EMBARKING ON A CIRCULAR VOYAGE

South Holland as the leading Creative Maritime Region through cross-pollination of Industry, Knowledge, and Society

COLOPHON

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INTRODUCING THE RESEARCHERS

Jens Berkien

It all seems so simple but this research has shown that collaboration is more challenging than changing the spatial layout itself.

Minseong Kim

Dealing with the vast domains of regional planning was the most challenging part, as unlike smaller neighbourhood-level projects where the scope of stakeholders and effects are limited, has taught me how to deal with uncertainties as an urbanist.

O'Neilmaye Leito

Achieving a circular economy is a marathon, not a sprint: 'steady does it'. Sharing a common vision and goal is key to see it all through till the end and to find common ground to work together effectively.

Francisca Mejia

We need materials to make things, but we need to now make use of materials already there if we want to keep on creating; that’s when really the idea that the human’s propensity for creativity is also the solution for the very problem it creates. And so, regional design.

ABSTRACT

The Netherlands has set the ambitious goal to have a fully circular economy by 2050. The Port of Rotterdam (PoR), the largest and busiest port in Europe, has strong potential to become a future circular hub. The PoR has been a major player in the seaport industry for centuries with, among others, a strong logistics sector and a robust shipbuilding industry. However, the Netherlands does not have a solid shipbreaking sector. During 2016 - 2020, an astounding 86% of the vessels that were serving Dutch beneficiaries were scrapped in the Global South. To achieve a circular maritime manufacturing sector in just under 30 years, collaboration between stakeholders is needed to realize innovative solutions. The research question is therefore how can cross-pollination between the shipbuilding industry, knowledge sector, and local makers lead to a circular ship manufacturing sector? A combination of literature review and research by design was applied to gain insight into the required changes in the material and waste flows, and the possible role of the Makers industry in realizing a Dutch circular maritime manufacturing sector. It is expected that the educational needs and skills required of the labor force will have to evolve to fit the circular economy, therefore, the requirements to ensure a just social transition were investigated. The results are a spatial vision for a circular maritime manufacturing sector anchored to the existing waterway networks of South Holland, and a road map to implement this vision. By 2050, South Holland is the leading creative maritime region, where stakeholders in the Randstad collaborate on innovative solutions based on a shared maritime identity, respect for nature, and accessible physical learning and working environments. With the projected sea level rise, achieving a circular ship manufacturing sector is poised to play a crucial role in realizing a resilient water-based future.

KEYWORDS: circular economy, shipbuilding, maritime manufacturing, steel recycling, makers industry

READER'S GUIDE

Chapter 1 gives an overview of the context and problem definition, and outlines the relevant developments and trends that affect the Port of Rotterdam. The result is a list of research questions that guide the subsequent analysis and design. Chapter 2 explains the approach taken during the research and design process. It includes the conceptual framework, the methodology followed, and the ethical considerations that create the boundaries within which this report operates. Chapter 3 presents the results of and key takeaways from the in-depth analysis into the current maritime manufacturing process and its related industries, including the impacts and opportunities for the future. This provides a solid base from which we can create the future vision for the province of South Holland.

Then, chapter 4 presents the visions for 2050 and 2100 for a circular ship manufacturing sector in the province of South Holland. Chapter 5 describes the governance structure and the key projects that can be implemented in the region, and provides a time frame in which the transition to a circular maritime industry can be realized. The areas where policies can improve the performance of the cluster as a whole are discussed. Finally, chapter 6 presents the discussion and conclusions.

CONTENT

1

INTRODUCTION

Defining the circumstances in which the Port of Rotterdam is currently navigating

Image 01. A view of the Maashaven, Rotterdam (Moll, 1878-1955a)

1.1 INTRODUCTION

1.1.1 INTRODUCING THE CIRCULAR VOYAGE

The Netherlands has set the ambitious goal to be fully circular by 2050, with a 50% reduction in raw material consumption by 2030 (Government of the Netherlands, n.d.). Achieving a circular economy is a global necessity, not just a national aspiration. The world is facing unprecedented pollution, depletion of essential raw materials, and loss of biodiversity. These global challenges can all be traced back to the take-make-waste economy in which we are currently operating. It is clear that we cannot continue on the current path, and a new and better global economic paradigm must be implemented to ensure not only our own well-being, but also that of future generations.

The Dutch government has, jointly with other actors, set up several programs to help steer the transition towards a circular economy. One of those programs is the "Circular Economy Implementation Programme 2021-2023" (Rijksoverheid, 2021). It includes transition agendas for five sectors, including the manufacturing industry (idem, p. 13). However, the five selected manufacturing value chains do not include basic metals, such as iron, as their main material. Yet, iron ore is globally the third most produced commodity by volume and the second most traded commodity (Larsen & Bjerring Olsen, n.d.). The production of steel, a metal alloy, is one of the most energy-intensive and CO2 emitting industrial activities in the world (Hoffmann, Van Hoey, & Zeumer, 2020). Steel is used in a variety of Dutch sectors, including building construction, urban infrastructure, delta technologies, and shipbuilding. Steel is a highly recyclable material that does not lose its key properties during the recycling process, making it an ideal candidate for going circular.

The Port of Rotterdam (PoR) has been a major player in the seaport industry for centuries due to its strategic location in the delta of the Rhine and Meuse, and its high-caliber management by the Port of Rotterdam Authority. The national government aspires for the maritime cluster to achieve 'an international sustainable leading maritime position for the Netherlands, achieved by an integral cooperation between the national government and the maritime cluster on a basis of a shared maritime strategy' (Dutch Maritime Strategy, 2015-2025). Becoming a leader involves being one of the best in achieving innovative solutions for local and global challenges. There are opportunities to achieve these innovations through close collaboration with the Makers industry. Makers are agile and in tune with the latest technological innovations, making them the ideal partners to start up and test new solutions for the big problems, before widespread implementation in the core business processes.

This research aims to provide the PoR with a road map to transition to a circular shipbuilding sector by following its main material flows. The spatial impact of this transition for the province of South Holland is designed based on the spatial elements involved in practices such as re-shoring, facilitating cross-pollination with the Makers industry and with education & knowledge institutions, and designing for a new aqua-industrial landscape.

1.2.1 INTRODUCING THE MARITIME CLUSTER

The Dutch maritime cluster is active throughout the Netherlands with 21.155 companies in 2020 that provided employment to approximately 266.650 people (Maritieme Monitor, 2021).

The maritime cluster includes the following sectors (Nederland Maritiem Land, n.d.):
1) Sea Ports
2) Shipbuilding, including yacht-building >24m.
3) Offshore (Energy)
4) Inland Shipping
5) Seagoing Shipping
6) Dredging
7) Maritime supply industries
8) Maritime services
9) Water Sports, including yacht-building <24m.
10) Fisheries
11) the Royal Navy
12) Maritime knowledge institutes

The Province of South Holland is the largest maritime region in the Netherlands in terms of number of people employed, and it had a share of 16,24% and 15,35% in the number of companies and the number of employees, respectively (idem, pg. 25-26). This amounted to 3.435 companies and 40.950 workers. The Province of North-Holland, with the Port of Amsterdam as its maritime center, holds the second place in the Netherlands due to a strong presence of offshore, seaports, and recreational yacht-building/ water sports (Maritieme Arbeidsmarktmonitor 2021, p. 23).

The PoR is an unlisted public limited company, and its shareholders are the Municipality of Rotterdam (approx. 70%) and the Dutch government (approx. 30%) (About the Port Authority, n.d.).

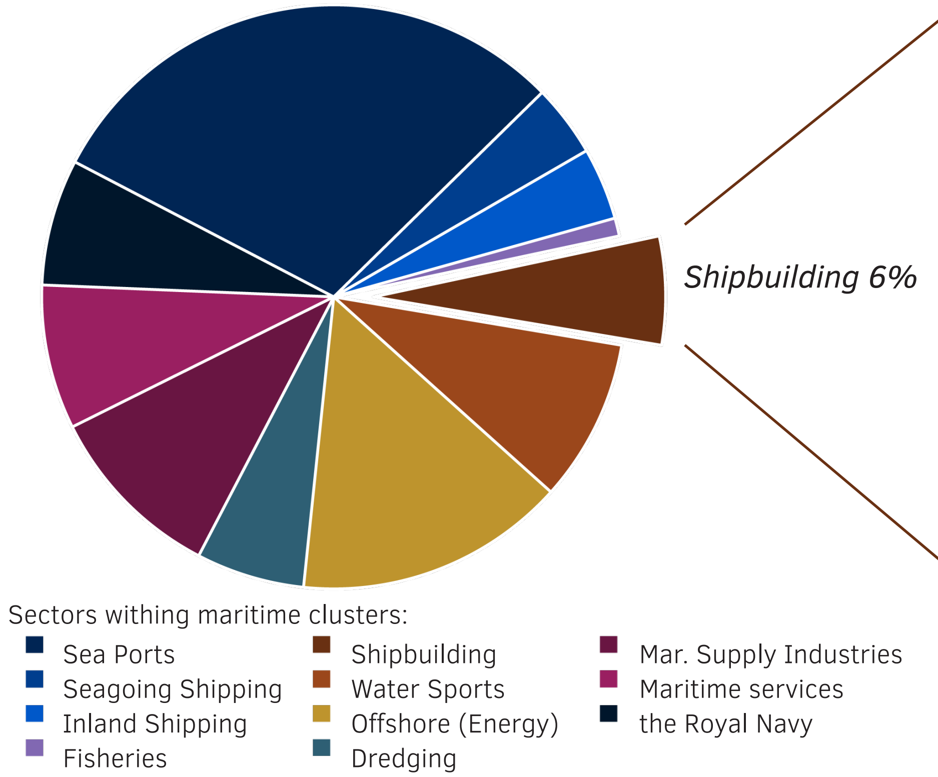


Figure 01. Sectoral distribution of direct employment in the maritime cluster in %, excl. knowledge institutions (Maritieme Arbeidsmarktmonitor, 2021)

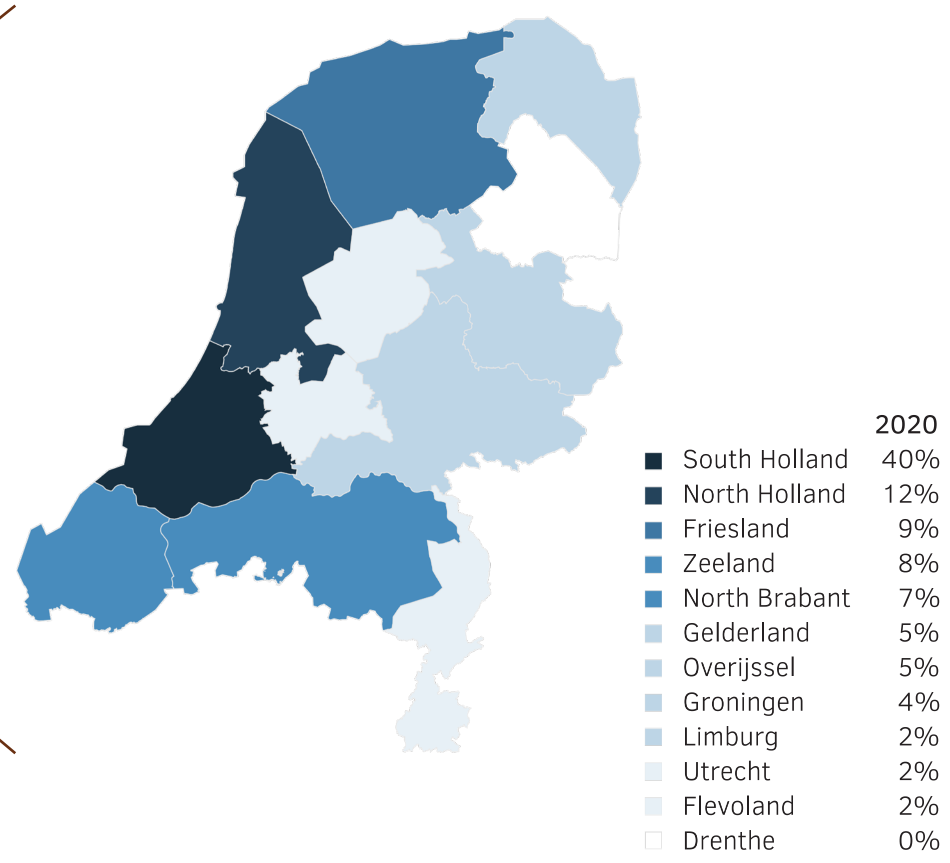


Figure 02. Regional distribution of direct employment in the Shipbuilding sector in % (Maritieme Arbeidsmarktmonitor, 2021, p.34)

1.2 PROBLEM DEFINITION

1.2.1 PROBLEM STATEMENT

The ambitions of the PoR to achieve an international sustainable leading maritime position and to develop into a circular hub (Port of Rotterdam, 2019) require a drastic change in how the cluster is currently operating. The dependency on fossil fuels, weakening competitive advantage, and shortage of technically skilled personnel are among the main global, national, and local challenges facing the PoR. But above all, the maritime cluster must reduce its CO2 emissions and become carbon-neutral to reduce its ecological footprint. To do that, the Dutch shipbuilding industry must redefine how it designs and manufactures ships and other floating structures, and how it will keep its main materials, such as steel, in a circular manufacturing loop. With steel being highly recyclable compared to other materials, there is great potential for the shipbuilding industry to achieve this goal.

The PoR together with the province of South Holland can become a leading creative maritime region by:

- Closing the loop with ship breaking and steel recycling through re-shoring;
- Pursuing cross-pollination with the Makers industry, and education & knowledge institutions;
- Working towards a just social transition;
- Buoying a shared port identity and culture.

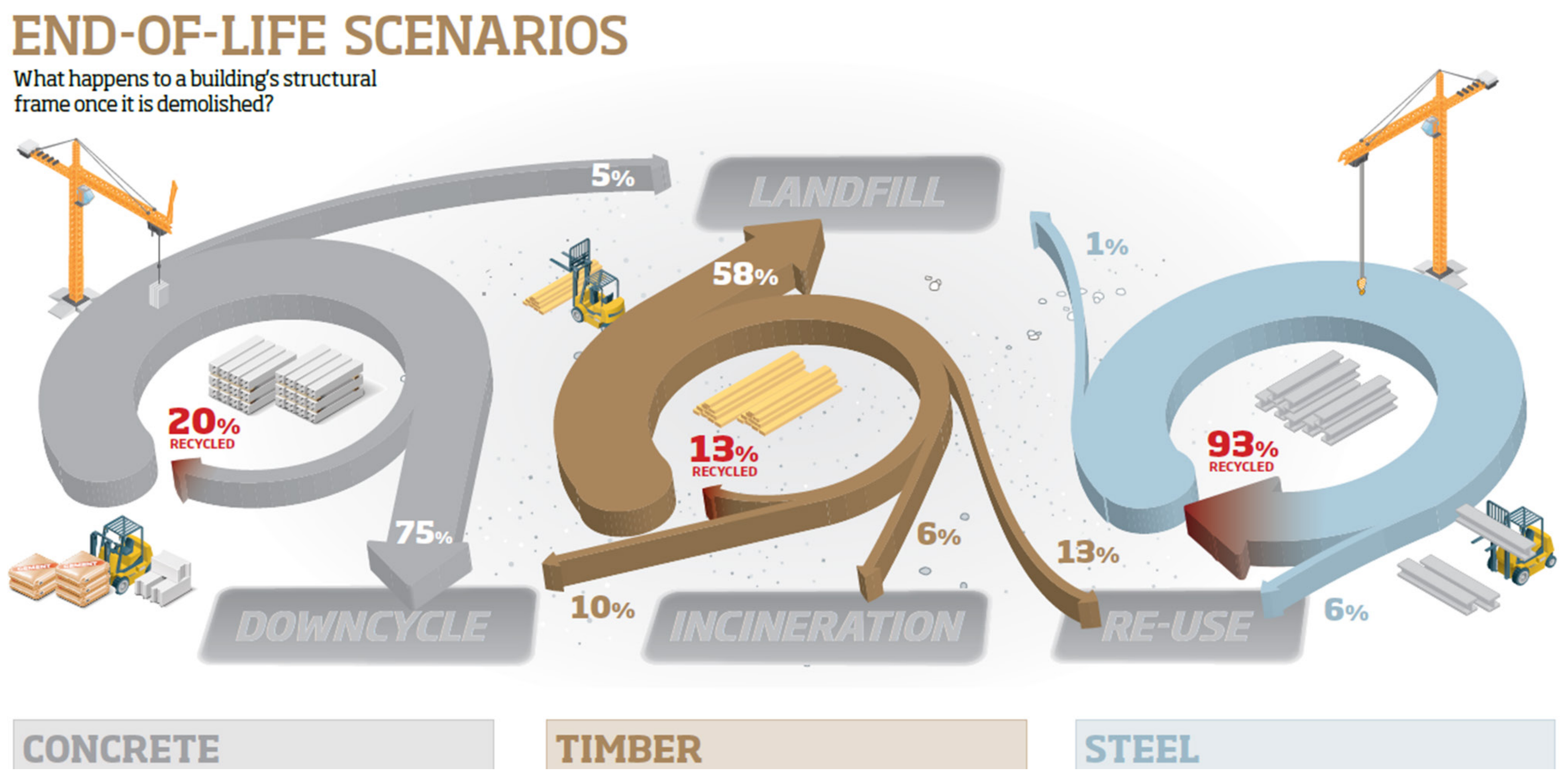


Figure 03. End-of-life scenarios for concrete, timber and steel; image by SteelConstruction.info (2013)

1.2.2 GLOBAL DEVELOPMENTS

In addition to the CO2 emissions by the global steel production industry, which amounts to 7% of the global CO2 emissions (Delasalle, 2021), the global shipping industry is responsible for almost 3% of the world's CO2 emissions (Nederland Maritiem Land, 2022). Despite the urgency to drastically reduce these emissions, the maritime sector still heavily relies on fossil fuels, both in the logistics industry and in the manufacturing processes. This is largely caused by zero-emission solutions being currently unavailable or not affordable (Maritiem Masterplan, n.d.). In contrast, digitalization and automation developments are rapidly advancing and offer both challenges and opportunities for the maritime sector. On the one hand, digitalization brings with it a rise in industry espionage and sabotage, and on the other hand automated ships and digitized ports are becoming a true possibility (Nederland Maritiem Land, 2022). Timely investments in these areas are necessary to strengthen the competitive position of the Dutch maritime cluster.

The Dutch sector is experiencing increasing pressure due to international competition from rising markets, and a lack of a level playing field in particular with China because of their national state support (Dutch Maritime Strategy, 2015-2025). At the same time, these new markets can provide opportunities in the form of increased demands in maritime products and services. Concurrently, the Makers industry is at risk from increased competition from countries with lower wages (Nederland Maritiem Land, 2022).

From an environmental point of view, sea level rise (SLR) due to climate change poses a major challenge for all coastal areas, and in particular for the delta region of the Port of Rotterdam and South Holland. SLR requires greater investments and innovations in floating structures and infrastructures to support a possible (future) migration of energy and food production, and of living and working space to the sea (Nederland Maritiem Land, 2022).

Circular economy is said to provide many opportunities for increased employment, a just social transition, and new business models for the later stages of the value chain (McGinty, 2021). However, being the first to achieve something could come with its own drawbacks. Transitioning towards a circular economy means making some drastic changes to the way of operating a business. Sacrifices might be necessary on the front of profit margins in order to fulfill the promise of operating within the environmental limits; a promise that others, who are still operating according to the take-make-waste paradigm, might not make. This has the potential to negatively impact the competitive advantage in global shipping in the short term, unless the Port of Rotterdam receives full political and financial support from its two shareholders, the Municipality of Rotterdam and the Dutch Government.

1.2.3 NATIONAL DEVELOPMENTS

The Dutch maritime cluster thrives due to the financial and spatial relations between the various sectors, with the ports playing an important role in the spatial connection between (large-scale) industries and service centers (Dutch Maritime Strategy, 2015-2025). This extensive 'shared' industry enables sharing of knowledge and talent as well as economies of scale (idem), and it is of great economic importance for the Netherlands. The use of ships is essential for the strategic autonomy of the Netherlands and Europe with regards to transport infrastructure, renewable energy production, coastal protection, and maritime safety (Maritiem Masterplan, n.d.).

As a result of the COVID-19 pandemic and other trade tensions, the concept of re-shoring is getting more topical for Dutch companies. Re-shoring, which involves bringing back business activities from low-wage countries to one's own country, would have a positive impact on local employment and knowledge development (KvK, 2016; Berenschot, 2021). Re-shoring also would make businesses more agile and more resilient to geopolitical and socio-economic development in the world, thereby improving their global competitive advantage.

The opportunities presented by the digital and circular economy transitions are in practice being challenged by the fact that the existing national labor force is insufficiently skilled to take on these transitions (Nederland Maritiem Land, 2022). Furthermore, there is an ongoing trend of insufficient enrollment of new students in technical studies, which means that the shortage of technically skilled people will only increase in the near future (BNNVARA, 2022; Onderwijsland.com, 2022).

1.2.4 LOCAL DEVELOPMENTS

Due to the agile nature of small and medium-sized businesses (SMEs) active in the Makers industry, and because they are used to working together to achieve efficiencies, these companies can play an important role in helping the maritime manufacturing sector realize the necessary technological and 'circular' innovations to achieve carbon-neutrality and a circular way of working. Mobilizing these SMEs and providing them with a platform that broadens their network and connections to the shipbuilding industry is important for the sector to capitalize on all the knowledge that the SMEs have.

Since the second half of the 20th century, the PoR has gradually grown spatially, economically, and organizationally apart from the city of Rotterdam (Huijs & Troost, 2014), in part due to the necessity to create distance between certain heavy and dangerous industries, such as the petrochemical industry, and the main urban areas. Nowadays companies in the city of Rotterdam do not serve the port, and the port companies mainly supply to international customers (idem). Port cranes, a physical staple of any port, can only be seen in the distance from the Erasmusbrug. The port culture, from which Rotterdam has grown, is no longer felt in the city. This weakens the ties that the citizens have with the port, and thus also the support and willingness to commit to the port as potential employer and business partner; something that the port will need to cope with the coming transitions.

A recent study has found that the PoR is the top polluting port in Europe with 13.7 million tons of CO_2 per year (Transport & Environment, 2022). As the largest port in Europe, the PoR states that it is no surprise that it is also the largest polluter, a result of the previously mentioned unavailable clean fuel alternatives (Port of Rotterdam Authority, 2022). There is no recent research done on the correlation between air pollutants emitted by the port activities and the air quality of the area surrounding the PoR. Research by RIVM from 2007 found that ships emitted in particular NO_2, SO_2, and fine particles, but it is unlikely that SO_2 emissions would have a direct health risk, while it is probable that NO_2 will adversely contribute to the health risks of people with existing respiratory ailments.

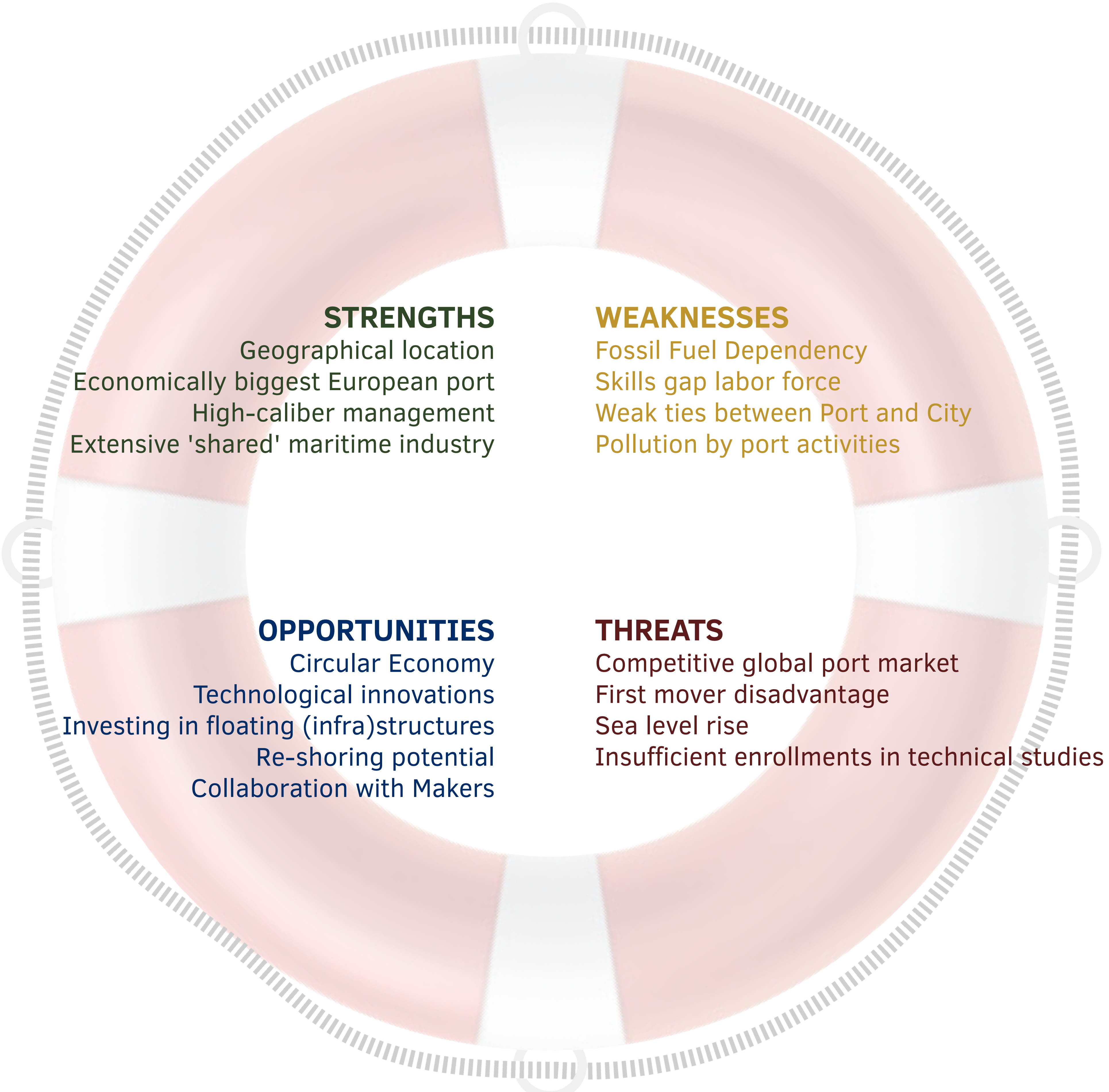


Figure 04. Summary of the SWOT analysis for the Port of Rotterdam

1.3 RESEARCH QUESTIONS

To achieve a circular maritime manufacturing sector, innovations in technological and business processes are needed. A key element of achieving innovation is collaboration between actors and stakeholders.

A shared focus and a shared maritime identity is conducive to achieving a durable collaborative culture. Therefore, the region of South Holland as a whole needs to take part in integrating industry, knowledge, and society.

Throughout this transition, actors must remain mindful of the social impact to ensure a just and equitable transition. The spatial requirements of a circular maritime manufacturing process must be designed with care to ensure environmental sustainability and a positive impact on biodiversity.

MAIN RESEARCH QUESTION

How can cross-pollination between the shipbuilding industry, knowledge institutions, and local makers lead to a circular maritime manufacturing sector?

SUBQUESTIONS

- Which process steps need to work differently or are missing in the Netherlands to close the circular manufacturing loop?
- What is the spatial impact of the adapted circular manufacturing process?
- What are the spatial requirements to facilitate cross-pollination between industry, knowledge, and makers?
- What is the contribution of a circular maritime manufacturing process to a just social transition?
- What are the societal impacts of the transition towards a circular maritime manufacturing process?

2 APPROACH

Identifying the key waypoints that will determine the compass bearing to get underway

Image 02. Daily activities on a quay, Dordrecht (Moll, 1878-1955b)

2.1 CONCEPTUAL FRAMEWORK

The conceptual framework in figure 05 gives a concise overview of the main concepts and ideas that will guide the research into and the design of a circular maritime manufacturing sector. The core pillars of this conceptual framework are:

- ◊ Circular Economy, the new economic paradigm towards which we are transitioning;
- ◊ Environmental Sustainability, the foundation for and the reason why we need to transition to a new way of doing business;
- ◊ Versatile Labor Force, an important condition for achieving circularity;
- ◊ Maritime Living, which aims to bring back the shared maritime identity that was at the basis of the growth of Rotterdam and the surrounding cities.

Possibilities for cooperation and cross-pollination between the actors corresponding to these pillars are investigated through eight research topics:

- The requirements for a Circular Manufacturing Process;
- The involvement of the Makers Industry in innovation efforts;
- Achieving Carbon Neutrality for the maritime sector;
- Re-shoring of Waste Management processes that will operate in a sustainable manner;
- Introducing Dynamic Education to ensure a just transition;
- Options for Physical Learning Environments that support the new dynamic learning programs;
- Urbanization through Port-Oriented Development in new water-living environments;
- Embedding the Port City Culture into the province of South Holland.

Circular Economy & Environmental Sustainability

The y-axis of the framework calls for economic activities within environmental limits. There are several global and European initiatives providing guidelines to tackle environmental and societal challenges. Among these are the European Green Deal (EGD) by the European Commission and the Sustainable Developments Goals (SDGs) by the UN.

The EGD, which provides guidelines for achieving climate neutrality by 2050 (European Commission, n.d.), has the circular economy principles as one of its main building blocks. The Maritime Green Deal is derived from the EGD to provide the Dutch maritime cluster with specific guidelines for the maritime and inland shipping and ports (Green Deals, 2019).

Research by CBS (Hoogerwerf, Blom, & Delahaye, 2022) identified synergies between achieving the goals of a circular economy and reaching the SDGs for the Netherlands. This practice-oriented research was based on the theoretical research by Schroeder, Anggraeni, & Weber (2018) on the relevance of circular economy practices for the implementation of the SDGs.

Working towards a circular economy (CE) will thus have beneficial consequences across the board. CE is an economy driven by design that is based on eliminating waste and pollution, continuously circulating products and materials (at their highest value), and regenerating nature (Ellen MacArthur Foundation, n.d.). The transition towards renewable sources of energy is an important prerequisite for a circular way of working (idem). The energy transition will have a positive impact on climate change through reduction of CO_2 emissions

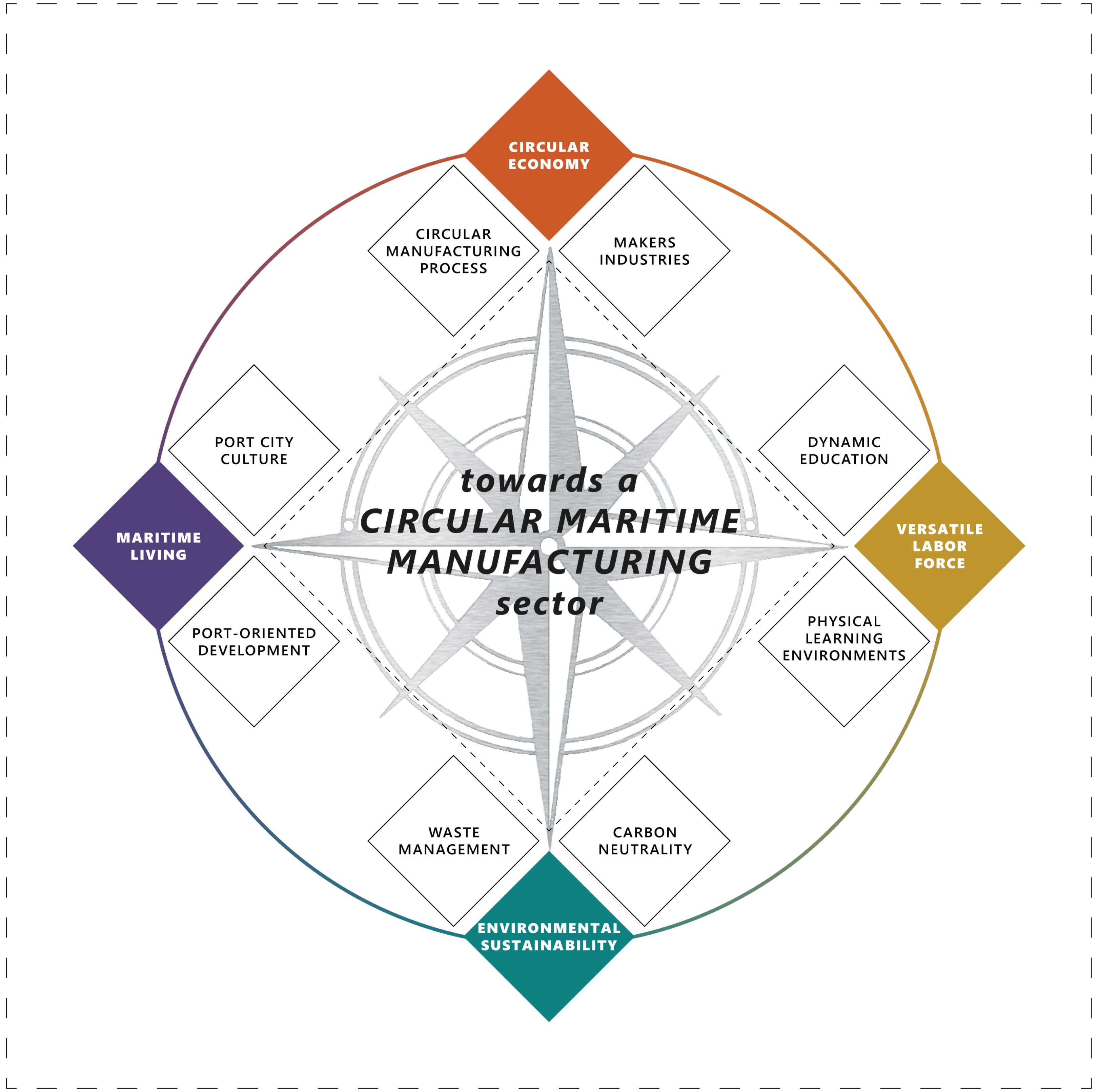


Figure 05. Conceptual framework for achieving a circular maritime manufacturing sector

within the circular value chain. In addition, achieving a circular economy will positively contribute to biodiversity through minimizing mining activities and limiting use of natural resources.

Versatile Labor Force & Maritime Living

The x-axis of the framework is concerned with the social dimension. On the one hand, there is the labor force, which is both impacted by the circularity transition and an important factor to achieve this transition. Schroeder et al. (2018) found a contributing link to the circular economy by SDG goals 4, Quality Education, and SDG goal 10, Reduced Inequalities, meaning that working towards achieving these SDG targets will contribute to the CE efforts.

The circular economy is expected to bring increased employment in the sectors active in the later stages of the value chain. Other global transitions, such as digitalization and automation, will result in some job types phasing out, while new job types are created. All these transitions have an impact on the required skills set of the labor force. To ensure that there are equal opportunities for all in this new economy, investments on national and regional level are necessary to re-skill and up-skill the labor force, and to create new learning programs and environment to teach these new skills.

On the other hand, all these efforts will impact the larger community of South Holland. New communities will be formed around the new circular sectors that will also take into account the effects of the projected sea level rise for South Holland. This will ensure that human and economic losses due to water-related disasters are not an issue in the future. Furthermore, the maritime identity and port culture are then further embedded into this delta region. Both objectives are part of the SDG goal 11, Sustainable Cities and Communities.

Figure 06. Relation between the conceptual framework and relevant SDGs, with SDG 7 and 13 as preconditions

2.2 METHODOLOGY

This project applied a combination of literature review and research by design through mapping as primary methods during the entire process. Literature review was performed on documentation provided with the project brief and on additional data and information found through Internet searches covering topics on, among others:

- Circular economy
- Maritime manufacturing process
- Training and education requirements for the future
- Makers industry and innovation
- Environmental impact and restrictions
- Social and spatial justice
- Maritime living

References of other circular manufacturing projects were consulted, and governmental and European policies were analyzed. The result is an evidence-based vision for the future state of the Dutch circular maritime manufacturing sector, and its spatial impact for the province of South Holland.

The research started with a site visit to the Port of Rotterdam and surrounding urban areas covering 80 km and including visits to, among others, Drecht cities, Waalhaven, RDM campus, Pernis, and Maasvlakte 2. As a research and design process is never a linear one, there were multiple iterations to crystallize the problem definition, the research questions, and ultimately the visions for 2050 and 2100 for the PoR and South Holland.

The second phase of the project covered the topics of governance and strategy to create a road map for the implementation of the circular maritime manufacturing sector in South Holland. Five strategic projects were developed to guide the efforts of implementation on a local scale and the phasing of the project on the regional scale.

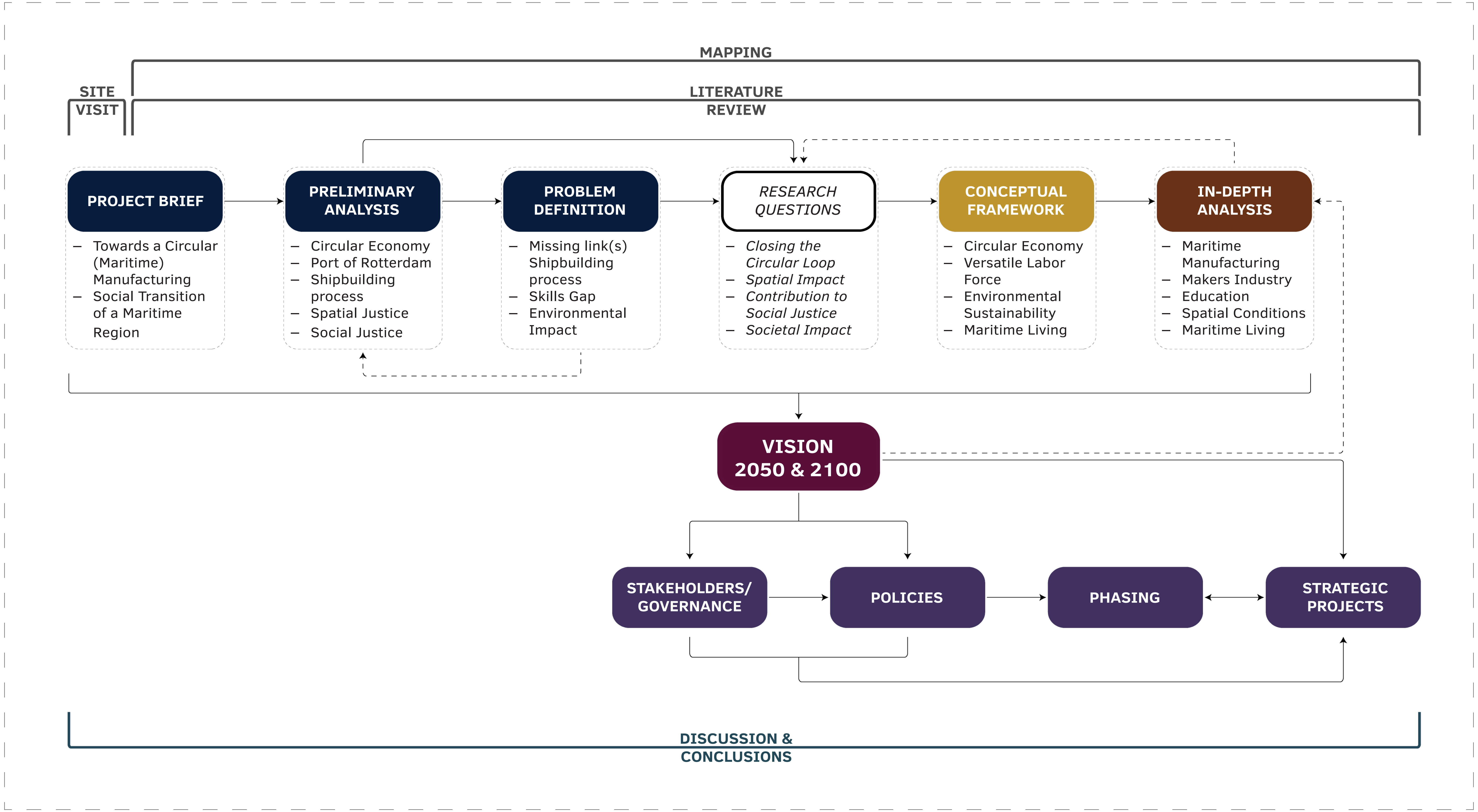


Figure 07. Methodology framework

2.3 ETHICAL CONSIDERATIONS

Part of the global transitions we are currently experiencing is the phasing out of job types, especially low-skilled and manual activities, and the creation of new digital and process-oriented job types. Furthermore, unintended negative (spatial) externalities are part of every design effort because of our inability to predict the future. All this makes it very important that we as urban planners and designers make a concerted effort to find the groups, including the non-human variety, who will be the most affected by these societal changes, to ensure a just and equitable distribution of these negative externalities, leaving no one behind.

A top-down approach, as was done during the modernist era, is not the way to approach the transitions in these times of extreme social, political, and economical complexity, increasing globalization, and rapid urbanization. Urban planners and designers must take their responsibility as "the world's stage designers" to make sure that every actor, and every understudy, gets their moment to shine. Therefore, it is important, when changing the spatial layout and its social and economic processes, to create an open engagement between all stakeholders involved, striving towards an organic way of participatory design.

It is also important to consider the social impacts created from the vision and strategies being introduced in this report. Without careful consideration of the impact of the ambitions and implementation in the region, negative externalities might even decrease the transition towards a social just society in the province of South Holland.

3

ANALYSIS

Understanding the past and present state to surface the conditions for shaping the future state

Image 03. The shipbuilding yard of the VOC in Middelburg (Arends, 1778)

3.1 HISTORICAL BACKGROUND

The story of Rotterdam begins around 1270. During the 12th century, after multiple floods rendered the area previously known as Rotta uninhabitable, a group of enterprising settlers built a dam in the river Rotte (van den Noort, 2020). The new settlement was given the name Rotte-dam. With the dam in place, it soon became clear that the location was ideal for transferring goods from seagoing vessels to smaller riverboats; and so the seeds were sown for what would later become the largest port in Europe (Port of Rotterdam, n.d.).

In the 1600s, the Dutch entrepreneurial spirit led to the establishment of the world's first publicly traded company, and at the time the largest trading company in the world, the Dutch East India Company (the VOC) (Kuipers, 2021). The success of the VOC led to an increase in (inter)national trade and shipping. This gave the city of Rotterdam the impetus to build more ports near its city center in the 17th century, such as Leuvehaven, Wijnhaven, Bierhaven, and Scheepmakershaven (Port of Rotterdam, n.d.). Port and city continued to grow together and the new ports became an integral part of the city's economy and daily life; Leuvehaven housed several breweries as well as the main market for fish trade in Rotterdam (van Capelleveen, n.d.), while a few hundred meters away ships were built for the VOC in the Scheepmakershaven (Stichting Heimisj, 2021).

The industrial revolution in the 19th century brought with it, among other things, larger steamships and an increasing economic importance of transit trade for Rotterdam (Stadsarchief Rotterdam, n.d.). The old existing ports were not capable of handling the larger ships and the required storage capacity for materials. It was therefore necessary to dig a new connection with the open sea, the Nieuwe Waterweg,

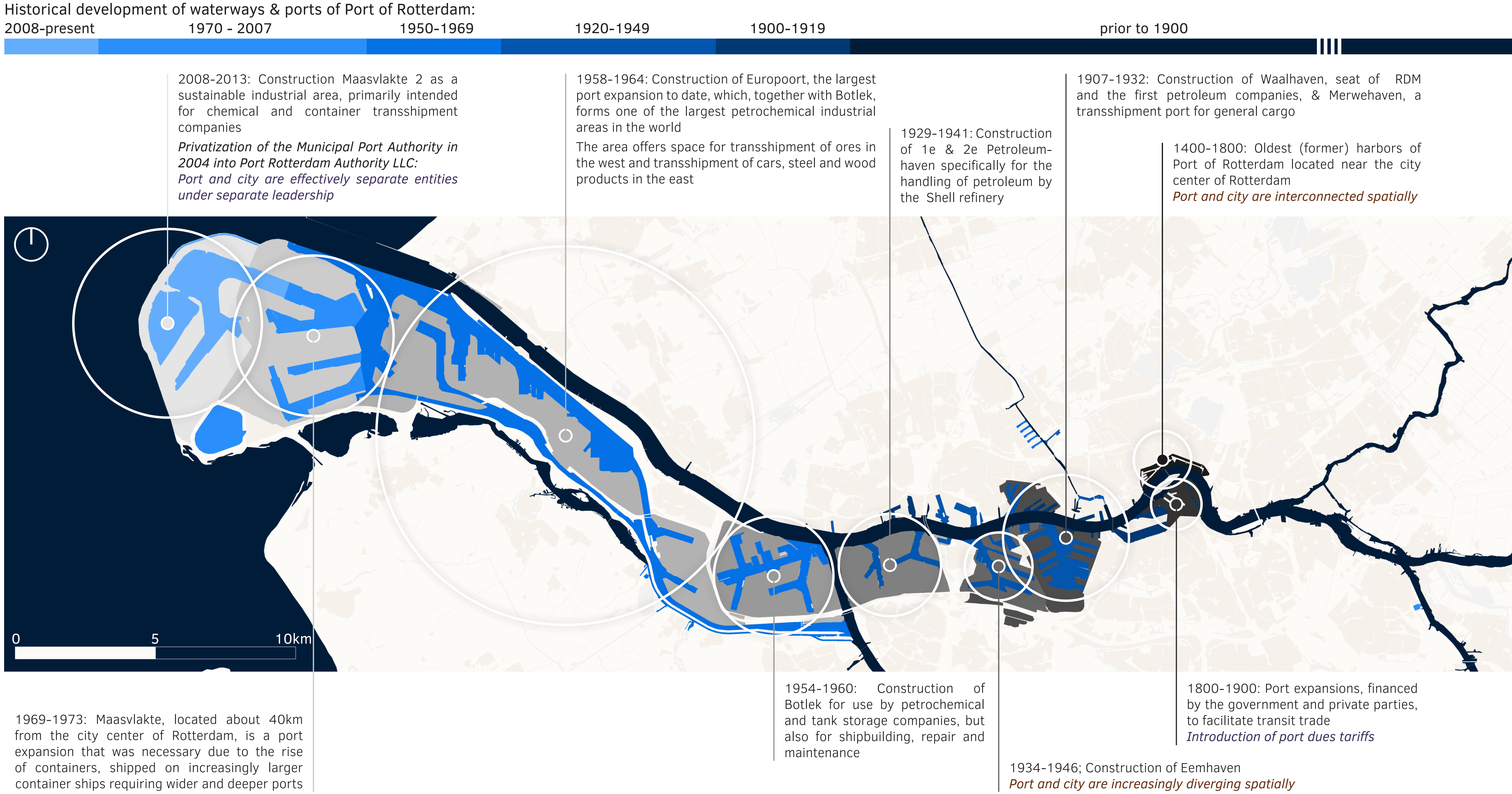


Figure 08. Historical and spatial development of the Port of Rotterdam (Port of Rotterdam, n.d.; Wikipedia, 2017-2022)

and to expand the port to the southern side of the river Maas (Stadsarchief Rotterdam, n.d.). The first official port entity, the Rotterdamsche Handelsvereeniging (RHV), was established in 1872 to help finance this expansion (idem). This expansion was quickly followed by further expansions along the river Maas in the first half of the 20th century with the larger ports Waalhaven, Merwehaven, and Eemhaven. These expansions heralded a new era for the city of Rotterdam, spurred by the transition from a merchant city to a transit city, and the resulting emergence of a new kind of Rotterdam entrepreneur, transit service providers instead of traders. The separation between port and city was quickly becoming an inevitable reality, and the port culture was becoming increasingly absent from the main urban area.

The second half of the 20th century saw the PoR being named the largest port in the world, following the expansions of the port to house the petrochemical industry in Botlek en Europoort. A title that the PoR held until 2004 (Port of Rotterdam, n.d.). 2004 was also the year that the PoR was privatized. Port and city were now spatially, economically, and organizationally separate from each other.

The 21st century is marked by an increasing awareness of environmental degradation resulting from the industrialization of our world (economy). The development of Maasvlakte 2 at the start of this century was executed with as much respect to the protected nature area of the Voordelta as possible. The PoR has the ambition to be a circular hub by 2050 and a leader in sustainable shipping.

IMPORTANCE OF MARITIME HISTORY AND HERITAGE FOR THE FUTURE OF SOUTH HOLLAND

Figure 09 shows the locations along the waterways where historical shipyard activities still inform the current concentration of shipbuilding companies, while also showing that shipbuilding, initially concentrated in the center of Rotterdam, has gradually moved out of the city towards less urbanized areas. A recent concentration of shipbuilding activities can be seen around Leiden, where primarily smaller recreational boats are built.

Historically, Dutch villages and cities have grown from settlements along waterways, as these waterways provided opportunities for fishing and later shipping, and an easy means of access via boats. With the practice of creating polders, the Dutch have molded and shaped their country, building dams and polder-boezem systems to keep excess water away. It is this long maritime/marine history that has enabled the Netherlands to flourish as a country, and it is this maritime systemic thinking that is needed to cope with future water-related challenges due to climate change. Building upon this heritage and the centuries-old knowledge base will certainly maintain the livability of the delta region of South Holland.

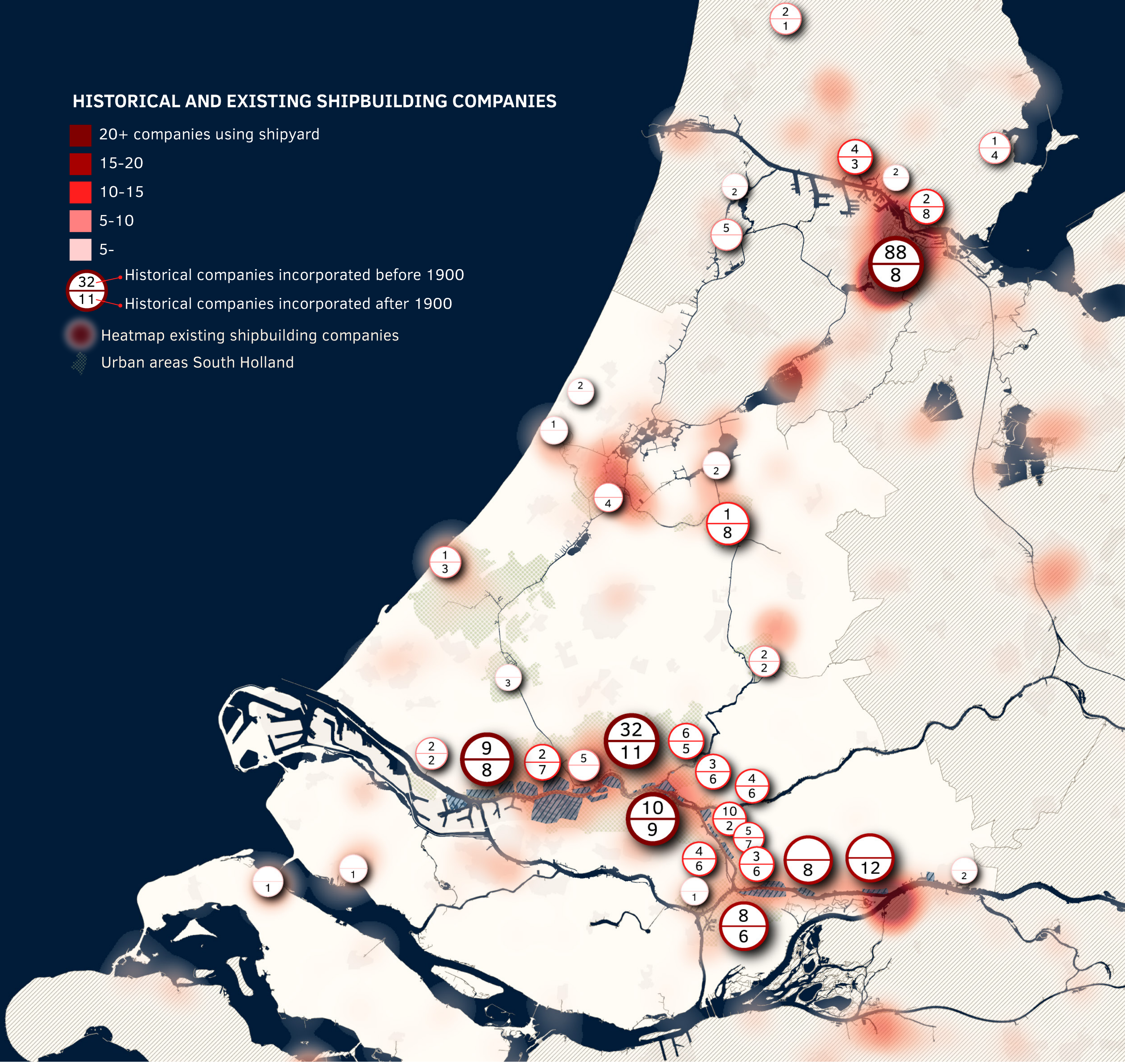


Figure 09. Substantial overlap can be seen between historical and current spatial concentrations of shipbuilding companies (Arcadis, 2019; Stichting Maritiem-Historische Databank, 2022)

3.2 MARITIME MANUFACTURING

3.2.1 SHIP MANUFACTURING PROCESS

In 2017, the Dutch shipbuilding industry was ranked as the 17th largest in the world and as the top 7th producer of sea going vessels in Europe. This industry directly deals with the greater national maritime cluster, serving the port's logistic functions, offshore activities, inland shipping, marine engineering, and fishing industries, among others (OECD, 2020). This massive 'shared' industry of the top maritime cluster sectors of ports (offshore), logistics (shipping), and shipbuilding (maritime-technical manufacturing) are all interlinked and interdependent, and the maritime cluster cannot operate without shipbuilding. Thus, as a key and top sector in the Netherlands, the basic operations, material and waste flows, and the sustainability of the current practices, trends, and potentials of the shipbuilding industry need to be assessed (Dutch Maritime Strategy, 2015-2025).

Process of Shipbuilding

Shipbuilding is part of a shared industry of maritime activities that considers it the spine of global trade, as it serves in ensuring the operations of global trade. 90% of internationally traded cargo is transported by ship (ICS, 2009). The ship manufacturing process is part of a ship's life cycle that spans from the import of materials to its dismantling in a ship recycling yard for high-value scrap to be obtained and placed back into the market. The building process constitutes of the following activities and steps (Lamb, 2003):

1. Acquisition wherein the acquired ship can be classified into the following:
   a. New Ship Construction
   b. Second-Hand Purchase
   c. Ship Conversion
   d. Ship-Sharing
   e. Contract of Affreightment
2. Design of a ship is overseen and needs the involvement of the following:
   a. Naval Architect
   b. Marine Engineers
   c. Designers and Technicians
3. Construction is begun and follows the following procedure:
   a. Procurement of Materials
   b. Stowage (Storage of Materials)
   c. Surface Treatment
   d. Assembly
   e. Launching
   f. Outfitting
   g. Sea Trials

In the Netherlands, different types of vessels are being produced. Since the 1980s, the Dutch shipbuilding industry evolved its market to oversee the production of more high-tech and specialized vessels as "cargo ships and tankers, dredgers, offshore service vessels, tugs, work/repair vessels, tankers, gas carriers, cruise/passenger ferries, fully cellular containers (FCC), bulk carriers and roll-on/roll-off (ro-ro) vessels" (OECD, 2020). Luxury superyachts and inland vessels are also part of this portfolio.

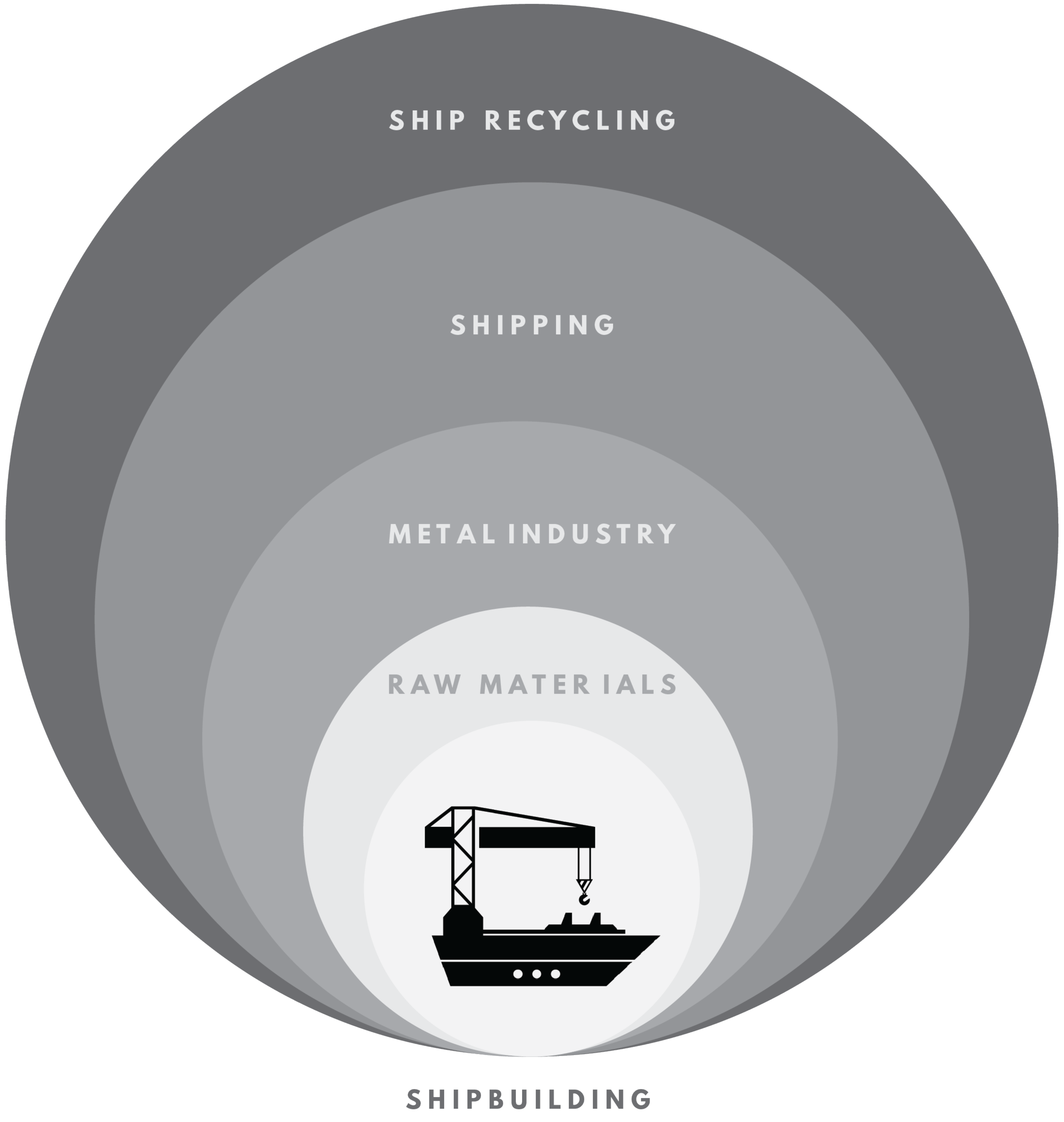


Figure 10. Interconnection between shipbuilding and other sectors

The shipyard is where most of these activities happen. This facility involves a series of processes that are allocated accordingly in space that comply with environmental zoning measures. Typically, shipyards for new construction, ship repair, and inland ship recycling share the same programmatic requirements. The most important components are harbor infrastructure, large storage capacity, enclosed assembly structures, and the provision of waste treatment and sorting facilities. Logistic mobility is in the heart of shipyard operations and requires much space and clearance from living areas due to the hazardous materials handled in the yard, which is why it is placed along heavy industrial zones wherein outdoor construction is permitted. Refer to appendix A and B (p. 204 - 205) for a diagram of the existing spatial programs of a shipyard.

The comprehensive size of a shipyard can be classified into three scales (Welaya et al., 2012):
1. Small-scale (<50.000 sqm)
2. Medium-scale (50.000-500.000 sqm)
3. Large-scale (>500.000 sqm)

Most shipyards in the Netherlands are found in the provinces of North and South Holland where the main shipbuilders are situated. In South Holland, a cluster of prominent commercial shipyards operated by Damen, Royal IHC, SLOB, among others, dominate in the Drechtsteden, Pernis, and Botlek areas, while a smaller cluster of prominent recreational shipyards such as the Van Leest and Van Lent are found further north.

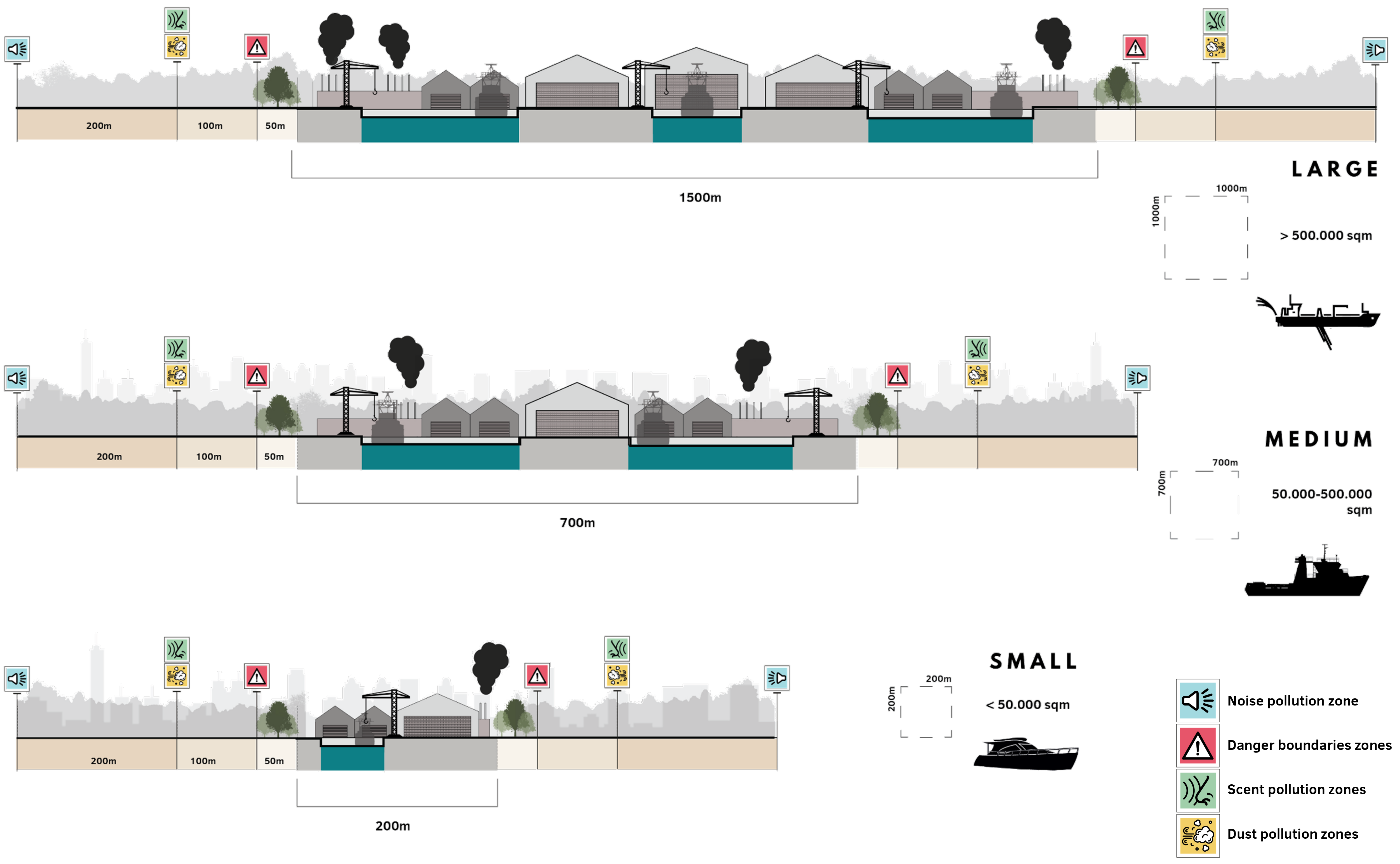


Figure 11. Existing average shipyard sizes

Sustainability of Current Shipbuilding Practices

The OECD developed a peer-review faction for the shipbuilding sector specific to member countries called the OECD Council Working Party on Shipbuilding (WP6) that has since published the Peer-Review of the Dutch Shipbuilding Industry (2020) after examining the environmental, climate change, and sustainable development issues that encompass the industry. The report posits that although shipbuilding, shipping, and ship recycling are separate industrial processes, their activities are strongly interlinked and contribute to the overall environmental impact of ships globally, thus their interdependent processes must be addressed (OECD, 2010).

Life cycle of a Ship and Material Flows

Although ships are considered the most energy-efficient form of transport, their manufacture and end-of-life processes (shipbreaking and ship dismantling), or more commonly known collectively as ship recycling, can cause serious harm to both human health and the environment.

The main environmental impacts of the shipbuilding process are the following (OECD, 2010):

1. Energy Intensive
2. Oil/Fuel for Ships
3. Wastewater (Ballast, Bilge, and Black/Greywater)
4. Toxic Gas Emissions
5. Noise

From raw material extraction, importation, and processing to the actual building of a ship, toxic emissions and wastewater pollution are the most dominant residual and dissipative flows, while high value scrap is produced and usually reused. Other material scrap that cannot be reused or are otherwise deemed not fit for sorting are relegated to landfills. The two other main industries connected

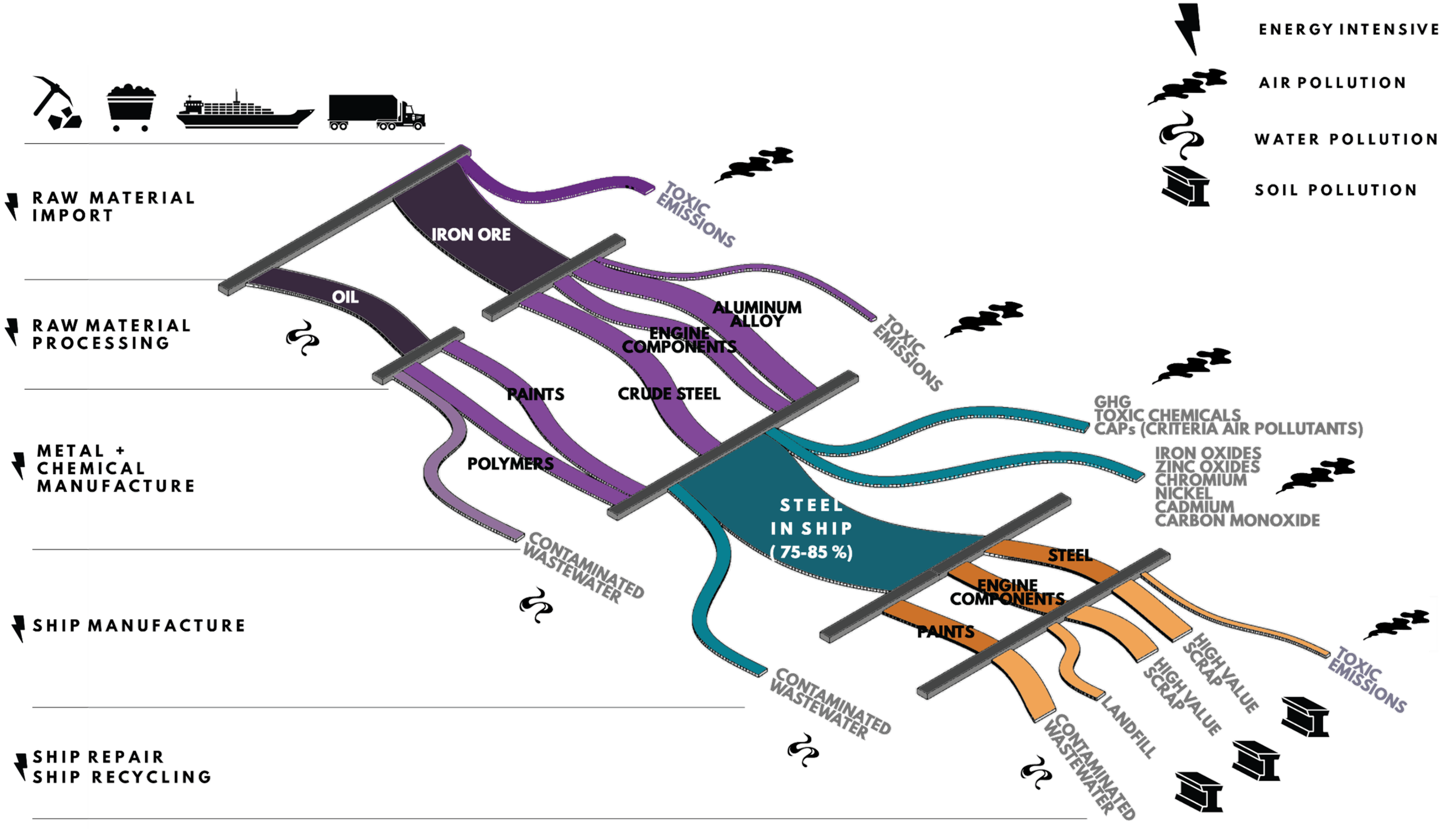


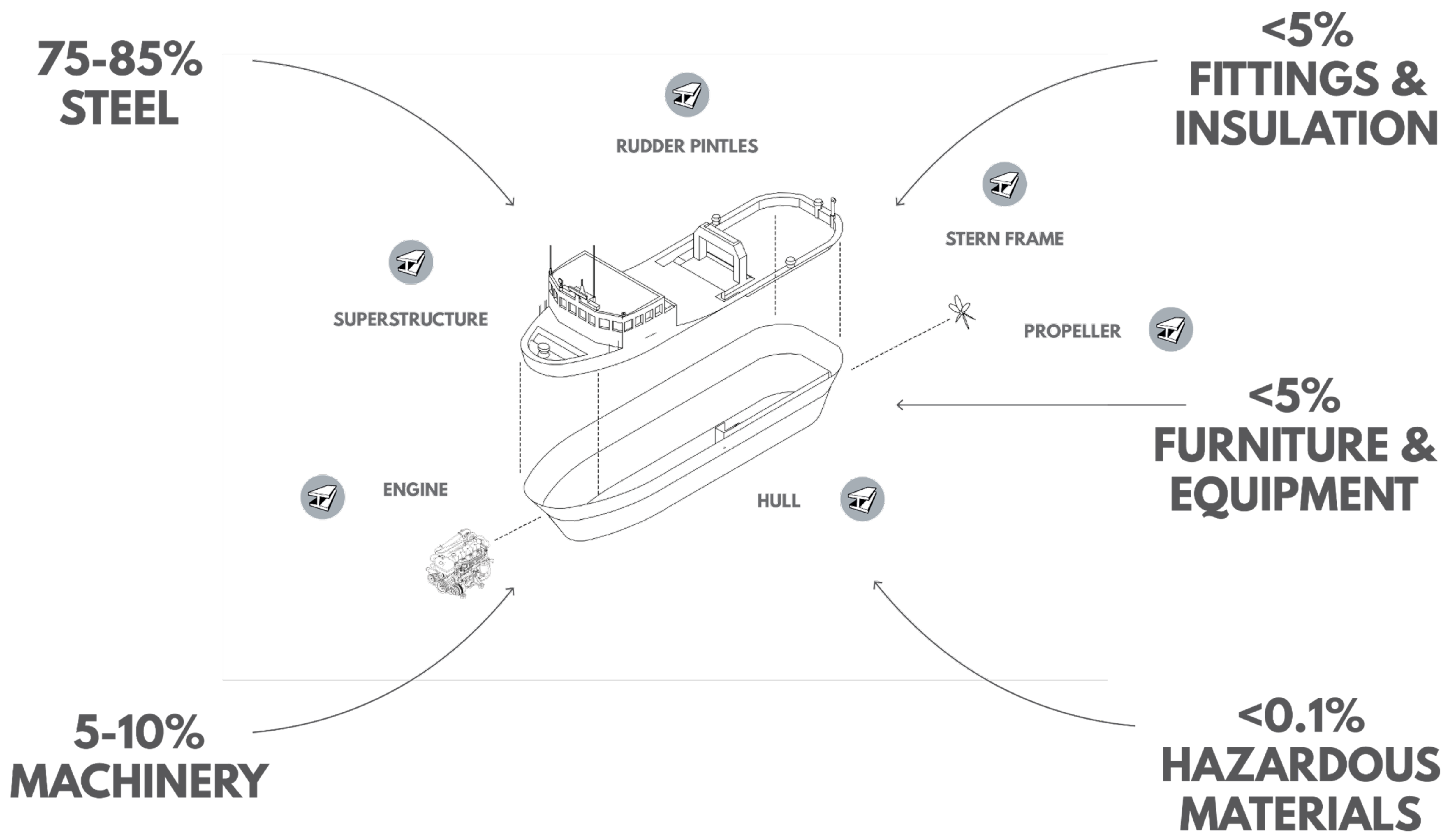
Figure 12. Ship manufacturing material and waste flow diagram

with ship manufacturing are the chemical and metal manufacturing industries that supply the main components of a ship. Roughly 85% of a ship is made of metal coated with chemical paints (specifically anti-fouling paints) that are required to ensure the ship product's overall quality and durability (SSI, 2021). The processing of metal and chemical ship components also have their residual wastes and toxic emissions that must be addressed as their impacts are far greater and require critical decarbonization in order to be more sustainable, particularly the steel-making industry (Mckinsey & Company, 2020).

Yet, supposedly to balance this is the high value scrap produced from the end-of-life dismantling of ships after their 35 year old lifespans expire, wherein their repair would cost more than acquiring a new ship.

In the Netherlands, most metal scrap from ship recycling and ship repair activities are part of the kilograms of metal scraps exported annually to countries with lower standards for ship recycling activities and metal scrap valuation for reuse in other industries (OECD, 2020; SSI, 2021).

In the Port of Rotterdam, the heavy industries of metal, chemical, and shipbuilding industries import raw materials of unrefined oil (for energy), chemicals for making paints and polymers, and ores for steel-making and processing. The aforementioned components are then delivered to and stored at shipyards for ship manufacturing, with some residual material wastes going to material recycling plants, but mainly exported along with the ship product for offshore disposal (PACE, 2020).



"THE SHIPBULDING INDUSTRY IS A BASIC METAL INDUSTRY"

Figure 13. Metal components of a ship

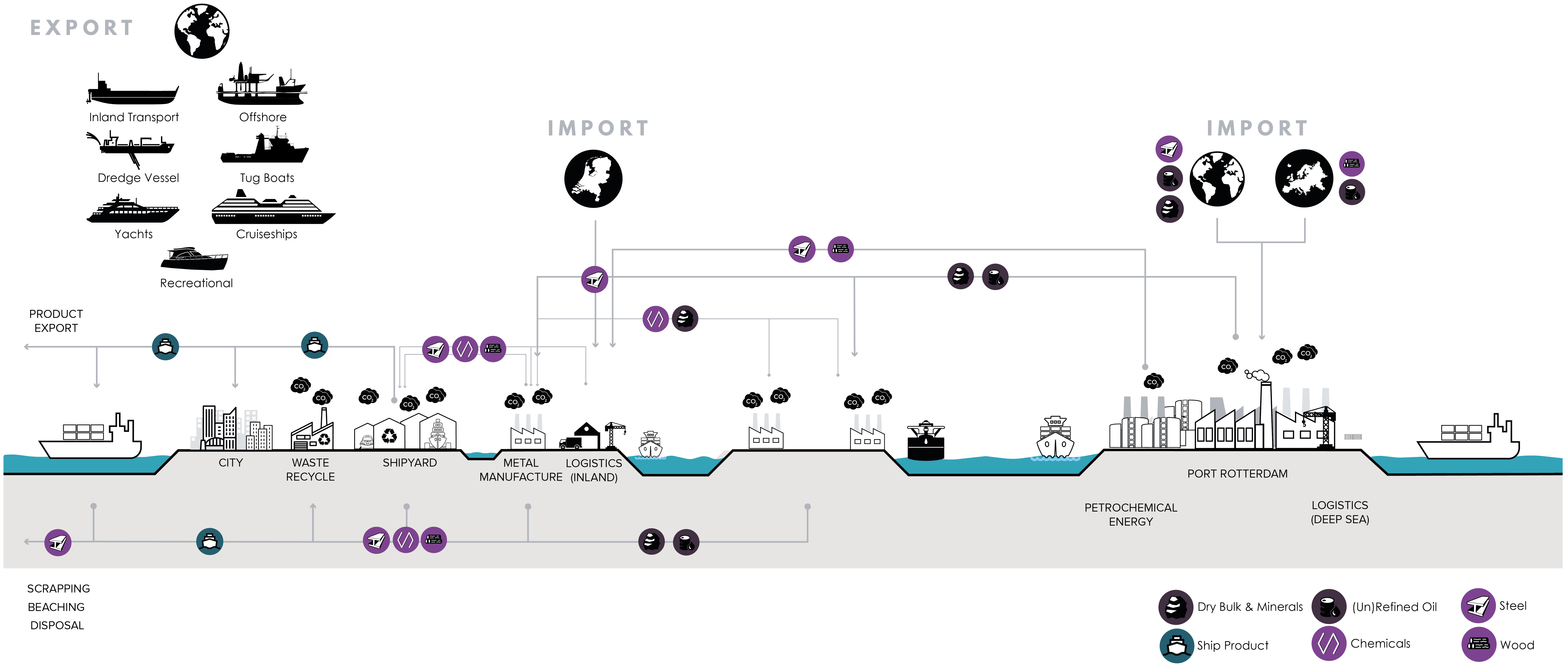


Figure 14. Systemic section of the shipbuilding industry

CO2 emissions from Material Transportation

The maritime sector is often seen as a highly polluting sector. Maritime transportation produces 3,5% of the total European CO2 emissions, while transportation on the road and in the air correspond to 19,4% and 3,8%, respectively (European Parliament, 2017). Although 3,5% might seem high, when considering that most international trade is facilitated by the maritime sector, the maritime sector is the most efficient transportation mode of goods.

The PoR wants to increase the use of inland shipping from 43% to 45% in 2035 (Olierook, 2012). According to the Clean Cargo Working Group (CCWG), the percentage of CO2 per container shipment has decreased over the years, clarifying again that global shipping is the most efficient transportation mode. Only we need to ask ourselves if these global transportation networks are necessary in a future sustainable world. The circular economy principle asks us for a more local and regional way of looking at what we consume and how we deal with waste.

In figure 15, the maritime networks between the PoR and important other ports around the world are shown, based on the transshipment of raw materials and oil. Based on the navigation tool of the PoR the minimal CO2 emissions per transshipment is calculated and translated into the number of trees[1]. When considering the number of weekly transportation routes between the PoR and the main suppliers of raw materials (Port of Rotterdam, n.d.), this will take 39.550 trees (or 2 million kg of CO2) annually to compensate for the deep-sea shipment of only raw materials and oil.

[1] Every tree can capture around 25 kg of CO2 per year

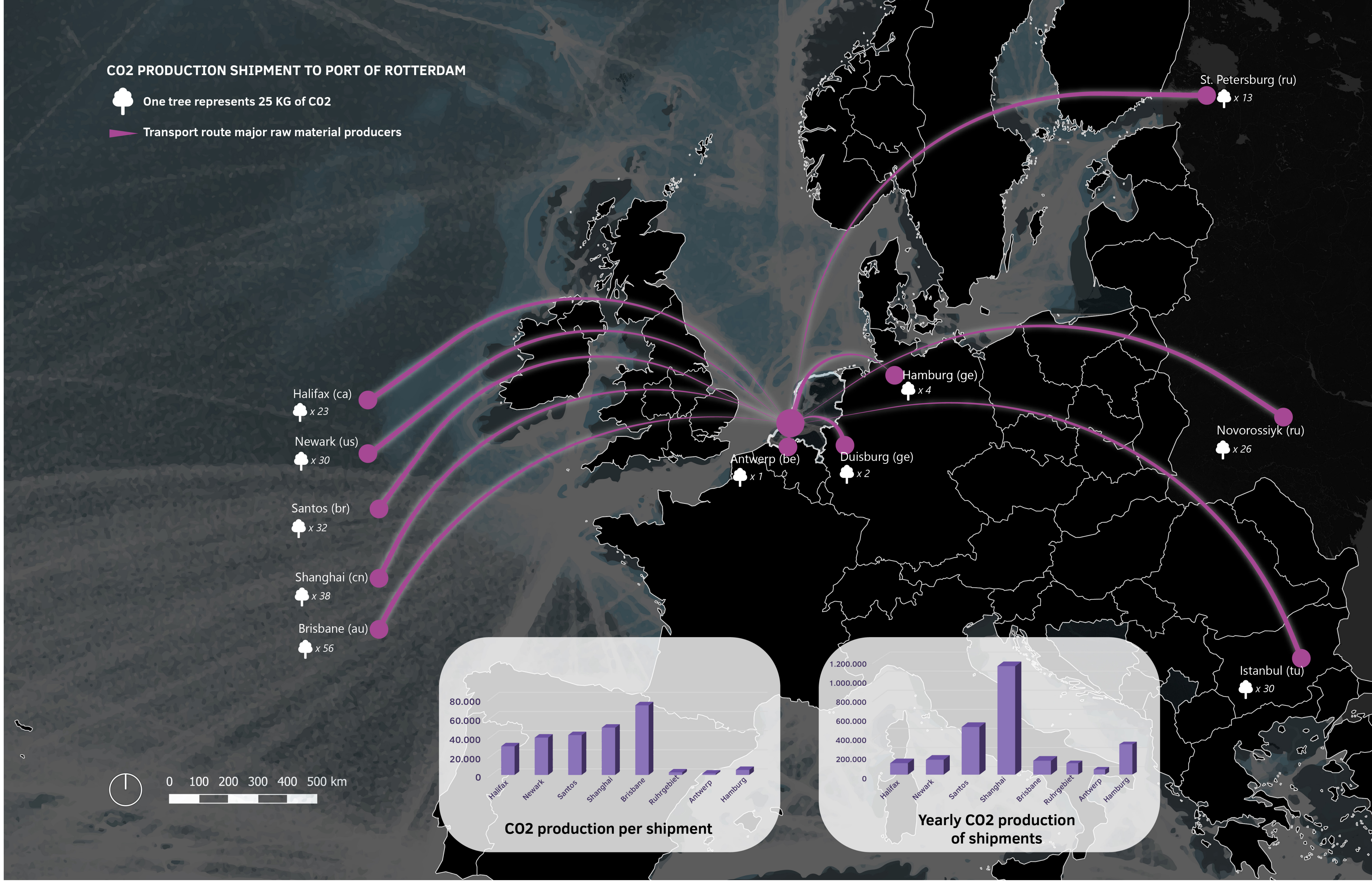


Figure 15. Transportation flows of raw materials to the Port of Rotterdam (Notten, Brummelkamp & van Rossum, 2016; CBS, 2021; Port of Rotterdam, 2022)

Steel and Metal Production

The production of steel is known for its high impact on the global environment. Globally between 7% and 9% of the total CO2 emissions is caused by the production of steel (Hall, 2022). If the total steel production around the world is seen as a nation, it would be the 5th largest producer of CO2 in the world (idem). This reminds us of the huge global impact the steel production sector has.

Although new techniques based primarily on carbon capture and recycling innovations have shown the potential to become a net zero-waste industry, there remains a problem. Metal is a material that can be easily recycled and reused in an integrated circular economy (Van Driel, 2019; World Steel Association, 2021).

According to the World Steel Association (2021), the steel and metal industry is considered to be near its zero-waste potential with an efficiency rate of 97,5%. This means that almost all materials and products being used in the production cycle are being used or recycled in later stages. But this system works on the conversion of raw materials into usable steel products. According to the Grondstofscanner (initiative started by the Ministry of Economic Affairs and Climate), the main component for the production of steel and metal, namely iron, has an undisturbed lifespan of 57 years (Grondstofscanner, 2022). A fully circular system cannot exist without an integral recycling system of scrap metal.

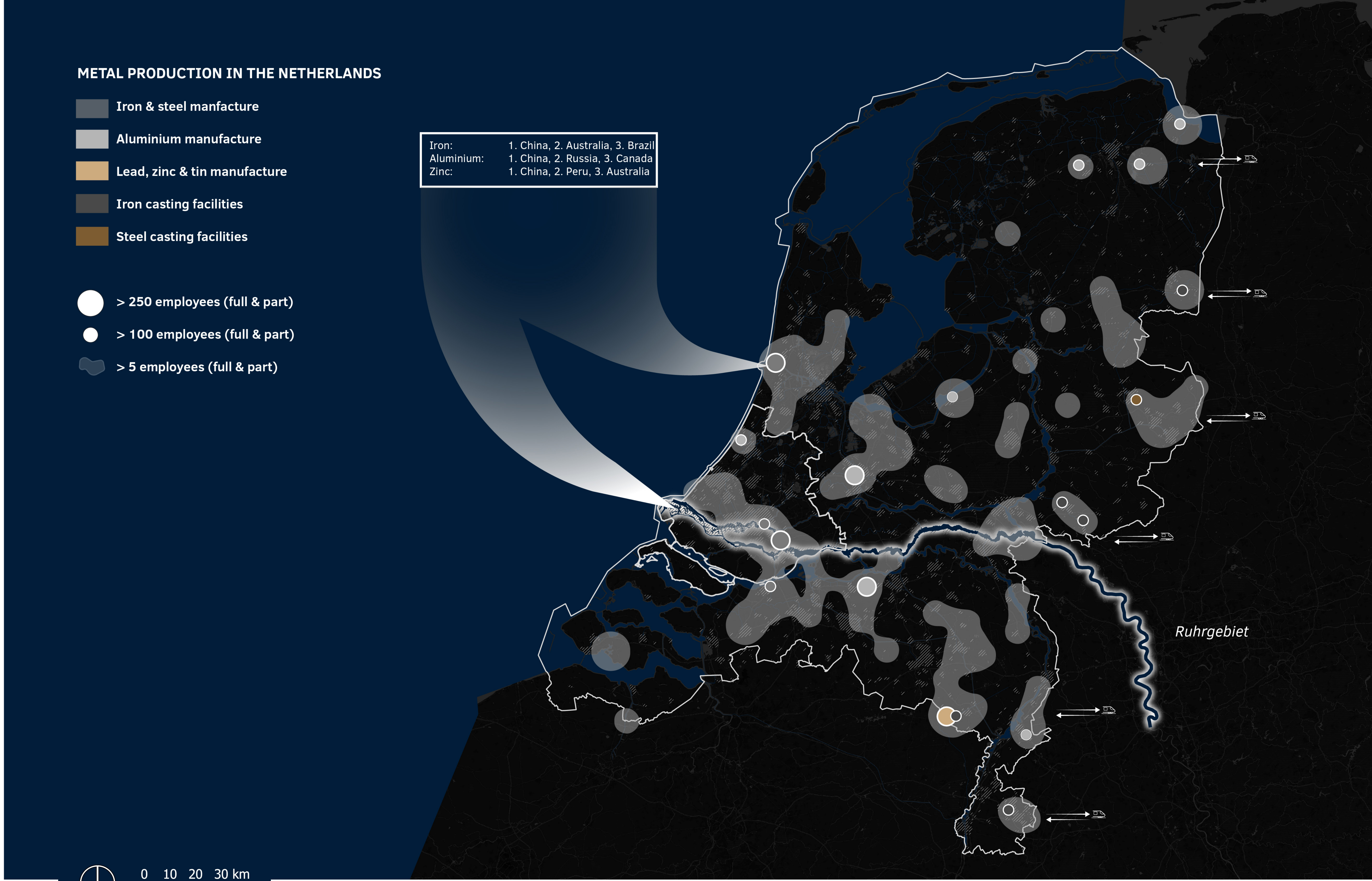


Figure 16. Metal production locations with the largest raw material producing countries in the world (CBS, 2021)

Metal Waste and Treatment Facilities

In the previous section on the Steel and Metal Production in the Netherlands (p. 44), the potential recovery rate of the steel and metal products was highlighted as extremely high (almost 100%). For the total production of steel, 70% is derived from raw materials with 30% coming from scrap metals (World Steel Association, 2021). The potential of these scraps is of fundamental importance for the reduction of industrial emissions. According to the World Steel Association (2021), every ton of scrap used saves 1,5 tons of CO2 and 1,4 tons of raw ores. Although the potential of a new circular economy sounds great, there are regulations and waste treatment processes in the Netherlands that decrease the potential circular usage of metal scraps.

To reuse steel and metal scraps in the entire metal production cycle, the scrap must be classified. But because the EU and the US classifications on the reuse of metal scraps are different from other international classifications, it is easier for metal manufacturers to sell scrap to nations that do not have strict regulations on the reuse of scraps like Turkey or China, than to treat waste locally (Van Driel, 2019; World Steel Association, 2021). This corresponds to the 2,878 million kg of metal scrap being transported to Turkey from the Netherlands each year (CBS, 2019). Due to high restrictions on the reuse of scraps, steel producers like Tata Steel, cannot reuse certain metal scraps due to earlier treatment with chemical coating layers, corrosion, and other minerals (Van Driel, 2019). Although the Dutch are leaders in the world of recycling and reuse, recycling 28,5% of total materials being used (CBS, 2019), given the international nature of scrap trade and the costs involved to treat metal to produce high-quality products, the current system shows the potential to change, but large international regulations block a necessary change in the metal industry.

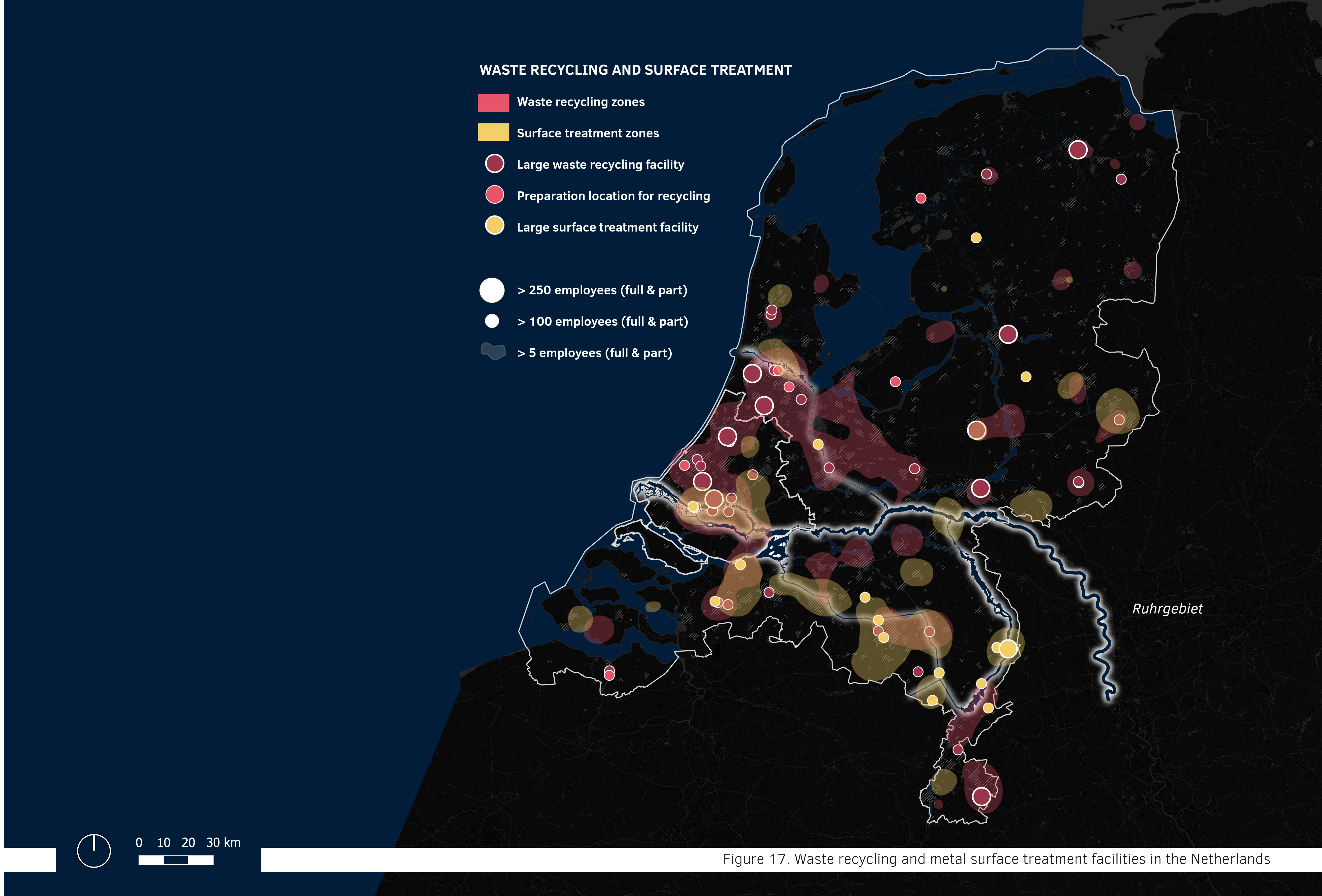


Figure 17. Waste recycling and metal surface treatment facilities in the Netherlands

Oil Consumption and Production

The trend towards a sustainable energy transition has decreased the interest in oil, also leading in the Netherlands to negative results, primarily in the metal and shipping industry (CBS, 2016). The shipping industry does not only rely on the production of bulk and oil carriers, but oil is still a large source of fuel for the industry. Also, the PoR heavily relies on the oil industry, currently providing 45% of its total cargo handling within the petrochemical sector (Havenbedrijf Rotterdam, 2019). Although this number has shown a decrease in the last years, big players like Shell, BP, and Vopak still have a major role in the annual 103,3 million metric tons of crude oil for the production of plastics, polymers, and other products including fuel for the shipping industry (Havenbedrijf Rotterdam, 2019).
Although the shipping industry has been changing its course to a more sustainable way of fuel and oil consumption as shown by the decrease in bunker oil consumption since 2007, the sector is still running on heavy polluting fuel sources (CBS, 2015). With the Climate Accords in Paris, the IMO has created a separate climate accord for the shipping industry, which strives for a 40% decrease in CO_2 in 2030 and 70% in 2050 (IMO, 2017). But according to Valkier (CEO of Anthony Veder, gas company), innovations around methanol and hydrogen power for ships are still underdeveloped and still considered dangerous when used, therefore, the shipping sector strives for the use of LNG (Liquid Natural Gas). LNG is considered better for the environment, but still relies on the fossil fuels of the gas industry (Jansen, 2020).
A new collaboration between the shipping industry and IMO has opened talks about international regulations for the decrease of emission numbers (Royal Association of Netherlands Shipowners, 2021). Due to a lack of international control on the shipping industry, because of the international water boundaries and the fact that many vessels sail under tax beneficial countries, the need for international measures is high.

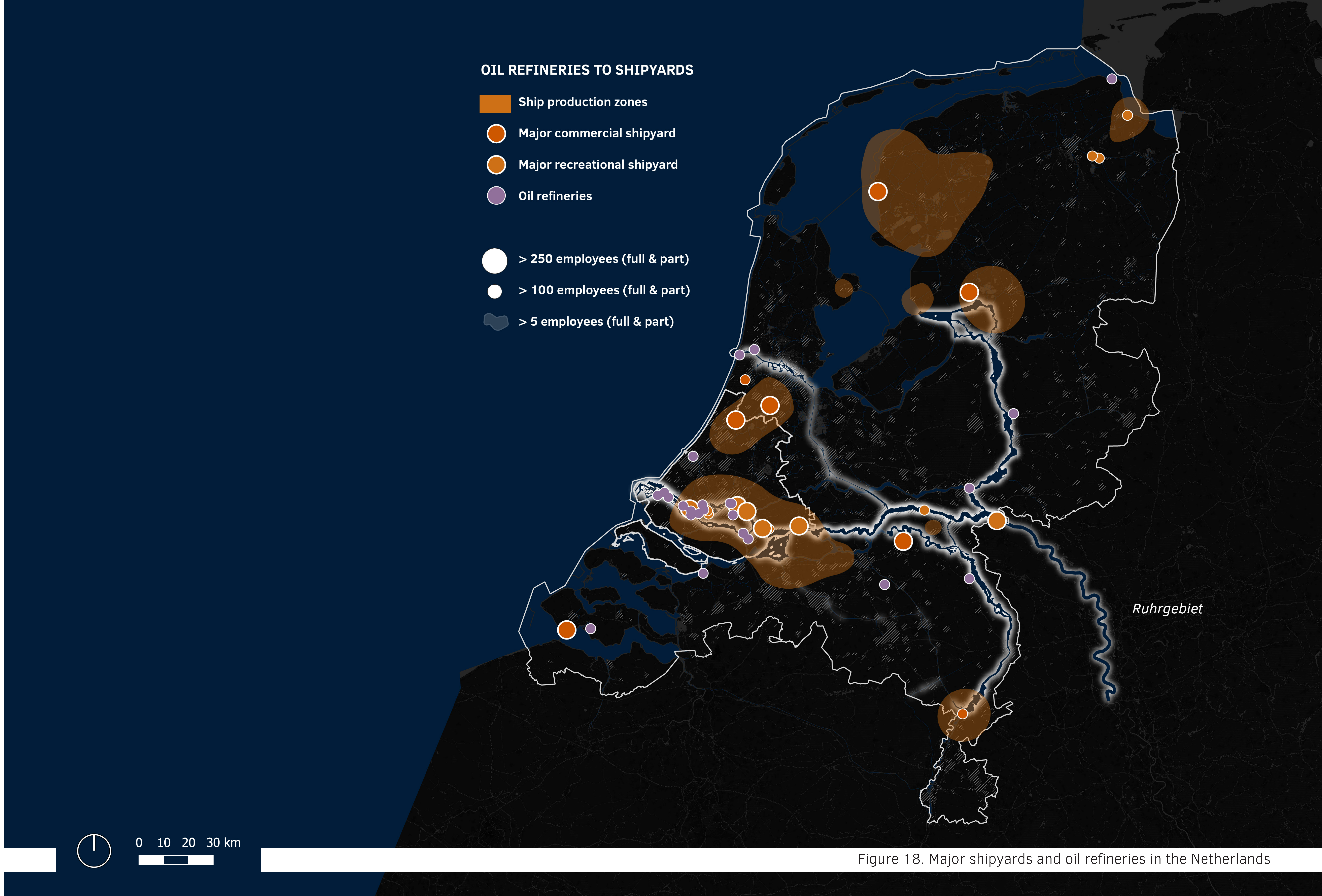


Figure 18. Major shipyards and oil refineries in the Netherlands

3.2.2 SHIPBUILDING AS A BASIC METAL INDUSTRY

Primary Metal Production Flows

The main steel production locations in the Netherlands are the blast furnaces of Tata Steel in Ijmuiden, where the raw ores of iron, aluminum, and zinc are being transformed into beams and plates. Tata Steel produced 6,62 million tons of crude steel in 2020 (Van Driel, 2019; Tata Steel Europe, 2020), which corresponds to around 7% of the total CO2 emissions of the Netherlands (Van Driel, 2019; RIVM, 2021).

For the production of steel and other metals, the PoR functions as a collecting ground for raw materials that are later being transported to the steel manufacturers of the Ruhrgebiet and the iron casting, aluminum, and zinc manufacturers in the eastern part of the Netherlands.

Due to the lack of raw materials in the Netherlands, and Europe for that matter, the Netherlands heavily depends on raw material transport from China, Russia, Brazil, Australia, and even Peru (CBS, 2021). China rapidly grew into a raw and rare material exporting nation, currently providing 80% of all rare materials on earth (Vos, Cengic, 2020).

Nowadays the Dutch rely more on the import of raw materials from Russia, but since the invasion of Ukraine, this dependency on geopolitical unreliable nations questions whether our metal consumption of 164 million tons annually (CBS, 2019) can continue. However, the recovery efficiency of metal products is extremely high (Drift & Metabolic, 2018; Van Driel, 2019; World Steel Association, 2020) and can therefore be easily recycled and reused.

Refer to Appendix C (p. 206) for the diagrams showing the production processes of oil into polymers and into protective coatings.

Iron ore to Steel

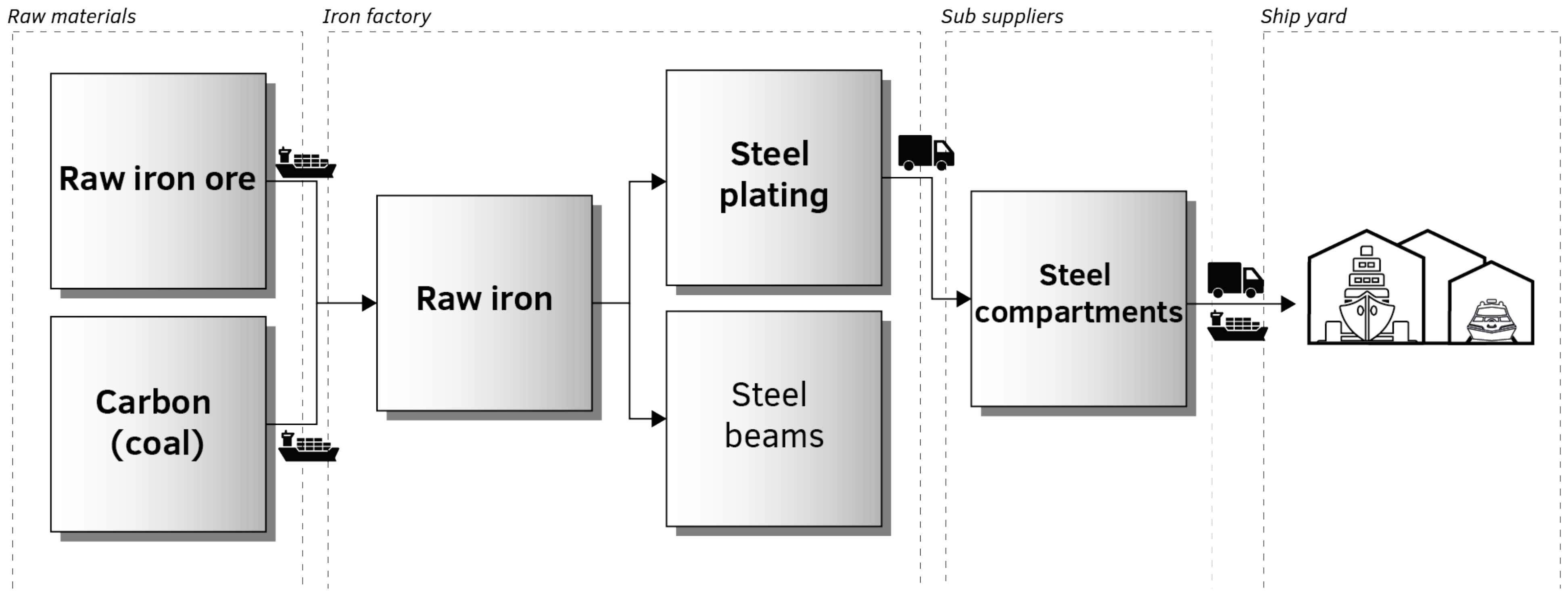


Figure 19. Diagram showing the production of steel and metal compartments out of raw materials (Worldsteel Association, n.d.)

Metal Waste to Shipyards

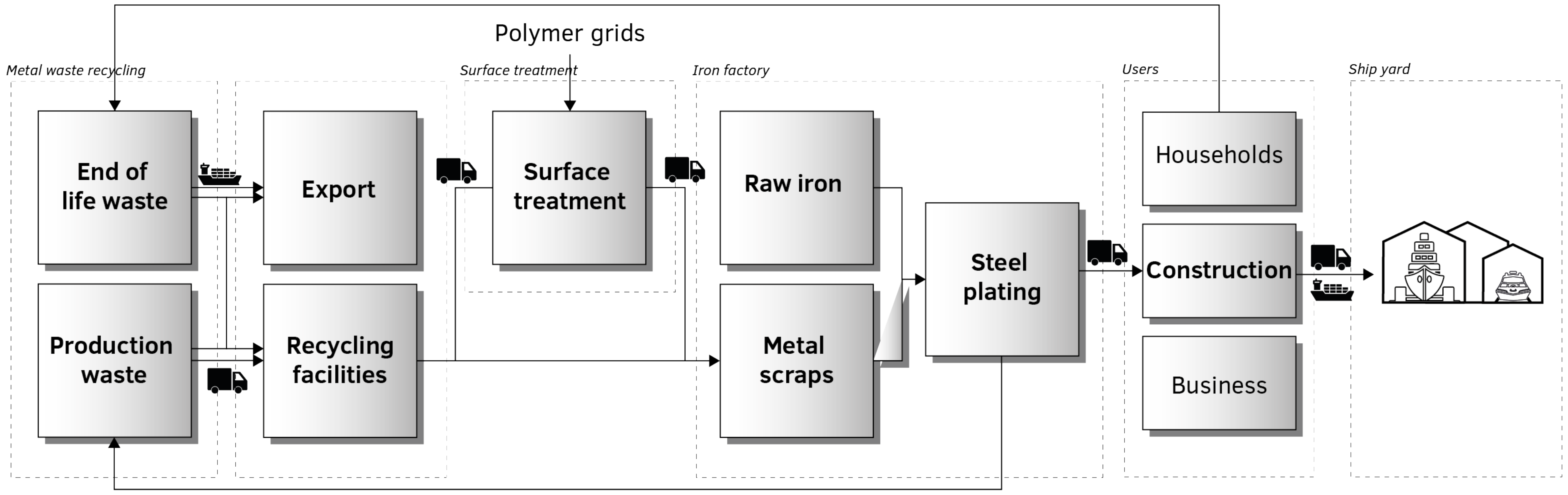


Figure 20. Diagram showing the life cycle of metal waste scraps into new compartments for ship manufacturing (Worldsteel Association, n.d; AB-Coat, n.d.)

Metal Waste Recycling and Treatment Processes

The total amount of steel, iron, and other metals in the province of South Holland corresponds to around 61.020 tons, of which a large part is used in the construction sector (Drift & Metabolic, 2018), but also in the shipping industry. Out of the 61.020 tons of metal, only 32.220 tons are being recycled, which is 53% of the total metal material (Drift & Metabolic). Although these metals have the highest environmental impact within the construction sector of the province of South Holland, their reuse and recycle potential is often overlooked. But even if this is reduced, there will still not be enough scrap available to meet the demand for the production of new steel and metal products.

Dutch metal manufacturers and smelters are able to properly treat metal waste from the shipping industry due to the high containment of its metal scraps, a result of oil infusion, corrosion, or the use of alloys. However, the current international scrap trade disconnects the metal scraps from the shipping industry to the metal waste treatment facilities in the Dutch region.

Studies by Netherlands Maritime Technology in 2016 have already indicated that within the Dutch inland shipping sector, there is high potential to change the way shipping companies deal with metal compartments. But due to international financial benefits and regulations of scrapping, rather than reuse of certain ship compartments, nothing has changed.

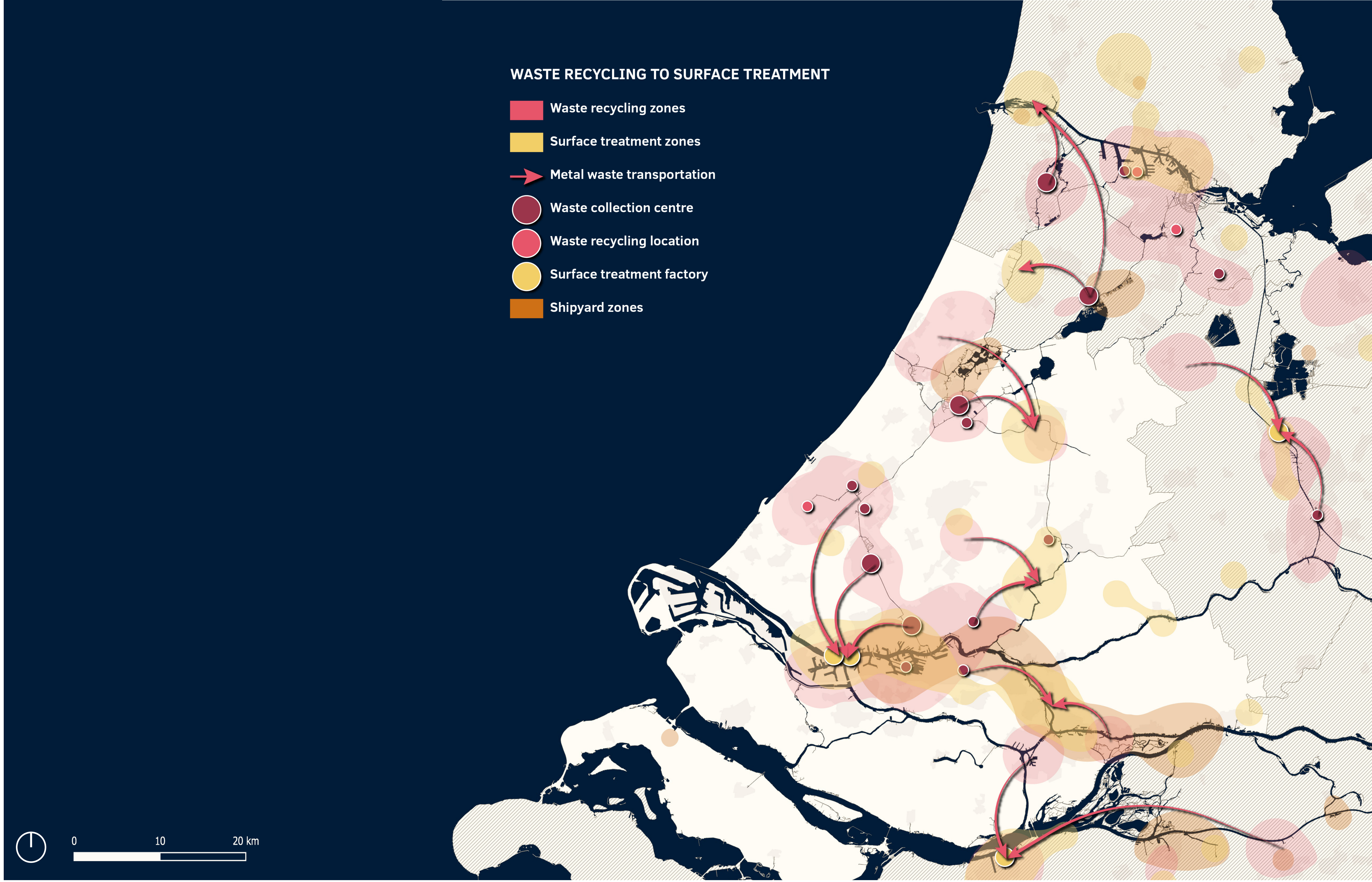


Figure 21. Transportation flows of waste recycling facilities to metal surface treatment facilities

Metal Manufacturing and Shipyards

The recent COVID-19 pandemic also impacted the Dutch Maritime sector. The total revenue of the Dutch shipbuilding industry corresponded in 2020 to 7 billion euros. The maritime industry, therefore, produces each year around 3% of the annual Dutch GDP (Netherlands Maritime Technology, 2020; Nederland Maritiem Land, 2021). Although the Dutch Shipping industry had to cope with economic uncertainties in recent years (COCID-19 pandemic, Chinese embargo, Russian invasion of Ukraine, economic crisis in the 2010s), the sector has always been a reliable industrial sector without large yearly differences in revenue. In 2020, the total order book[1] of the Dutch Maritime sector corresponded to around 456.393 gross tons of metal, of which 211.196 tons were being produced and delivered from Dutch shipping companies to clients all over the world (Netherlands Maritime Technology, 2020).

The large shipyards of IHC, Damen, and Boskalis can be found along the main waterways of the Drecht cities (Oude Maas, Beneden Merwede). With Tata Steel as the main producer of metal and steel in the Netherlands, metal products for the assembly of ships will need to be transported along the waterways (mainly by the North Sea & Amsterdam-Rhine canal). Although there is a large metal manufacturing company located right in the middle of the shipyard cluster in the PoR, FN Steel, it does not facilitate the surrounding shipping industry to its full potential (refer to figure 22). FN steel is specialized in the production of wire rods, bolts, nuts and springs for the automotive industry. The only connection between the industries of metal production and the shipping industry can be found within the Tata Steel region and the regions of the eastern Netherlands.

[1] An order book of an industry shows the interest of the market in a particular industry of that country

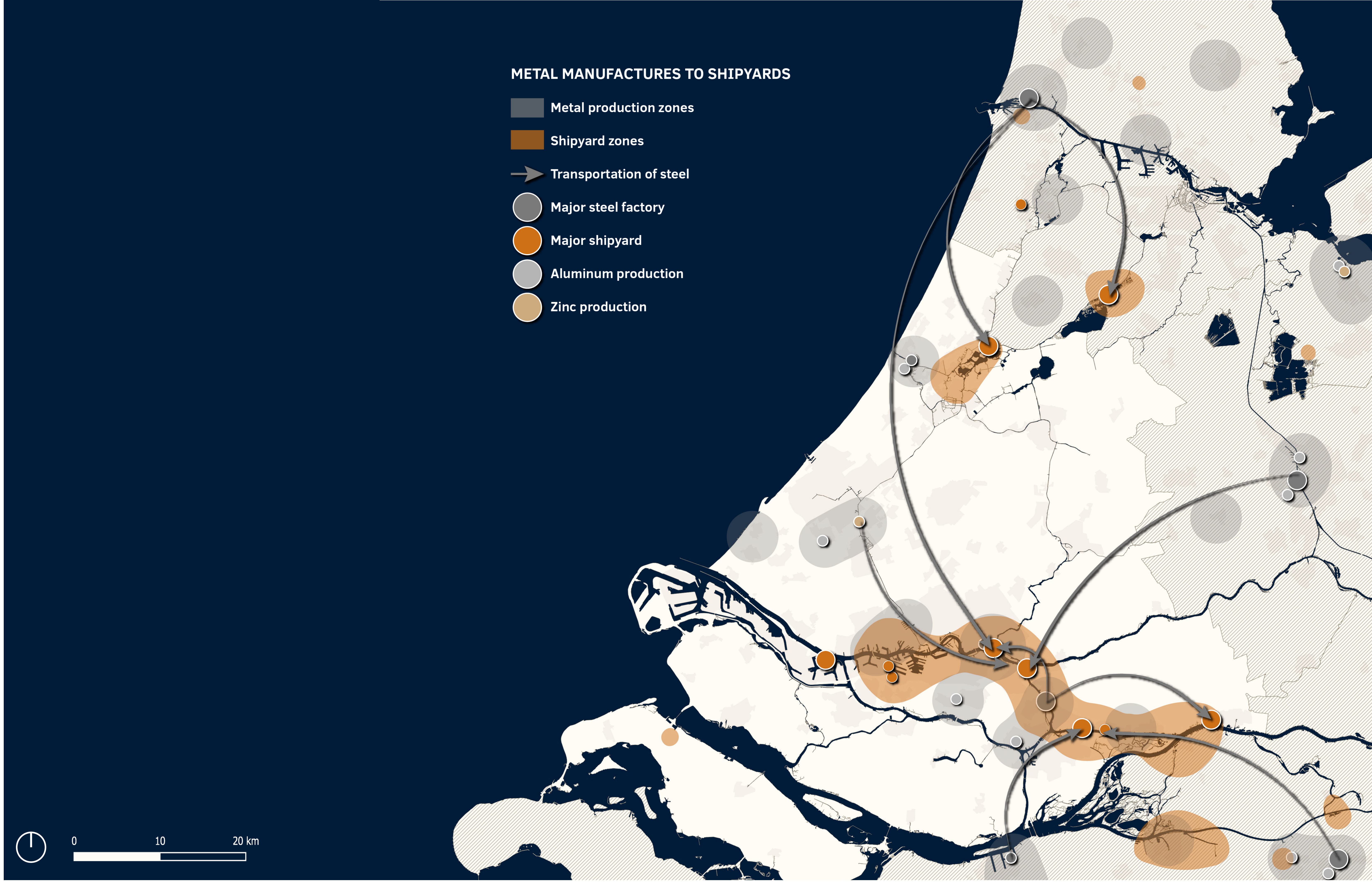


Figure 22. Transportation of metal production facilities to the shipyards of South Holland

Polymer Production Process

The total greenhouse gas emission corresponding to the polymer value chain is estimated by the European Union at around 208 million tons, of which 63% is caused by its production (ETC & WMGE, 2021). The production of polymers all starts with the distillation of crude oil in large oil refinery factories, of which the Port of Rotterdam has five regular and six plant-based refineries (Port of Rotterdam, 2019).

Global oil refineries produce around 6% of the total greenhouse emissions in the world, making it the third-largest emitting sector (Cell Press, 2021). Oil refineries are crucial for many industrial sectors that rely on the use of one of the products from the refinery process that takes place under more than 330 degrees Celsius. In appendix C (p. 206), the products of the refinery process are shown. One of the products, Naptha, is used for the production of polymer grains, which takes place on the industrial sites of Moerdijk, one of Europe's largest producers and recyclers of polymers (Havenbedrijf Rotterdam, 2021). These polymer grains can then be transformed into plastics that are used in various sectors, including the shipping industry.

Although the production of polymers is considered to be extremely polluting, it is categorized as a circular process. However, according to Drift & Metabolic (2018), only 13% of total polymer waste in the province of South Holland is recycled. One of the key problems is the lack of division within waste streams, which means that the waste collection of polymer products is not fully optimal. The Dutch National Government even pointed out that the polymer chain in Dutch daily life is one of the five transition areas that are of importance (Rijksoverheid, 2020). The goal is a circular economy of the polymer cycle in 2030.

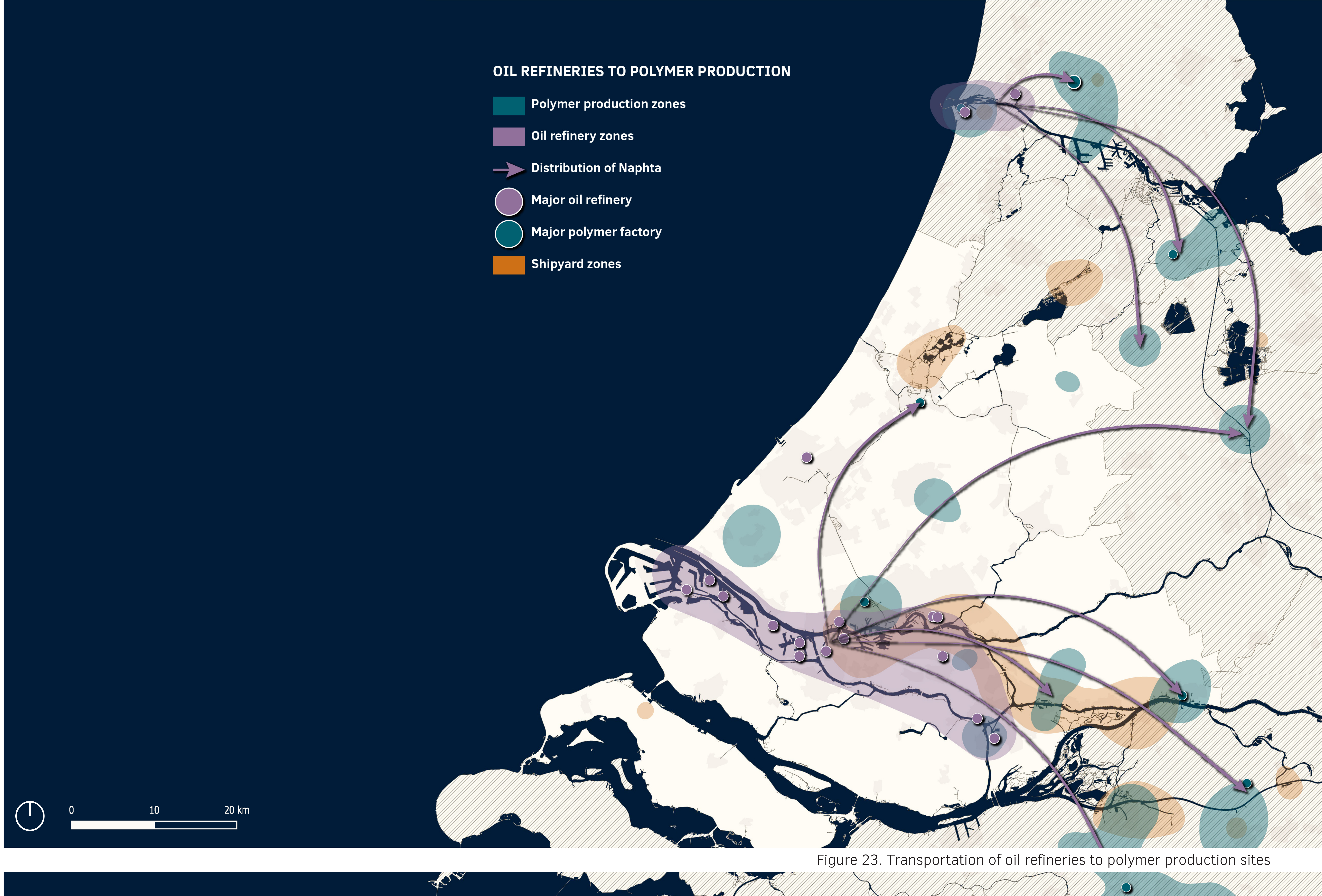


Figure 23. Transportation of oil refineries to polymer production sites

Coating Production Process

In addition to the reliance on oil to produce fuel for the shipping industry, oil is also a vital component in the protection of vessels in the form of corrosion-free and protective coatings. There are many ways in which coatings for the maritime sector can be produced but two vital parts are polymers and minerals, where minerals function as a protective layer against corrosion (refer to appendix C, p. 206). The mineral zinc is often used due to its high protection rate against the oxidation of iron and metal surfaces of the vessel itself.

In the previous section on Polymer Production Process (p. 56), the environmental impact of polymer production within current refineries has shown how polluting this sector is. The fact that polymers and zinc are necessary for the production of coatings, but they are also heavily polluting and finite, makes it important to look for other ways to facilitate a circular shipping sector.

Not much is known about new ways to produce an environmentally friendly coating for the shipping industry. If the national governments and other public bodies want to decrease the usage of polymers and raw materials (Rijksoverheid, 2020), new ways of protecting vessels are needed to facilitate a change in the maritime sector. A start-up called QLayers has shown a potential new way to protect vessels, namely by printing a tiny micro-structured layer on the metal compartments, based on the principle of how sharkskin functions in the water, thereby reducing 8.000 tons of CO_2 annually (Kraaijvanger, 2018). More of these innovations are needed to create a sustainable maritime sector.

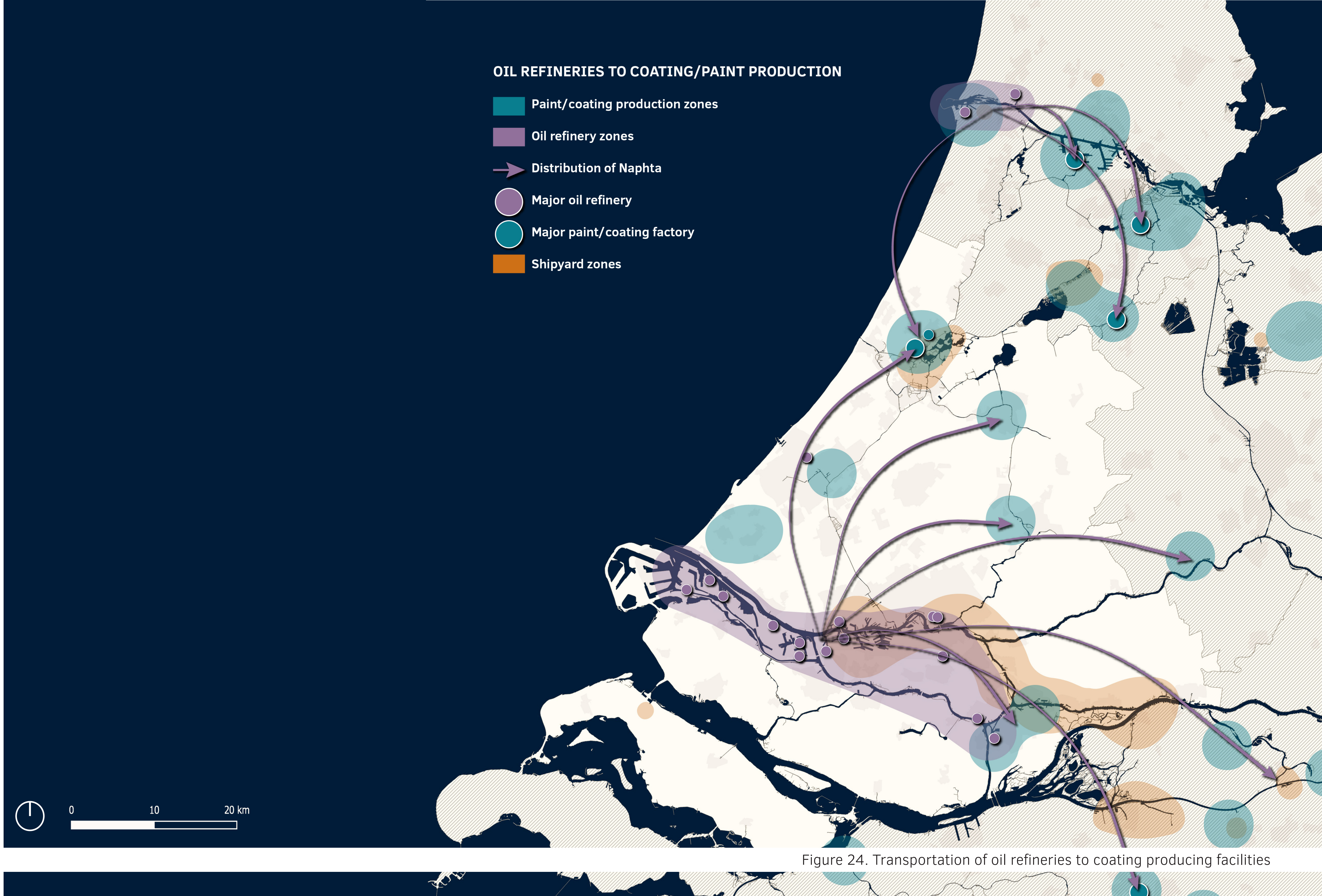


Figure 24. Transportation of oil refineries to coating producing facilities

3.2.3 END-OF-LIFE OF A SHIP

Although metal is one of the most well-recycled materials (Reck & Graedel, 2012), the dismantling of ships still remains an issue on environmental and ethical grounds. Out of several ship breaking methods, ranging from mere long-term storage to sinking the ships for marine biodiversity or navy target training, the predominant way of ship disposal is overseas disposal due to its cost-effectiveness (Hess et al., 2001). This practice is usually done in unaccountable underdeveloped nations through the beaching technique, which means shoring a ship on a beach and manually dismantling the ship with minimal oversight and safety measures.
In order to regulate this problem, The International Maritime Organization (IMO) adopted the Hong Kong convention in 2009, which aims to minimize exposure to hazardous materials; after 12 years since adoption, this treaty is still not in effect yet (IMO, 2021). In the meantime, the EU is enforcing much stricter EU Waste Shipment Regulation under the framework of the Basel Convention. The Netherlands has signed both treaties. However, NGO Shipbreaking Platform (n.d.) reports that most of the ships are still circumventing this rule by falsely selling the vessel as "further operational use" or "repair" instead of the actual intent of scrapping the vessel. This means that if a Dutch-owned ship is sold to India for breaking, unless in an extremely rare case where the original owner (Dutch) discloses the intent to dispose of the vessel along with the sale, India is responsible for the waste even though the vessel has been serving the Dutch owner for its whole lifetime.
Based on NGO Shipbreaking Platform's data, the results are quite shocking: during 2016 – 2020, 86% of the vessels that are or originally were serving Belgian, Dutch, and German beneficiaries have been scrapped in the global south. If weighted by the vessel's gross tonnage, it was a whopping 98%, meaning only a number of smaller ships were scrapped in the global north. Bringing these vessels into more accountable nations, including the Netherlands, will be more responsible and may create material resiliency by practically creating enormous metal sources in the country.

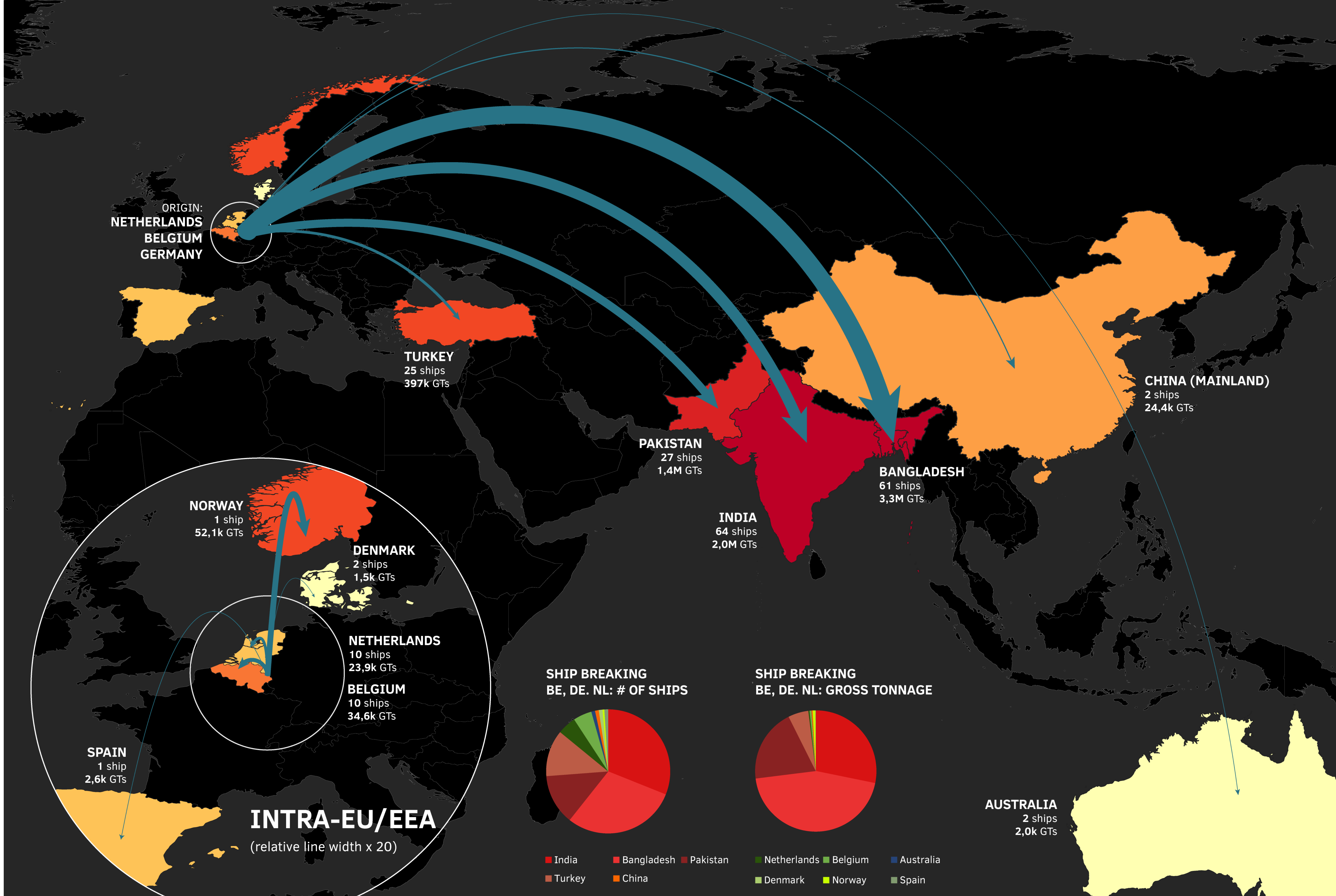


Figure 25. Destinations of disposed ships between 2016 to 2020

3.2.4 CREATING A SUSTAINABLE SHIPBUILDING INDUSTRY

What is Circular Shipbuilding?

From the review of the shipbuilding process' material and waste flows, as well as its environmental impact, it is clear that there is much to be gained. Ship repair ensures that ships can still operate beyond wear and tear, and based on the flows the industry generates, it can most effectively be looped back into the manufacturing system as new material input to make ships again or even for use in making products in other manufacturing sectors. Metal is introduced here as the crucial material as it covers the largest composition of a ship product.

"Metal recycling closes the loop within the production process, therefore reducing the amount of waste that goes into landfill and the amount of primary materials required" (EuRIC, 2020). The possibilities of extending the circular use of materials within the shipbuilding industry are substantial due to the many ways metal can be disassembled, treated, and re-processed.

Aside from managing material flows, the Sustainable Shipping Initiative (SSI) conducted a study of how the shipbuilding industry could be more circular. Its report titled 'Exploring Shipping's Transition to a Circular Industry' (2020) concludes the need for the following to apply CE into the shipbuilding industry:

a. De-carbonization Efforts
b. Innovation in Design and Construction of Ships
c. Increase in Ship Recycling Capacities
d. Regulatory Changes
e. Global Sustainability Transition

Technology, Regulation, Business Model Innovation, and Knowledge are the key foundational factors in creating a circular shipping industry (SSI, 2020).

It is proposed that for the long-term system change in the shipbuilding process, foremost would have to be at its design phase. The use and innovation of new materials must be explored, and recycling of existing materials must be enforced as the global shipping fleet continues to grow. Furthermore, it is emphasized that stronger national legislation and collaboration is essential between shipowners, shipbuilding companies, ship recycling yards, metal and chemical manufacturers, and other stakeholders to create a well-functioning loop for the ship life cycle to become truly circular and sustainable --- built upon shared value and adapting new ways to keep material streams fit for continual reuse (SSI, 2020).

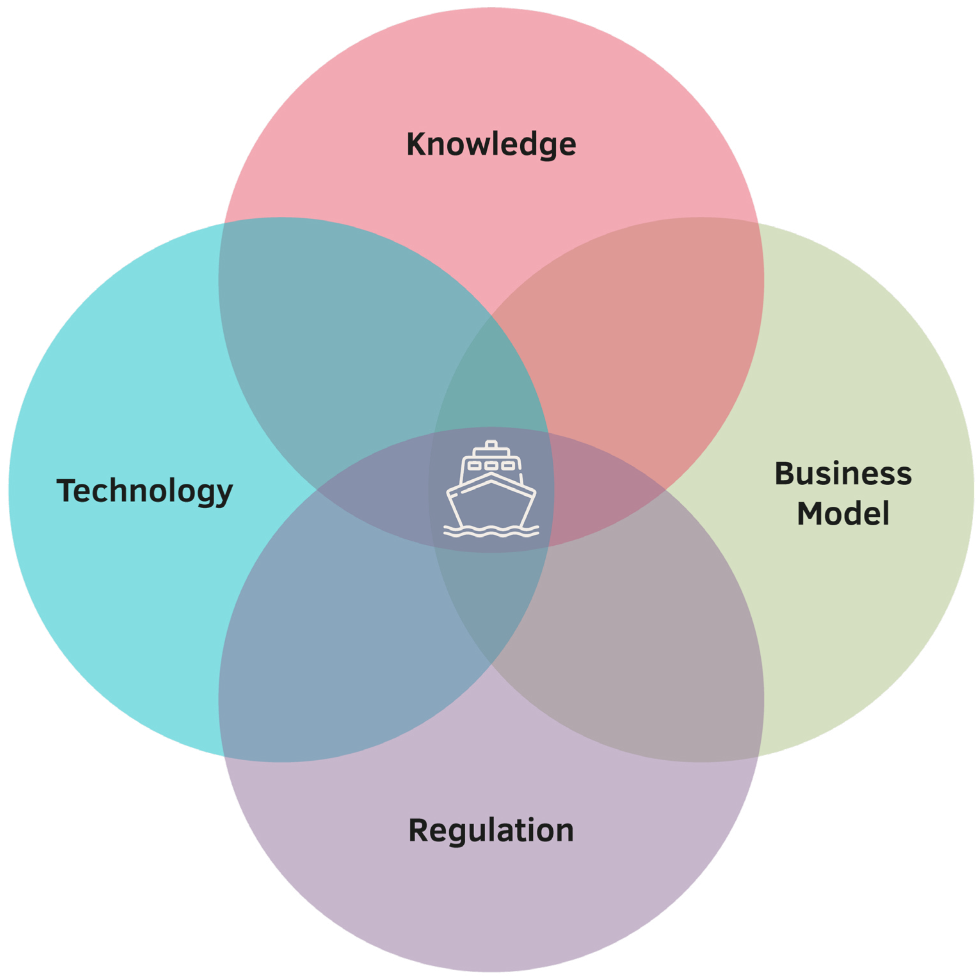


Figure 26. Components of a circular shipbuilding industry (SSI, 2020)

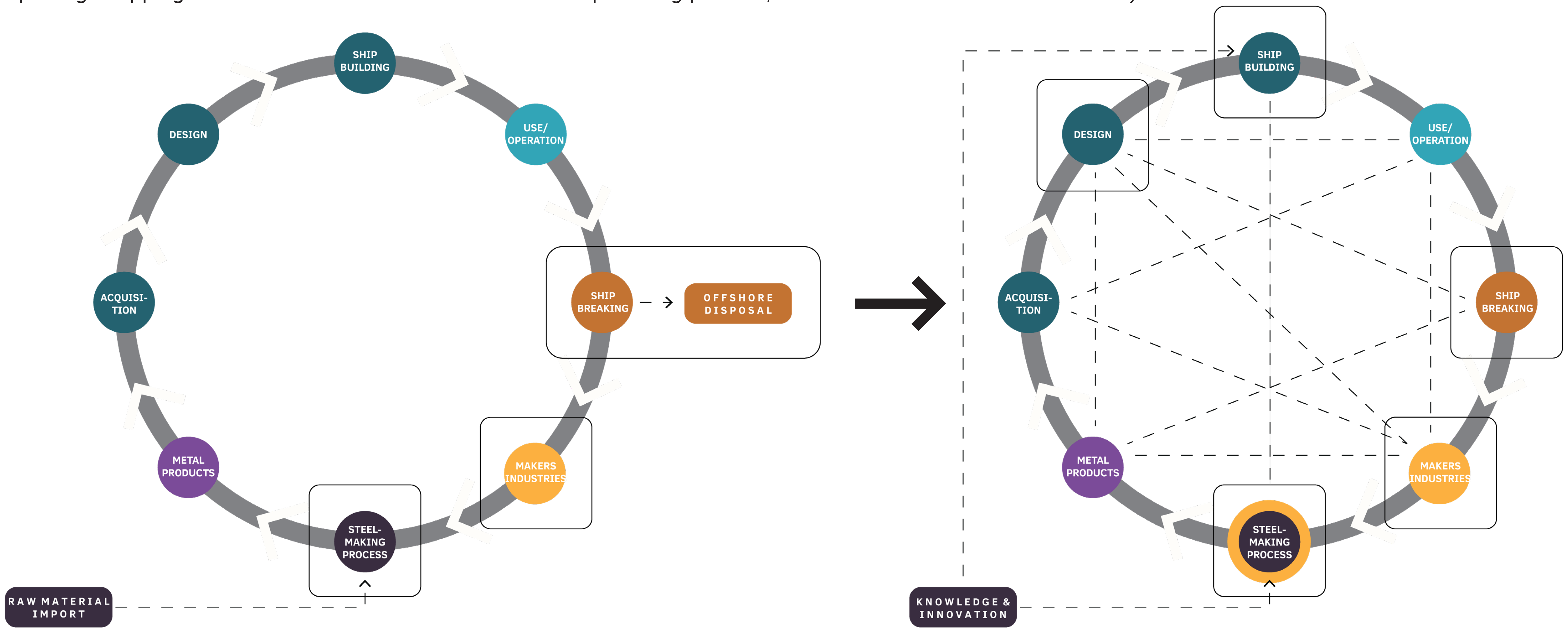


Figure 27. The current shipbuilding process, with shipbreaking as the missing link (left) and the future process with the key steps where interventions are required highlighted

Shipbuilding 4.0

The shift into the fourth era of the industrial age, or what is known today as Industry 4.0, is examined as to how this will affect the shipbuilding industry of the future and all the processes within it. The term 'the Digital Shipyard' or 'Shipyard 4.0' is ascribed to a shipyard that would incorporate the use of Cyber-Physical Systems (CPS) and the Internet of Things (IoT) in their operations. These systems can be utilized to improve the design of ships, make safer testing environments, and save energy and resources. More digital systems also preclude needing huge amount of space for operations that would otherwise need manual labor. Other technologies applicable to the improvement of shipyard include 3D Modeling, 3D Printing, 3D Scanning, Robotics, Blockchain, High-Performance Computing (HPC), Augmented Reality (AR/VR), and Artificial Intelligence (AI/ML). Thus the impact on the need for more skills and labor geared towards this shift is more imminent and will require new training and capacity-building programs within universities or other educational centers (Rouwse, 2021).

Hexagon, an R&D-based technology company that focuses on automated solutions in the manufacturing industry, recognizes the role of digital infrastructure within the shipbuilding manufacturing process as integral to the global goal for decarbonization by 2030, as supported by the International Maritime Organization (IMO). They report that closer coordination between design and operation must be in place for new construction, and efficiency in ship operations must be supported by designers through an integrated digital framework, such as a Digital Twin, that can simulate physical characteristics and dynamics of a projected product. "Such a framework will allow all stakeholders to collaborate on developing the best possible designs. Implementing an integrated framework will also position shipbuilders for the advent of smart connected ships, digitally integrated yard…Digital platforms will need to connect supply chain management and yard manufacturing operations to provide end-to-end visibility of every process and outcome" (Piirainen, 2021).

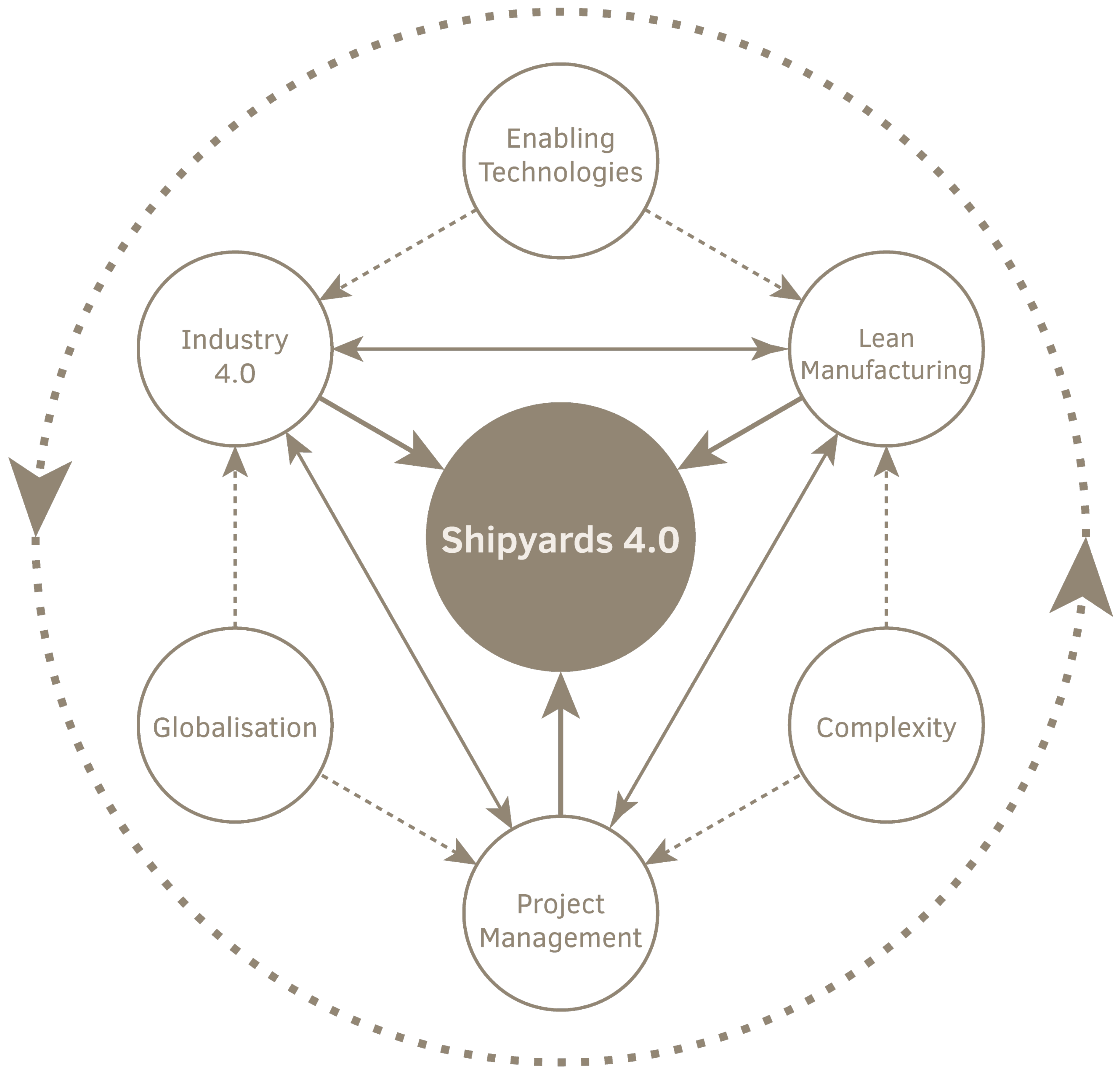


Figure 28. Framework of shipyards in Industry 4.0 (Sánchez-Sotano, 2020)

Green Shipyard

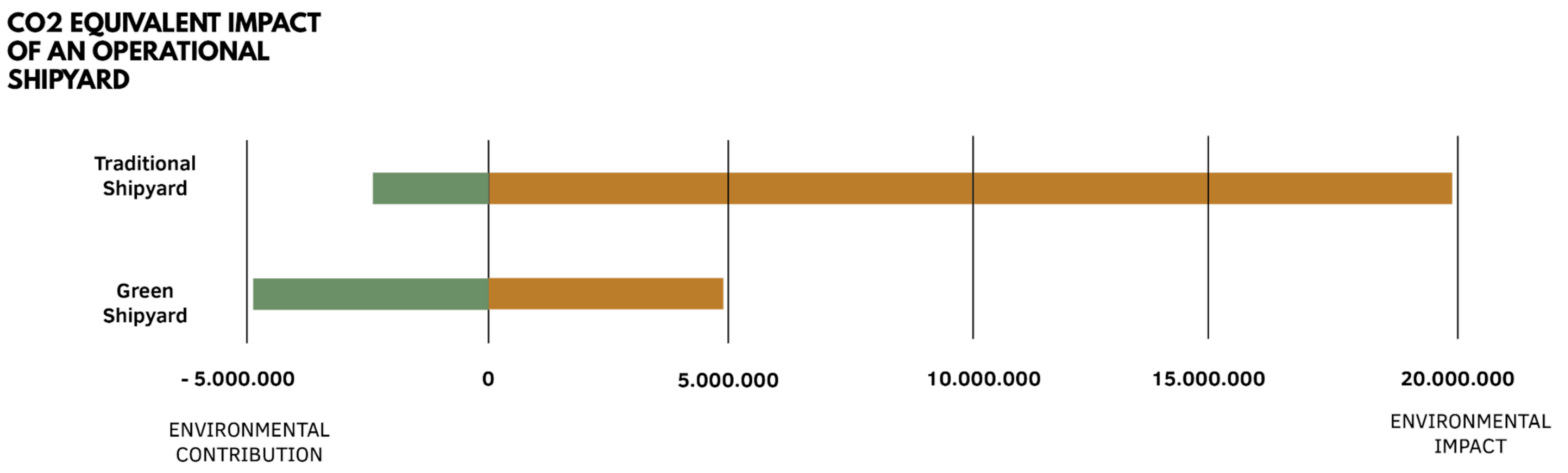
Sustainable transformation in the shipbuilding industry must not only be embattled in the educational and product innovation front, but also within its very facilities. Shipyards are long overdue for a re-design in that as the industry aims to mitigate its environmental impact as a whole, managing the resources that go in and out of shipyards are pivotal in building a circular maritime manufacturing sector. Janson, in collaboration with shipbuilder Damen and the University of Twente, published a study and proposal called 'The Development of a Green Shipyard Concept' in 2016, creating guidelines as to how shipyards could be designed and planned more sustainably: “A shipyard is considered green when the development, repair, or conversion of a ship, using different processes and systems, has an environmental impact for both energy and pollution of null” (Janson, 2016). Here they clarify that the green shipyard concept delineates itself to the sustainable production and repairs of vessels. To attain null impact, minimization of energy use and management of pollution/waste are required. The resulting impact of the production process is compensated by positively contributing to the environment (Janson, 2016).

Minimization of energy use and management of pollution is achieved by:

1. Reducing the use of energy and the production of waste
2. Using renewable energy resources
3. Increasing the efficiency of the resources used (Reduce, Reuse, Recycle Materials)

To further achieve a null-impact yard, a strategy that integrates the following principles are proposed:

1. Management Dedication
   a. Adapt and implement environmental policy, strategy and monitoring systems
   b. Full transparency of environmental performance by clear monitoring and evaluation processes
   c. Implement Green Performance Framework (GPF) for self-assessment
2. Shipyard Layout and Process Optimization
   a. Optimize shipyard layout
   b. Implement Lean Manufacturing and Design Production
   c. Limitation of Portfolio and Utilization of Modular Designs
3. Green Civil Works
   a. Infrastructure to support the first two principles
   b. Using nature-based solutions



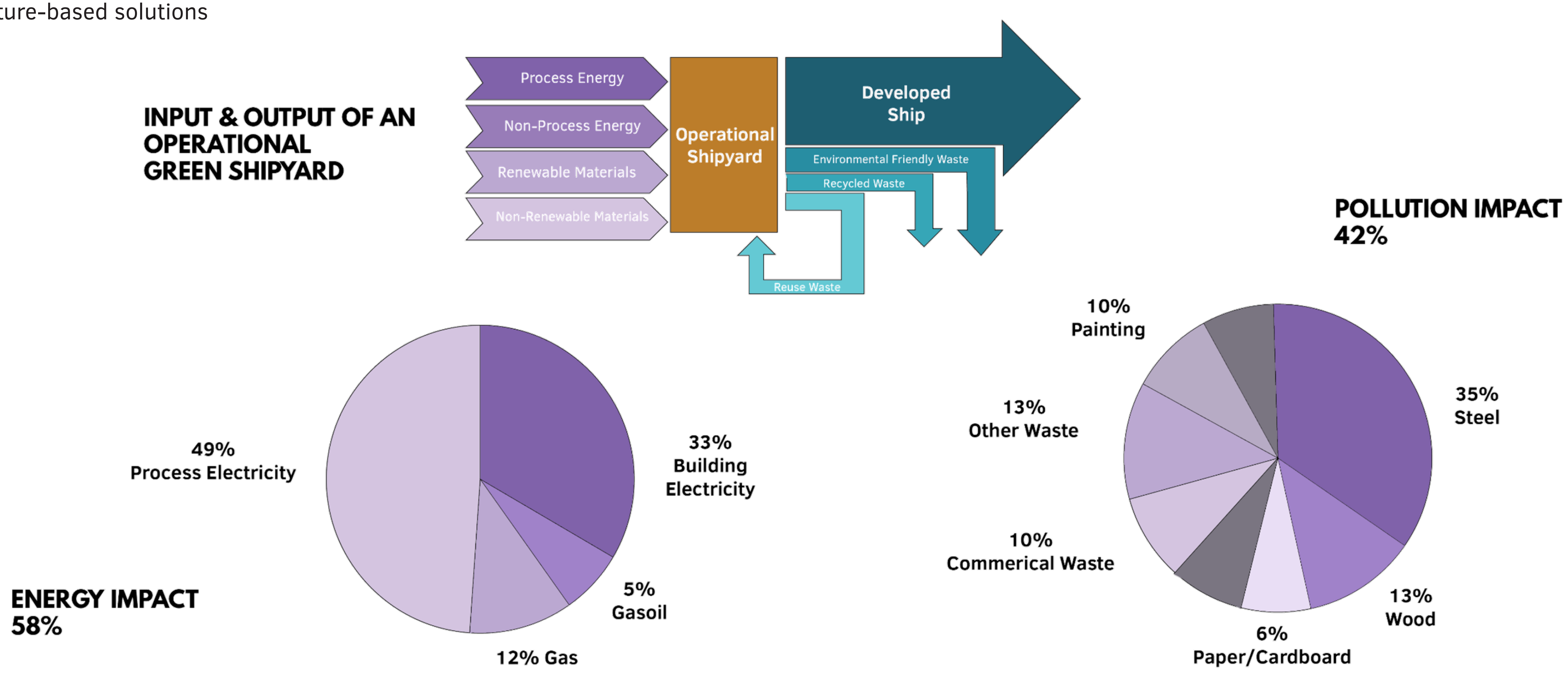


Figure 29. Environmental impact of a green shipyard (Janson, 2016)

Ship Recycling as the Possible Missing Link

The OECD Council Working Party on Shipbuilding's report provided a SWOT Analysis of the Dutch Shipbuilding Industry that indicates its great potential for improving the current industry with the Netherlands' high capacity for innovation and collaboration between the maritime cluster members and other stakeholders. Intense cooperation between suppliers, shipyards, and the national government are key factors to obtain a significant market share in the green and smart shipping market. Moreover, it emphasizes that this collaboration between the related industries culminates and intersects in the practice of ship recycling regarding the urgency needed for a more sustainable and holistic shipbuilding industry (OECD, 2020).

As much as there are regulatory bodies, such as the Hong Kong International Convention for Safe and the Environmentally Sound Recycling Ships adopted by the International Maritime Organization in 2009, in place for the ship recycling industry worldwide, local initiatives for recycling prove to be a missing link in the Netherlands to create a more sustainable and circular shipbuilding industry. The European Union's updated regulations on Ship Recycling within its territories in 2013 is supporting this, with the aim "to prevent, reduce and minimize accidents, injuries and other negative effects on human health and the environment related to the recycling of ships flying the flag of European Union countries" (European Commission, 2013). The regulation stipulates stricter measures on handling toxic materials and substances in the processes by requiring Ship Recycling Facility Plans before construction and an Inventory of Toxic Materials to be handled by each shipyard. Financial incentives are also proposed for shipyards that comply and follow the regulations.

Green growth is the main aim for the more technically advanced OECD member states, such as the Netherlands, where more firm technological and environmental regulations for shipyards and ports could be set in place regionally, and where partnerships between local authorities and innovators could build more cognizance on the potentials for more environmentally-sound options for conventional designs, materials, and processes used in the industry (OECD, 2010).

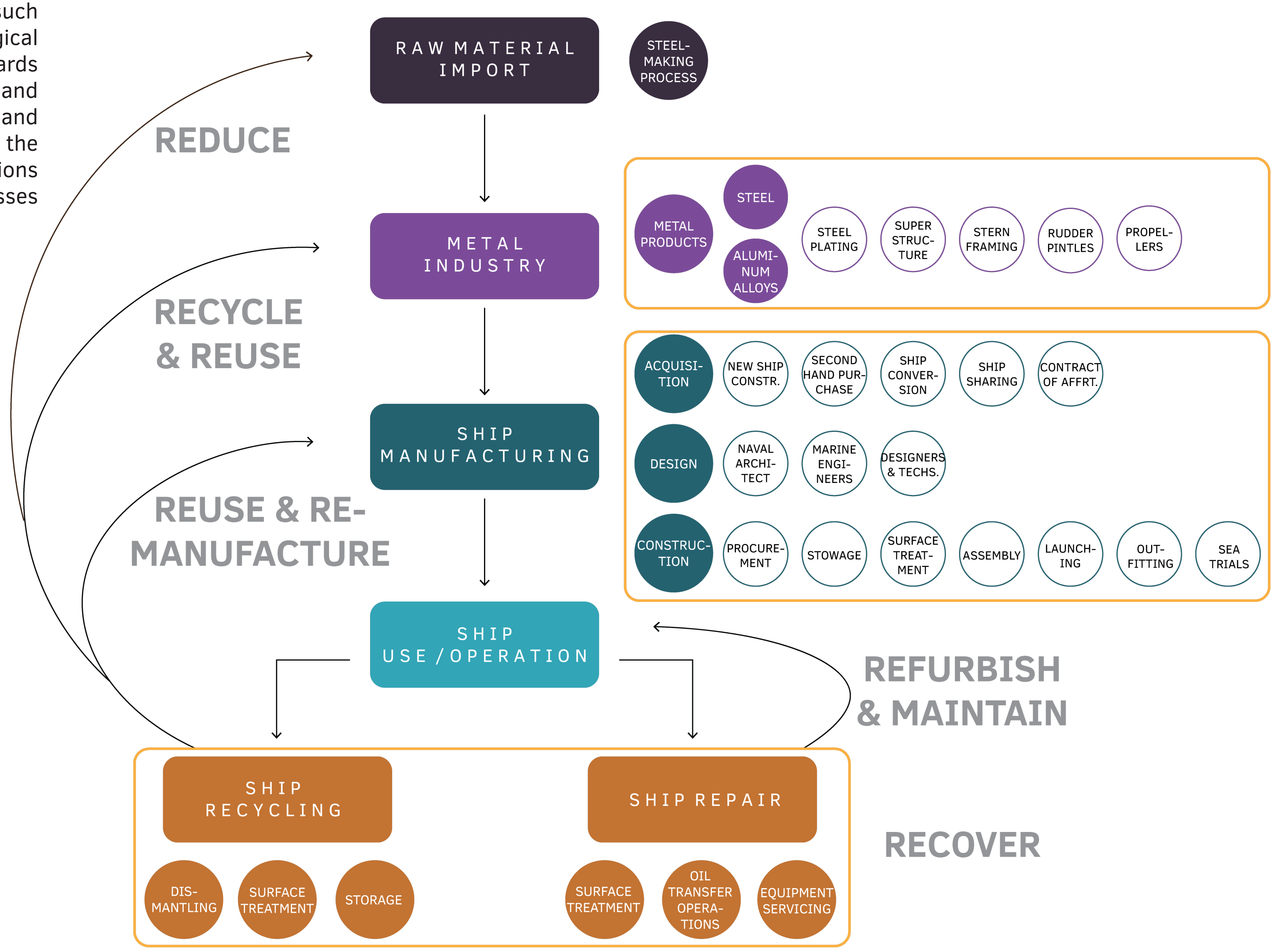


Figure 30. R-Hierarchies within a new circular manufacturing process

3.3 MAKERS INDUSTRY

3.3.1 MAKERS AND MARITIME MANUFACTURING

The evolution of the human race is fueled by the maker spirit. From the first hunting tools in the prehistoric days to the latest self-driving cars, through making is how we physically shape our world. Since the advent of the industrial revolution, ‘making’ became ‘manufacturing’[1] and mass production became commonplace in our search for efficiency and productivity. With the ascent of globalization, and the increasing price competition because of it, the art of making fell into decline and manufacturing was increasingly outsourced outside of European cities or physically moved outside of the boundaries of local urban areas.

Today making has gained a new meaning and importance. On the one hand we have the makers who are part of the maker movement, characterized by individuals who use their own ‘ingenuity’ to create things (Dellot, 2015, p. 13). According to Dellot (2015), the maker movement came about because of people feeling lost and disaffected due to the rapid rise in the use of technology in our society. They were seeking to gain ‘mastery over technology’ and to get back their sense of ‘being in control’ (idem).

On the other hand, the term makers is also used to refer to city-oriented urban manufacturers, primarily small- and medium-sized manufacturing businesses that are placed in the urban fabric. These urban manufacturers depend on "knowledge, technical skills, ambition, sources of finance and concentrations of technology" that the cities can provide to them and/or they provide valuable services to other urban actors, such as hospitals, where physical proximity is important (Hill, 2020).

For the purpose of this report, makers^{ind} with lowercase M refer to individual makers (their meeting locations are referred to as makerspaces), and Makers^{mb} with uppercase M refer to urban manufacturing businesses (their physical locations are referred to as Makers Areas).

Maritime manufacturing centered in the Port of Rotterdam consists mainly of the manufacturing of large ships and floating structures and relies heavily on steel and other metals. Because of the large lead times, the distance between port and cities, and the distance between large companies and smaller supply and start-up companies, innovations do not occur rapidly (Hirschman, 2018). Yet, innovations are needed right away. With an average lifespan just shy of 25 years, 2050 is only ‘one ship-generation away’ (Lauber, 2020).

Makers^{mb} can play an important role in helping the maritime manufacturing sector to achieve its goals of halving its CO_2 emissions by 2050 and digitalizing its operations as well as to transition to a circular manufacturing ecosystem.

Makers^{mb} are more agile and more in tune with the latest innovations. According to PortXL, a maritime accelerator founded in the PoR, the majority of the maritime start-ups are founded by former professionals from the maritime sector (Hirschman, 2018), so they know and understand the maritime industry. However, maritime-related start-ups and scale-ups are currently missing dedicated Makers Areas and maritime Makers platforms where they can find and collaborate with each other (Hirschman, 2018). A situation that is one of the strengths of the makers^{ind} and the makers movement; all around the world there are physical makerspaces and makers faires where makers^{ind} can interact with and learn from each other.

[1] Manufacturing is defined as: 1) the transformation of physical material; 2) through labor, tools and/or machines; 3) resulting in a product; 4) and produced at scale (Hill, 2020)

3.3.2 SYMBIOTIC POTENTIAL

There is great potential for a mutualistic relationship between the shipbuilding industry and the Makers industry. Makers^{mb} can contribute to the shipbuilding companies with innovations in parts manufacturing and maritime technology, as well as offer educational and training spaces for the labor force. If physical proximity to Makers Areas is facilitated, makers^{ind} can make use of the tools and infrastructure for prototyping that Makers^{mb} already have.

The makers^{ind} community and makerspaces have a very low barrier to entry for individuals to start tinkering on their ideas. The shipbuilding industry can stimulate their employees to seek out opportunities to use their knowledge and expertise to become makers^{ind}, and they can be potential customers for and provide real-life testing ground to the Makers^{mb}.
A prerequisite for this symbiotic relationship is the availability of zone locations where Makers^{mb} and makers^{ind} can settle near each other.

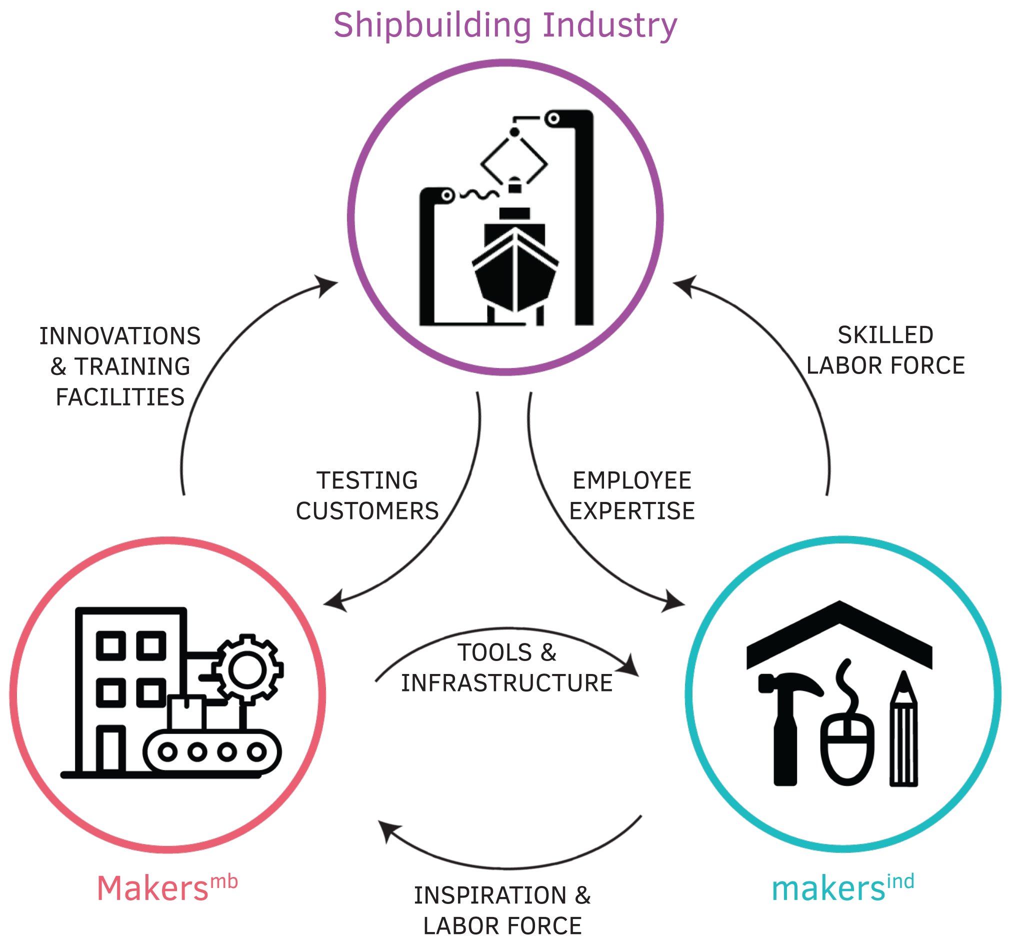


Figure 31. Potential for symbiotic relationships between shipbuilding, Makers^{mb}, and makers^{ind}

3.3.3 SPATIAL IMPACT OF MAKERS INDUSTRY

Sociologist Mark Granovetter distinguishes between 'strong ties' and 'weak ties' when classifying the strength of social connections between people. The strength of a tie refers to the ease of access to and the available knowledge, information, and resources a person has from people in their social environment (Granovetter, 1973). The best innovations around making tend to occur when people with 'weak ties' get together to share experiences (Hirshberg, Dougherty, & Kadanoff, 2016). Physical proximity is thus essential to enable the makers community to share ideas and resources, to co-create, and to inspire each other to an 'Aha moment'.

In addition to dedicated physical locations where the Makers industry can capitalize on their symbiotic relationship, regular maritime-related events are also valuable for interacting with other stakeholders in the circular economy. For makers^{ind}, makers faires are ideal events to interact with makers^{ind} from other regions, to engage the local community, and to help cultivate a maritime culture.

For Makers^{mb}, Maritime Makers Markets, their equivalent of the makers faires, facilitate the sharing of ideas among start-ups, scale-ups, universities, knowledge institutions, and shipbuilding companies. To capitalize on ideas generated during a Makers Market, skills hubs co-created with educational and knowledge institutions, and in collaboration with companies from the maritime sector and the city officials, provide an infrastructure to develop and train the skills necessary for emerging circular sectors.

POTENTIAL LOCATIONS FOR MARITIME MAKERS INDUSTRY IN SOUTH HOLLAND

Potential locations for dedicated Maritime Makers Areas are locations that have the following facilities within easy access, i.e., 2 km radius (10-15 min. cycling distance):

√ MBO, HBO, WO campus (knowledge)
√ Train station (accessibility)
√ Docking locations/small harbor infrastructure (accessibility)
√ Urban area (urban facilities & community)

Proximity to knowledge institutions, e.g., TNO, and existing business park zoning are a plus.

Furthermore, locations must be variable in size (space gradients) to accommodate different types of Makers^{mb} companies:

- Small-sized Makers Areas with makerspaces within high density urban areas (for example, Delfts Schieweg);
- Mid-sized Makers Areas for heavier tools and infrastructures in zoned business parks near urban areas (for example, Spaanse Polder).

Existing Makers Areas such as RDM and M4H can be blueprints for the new Makers Areas.

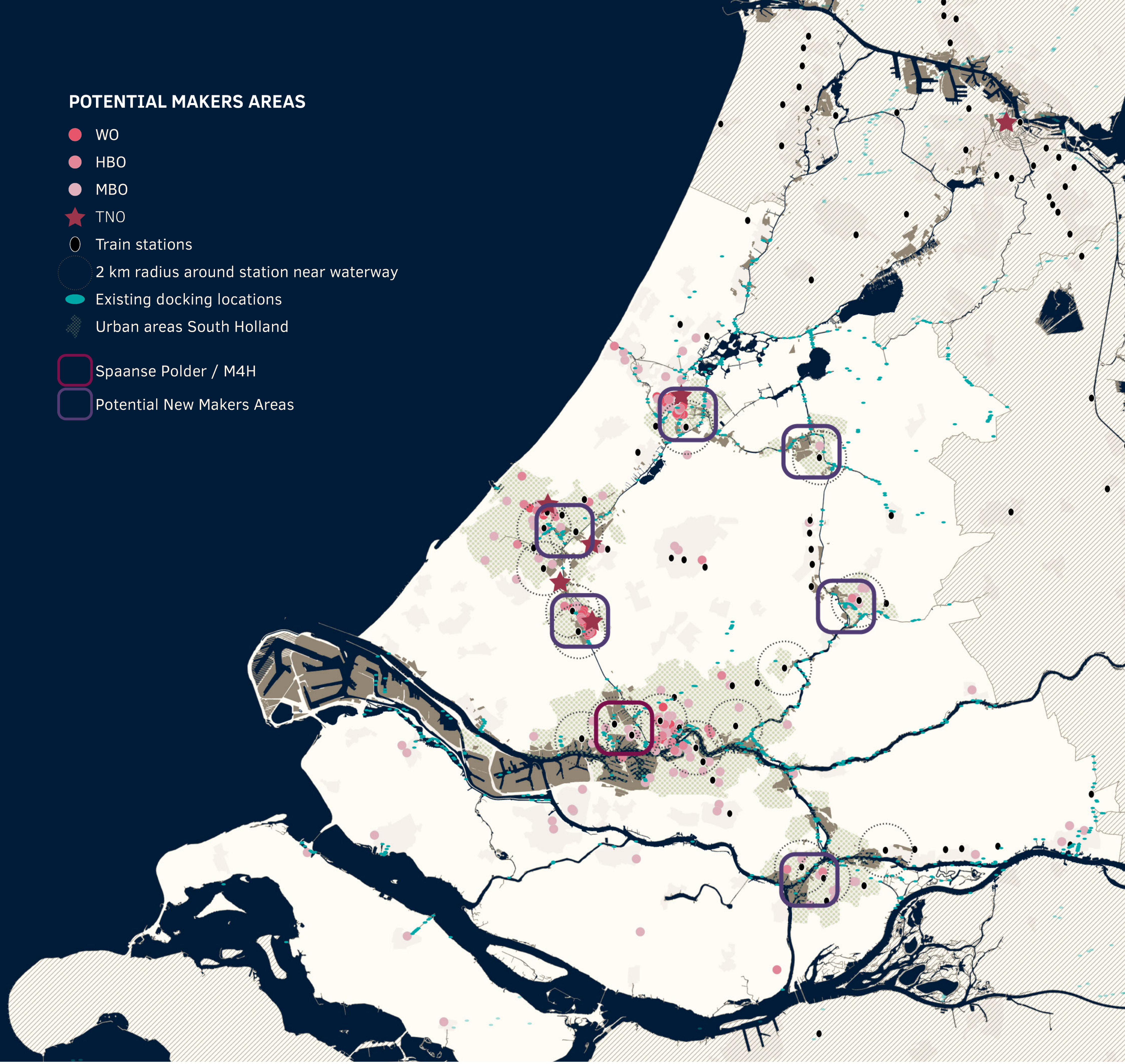


Figure 32. Locations in South Holland identified as potential dedicated Makers Areas based on the specified spatial criteria

3.4 SPATIAL CONDITIONS

3.4.1 ENERGY TRANSITION

According to the Port of Rotterdam's strategy for energy transition, the PoR will focus on green electricity, hydrogen, biomass, and waste for its energy systems in 2050 (WIRM, 2019). While planned green electricity projects like offshore wind farms are generally spatially low-impact, the hydrogen transition will likely bring immense spatial impact, especially on the existing petrochemical use. Specifically, out of several color-coded ways of hydrogen production, the port plans to use two (seemingly) clean methods: Green and Blue.

Green hydrogen uses electrolysis, requiring a large amount of electricity but not creating any further emissions in the process. Blue hydrogen, on the other hand, is largely identical to the dirtier Grey hydrogen: it uses Steam Methane Reforming (SMR), requiring natural gas and resulting in both hydrogen and greenhouse gases in the process. It is also relatively easy to make a transition to Blue hydrogen using the existing petrochemical infrastructure. Blue hydrogen differs from Grey hydrogen in carbon capture, as the majority of CO2 emission created is captured and stored underground (Peters, n.d.) This does not mean that Blue hydrogen is fully sustainable, as other greenhouse gases like fugitive methane are not captured, making its greenhouse gas footprint greater than purely burning natural gas or even coal in some usage scenarios (Howarth & Jacobson, 2021). This is why the PoR plans to adopt Blue hydrogen production as a short-term measure, while the large-scale renewable energy infrastructure for Green hydrogen production is being prepared.

In the long-term, the Blue hydrogen will be eventually phased out and fully transitioned into Green hydrogen production (WIRM, 2019). The Blue hydrogen transition will be facilitated as soon as 2024, with the finishing of the PORTHOS project that stores captured carbon in the gas cavities under the North Sea, and the Green hydrogen transition will start around 2030 with extra wind farms on the North Sea combined with electrolysis facilities. This will mean that existing petrochemical facilities will likely stay a similar size for the time being, but after 2030, it will require spatial intervention to make a transition into new suitable uses.

Refer to appendix D (p. 207) for an overview of sustainable energy projects in 2021.

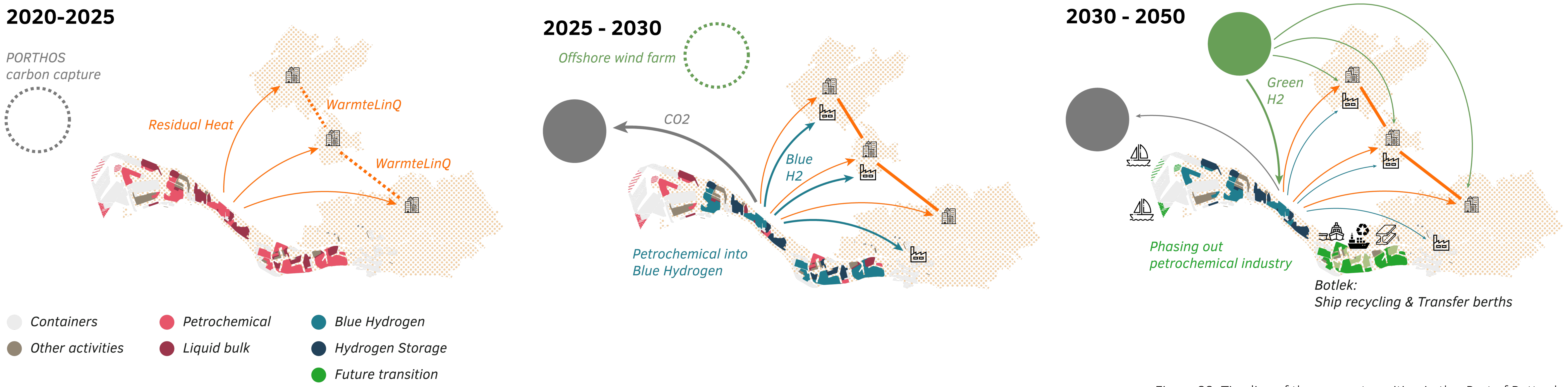


Figure 33. Timeline of the energy transition in the Port of Rotterdam

3.4.2 TRANSPORT AND INFRASTRUCTURE

In terms of energy efficiency, inland water transport (IWT) is undoubtedly the most sustainable mode of all modes. When transporting bulk cargo, it uses a mere quarter of energy per ton-km compared to road transport and 53% compared to rail transport. Even on lighter container cargo, IWT still consumes 44% and 56% of energy compared to road and rail, respectively (PLANCO & BfG, 2007). This efficiency primarily comes from its scale: the standard Kempenaar Barge (Class 2) can transport 655 tons of bulk cargo, an equivalent of 22 freight trucks, and a Neokemp container ship can transport 32 20ft containers, an equivalent of 16 trailer trucks (Bureau Voorlichting Binnenvaart, 2016). This suitability for transporting heavy bulk cargo makes it ideal for transporting materials for maritime manufacturing, which involves metal, scraps, soil, hydrogen, and more. It is clear that the benefits of IWT are aligned with that of this project, not to mention that the resulting strengthened maritime sector can benefit from and adapt to the increased demand for localized inland vessels for South Holland. Based on this assessment, we decided to use the inland waterways as the primary armature for transporting resources like waste and materials.

One shortfall of IWT is that it is generally not suited for rapid passenger transport, as high-speed passenger vessels require wider waterways (Gemeente Delft, 2021). This is the case for the Maasvlakte - Rotterdam – Drechtsteden corridor, where rapid ferry service is well-established; however, in the densely populated inland areas of South Holland, it is unfortunately not the case. This is why alternative modes of transportation are also important for the movement of passengers. Thankfully, almost all of the areas along the waterways that pass through major urban areas of South Holland are also served by motorways and railways.

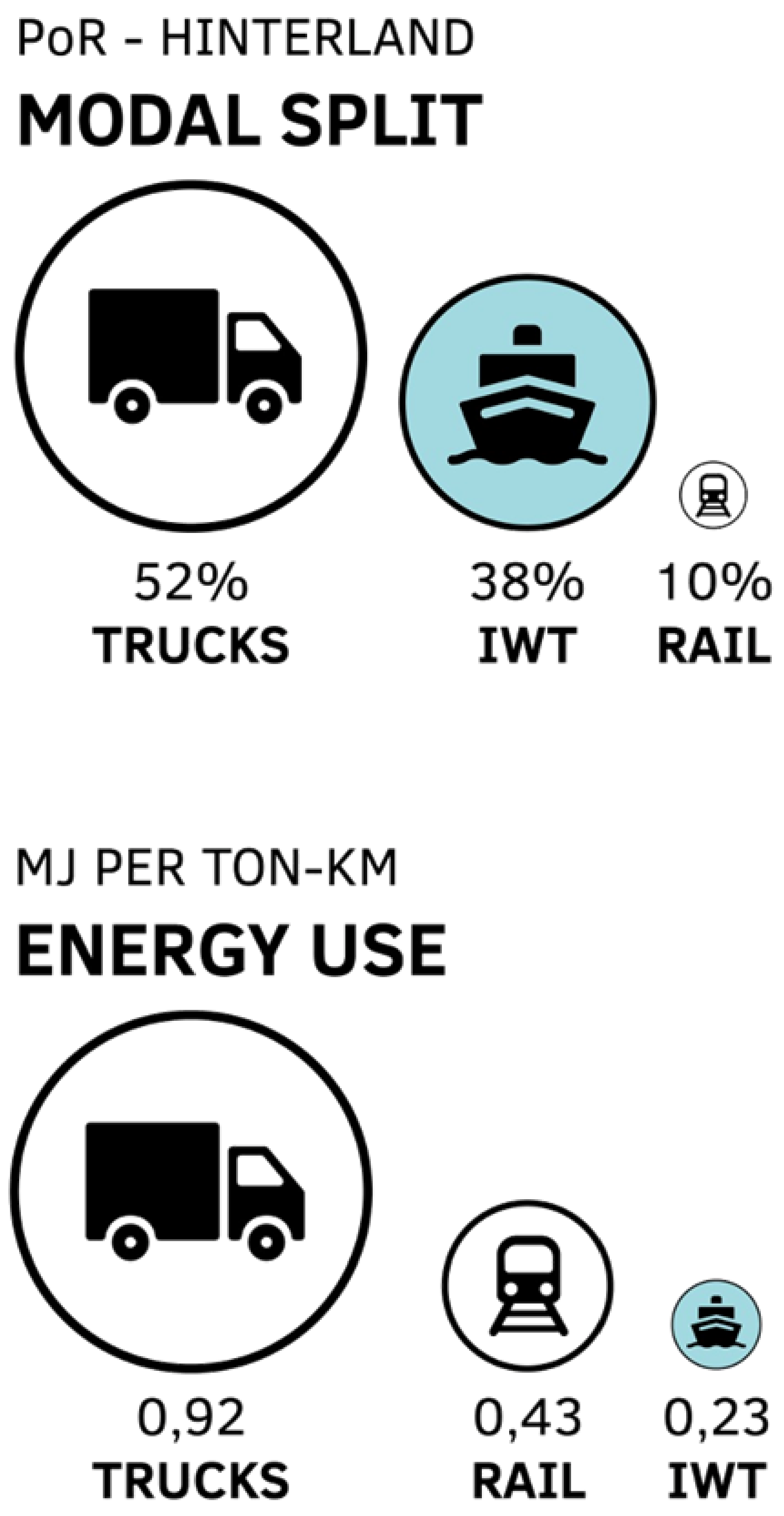


Figure 34. Diagram of modal split

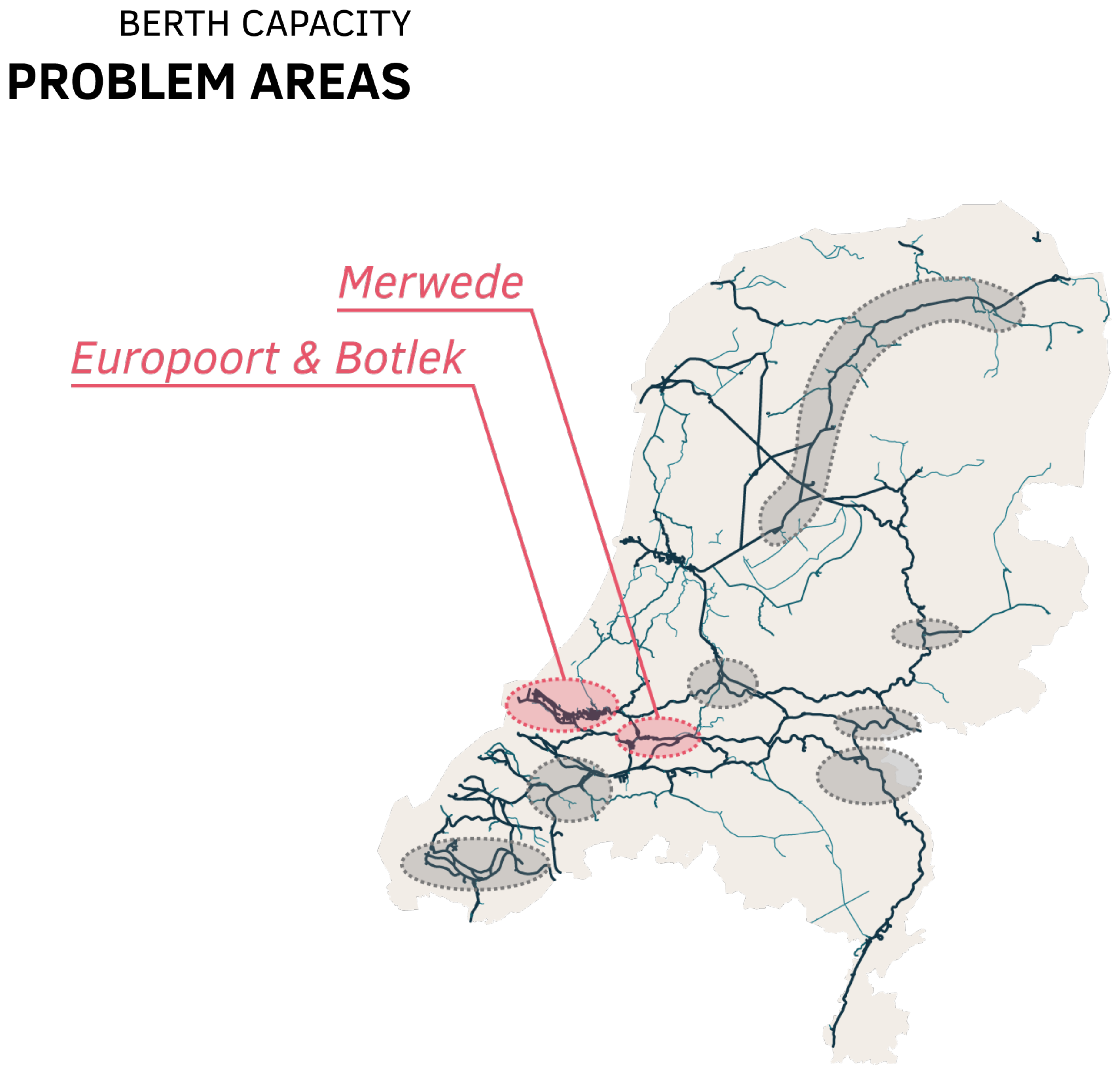


Figure 35. Diagram of main problem areas for IWT

In terms of infrastructural limitations on IWT, the permitted vessel size clearly differs between corridors. The western corridor between Rotterdam – Delft – Den Haag - Leiden is relatively smaller than the eastern counterpart of Rotterdam – Gouda – Alphen a/d Rijn, as larger ships of class 4 or higher can be only traversed through the eastern corridor.

This can guide the directions of future industrial developments based on the weight of the cargo: nurturing knowledge-based small-scale makers in the western corridor (knowledge corridor), while focusing on heavier material-related industries in the eastern corridor (materials corridor).

Apart from the vessel size limit, other significant infrastructural limitations on IWT capacities are generally limited to areas outside of the hinterland of Port of Rotterdam; however, the IWT transporters suggest the port itself lacks sufficient berths for ships to moor on (COV, 2012).

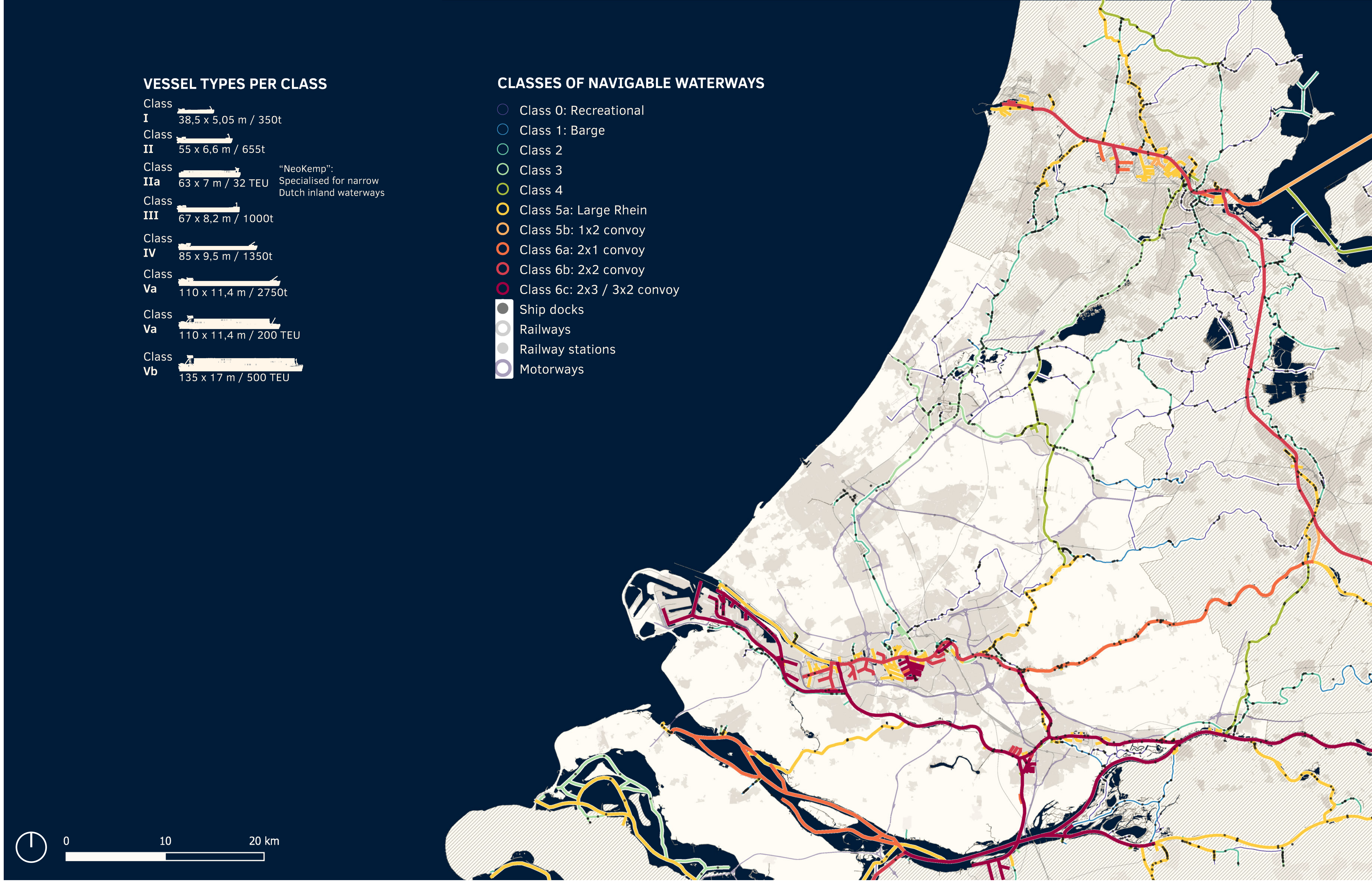


Figure 36. Map showing the classes of navigable waterways and some of the corresponding ship sizes

3.4.3 LANDSCAPE QUALITIES

Unstable Soil Conditions

Based on the map of soil conditions, it is clear that the east of the province is predominantly covered in peatlands and flood plains; this is one of the reasons why the area is still kept as part of the "Groene Hart", literally "Green Heart" in the center of highly urbanized Randstad.

Peatlands are extremely unstable soil that is expensive to build upon, which is costing municipalities like Gouda considerable money on extra infrastructure maintenance like roads and sewers. Not only is it costly, but also drained peatlands will oxidate and produce greenhouse gases, which are responsible for almost 6% of the global annual anthropogenic CO2 emissions.

This subsoil instability has resulted in a high level of land subsidence in the area. It is not ideal to attract too much residential development around the area, but rather to find an alternative with water-based, environmental solutions that can adapt to climate change.

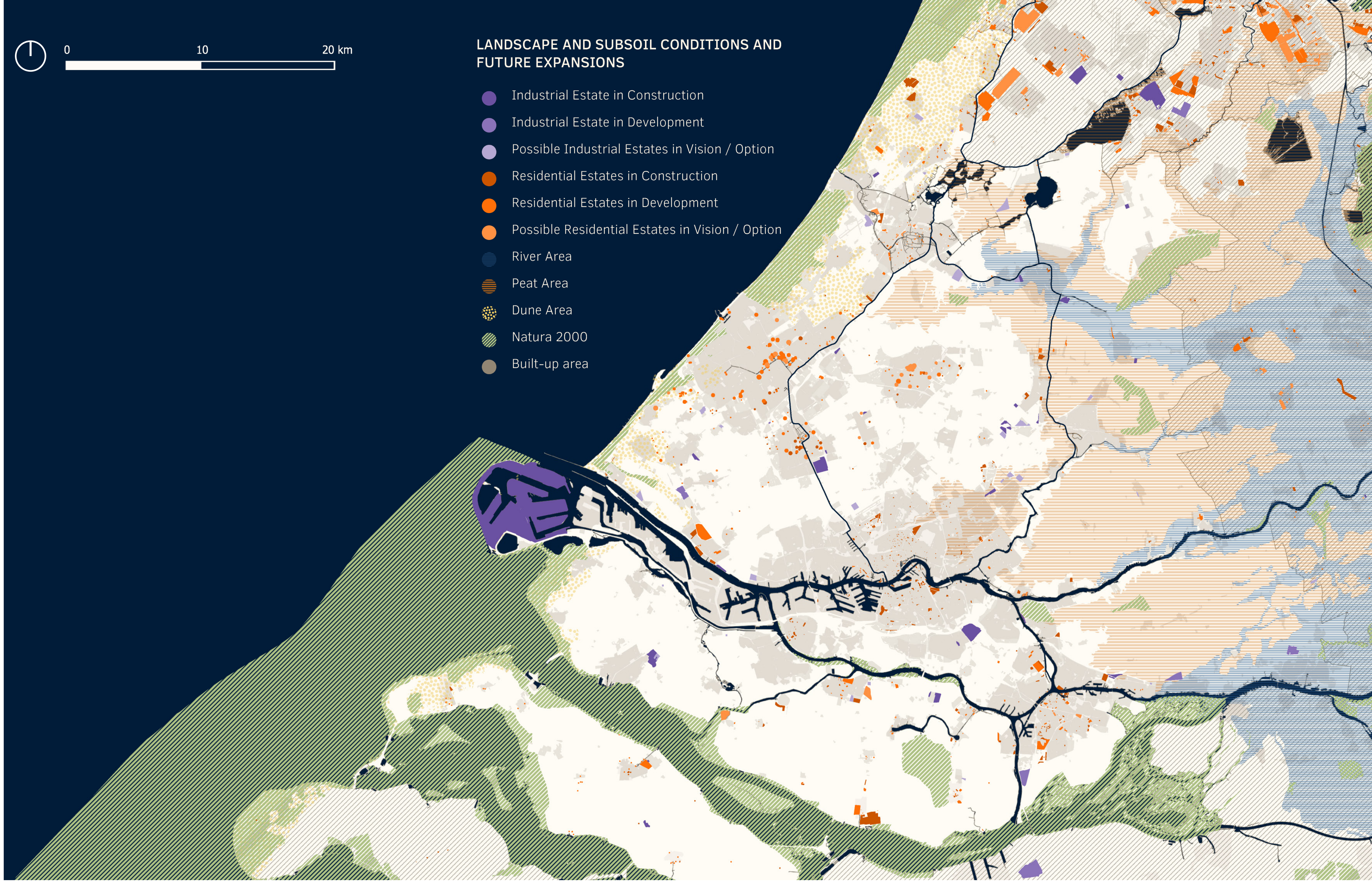


Figure 37. Map showing subsoil conditions

Flood Risks

Flood protection is lacking in some areas along the river, with large patches of unprotected natural plains in the south-east. These strips of unprotected lands are also not ideal for settlements in general, but for some industries (including maritime manufacturing) that require the facilities to be closely related to the waterways, it can be an ideal location.

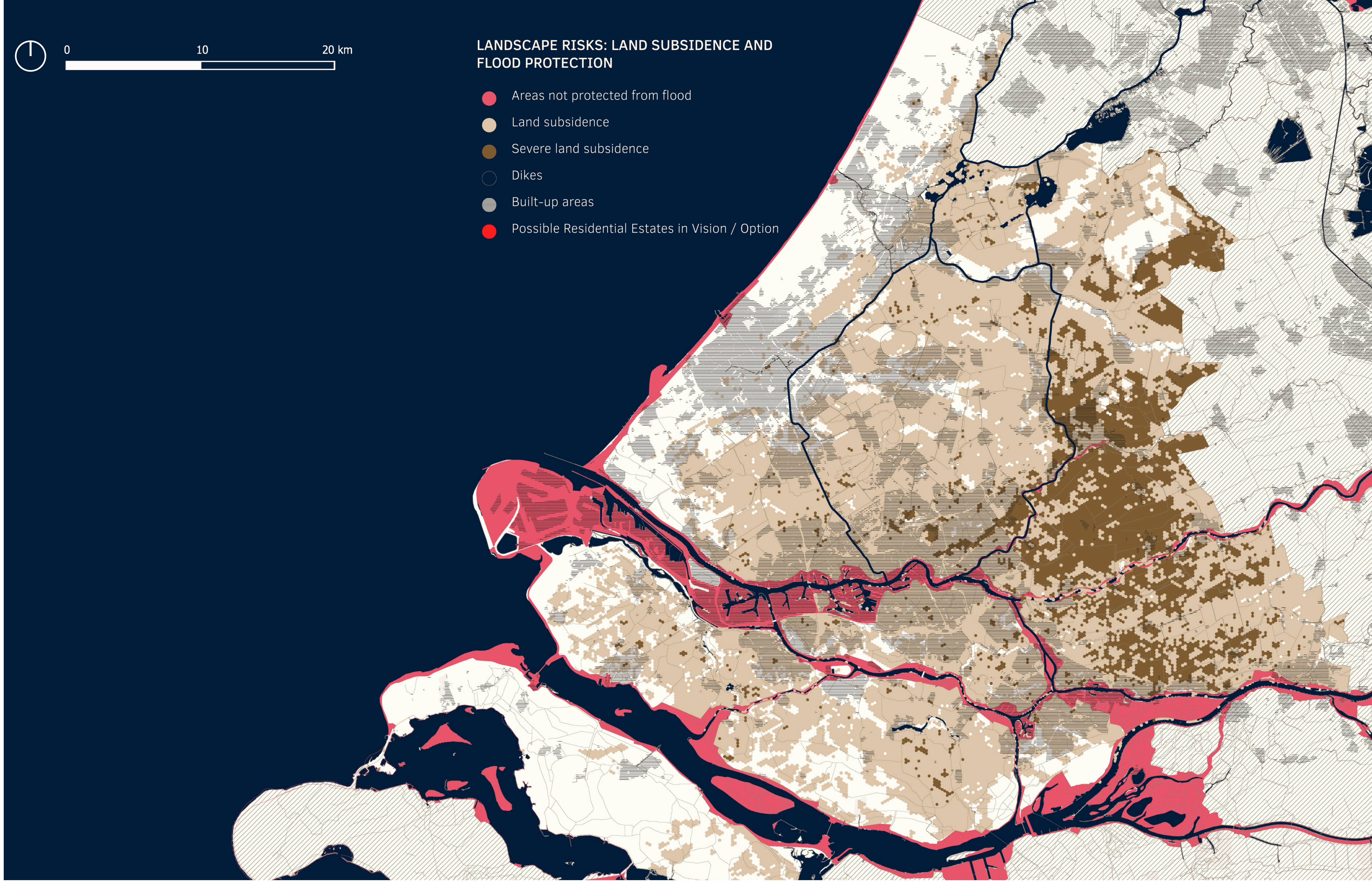


Figure 38. Map showing land subsidence combined with "buitendijkse gebieden"

Public Rights to a Green-Blue Space

Land use along the waterway corridor shows a great mix of functions, ranging from agricultural to industrial; inside the urban areas, the waterway is likely to be connected to the industrial areas, while between patches of urbanized areas, it is predominantly located between vast agricultural landscapes.

However, even though the traditional green-and-red dichotomy is fairly well balanced along the waterways, it is worth noting that the green areas along the waterways are not publicly accessible; in fact, the publicly accessible green spaces are relatively lacking along the waterways compared to other parts of the province. This is especially noticeable in the eastern part of the corridor compared to the western part, where more urban parks and coastal dunes provide an extensive network of public green spaces.

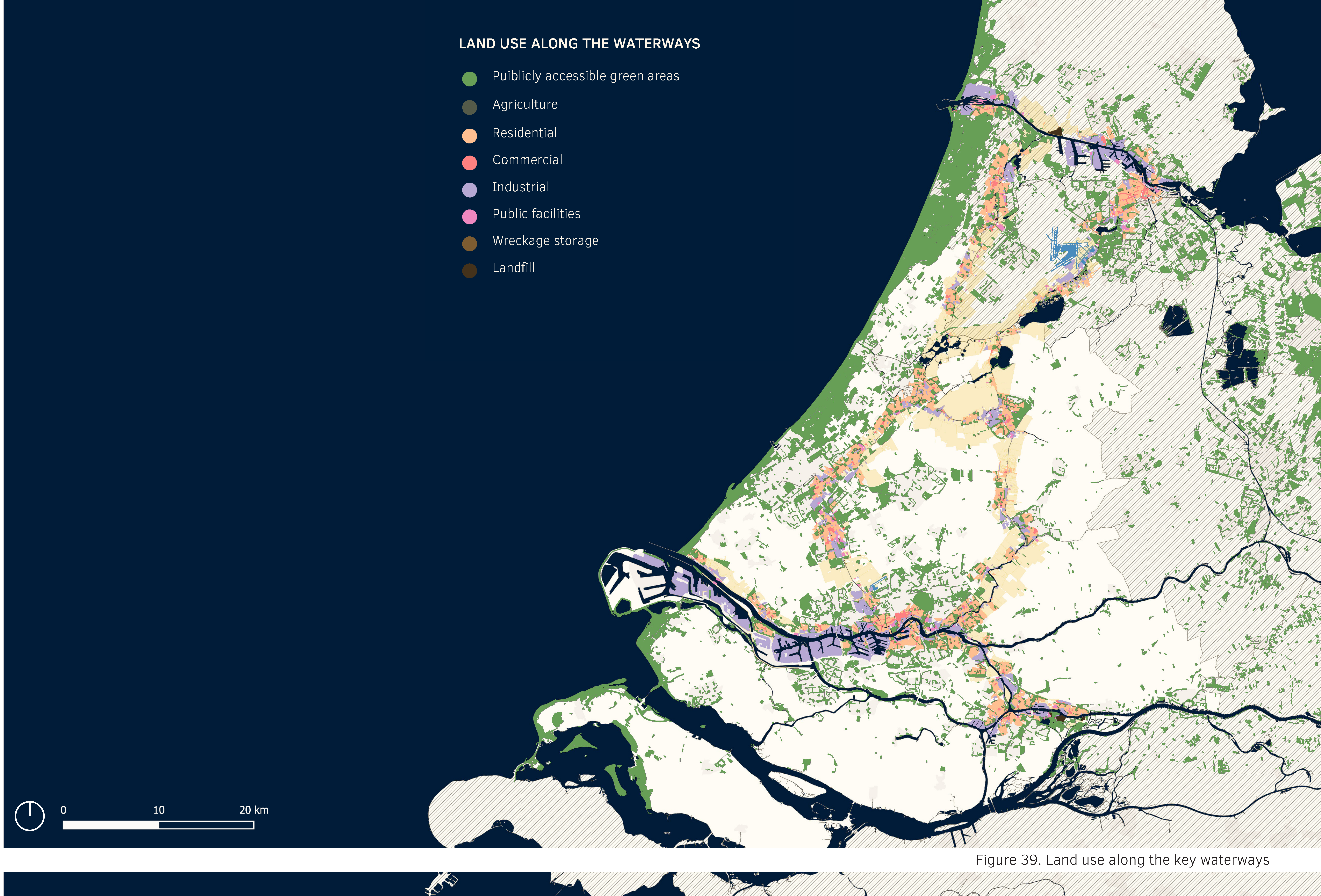


Figure 39. Land use along the key waterways

3.4.4 SOCIAL CHALLENGES

Poverty Index

As industrial transition inevitably involves both creating opportunities and taking away jobs from large groups of people, it is crucial to address changes in the socio-economic situations of each neighborhood. In order to address this, we created a formula based on the unemployment rate of working-aged citizens weighted by the percentage of households living below or around the social minimum. This way, we addressed the neighborhoods that are not only struggling to access jobs but also squeezed out of decent jobs. In line with our goals, we have found that the existing waterway-connected Makers Areas of Binckhorst (Den Haag), Schieoevers (Delft), RDM/M4H (Rotterdam) are located near impoverished neighborhoods; the majority of them started as working-class neighborhoods. This also concludes that the creation of new job opportunities will be well-connected to the impoverished areas.

Furthermore, we compared the formula in the 10-year span (2009 vs 2019) using the same metric. As the median difference of -5 shows, the socio-economic status in the majority of the neighborhoods has been improving across the province; however, neighborhoods around the port have been noticeably falling behind, especially the traditional maritime manufacturing region Drechtsteden was noticeably lagging behind.

Spijkenisse and Rozenburg, where a large part of the population relies on the petrochemical port activities, were also already falling behind, suggesting further socio-economic vulnerability that can be exacerbated with the energy transition of the area. Therefore, knowledge institutions and educational facilities should also actively retrain the vulnerable workforce relying on the existing industries.

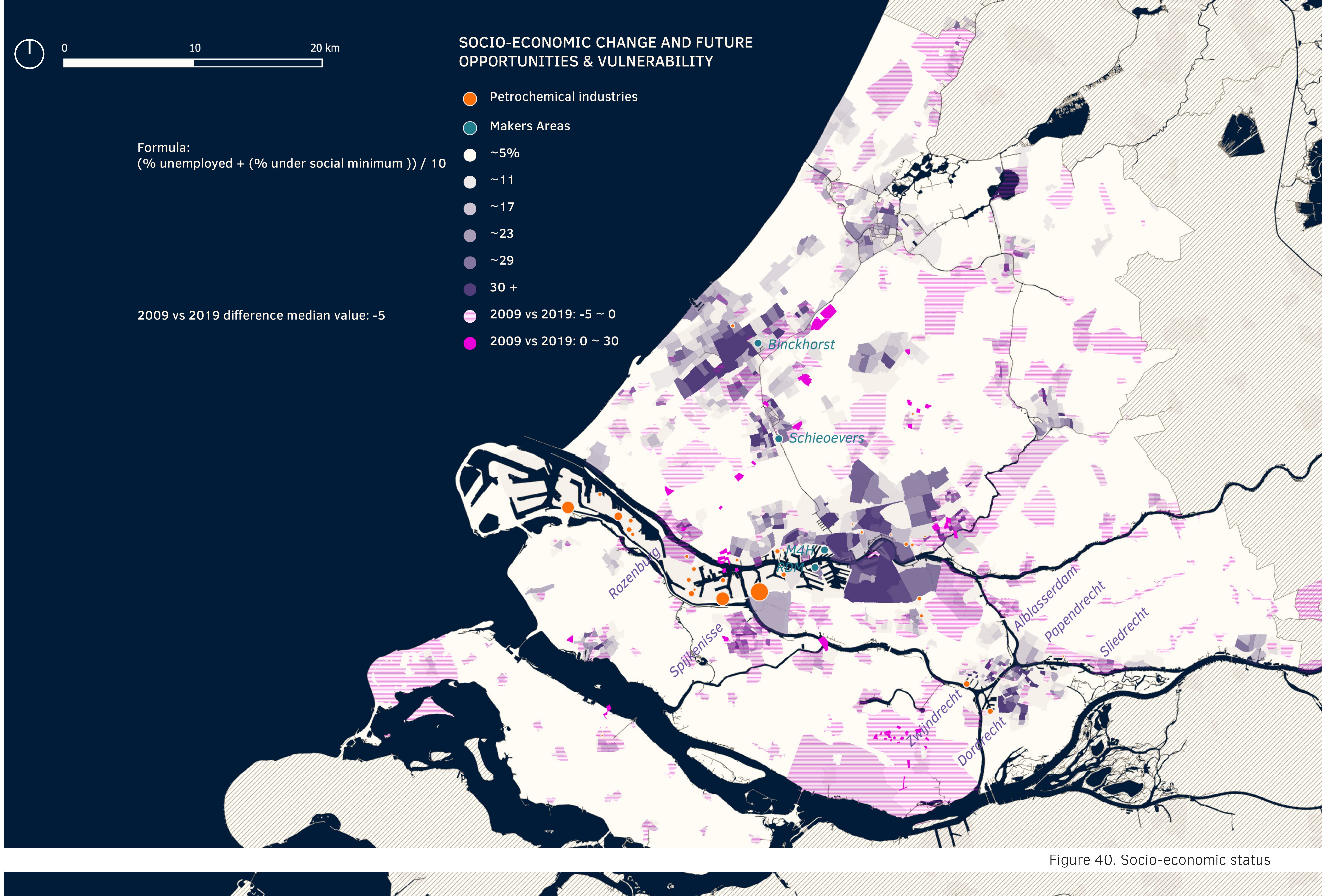


Figure 40. Socio-economic status

3.4.5 ENVIRONMENTAL CONSTRAINTS & ZONING

Conform Dutch spatial planning practices, different industries are categorized according to an environmental code. This environmental code represents the distance that must be applied between an industrial site and a residential neighborhood (VNG, 2009). The figure on the next page shows the different industries connected to the maritime sector and their environmental zones, categorized in scent, dust, noise and danger distances.

The Dutch zoning plans of the different municipalities must keep this direction when planning new residential neighborhoods near existing industrial sites or the other way around. But a recent change in the Dutch spatial planning practice with the introduction of a new all-embracing zoning instrument (Omgevingswet) made it possible to reconsider certain boundaries of the environmental zoning law that had been implemented in 2003.

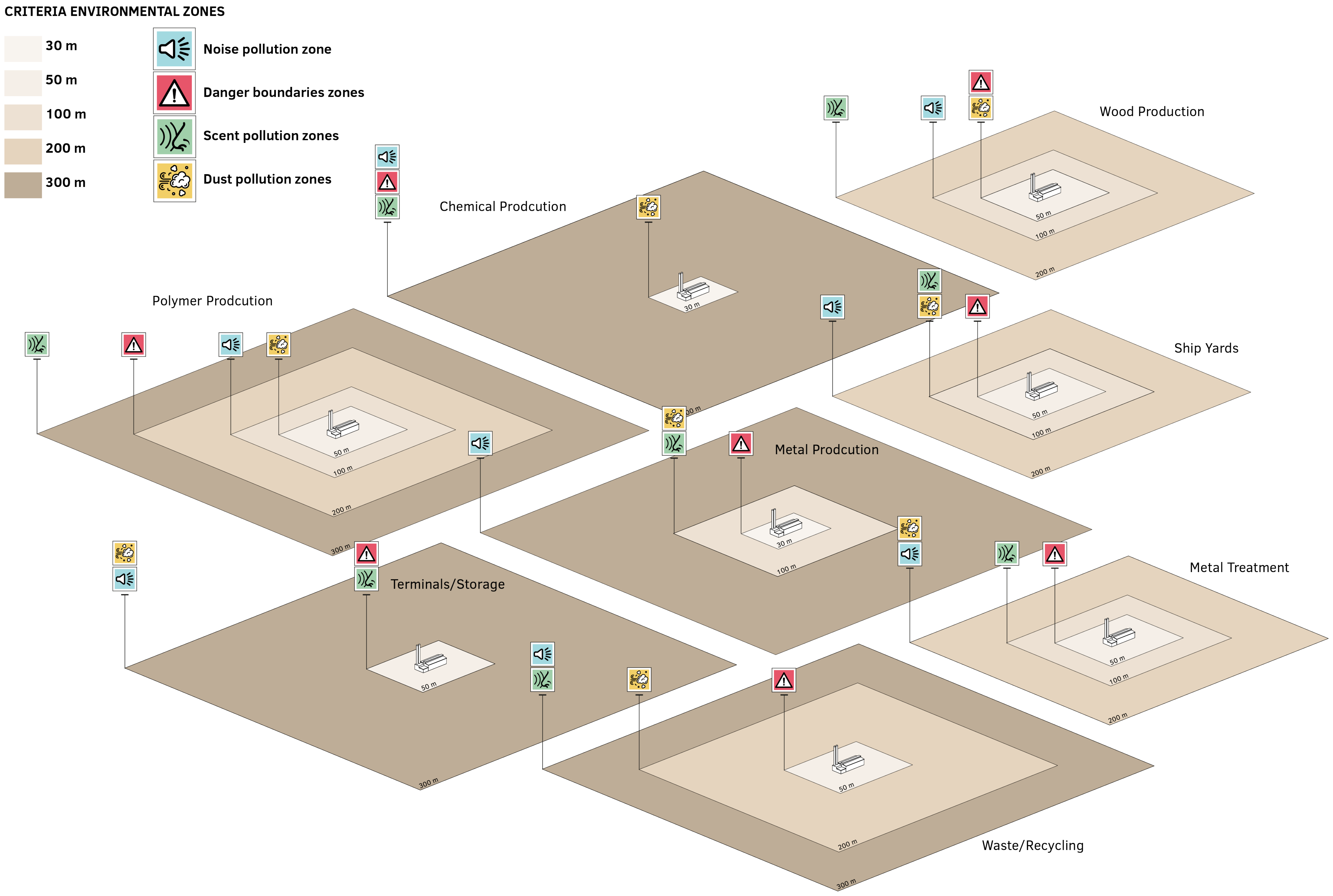
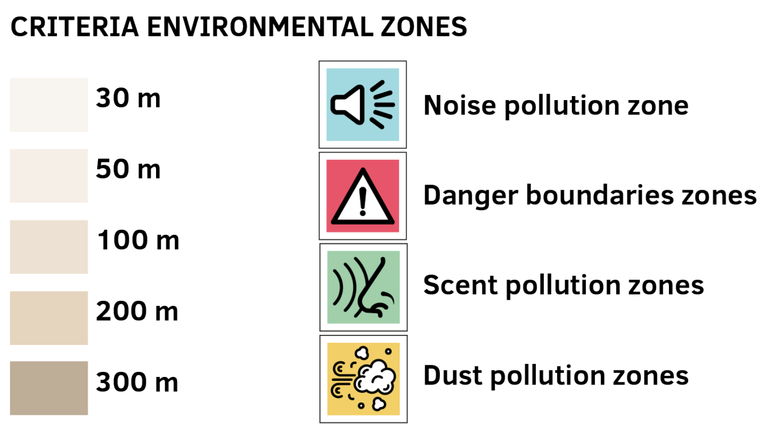


Figure 41. Spatial configuration existing environmental zoning regulations of maritime manufacturing related industries (Author, 2022; based on VNG, 2003)

The new environmental zoning regulations have added another spatial environment. Next to the distance between industrial areas and residential areas, a new mixed typology is added. This mixed typology consists of zoning for residential, retail, office space and local industrial oriented businesses (VNG, 2019). Only in case of noise pollution does this have an impact on the environmental distance to a shipyard[1]. This means that when a mixed neighborhood is placed adjacent to a shipyard at a distance of 100 meters, this distance is sufficient.

[1] Only the shipyard is considered due to its lower environmental code



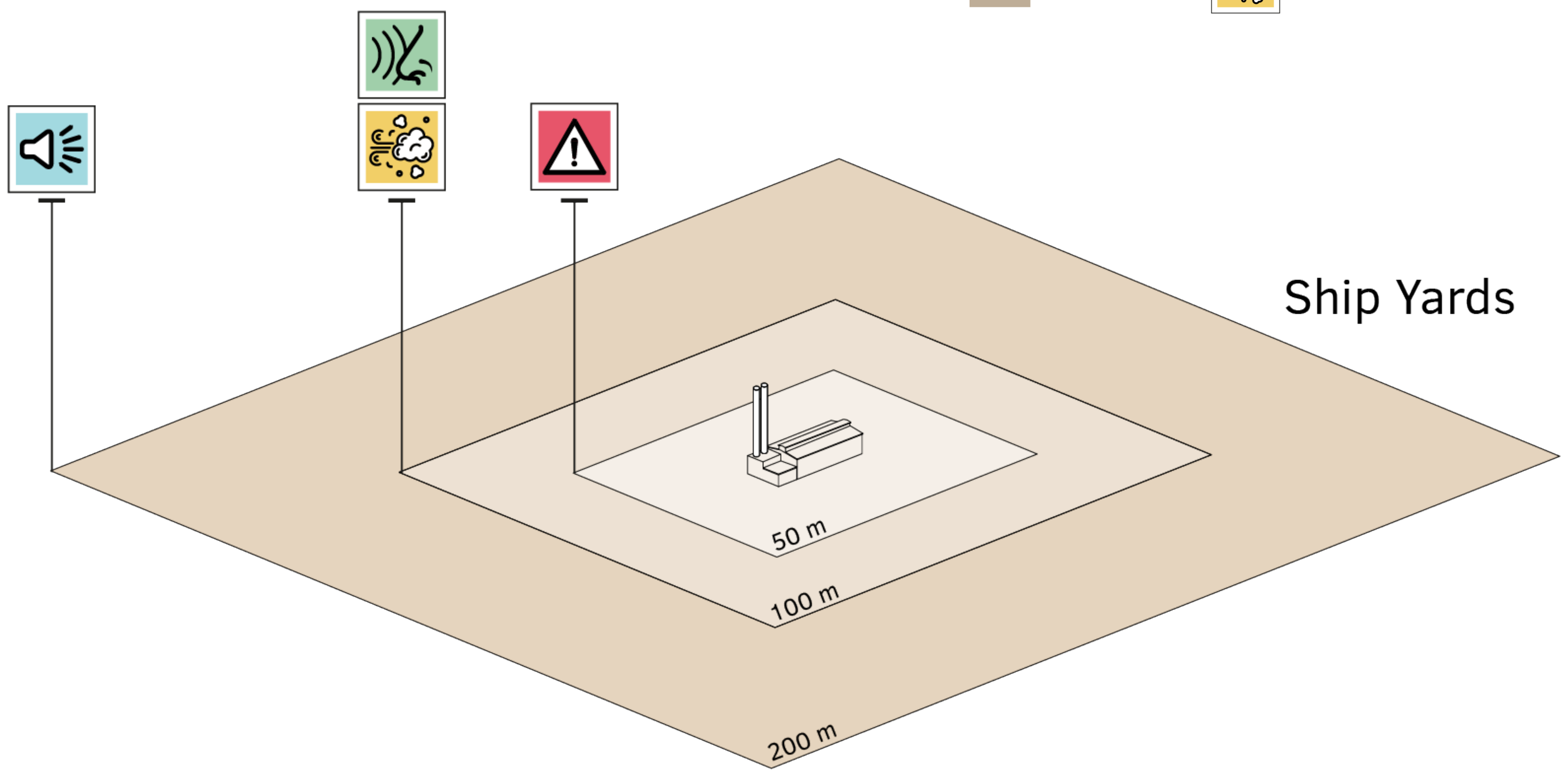


Figure 42. Spatial configuration existing environmental zoning regulations of shipyards (Author, 2022; based on VNG, 2009)

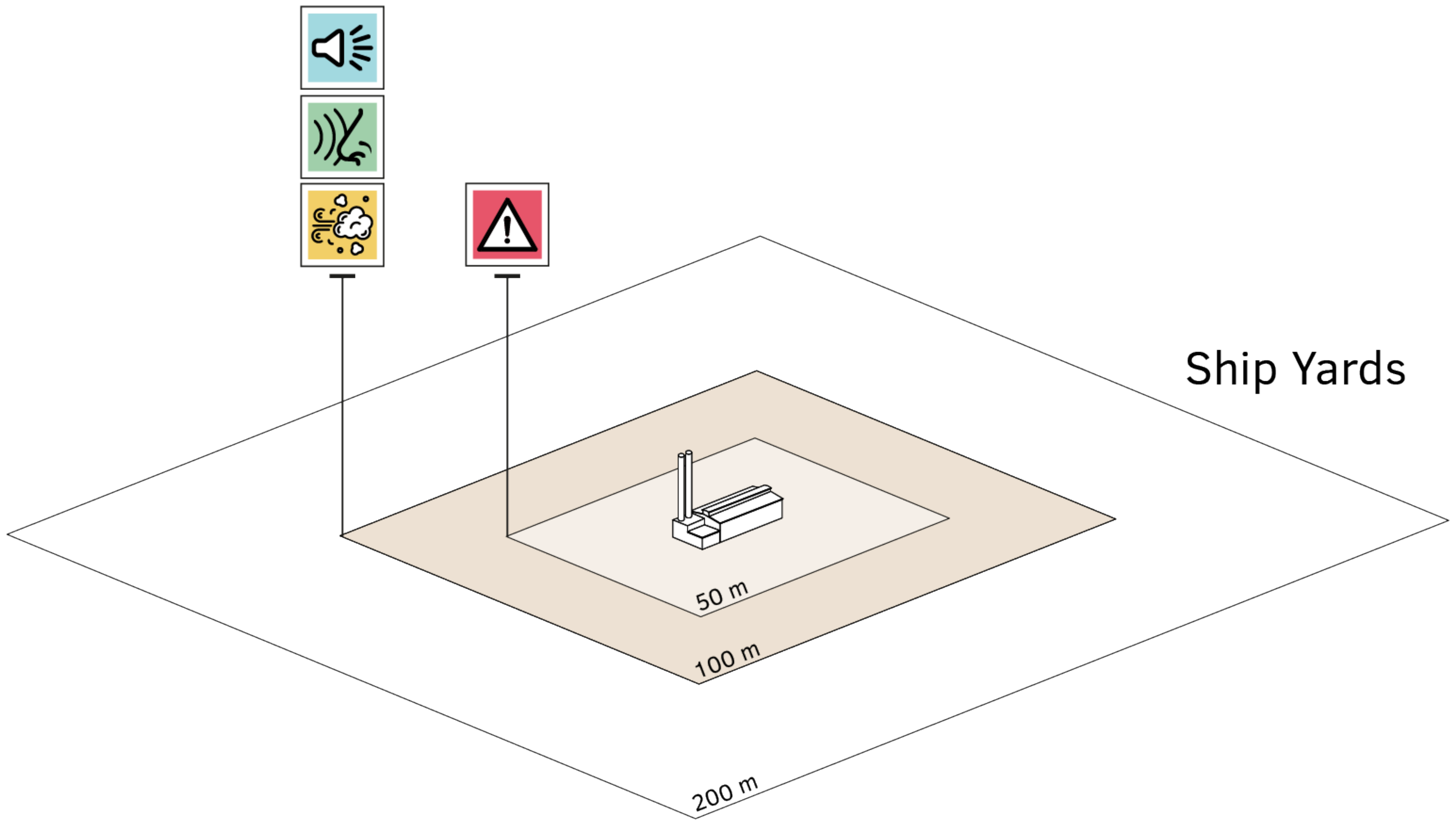


Figure 43. Spatial configuration new environmental zoning regulations of shipyards (Author, 2022; based on VNG, 2019)

3.5 EDUCATION & TRAINING

3.5.1 FOCUS ON SKILLS DEVELOPMENT

Since the second half of the 18th century, industrial revolutions were among the major disruptors of the global economy and in the related workplaces (Wallace, 2020). Until recently, the changes caused by these industrial revolutions alone in the work environment and in the skills required of employees have been relatively gradual. By 2020, 70 years after the emergence of Industry 3.0 (i.e., the era of digitalization), 63% of European companies and 70% of European municipalities have actively invested in their digital transformation (EIB Economics Department, 2021).

Almost a decade after the emergence of Industry 4.0, however, the COVID-19 pandemic unexpectedly added an additional disruptive force to the way we work, resulting in rapid acceleration of digitalization in the workplace, an increase in the adoption of higher-level automation powered by artificial intelligence, and making hybrid and remote working commonplace (World Economic Forum, 2020). In addition to this complex set of technological transitions affecting the work environment, there is an increasing urgency for climate action and for transforming our current linear and waste-based economy into a circular economy, which calls for a radical change to the supply and labor chain.

Achieving a successful digital transition together with a shift to a circular economy also requires a fundamental change in mindsets and skills from both employers and employees (Circle Economy, n.d.). Digitalization, automation, hybrid working, and circular economy will result in certain jobs becoming redundant, while new digital and 'circular' jobs emerge (World Economic Forum, 2020; Circle Economy, n.d.). These emerging job roles call for a different set of specialized skills and, more importantly, a greater emphasis on transversal[1] soft skills that can be used in different situations and industries (Goodwin Brown, Haigh, Schröder, Bozkurt, & Bachus, 2021, p. 14).

The expectation is that a circular workplace will increasingly involve inter-sectoral and multi-disciplinary work in multi-cultural teams with different educational levels (Havenvisie Rotterdam, 2019, p. 28; Goodwin Brown et al., 2021, p. 14). This new way of working puts the emphasis on skills development as a key factor for a successful and just transition. This signifies a paradigm shift in the labor market where skills are the new, dynamic, metric (Lu, 2019).

Studies into the existing labor market skills, unfortunately, paint a troubling picture. According to the WEF's research into the jobs and skills of the future (World Economic Forum, 2020), over 55% of the 291 surveyed global companies noted 'skills gaps in the local labour market' as one of the main barriers to the adoption of new technologies. The labor market research for the Haven- en Industriecomplex Rotterdam (Dekker, Zandvliet, & de Vleeschouwer, 2021) recorded that 70% of the surveyed companies have difficulties filling vacancies, primarily due to a lack of IT-related and key soft skills.

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[1] Transversal skills are also referred to as transferable skills (UNESCO-UNEVOC, n.d.)

Important soft skills for future jobs include:

(Havenvisie Rotterdam, 2019, p. 49; World Economic Forum, 2020; Dekker et al., 2021)

Figure 44. Important soft skills for future jobs

3.5.2 CLOSING THE SKILLS GAP

The existing, and likely to grow, skills gap therefore requires the (up-)skilling and reskilling of the current and future workforce by embedding circularity into education and employees' training programs (Dufourmont & Goodwin Brown, 2020, p. 9). Unfortunately, the current education and training system is not set up to accommodate the interdisciplinary and cross-sectoral schooling that is vital to develop flexible and broadly trained workers who can easily adapt to changing work requirements.

The current learning methodology is task-oriented, and life-long learning and continuous development is not embedded in the culture (Dufourmont & Goodwin Brown, 2020, p. 10). Furthermore, the uncertainty about the skills that will be needed in the future circular economy (idem) calls for an education system that is itself flexible and adaptable based on new insights on required skills.

The European Commission has identified vocational education and training (VET) as a key mechanism by which (up)skilling and reskilling of the labor force can be achieved (European Commission, 2020; Goodwin Brown et al., 2021, p. 6). VET puts skills development at the forefront, with vocational training undertaken at all educational institutions, including tertiary education (European Commission, 2020, p. 16). Additionally, VET contributes to social inclusion through Initial Vocational Training (IVET) as part of a labor market integration, and it supports lifelong learning through Continued Vocational Education and Training (CVET) (European Commission, 2020, p. 17; Goodwin Brown et al., 2021, p. 7).

Key success factors for VET (Goodwin Brown et al., 2021):

- Collaboration between educators, industry actors, researchers, and labor unions both to develop training programs through co-design and to validate new and future skills requirements;
- Interdisciplinary courses and innovative forms of learning, such as innovation centers and demonstration sites, that encourage knowledge exchange between industry and education;
- Digital learning environments and tools that combine online learning with on-the-job and workplace-oriented learning;
- Full governmental support through skills-centered policies and funding.

3.5.3 SPATIAL IMPACT OF NEW LEARNING SYSTEM

The Port of Rotterdam (PoR) underscores a VET approach to learning for the new economy. In their port vision report the following human capital ambitions are regarded as key guiding principles for achieving a just social transition (Havenvisie Rotterdam, 2019, pp. 59,62; Voortgangsrapportage Herijkte Havenvisie, 2020, pp. 31-38):

i. Strengthen high-quality training
ii. Connect labor market & education
iii. Attain an inclusive labor market
iv. Stimulate labor mobility

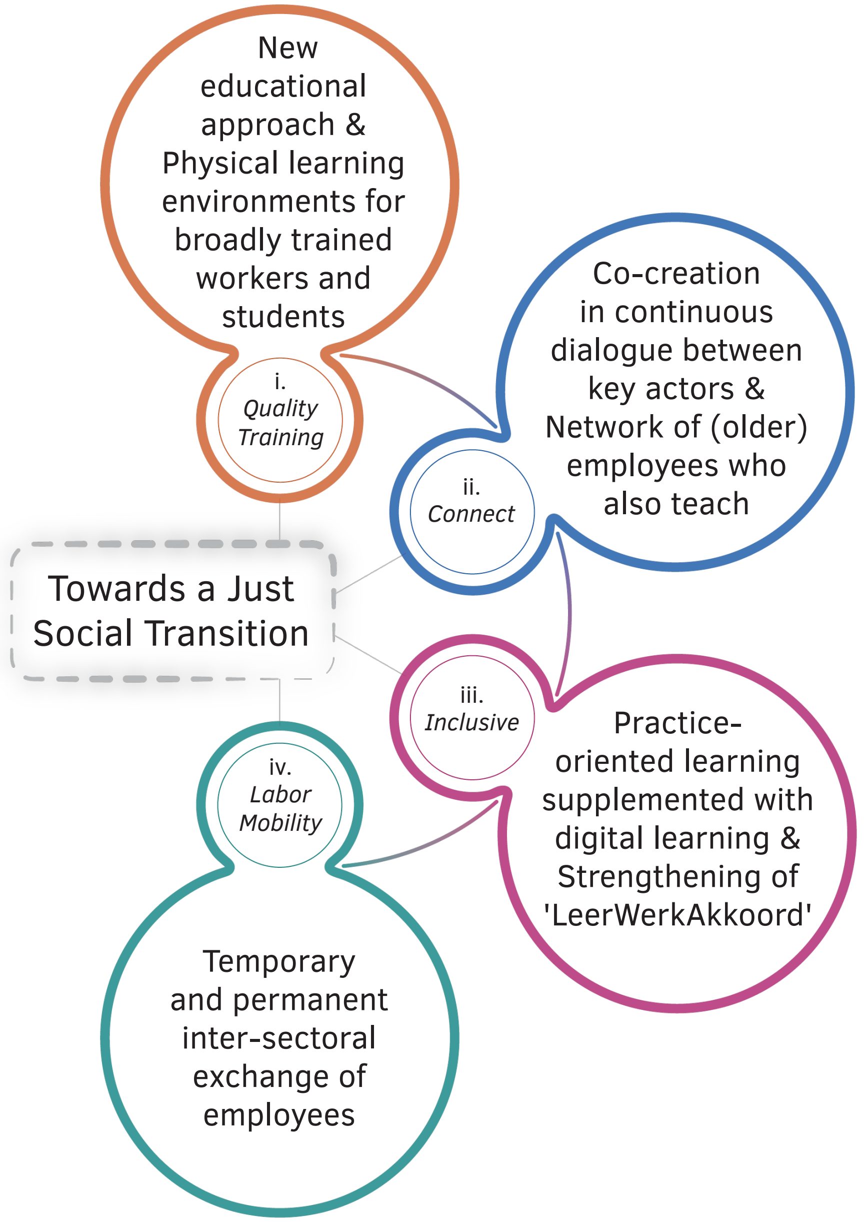


Figure 45. Key elements of Human Capital ambitions PoR

It is crucial to recognize that the learning program and approach should inform the physical learning environment, and not the other way around (Ifenthaler, 2012). Considering that we are currently operating in an economy in transition, and with the prospect that the pace of technological changes will likely continue to accelerate, the learning approach must therefore be flexible and adaptable. This means that the physical learning environment must also be flexible and adaptable. Furthermore, teaching relevant transversal soft skills, such as adaptability and effective communication, in addition to specialized 'circular job' skills requires dynamic physical learning environments that closely resemble the real-world complexity.

Dynamic physical learning environments have the added benefit of facilitating meeting and working together with student colleagues from different disciplines and education levels. They also provide a platform where employees from the shipbuilding industry can come and share their knowledge and expertise through live demonstrations. Live meetings between students and workers stimulate collaboration, and create the opportunity for cross-pollination of ideas, approaches, and knowledge. Physical locations close to urban areas can also be used in multi-functional ways, by opening the spaces to citizens for education on topics related to circularity and/or as community hubs.

IT-skills must become an integral part of all learning programs to ensure digital literacy of the labor force. Tools such as virtual reality and gaming can be used to simultaneously teach soft, specialized, and IT skills in an intuitive way. These digital tools also require modular spaces that can be easily adapted to new simulations and different group sizes.

Figure 46. Key spatial design principles for physical learning environments of the circular maritime manufacturing sector

In the new labor market paradigm where (soft) skills are the new metric, continuous development is the new normal, repetitive tasks are robotized, and circularity is synonymous with collaboration and labor mobility, everyone is highly skilled, just with a different combination or set of skills.

Traditional "low-skilled" labor activities, such as maintenance, (dis)assembly, and recycling activities, are as crucial for successfully running a circular economy as traditional "high-skilled" labor such as design engineering. Acknowledging the value of all actors in the circular ecosystem is the first step towards achieving a just social transition.

POTENTIAL LOCATIONS FOR PHYSICAL LEARNING ENVIRONMENTS IN SOUTH HOLLAND

Potential locations for new physical learning environments are locations that have the following facilities within easy access, i.e., 2 km radius (10-15 min. cycling distance):

√ MBO, HBO, WO campus
√ Docking locations/small harbor infrastructure (micro/mini shipyards)
√ Shipbuilding companies (large shipyards)
√ Train station (accessibility)
√ Urban area (urban facilities & community)

Furthermore, priority should be given to locations in proximity to Makers Areas.

Existing Learning Location RDM can be a blueprint for the new Learning Locations.

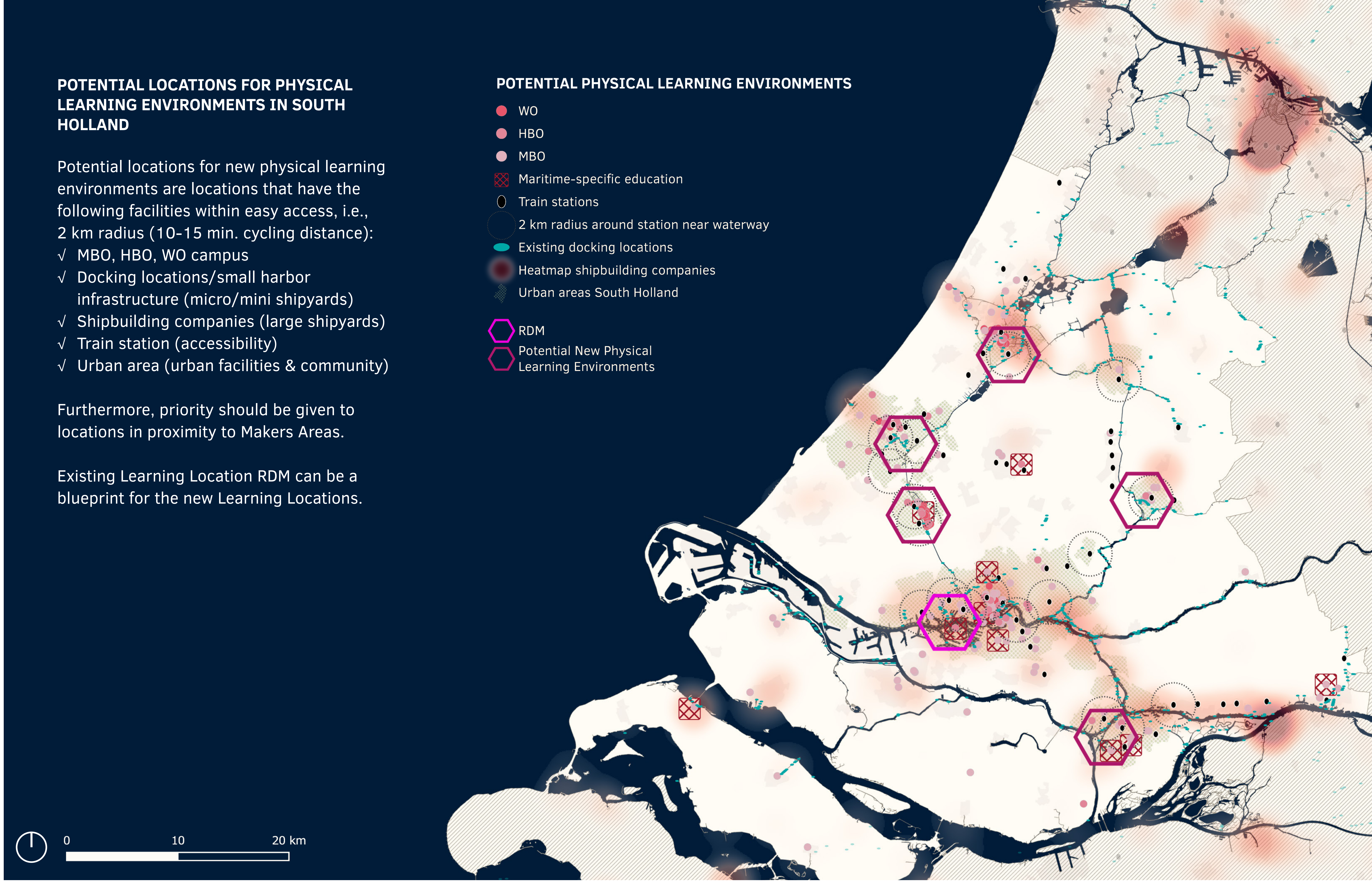


Figure 47. Locations in South Holland identified as potential physical learning environments based on the specified spatial criteria

3.6 SOCIO-SPATIAL QUALITIES

3.6.1 MANUFACTURING AND THE PORT

The process of maritime manufacturing is detached from the daily lives of people who use products daily that the port receives, makes, or delivers for them. For the rest of the South Holland region, the port has always been considered a hinterland, yet as the Dutch Maritime Strategy reiterates, "The ports are a perfect example of spatial relations in the maritime cluster, because they have a logistic hub function and they provide an important settlement location for (large scale) industry and service centers. This also allows other companies to benefit from the agglomeration and image effects arising therefrom" (Dutch Maritime Strategy 2015-2025). With the PoR as the main hub of heavy industry and manufacturing for South Holland, with potential to be more strongly linked to the region, it plays a crucial role in the development of the region for the future.

The strongest physical link between the PoR's maritime sector and the city are the waterways, thus we develop Port-Oriented Developments according to the principles of 'Cities of Making' and Industrial Symbiosis, interspersing the ship's life cycle into the physicality of urban cores, wherein people can pro-actively participate, engage, and contribute to the circular maritime manufacturing process, ensuring cross-pollination of knowledge, industry, and society. It is determined that the potential missing link to the shipbuilding industry's manufacturing process is shipbreaking, a sector that is yet to anchor in the Netherlands completely.

3.6.2 PORT-ORIENTED DEVELOPMENT

In comparison to Transit-Oriented Developments (ToD) wherein public transport is at the heart of each neighborhood and linked to the public transportation network covering a region, Port-Oriented Development (PoD) has the waterways as backbone for regional landscape development, including a network of living environments centered around makers-shipbreaking-bufferzones, characterized by enhanced harbor infrastructure, mixed functions, and living with respect for nature.

These PoDs, when integrated into the existing regional fabric, shall texturize and transform the new South Holland landscape with the PoR as the main engine, converging knowledge, industry, and society.

Principles of PoD

A. ***We consider the PoR as the driver of the entire urban system of the greater South Holland region through the backbone of the waterways.*** Existing waterways and the surrounding uses and activities are assessed in key locations to see potentials for sustainable transport and land use development along the riverbanks; introducing new possible combinations between the urban environment and nature.

B. ***Circular Manufacturing is integrated into the system through production of innovative knowledge in existing knowledge centers and by creating platforms for making and collaboration.*** 'Hydrophilic Seed Zones' for sorting and storage of high-value scrap that can be processed, and re-invented, are dispersed in between key urban areas. Refer to appendix E (p. 208) for a diagram of Hydrophilic Seed Zones.

C. ***Industrial Symbiosis forms the basis for people, networks, and policies to build a City-Territorial Symbiosis*** as bridged by the shipbuilding industry, education, other manufacturing sectors, alongside new 'seed' zones and Makers Markets.

D. ***Shipbreaking becomes a new industry that can become an anchor for cities*** to be more integrated in the process of circular shipbuilding, with buffer zones as interstitial areas that form a new industrial landscape that would create the living symbiosis of water, industry, and people.

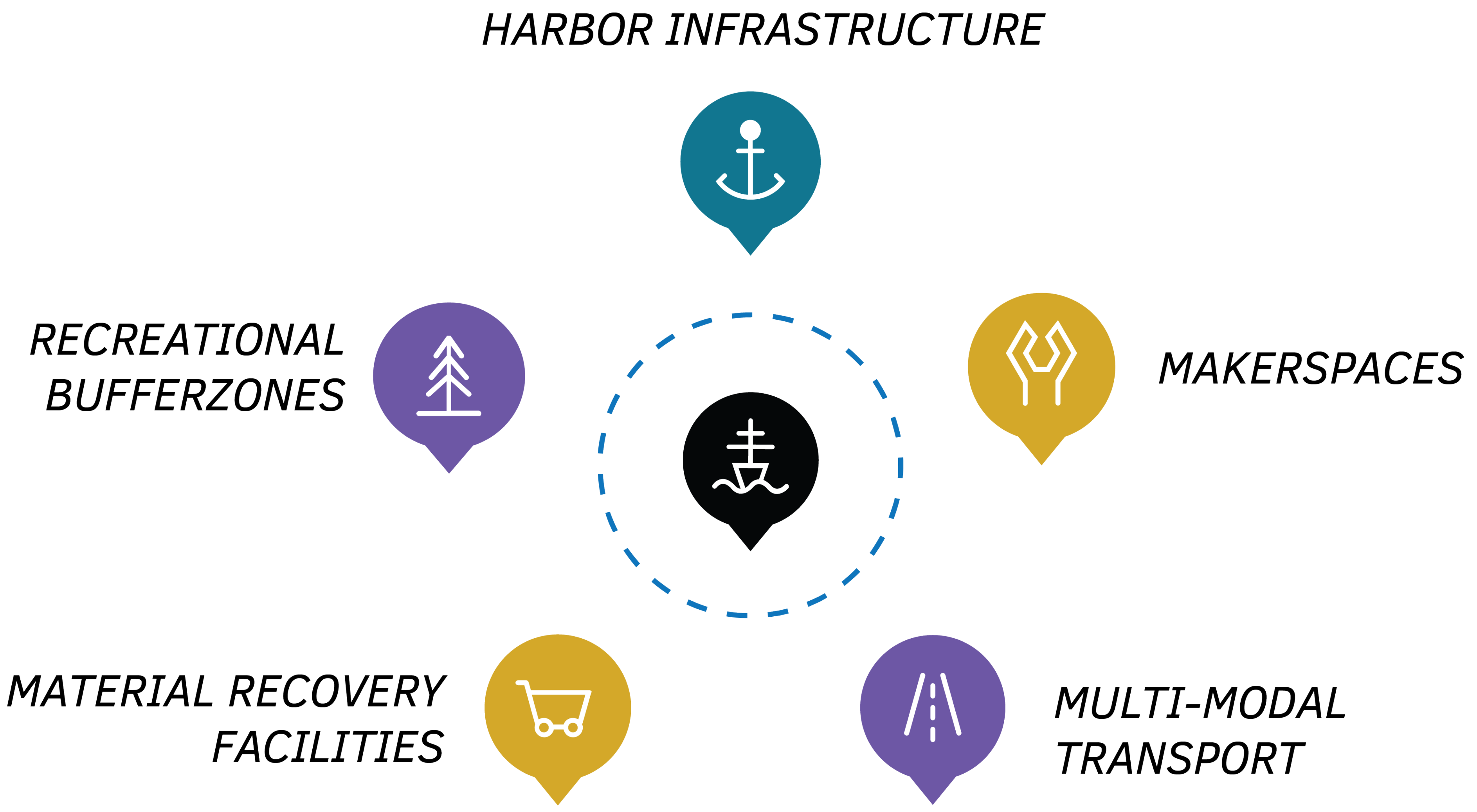


Figure 48. Spatial components of Port-Oriented Development

3.6.3 CIRCULAR ECONOMIES NEED CITIES

It is acknowledged that manufacturing in cities is propelled by people whose presence and participation, if entirely missing, would not make a circular economy possible. It is seen that South Holland has the most auspicious prospects for knowledge empowerment and cultivation that could spark and inform the regional transition to circularity. The activities associated with making in the city are processing materials, accommodating skills and new technology for repair and maintenance, as well as sound foundation for innovative technology (Hausleitner et. al., 2022). And we need people to perform and engage in these for the transition.

Looking at the urban form of South Holland, the waterways play an important role in facilitating services needed in industry, while intermodal connections (railway and highways) can be integrated to realize easy accessibility. Land use along the waterways (refer to figure 49) and their functions are looked upon to see their combinations and where they overlap or miss to serve the new manufacturing chain that could be more suitable for living.

Structure of the urban form:

- Waterways
- Transport network
- Building types
- Built density
- Centrality of locations
- Highways

Key locations as Delft, Alphen aan den Rijn, RDM in Rotterdam, and Nieuwerkerk are identified as potential urban core zones with key qualities based on their potentials to become Port-Oriented Development areas.

Figure 49. Potential zones with socio-spatial qualities suitable for circular maritime manufacturing identified in South Holland

Spatial Typologies along Waterways

The main spatial typologies that can occur on a local scale along the waterways as well as the possible combinations in which they can be implemented in the different local areas, taking into account certain environmental zoning rules and the concept of circularity in urban manufacturing, are depicted in an abstract way in figures 50 and 51 to be used for easy allocation and as a basis for future choices.

In figures 52 to 55 the chosen future combinations of spatial typologies for the selected key locations are shown, based on careful analysis of the existing spatial qualities of the selected locations.

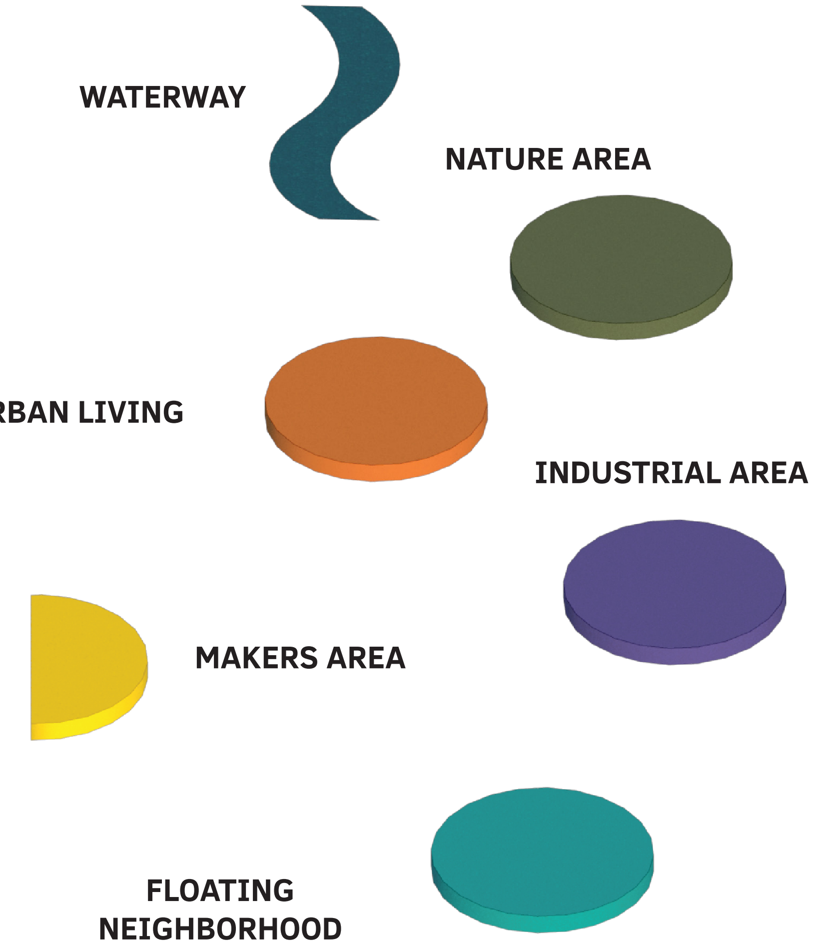


Figure 50. Icons representing possible spatial typologies that can occur along the waterways in South Holland (SH)

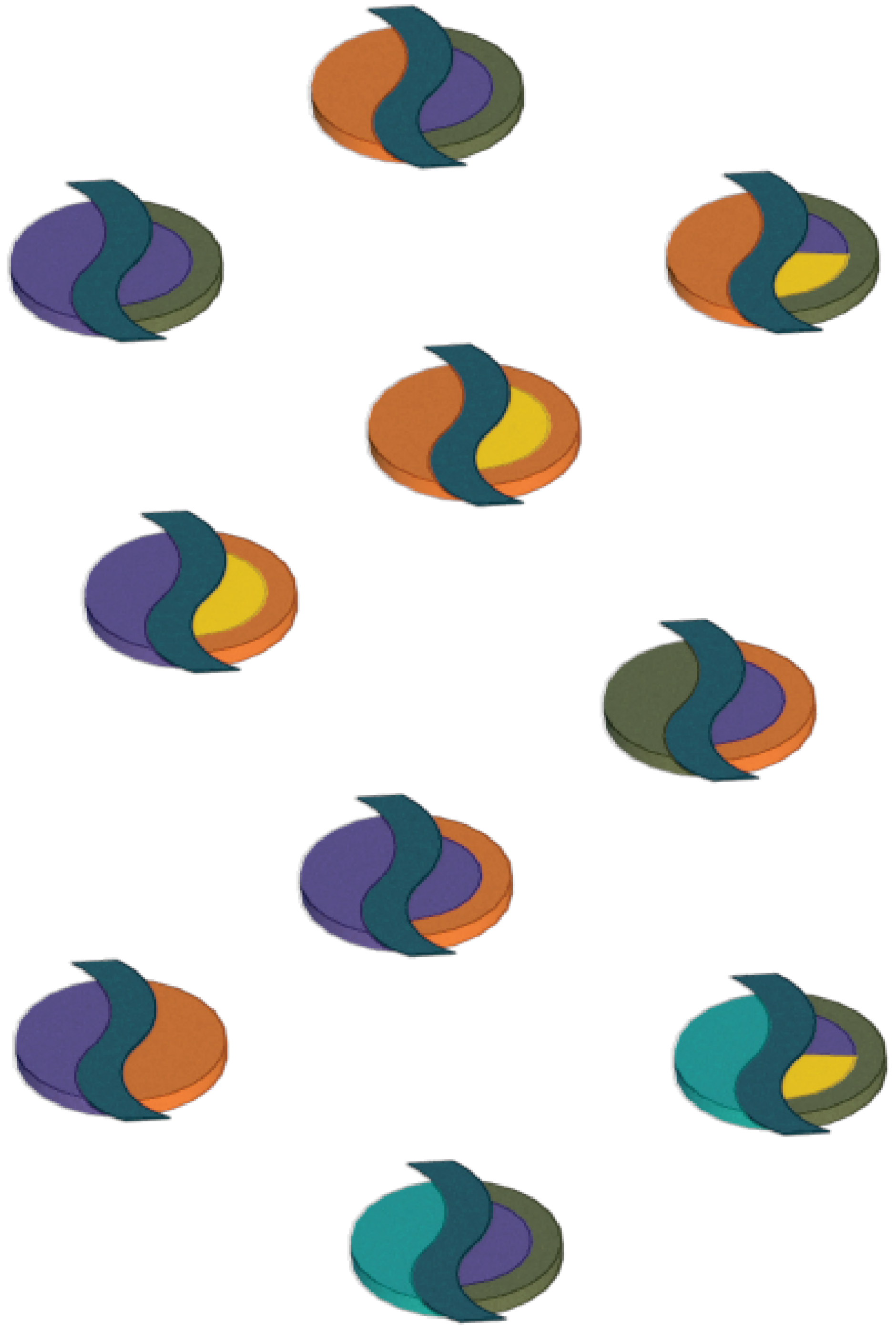


Figure 51. Icons representing different potential combinations of spatial typologies along the waterways of SH

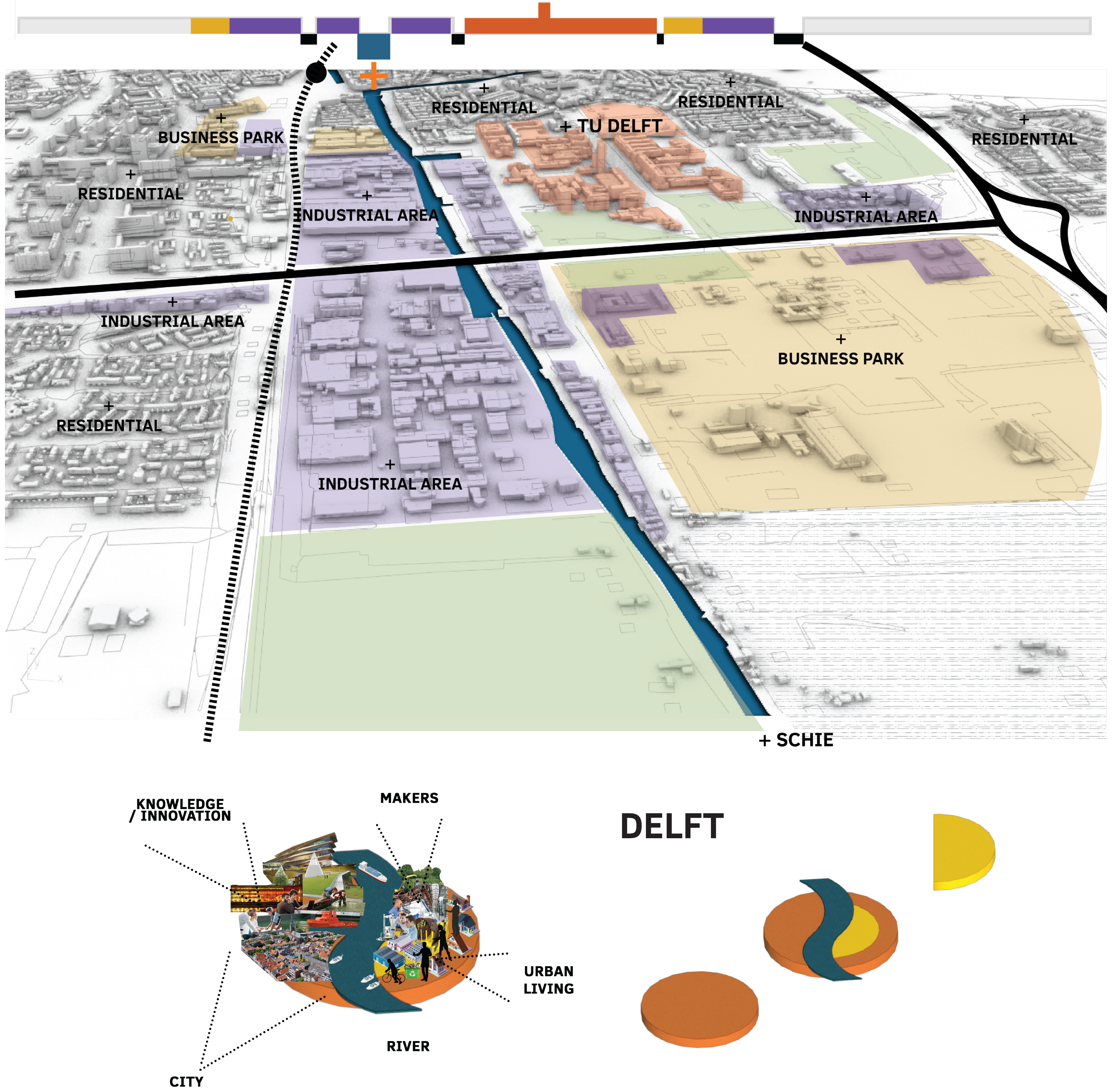


Figure 52. Landscape analysis along the waterway in Delft (top) and Spatial typology combinations for Delft (below)

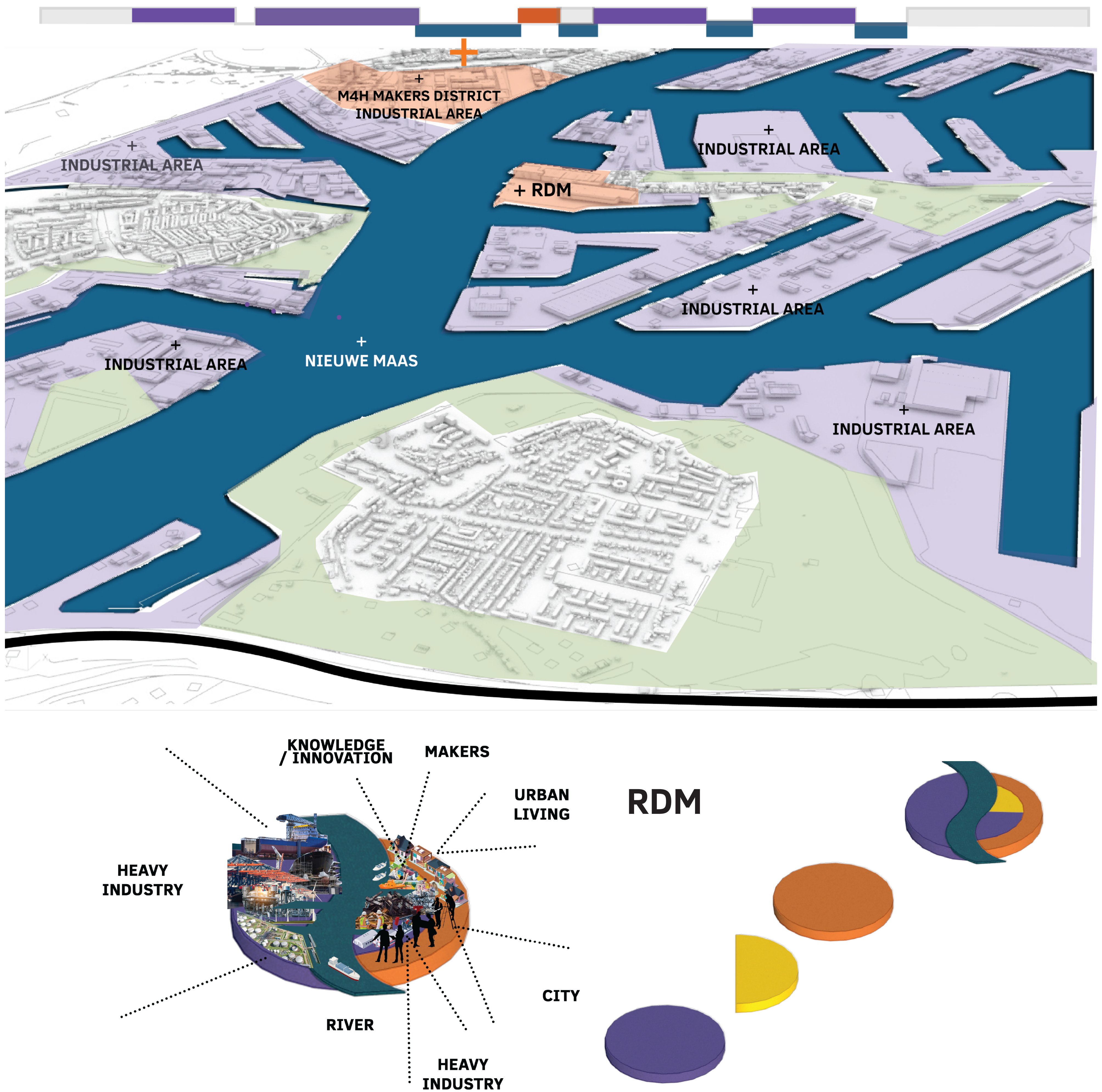


Figure 53. Landscape analysis along the waterway in RDM (top) and Spatial typology combination for RDM (below)

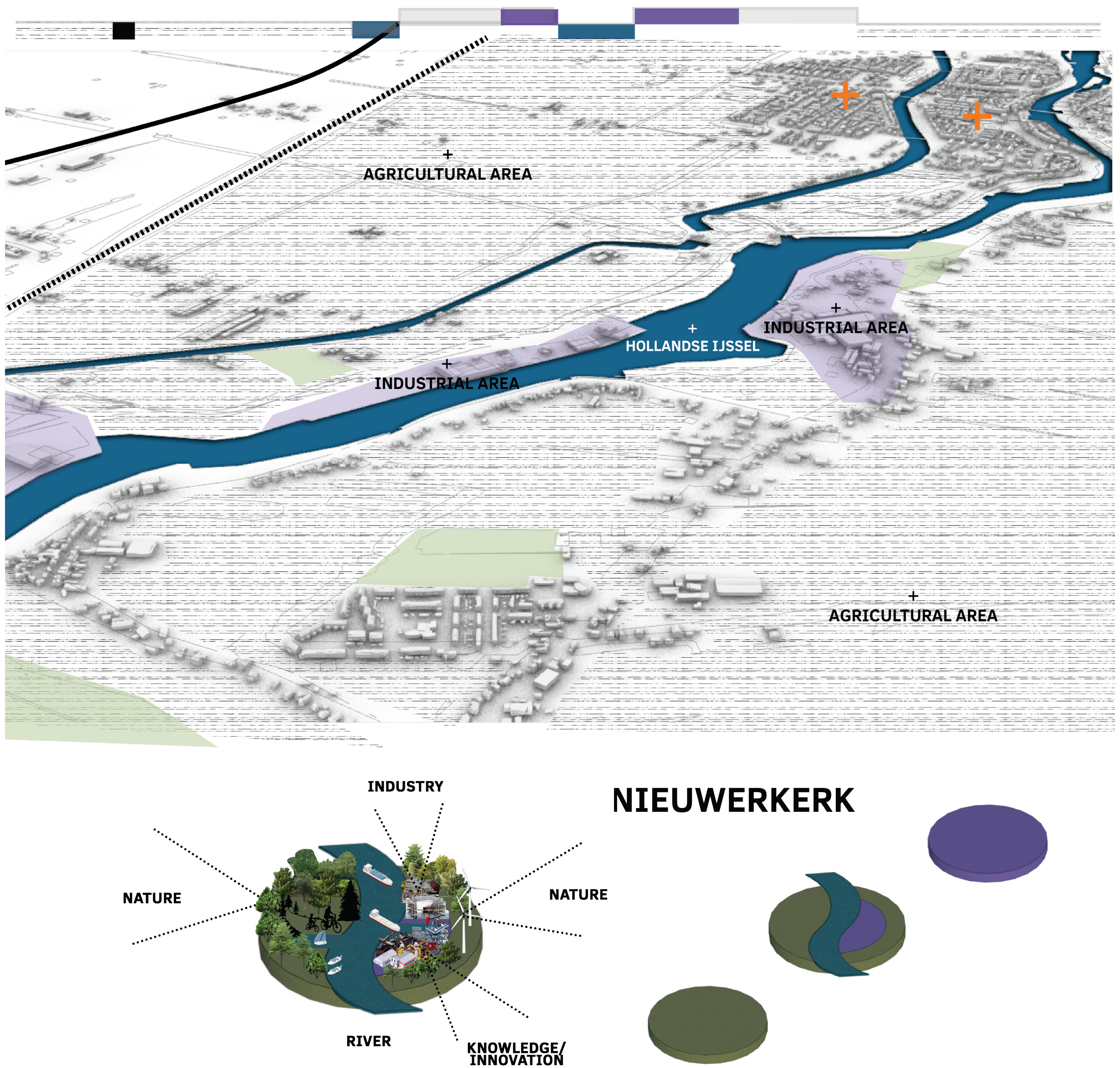


Figure 54. Landscape analysis along the waterway in Niewerkerk (top) and Spatial typology combi for Nieuwerkerk (below)

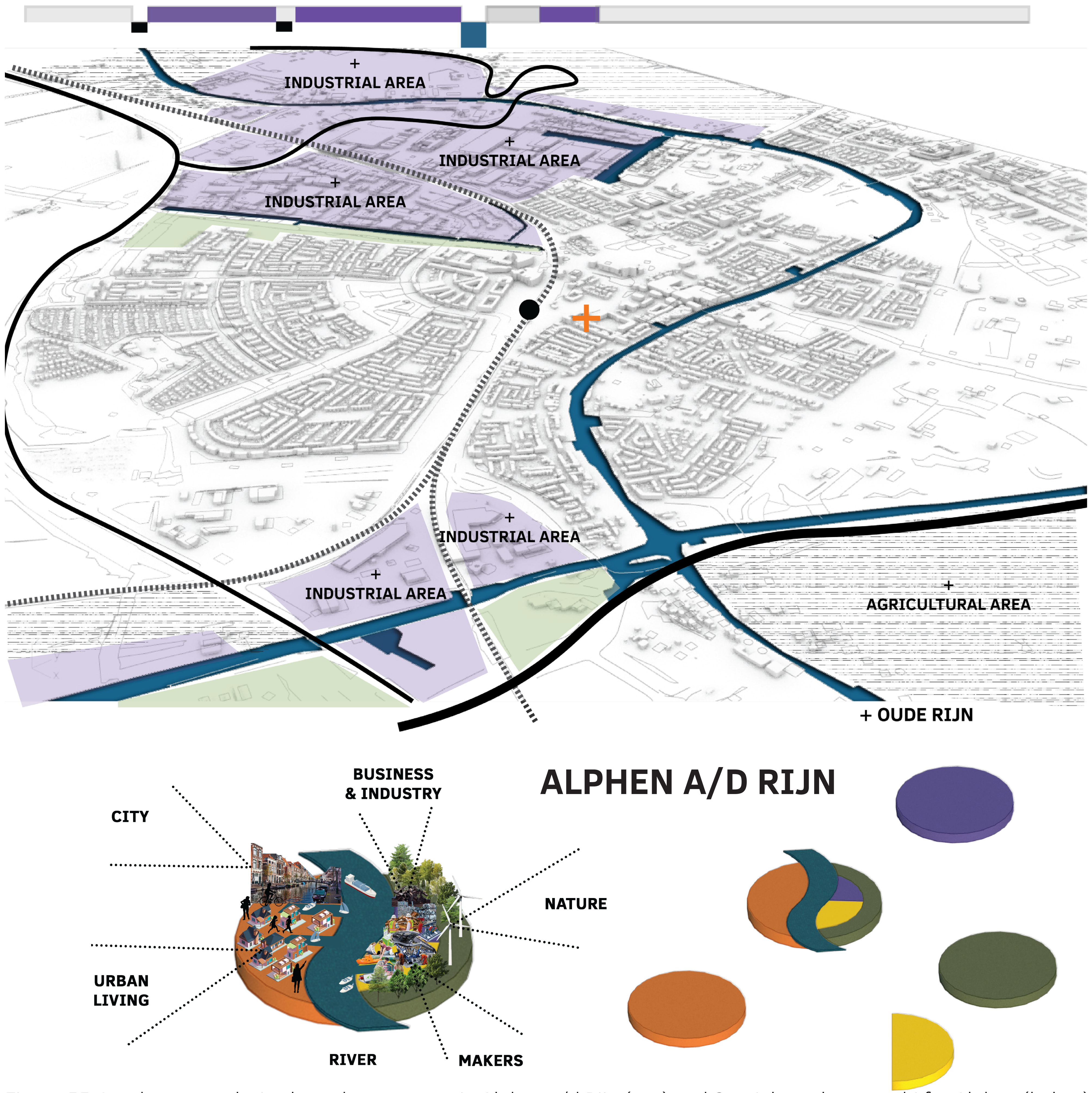


Figure 55. Landscape analysis along the waterway in Alphen a/d Rijn (top) and Spatial typology combi for Alphen (below)

The Three Pathways to Circularity

1. Circularity and Technology
   - Innovation – flow of resources and technology
   - Use and recovery opportunities
   - Nurture inner loops for repair and maintenance
2. Urban Integration
   - What are the main potential settings of manufacturing sites?
     a. Harbor infrastructure
     b. Material storage, sorting, and treatment facilities
     c. Proximity to manufacturing sites with Makers and education
   - What spatial structures can provide conditions for urban manufacturing in proximity to other functions?
     a. Makers Areas in combination with education, industry, waterway, and the city
     b. Maritime Makers Markets with business parks and city centers
     c. Ship recycling zones with nature, Makers, and city
     d. Industrial zones with nature, Makers, and city
   - What local qualities allow for livable affordable proximity?
     a. Refining environmental zones around industries with buffer zones
     b. Synchromodal transport and shipping network
3. People, Network, and Policies
   "A city becomes more and more sustainable as it becomes more and more able to develop and improve symbiotic relationships."
   (Diemer et. al, 2017)

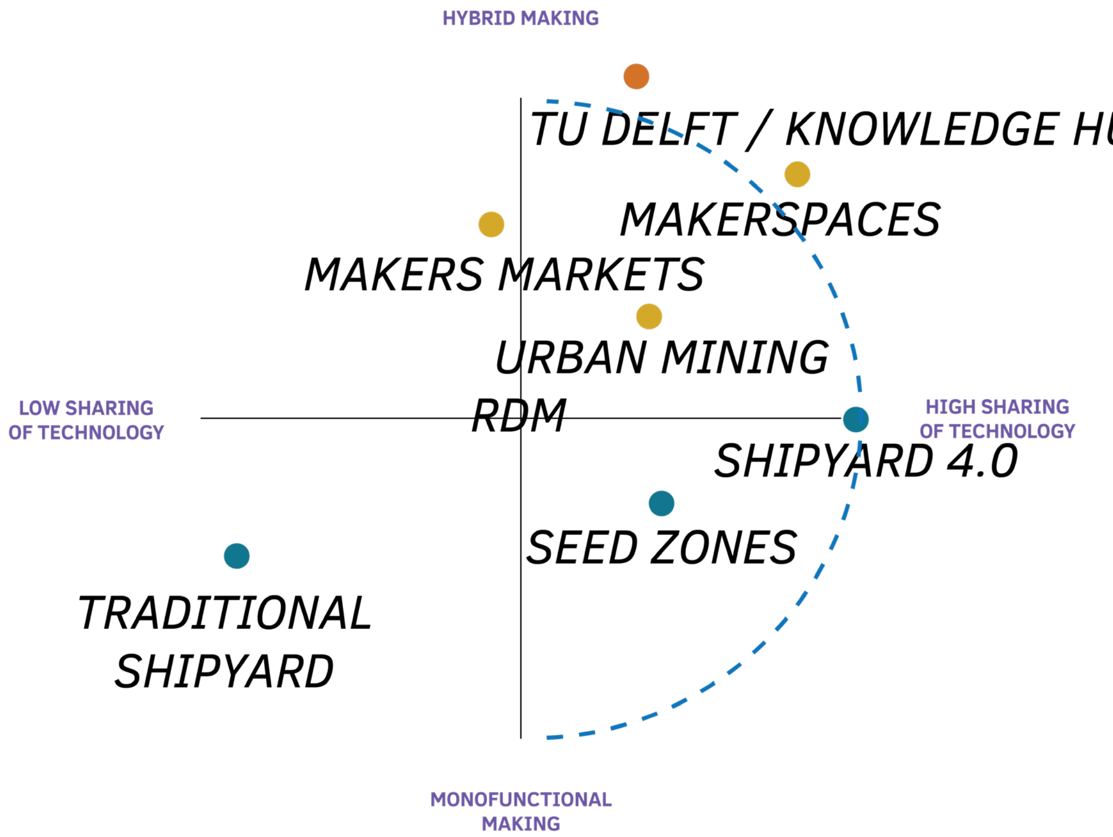


Figure 56. Place matrix for circular shipbuilding in South Holland, adapted from Urban Manufacturing for Circularity (Hausleitner, 2022)

Industrial Symbiosis (IS) is an approach adapted into industrial systems for a more holistic, collaborative, and sustainable chain of activities between different actors that would make use of resources otherwise scrapped or dissipated for greater overall benefits to those involved. IS involves organizations operating in different sectors of activity that engage in mutually beneficial transactions to reuse waste and by-products, finding innovative ways to source inputs and optimize the value of the residues of their processes, for instance by using waste or by-products from one activity as an input for another activity.

There are 2 main types of IS network applied today:
1. Managed, which can be a). Facilitated or b) Planned; and
2. Self-Organized.

With the latter type of IS network, some of the most promising case studies come from networks with anchor tenants (Lehtoranta, 2011), "where a central actor plays a relevant role in the network coordination by providing a large number of potentially valuable by-products but also exercising de facto roles of coordination and connection between actors" (European Commission, 2018).

The PoR as a hub for large scale industry and activities has the greatest potential for intensified symbioses (Haezendonck, 2020). Indeed there are areas in the PoR like the Drecht cities, Botlek, Stormpolder, and RDM that host the largest commercial shipbuilding and ship-repair yards in the Netherlands. Stakeholders and other possible actors associated with shipbuilding have been identified, such as metal manufacture, chemical manufacture, material recycling, metal surface treatment, and other sectors that could re-use materials from shipyards' high value scrap for re-manufacturing in, among others, the building/construction, automotive, furnishings, electronics, and packaging sectors (figure 59), further expanding circular manufacturing in the region. Makers Areas already existing as well as potential areas are also identified for the opportunities in developing local involvement in such heavy industrial zones.

Moreover, a key component of the highest importance in fostering cooperation in sustainability networks proves to be 'recycling materials and/or energy'. With the metal scrap produced from the shipbuilding industry, metal recycling could be the medium by which relevant actors can mutually benefit for sustainability. Through this, shipbuilding and shipbreaking could then be the main anchors alongside knowledge/innovation hubs, depending on the location and the existing entities already residing there to begin this symbiotic network. Alphen aan den Rijn, a potential location for large industrial and business zones along the waterway coinciding with existing industrial sites is shown in figure 60.

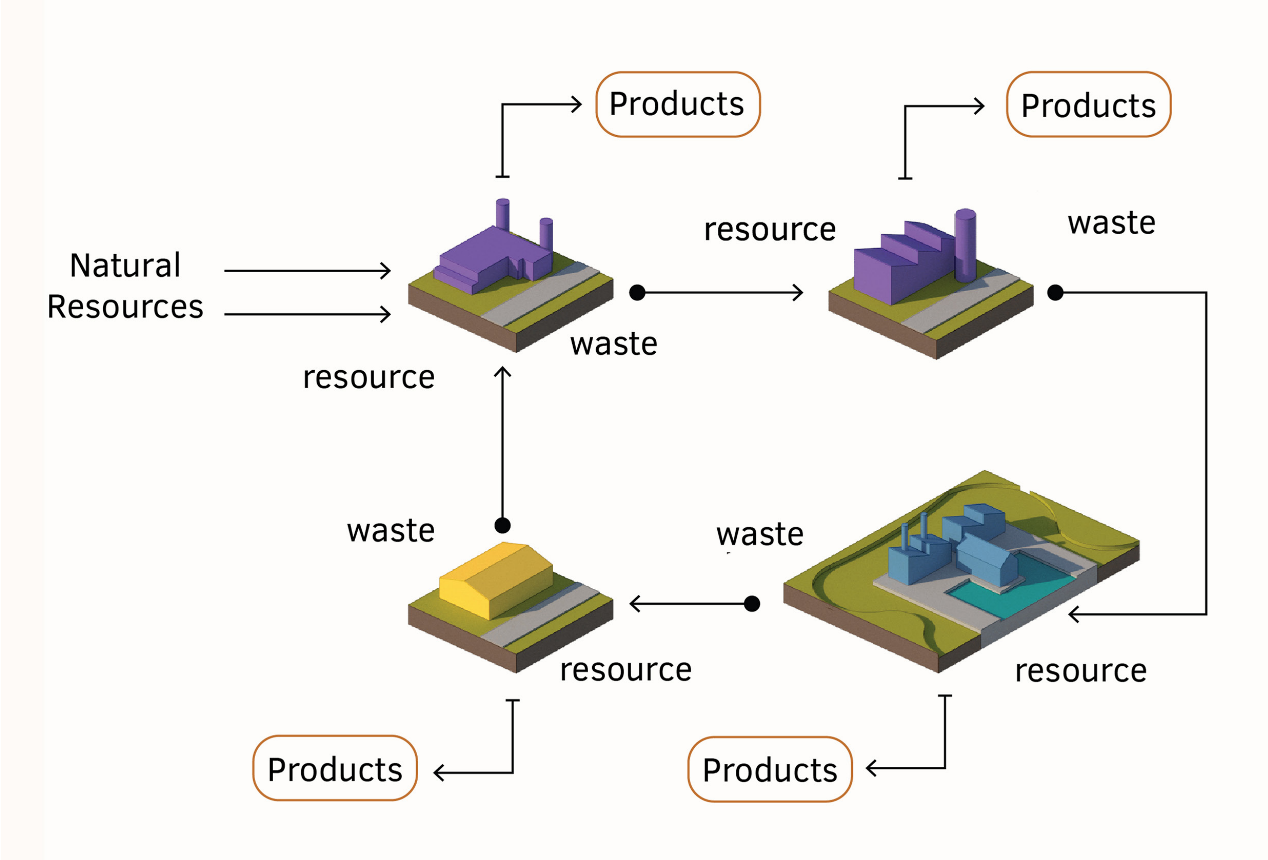


Figure 57. An industrial symbiosis network diagram

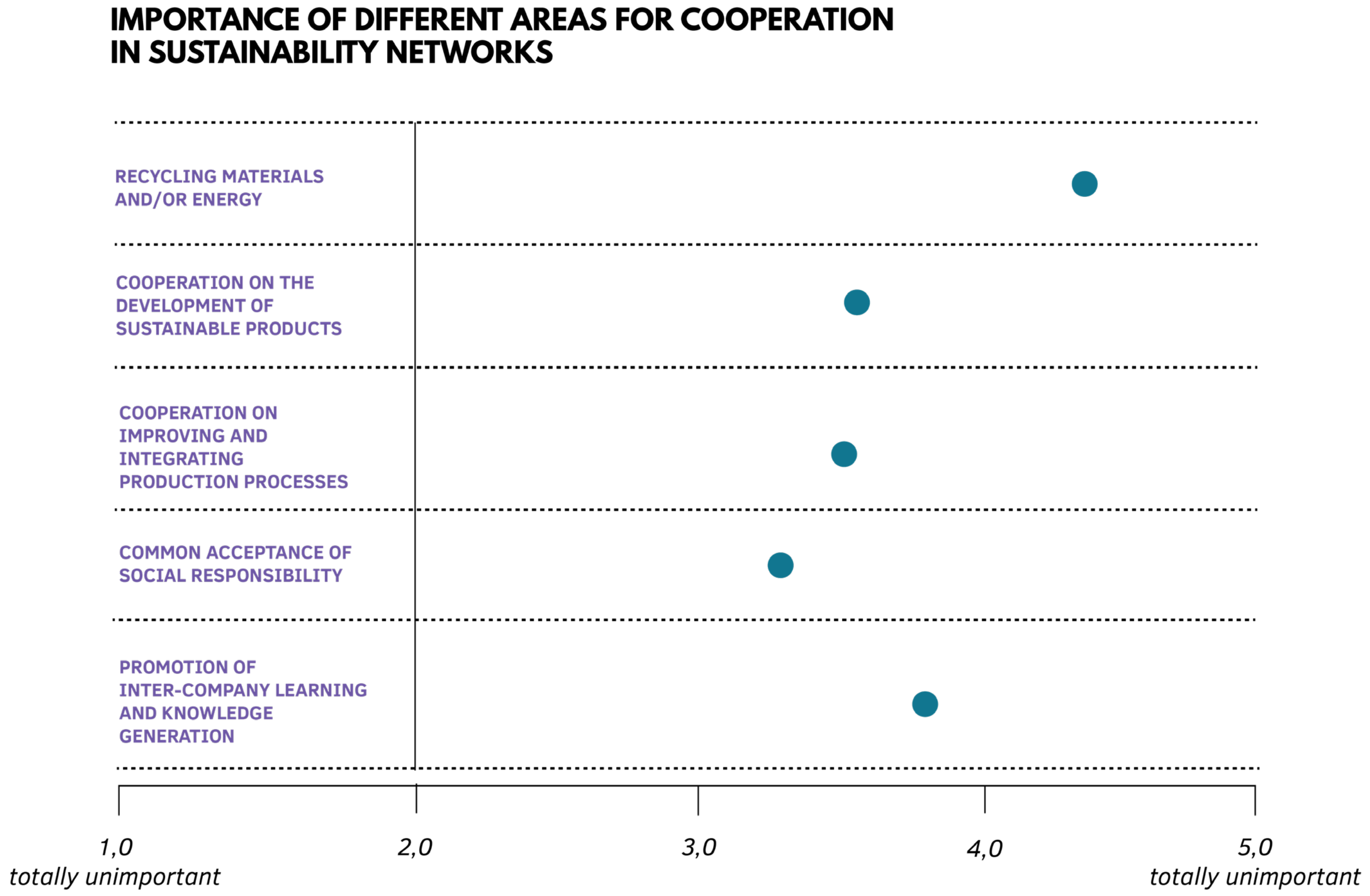


Figure 58. Important areas for IS networks (Posch, 2010)

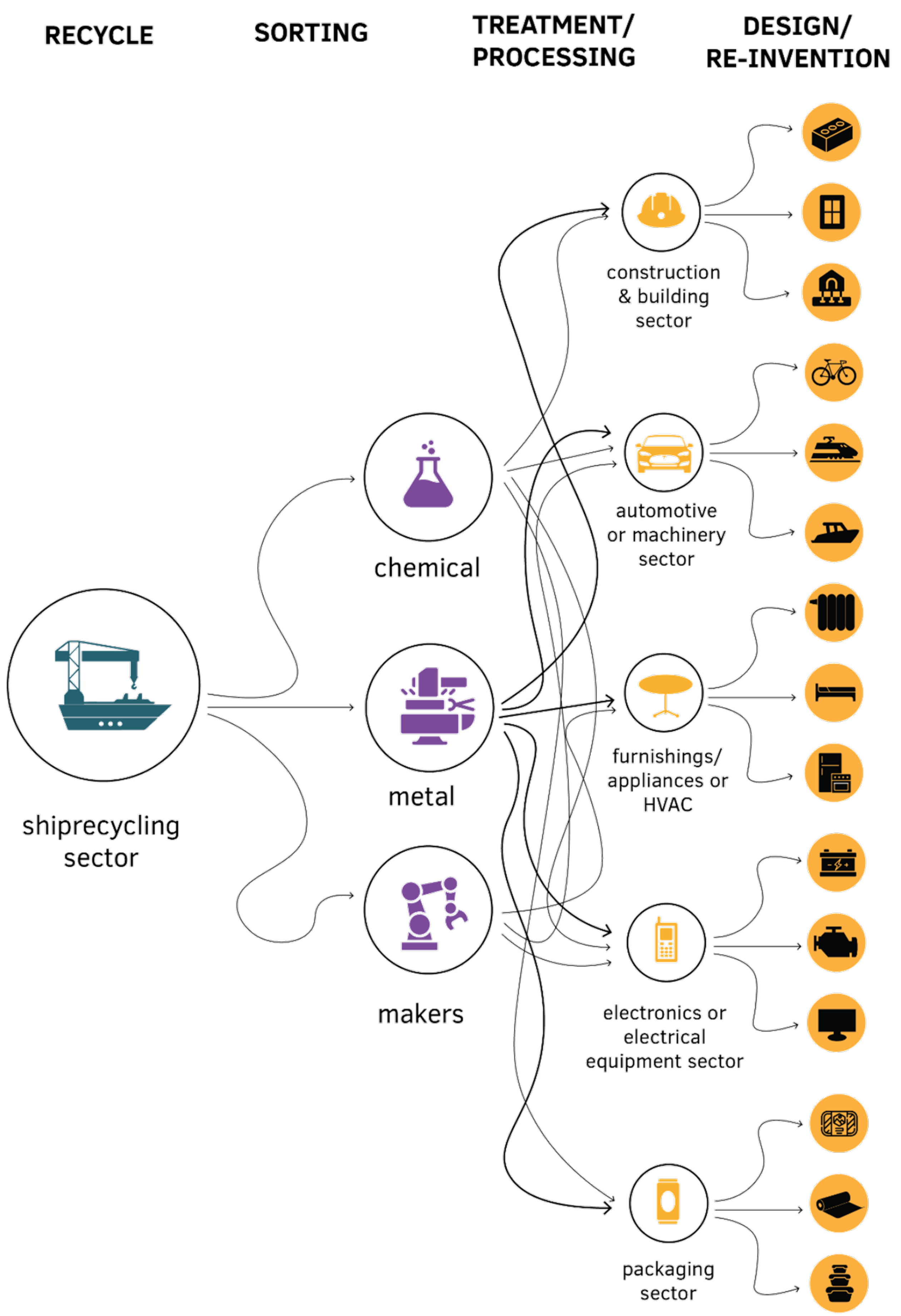


Figure 59. Potential Waste-to-Value chain for metal scrap to other manufacturing sectors existing in South Holland

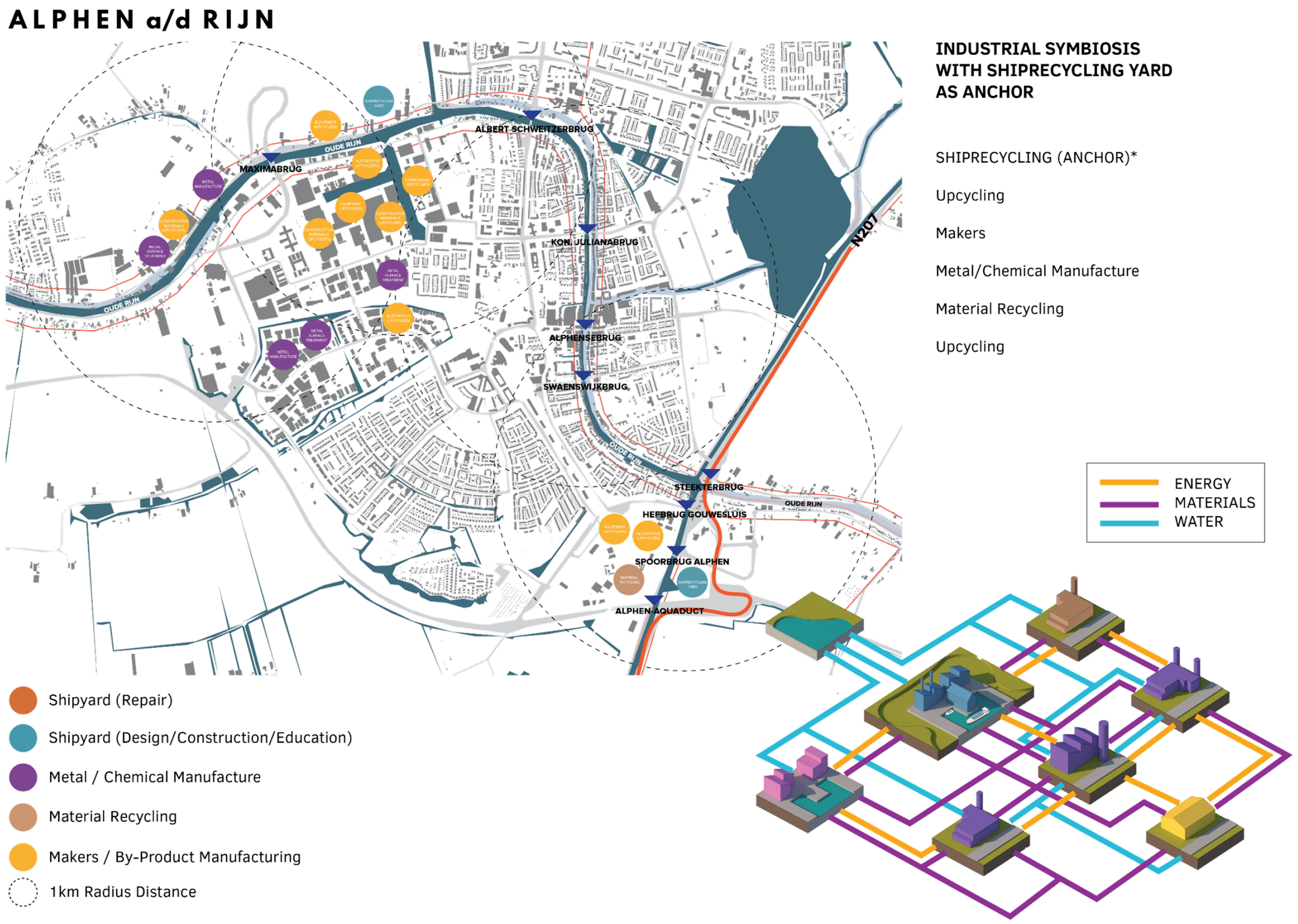


Figure 60. Industrial symbiosis zoom-in analysis of Alphen a/d Rijn -- for other key locations, refer to appendix F - I (p. 209 - 212)

3.6.4 THE AQUA-INDUSTRIAL LANDSCAPE

Regional design with the need for innovative and integral forms of urban landscape planning and design strategies must offer spatial means for (Nijhuis, 2017):

1. Urban transformation
2. Biodiversity production
3. Water resource management
4. Recreation
5. Community building
6. Cultural identity
7. Economic development

These qualities can be placed in line with industry as current environmental zoning are inflexible and only define distances rather than qualifying the environment that these prescribed easements offer to people, further widening the gap and darkening the opacity of industry with the people. By redefining these 'no man's land' areas as possible places for people and nature, proximity between industry could be evolved, enhancing the manufacturing sector's services and people's quality of life.

With the concept of the Green Shipyard (Janson, 2016) integrated as the anchor industry, existing environmental zones are optimized by applying Nature-Based Solutions in managing waste and emissions and embedding different possible functions as recreation, sports, energy capture, and urban agriculture opportunities that would otherwise be untouched and toxic land areas. For example, the use of particular types of trees and vegetation to facilitate oxidation and filtering of toxic emissions like pines (both endemic and evergreen so they last a whole year) as well as the use of constructed riparian areas for wastewater treatment allow for systems to become cleaner and safer. Refer also to figure 62.

The participation of biodiversity in ensuring the safety of the environment for people also promotes sustainability at all fronts, encouraging a renewed relationship between industry and people. A new landscape with the new shipbreaking industry is formed with these buffers, creating a symbiosis with the waterway and the city – an aqua-industrial landscape.

Water-Based Living (Case Study)

As sea levels rise, the region is challenged for the future in considering fully living with water. With that, the shipbuilding industry will adapt and evolve to serve demands for more water vessels, while floating neighborhoods, particularly in more critical flood-prone and vulnerable peatland areas like the city of Gouda, could be made possible for the city to remain in its place, still thriving, but in a different setting.

As the fitting case study for Water-Based Living Neighborhood developments, Schoonship in Amsterdam by architectural design firm Space&Matter, stands as the innovative built design that includes the participatory process in the design to create a circular neighborhood as the “prototype for floating urban developments”. A total of 46 floating dwellings on 30 water plots are connected by a jetty with integrated utility systems for sustainable energy, water, and waste. Decentralization is the key of this sustainable neighborhood that aims to propose such an adaptation strategy with the current sea level rise projections and climate emergency (Space&Matter, 2021).

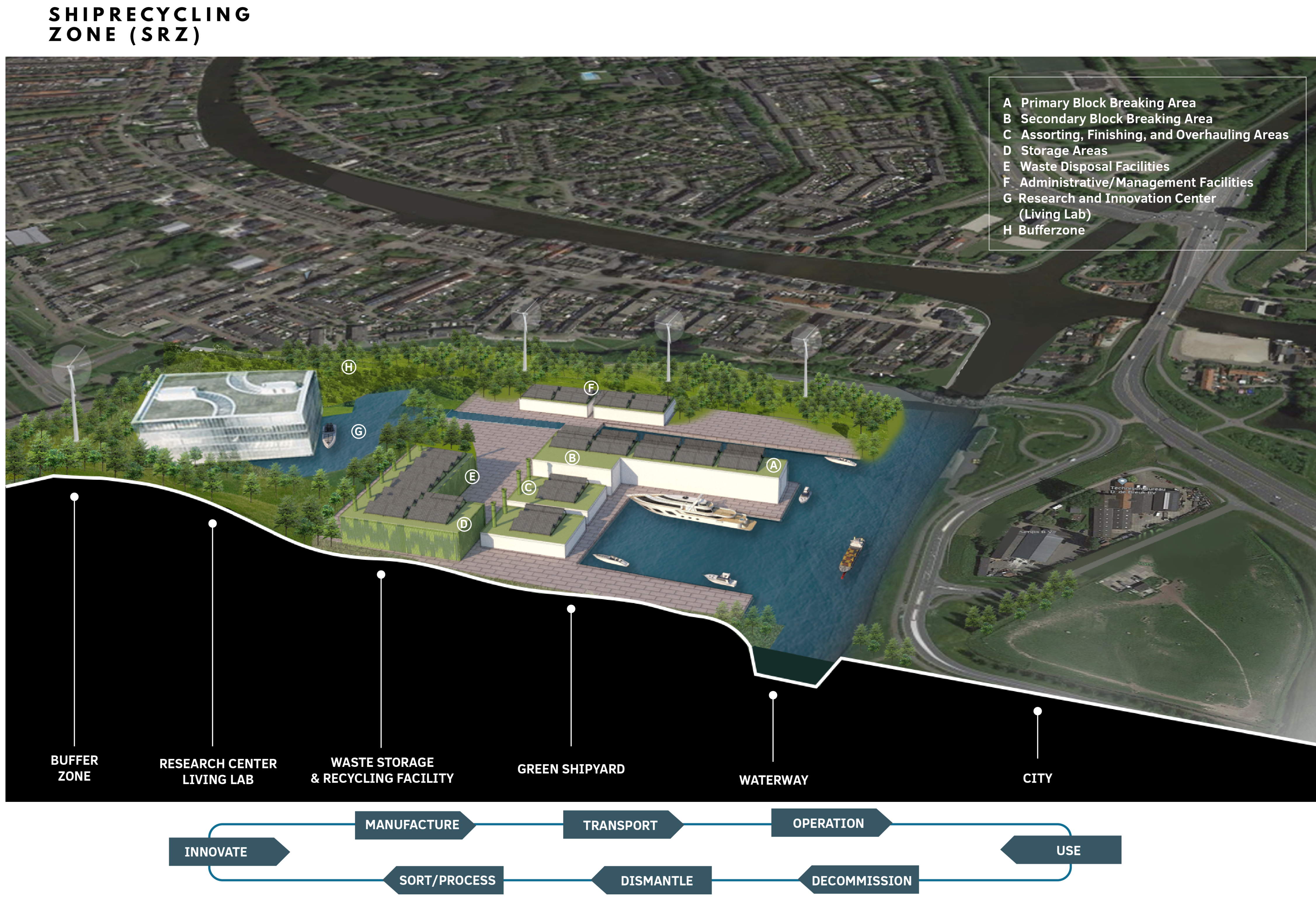


Figure 61. 'Persection' of a Ship Recycling Zone (SRZ) along Alphen aan den Rijn embedded in the city, introducing a new industrial landscape

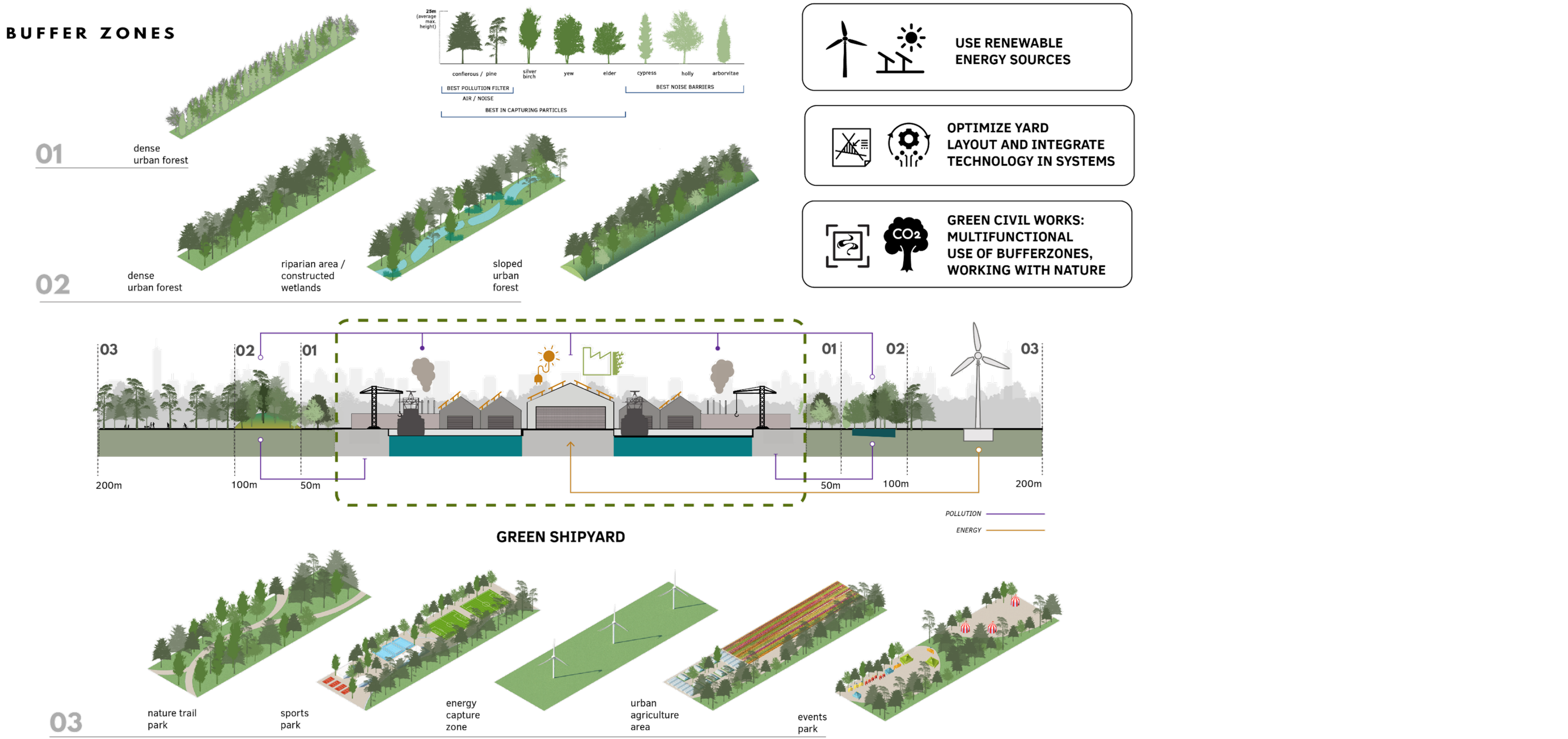


Figure 62. Qualities of buffer zones around industry for people integrated with Green Shipyard concept

4

VISION

The magnetic north of a circular, innovative, just, and leading Dutch maritime sector

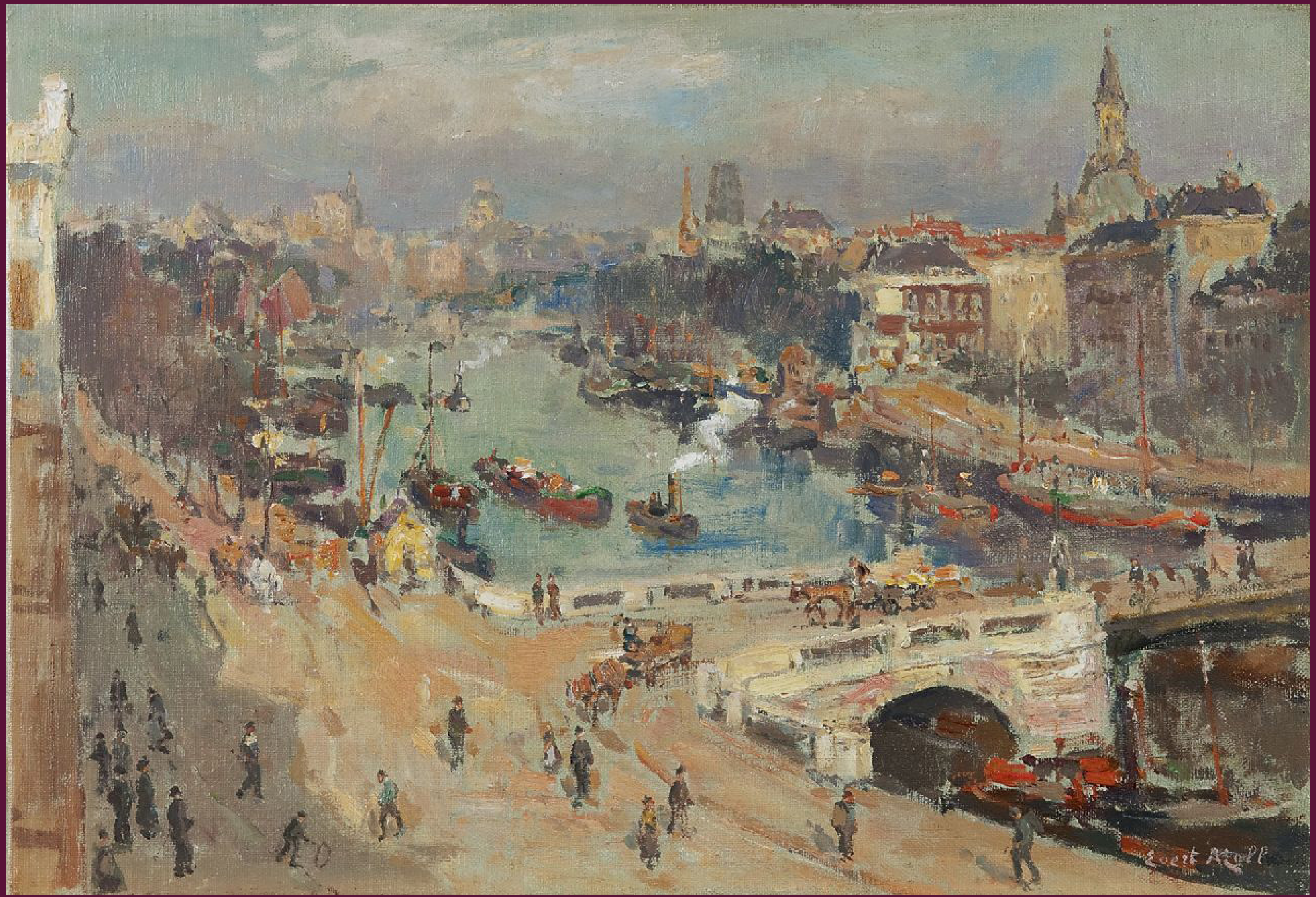


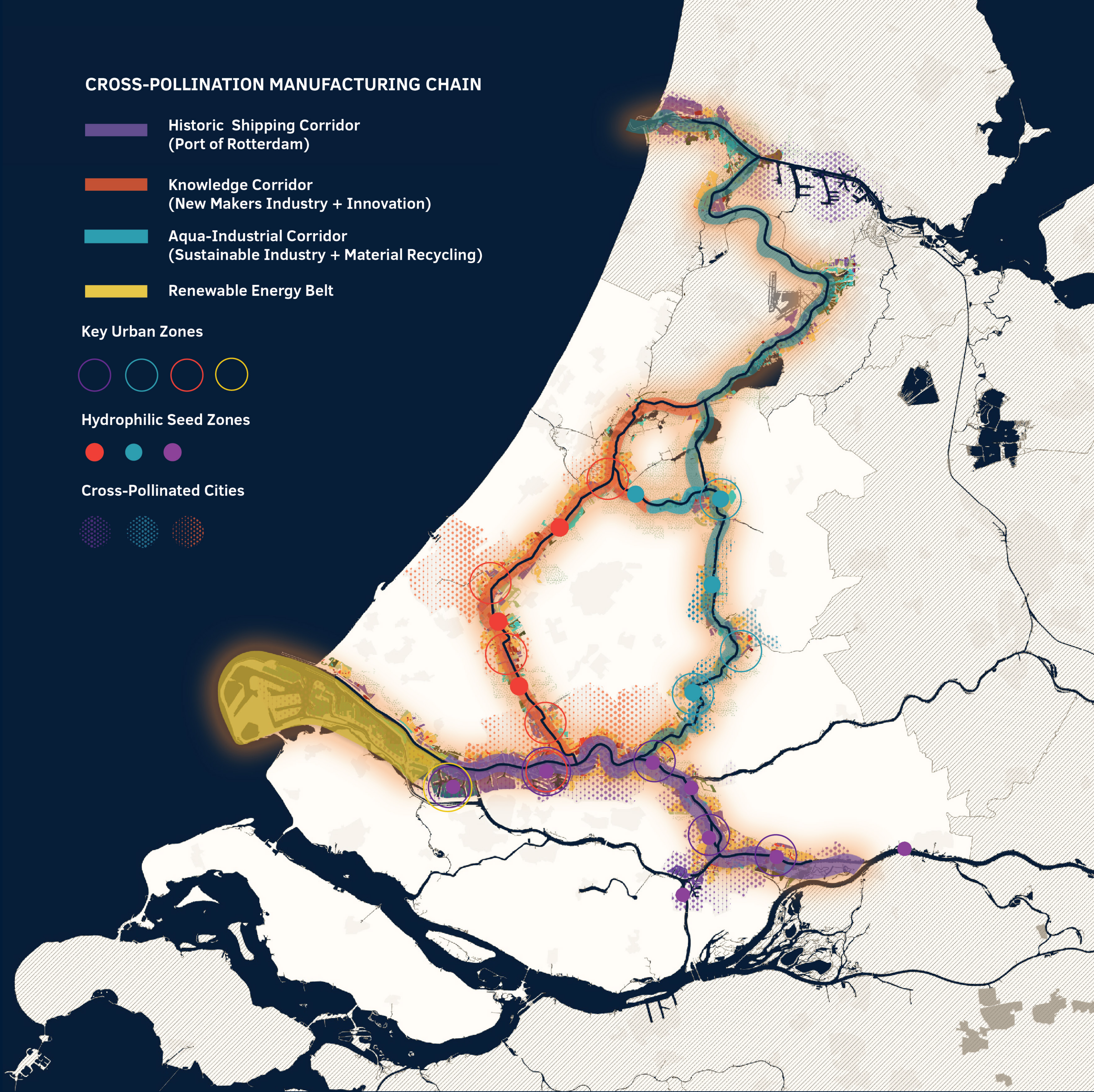
Image 04. Painting of a sunny winter morning at Leuvehaven, Rotterdam (Moll, 1878-1955c)

4.1 VISION 2050: CROSS-POLLINATION MANUFACTURING CHAIN

By 2050, South Holland is a creative leader in the circular maritime manufacturing sector, where stakeholders in the Randstad region collaborate on innovative solutions based on a foundation of shared identity, respect for nature, and accessible physical learning and working environments.

With the waterways as the backbone, **Industry** is transformed by developing a symbiotic Makers and Recycling culture with **Knowledge** as the propeller of this transition into a **Circular Society**.

Cross-pollination opportunities are not only sought after within the ship manufacturing and metal industries, but also with other sectors, such as the biochemical and the construction industries, and with other disciplines, such as biomimicry, to spark truly innovative solutions for realizing a circular maritime manufacturing sector.



4.2 VISION APPROACH

1 The approach begins with recognizing the Port of Rotterdam as the main driver of industry in South Holland, holding within it a distinct and versatile shipbuilding sector of which a shared identity can be formed not only in the region, but also on a national level.

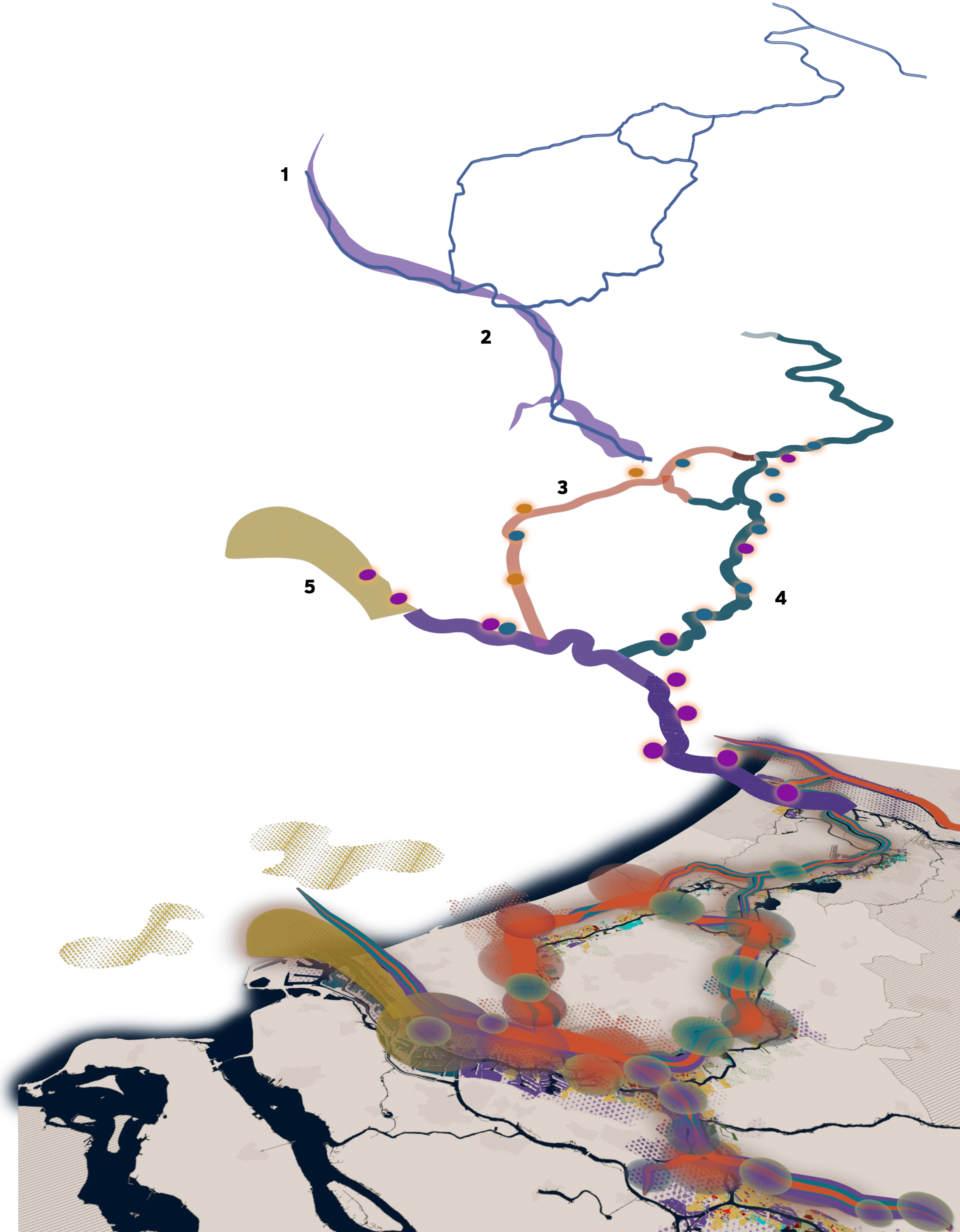
2 Strengthening the utilization of the existing waterways that are the direct links between the PoR and the main urban cores shall provide a streamlined flow of materials for the manufacturing sector and ease of accessibility for both logistics and people.

3 With some of the best research and technical universities located in South Holland, educational institutions are stimulated to forge innovations that a circular maritime manufacturing sector seeks and requires. A continuance of an already established knowledge corridor is opportune in proximity with the waterways, and with opportunities to uplift other urban cores on the eastern side of the region, another corridor is linked.

4 With shipbuilding's environmental impact, shipbreaking as a new sector in the region is intertwined with existing industrial areas to make space for Makers Areas and Makers Markets, to be supported by new hydrophilic seed zones (storage, sorting, and processing facilities) that serve as the interface for recycled materials to be retrieved. These new ship recycling zones shall also include innovation centers linked with the existing knowledge that could also potentially spur new centers independently.

5 With looping back the high value waste flows from shipbuilding into re-manufacturing and then re-use, the energy transition is a co-requisite development for a complete circular manufacturing chain that adds more value to nature and living environments. The decommissioned petrochemical areas around the Maasvlakte and Botlek areas are conferred to hydrogen-based renewable energy sources, creating a Renewable Energy Belt.

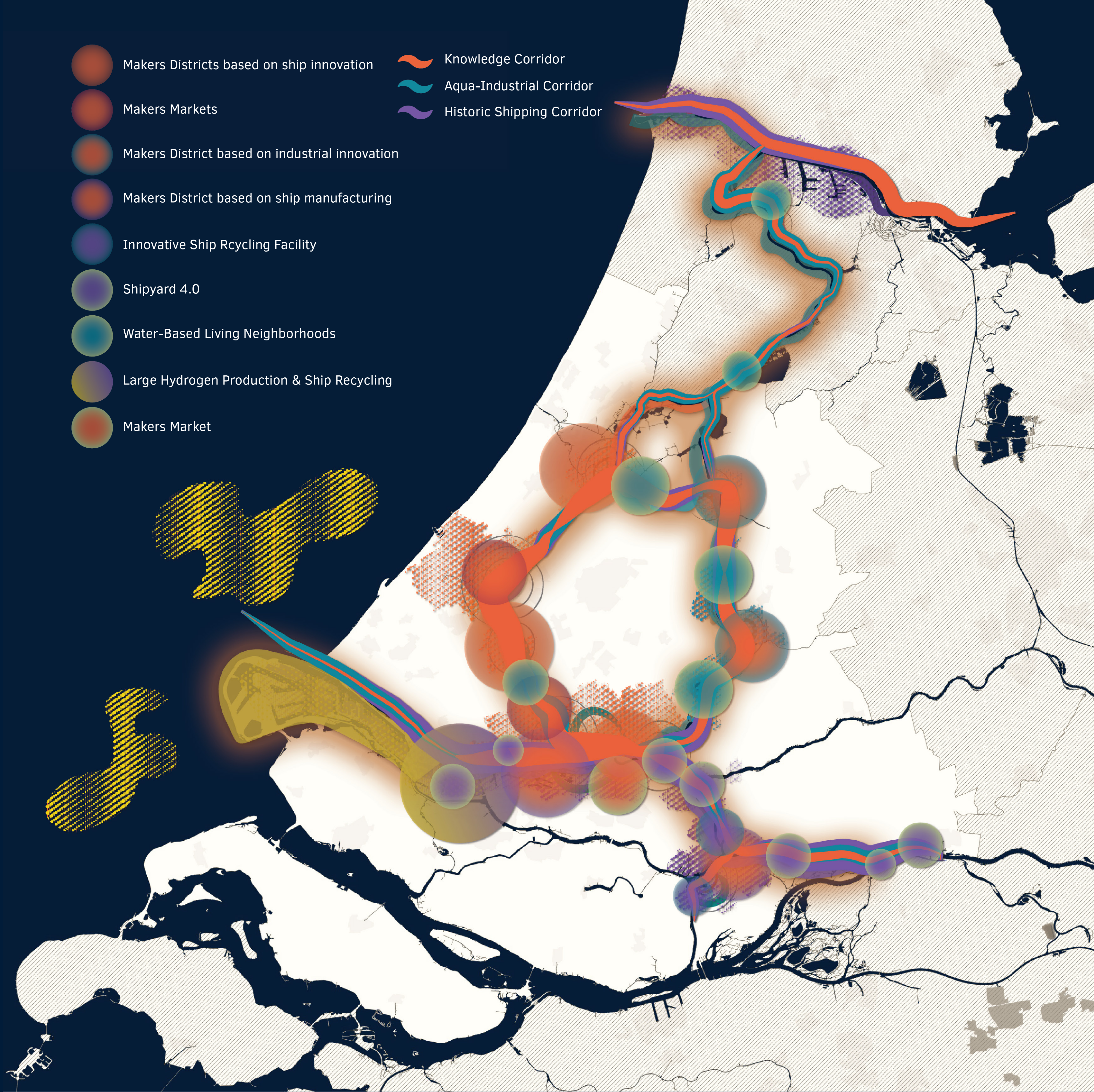
Thus, the entire region as a whole is now considered to take part in integrating knowledge and industry, as cross-pollination between sectors and people is initiated, cultivated, and activated towards a thriving South Holland.



4.3 VISION 2100: EMBARKING ON A CIRCULAR VOYAGE

By 2100, a water-based society is envisioned that is holistically supported by the circular shipbuilding industry that has now cross-pollinated different actors, Makers, and other stakeholders to make it possible for more innovation and creative growth in a sustainable and resilient water-based setting.

The culture of circular products and shared resources and knowledge is now fully thriving alongside the waterway with floating living environments in symbiosis with industry and nature.



5

STRATEGY

Steering South Holland towards the future state of a circular economy

Image 05. Painting of the Shipyard 'St Jago' on Bickers Eiland, Amsterdam (Bertichen, 1823)

5.1 STAKEHOLDER INVOLVEMENT

Circularity is a collective effort. We must actively collaborate, work together, cross-pollinate in order to achieve the goals set. It is vital that all actors and stakeholders involved in and/or impacted by the transition to a circular economy are identified to ensure that all voices are heard and no one is left behind. Understanding their demands and needs as well as considering the power and interest levels that each actor and stakeholder has with regard to the projects set out, are prerequisites to effective governance and effective coordination through the different project phases.

5.1.1 ACTORS AND STAKEHOLDERS

Penta-helix Map

The key actors and stakeholders (interest groups) involved in or impacted by the efforts to achieve a circular maritime manufacturing industry are depicted in figure 63. The distinction between actors and stakeholders is based on whether they must have an active (contributing) role in driving the transition towards a circular manufacturing system or are interest groups that must be kept informed of and/or engaged with the progress of the transition.

Three main group types are distinguished:

- Public sector
- Civil society
- Private sector

The civil society groups can be further differentiated into educational & knowledge institutions and community representatives. The private sector is further divided into financial institutions & land owners and the companies providing products and/ or services.

The section Knowledge, consisting of educational & knowledge institutions, contains only actors. As concluded in paragraph 3.5, the educational & knowledge institutions must play an active role in developing learning and training programs that will be necessary to educate the labor force and students on future skills for the circular economy. Furthermore, knowledge institutions can have a leading role in mobilizing actors involved in innovative research relevant for the ship manufacturing industry.

The Public Services section contains the key decision makers with regards to policies and granting subsidies. Targets for the circular economy are set at the national level by parties such as the European Union. Targets for the maritime cluster are set by, among others, the IMO.

The section Business includes all companies directly involved in the maritime cluster or providing services to the maritime cluster. The business processes of these companies are directly impacted by the circularity and the energy transition. All actors operate on the local and regional level, while the stakeholders have equal interests beyond the province of South Holland.

The Capital section involves the land owners and financial institutions who can facilitate the transition through financial means.

Community contains only stakeholders. These groups need to be informed and kept engaged, and if possible mobilized through their interest to become active supporters and co-thinkers in how to embed the changing sector into the different communities.

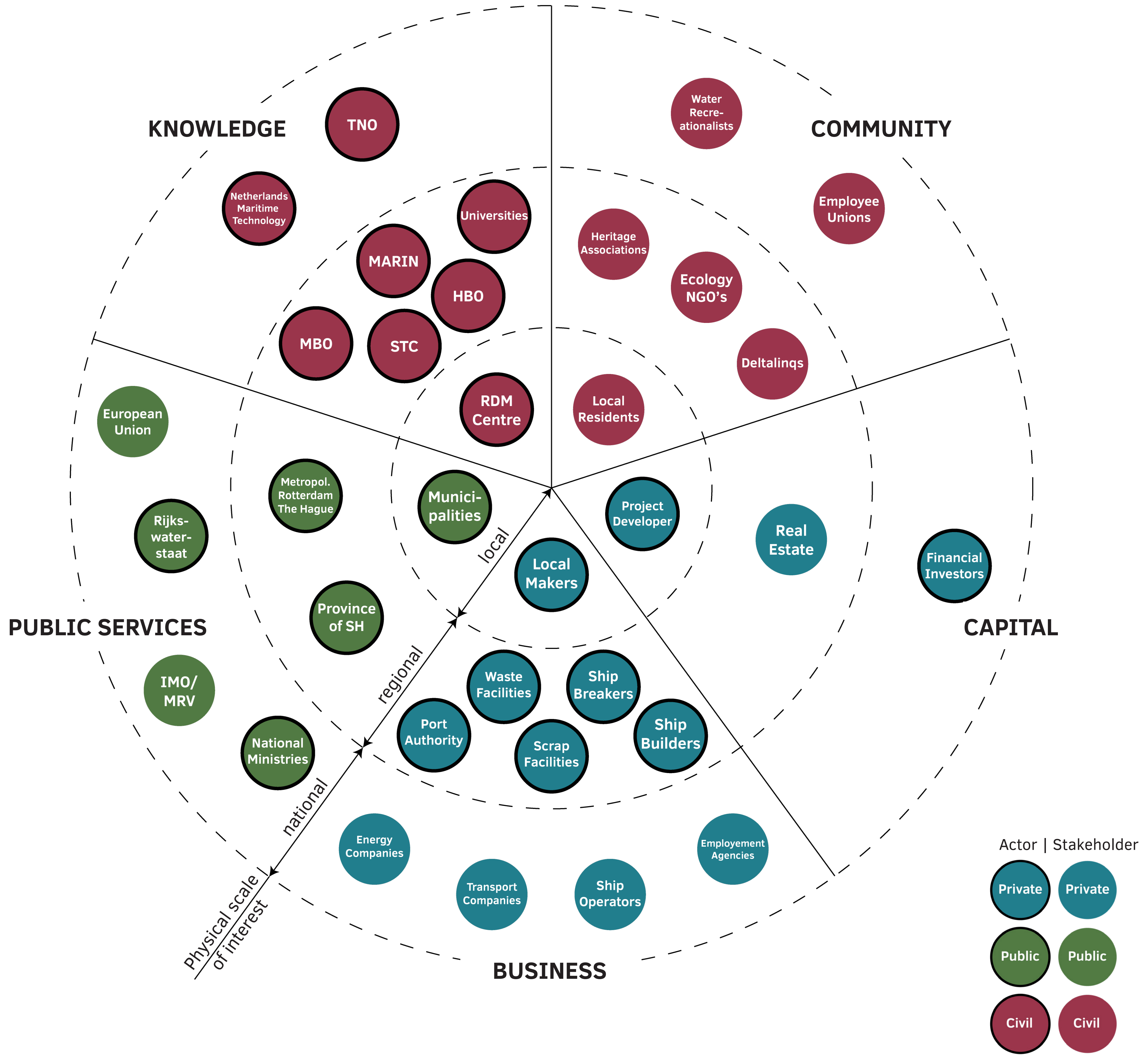


Figure 63. Penta-helix map (source: Osmos) of actors & stakeholders based on their role and the scale at which they are active

Power/Interest Matrix

The actors and stakeholders are mapped in figure 65 according to their power and interest levels. The combination of interest and power level determines the engagement level necessary to manage the involvement of each actor and stakeholder.

While stakeholders such as the European Union and the IMO have very high power levels with regards to setting policies and rules as well as a high interest in how countries and sectors are making sure to achieve these rules, they will not want to be involved actively in the day-to-day practice of managing the transition. Therefore, these stakeholders are not depicted in the power-interest matrix.

The groups with medium/high power and high interest include the actors that are the driving forces behind the new economic and spatial reality. These actors must actively collaborate with each other, based on the shared vision and mission, to balance out the positive and negative consequences of each decision made. The actors and stakeholders with low/medium power and high interest must be kept involved during the project as they can assist and facilitate the change through their expertise and connections.

The medium interest actors and stakeholders must be engaged and monitored, based on their power level, to ensure that they are on board with the plans and do not have objections that might present roadblocks for the project. If possible, their interest should be increased to become active supporters of the strategies.

The groups with low interest and low/medium power need to be empowered to make sure that their voices are heard and that the impact of the transition on them is not overlooked by the actors. The high power and low interest actor and stakeholder must be regularly consulted as they are product owners of important spatial elements in the circularity transition.

5.1.2 GOVERNANCE

Strategy Building

When providing strategies based on a changing maritime sector, many different stakeholders and actors are involved or have at least an interest in their gains from these new strategies. Different instruments can be used to facilitate change in the current province of South Holland. The nature of strategy building is complex, multi-functional, has a long time frame with multiple different interests, and is often confronted with changes in politics, financial structures, and cultural and social practices (de Zeeuw, 2019). Therefore, careful consideration should be made to create an overall strategy based on the needs of the current and future generations. Planning of these strategies is largely about the coordination and steering of stakeholders with different opinions and interests.

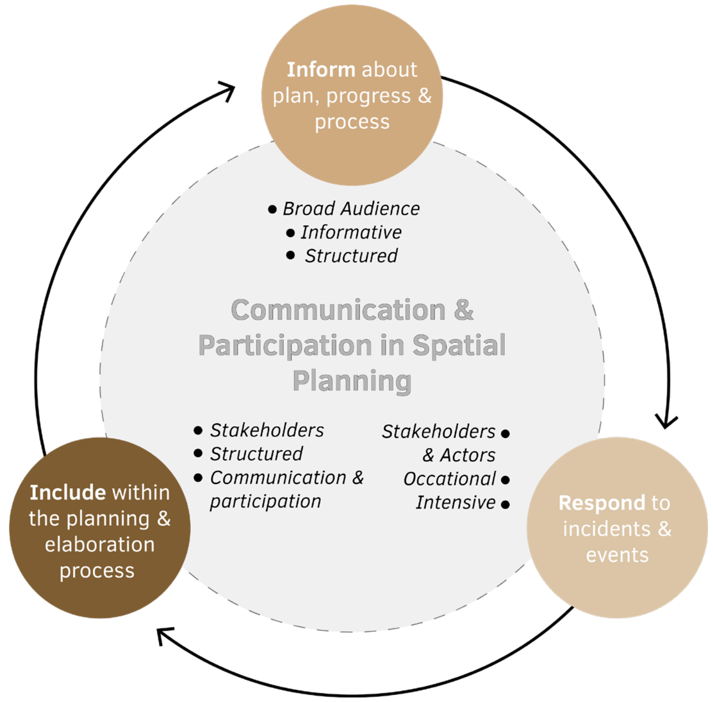


Figure 64. Participation matrix (de Zeeuw, 2018, p. 154)

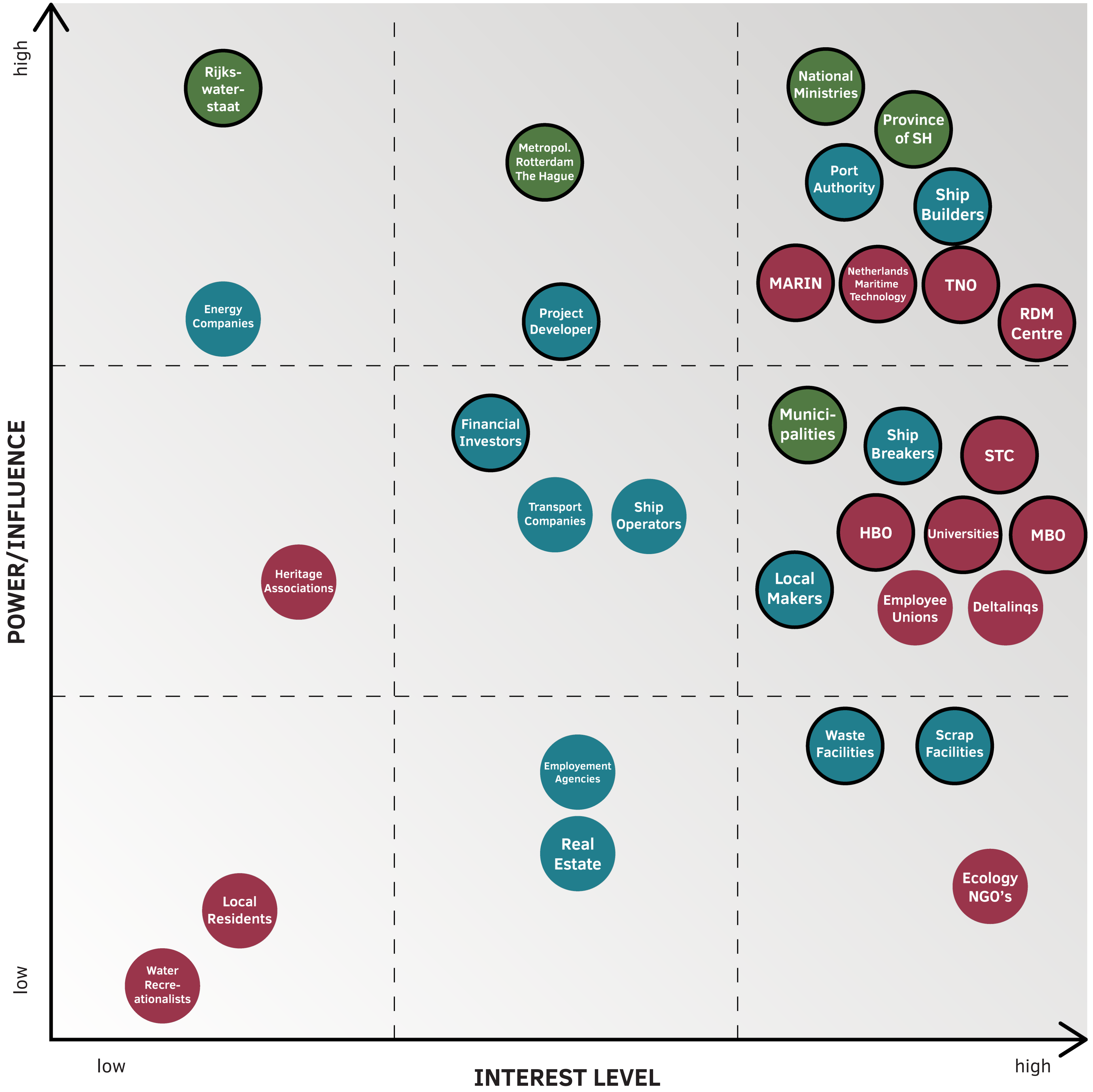


Figure 65. Matrix depicting the current power and interest levels of the actors and stakeholders in relation to the project

Planning Strategies

There are various ways in which a spatial planning strategy can be governed. Most of these planning strategies can be considered as part of an integral system, where big players strive to one certain end, bound on a structured route towards the finish line.

Since the end of the economic crisis of the 2010s a new organic system has been taken up, giving more space for smaller parties to collaborate with larger parties in collaborative ventures (de Zeeuw, 2019). There is no right or wrong strategy to be used. Different interventions ask for different ways of governing a strategy. When big changes within the strategy are necessary to facilitate more space for the industry, it might be more beneficial to handle an integrated system rather than an organic system based on the fact that it consists of larger companies, where larger investments and financial structures are attached to it.

On the other hand, the organic system offers a freer and more innovative collaboration structure, especially good for the creation of Makers Areas. Here, local Makers are bound to a collaborative structure, facilitated by local governments, where they are free to experiment and develop organically. In further chapters, the different strategy systems will be connected to the interventions of the phases.

Integral Planning Strategies		Organic Planning Strategies
All at once	Approach	Gradual steps
Top down	Development Scale	Bottom up
Project-oriented	Organisation	Process-oriented
Working to a final image	Planning Instrument	Strategic management
Large professional parties	Partnerships	Small developers & civil organisations
Active	Governmental Role	Facilitate

Figure 66. Diagram showing the two main planning strategies of the spatial planning process (de Zeeuw, 2018, p. 148)

Making a Threat a Chance

The planning practice has always been confronted by threats and chances. Stakeholders, and people in general, are reluctant to take risks when the current situation provides them with good benefits and revenue. However, to facilitate fundamental change to cope with a new circular economic structure, risks need to be made. So, it is important to understand the 'span of control' of the different stakeholders and parties involved in the change that is to be implemented.

Politics, and therefore most of the public parties, change every 4 years due to the elections. In the time frame of strategies, this asks for careful consideration especially when addressing municipal governments. Whereas the province and the state have always been stable public parties, the municipal level can change course radically. Therefore, it is important when considering a strategy based on large public interest to always keep close contact with those within the sector. In figure 67 a couple of potential threats are shown, which can disrupt spatial planning strategies. To cope with these threats, it is important to make new changes. Therefore, it is necessary to act quickly on potential changes in the collaborative structures. These collaborations need to be kept intensive from the beginning to understand each other's position within the overall strategy.

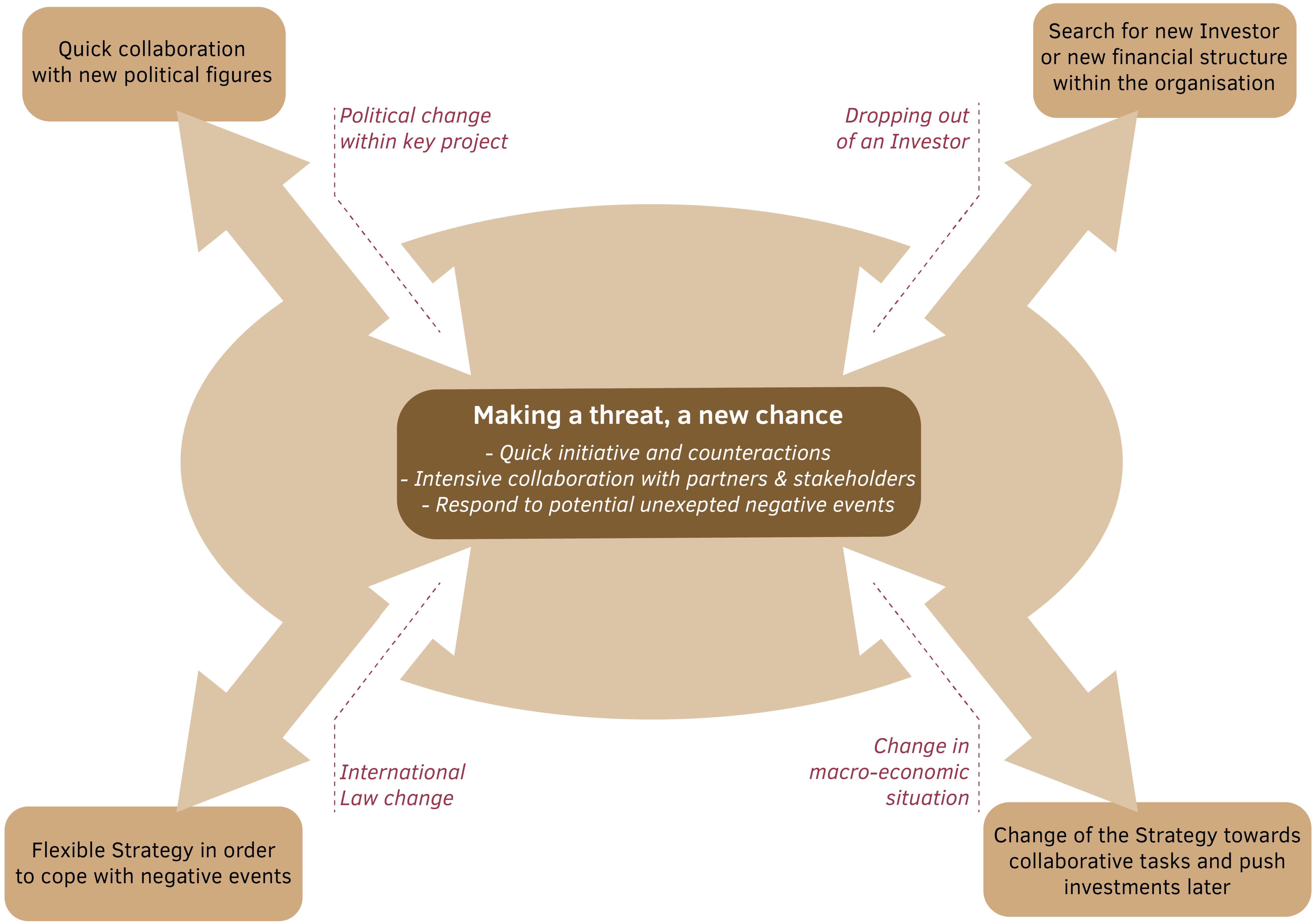


Figure 67. Diagram showing how to deal with potential threats by making chances out of threats (de Zeeuw, 2018, p. 54)

5.2 PHASING

5.2.1 PHASING OF THE STRATEGIES

Before explaining in detail what the new circular ship manufacturing sector will look like in the future, it is important to understand which phases make up the transition from linear ship manufacturing to a circular ship manufacturing sector. The complexity of the changing the global economy for the maritime sector asks for many actions that are necessary to make the sector more sustainable and flexible for the future. Therefore, we have identified 4 phases spanning a period of 60 years. We choose 60 years because of the fundamental changes we are about to introduce and because the maritime industry has shown to be a very robust industry, reluctant to major changes, therefore a longer period is necessary.

The following four phases are distinguished:
- 2022-2032: Initiate Circular Manufacturing
- 2032-2052: Cultivate into an Evolved Ship Manufacturing Process
- 2052-2062: Activate Circular Manufacturing Flows
- 2062-2082: Thriving New Industry & Maritime Living

Each phase has goals, milestones, and policies attached to them, which the next phase can build upon. This way we ensure that these phases are connected and that because of the long timespan of certain interventions, multiple changes can happen during multiple phases.

Figure 68. Map showing total interventions for the change towards a circular maritime manufacturing process

Initiate Circular Manufacturing

The maritime industry has shown to be very robust, heavily relying on a global network of material flows and economic transactions. To start this change as quickly as possible, we are starting on the lower levels of the sector, connecting industries and innovations to the maritime industry by looking to connect the available knowledge and industries that are already present. First, by setting up new Makers Areas connected to the existing educational centers in Delft and Leiden, we can create innovations and knowledge as the initiator for the change in maritime industrial practices. Second, a new maritime industrial practice in the future also asks for two other changes, the change in labor & education and the change in resource materials. New educational programs will bridge the gap between the maritime industry and the labor force, while new recycling programs optimize waste flows.

Cultivate into an Evolved Ship Manufacturing Process

After the start of the optimization of the current industrial systems and available knowledge, it's time to start cultivating these new ways of producing knowledge and materials into new opportunities for new functions, industries, and labor programs directly connected to the maritime sector itself. New principles of increased open management will show the shipyards of South Holland a new way to change their layout and practice. Open management will set possibilities to trade and share goods on a local and regional level, whilst also creating a more sustainable manufacturing process in the physical shipyards themselves. Providing new ways of manufacturing comes in the form of the new Maker Markets, where Makers, research centers, education and the industries can share knowledge and set up collaborations for a change in the manufacturing chain of the maritime industry, by providing prototypes and ship compartments which are produced on a local level throughout the province.

Activate Circular Manufacturing Flows

After the cultivation of new initiatives and innovation within the maritime industry, it is time to change the sector on a larger scale. The previous phases have created a foundation of available knowledge, new manufacturers and Makers, a flexible labor force and a change within the layout and management practice of the ship manufacturing process. This creates new potential to expand the innovative ship manufacturing practice in the region of South Holland. New industrial facilities will be needed to facilitate these ambitions, whilst research centers and educational facilities have created new ways to facilitate an environmentally friendly basis for the symbiosis between industry and nature. This will create new opportunities to connect new nature-based buffer zones with surrounding residential neighborhoods and cities.

Thriving New Industry and Maritime Living

The new industrial facilities based around the central waterways of South Holland will facilitate a new metal-based manufacturing sector where the maritime industry will thrive. Energy transition areas of the PoR will have been developed into new energy storage facilities, whilst also creating a physical location for the decommissioning of larger deep-sea vessels. New nature-based buffer zones in combination with the increasing need for water-based living solutions due to climate change, will create new residential neighborhoods on the edges of existing cities. Knowledge and innovation gathered in the previous phases will be the foundation of these new residential neighborhoods, provided by the maritime sector.

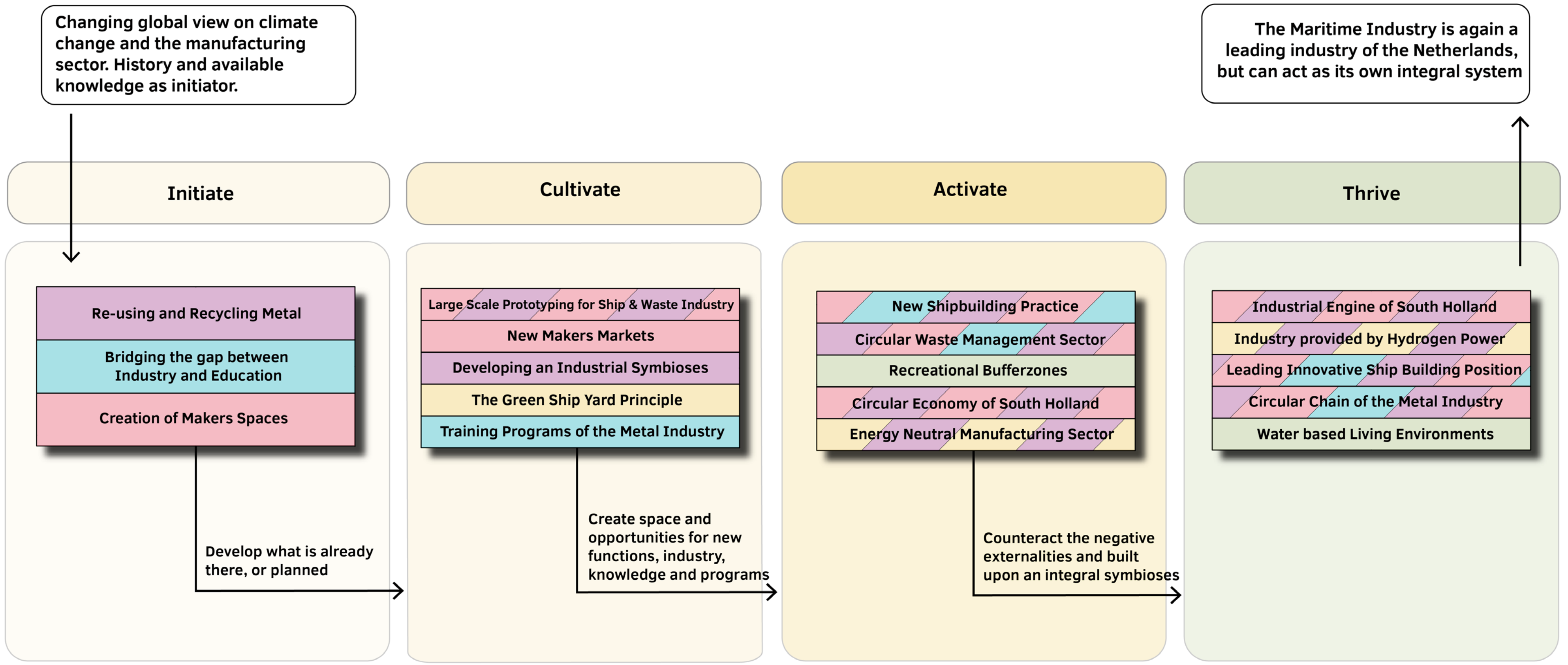


Figure 69. Abstract time frame of the phasing for the strategies of the circular change

Intervention waves (active actions)

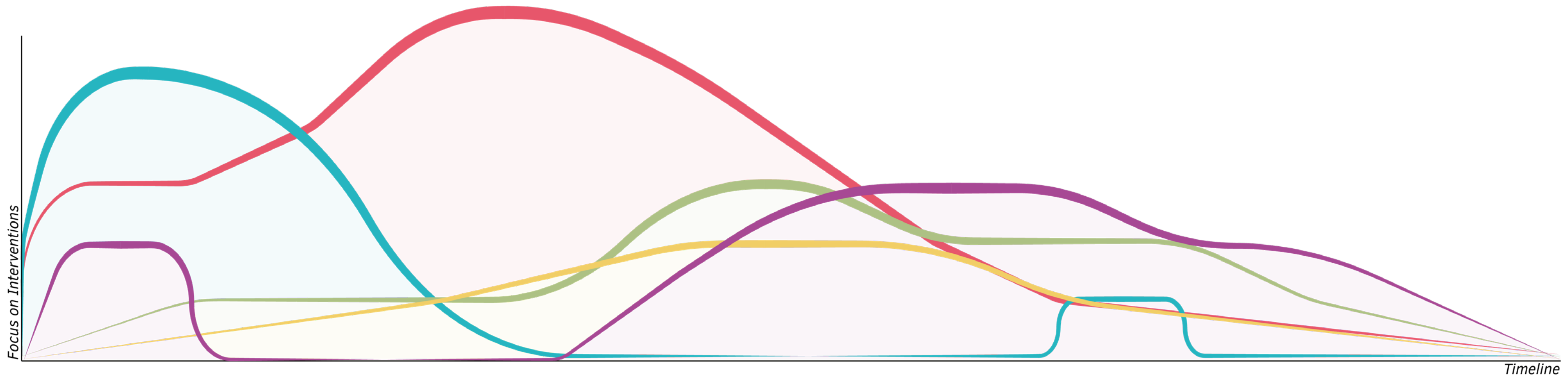
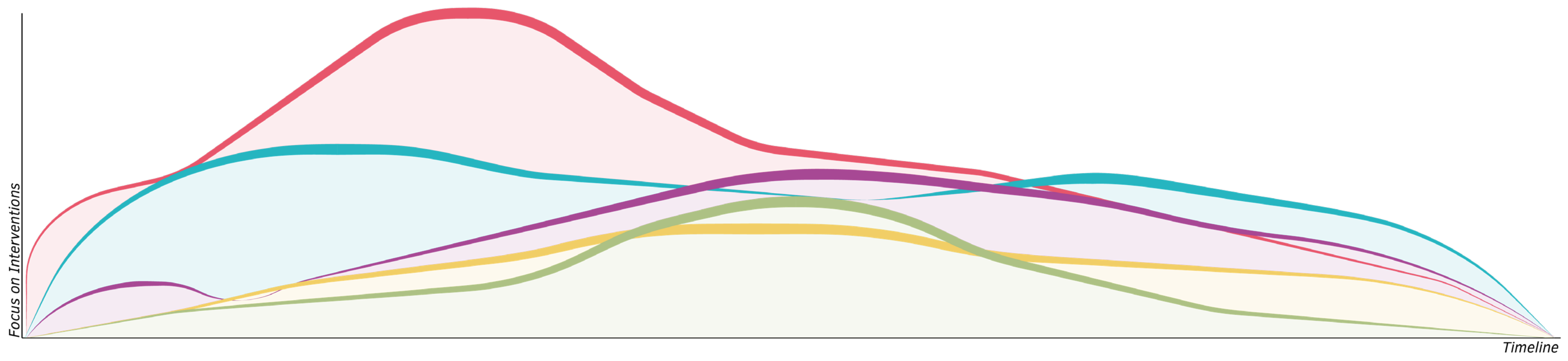


Figure 70. Intervention waves of the active actions needed per sector

Intervention waves total



CIRCULAR MANUFACTURING SECTORS

- Circular Economy & Knowledge
- Industry/Economy (Heavy)
- Labour and Society
- Energy
- Living Environments

Figure 71. Intervention waves of the total phasing per sector

5.2.2 PHASE 1: INITIATE INNOVATION & MAKERS INDUSTRIES

To initiate a circular economy within the maritime industry in the province of South Holland, it is important to start with what is already there and to build a solid foundation upon which the later phases can develop. To do this, new Makers Areas are created alongside existing educational hot zones in Delft & Leiden. The Makers Area of RDM in Rotterdam that is already there will be used as an example for other cities.

To start a collaborative synergy between the different Makers Areas within the overall maritime ideology, every location is connected to a specific industrial sector. Whereas Delft and Leiden will become innovation locations where innovations in the ship manufacturing process, ship design, material sciences & chemical sciences will create new knowledge and insights for the maritime sector, the Makers of RDM will be more closely connected to the maritime industry providing physical innovative products as part of the decentralization efforts of the ship manufacturing process. As seen on the map in figure 72, the Makers Areas will become inter-connective zones, connecting education, research, innovation, materials, and attention neighborhoods with each other, providing new opportunities for residents and Makers to share information and meet with each other. As part of the material transition urban mining programs and new metal waste collection facilities will be set up.

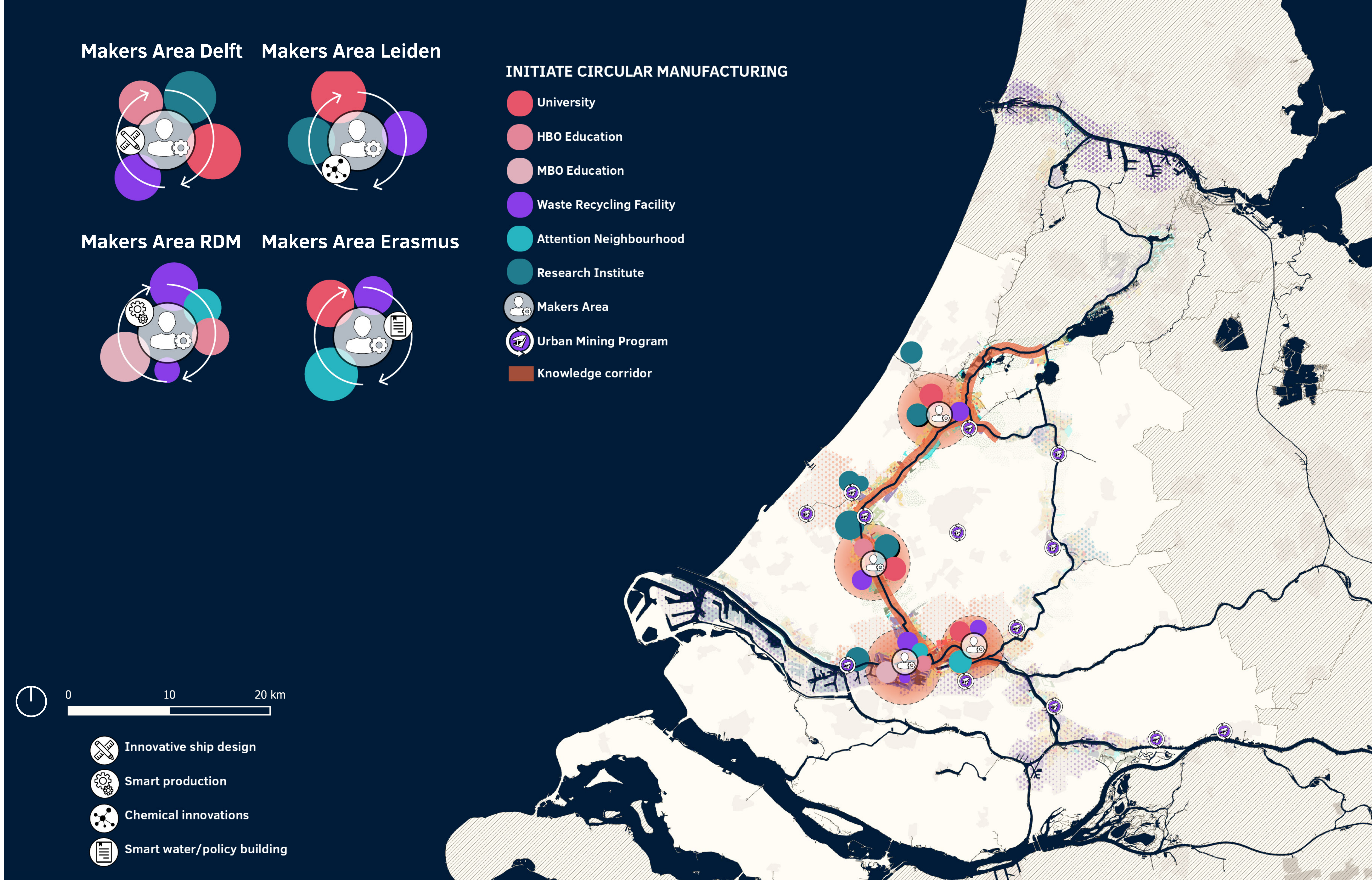


Figure 72. Map showing key interventions in phase 1: Initiate Circular Manufacturing

GOVERNANCE & TIMELINE

Creation of Makers Industry

To kick off the transition of the maritime sector, a new policy change will be introduced within the national zoning regulations. The new Makers industry will become part of the indication of the national zoning regulations, falling under the category of 'mixed'. Therefore, it will be easier to plan Makers Areas in the future. The municipalities will facilitate this under new organic collaborations, indicated by the Capacity Building method, with local Makers and educational facilities. Subsidies can be provided by the national government to kick-start these new ventures within the DEI+ regulation that provided 180 million euros in 2019 (RVO, 2019).

Specifically for the maritime industry (inland & deep-sea) the Dutch National Government, with funding from the EU, allocated 95,7 million euros for research to create a more sustainable maritime industry (RVO, 2019) within the CEF transport budget from 2014 to 2019, which will continue in 2021. The ideology behind the creation of the Makers Areas is to facilitate a change in the way the shipbuilding and maritime industry operates, and to close the gap between the industry and the labor market by providing business areas and housing to develop start-ups and other industrial activities.

Creation of Flexible Labor Force

The Horizon 2020 program of the EU and specifically the Smart and Sustainable Cities program, provided funding for the increase in labor participation within the overall idea to strive for innovative and sustainable cities (RVO, 2019). To close the gap between the need for a flexible labor force in the maritime industry and to create a better image for the maritime sector, new city branding campaigns in the city of Rotterdam in collaboration with the maritime sector are necessary to kick-start the creation of a new call for workers. But the national government in combination with the educational facilities and private companies from the maritime sector need to also collaborate with new educational programs to facilitate the transition towards a flexible labor force for the industrial sector.

Setting up Material-based Collection

Under the Horizon 2020 program of the EU, projects are being funded for resource efficiency and raw materials innovations, therefore urban mining programs can be set up with public funding (RVO, 2019). To facilitate these new programs for local municipalities, the national government must take the lead and organize a structure wherein municipalities can work. This will also require new waste collection centers where waste can be better recycled and reused.

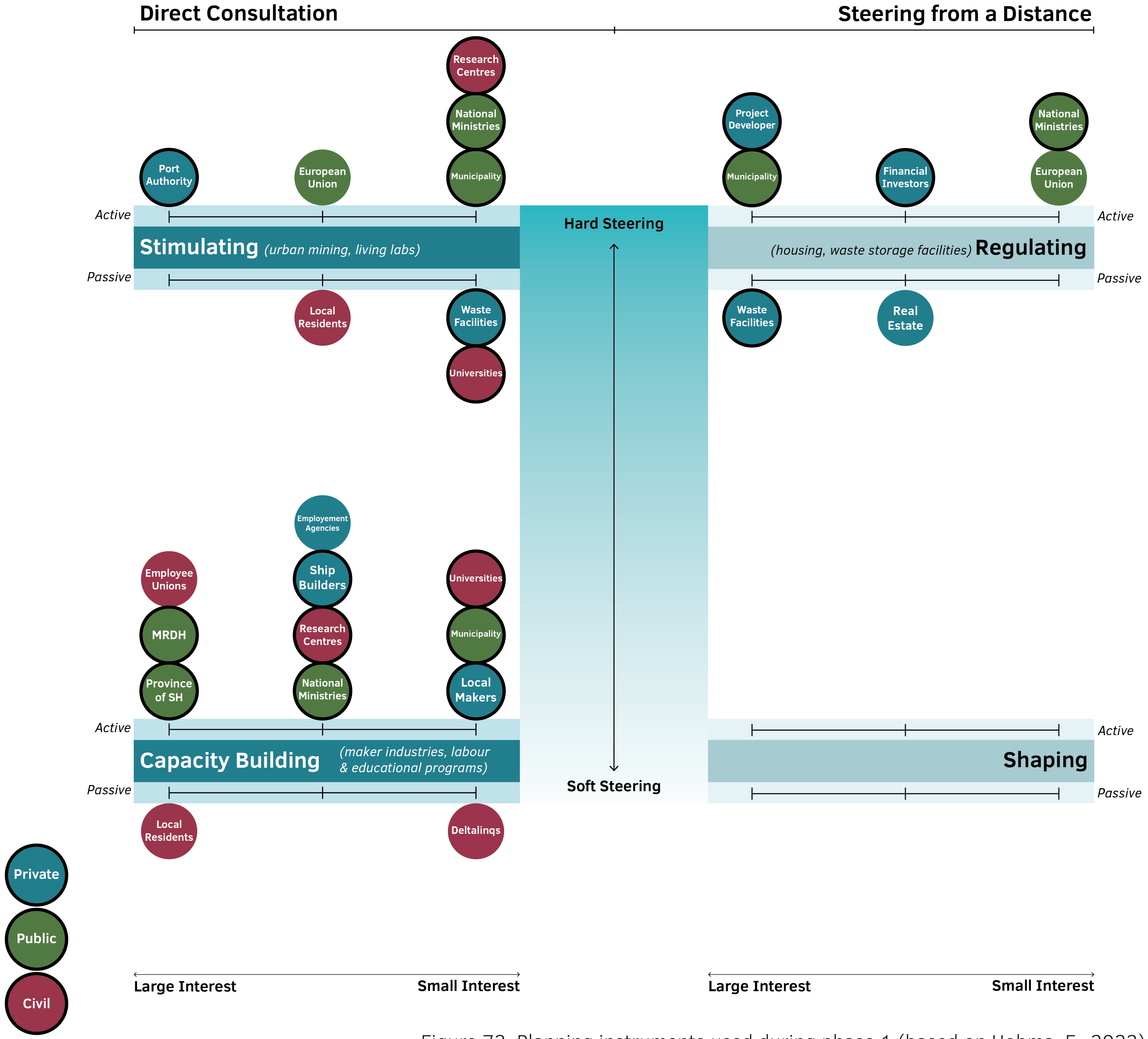
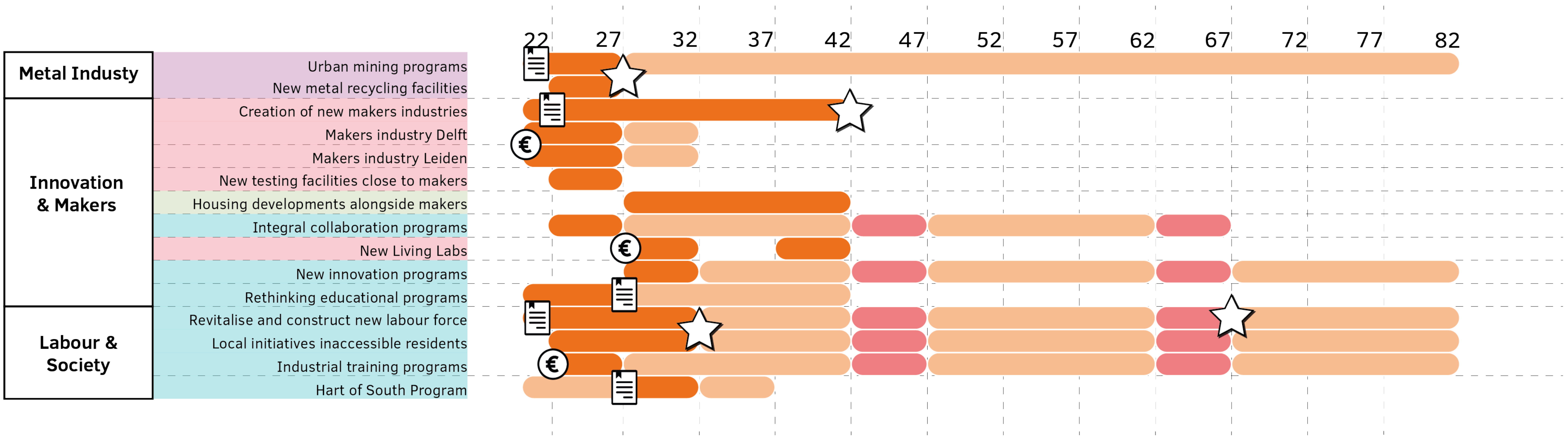


Figure 73. Planning instruments used during phase 1 (based on Hobma, F., 2022)



- The Province of South Holland is able to collect urban metal waste efficiently over the main cities
- The first programs based on the creation of a new labour force are showing their effects
- The new makers industries connected to the innovation centres contribute to the revitalisation of the shipping sector
- After evaluation on the collaboritative labour progams, changes in the labour market are easily picked up

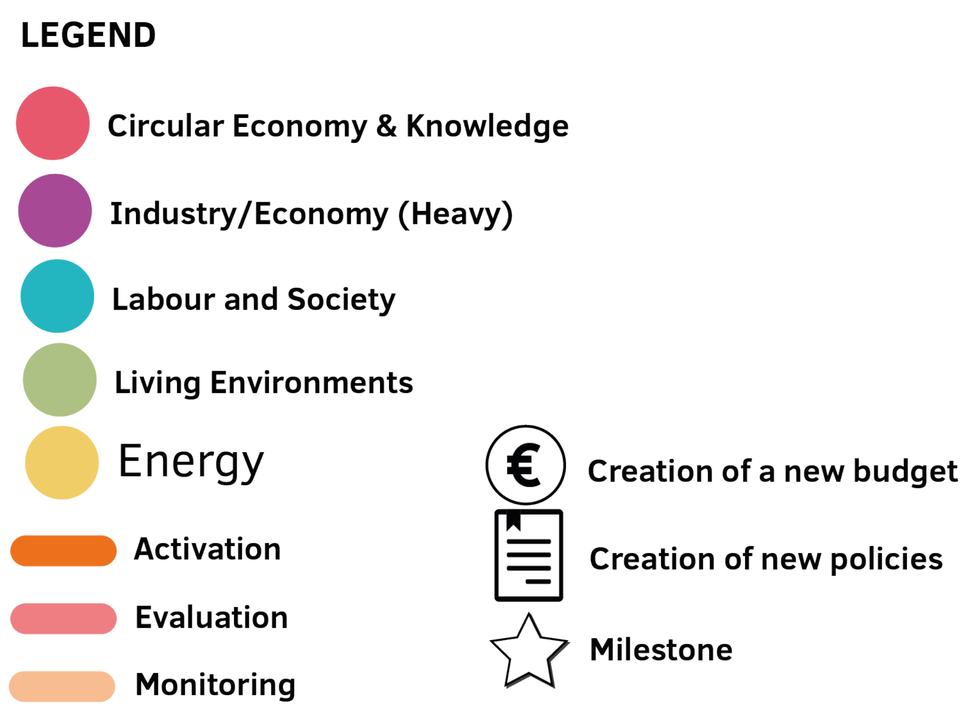


Figure 74. Timeline for phase 1: Initiate Circular Manufacturing

5.2.3 PHASE 2: CULTIVATE THE CIRCULAR ECONOMY

After laying the Makers, labor, and material foundations in phase 1, it is important to cultivate this into a new ship manufacturing ideology based on sustainability and circular economy. The current shipyards of the Dutch maritime sector will start their transition towards 'Green Shipyards', where spatial changes will create a more sustainable production process and where waste flows based on heat, water, and metal will become connected to the new industrial symbioses programs. These programs facilitate local collaboration and trading of goods, information, and knowledge between industrial companies, research institutes, and the new Makers Areas.

These collaborations will reduce the environmental footprint of the ship manufacturing process and contribute to an innovative circular South Holland region. Specific new locations for a new type of Makers Area will be allocated to the Binckhorst (DH), Spaanse Polder (R'dam), and Rotterdam Ahoy, where occasionally Makers have the opportunity to sell and distribute their products to the larger companies and public parties, increasing collaboration between local Makers and large-scale maritime industries. Therefore, large prototyping locations in RDM will create new opportunities to decentralize and optimize the shipping industry and its resource usage. Rotterdam Ahoy is specifically chosen as a connecting factor between Makers, industries, and the social program of Heart of the South (Hart van Zuid, n.d.), where residents have the opportunity to connect to a sector increasingly needing new workers. Next to that, two innovation centers in Alphen aan den Rijn and Gouda will kick off their part of the whole chain by creating space for Makers but also allowing larger industries connected to the metal sector to coexist.

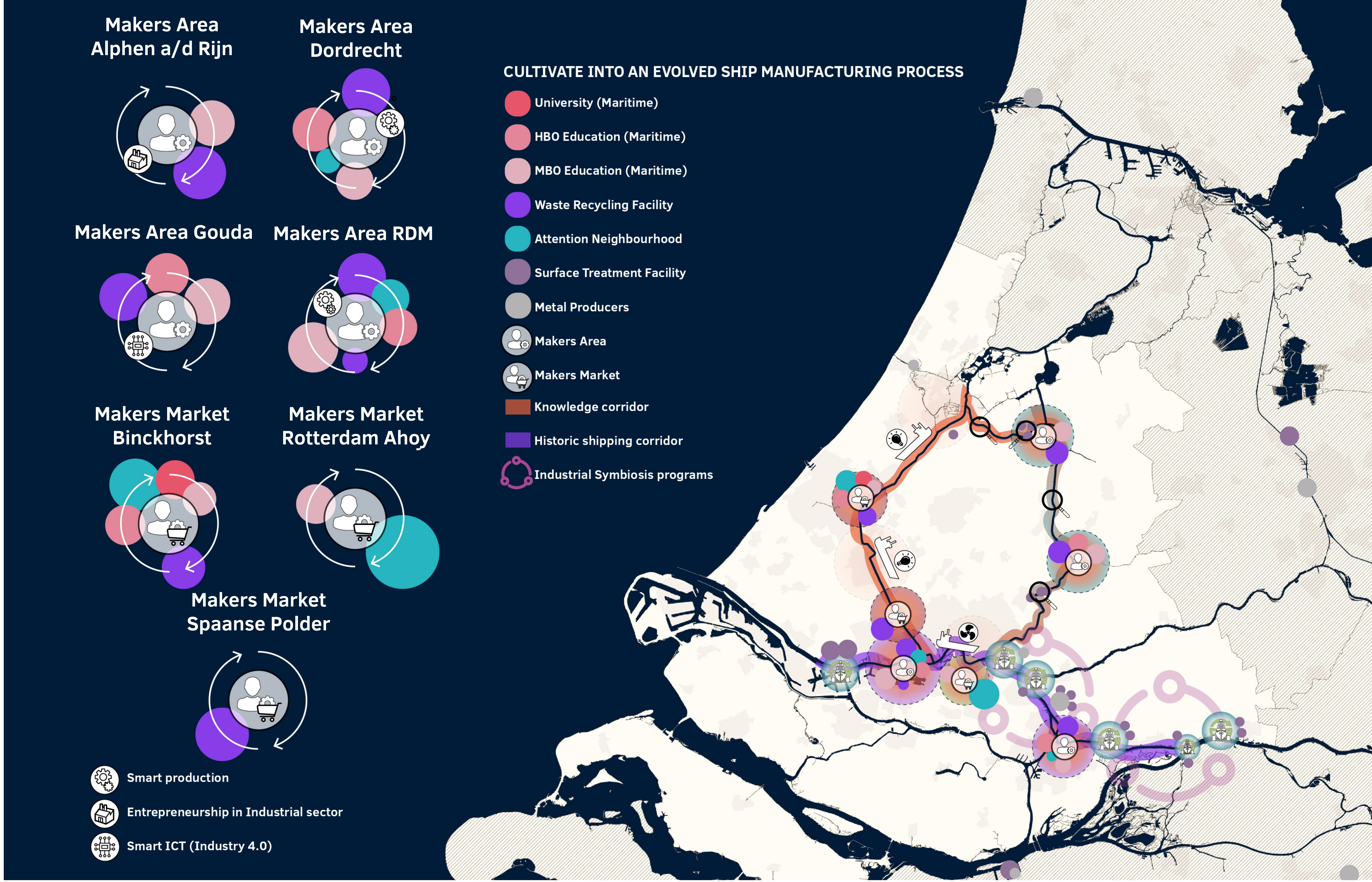


Figure 75. Map showing key interventions in phase 2: Cultivate into an Evolved Ship Manufacturing Process

GOVERNANCE & TIMELINE

Makers Industry

To facilitate new Makers Areas in the region of Alphen aan den Rijn and Gouda based on (ship)recycling and ICT, respectively, both municipalities need to be persuaded to participate in the strategy for South Holland. Therefore, the introduction of a new industry in Alphen aan den Rijn and an ICT and water-based knowledge center in Gouda are connected to their existing vision for 2030 (Gemeente Gouda, 2019; Gemeente Alphen aan den Rijn, 2022), building upon the current knowledge and skills already available in the region. The same policies, and knowledge and innovation-based budgets of phase 1 can be used to facilitate this transition. Only on the local scale, changes in zoning plans are facilitated by local governments and symbiosis programs are set up to make an organic organization structure possible, where Makers, residents, and businesses can benefit from free and integral information sharing and business & entrepreneurial opportunities. Therefore, the municipalities need to build on the capacity of the newly created areas with other interested actors and stakeholders.

On the other hand, a new element within the Makers industry is created, namely Makers Markets, where local Makers, research institutes, and educational facilities can come together to share and discuss information related to innovation in the (maritime) industrial world. This asks for vision shaping by municipalities and the provincial government in collaboration with research institutes to be able to develop this new typology of Makers Markets.

Symbiosis Programs

To build upon the idea of Makers Markets, integral symbiosis between the public, private, and civil sectors are necessary to facilitate new collaborative projects, like the 'Green Shipyard', to further reduce the environmental footprint of the maritime industry and increase material flows and material efficiencies. Environmental policies by the EU and the new climate accord signed by the IMO, which is based on the European Green Deal, create opportunities for the increase of a sustainable manufacturing process of the maritime industry, with additional funding (IMO, 2017; RVO, 2019). On the other hand, subsidies are created under the RDM subsidy regulations of the national government, also cited to increase the strategic positions of the Dutch maritime industrial sector (Nederland Maritiem Land, 2020, p 4).

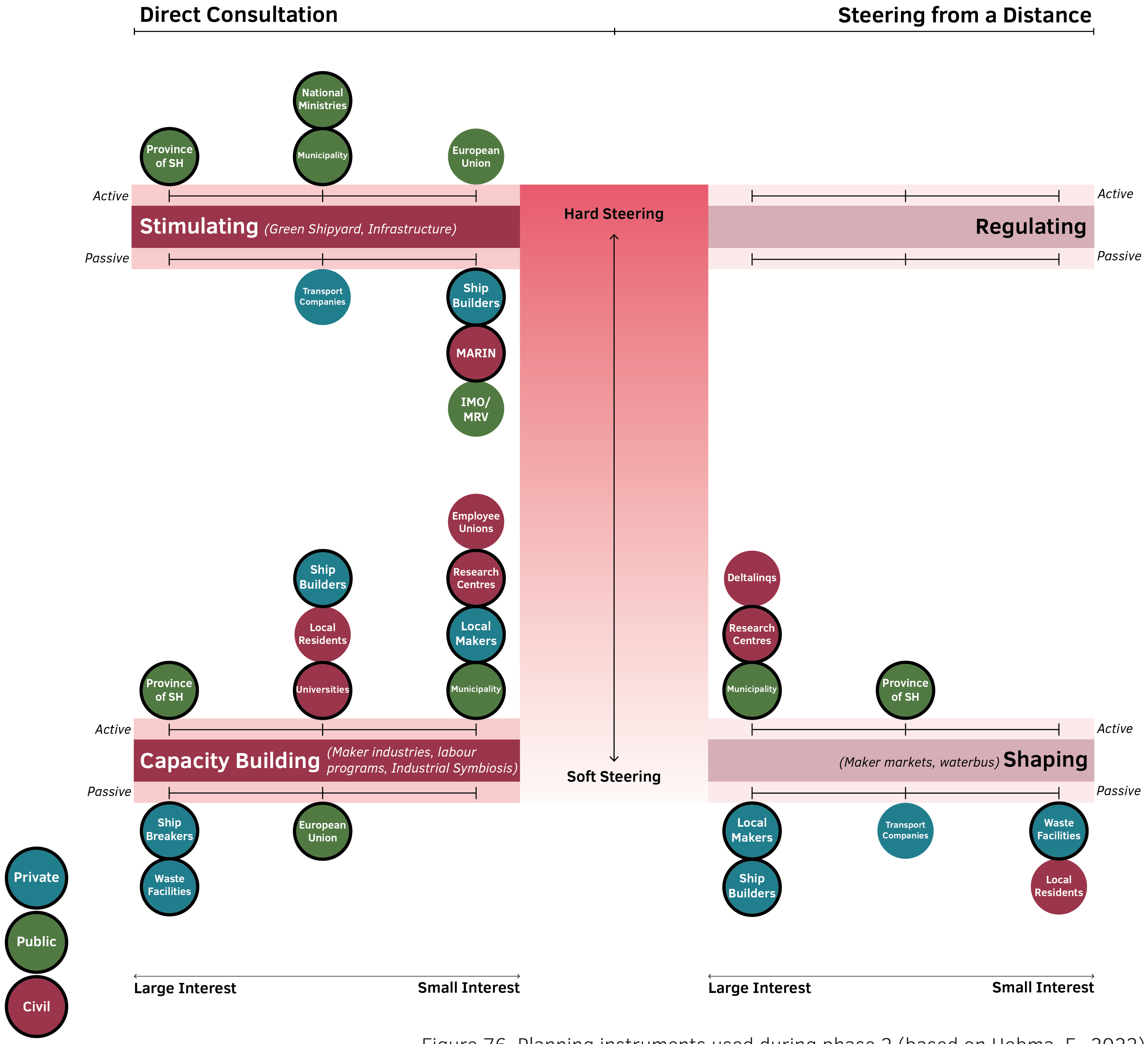
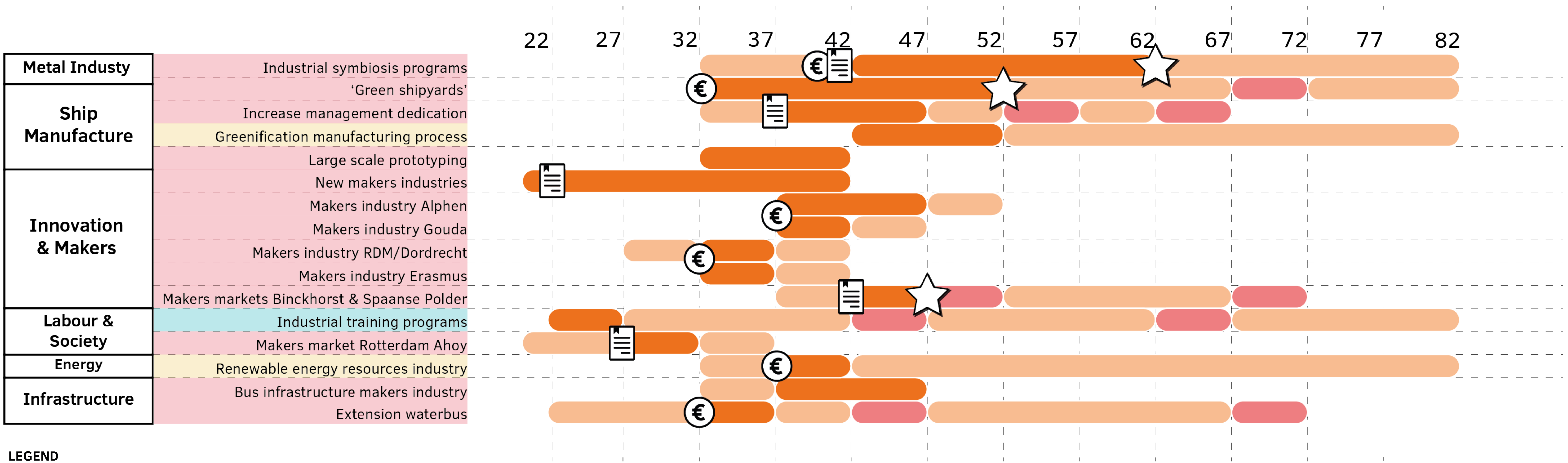
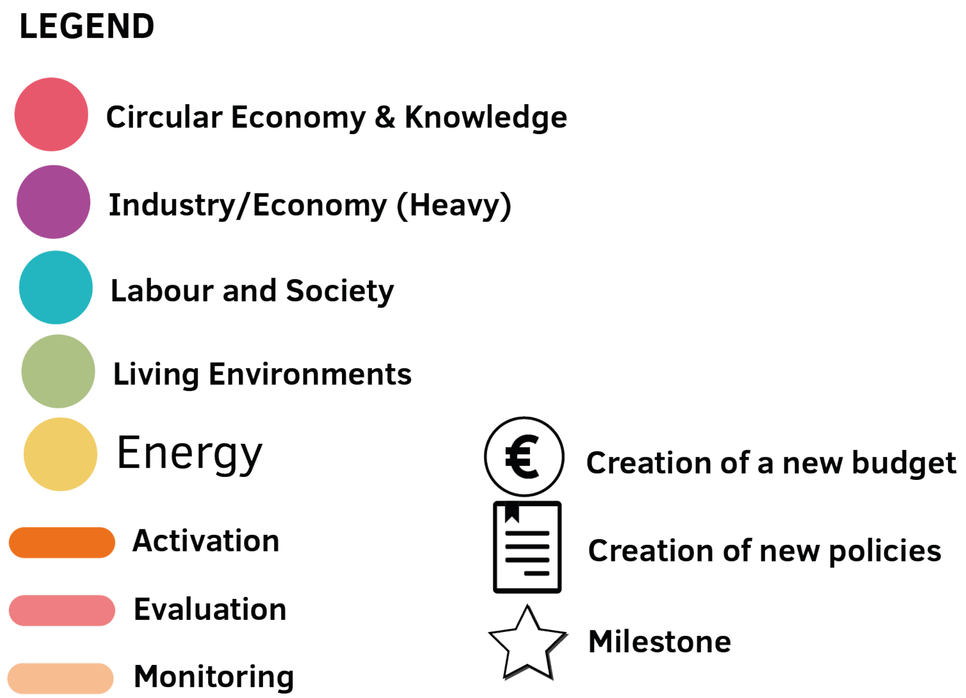


Figure 76. Planning instruments used during phase 2 (based on Hobma, F., 2022)





☆ New makers markets in the Binckhorst & Spaanse polder create a location where makers can show and sell their products

☆ The green ship yard principle is in full operation across the South Holland shipbuilders. Sharing of water, waste and energy can begin

Figure 77. Timeline for phase 2: Cultivate into an Evolved Ship Manufacturing Process

5.2.4 PHASE 3: ACTIVATE NEW INDUSTRIES

After the initiating and cultivating phases have created a solid foundation of maritime production, material efficiency, innovative initiatives, and collaborative consortia, the next step is to expand the industrial and environmental sector of the maritime industry. To do this, it is necessary to increase the number of industrial locations along the waterways of South Holland, with a waste recycling and shipbreaking corridor in the east of the province.

The new Makers Areas in Alphen aan den Rijn and Gouda give new insights and stability for newly created industries based on waste treatment, ship-breaking, and ship manufacturing. The foundation created by the industrial symbiosis programs makes it easier for these new industries to gain a foothold in the region. But due to EU regulations, it is necessary to add additional environmental and recreational zones to balance the negative externalities by these new industrial locations. Also, in accordance with the environmental zoning regulations by the VNG (2019), it is necessary to create buffer zones between the industries and the surrounding agricultural and residential neighborhoods. But we see it as an opportunity to connect the industries and the residential neighborhoods, by creating nature-based buffer zones that have recreational, noise-canceling, and possibly innovative characters.

Because of the disappearing appeal of the petro-chemical sector in the PoR, we can take advantage of the freed up the space to create new locations for shipbreaking and ship manufacturing, whilst also facilitating new energy sources based on hydrogen production and storage.

Figure 78. Map showing key interventions in phase 3: Activate Circular Manufacturing Flows

GOVERNANCE & TIMELINE

Industrial Programs and Environmental Buffer zones

The activation of a new circular manufacturing chain asks for the allocation of industrial sites on existing industrial locations, but also on agricultural land, primarily on the grassland used for livestock. The need for new industries is shaped by the fact that the European Union wants to decrease their dependency on the manufacturing powers of Asia (European Commission, 2020), but local and national governments need to provide the space for the allocation of these new spaces. Hard steering is necessary for governmental bodies to strive for a new industrial basis for the region, providing new revenue and jobs in the maritime sector. Careful consideration and collaboration with residents and municipalities are necessary to decrease negative externalities as much as possible.

The allocation and creation of these new nature-based buffer zones can be a consultation tool between industries, public parties, and civil organizations, where funding could be provided by the public and private sectors. New industrial policies of the Dutch government and the European Union always connect new industries to research and development programs, provided by Horizon Europe (VNO-NCW & MKB-Nederland, 2016; European Commision, 2020). Therefore, the allocation of the Makers industry and innovative developments in Alphen aan den Rijn and Gouda make it more feasible for the new creation of industrial activities in the province of South Holland.

Energy Transition

The disappearing appeal of the petrochemical sector in the Port of Rotterdam creates the opportunity for the allocation of a new energy source for the industrial sector of the province (Port of Rotterdam, 2019). Where the European Union and the Dutch government have the ambition to power large sectors with clean hydrogen by 2050 (Ministry of Economic Affairs and Climate, 2019), the maritime sector is still reluctant to the usage of hydrogen, but by 2050 the innovation and knowledge collected by the research institutes and Makers industry, create new examples for the implementation and the use of new energies to power the manufacturing process and the vessels themselves. Therefore, industrial symbiosis programs between public, private, and civil organizations are again vital for the implementation of new innovative transitions in the maritime industry.

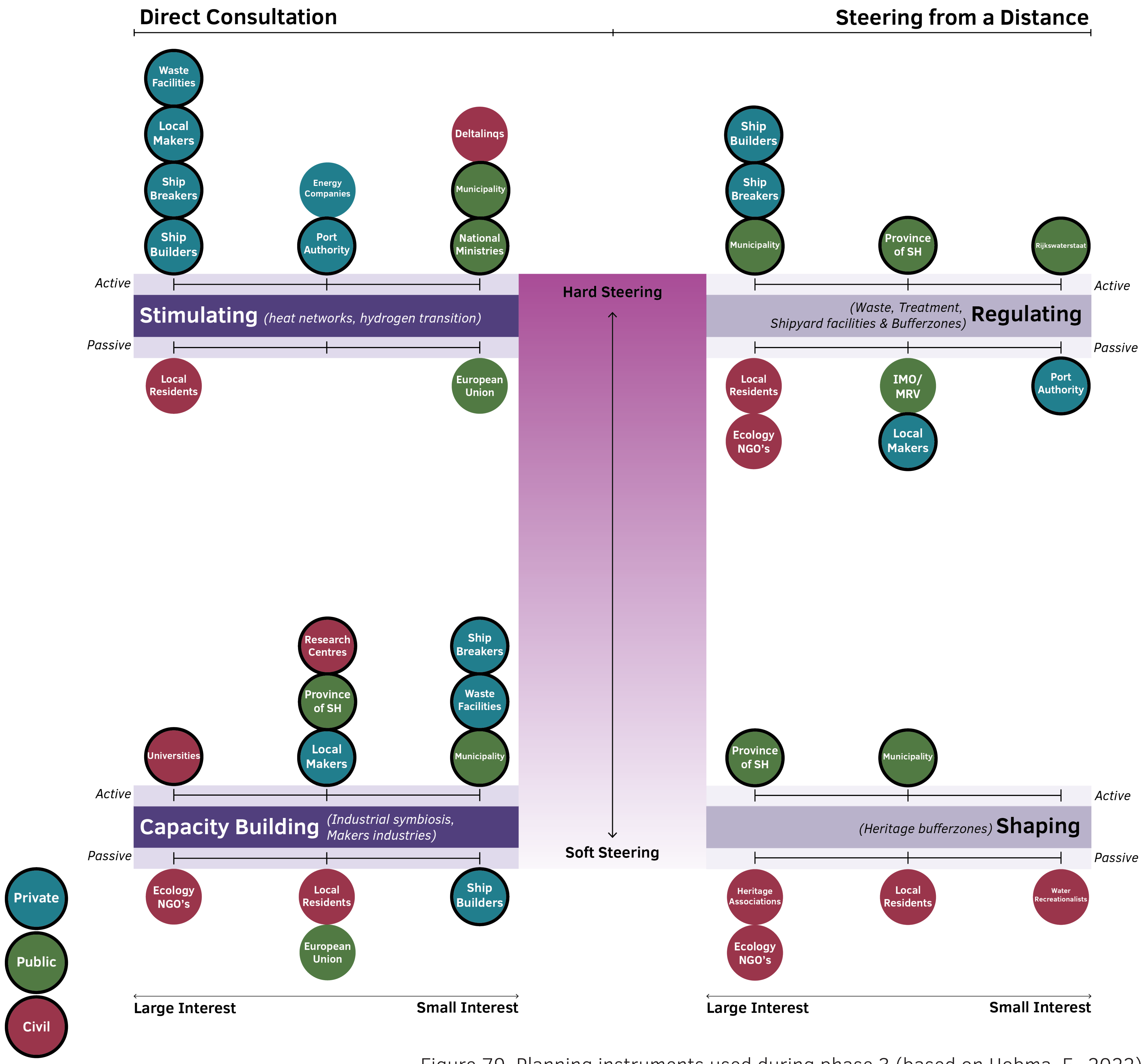
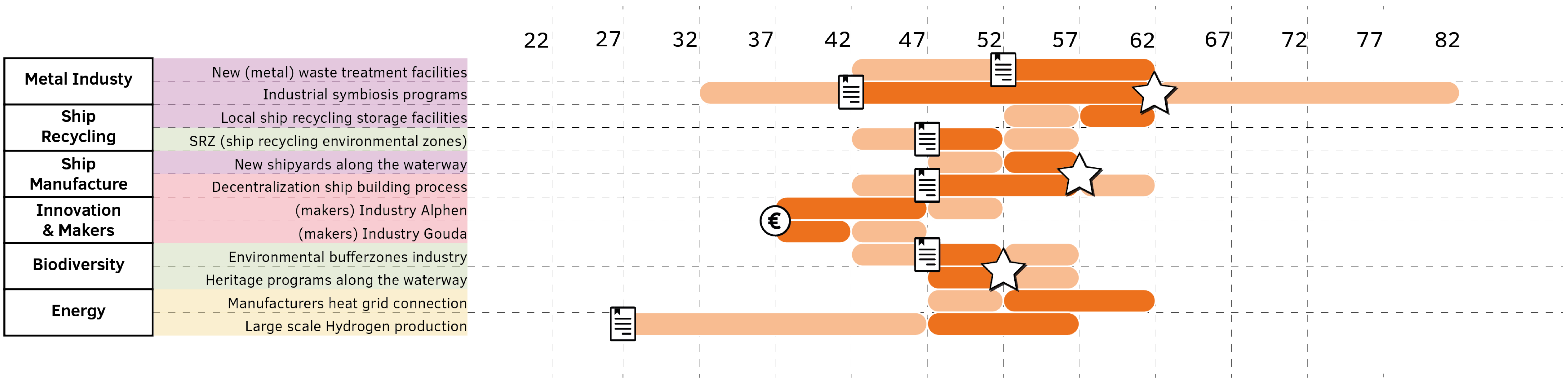


Figure 79. Planning instruments used during phase 3 (based on Hobma, F., 2022)



Due to the creation of multiple new industries along the waterways, the need for a recreational bufferzone offers a lively transition

New shipyards based on the increase of usage of the shipping sector calls for an optimisation of the shipyards and possibly new yards aswell

Industrial symbiosis programs between industies on location and new waste treatment facilities, can facilitate an integral sharing system of goods and services

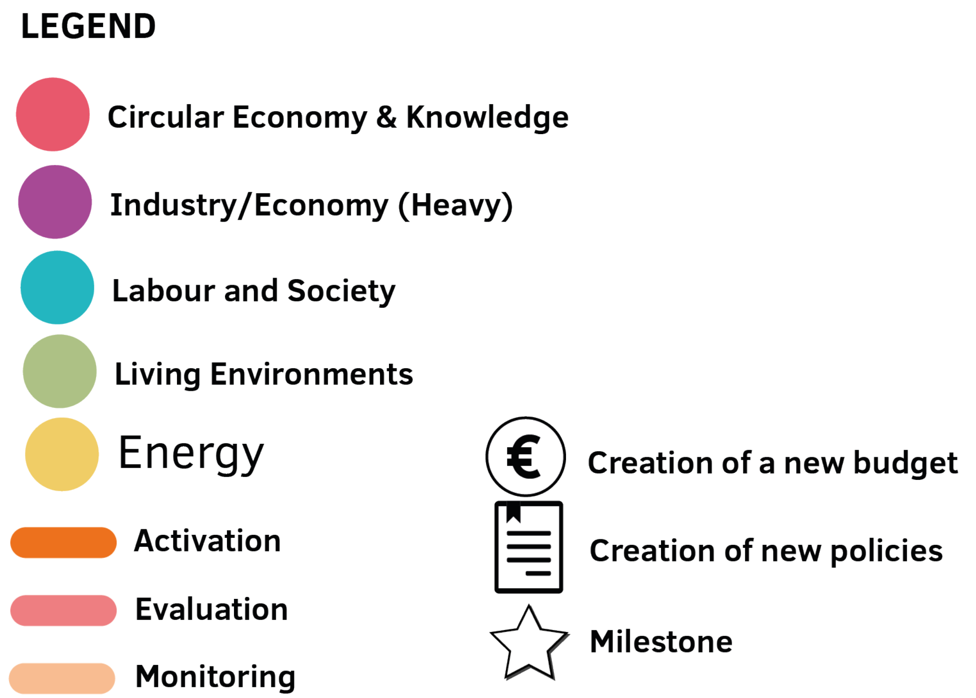


Figure 80. Timeline for phase 3: Activate Circular Manufacturing Flows

5.2.5 PHASE 4: THRIVING WATER-BASED SOUTH HOLLAND

The final stage of the circular economy transition of the maritime industry in the province of South Holland combines the further allocation of new industrial programs with new water-based residential neighborhoods. While the PoR is moving into the final stages of the allocation of new energy and industrial facilities, new neighborhoods are established in the east where the new industrial sites of the waste and recycling sectors have created more jobs and opportunities. Therefore, new residential neighborhoods are necessary.

To implement knowledge and innovation for the water-based programs of Gouda and Rotterdam to practice, low lying agricultural land is transformed into a water-based living environment. This provides a new way of living, coping with the consequences of sea level rise and the subsidence of the peatlands and old reclamation areas of the east. These final stages also provide the final developments on both sides of the scale. On the one hand, with the new large industrial shipbreaking facilities in the Port of Rotterdam, which can decommission larger deep-sea vessels, the final stage of the ship recycling cycle is provided. On the other hand, the new water-based living environments built upon a water-based vision are created to which the maritime sector perfectly aligns. These stages will transition the region of South Holland into a leading innovative circular maritime industry.

Figure 81. Map showing key interventions in phase 4: Thriving New Industry & Maritime Living

GOVERNANCE & TIMELINE

Industrial Programs

The larger shipbreaking facilities, which are allocated in the Port of Rotterdam, provide new materials for the now existing circular metal chain in the province. The allocation of these facilities asks again for careful consideration and collaboration with industrial companies. Strong regulation is necessary to create an environmentally safe decommissioning site because the decommissioning of large deep-sea vessels needs more precise treatment. These new facilities will give examples for other countries on how to integrate large shipbreaking facilities within a circular chain, making it possible to address the human tragedies in India, Pakistan, and Bangladesh where vessels are dumped for locals to dismantle (Torset, 2014). Although regulations have been created with the new Hong Kong Convention for cleaner and safer decommission of vessels, regulations have to be directed directly to the ship manufacturers and tax regulations of international shipping. Therefore, it is necessary to draft new policies and regulations, providing stricter regulations on international shipping, which start around 2050.

Water-based Living

Currently, subsidies for the increased impulse to build more housing in the Netherlands are already implemented to cope with the current tight housing market. Around 2060, these seem to be gone due to the decrease in the number of Dutch citizens, but new typologies of housing are necessary to cope with the increase in sea level and the increasing subsidence of the lower lands of South Holland. Therefore, stimulation by local governments and institutions like Rijkswaterstaat is needed to create the potential locations for these new living environments. In collaboration with educational and research institutions that have been innovating the water-based living sector, these neighborhoods are easier to implement. But before these neighborhoods can be constructed, visions need to be shaped for financial investors, real estate companies, and local residents to create an integral participation process.

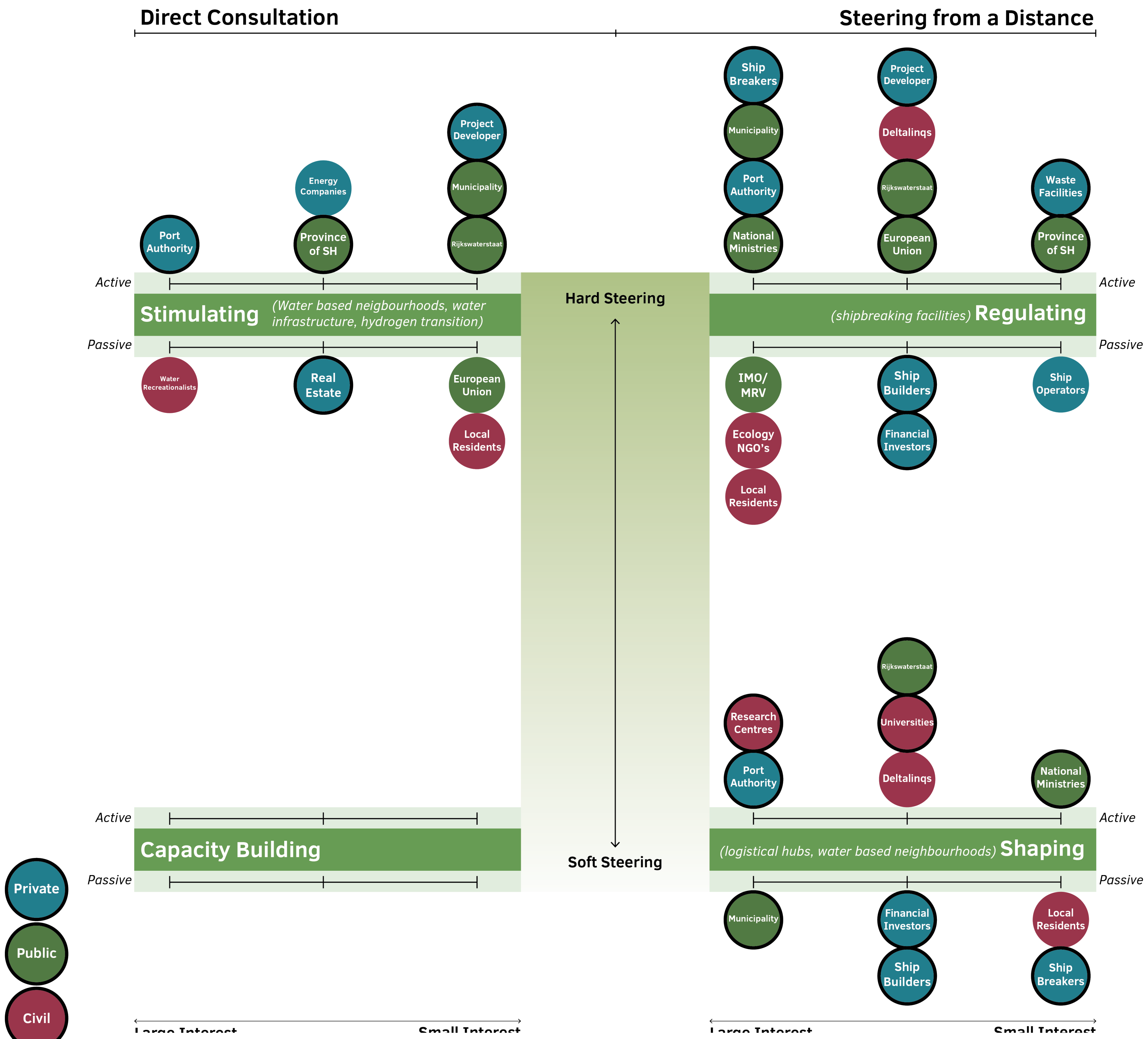
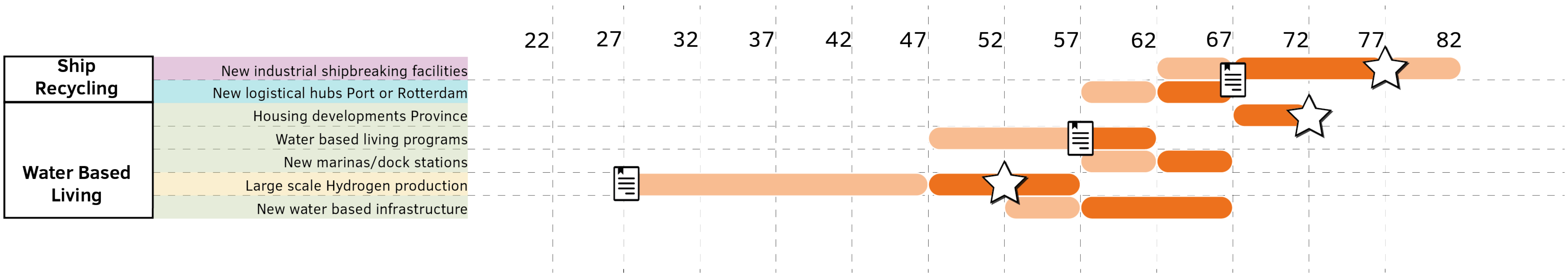


Figure 82. Planning instruments used during phase 4 (based on Hobma, F., 2022)



Large scale Hydrogen production is operational in the Port of Rotterdam, and connects to the Maritime sector for a fuel transition in the sector

After the creation of water based innovation locations around the eastern corridor, the first water based housing developments are finalized.

Large open spaces after the transition of the petrochemical sector leave open space for the final step in bringing back l arge shipbreaking facilities

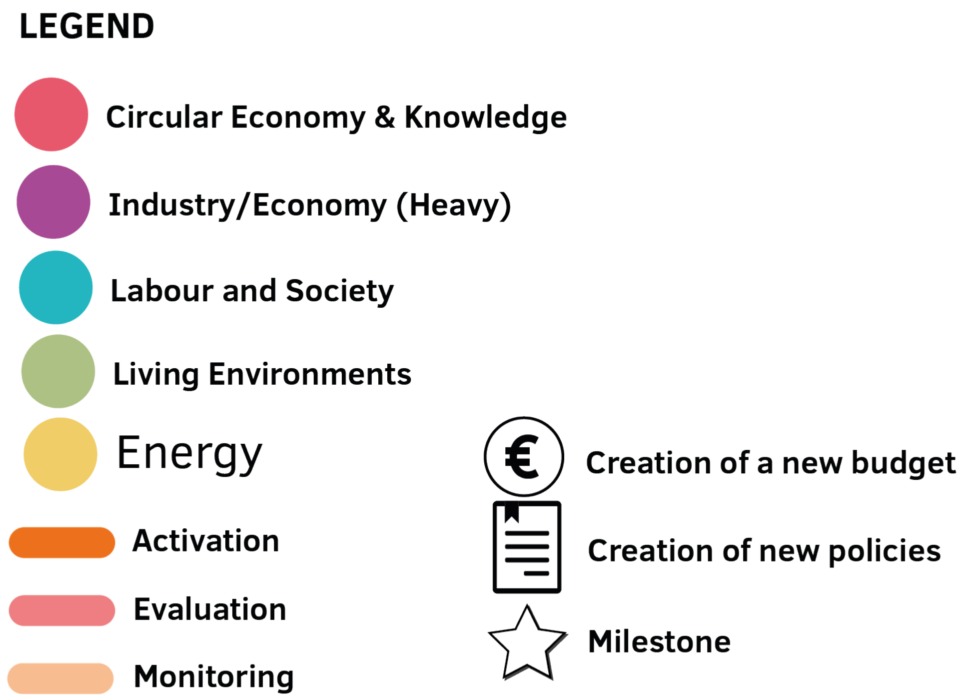


Figure 83. Timeline for phase 4: Thriving New Industry & Maritime Living

5.3 STRATEGIC PROJECTS

5.3.1 PROJECT GOALS

DELFT - RDM - BOTLEK

Phase 1

New innovative Makers Areas in Delft, RDM, and M4H are connected to existing educational facilities close by providing an interface for knowledge and innovation sharing between industries and research institutions. Local urban mining programs connected to existing industrial zones and companies provide the first steps to optimizing a circular metal chain. To strive for a new flexible workforce, training programs and collaborative labor programs with educational institutions and municipalities are set up. The foundation for the next phases is providing knowledge, training a new workforce, and starting to change the metal sector layout.

Phase 2

The new Makers Areas and educational facilities provide new innovative techniques that are shared in the new Makers Markets of Spaanse Polder and Rotterdam Ahoy, whilst also providing new large scale prototyping locations in the Waalhaven and Eemhaven near RDM. In collaboration with local shipbuilders like Damen, innovations can be developed as part of the ship manufacturing process. These collaborative projects are connected to the new industrial symbiosis programs that provide an open data source between involved industries, optimizing material, energy, and waste management. Due to the climate goals of Europe, a Green Shipyard principle is introduced with local shipbuilders, striving for an energy-neutral ambition of the shipbuilding process.

Phase 3

The new industrial symbiosis programs and integral collaborations within the ship manufacturing process lay the foundation for the expansion of ship manufacturing in the region. Therefore, new shipbreaking zones and shipyards are placed around the PoR on existing industrial sites, providing new material for the ship manufacturing industry. To counter the negative externalities to the surrounding areas, new environmental buffer zones are placed, creating new nature areas for residents. The phasing out of the petrochemical sector creates an opportunity to shift towards a new energy source, whilst also providing space for existing and new shipbreaking facilities.

Phase 4

To finalize the transition of the region into a circular ship manufacturing zone, new large-scale deep-sea shipbreaking facilities are allocated to the existing industrial sites of the old petrochemical sector. These new locations will provide a clean source of energy for the ship manufacturing process and fuel usage of vessels. Furthermore, these locations will provide new industries related to the decommissioning of large deep-sea vessels, bringing the full circle of the ship manufacturing process to the region of PoR.

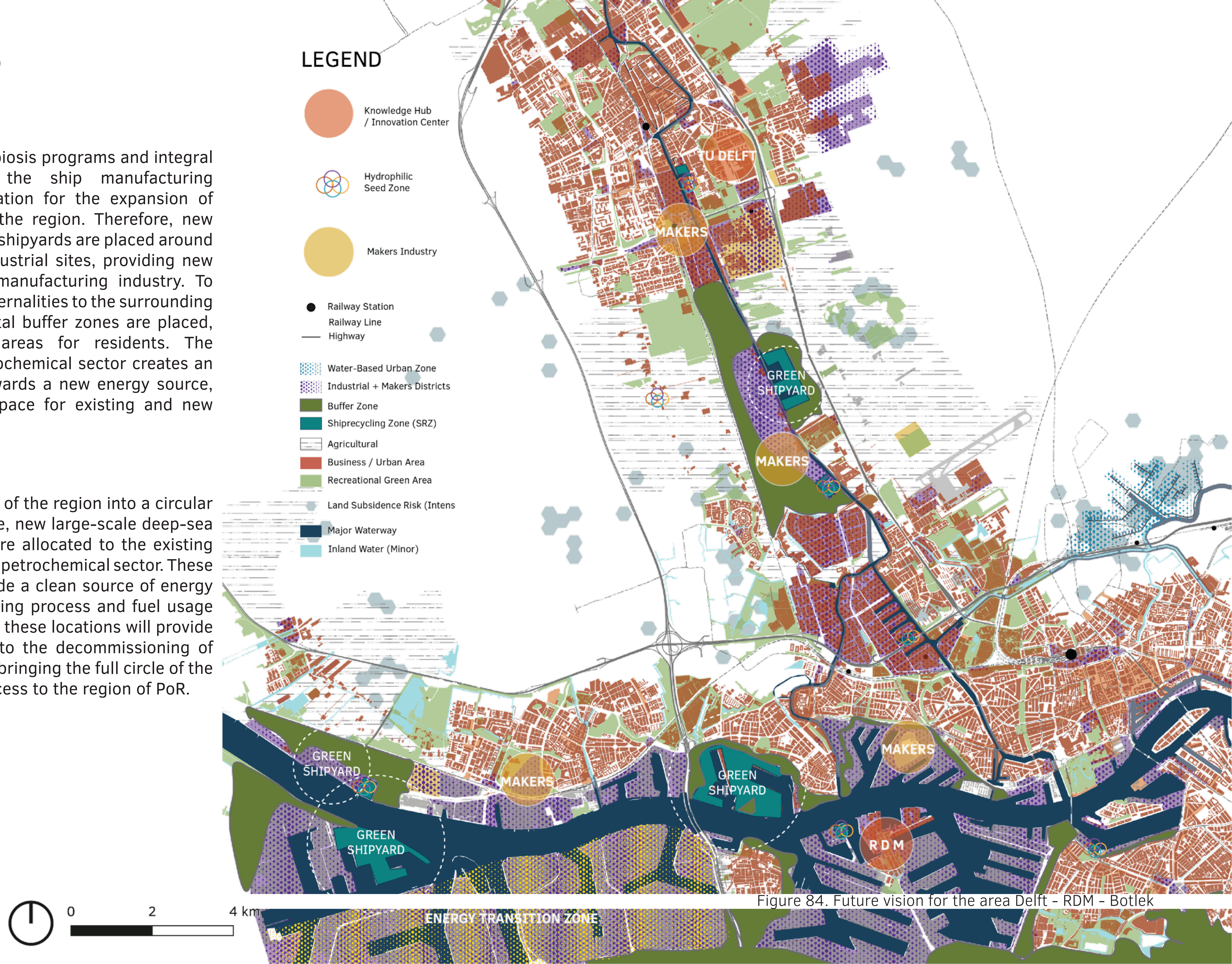


Figure 84. Future vision for the area Delft - RDM - Botlek

Figure 85. Power-Interest matrix Delft, existing situation and necessary future shifts

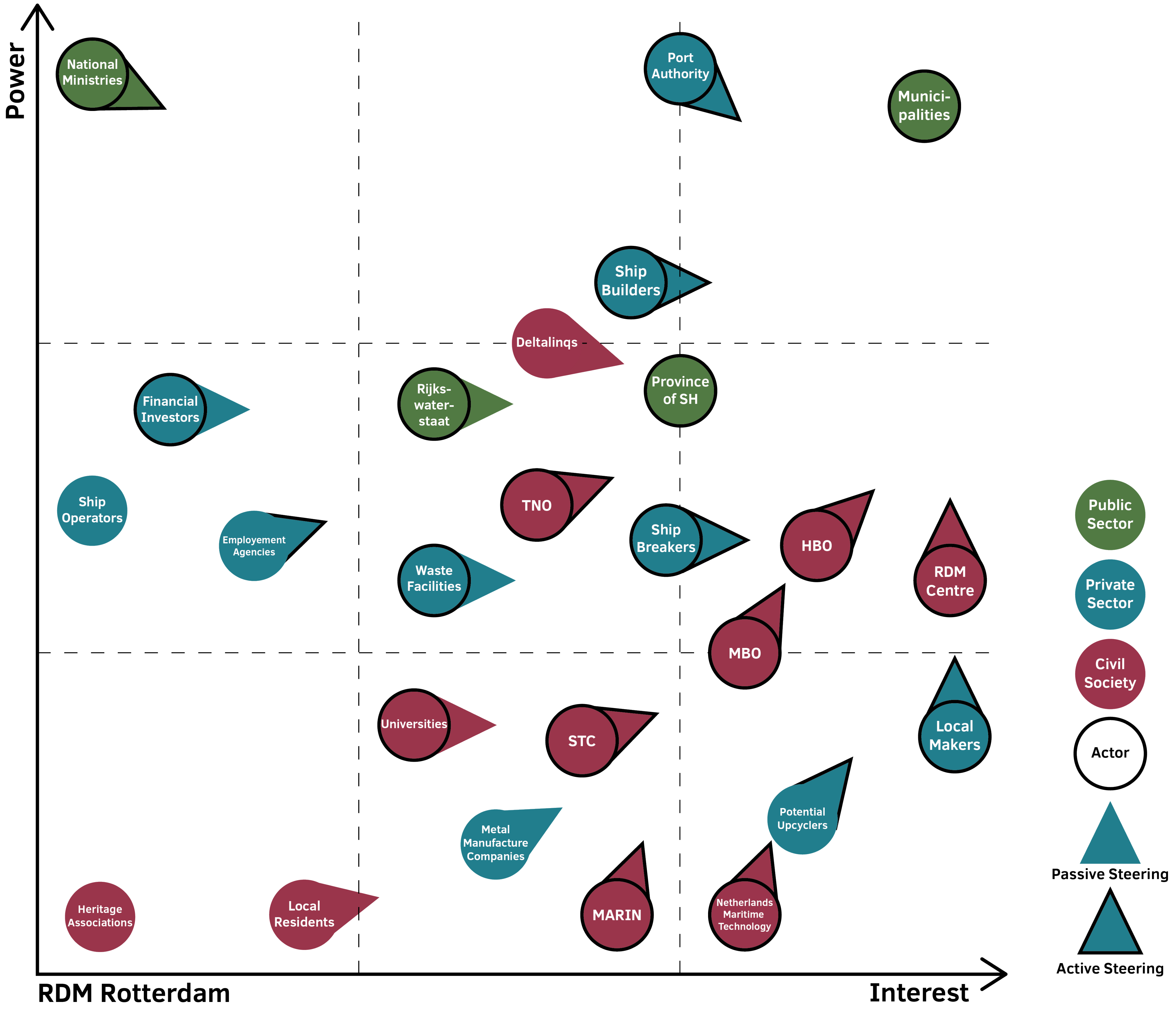


Figure 86. Power-Interest matrix RDM Rotterdam, existing situation and necessary future shifts

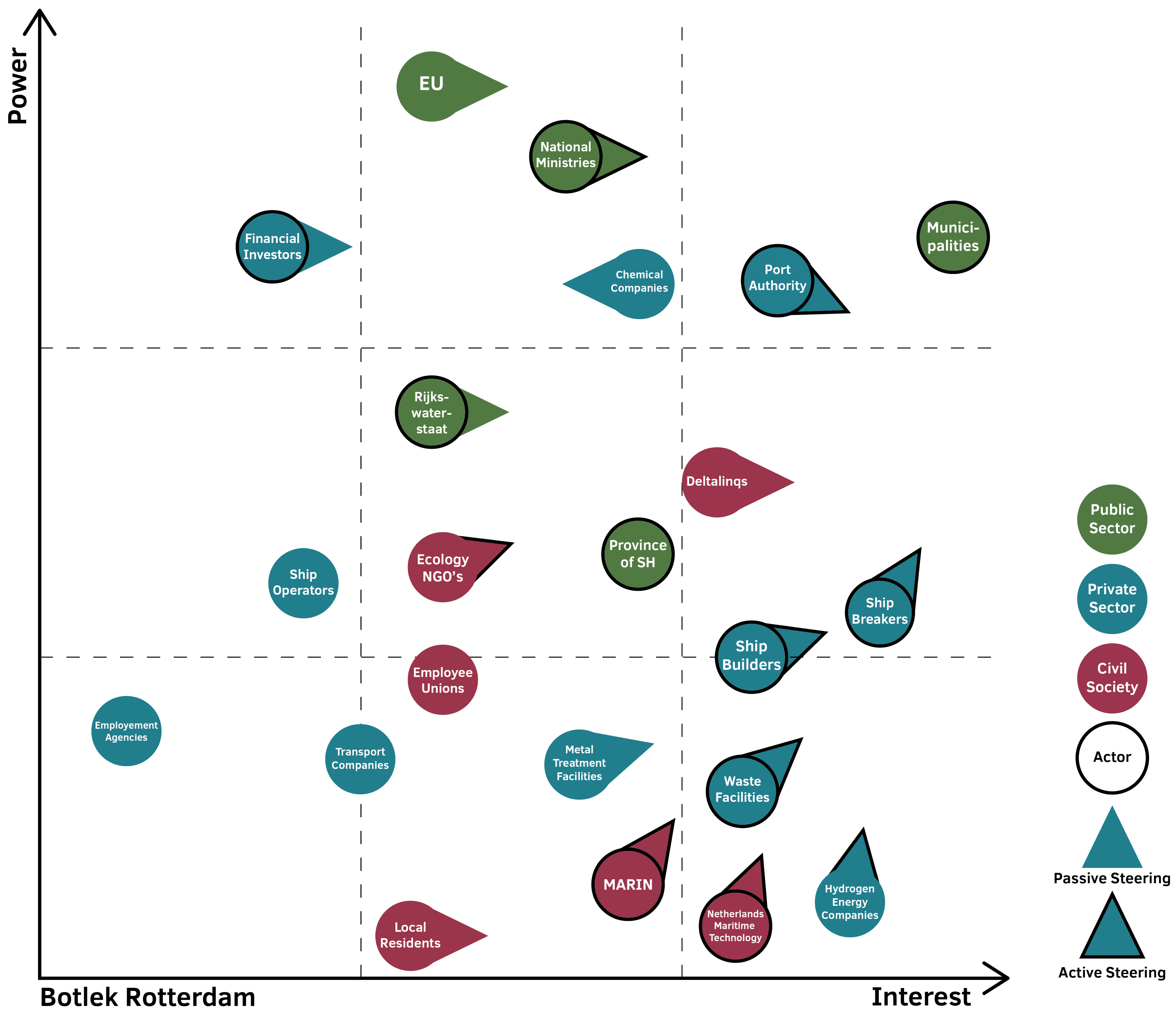


Figure 87. Power-Interest matrix Botlek Rotterdam, existing situation and necessary future shifts

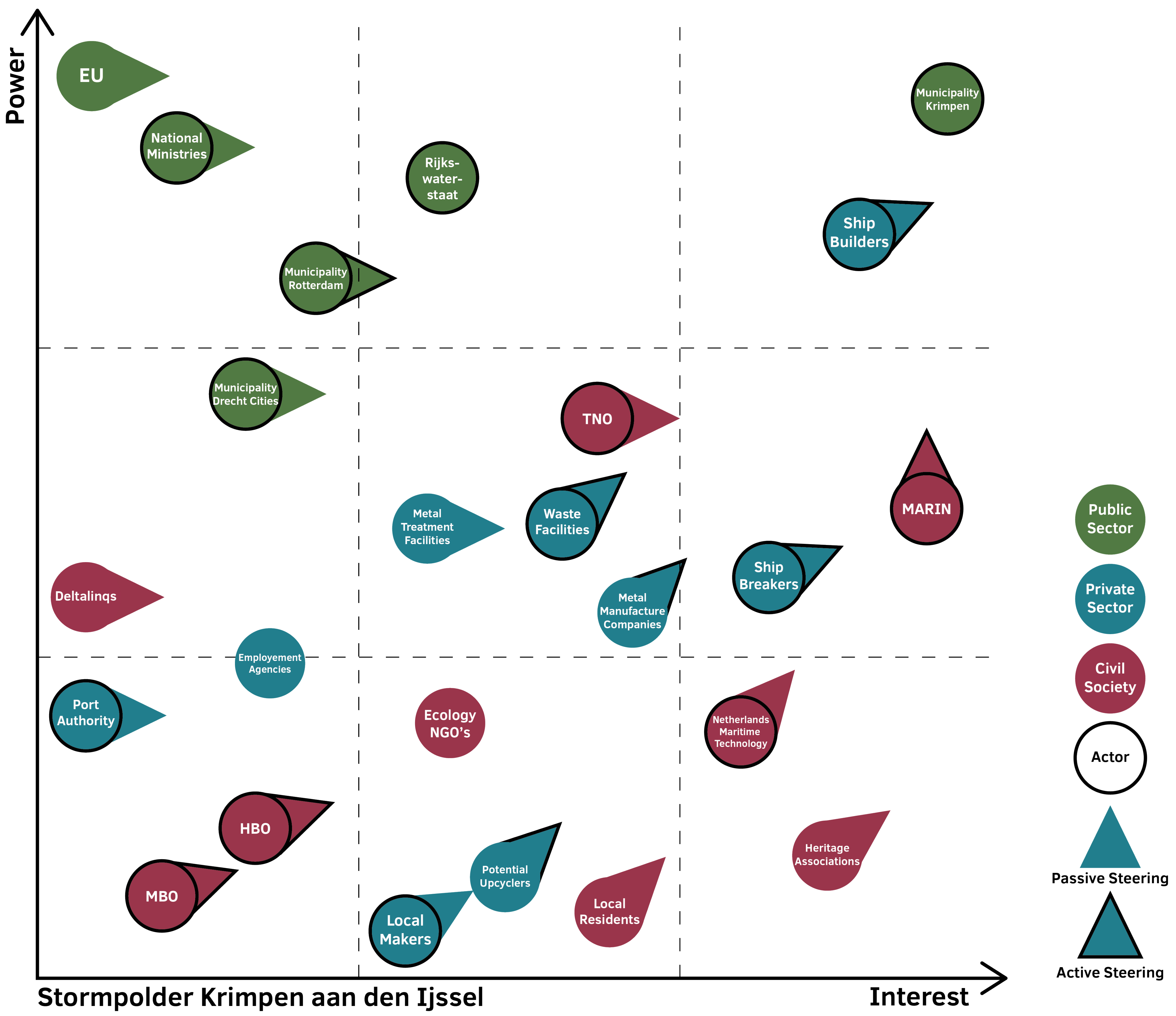


Figure 88. Power-Interest matrix Stormpolder Krimpen aan den IJssel, existing situation and necessary future shifts

GOUDA - NIEUWERKERK

Phase 1

To strive for a circular metal chain in the province of South Holland, urban mining programs and new waste collection facilities are necessary. To provide the space for the increase of metal collection, existing industrial facilities around the waterways are optimized to facilitate new space. Collaborative labor programs are set up to create new labor opportunities for the industrial sector.

Phase 2

New Makers Areas in Gouda are created to facilitate innovations based on the ICT and water-based knowledge ambitions that the municipality of Gouda is striving for. By connecting these new Makers to existing metal manufacturers and other industrial facilities, an integral sharing of information, data, and waste flows can be facilitated within new industrial symbiosis programs. Further extending new industrial training programs will increase the number of skilled and flexible workers for the new industries.

Phase 3

By extending the ship manufacturing process within the province of South Holland new opportunities occur for new industrial ship recycling zones and shipyards to provide an integral flow of materials and products for locals to use. The introduction of new industrial facilities along the waterways may cause new negative environmental externalities. Therefore, the introduction of new environmental buffer zones around the new industrial facilities is needed to decrease nuisance, whilst also providing new nature environments for recreation.

Phase 4

For the final steps towards a thriving water-based society, new residential water-based neighborhoods are created around the areas of Gouda and Nieuwerkerk. Based on the collection of innovative solutions in the local water-based educational institutions of Gouda, knowledge needed for the implementation and prototyping of water-based neighborhoods is gathered for the implementation on current agricultural grounds. These new neighborhoods will need new infrastructure and facilities to exist, therefore place is created for shipyards, retail, and businesses.

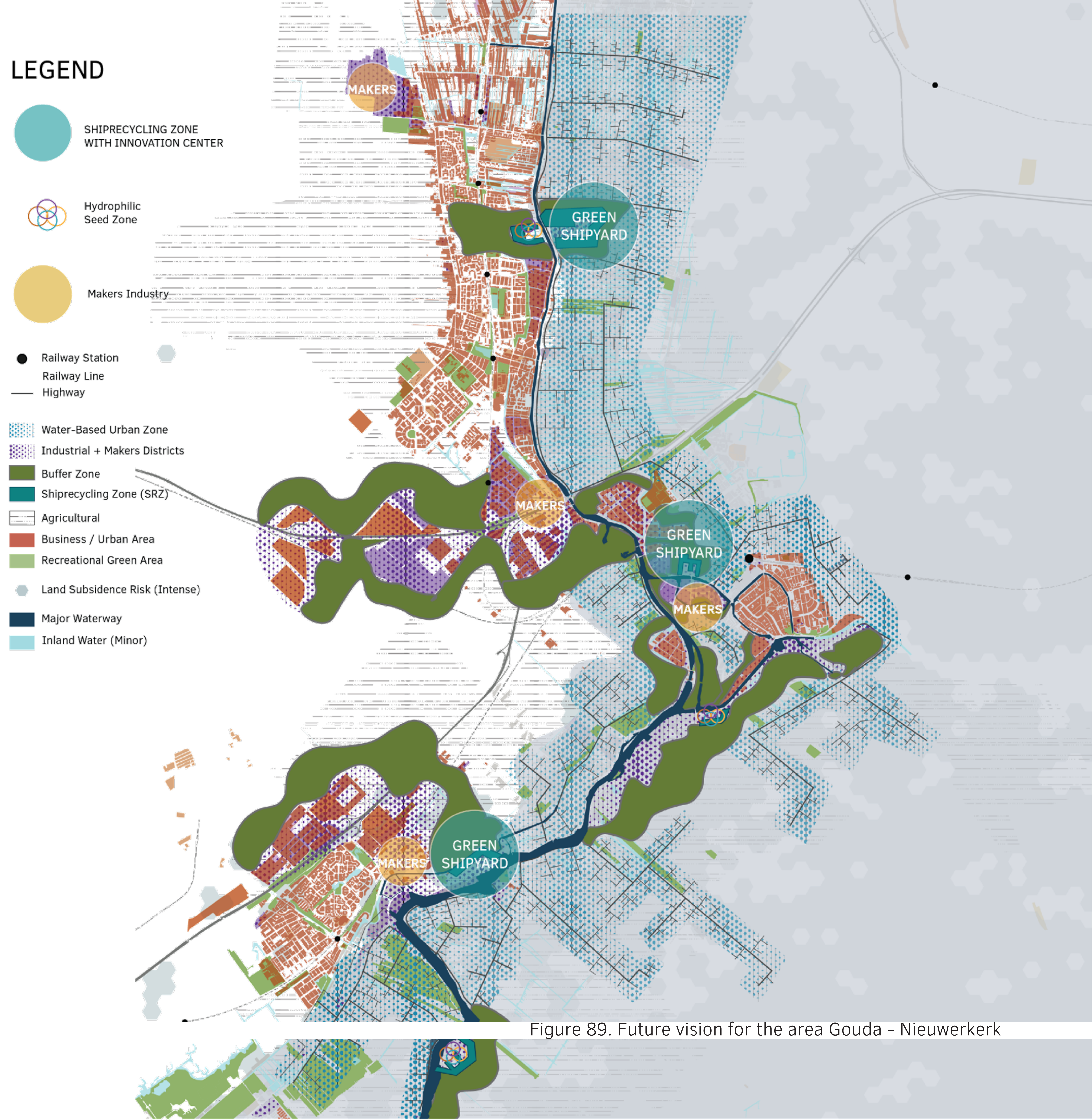


Figure 89. Future vision for the area Gouda - Nieuwerkerk

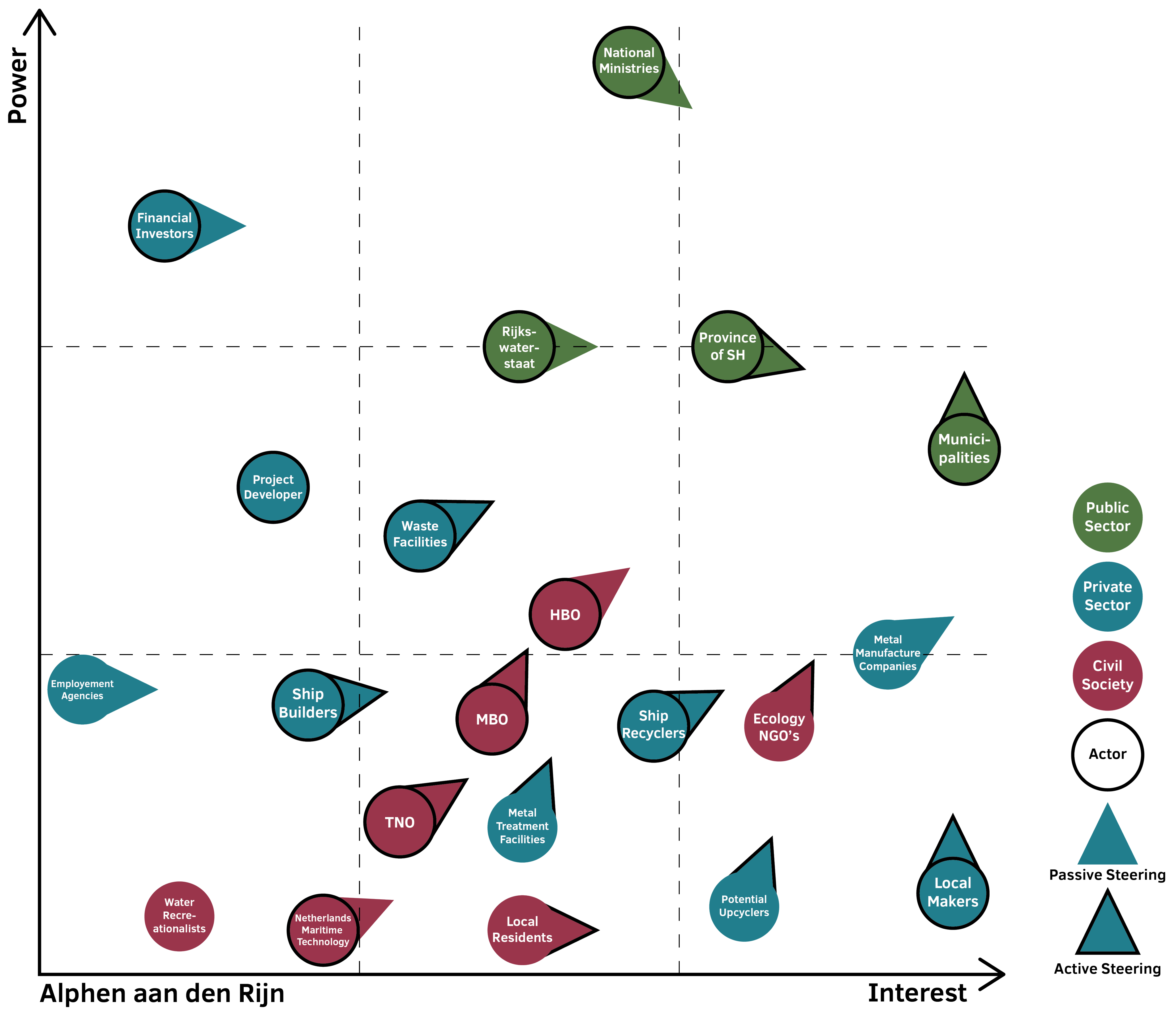


Figure 90. Power-Interest matrix Alphen aan den Rijn, existing situation and necessary future shifts

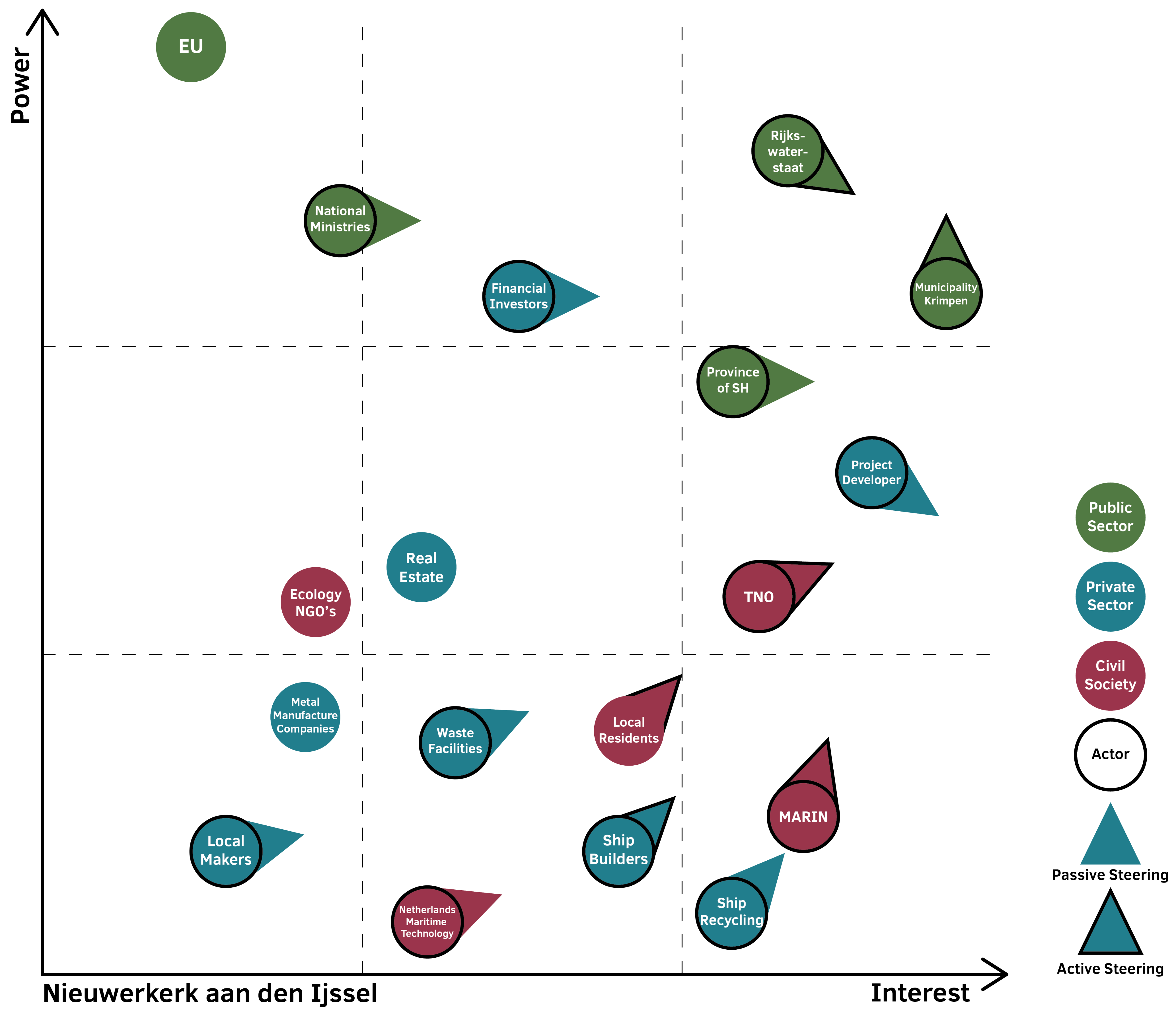


Figure 91. Power-Interest matrix Nieuwerkerk aan den Ijssel, existing situation and necessary future shifts

5.3.2 DELFT, INITIATOR OF CIRCULAR MANUFACTURING

Delft becomes a haven for students, researchers, and Makers; essentially, people who can innovate the entire manufacturing process into a circular one. The social transition propels the change towards a more sustainable ship manufacturing industry with development of the existing knowledge hub that is TU Delft that has a strong maritime, and research and innovation programs and facilities. 'Learning by Living' is the concept that drives this key urban core that shall coalesce the Makers industry, new maritime testing facilities, hydrophilic seed zones (metal recovery and storage facilities), and develop close proximity between local business with education, building a relationship with residents, involving people every step of the way to truly initiate the voyage to circularity in South Holland.

5.3.3 RDM, CULTIVATOR OF EVOLVED SHIP MANUFACTURING PROCESS

As innovations begin with the Knowledge Corridor, it is ever strengthened with the connection to the PoR's strong shipbuilding industrial corridor where materials are manufactured and distributed for making. The current Rotterdamsche Droogdok Maatschappij NV (RDM) and M4H Makers district being developed along the Port area shall cultivate this propelled innovation from the other knowledge hubs such as TU Delft, Leiden University, De Haagse Hogeschool, and potential new schools in the other new urban cores as the main sites for making with the ship manufacturing industry. Large-scale prototyping expanded Makers Areas with a connected Makers Market, more accessible transportation, and more suitable training to engender a versatile workforce that can adapt and further develop the circular manufacturing sector and the industries that are bred through their cross-pollination. Here the education sector is directly linked with large-scale industry. Shipyards along the port shall also begin its more sustainable transformation into Green Shipyard developments, managing waste and switching to renewable sources for their operations that in turn will begin to influence the working and living environments around them.

5.3.4 ALPHEN A/D RIJN, ACTIVATOR OF CIRCULAR MATERIAL FLOWS

Alphen aan den Rijn is poised as the prototypical setting for activating the circular material flows in the region with its existing industrial developments and businesses that are already in place, only needed to be guided towards symbiosis with a new industry. From the green transformation of traditional shipyards along the Port area shall arise the new industry of shipbreaking and metal treatment, serving the demand that a larger fleet of ships shall need to keep materials in the manufacturing loop. Metal scrap shall be a new medium of trade between many manufacturing sectors that could use those from recycled ship components aside from feeding it back into the ship manufacturing industry. Ship recycling zones (SRZs) shall be established around a new Aqua-Industrial Corridor wherein research and living labs can be integrated to connect with the knowledge hubs and Makers Areas for further innovation of the industry; from material substitution to more bio-based solutions for surface treatment. As more platforms for research and trials are provided, new makers and industries can also be produced from this cross-pollination of new industry and knowledge.

5.3.5 NIEUWERKERK, THRIVING MARITIME LIVING

The newly identified urban core of Nieuwerkerk is a site wherein new housing developments on water shall be developed due to intense land subsidence risks identified in the area. With the circular ship manufacturing in place within the cross-pollination chain, innovation in material re-use specifically for the building sector could greatly contribute to this possible future need for new floating environments. By 2100, Nieuwerkerk becomes a well-integrated and resilient city that has a well-connected multi-modal transport network, with new marinas for water vessel parking, more material recovery facilities and seed zones, forming this new thriving aqua-industrial landscape that melds industry and nature.

5.3.6 BOTLEK, THRIVING NEW ENERGY AND SHIP RECYCLING SECTOR

With the new circular material and manufacturing flows activated throughout the region, sustaining this system requires energy that is renewable to establish a cleaner industrial sector and environment for people. The Botlek and Maasvlakte areas where the old petrochemical storage and processing industrial sector currently resides shall begin making space for hydrogen-based renewable energy. As this renewable energy also evolves and become more optimized, more space shall be allocated for larger ship recycling and waste treatment facilities, maritime manufacturing logistics hubs, and larger hydrophilic seed zones.

6

CONCLUSION

Evaluating the feasibility, limitations, and value of the charted course

6.1 DISCUSSION

6.1.1 CURRENT POLICIES AND PLANNING CONTEXT

At the outset of forming this project, the current spatial, political, and governmental situation has always been the foundation upon which we build. The new Makers Areas in combination with innovation and labor programs have been placed according to the vision and goals of the local municipalities. Furthermore, we have striven not to expand the industrial sector to agricultural land before first investigating the expansion and allocation of the new industries on already existing or planned business parks. Thus, we attempted not to change the ambitions and current situation of the spatial layout of the province, rather we tried to enhance the current knowledge and innovation available to the next level by introducing new symbiosis programs to strive for a change in the maritime sector of the Netherlands.

We acknowledge existing policies and regulation documents connected to the new climate agendas and existing environmental restrictions and try to find evidence for the placement of certain functions on locations. Changes in policies by the IMO, the EU, and the Dutch governmental bodies form the foundation on which we want to build further, for example, by introducing new regulations within the Dutch zoning codes with the addition of Makers Areas as new regulatory zoning. For the new shipbreaking sector to be introduced, more research into their opportunities is needed considering their strong potential to truly change the industrial landscape and to be integrated into living environments with the proposed buffer zones, which entails more collaborations across disciplines. The current policies and the increase of innovation that we suggest for the province will bring the maritime sector of the Netherlands to the next level as a new leading maritime region.

6.1.2 EXTERNAL DEPENDENCIES

Although this project suggests new strategies to uplift the region of South Holland based on a new circular maritime industry, we must acknowledge that there are dependencies. Without certain interventions and strategies, the next steps in the phasing process of the region cannot (fully) be reached. We introduce new major collaborative tasks for all actors and stakeholders to take part in. Without the willingness of certain actors to participate in the industrial symbiosis and educational training programs, the sharing and trade of waste, knowledge, and energy cannot reach its full potential. Therefore, it is necessary that within these strategies, the benefits are emphasized. This will require a strong political will from local municipalities and major shipping companies to take the lead in these symbiosis programs.

Furthermore, we see that without innovation and knowledge, a change in the maritime industry is not reachable, therefore we are dependent on the innovation and knowledge accumulation of these new industries. Although we give them around 10-30 years to innovate in the maritime industry, major setbacks in policies and funding programs can slow down progress. The introduction of the new Makers Markets creates physical locations where actors and stakeholders in the maritime industry have the opportunity to meet and exchange knowledge, so steps are taken to strive for optimal collaboration. More trends could also be evaluated to enrich this research as to how the maritime industry is also trying to evolve within for more people to be involved. Besides the dependencies on collaborative and knowledge accumulations, the maritime industry will not change into a new industrial age, without stricter

international regulations on material use, fuel use, and dismantling of vessels. Therefore, European and Dutch governments need to address these new international policies as quickly as possible. Although most of these governmental bodies have already addressed the new ambitions of the maritime sector in recently published documents, the implementation on the local level is still uncertain and no regulations on international shipping have yet been created (although the IMO is now creating new international laws).

6.1.3 ETHICAL REFLECTION

To be able to place and expand the new circular manufacturing chain of the maritime industry into the province of South Holland sounds promising. Although we tend to create more labor opportunities for the less fortunate residents of lower-class neighborhoods in the large cities, we acknowledge that with the creation of these new job opportunities, new industrial sites are imminent. Also, since a new leading role of the maritime sector in the region asks for more industrial space, careful placement of these industrial sites is necessary to decrease negative environmental externalities as much as possible to local residents. Therefore, organic planning strategies are necessary to carefully highlight and also connect each voice in one integral strategy. These symbiosis programs therefore should also address local residents instead of only the public and private sectors.

The allocation of new industrial, environmental, and Makers zones around the province will have an impact on existing industries and functions. We try to tend to the needs of these stakeholders by incorporating them within our new programs and show them the benefits of contributing to our new shipping manufacturing chain. But to the industries that will slowly move out of the region, like the petrochemical sector of the PoR, new training programs connected to the maritime industry will provide new opportunities to create a new flexible workforce.

The new circular transportations routes along the rivers will create an integral metal chain, but the increasing use of the current waterways creates a so-called battle for the water between industry, recreationalists, and nature. This project counts on the fact that the current water system can hold a place for everyone involved, but an increase in commercial shipping will create new ways for people to see and experience the waterways and rivers of the province. Therefore, the integration of these new industries with environmental buffer zones is important to counteract the potential industrialization of the waterways.

With our strategy, we propose to redevelop certain industrial areas close to existing knowledge institutions, into thriving Makers Areas with space for the industry but also for local housing. These new thriving industries could drive up prices of surrounding residential neighborhoods, which is especially a threat for the less expensive neighborhoods where there is a higher percentage of poverty and social exclusion. Therefore, it is important when redeveloping these areas to create an equal percentage of dwellings around the different price categories.

6.1.4 RELEVANCE OF THIS PROJECT

With our project, we aim to create a shift in maritime industrial practices by creating new collaborative initiatives, Makers Areas, labor opportunities, circular industrial practices, and living environments. By establishing a circular maritime manufacturing process in the province of South Holland, the area will become a leading example in the integration of the large international shipping industry with the local Makers industry. By showing this example to the international maritime sector, we hope to evoke innovation within one of the largest polluting sectors in the world.

Furthermore, the integration of large industrial practices with environmental zoning will become a leading example on the international stage. The combination of industrial and environmental sites are connected with the waterscape of the province of South Holland, and we want to increase this feeling again with all parties involved. The province of South Holland is rich in its shipping and water innovation traditions. By highlighting this underlying heritage of the region, we connect the history of the province with the new circular practices of the maritime industry. Lastly, we also aim to redefine what it means to be a 'leading' example for industry in such a hyper-globalized world wherein environmental sustainability is at the forefront, reconsidering metrics as GDP and economic activity for quality of life.

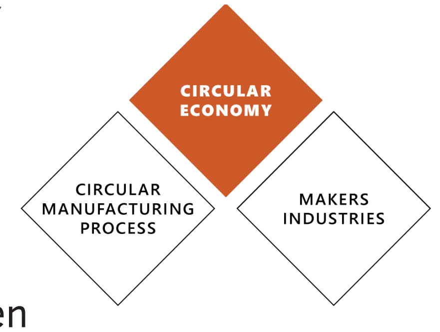
6.1.5 RECOMMENDATIONS FOR FUTURE RESEARCH

This project aims to show the possibilities of creating a new circular metal chain connected to the maritime industry. Although the process steps are well connected, the amount of metal being transported along the waterways is not yet known. More research should be done on the statistical side of the story, therefore creating new and more precise insights into the amount and spatial implications of new scrap and storage facilities that need to be facilitated along the waterways. This is also reflected in the current capacity of the waterways themselves. An increase in water transport might need an extension of the existing waterways, bridges, dikes, and sluices. This research could have major implications for the potential implementation of this circular manufacturing chain.

Furthermore, as said earlier in this chapter, we try to include the public, private, and civil organizations in our industrial, training, and educational programs. To make this happen, participation and active collaboration between these actors and stakeholders are vital for the creation of an efficient and collaborative process. Insights on the opinion and willingness of these parties are not yet known, therefore more research and integrating an active participatory process are necessary to understand the framework in which stakeholders are willing to cooperate in order to truly involve people in establishing this vision.

6.2 ASSESSMENT OF SDGs

6.2.1 CIRCULAR ECONOMY



Responsible consumption and production

The introduction of industrial symbiosis between manufacturers, waste recyclers, and shipyards increases the efficiency of the manufacturing process of the maritime industry. Therefore optimizing the manufacturing process and the responsible use of materials within the production process can be realized. Local collected and reprocessed metals form the foundation of this new manufacturing chain.

Decent work and economic growth

The integration of the Makers industry as an integral part of the manufacturing process within the maritime industry, providing innovation, usable prototypes and ship compartments, shows a new direction in providing economic growth for the region of South Holland. The cross-pollination of industry, innovation, and knowledge creates a new economic foundation for the maritime industry, providing innovation as an export product rather than real products.

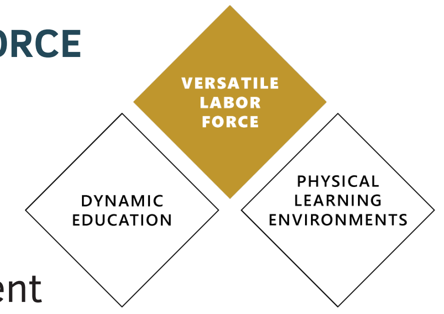
Partnerships for the goals

Collaborative projects between public, private, and civil organizations are the basis on which a changing innovative maritime sector can thrive. These projects strive for an interchange of knowledge, materials, data, energy, and waste between educational institutions, civil organizations, the private sector and the public sector. The physical embodiment of these collaborative projects thrive in the newly created Makers Markets where knowledge and innovation can be shared face-to-face.

Industry, innovation and infrastructure

The driving force behind the cross-pollination between industry, innovation and society is seen in the waterscape of the province of South Holland. These iconic waterways create the basis for the interplay between the different actors and stakeholders of the region. Furthermore, it creates collaborative partnerships between makers, industries and educational institutions, providing the foundation for industrial symbiosis and circular manufacturing programs.

6.2.2 VERSATILE LABOR FORCE



Industry, innovation and infrastructure

The allocation and placement of new industries along the waterways of South Holland creates new opportunities for the extension of a labor force within the technical sector. The need for skilled and flexible workers in the industrial sector is high. Collaborative programs between ship manufacturers and educational facilities make it possible to directly train the skills needed for a changing maritime industry.

Reduced inequalities

To strive towards creating equal opportunities, jobs, healthy living environments, and a sustainable and inclusive maritime industry, there must be a shared identity between stakeholders and actors. Participation between residents, governmental bodies, industries, and innovators creates the foundation for vital dialogues and collaborative programs, therefore optimizing the implementation of a just and circular maritime industry in the province of South Holland.

Quality Education

To close the gap between the lack of a suitable labor force and the current educational programs, new collaborations between industries and educational facilities will create new programs that facilitate the creation of a skilled and flexible workforce.

6.2.3 ENVIRONMENTAL SUSTAINABILITY

Life on Land

The promotion of a circular-based manufacturing sector creates growth opportunities for new sustainable ways to produce products for the maritime industry. Green shipyards not only strive for a net-zero production chain but also incorporate nature-based environmental zones with the manufacturing process, by promoting nature-based solutions for the treatment and cleaning of ships.

Life below water

New maritime living environments alongside existing neighborhoods create new opportunities to combine living with a water-based environment, providing more space for flora and fauna to thrive. Innovations in the maritime industry reduce emissions produced by vessels, therefore providing cleaner rivers and waterways.

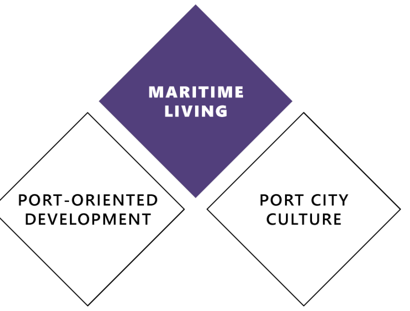
Affordable and clean energy

Climate charters adopted by the IMO, create a foundation on which the maritime sector strives to reduce its environmental footprint in the world. New innovative technologies provided by the Makers industry and research institutions create a basis upon which the maritime industry can build. The hydrogen transition of the Port of Rotterdam creates new opportunities for the implementation of new sustainable fuel and production techniques.

Climate action

This project aims to create an integral circular economy based around the maritime industry, providing new innovations, technologies, and knowledge that strive for a sustainable region with decreasing emissions by implementing 'Green Shipyards' and an upgraded international maritime practice. New policies and stricter regulations create a basis for innovation and knowledge to create a foothold within the maritime industry.

6.2.4 MARITIME LIVING



Sustainable cities and communities

New thriving and attractive Makers Areas create the potential to combine the industrial practice with affordable housing, whilst new water-based living environments in the countryside create new synergies between residents and the natural environment. The new metal manufacturing chain provides knowledge and implementation of these new neighborhoods, bridging the maritime sector to the living environments of residents.

6.3 CONCLUSIONS

The Dutch have always been known for their maritime reliability and innovative qualities on the global stage. Contributing up to 3% of the total GDP of the Netherlands, the maritime industry is an important player in the Dutch economy. But recent climate goals and ambitions set by various governmental bodies, including the IMO, have created new challenges for the maritime sector to show its capabilities in changing into a sustainable industry. Although the maritime industry has always been seen as a very robust industry reluctant to major change (Jansen, 2020), opportunities arise within the province of South Holland. Existing international shipyards, extensive harbor infrastructure, and an innovative knowledge base of internationally known educational institutions could provide a solid foundation for the transition of the maritime industry into a circular economy.

At the beginning of this report the main research question was introduced:

How can cross-pollination between the shipbuilding industry, knowledge institutions, and local Makers lead to a circular maritime manufacturing sector?

This question was further divided into different sub-questions, creating the framework for this report.

In order to facilitate a future circular manufacturing chain in the province of South Holland, it is vital to understand potential missing links in the metal manufacturing sector. Therefore, the question being answered is: which process steps need to work differently or are missing in the Netherlands to close the circular manufacturing loop? The research conducted in this report introduced the current manufacturing and material flows of the Netherlands and the province of South Holland. The main materials of the ship manufacturing sector are metals, minerals, polymers, and oil-based coatings. The global impact of the transportation of these materials creates a large environmental footprint due to the lack of raw materials in the Netherlands. So, to reduce this environmental footprint, the province of South Holland needs to provide a solid material-collecting base for a circular manufacturing chain. Therefore, it is necessary to extend current industrial practices in the form of net-zero metal treatment, waste storage, shipyards, and shipbreaking facilities along the waterways of the region. But to interlink the product and waste flows being produced within the industrial sector, an open management system is vital between the public, private, and civil organizations. Therefore, industrial symbiosis programs interlink products and waste between the different stakeholders, creating an efficient manufacturing chain without large losses in waste, energy, and water use. To facilitate the climate transition of the maritime industry, a large role has been allocated to the educational and new innovative Makers Areas in the region, providing new manufacturing techniques, fuel and coating sources, nature-based solutions, and prototypes for the maritime sector.

The next step in this report was to understand the spatial impact of this new manufacturing process within the province of South Holland. The allocation of new industrial facilities along the waterways has a large impact on the environment and its close surroundings. Therefore, it is vital to optimize current industrial sites, which already exist, along the waterway. Because the increasing ship manufacturing process in the future asks for new industrial shipyards and shipbreaking facilities, it is not viable to only use existing industrial locations, therefore, new facilities on agricultural land will be needed. In order to facilitate a transition zone around these industrial facilities, new nature-based buffer zones are created, providing not only a reduction of industrial nuisance but also providing new recreational space, reintroducing a potential connection with the maritime heritage. Furthermore, new Makers Areas are important in facilitating new innovative ship design, asking for physical locations for the establishment of these Makers Areas. Close relations between Makers, research and educational institutions make it possible to establish a cultivating hotzone for innovative businesses. The production of certain ship compartments in these Makers Areas creates the potential for existing shipyards to optimize their spatial layout, by decentralizing certain processes of the production chain and therefore creating more opportunities for the final launch of new vessels.

To be able to create new collaborative relations between the different stakeholders involved it is important to understand how these collaborations take form and what the spatial requirements are to facilitate the cross-pollination between industry, knowledge and Makers. The waterscape of the province of South Holland will have an important role in facilitating cross-pollination between the stakeholders and actors of the maritime industry. To provide new opportunities for the industrial sector, the educational and research institutions, and the new Makers to collaborate, new programs are needed to facilitate integral sharing possibilities of goods, waste, water, and energy. These new symbiosis programs facilitate the change in the maritime industry, providing decentralization of the manufacturing process, and reducing the environmental footprint of the global industry by placing the process locally. Furthermore, new principles surrounding the 'Green Shipyard' tackle local environmental problems of the manufacturing process, striving for the reduction of material, waste, and energy needed for the manufacturing process.

By introducing physical locations in the form of newly created Makers Markets, collaborative partnerships become face-to-face partnerships. This is important for the activation of an innovative maritime industry between knowledge and research institutes on the one hand and businesses and industries, on the other hand, provided by the linkage of the Makers themselves. These Makers Markets are strategically placed close to existing harbor infrastructure, large cities and lower-income neighborhoods, providing good connections and opportunities for these surrounding neighborhoods with jobs and training possibilities.

Furthermore, the addition of physical learning environments will facilitate lifelong learning as well as opportunities for the private sector to participate in training the future labor force, and to share their knowledge and expertise with the educational institutions for further enhancement of the maritime-related educational programs.

The previous research creates a framework for the physical measurements and collaborative programs of the new circular maritime manufacturing process. Although this framework creates a more sustainable maritime industry, it still does not fully contribute to society. Therefore, it is necessary to understand the contribution of a circular maritime manufacturing process to a just social transition. With the allocation of new Makers Areas and industries along the waterways of the province, new entrepreneurial opportunities will be provided for local residents and manufacturing companies. These opportunities

connect to the new industrial symbiosis and training programs, providing additional opportunities to connect to the larger shipping companies, governments, and research and knowledge institutions. Therefore, potential buyers and markets will be directly available to the local Makers Areas. Furthermore, collaborations between educational, private, and public institutions will create new foundations for the training of a flexible workforce, necessary to facilitate the circular transition. These programs will not only be connected to existing and potential industrial workers, but they will also create opportunities for surrounding lower-income neighborhoods to benefit from yearly training programs provided by the private sector itself.

By re-introducing the final stage of the life of a vessel, awareness will be created, showing the industrial changes that have been made in the previous years. This shows the residents where their metal will come from in the future. Furthermore, the introduction of large shipbreaking facilities in the region will provide the final steps into the local shipbuilding and decommissioning industry of the Dutch Maritime Sector. Although this will need stricter policies in the future by the IMO and the European Union, it shows the potential of changing a robust industry into a locally-based and connected industry, bringing the smaller scale closer to the global Maritime industry.

Showing the contribution of the circular maritime manufacturing process to a just social transition provides initiatives and programs to strive towards a socially just society, but we do not yet know the societal impacts of the transition towards a circular maritime manufacturing process. By interlinking the local scales of the Makers Areas and labor training programs to the global maritime industry, the whole sector becomes more tangible for residents. This will be shown in full detail in the newly created water-based living environments on the outskirts of large cities. These neighborhoods will show the synergy between society and nature facilitated by the maritime industry in the form of new water infrastructure and localized shipyards for the production of small boats and floating living spaces for residents.
The decentralization of ship manufacturing around the province of South Holland will make the industrial practice more tangible, and thus more attractive as a business opportunity for residents, further increasing the maritime identity of the region. With the ability to show the manufacturing chain more closely to the eyes of the residents, more awareness is created of the climate impact of the current global metal economy. The urban mining programs will show residents opportunities in contributing to the reduction of the dependency on raw materials and replacing it with a new circular maritime manufacturing process.

By embarking on a circular voyage in the province of South Holland, the Dutch maritime industry is strengthened towards becoming a leading innovative maritime example on a global scale. The collaboration and partnerships between the public, private, and civil society take physical form in the newly created Makers Areas and Markets as well as the physical learning environments, providing the knowledge and skills necessary for the maritime industry to walk the path towards sustainability. The new industrial character of the province will not only create new job and training opportunities, but it also provides the base for the creation of new water-based living environments, bringing back the maritime history that the region is known for.

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8

APPENDIX

A. Existing Spatial Program of Operational Shipyard

B. Existing Spatial Program of Operational Ship Recycling Plant

C. Production Process from Oil into Polymer & Coating

D. Overview of Sustainable Energy Projects of 2021

E. Diagram of Hydrophilic Seed Zones

F. Industrial Symbiosis Analysis for Delft

G. Industrial Symbiosis Analysis for Dordrecht

H. Industrial Symbiosis Analysis for Stormpolder

I. Industrial Symbiosis Analysis for RDM

J. Botlek 2020

K. Botlek 2030

L. Botlek 2050

M. Phasing of Gouda-Nieuwerkerk (aqua-industrial) and Delft-RDM (knowledge) areas during phase 1

N. Phasing of Gouda-Nieuwerkerk and Delft-RDM areas during phase 2

O. Phasing of Gouda-Nieuwerkerk and Delft-RDM areas during phase 3

P. Phasing of Gouda-Nieuwerkerk and Delft-RDM areas during phase 4

APPENDIX A

Existing Spatial Program of Operational Shipyard

A Plate and Section Stockyard
- Storage of steel plates and profiles

B Marshalling and Preparation Hall
- Selection and Organization of Materials

C Prefabrication Hall
- Plate Cutting/Machining

D Section Hall
- Section/Sub-Panel Assembly

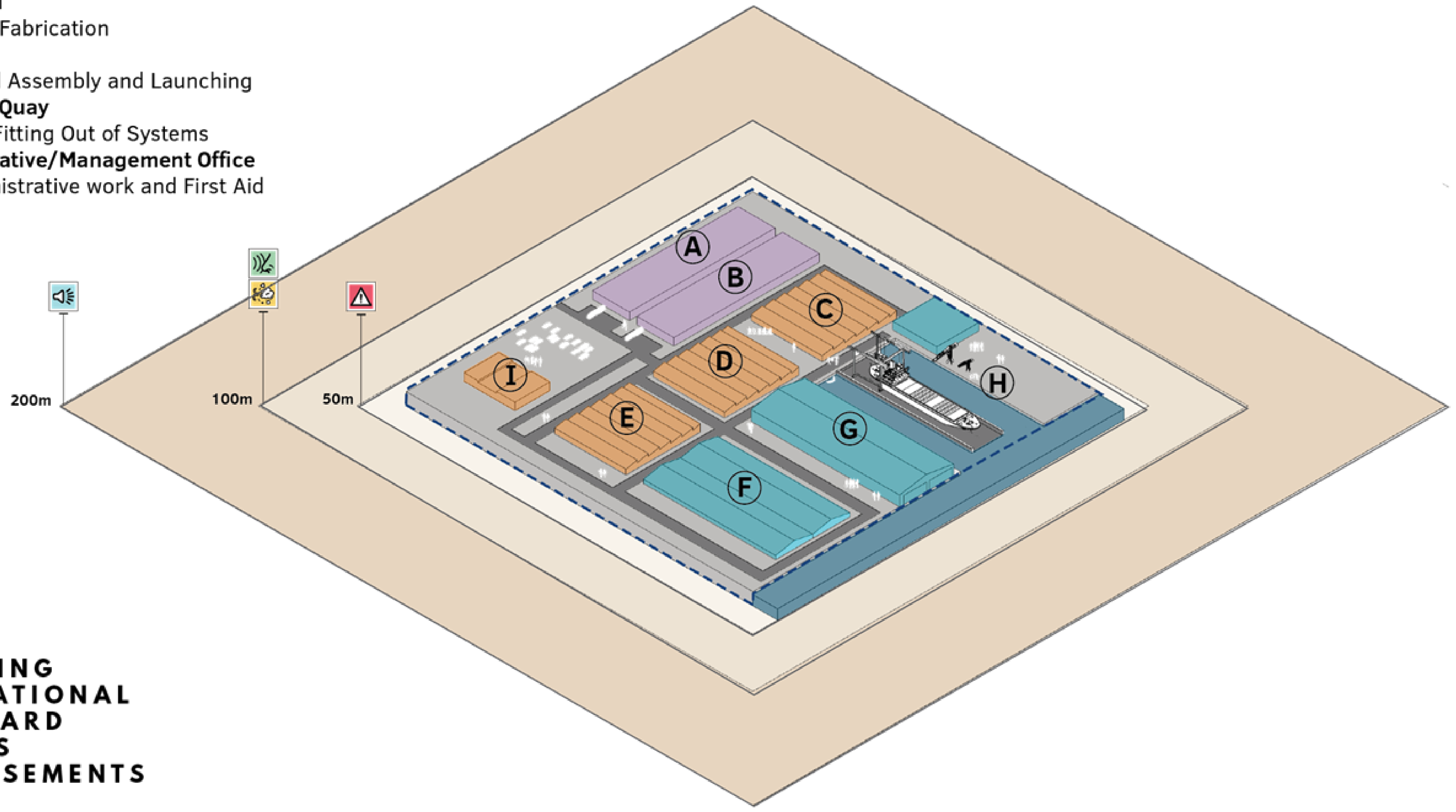
E Conservation Shed
- Module/Section Standby

F Block Hall
- Block Fabrication

G Slope
- Vessel Assembly and Launching

H Finishing Quay
- Final Fitting Out of Systems

I Administrative/Management Office
- Administrative work and First Aid



EXISTING OPERATIONAL SHIPYARD ZONES with EASEMENTS

APPENDIX B

Existing Spatial Program of Operational Ship Recycling Plant

A Primary Block Breaking Area
- Removal of sludge and fluid
- Dismounting of re-usable equipment
- Cutting of large ship segments
- Removal of asbestos and batteries
- Emptying of fire protection systems and CFCs from cooling systems

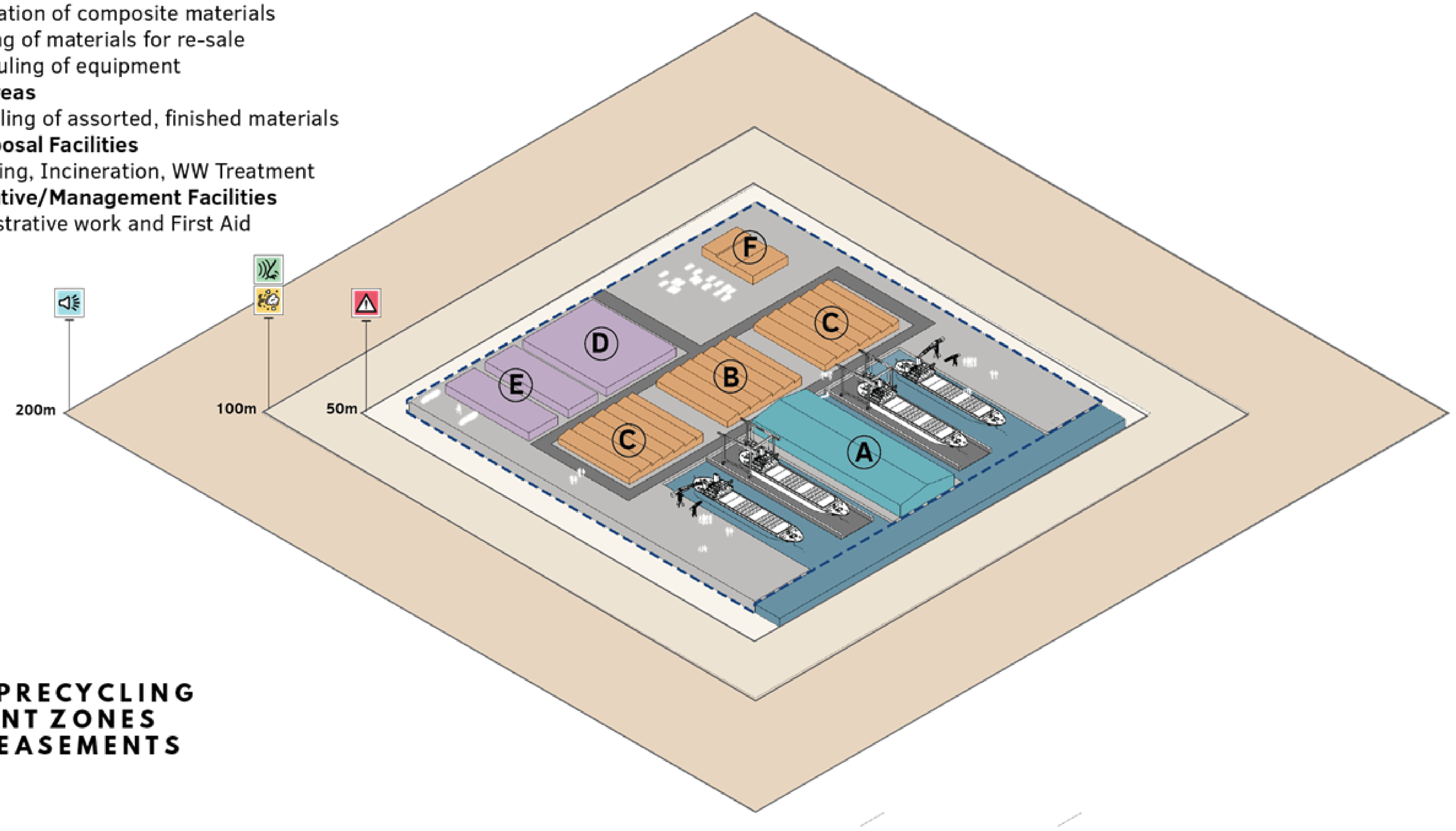
B Secondary Block Breaking Area
- Primary sorting of components
- Further cutting of sections for transport

C Assorting, Finishing, and Overhauling Areas
- Definitive sorting of materials and equipment
- Segregation of composite materials
- Finishing of materials for re-sale
- Overhauling of equipment

D Storage Areas
- Stockpiling of assorted, finished materials

E Waste Disposal Facilities
- Landfilling, Incineration, WW Treatment

F Administrative/Management Facilities
- Administrative work and First Aid



SHIPRECYCLING PLANT ZONES with EASEMENTS

APPENDIX C

Production Process from Oil into Polymer & Coating

Oil to Polymers

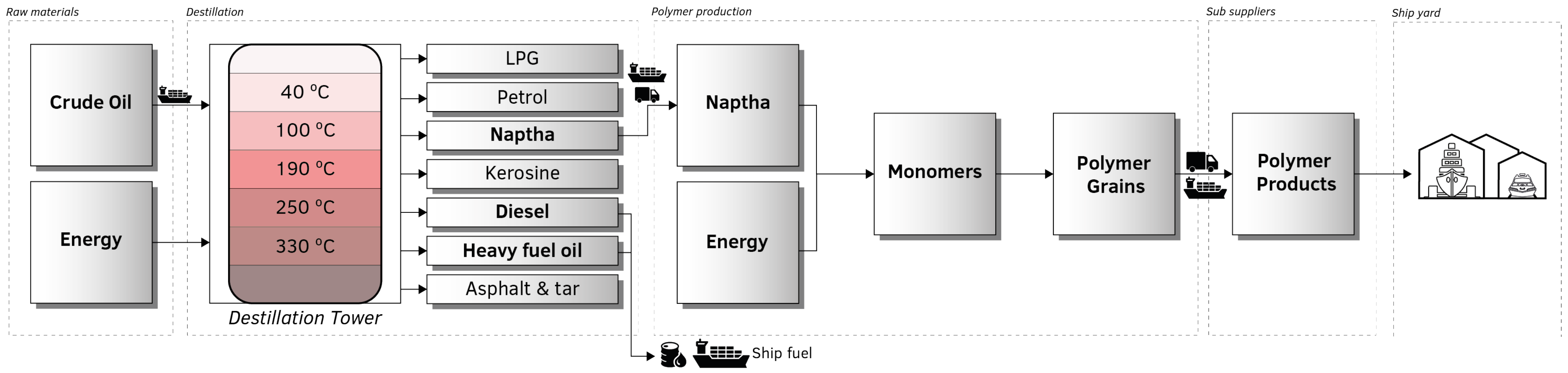


Diagram showing the production process of oil into polymers used in the shipbuilding industry (Energy Information Administration, 2022; Kunstofoveral, 2022).

Oil to Coatings

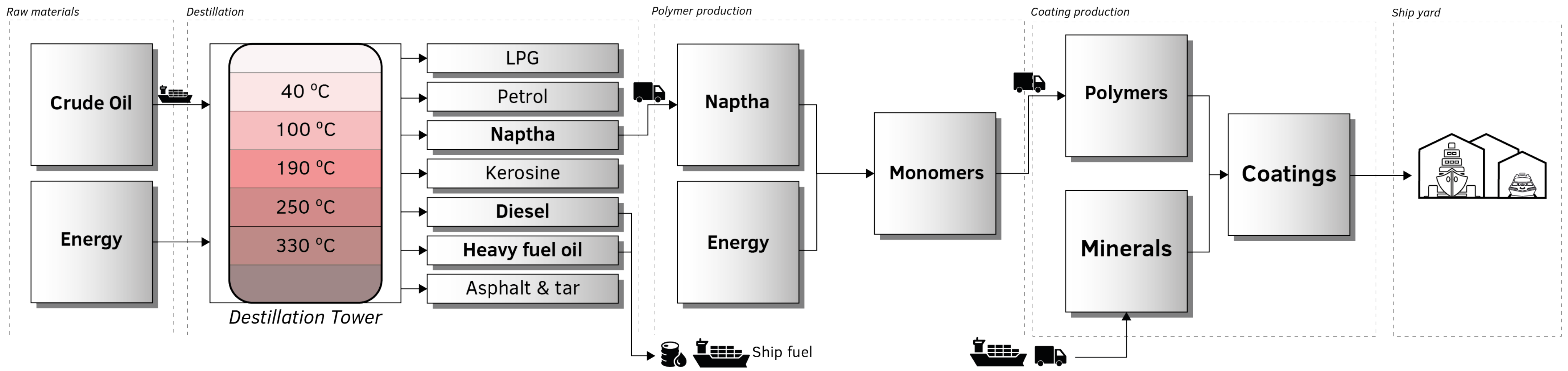
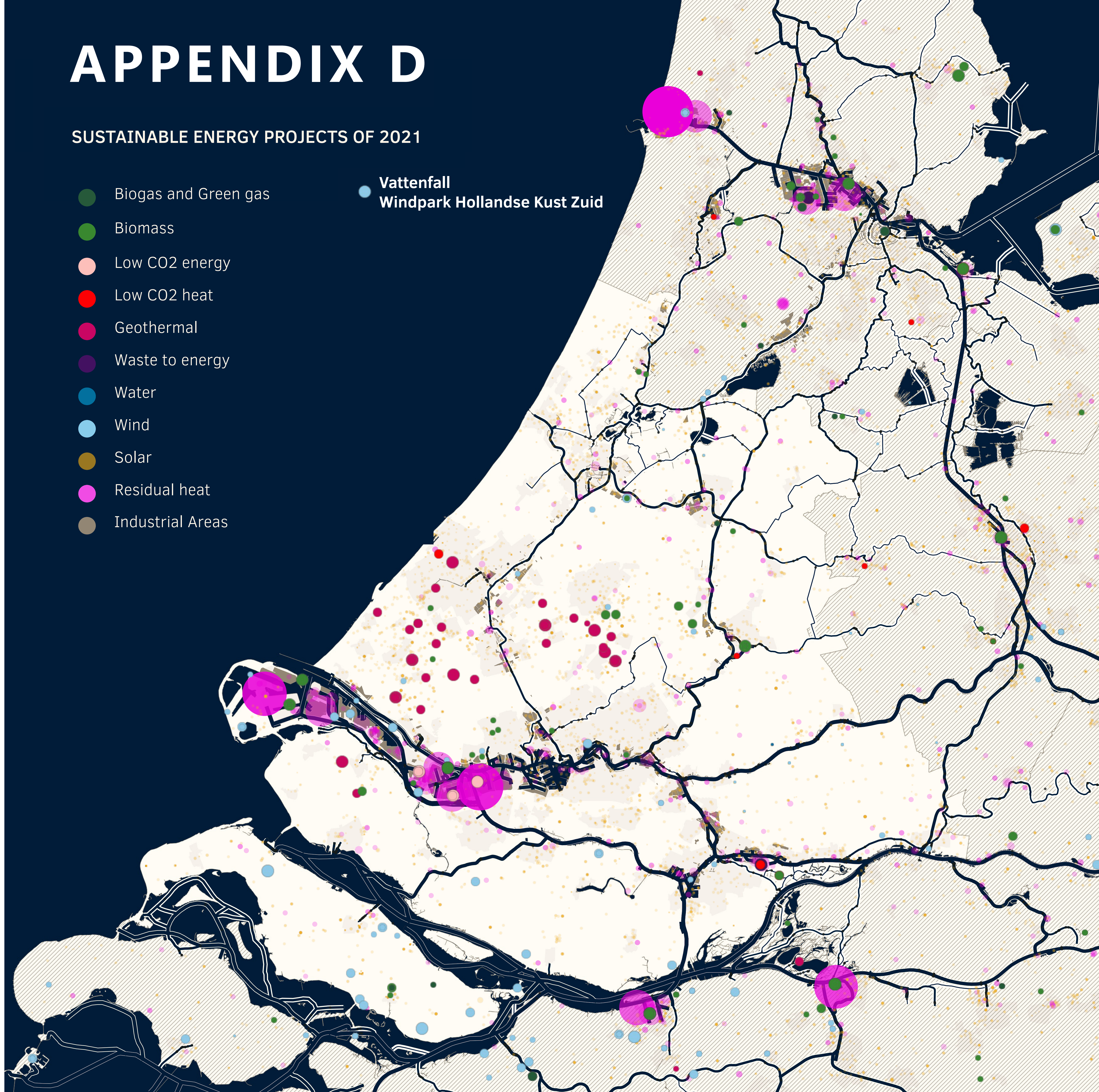


Diagram showing the production process of oil into protective coatings used in the shipbuilding process (Deltares & TNO, 2015; Energy Inforamtion Administration, 2022).

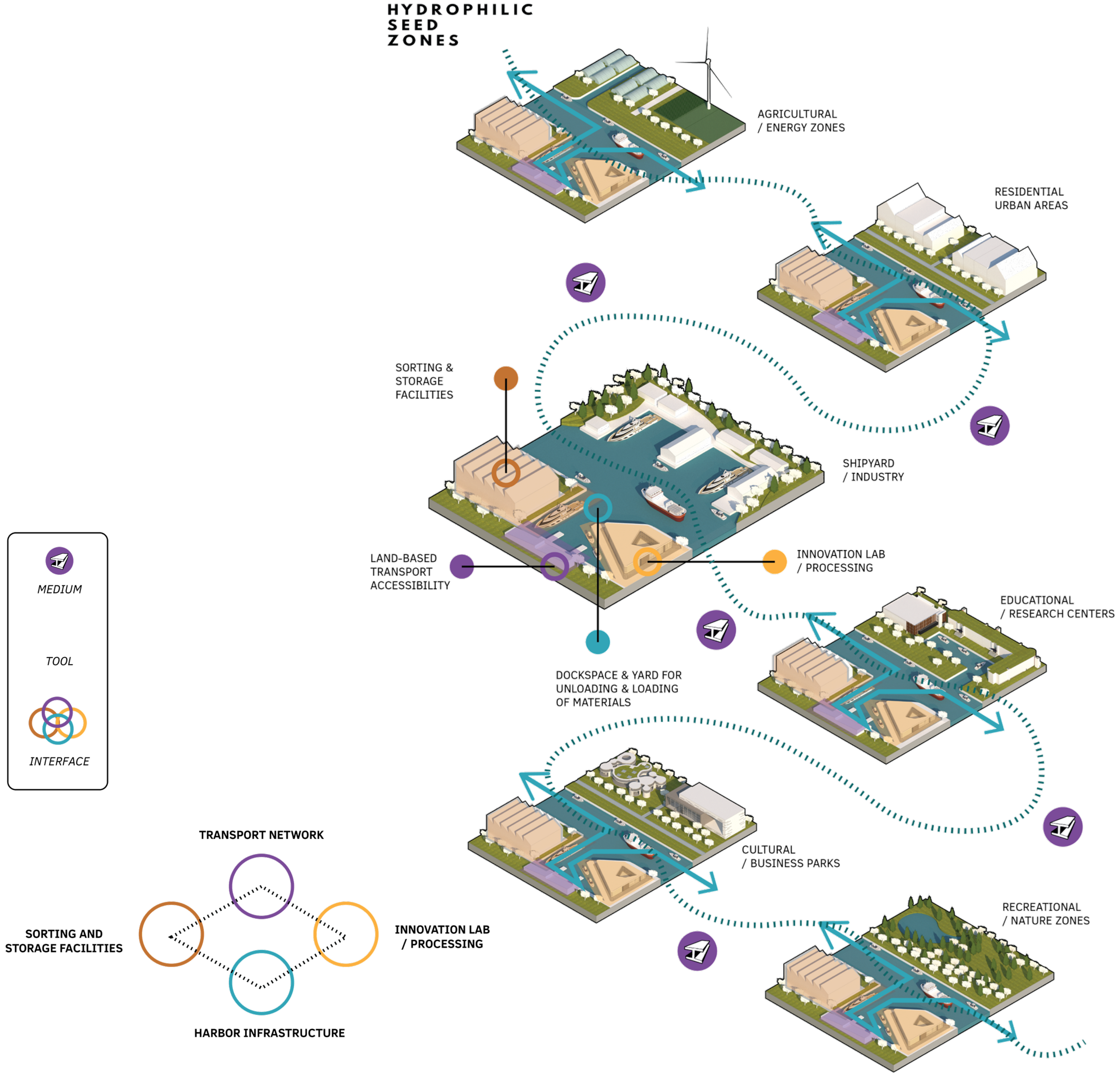
APPENDIX D

SUSTAINABLE ENERGY PROJECTS OF 2021



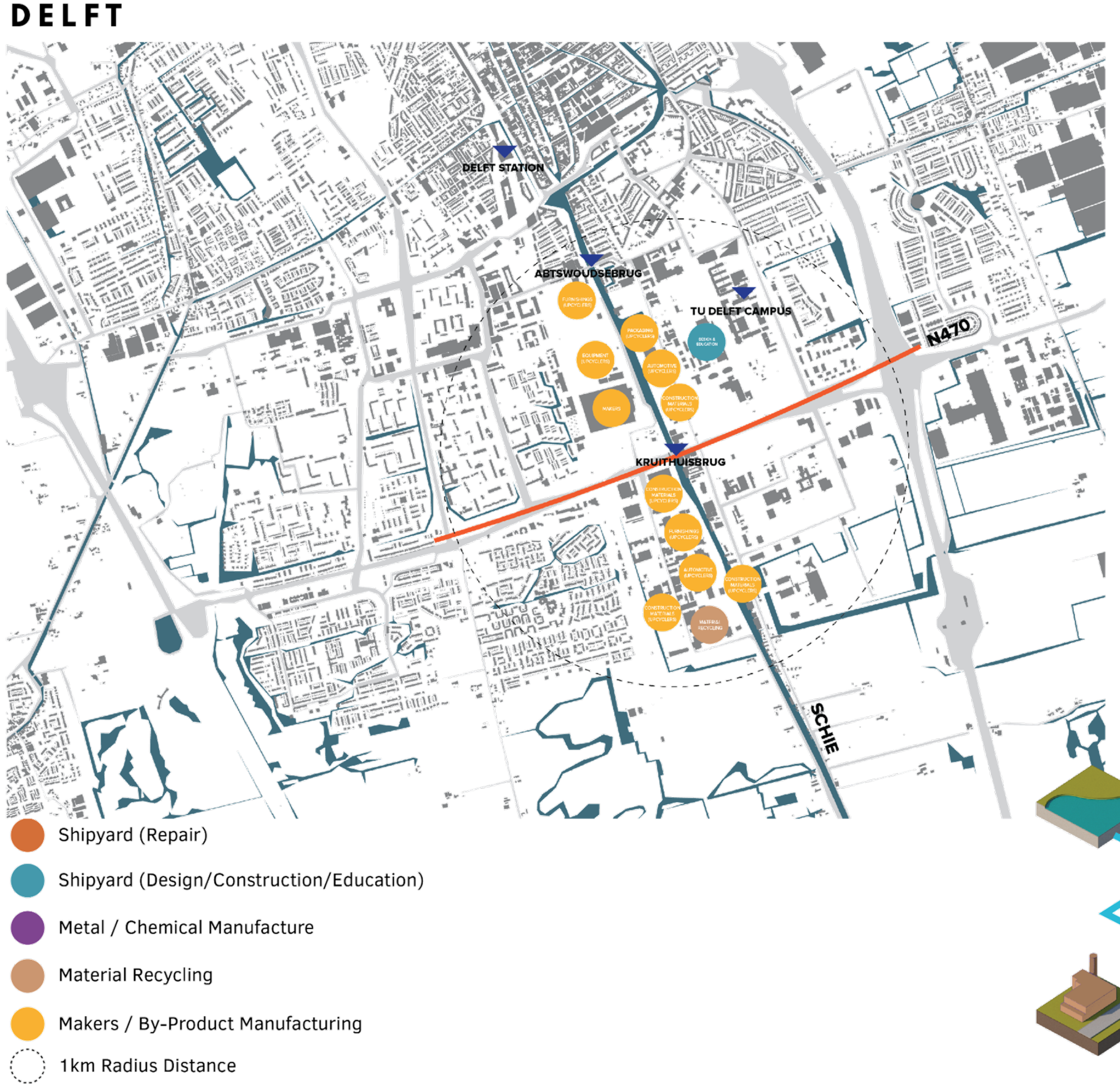
APPENDIX E

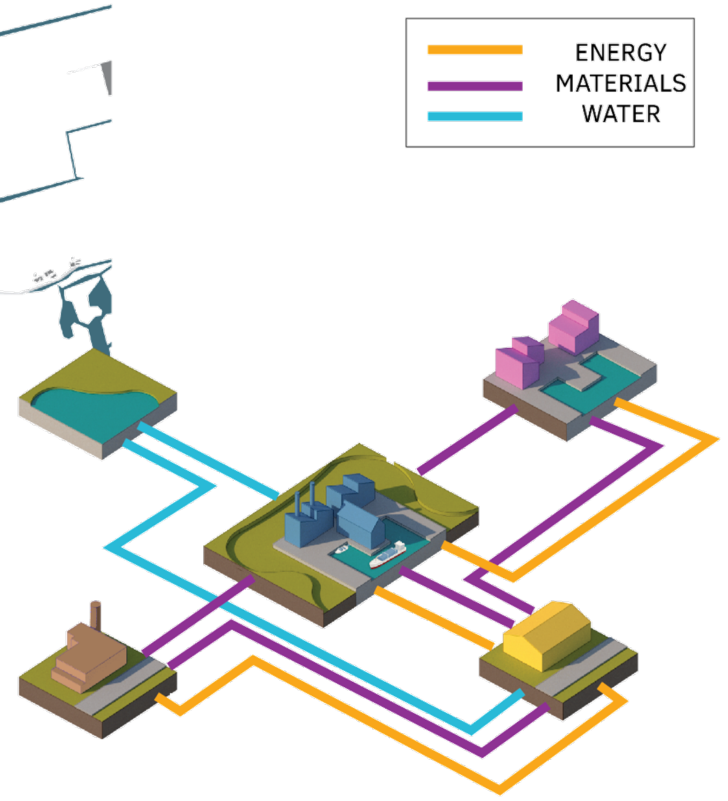
Diagram of Hydrophilic Seed Zones



APPENDIX F

Industrial Symbiosis Analysis for Delft

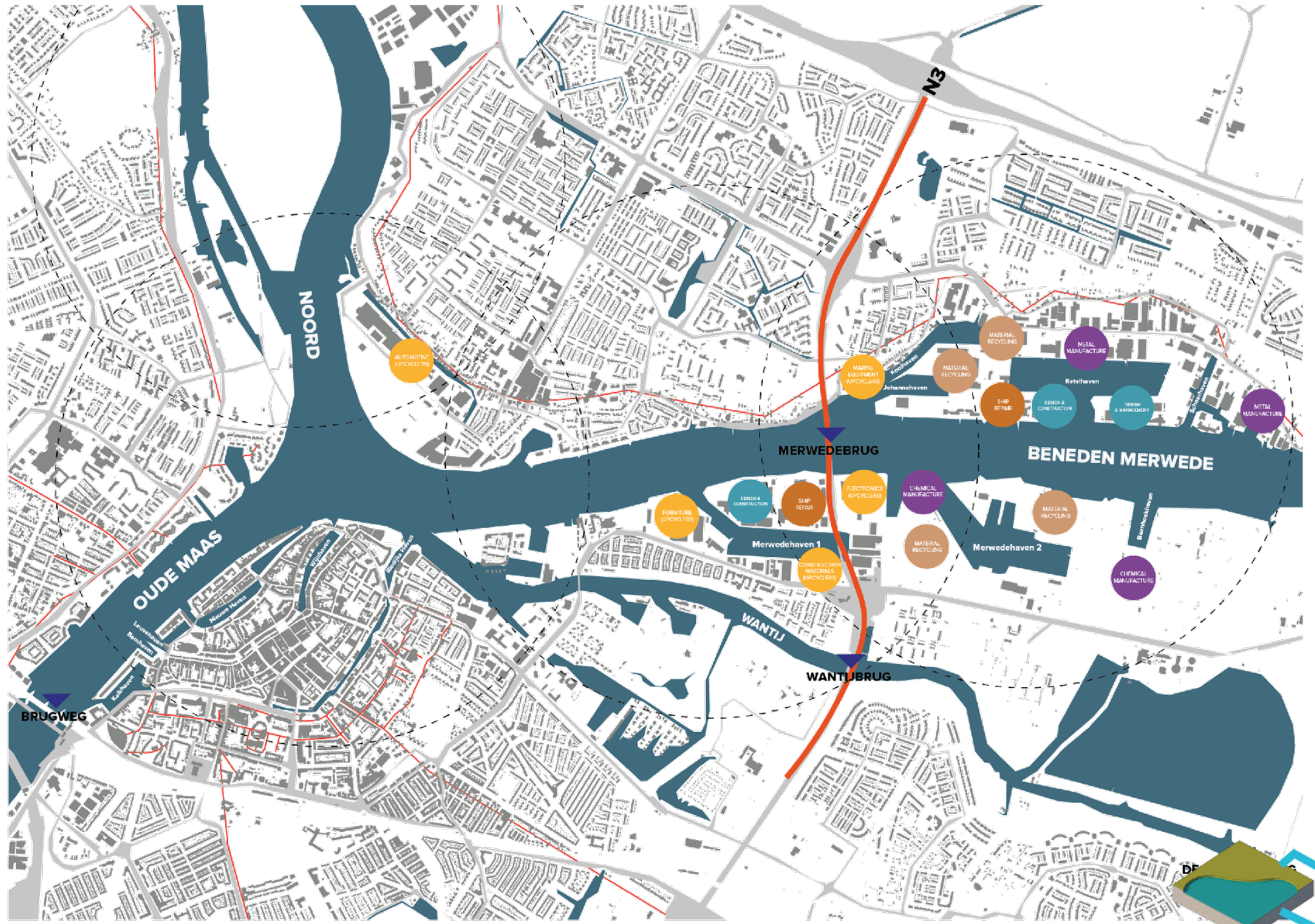




APPENDIX G

Industrial Symbiosis Analysis for Dordrecht

DORDRECHT



INDUSTRIAL SYMBIOSIS WITH SHIPYARDS AS ANCHOR

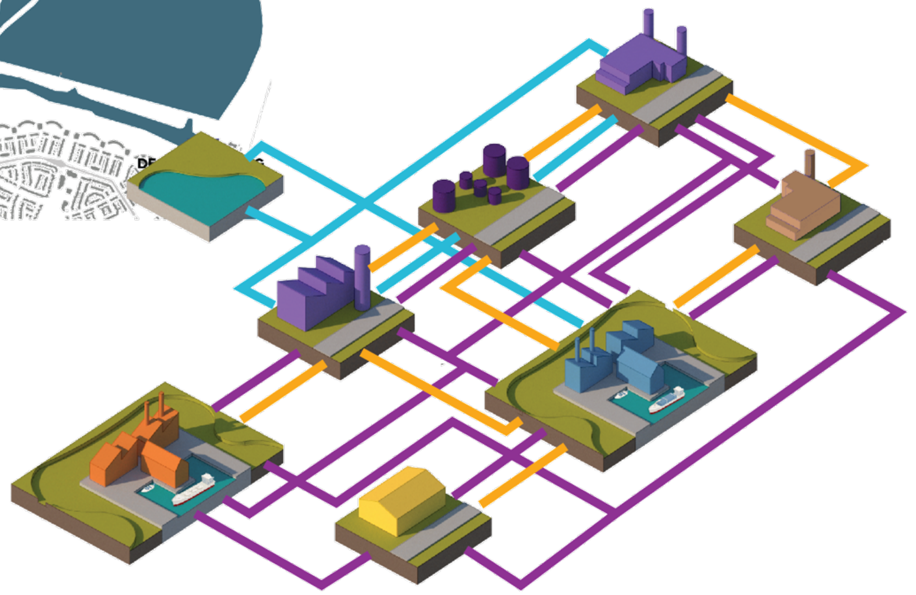
SHIPYARD (ANCHOR)

Upcycling

Metal/Chemical Manufacture

Material Recycling

ENERGY
MATERIALS
WATER

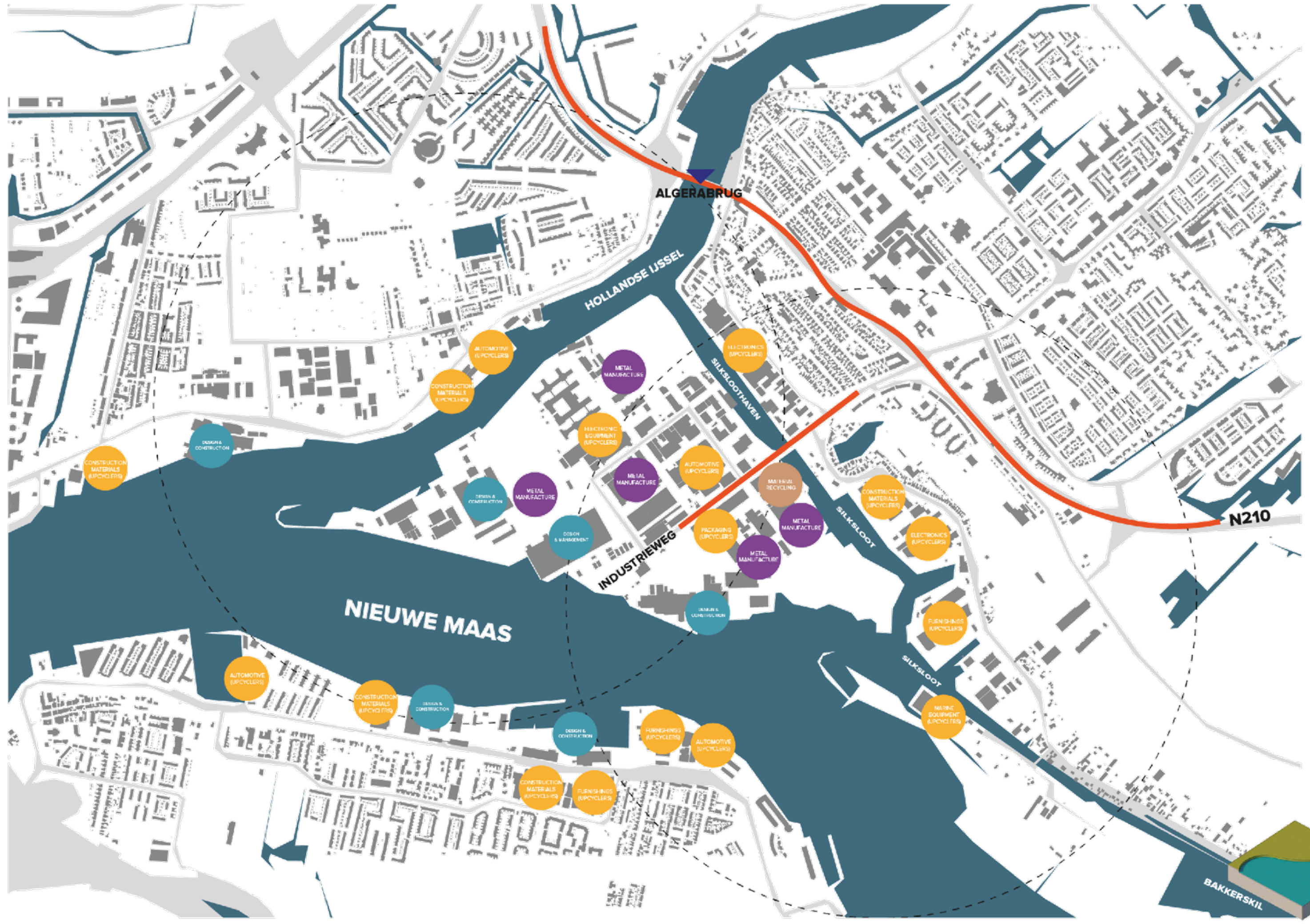


- Shipyard (Repair)
- Shipyard (Design/Construction/Education)
- Metal / Chemical Manufacture
- Material Recycling
- Makers / By-Product Manufacturing
- 1km Radius Distance

APPENDIX H

Industrial Symbiosis Analysis for Stormpolder

STORMPOLDER



INDUSTRIAL SYMBIOSIS WITH SHIPYARDS & METAL MANUFACTURING AS ANCHOR

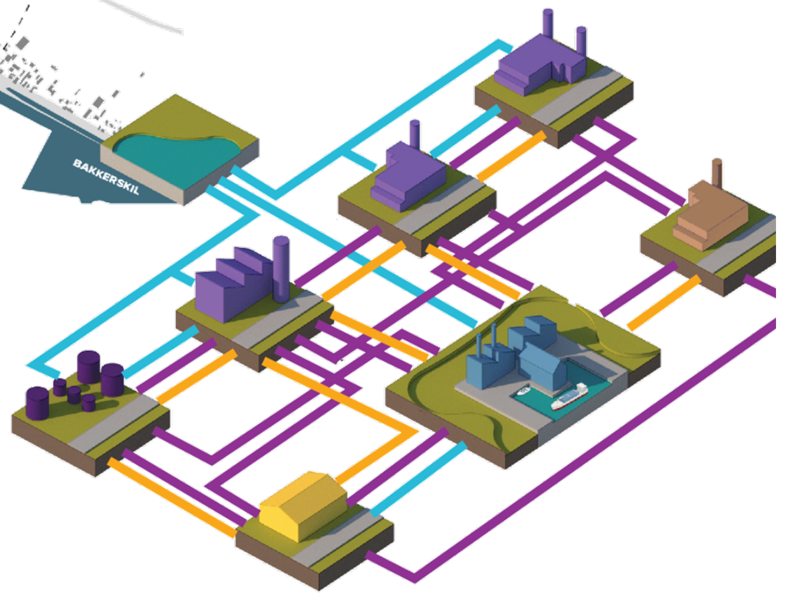
SHIPYARD (ANCHOR)

Upcycling

Metal Manufacture (ANCHOR)

Material Recycling

ENERGY
MATERIALS
WATER

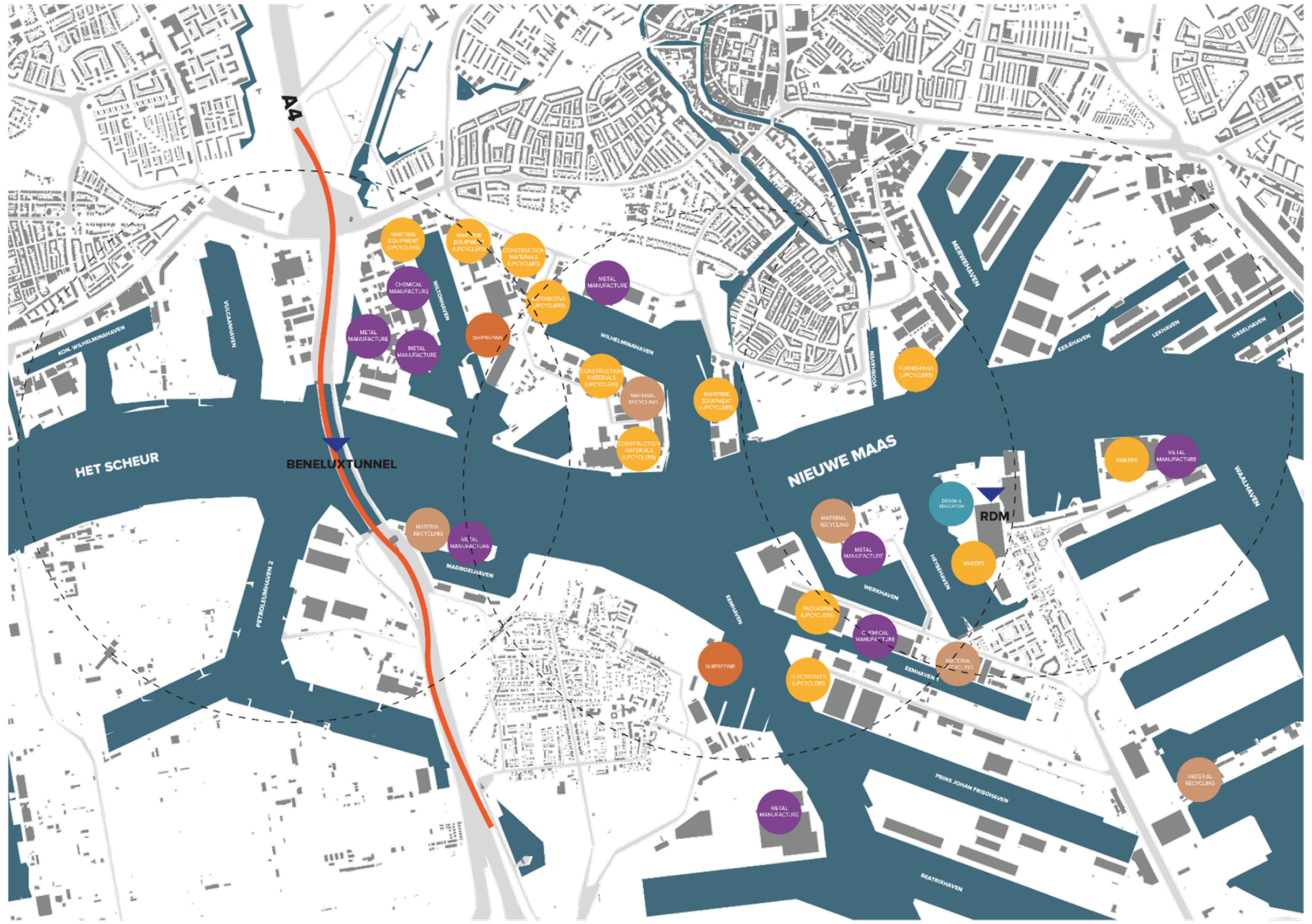


- Shipyard (Repair)
- Shipyard (Design/Construction/Education)
- Metal / Chemical Manufacture
- Material Recycling
- Makers / By-Product Manufacturing
- 1km Radius Distance

APPENDIX I

Industrial Symbiosis Analysis for RDM

RDM



INDUSTRIAL SYMBIOSIS WITH MAKERS INDUSTRIES & SHIPREPAIR AS ANCHOR

Education/Makers

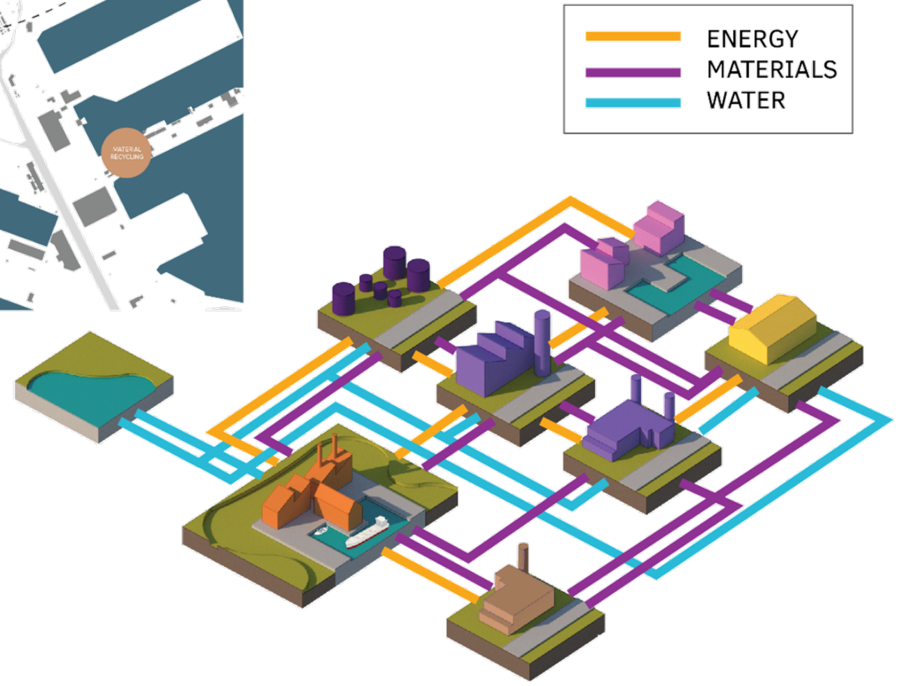
Shiprepair Yards (ANCHOR)

Metal/Chemical Manufacture

Material Recycling

Upcycling

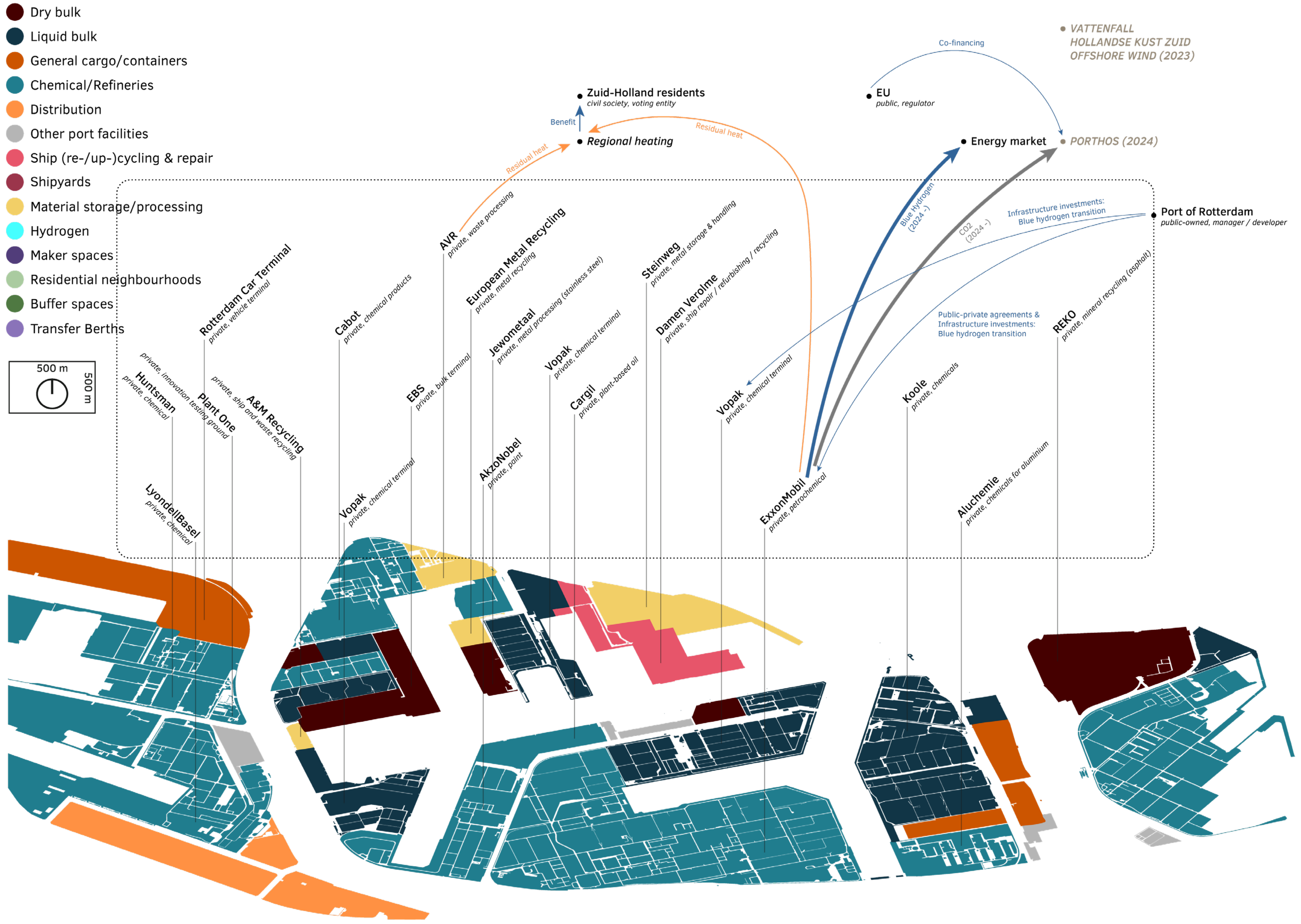
Makers Industry (ANCHOR)



- Shipyard (Repair)
- Shipyard (Design/Construction/Education)
- Metal / Chemical Manufacture
- Material Recycling
- Makers / By-Product Manufacturing
- 1km Radius Distance

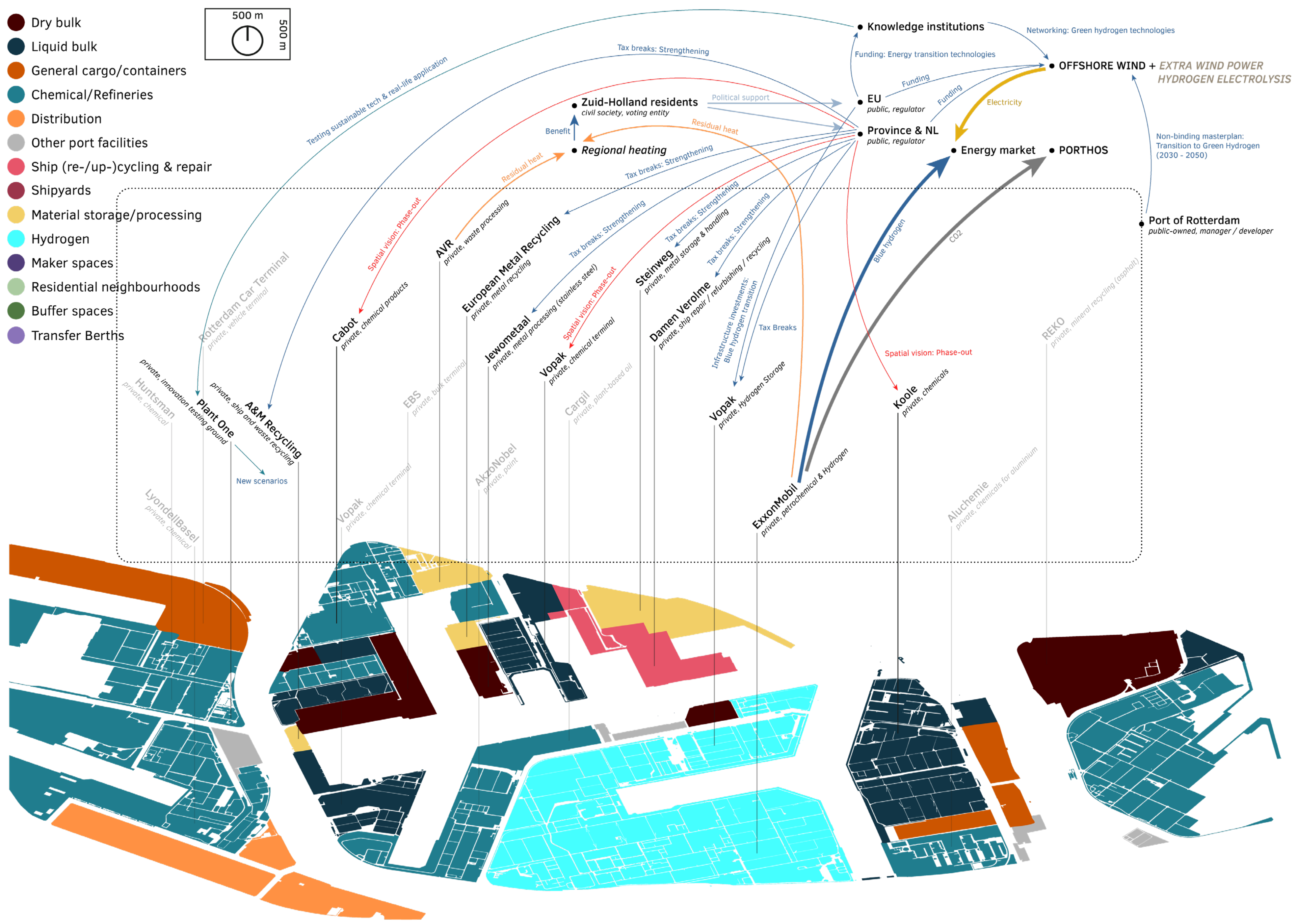
APPENDIX J

Botlek 2020



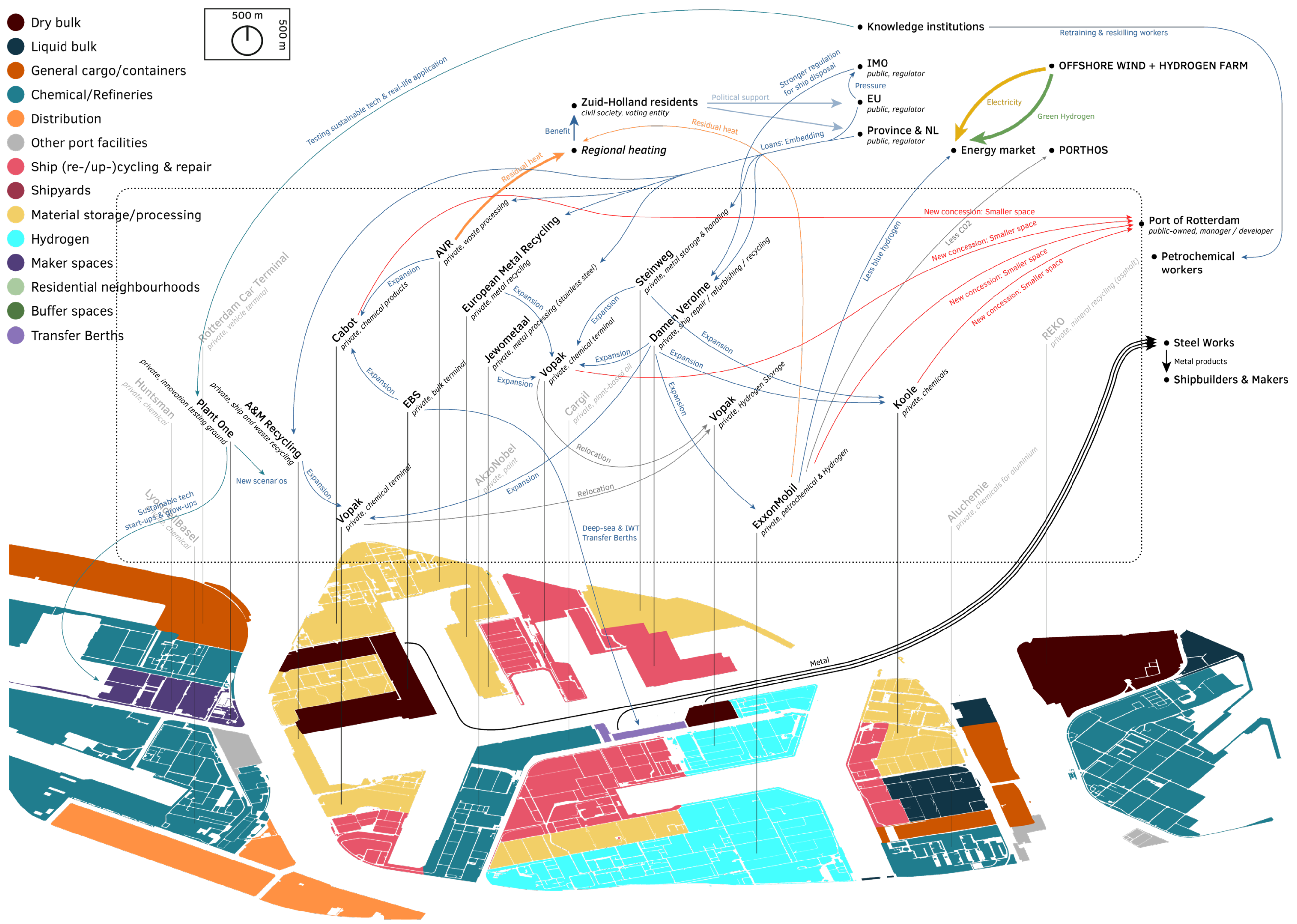
APPENDIX K

Botlek 2030



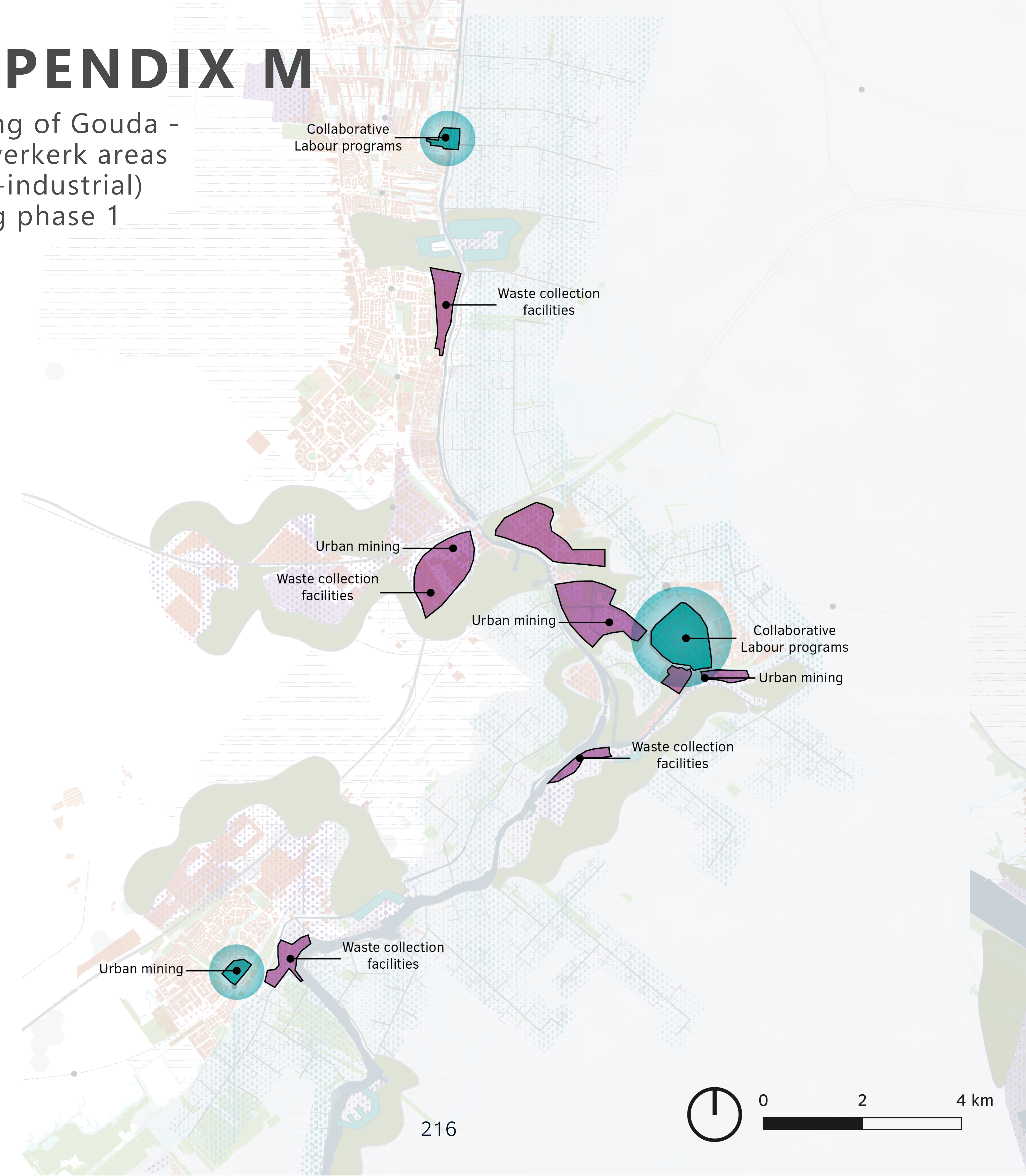
APPENDIX L

Botlek 2050

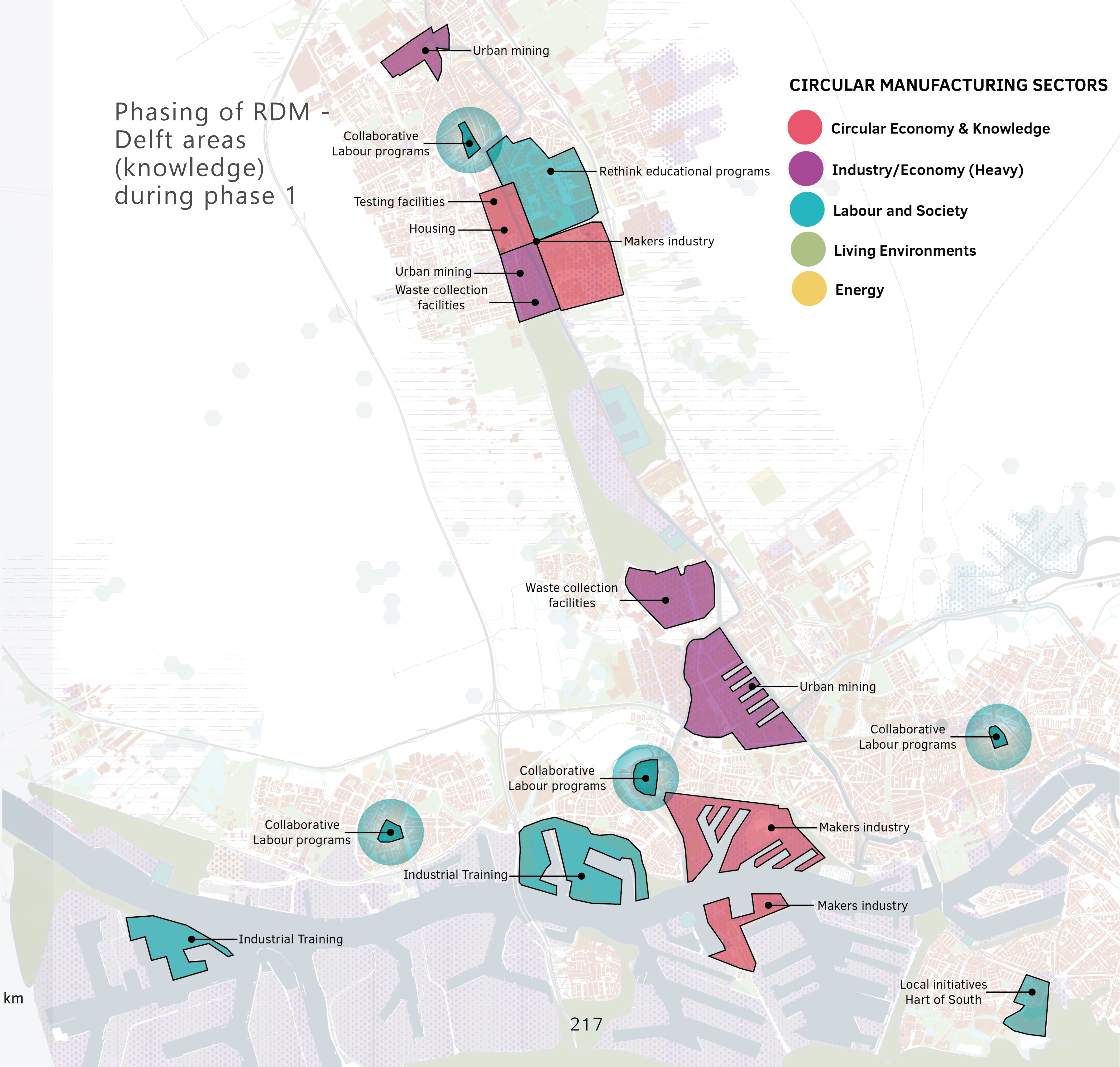


APPENDIX M

Phasing of Gouda - Nieuwerkerk areas (aqua-industrial) during phase 1



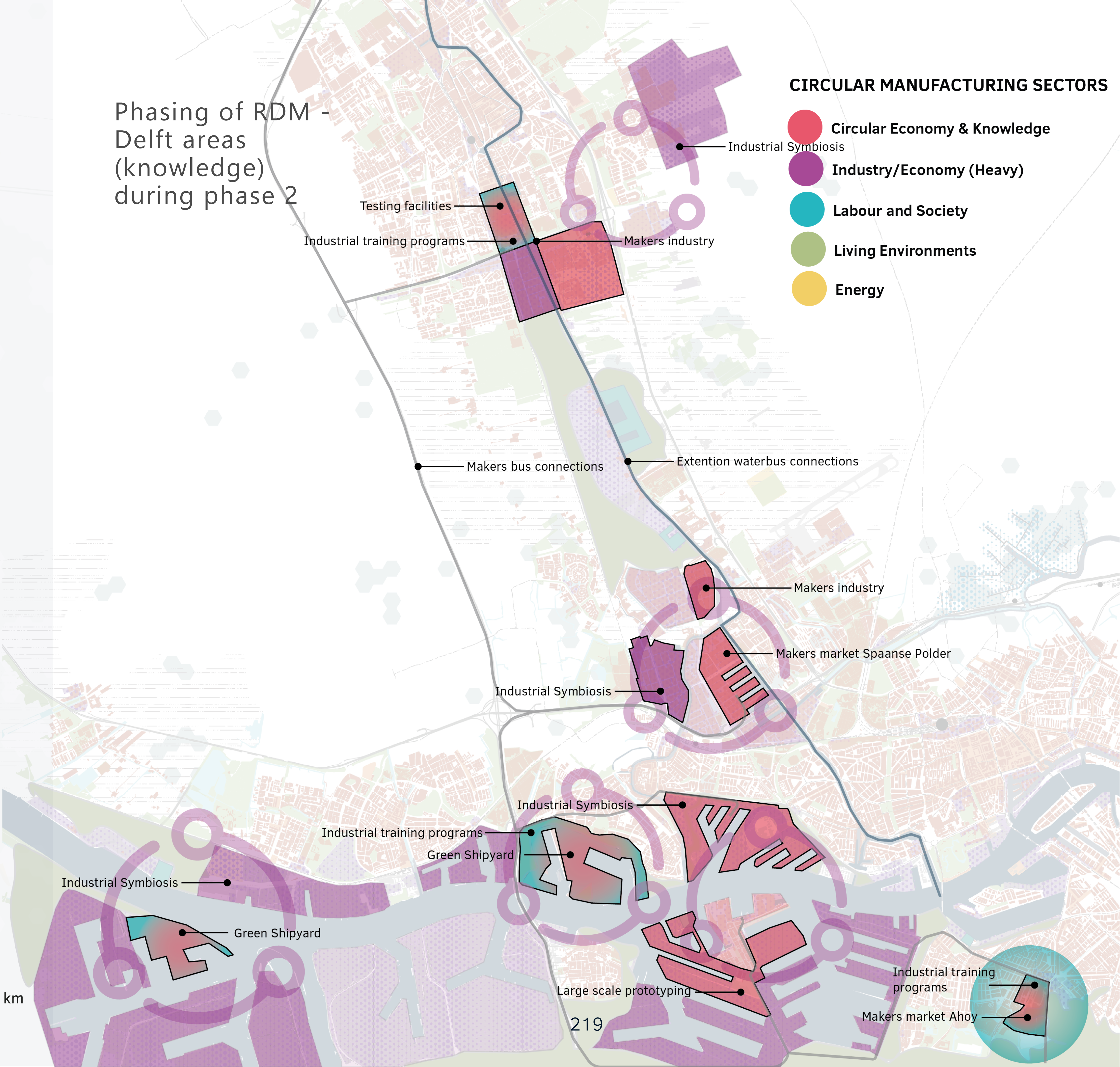
Phasing of RDM - Delft areas (knowledge) during phase 1



APPENDIX N

Phasing of Gouda - Nieuwerkerk areas (aqua-industrial) during phase 2

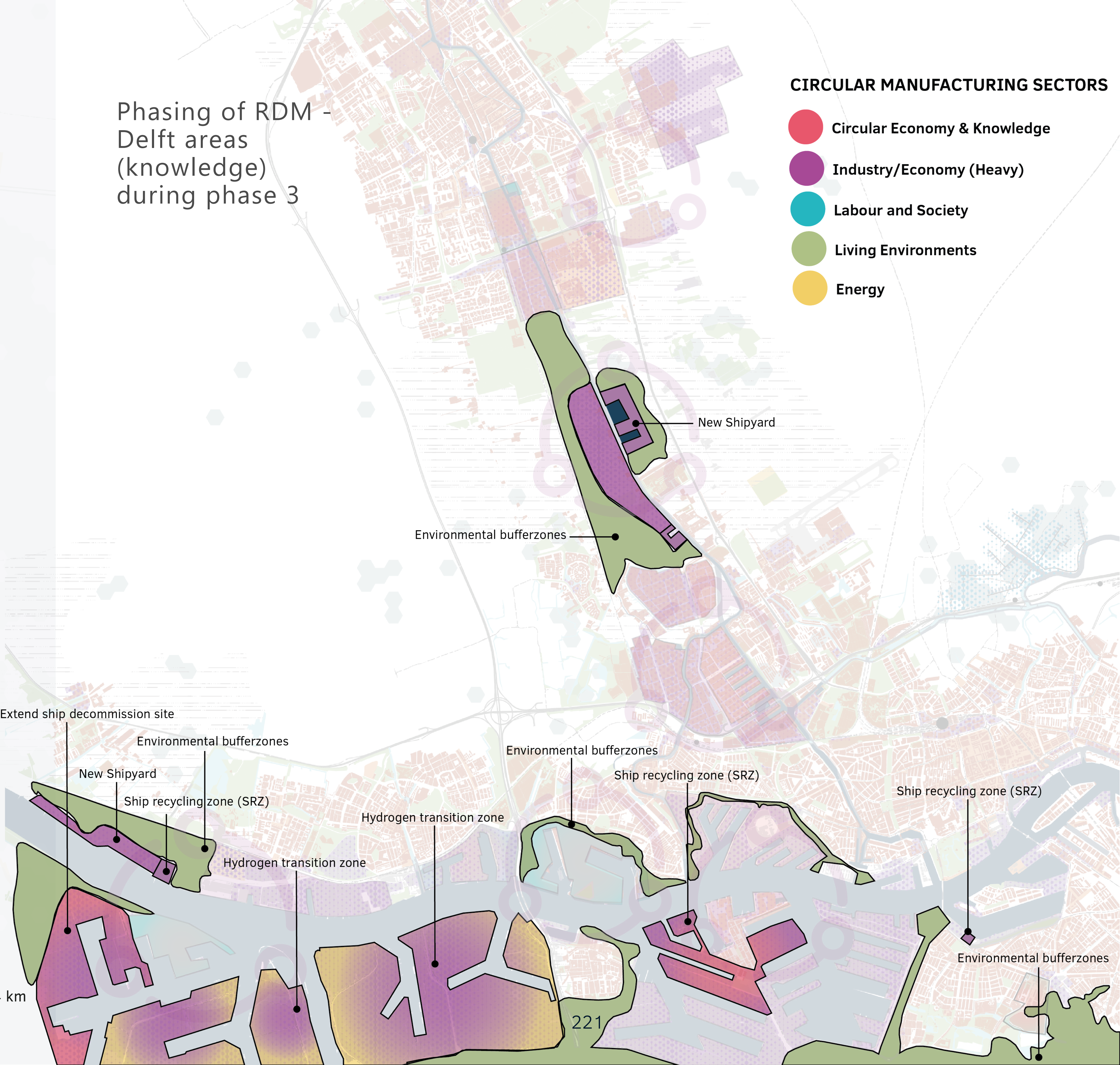
Phasing of RDM - Delft areas (knowledge) during phase 2



APPENDIX O

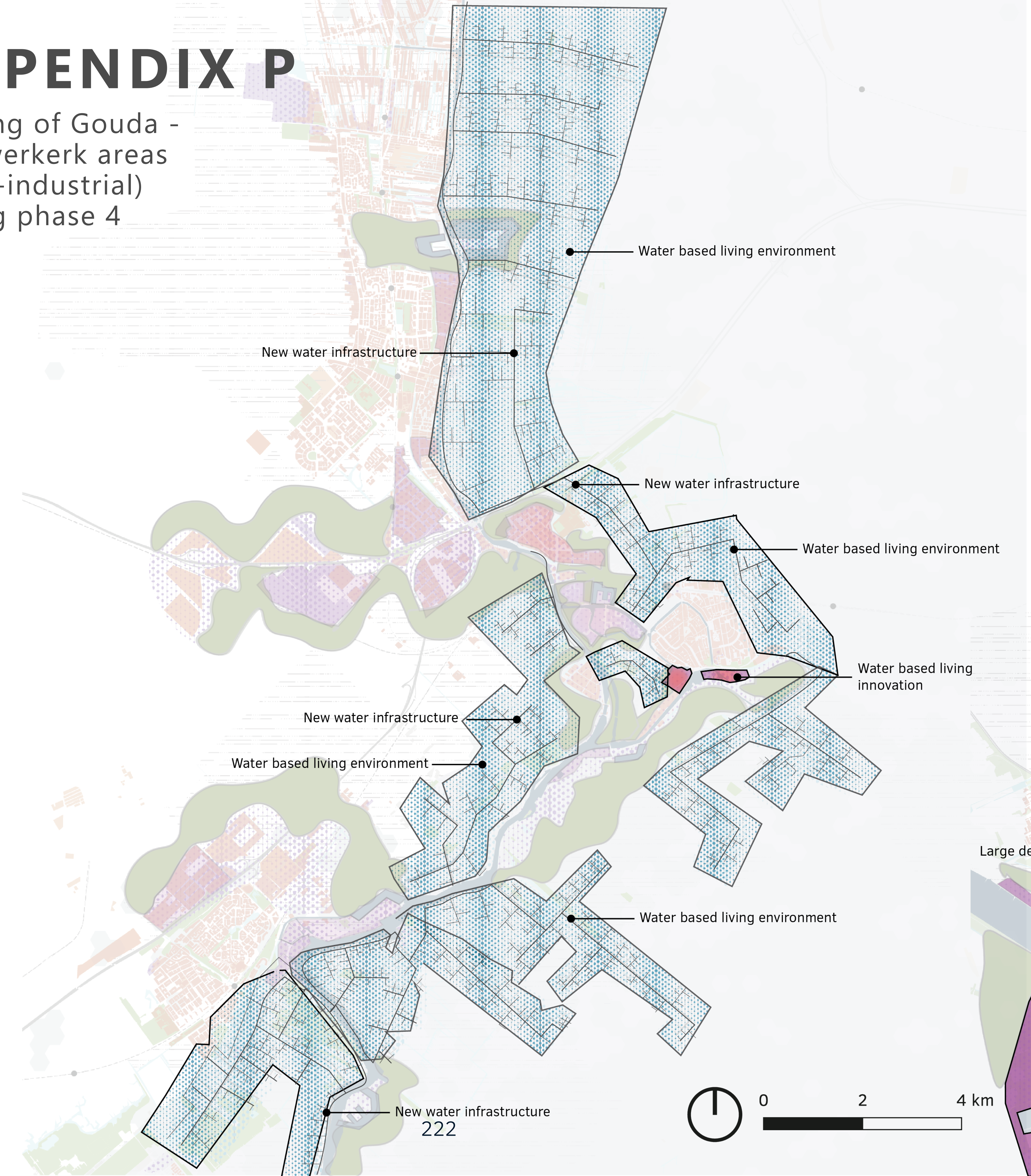
Phasing of Gouda - Nieuwerkerk areas (aqua-industrial) during phase 3

Phasing of RDM - Delft areas (knowledge) during phase 3



APPENDIX P

Phasing of Gouda - Nieuwerkerk areas (aqua-industrial) during phase 4



Phasing of RDM - Delft areas (knowledge) during phase 4

9

REFLECTIONS

Reflecting on observations and experiences is a surefire way to anchor wisdom

REFLECTION JENS BERKIEN

As a proud Dutchman, I was immediately interested in the circular economy of the Maritime sector. The impact of the maritime industry on the global stage is immense and that is why I was interested in this topic. As we further researched the processes, impacts and policies of the maritime industry on the environment, the disconnection between the industrial sector and society became apparent to me. I have known the Maritime industry of the Netherlands as a sector connected to its people. From the canals of Amsterdam to the iron casting facilities of the Port of Rotterdam, all of them carried a social aspect that currently seems lost. Therefore the way of implementing a new circular manufacturing chain within the province of South Holland seems to restore the missing link between the social and local connection between ship manufacturers and society.

At first glance, this problem seems easy to solve, but implementing local and regional strategies within a sector based on global trade does not change, without changing the global context as well. The province of South Holland can be shown as an example of how to implement a circular economy based on ship manufacturing, but without change in global policies, the private sector will not budge unless you connect with them from the beginning. These shipping companies have the knowledge and practice to deliver a potential vision of a circular economy that the government is striving towards. Combining that with the educational and innovative thinking of research institutions and new makers industries, this will create an integral symbiosis within circular economy. But this can only happen when these stakeholders are willing to change and share their information with other, optimizing material and waste flows. The complexity of these synergies and collaborative projects attracts my extension. It all seems so simple but this research has shown that collaboration is more challenging than changing the spatial layout itself.

This is even more complex when the regional scale comes into play, with more stakeholders, more opinions, more backgrounds and more issues to be taken care of. This makes creating strategies and an overall phasing difficult, because it asks visionary thinking of strategies that change the way we live. So it's our job as spatial planners to show these possibilities to all parties who have stakes in the sustainability transition of, in this case, the Maritime industry. To implement global and European changes in policies, the provincial scale is vital in providing the framework for bridging the gap between politics and implementation at the local level.

During this collaborative progress, I got Covid and I'm still feeling its effects, so I was not able to give my full energy for half of this course. Still, I learned a lot from doing this course. Although the group dynamics could have been improved, the overall collaboration between me and my student team went quite well. I wish we had known this from the beginning, having more time to set up a strong framework in which we could have been working. Although this process had been too unorganized as I had imagined, it showed new insights into how people work and how to collaborate with different personalities and characters.

REFLECTION MINSEONG KIM

This quarter's topic on the circular economy brought some quaint feeling to me, coming from the experience of my home country where "minimising imports" has been one of the primary goals of political decision making for decades. This stems from the same reason Europe is suddenly focusing on circular economy: the heightened global geopolitical instability[1], which in South Korea's case instability has been consistently there throughout history. This widening of the scope has given me a brief idea of how politics can also affect spatial planning, which often was too vague how to concretely translate into spatially.

Dealing with the vast domains of regional planning was the most challenging part, as unlike smaller neighbourhood-level projects where the scope of stakeholders and effects are limited, has taught me how to deal with uncertainties as an urbanist. During the project occasionally I found myself researching a topic that is too complex to cover in a quarter while not being too central to the project, such as the origin-destination of the port's hinterland cargos; through this, I have realised that it is best to find a reasonable point of safe assumption to resort to and widen the scope of understanding.

The most valuable experience I have gained from this quarter was finding the balance in mixing and separating functions spatially. On the one hand, urbanism today should be able to spatially connect knowledge and industries, i.e. "a farmer with PhD in Computer Science"(Ibid.); and on the other hand, spatially hard-mixing industries will result in industries being pushed out[2]. Adding to that also having to congregate around the existing built-up areas to not infringe upon the natural landscape, translating this requirement into a spatial framework all while aiming the spatial toolbox to have enough universality to be applied across the province scale is a challenge. Our approach was to give different qualities to the space for distancing itself, creating new meaning and role in the regional scale.

While creating a stakeholder relations diagram for Botlek, the challenge of coordinating multiple stakeholders while having a goal that one party (powerful) would not appreciate became apparent: it involved countless trade-offs, sacrificing in terms of time/scale/etc., and still won't be ever sure that the goal will be shared or the scenario will happen according to that (I believe likely not). Through this project we could experience the smaller-scaled coordination task inside the team; through the multitude of communication problems, not only for the different approaches but also stemming from each other's specialisations. For me, the expectation of sharing the data and creating different takeaways based on each other's specialisation was not always possible due to differences in each team member's GIS proficiency. I tried to minimise this problem by creating a small "toy" filled with all the relevant layers. I found this approach can be valuable in actual stakeholder coordination, where erasing technical barriers may encourage smaller stakeholders to clearly express their ideas, remedying imbalance in information access, particularly for the traditionally less powerful parties.

1 Van Den Berghe, K. (2022). Lecture on Circular Ports [Capita Selecta lectures on Monday afternoon 7 Feb].

2 Hausleitner, B. (2022). Spatial conditions for Manufacturing SDS lectures on Wednesday morning 9 Feb].

REFLECTION O'NEILMAYE LEITO

During the bachelor program Bouwkunde, we were very much focused on the small-scale; designing one building at a time, looking primarily at form, structure, and scenography. Sustainability and the complexities of our global society, how they relate to and impact the context for which we were designing, was not a primary focus. Yet, in these times of multiple transitions, all at the same time and quickly accelerating, the important contributions, in my opinion, will not happen at first at the small scale. Looking at how society can go through these transitions together and come out stronger and with a renewed sense of community on the other side, that is were the interesting design challenges lie. Urbanists are the world's stage designers, and the set we are designing for our and future generations will have great impact on how successful we will be in traversing the ongoing transitions, and in not leaving anyone behind. It is a great responsibility, being at the forefront of shaping the future. Fortunately, it is not an endeavor that we urbanists will be doing alone. It is actually of utmost importance to (physically) shape our future with multiple actors from different disciplines, offering different perspective so that we could try to grasp the complexity of the challenges before us. Always keeping in mind, of course, those stakeholders who are not currently sitting at the table, but whose (silent) voices are very important for embedding and sustaining the changes we are trying to implement.

This course required us to balance analytical research and visionary design efforts to achieve an evidence-based spatial design that could be both feasible and innovative. In the end, our efforts resulted in a design that is not necessarily revolutionary, but builds upon existing spatial frameworks and connections to incrementally reach our envisioned future. These complex national, and global transitions are marathons, not sprints. Keeping the pace along the route is important to reach the finish line; like the saying goes, 'steady does it'. So, starting from a space of 'knowing', building upon history and heritage, gives a solid foundation to handle the necessary changes ahead.

A parallel can be drawn between the complexity of achieving economic and social transitions with multiple stakeholders, and intensive collaboration in a team consisting of different personalities and way of working to realize a vision and strategy for a very complex issue within a very short time. When things get too complex or too alien, it is a natural tendency for people to drift towards the area where one feels the safest and surest. In those times, it is a benefit that we have shared, from the very beginning, a common vision and goal for South Holland, which was the key element that ensured our willingness to see it all through till the end and find common ground to work together effectively. That is the same role that a regional vision would and should play for the community at large[1].

I have learned a lot about balancing multiple aspects that come together at the regional scale, while needing to acknowledge that there is no one perfect solution for these challenges. That is not a surprise, as life works like that as well. Achieving a circular maritime economy will take perseverance, willingness to cooperate and collaborate[2], and a shared vision, built upon a foundation of shared (maritime) identity and respect for nature.

1 Rocco, Roberto (2022). I have a dream. Methodology for Urbanism Series. TU Delft.
2 Rocco, Roberto (2022). Attention, please! Methodology for Urbanism Series. TU Delft.

REFLECTION FRANCISCA MEJIA

The addition of Circular Economy as a layer in regional design is a definite challenge, and one that I was both curious and enthused to take on. Although I didn't get to fully delve in the 'energy transition' topic which was my first choice, dealing with a circular manufacturing sector seemed more daunting as I got to know it better, and how intertwined it is with everything else. I am constantly piqued, being someone in the creative industry, how we humans can still create products in a world wherein resources are getting depleted everyday by our very own activities. We need materials to make things, but we need to now make use of materials already there if we want to keep on creating; that's when really the idea that the human's propensity for creativity is also the solution for the very problem it creates. And so, regional design.

From the excursion, the expanse of the Port of Rotterdam, which I have so often heard as notorious, yet majestic in its own way, was proven to me. When my groupmates and I drove through the highway that flanked the Maas, overseeing the petrochemical storage areas and the landscape of jutting chemical oxidizers, I uttered, "a dystopia.'' Developed industry in its glory. Touching on shipbuilding was something that at the outset I was swept into, as it is of deep interest to one groupmate. I then began to ask why this sector, and it being a point of pride or heritage for him, was enough for me to take better interest in the sector and see where the study would lead us in terms of design for the whole region. History and context are most important to me in driving the vision of any project. To make something human out of something as monolithic as the shipbuilding industry would be a feat, and I believe somehow our group has managed to make it a more tangible industry that the people – even local people - could be truly involved in. It indeed has relevance, no matter how massive the transformation has to be as we are touching some of the most politically motivated and strongest industries as 'metal' in this still very capitalist world. Through the research, we have seen the ethical implications of these industries and how they have been defining people's lives, lifestyles, not only in the Netherlands, but the entire world. The 'just' part in the CE social transition is yet to be proven as the many actors and stakeholders that take part in a plan have so many interests, overlapping and contrasting, that one would really start to think whether there is a way to make anything happen at all.

From the SDS lectures and the discussions in the Methodology course, what struck me the most was the lecture by Rodrigo Cardoso on the 'Citification of the Region'. This particular lecture and the corresponding paper it presented somehow opened my eyes to a different way of looking at urban growth wherein polycentricity is the ubiquitous prognosis for cities' structures and sprawl[1]. I started to look at our project differently and the entire South Holland as a contiguous city and saw this informs the process of regional design in that the port does not necessarily belong now to Rotterdam, but to the entire region.
With this project, I have become more interested in the interstitial zones that define the functions that could be in proximity with each other in real life at a local scale, yet also how these translate in and affect the regional scale.

Drawing lines on a piece of tracing paper to say this is a 'knowledge corridor' as opposed to, say, talking to the head of a research institution to stimulate innovation are 2 very different activities that a planner must navigate through and strategize to achieve the best solution, for lack of a better term, for the most complex of issues that seems to be always hurling our way as urbanists. It's been a very eventful ride in this quarter for me in that the collaborative process was also put to the test, but one that proved nothing can't be done without others.

1 Cardoso, R., & Meijers, E. (2021). Metropolisation: the winding road toward the citification of the region. Urban Geography, 42(1), 1–20. https://doi.org/10.1080/02723638.2020.1828558\