion

Chapter content

This section summarizes and provides feedback on the entire report process and analyzes the limitations of the new strategy and spatial design. The scientific reference and societal relevance of the whole report is presented. Finally the new strategy and design are analyzed again to explain how to achieve the goals of SDG.

6.1 Conclusion

In the whole process of the report, we started with the current situation and the background of the port of Rotterdam. We researched the different industries, transportation and economic situation of the port of Rotterdam in order to summarize the current problems. We looked deeper into the related manufacturing processes and unveiled a lack of responsiveness of plastic producers to global, pressing issues like climate change and economic vulnerability. We decided to investigate the much needed transformation of the plastics industry with the goal of circularity in 2050 in mind. An analysis of the spatial structure of the plastics industry was performed. The strengths, weaknesses, opportunities, and threats of the industry were summarized to guide the vision strategy and subsequent spatial structure. After a thorough analysis, we came up with a vision statement for the future. Through the encouragement of reusing, repairing and recycling simultaneous with the development of a new bio-plastics industry, we show how we aim to achieve a sustainable system transformation of the Rotterdam port. The main structure of the vision is divided according to four domains: innovation, bio-plastic, recycle, and a social layer, which were each analyzed step by step. Finally, the different layers were superimposed to form the final result. A timeline for the phasing has been produced to guide the vision to 2050. For an extra layer of transformation, actors and policies were mapped out. After the completion of the overall strategy, we chose three main representative areas to further demonstrate how our strategy will be applied to the spaces and how these will evolve over time. Finally, the overall designs of the 3 areas were retraced for analysis and reflection.

Sub-question 1: What is the current (spatial) structure of plastics manufacturing in the Rotterdam maritime region?

The current spatial structure of plastics manufacturing in the Rotterdam maritime region consists of large scale petrochemical landscapes and its subsequent infrastructure. These industrial zones are connected through an established infrastructure system and several transport routes. Raw material like oil flows through multiple pipelines to and from the port of Rotterdam. Shipping transport over waterways like rivers or oceans, is essential for the import and export of plastic goods in the port.
However, there is a (spatial) divide of industrial landscapes, like the Maasvlakte, and neighbouring urban areas. As the port and its plastics industry has grown, its position has shifted out of the city. Currently, the social realm is hardly connected to the production landscapes. Public transport, roads or railways are hardly present in the production landscapes in the west.

Answer sub-question 2 How sustainable and resilient is the plastics manufacturing sector currently?

The plastics manufacturing sector in the port of Rotterdam is currently not sustainable. The use of finite, fossil-based raw material is still largely in motion. The port and the plastics production system are dependent on the import of crude oil from different countries, making them vulnerable to global shocks: it is not resilient.The lack of cooperation between the companies involved in the entire plastic product manufacturing process makes the overall efficiency low. Moreover, there are many international relations that produce dependency. Plastic waste is only partially recycled and partially burned to be used as energy, which sounds circular, but is one of the lowest uses of the material. The plastic waste collection companies and recycle companies are not well connected with each other and it is hard to recycle the plastic waste in an efficient way. However, these practices, including both the production and processing, release large amounts of carbon emissions. Lastly, only a small part of plastic production is bio-based without the use of fossil-based raw materials.

Sub-question 3: How can the plastics industry be made circular?

The whole system of plastic companies can be more circular through two ways. One is to introduce bio-plastics and phase out the fossil-based plastic. Bio-plastics have the potential to be produced and recycled in a more environmentally friendly way. The production, degradation and disposal of bio-plastics is more environmentally friendly than fossil-based plastic and has a renewable source.The other way is to make the progress of recycling more complete and use innovation to activate the knowledge and skills for reusing, repairing and recycling recycling. We also make residents participate in the waste collection progress to make the recycle chain more efficient.

Sub-question 4: What spatial interventions could facilitate a circular plastic economy in the Rotterdam maritime region?

Spatial transformations like changing functions in the petrochemical landscapes to more bio-based ones, using locally grown sources as feedstock for bio-plastic production and improving collaborations between innovation centres could facilitate a circular plastic economy in the Rotterdam maritime region. Current fossil-based production spaces are changed to the production, storage and distribution of bio-based plastics. The existing infrastructure is re-used and new ones are created to enhance connectivity between production, recycling, innovation and users. Two types of axes

are created. The knowledge axis ensures the influx of new ideas for both fossil- or bio-based recycling or remanufacturing. The establishing of new innovation together with the creation of maker spaces encourages new talent to the circular plastic production process.

Sub-question 5: How can a just transition to circular plastics manufacturing be achieved in the plastics industry?

For the achievement of a just transition towards a circular system of plastics, we aim to involve citizen participation as much as possible. The involvement of current, but also new, residents help to shape healthy consumer environments of plastic products. Our spatial interventions will be executed parallel to existing development plans of municipalities. This way, the impact of the transformation is not that big on current residents and neighbourhoods. The creation of new maker spaces, including a high diversity of creative businesses and functions, in proximity to citizens can encourage participation in the collection of waste for example. Our strategic areas show diverse connecting elements between production, recycling and reusing and waste spaces. By implementing R-ladder amenities into existing neighbourhood structures, the social identity will be kept.

Main research question: How can the transition to circular plastic manufacturing in the Rotterdam maritime region contribute to a more sustainable, resilient and just economy?

The transition to a circular plastic manufacturing system can contribute to the economic development of the port of Rotterdam in three ways:

1-Sustainability
Through the introduction of a new, more environmentally friendly and locally sourced types of bioplastics, while phasing out the fossil-based plastics industry the port will become more sustainable. As the port of Rotterdam plays an important role in the global plastic production chain, this sustainable transition can have a global influence. Built upon a backbone of clean energy sources, like hydrogen, solar or wind, the production process of new bio-plastics can co-exist with the energy transition set out for 2050 as well.

2-Resiliency
A resilient economy is able to 'bounce back' after shocks. By introducing bio-plastic production using locally sourced feedstock, global dependency of raw material will be minimized. This way, a global crisis will have less impact on the production process of bio-plastics. As our transition also includes R-ladder strategies, recycling and reusing plastics will be encouraged. This will also lessen the dependence on new plastic materials. After all, what stays in the region does not need to be imported or produced.

3-Justice
Not only the production of plastics should be changed, the consumer level changes and effects are equally as important. A circular plastics industry includes citizen participation in waste collection, R-ladder facilities and innovation creation. The circular port of Rotterdam will be able to facilitate these consumer level processes in order to encourage participation. Creative maker spaces will transform urban industrial areas into lively places of discussion and leave room for new housing development. Smart housing created using recycled plastic materials will connect all people to the new circular production and recycling system of both fossil- and bio-based plastics.

6.2 # Discussion

6.2.1 Limitations & Ethical issues

Limitations

The vision and strategy for the Port of Rotterdam and the province of South Holland is made for the regional scale, both regarding space and governance. Many of the processes in the plastics industry are operating on a higher scale. This causes the vision to be dependent on processes that are out of the sphere of influence. It is unlikely that the transition will happen if the national government or the EU are not actively working to shape the circularity transition. Even though this dependence threatens feasibility, the vision and strategy are based on observable trends and existing policies of these higher levels of government. We therefore assume that new policies will be made according to existing policy, but policy making can be slower than wishful or go in a slightly different direction.

Important to mention as well is the production of biomaterials. Something that has not been elaborated on that much in the vision is that biomaterial is critical for the production of bioplastic. When and where material can be produced has a strong influence on the industry and the pace with which the bioindustry can develop. This is dependent on different stakeholders, primarily farmers, which makes this an important group to further involve in the strategy.

Lastly, due to the long timeframe, there will likely be external events that could shake up the vision. Already in recent years we have seen events that change the way that we view the plastic industry, and industry in general. The Covid pandemic and the war in Ukraine exposed the need to become more resilient. There are several external events that might influence the vision and strategy. This could go in two directions: external events could either accelerate or slow down the transition. Acceleration might happen due to events that expose our vulnerability, such as the current war in Russia. A slowdown of the transition might be caused by economic recession, which could cause us to resort to the standard methods, instead of experimenting with new technologies.

Ethical issues

In the vision for Plasticity we expand the technical circularity cycle in urban areas. Plasticity envisions people as actors of change. Through the strategic interventions some of the possible spatial and social consequences on the neighborhood level have been developed in more detail, but what the exact social and economic consequences of such interventions are remains an open question. In the development of local circularity initiatives the issue of justice needs to be further addressed, especially regarding the form of circularity. Circularity can be very cheap, when it comes to reusing and repairing. It can however also be expensive, with leasing or higher investment costs for modular products. Even though one form of circularity is not necessarily better or worse regarding economy or sustainability, access and affordability of these circularity initiatives are important issues to be addressed in specific local development.

The biological cycle which we encourage in the port of Rotterdam needs bio-material as feedstock. This has a certain spatial demand. Even though there are promising developments in the use of algae and organic household waste, the current situation would still require regular agriculture for new biomaterials for bio-plastic production. Because space for agriculture is already scarce, this will create conflicts. It could either have an effect on natural areas that would have to be used for agriculture or there will be a conflict with food security if only existing agricultural land is used. This could partially be compensated by a smaller share of cattle, which is already an existing plan in the Netherlands, but this will likely not be enough. A possible solution is to produce biomaterial overseas, but it should be avoided that the Rotterdam bio-plastic industry will be supplied by unsustainable forms of agriculture overseas. In order to avoid depletion of natural resources, national and international agreements would have to be made about sustainable sourcing of bio-material. This has been included in the strategy and should be highlighted as crucial. It also emphasizes the need to minimize demand for plastic products. This might also mean that the bio-industry should be regulated.

Lastly, in our vision there remains to be fossil-based plastic in the system and new production of bioplastic is encouraged. This means that there will still be some environmental pollution of plastic, but we aim to bring this level down as much as possible.

6.2.2 Scientific relevance & Societal relevance

Scientific relevance

The resulting vision and strategy of this report is based on a combination of research and design. The report has aimed to contribute to an understanding of the possible ways in which the transitions in the plastic industry will be implemented in space. In this way it has connected divergent disciplines - from economics to sociology to chemistry - with the discipline of urban planning, contributing to an integration of relevant fields of study.

Some of the results of this research can be used in different planning tasks. First of all the two different approaches of the biological cycle and the technological cycle of plastic offer an interesting perspective to circularity in plastic. Rather than using only one approach, a combination is more likely to be closer to real life. The combination of approaches can be applied to other regions that wish to transform their chemical industry. Secondly, the facilitation of different scales of businesses, from niches to larger companies is recommended for the planning of transitions in other regions as well. This principle is based on literature on technological lock-ins, and given a spatial dimension in this vision.

<u>Recommendations</u>
The research into the transitions of the plastics industries sparked a few new questions. First of all the vision is proposed on a regional level. While some lower-scale consequences have been explored, there is a need to develop the lower scale even more, especially the consequences for different circularity models on justice. The second recommendation based on this research is to explore the different degrees in which new bioplastic production and recycling are present. Both have been treated equally in this approach, but it is likely that one system will contribute more to circularity and spatial development than the other. Lastly, the focus of this report has been on maintaining current levels of plastic use, but there is an increasing call for the reducing of plastic products. Exploring the possible spatial consequences of this offers another interesting research direction.

Societal relevance

Plastic is a very social topic, as everyone engages with the product. Therefore a circularity transition in the plastics industry is of interest to everyone. Policies and reports regarding the plastics industry are often textual and focused on policies and details. This report translates the policies in a visual way to the level of the actors that experience the transition: the people. The report shows a possible approach to redevelop the plastics industry in a resilient, sustainable and just way. This highlights not only the negative aspects of a transition that people might feel (something being taken away), but also the future possibilities of a transition.
The vision and strategy can help to shape policy, but also help with participation. It can serve as a starting point of an open discussion to talk about the desired shape of the future plastic industry, giving it a democratic value.

6.2.3 Assessment

Reflection on the SDG's goals

Quality Education
After connecting the innovation center of RDM campus, Tudelft and Leiden University, we have formed a complete and continuous system of knowledge and technology sharing. We will enrich new plastic resources as well as facilities in key nodes of plastic recycling and surrounding areas. With the influence of the school key nodes, there will be more places to train skills and exchange knowledge. In the future, through innovation-related strategies, more young people will be given the opportunity to learn technical and vocational skills. And more jobs will be available.

Affordable and clean energy
In the new strategy, we are switching the plastic manufacturing from fossil to bio-plastics, thus partially saving the related energy and decrease environmental pollution. And in the Rotterdam port area we will introduce more sustainable energy sources such as hydrogen to reduce our dependence on fossil fuel. When these goals are achieved, it will increase substantially the share of renewable energy in the global energy mix.

Decent work and economic growth
The circular economy is an important part of our overall strategy. By establishing an entire innovation-driven bio-plastic system, we improve the efficiency of the bio-plastic making process and plastic recycling. This will lead to a circular economy for the entire area regarding the plastics manufacturing, drive the development of the plastics industry, and promote the development of more maker companies and mutual cooperation. The cooperation between global and local companies will also lead to the development of the circular economy and enhance the vitality of the industry. And the combination with innovation will also promote the economic development.

Industry, innovation and infrastructure
Through the establishment of a circular industry system and a new bioplastic integrity system, we will fully develop the plastics-related manufacturing industry throughout the port of Rotterdam. Our goal is not only to develop the plastics industry, but also to develop the entire manufacturing industry in a sustainable manner. Through innovation and R-ladder, the cooperation of globa local companies, and the cooperation of companies in different sectors, we will develop and promote the industry.

Sustainable cities and communities
Sustainability is one of our key concerns. We do this in many ways and through many strategies. First, we have established a circular economy and a new bioplastic production process to achieve more sustainable plastic production goals. Then we also engage residents in the process of plastic waste collection to achieve more sustainable participation. And we activate innovation and knowledge exchange about sustainability throughout the site through the innovation component.

Responsible consumption and production
On the social side, we are trying to achieve social transition through two parts: on the one hand, we involve the residents in the daily plastic waste collection activities, and increase the efficiency of plastic recycling and the residents' attention. On the other hand, we activate the development of education through innovation, providing more educational resources and job opportunities for the residents, thus enabling the public to participate in the development of the industry.

References

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8

Appendix

Chapter content

Individual reflections

Sophie van Hal

During this quarter I was able to explore and broaden my knowledge of the plastic production chain in the Port of Rotterdam. My personal fascination about sustainable development, focussing on climate change excited me right from the start. During the fieldtrip we observed plastic pollution in the water, which sparked my interest to pursue this topic. I believe that spatial planning targeted towards climate adaptable measures will ensure sustainable development, so this course was very valuable to me. Sustainable, resilient and circular development are broad terms. I believe that the report of Plasticity tackles real-world issues, like the overwhelming amount of plastic pollution into the environment, and unveils how port related activities contribute to this problem. The port of Rotterdam is not the only port in Europe with great economic significance, so the issues and need for global transformation is important. The base framework, which the main ideas of Plasticity is built upon, could be extracted from the project, adapted and possibly implemented in different port regions throughout the world.

During the quarter, I worked together in a team of four people each with their own background and strengths. I think our team did the division of the tasks according to each of the members' strength very well. I felt like I could utilize my strengths fully and could learn from others to improve my weaknesses. I think I did well in opening myself up to new methods of working, like the analysis of plastic production flows or several spatial planning methods. Eventhough the topics were very complex, I think I learned alot of new skills during the course. As we picked the complex problem of plastics in the port of Rotterdam, I sometimes felt a bit lost in the overwhelming amount of information. When this happened, I quickly lost focus and felt like I couldn't see the structure anymore. I was afraid to ask for help as I felt that I should be able to digest the large quantities of information like policy documents. As I am not that familiar in the field of spatial planning, it often took me a bit longer to understand the proper steps we were supposed to take. This hindered me in efficiently working on the tasks ahead. I felt like this hindrance also effected my part in the overall team. Usually, I am a vocal person when it comes to group discussions or descision making. However, due to my lack in knowledge of spatial planning and port-related economic systems, I felt as if I couldn't be as vocal as I should have been.

I want to improve on being able to search for information more specifically and targeted. It is easy to get lost in large policy documents, so improving in targeted information searching will help me in this way. As a designer, I will face lots of challenges in diverse scales and topics. I should become more confident in trusting my strengths and not put up big expectations of what I should be in each project. I should thus utilize my strengths and view weaknesses as opportunities to learn, instead of a negative aspect of my skills.

Xiaoge Huang

In this quarter, we are trying to do the regional design with a larger scale of Rotterdam Port. We are asked to explore two interrelated thematic topic with transition towards a circular port economy and social transition which happens with the port's enhanced circularity. We need to think about the spacial visions,development and strategies under a certain topic. We choose the circular manufacturing topic and specific on the plastic manufacturing in the port of Rotterdam. In the whole context of the research, I found that the whole economic system of the port of Rotterdam now is very dependent on the import and export of global companies throughout Europe. The dependence on the processing and transportation of raw materials has limited the future development of the port to a certain extent. In order to reduce the dependency of the port's entire manufacturing industry on global companies and to enable the port to form a self-sufficient circular industrial chain. We use the plastics manufacture as a typical type of manufacture to further explore the composition of the plastics industry,relevant product ,waste recycling, the social transformation and impact of the industry transformation.Throughout the research process, I found that the manufacturing and recycling components related to the plastics industry are very complex, and sometimes it is difficult to precisely correspond to the space and analyze it in the context of traffic. Therefore, we went through many improvements and discussions when mapping the spatial structure and future vision map. Gradually, we began to understand how to present a more abstract component and key nodes on the map, so as to reflect the overall design ideas and design system. In addition, we discovered a new type of plastic industry, namely bio-plastic, during our research, and we collected a lot of relevant information and thought about it. So how to realize the whole transformation from fossil plastic to bio-plastic is one of the important parts of our thinking. I learned a lot during the whole process of thinking, and I started to understand the relationship between the spatial form and the overall planning and design goals, and how to present the strategy in the space. How to reflect the development and impact of the strategy from a more precise perspective after it is implemented. I think in the coming days I will think more seriously and reflect on my learning and knowledge in this quarter.

Natalia Yu

The circular economy is an all-time critical topic for urban design, which integrates spatial design, human geographical theories, and aspires for sustainable development, in that way, the urban designers are not only designing the spatial configuration but also coordinators between different social issues, actors and the human-nature relationship. As a student with an architecture study background, this quarter is very challenging because it is the first time for me to think of urban design on a regional scale from an overlooking perspective. But it is still rewarding, as it trains my mindset to think of the overall system first, and then the details.

Compared to the previous semester where creative design plays an important role, the studio in this quarter forces more on us to think more practically and be considerate about the relations between the economy, ecology, social justice, and sustainability. During the process, I was frequently struggled to think of how to realize the circular economy concept in real locations, because this topic related to social science seems to be abstract and intangible to put into practice in urban design. The maritime circular economy is also a complicated topic when it is discussed together with the port of Rotterdam, one of the largest ports in the world, which forces us to think more about its identity in the topic and for the region. Despite its difficulties, after each studio session and the methodology course, I gradually managed to dive into the core of the problem and grasped the approach to move forward.

In the first few weeks before the intermediate presentation, our group was a little stuck and lost because the topic that we were focusing on was not specific enough and we spent too much time on research and analyzing, which results in our lagging behind the schedule in a certain degree. After we figured out the problem, we narrowed our scope to focus on "bioplastic production" and left out unnecessary research just like the pruning of a tree. Based on that, we made great progress and got more confidence in the work. These setbacks remind me of the importance of simplicity, and that sometimes, less is more. What I also find valuable for my career is participatory planning, where social participation is attached to great importance with methodologies to support the justice and efficiency of the process. In that, the design puts much effort into getting citizens and stakeholders involved in the decision-making, the process of development, and evaluation. For my further studies, I will practice more to integrate the professional skills that I learned in the courses and always bear the target of achieving the circular economy in mind.

Matthijs Koch

It was very exciting to begin my journey as an Urbanism student by working on the regional scale. I generally favour the larger scale levels and I had missed the critical reflection on justice in the bachelor courses. At first it was a bit strange and overwhelming to start this course, but I soon realised that the overwhelming part was the case for more people. The regional scale showed a lot of complexity, with many stakeholders and flows operating on a variety of scale levels. This makes understanding of and planning for such a region difficult in itself, but especially in combination with a circularity and societal challenges. However, I also found the potential of regional planning to be fascinating. I loved dealing with the complexity and integrating it in design. And if there is a level to bring all these flows, scale and challenges together and bridge the missing links, it is the regional level (Thöle, 2022). It's a shame that in practice this level is not too influential in the Netherlands.

The complexity made that we had some difficulty with establishing our focus in the first weeks of the course, because where do you begin with all these kinds of sectors and transitions? We started off with a more holistic approach of minimizing dependency on global supply chains and decided to use the plastic industry as a method to unveil issues of dependence and resilience. The plastics industry proved to be a useful example for this, but this topic also brought new layers of complexity. The plastics industry is quite non-space specific, with many parts of the production chain in different places and for many flows it remains unclear where they originate and end. Companies aren't necessarily transparent in their material flows, which made understanding the flows and networks hard at times. As a result of trying to understand the complexity of flows and of plastic materials themselves, we ended up in very detailed investigations of different types of plastics and their production process and sometimes got a little lost in this. It did help in our understanding of the industry, but made it clear that the plastics industry is very diverse and not very place-specific. This initially caused some difficulty in formulating a spatial vision, and even though we have progressed on this vision in the last weeks, I'm quite sure that the vision could be more pronounced and spatial if we were to do it again.

After the mid-term presentation we looked more into bioplastics. This large-scale type of manufacturing was a bit further away from the people than I would have liked. As we have tried to bring across, the transition in the behaviour of people regarding plastics and their general interaction with the circular economy is of great importance to make a transition in a socio-technical regime. To get a little more involved with this interaction with citizens and other stakeholders I ended up focussing a little more on the strategic actions and stakeholder involvement in the last phase. I really liked to have this practical aspect in the course. I was glad to receive information on the practicalities of governance in the SDS lectures and the methodology course and have tried my best to include this in the strategy. This combination of design and governance in a project clearly showed their interaction and mutual dependency to me.

Even though I ended up doing more strategic work than visualisation, I really enjoyed working on the regional scale and can definitely see myself working more often on this level, using all the knowledge and tools gained by this course.

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