PowerShift

Towards a sustainable post-fossil scape

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Abstract

Since the Industrial Revolution, fossil fuels, such as coal, oil, and natural gas have provided the vast majority of energy used by our globalising civilisation. The rapid growth in energy use in the past 250 years has led to increasing fossil fuel usage, which has been the primary driver behind the ongoing climate emergency. Policy measures in the Netherlands aiming to reduce the country's carbon emissions have so far been insufficient because of a lack of visioning and concrete strategies. A primary source of the persistent emissions is the Port of Rotterdam, which acts as Europe's fossil fuel gateway as well as the most polluting port in the continent, due to the excessive petrochemical activities. The pollution is one of the causes of climate change, which threatens the Dutch landscape with possible extreme sea level rise and weather conditions. The main objective of this report is to imagine a carbon-neutral post-fossil fuel future where the changing water landscape is considered, and the Port-region of Rotterdam adopts a decentralised energy system by 2100.

Historical and social analysis of the ports' position in the energy system together with the current policies of the energy transition was used to formulate goals and a conceptual framework. By using scenario building for uncertainties and their evaluation, a final vision of an inclusive energy transition was developed. To achieve the desirable systemic shift, this report outlines a set of development strategies through toolkits, new policies, and strategic sites namely in the Port of Rotterdam, Zeeland, Dordrecht, and the Green Heart. A detailed example of Port of Rotterdam is chosen to illustrate how specific actors can define the new energy-inclusive built environment.

This report aims to outline a transition pathway from the polluting and exclusive energy system towards a decentralised, sustainable, and carbon-neutral energy system that empowers communities and individuals in the Eurodelta region. A crucial element of the project is the establishment of a resilient energy system, taking in the consideration of sea level rise and worsening climate situation expected in the next decades. The integration of renewable energy, nature-based water management solutions and redevelopment of obsolete fossil-fuel scapes will transform the ports, urban centres, and peri-urban areas into a dispersed energyscape. This way, the new energyscape is inclusive and adaptive, allowing people to have a voice in their energy production while also being more in touch with nature.

Keywords
energy transition, decentralisation, fossil-fuel landscape, Port of Rotterdam, climate change adaptation and mitigation

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01

Introduction

Museum of Energyscapes

Figure 1. The Distant Past

Tulip Fields Near the Hague
Claude Monet (1840-1926), 1886

Figure 2. Recent History

A Polluting Port in the Style of Van Gogh
Midjourney AI, 2024

Figure 3. Today

Post-Fossil Landscape in the Style of David Hockney
Stable Diffusion, 2024

Delft, April 10th 2100

Welcome to the Museum of Energyscapes!

Here, you can explore the relationships between humans and energy throughout history, and the impact of these relationships on our built environment. This is important for our generation to learn from the mistakes that have been made in the past. Reflecting on the remarkable progress our ancestors achieved since the dawn of the 21st century, we can only be grateful for the resolute efforts they made to keep the Earth liveable for us and future generations. We have come such a long way that now we are only familiar with the environment of green renewable energy with which we produce our own clean energy in our homes and around the corner. But it has not always been sunshine and roses; not even 80 years ago humankind was in the middle of an energy crisis.

The windmills that are still iconic for the Dutch landscape were the first shapers of the energyscape in this country. They were used for pressing oil from oilseeds, grinding grain and sawing wood. Then from the start of the 18th century, fossil fuel was introduced, initiating the industrial revolution and reshaping the energyscape altogether.

Fossil fuel was amazing, it gave us almost endless power and possibilities. But it also ruined our planet. The polluting emissions that came with the use of fossil fuels started getting out of hand by the end of the 20th century, when researchers found the negative effects of using natural gas, petroleum and above all, coal. But because of the fossil lobby, these effects were kept silent until it was already too late to prevent any global warming and with this, sea level rise. The latter was going to be a big issue for The Netherlands, a country where at that moment every fifth person lived below sea level. In the beginning of the 21st century, humanity stood against an immense challenge to stop this process before it would become irreversible, with the very real and frightening possibility of moving towards human extinction. Only through joint efforts with all nations we were able to address the climate crisis. The Paris Agreement, signed by 195 countries in 2015, was a breakthrough for international collaboration. The hopes were high, but the goals were too ambitious and vague that countries had difficulty to achieve the goals set in the agreement.

2024 marked the moment that The Netherlands decided to take the risk and take a different turn on the road towards a carbon-free future. In this report, you can read the research and vision-building that came before the nation's new vision: the PowerShift. And as we know by now, we managed to get back on track and created the new landscape that we live in today.

Enjoy this report as you travel back in time to last century's twenties!

02

Methodological Framework

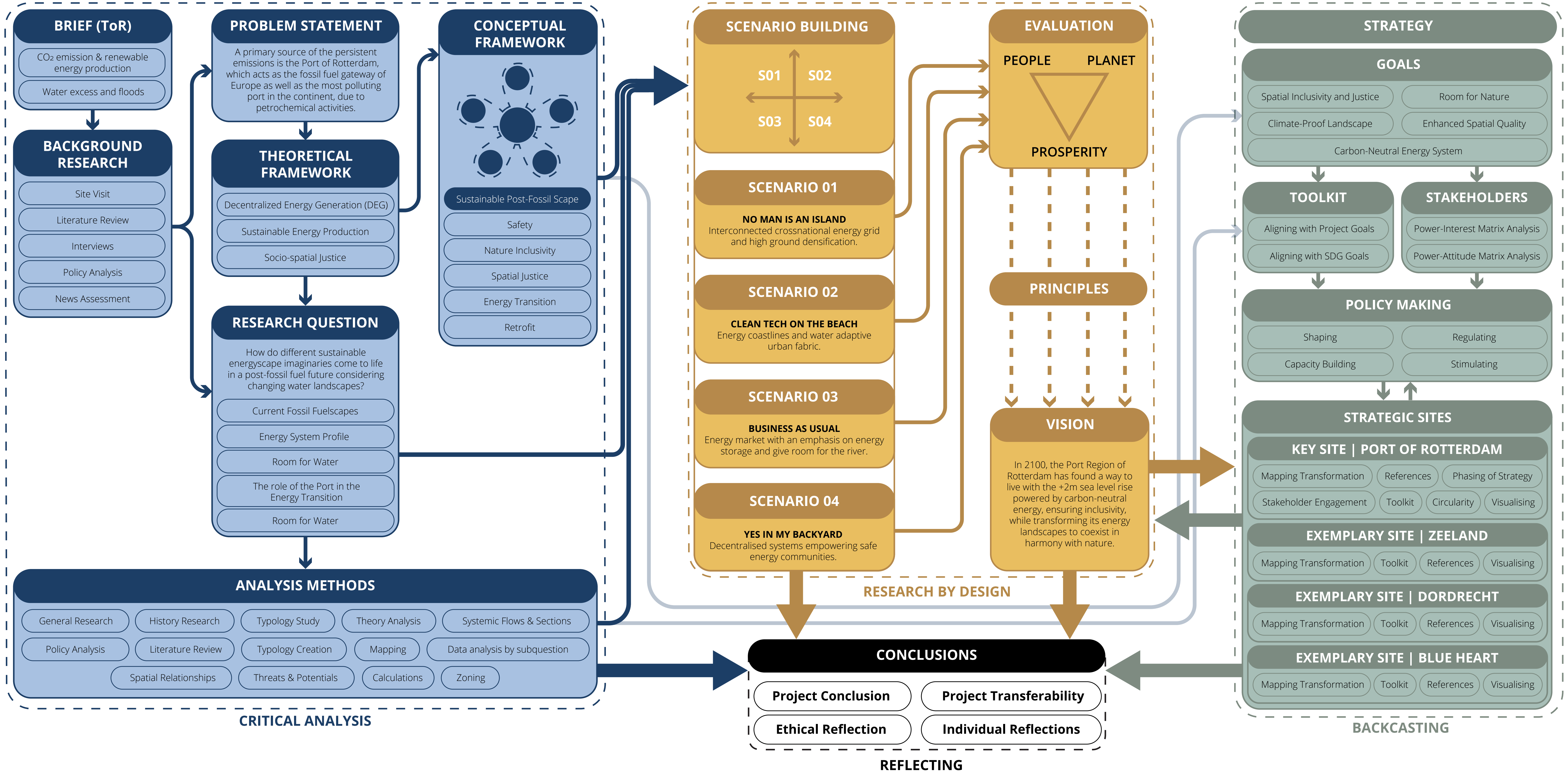


Figure 4. Diagram showing series of methods and methodology used in the project, also explaining thinking framework from brief, background research, analysis, vision and strategy, and conclusion.

2.1 Methodology and Methods

The project vision addresses the spatial, economic and policy implications of the imminent energy transition, and the possibilities of integrating this transition with one concerned with the development of a circular economy. The project is structured in way that it first explains the right of its own existence by explaining the current situation, challenges and contexts of the fossil fuel and energy industries and the importance of port-scapes in said industries. Next, the Vision summarises the future that the project considers desirable. This is followed by the introduction of the strategy that would lead to this envisaged future.

The creation of the report followed a four-step methodology. At the beginning, a critical analysis took place, including background research on the project brief that led to the formulation of a problem statement supported by multiple research questions. Building on the problem statement, a theoretical framework was set up that further supported the research question as well as provided a basis for the project's conceptual framework. The analysis methods that laid the foundations for these steps can be seen in figure 4

Building on the critical analysis stage, the concept of 'research by design' was followed; Analysis and research efforts were continued alongside the scenario building process. The four scenarios were then evaluated based on a criteria system that was set up from the conclusions of the analysis. Finally, considering the results and principles of the evaluation process, a vision was formulated.

In the third stage, a back casting process was done to support the project vision. Five main goals were formulated that best support the achievement of the vision, supported by the identification of stakeholders and planning tools relevant to these goals. Combining the available tools with the relevant stakeholders a policy making process was executed outlining the available agency and processes at the project's disposal. This was followed by the creation of four strategic intervention plans that display how these policies and strategy would act towards the achievement of the vision.

Lastly, to conclude the project, the feasibility and transferability of the project was examined with considerations to the possible limitations. Ethical and individual reflections were also conducted to improve the legibility of the project.

2.2 Problem Statement

In order to minimise the adverse effects of climate change, the European Union (EU) has set ambitious climate targets (European Commission, 2019) aiming to reduce greenhouse gas (GHG) emissions by 55% by 2030 and become the first climate-neutral continent by 2050. As one of the primary drivers of global temperature rise, CO2 is largely emitted by the energy-generating industry, relating to 43% of the total emissions globally (Ritchie et al., 2023). In decades to come, electricity demands are expected to grow due to the electrification of most aspects of human activity. To meet this demand the EU Commission envisions that 80% of the electricity supply will be provided from renewables (European Commission, 2019). This major change in the current energy system will urge a reimagination of our energy landscape, posing both opportunities and challenges in a post-fossil future.

The fossil fuel revolution had such a massive impact that it has not only formed the morphology of the built environment but has also shaped the new lifestyle focused on consuming. Today, the Eurodelta region has been developed around the fossil fuel energy system, with the Netherlands operating as the major oil distributor in Europe with an extensive supply network of ports, storage facilities and pipeline connections. This current intertwined reliance on oil, natural gas and their established petroleumscapes is making the phasing out from fossil fuel reliance challenging for spatial planning. The on-going energy transition is already applying spatial effects, "reshaping landscapes and their connections to urban and rural spaces, culture, nature, and material practices" (C. Hein, 2021b). As this transition unfolds, supervising the transformation of these petroleumscapes and their re-integration into their regions becomes crucial.

The Port of Rotterdam is a key example of a segregated petroleumscape. It is Europe's largest seaport and among the top 10 largest globally in terms of cargo tonnage, contributing significantly to the Dutch economy (CBRE, 2022), while also being the most polluting European port due to its heavy fossil-fuel related activity, producing 22.5 Mton of CO2 in 2022 (Port of Rotterdam, 2022) and contributing to environmental degradation and climate change.

The Industrialisation in the 19th century has parted the relationship between ports and cities, by transforming ports into centralised polluting industry hubs and separating themselves from the city centres that once hosted them. The beneficial economic development and influential stakeholders has led decision makers to allow the expansion of the ports seizing rural landscapes and following urban annexation plans, at the cost of deteriorating relations with nearby residents and a loss of communication between port and city institutions. However, the trend is shifting away from isolation as "the planning process of Maasvlakte II has shown how environmental issues have had a major impact on existing port-city-region relations and planning decisions, including the vital element that this would be the last extension into the sea" (Koppenol, 2016) (C. M. Hein & van de Laar, 2020). The vast port currently occupied by petroleumscapes creates an opportunity to adapt it into the city while also transforming and integrating the new energy system.

It is important to understand, that when working with transforming the current energyscape, there are many variables that influence the systems. One of the uncertainties is related with the importation or production of energy. As current world conflicts, such as the Russo-Ukrainian war, illustrate the need to strengthen the North-West regional or Netherlands national energy production. Other uncertainties are tied to rising sea level and extreme weather events are increasing which in combination with Dutch water strategies, highlighting changes in landscapes (Hayhoe et al., 2018). How do we deal with these uncertainties will also shape the vision for a new green energy transition in the port-maritime region.

2.3 Research Questions

How do different sustainable energyscape imaginaries come to life in a post-fossil fuel future considering changing water landscapes ?

Current fossil fuel-scapes

- How does the Fossil fuel shape the built environment?
- What are the dynamics between the port petroleumscapes and its surroundings?
- How are the financial and physical flows of fossil fuel shaped?
- What is the current energy profile relating to imports and exports?

Energy system profile

- What are the benefits and consequences of implementing a centralised or decentralised energy systems?
- How does shifting towards a more decentralized energy system impact the landscape and how can we sustainably reallocate land?
- How could a hybrid land-use be incorporated to dedicate more space for water, housing and energy?
- Can planners have an influence over energy consumption patterns?
- How will the post fossil fuel energy mix look like?

Room for water

- How will Dutch water strategy influence the energy production in the future?
- What are the different water-related scenarios for the country in the future?
- How would creating space for water change the current landscape?
- Is there energy potential in regulated water systems?

The role of the Port in the energy transition

- What is the role of the Port of Rotterdam regarding the energy transition on a Eurodelta and EU scale?
- How is the Port's transformation key of broader shifts in energy landscapes?
- In what ways can the changes in petroleumscapes around the Port of Rotterdam serve as a model for similar transitions in other regions?
- What are the stakeholders being involved in the decision-making processes?

Post fossil fuel future

- How would the new energyscape look like in a fossil-free future? What are the new dynamics that are being created?
- What can be done with the existing infrastructure of the fossil industry?
- Could petroleumscapes become part of our built heritage?
- How can spatial design support the energyscape transformation post petroleumscapes?
- What will be the socio-economic impact to the urban life?
- How can the energy transition threaten spatial justice along global supply chains?

2.4 Conceptual Framework

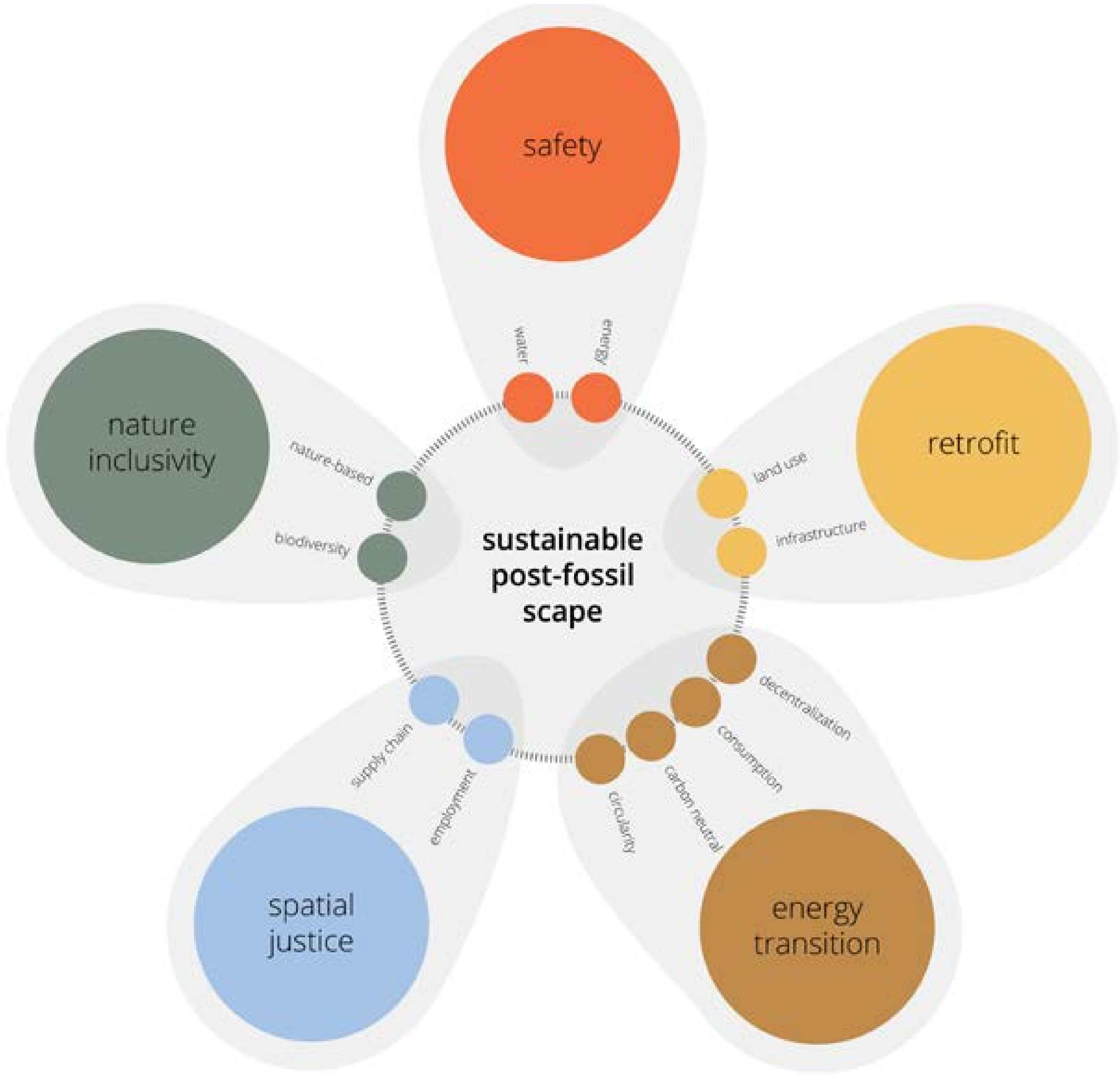


Figure 5. Conceptual framework showing five main concepts that became the basis of the project, with smaller focuses on each concept.

As mentioned before, to mitigate the impacts of climate change, our societies must accelerate the shift from fossil fuels to renewable energy. This transition will prompt a reimagining of our energyscapes along with many other aspects of daily life, presenting both challenges and opportunities. After conducting thorough research and discussions on transitioning post-fossil landscapes, we have identified five main concepts and additional sub-concepts that supported our research by design project. Starting from a theoretical framework research, our team identifies the following five concepts as crucial in driving this transition. On this pathway, the concepts are interconnected and mutually influential.

Energy transition

Our world needs to shift away from fossil-related energy production to sustainable energy sources. In the past, historical transitions between energy sources have occurs but took a long time (Solomon & Krishna, 2011), but now, the transition needs to be more rapid. At the same time, ensuring reliable energy services, combating energy poverty, and addressing climate change require effective infrastructure (Goldthau, 2014). At the same time, energy infrastructure is characterized by the involvement of a vast number of actors (Goldthau, 2014). With numerous stakeholders and complex regulations, governance of energy infrastructure is challenging and must adapt to changing environments to remain resilient, emphasizing the need for dynamic governance arrangements (Goldthau, 2014).

Our baseline concept for this project is decentralization in the energy system. Centralized energy systems are considered as "*large-scale energy generation units (structures) that deliver energy via a vast distribution network, (often) far from the point of use*" (Vezzoli et al., 2018). On the other hand, decentralized energy generation involves producing energy on a smaller scale closer to the point of use encompassing smaller-scale units distributing energy locally, either independently or linked to nearby units for resource sharing (Vezzoli et al., 2018). These systems often rely on renewable resources like solar, wind, water, biomass, and geothermal energy, promoting environmental sustainability by utilizing locally available and renewable sources (Vezzoli et al., 2018). They offer enhanced reliability and resilience through their distributed architecture, better equipped to handle individual failures. Furthermore, decentralized energy systems facilitate a democratization of energy access, potentially reducing inequality and fostering community self-sufficiency and self-governance (Vezzoli et al., 2018).

Another key concept is circularity of materials and carbon. In our project circularity can take the form of industrial symbiosis, reuse of existing fossil-fuel infrastructure or circular materials flows. Key categories of symbiotic synergies include: energy cascades to utilize waste energy and materials, fuel replacement to reduce the use of fossil fuels, and bioenergy production based on symbiotic relationships (Fraccascia et al., 2021).

Spatial justice

Our current energy system is fundamentally unjust, but energy transition offers an opportunity to shift towards a more just future (Aspen Global Change Institute, n.d.). However, transitioning to a cleaner energy system can potentially create more injustices (Newell & Mulvaney, 2013). The concept of "justice" has been discussed for millennia, from ancient Greece to modern times. Today, justice is often associated with fairness, serving as a bridge individual and groups desires, resolving conflicts and distinguishing better and worse decisions (Sovacool & Dworkin, 2014). Illustrated in Figure 6., "*the tenets of energy justice*" framework can help recognize the principles of energy justice - distributional justice, procedural justice, and recognition justice (McCauley et al., 2013).

As the transition to post-fossil futures accelerates, it's crucial to ensure that is achieved in "a just and equitable manner providing prosperity for all" (Cabré & Vega-Araújo, 2022). Spatial justice relating to energy transition is associated with various aspects, namely reduced inequalities (Cabré & Vega-Araújo, 2022), fair distribution of burdens and benefits (Sovacool & Dworkin, 2014) across all scales, communities and regions, access to clean and affordable energy sources (Hearn et al., 2021), as well as opportunities to participate in the transition (Aspen Global Change Institute, n.d.). Additionally, a just transition takes into consideration the social and environmental impacts of energy projects, with the main aim being to maximize positive outcomes and minimize negative effects (Hearn et al., 2021).

Justice can be threatened along the energy supply chain, distribution, and production. Considerations should be made regarding sourcing of raw materials, the locations of energy productions areas, employment, and waste disposal (Hearn et al., 2021). Ensuring fairness in employment opportunities also involves supporting the transition of workers from traditional energy sectors to new green jobs in renewable energy or other related fields (Hearn et al., 2021). In a word, a just transition requires "respecting human rights throughout all the length of the energy supply chain (Cabré & Vega-Araújo, 2022).

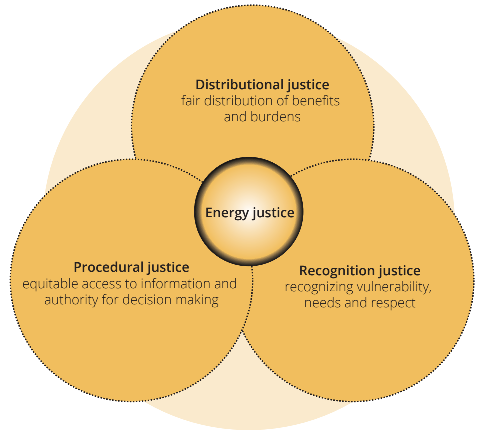


Figure 6. The "Tenets of energy justice" framework can help recognize key principles of the concept, (Aspen Global Change Institute, n.d.)

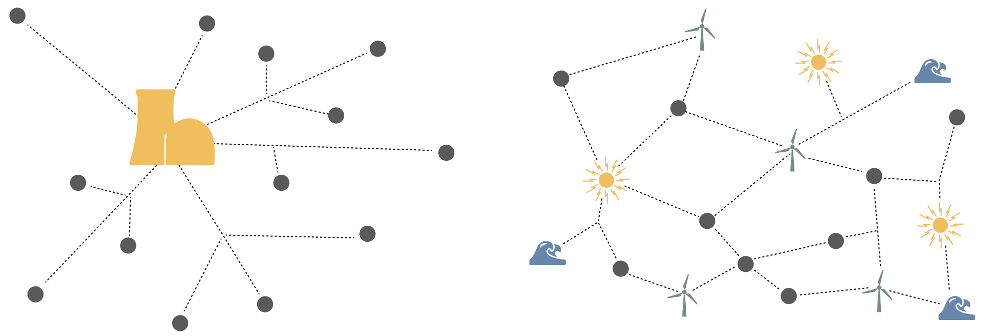


Figure 7. Diagrams illustrating the centralized (left) and decentralized (right) energy production systems, (see sources in Bibliography)

Safety

Another key aspect is safety related to water risks but also energy safety. In order to safeguard our communities from sea-level rise, pluvial and other forms of flooding an integrated approach of different perspectives like coastal engineering, finance, social sciences and planning is needed (Hinkel et al., 2018) and implemented in our project. Regarding energy safety, researches have shown that the use of renewable energy represents a safer future than traditional energy (Andeef et al., 2023). Several reasons why renewable energy is a safer choice have been studied, including reducing harmful emissions of nuclear energy and reducing the risk of pollution from coal and oil (Andeef et al., 2023). At the same time, renewable energies are also a geopolitically safer source as reliance on fossil fuels puts countries vulnerable to geopolitical tensions and conflicts over energy sources (Andeef et al., 2023). Additionally, renewable energies are also financially secure. Although the costs of building renewable energy infrastructure may initially be high, they are stable and are not exposed to economic tremors.

Retrofit & Nature inclusivity

Spatial quality, sustainable land use and effective infrastructure management are also key components of our framework with nature playing a crucial role in our approach. Nature-based solutions and working with nature are central to transforming fossil-scapes into climate adaptive and carbon neutral environments.

Numerous frameworks have been developed regarding the urban and peri-urban local development throughout the years. An overarching framework for our project in the European Green Deal that emphasizes on strategies related to climate goals, biodiversity, civil protection, agriculture, circular economy, energy storage, clean and affordable energy, forests and others (EU, 2020). Similarly, the New Urban Agenda highlights the importance of sustainable urban development, while addressing challenges and underscores the importance of spatial frameworks (UN, 2017). At the same time, it promotes nature-inclusivity and nature-based solutions to tackle challenges such as climate adaptation and resource management (UN, 2017).

03

Unwrapping the Challenges | Analysis

3.1 Fossil Fuel, CO2, and Climate Crisis

A. The iceberg of fossil fuel

Since the widespread use of coal started during the First Industrial Revolution, our civilisation has developed using fossil fuels. Today, our lives revolve more around coal, oil, natural gas, and petrochemical products, than most people could imagine. We use coal, oil, and natural gas to generate electricity and heat; these materials are fundamental in lighting up our buildings, powering our appliances, and heating our homes and factories. Although, humanity has figured out how to generate this electricity and heat in other ways, such as using nuclear fission, or renewable energy, yet, we still generate the majority of our energy from fossil fuels.

Hydrocarbons, especially oil is not only used to generate energy; by splitting naturally occurring oil and natural gas into its components through a series of refining processes, a wast variety of chemicals can be produced. By combining these components in different ways, the chemical industry can create a plethora of materials that can be found in most of the things we use; from our clothes, plastic bags, and reusable bottles, through our furniture, electronics, and plastic appliances, to our construction materials, roads, drugs, and medical prosthetics.
When we travel or carry things around, we also rely on fossil fuels. The petrol powering our cars, diesel fuel used in container ships, and kerosene fuelling our planes are all made of crude oil - thus, related to fossil fuels.

There is no denying that hydrocarbons surround us wherever we go, and we interact with them all day, every day. According to a piece in Time Magazine (Smil, 2022), all four fundamental materials - cement, steel, plastics, and ammonia - require fossil energy, making oil the "lifeblood" of our civilisation.
However, by this day it has also became abundantly clear that these materials that has powered our civilisation to its current form are also poisonous for our environment; Microplastics destroy Earth's ecosystems in an unprecedented pace, greenhouse gases emitted by burning fossil fuels for energy heat up our planet, and various petrochemicals contaminate soil, water, and air.

We have to stop using hydrocarbons as soon as possible. This promises to be a tremendous task, but there is no denying that a sustainable future cannot be imagined with fossil fuels.

Figure 8. (Left) The iceberg visualization of the petroleum culture, with the top part of the iceberg (depicting apparent benefit) showing the importance of fossil-based products in our daily life, and the submerged part of the iceberg (depicting negative impact) showing the different happening climate crisis, with an ocean full of garbage as a background (see sources in Bibliography)

B. CO2 emissions

As mentioned earlier, the greatest issue arising from the use of fossil fuels is the emission of CO2 when we burn them to generate various types of energy. As visible in figure 6, four out of the seven most polluting aspect of human life are directly related to the burn of fossil fuels. Electricity and heat, aviation and shipping, other transport methods, and industry all emit the wast majority of their total CO2 emissions from fossil fuels.

Electricity and heat generation alone is responsible for almost as much emissions as all the other sectors combined. On one hand, this shows that despite being aware of the potential consequences of CO2 emissions societies have done little to reduce the carbon intensity of their energy; on the other hand, however, tackling CO2 emissions related to the energy sector promises a great chance to halve global CO2 emissions in the future.

Acknowledging that electrical and heat energy are the greatest contributors to global CO2 emissions, this project pledges to eliminate these emissions and provides a potential pathway towards a fossil-free future by 2100. Although, the project has been commissioned with the knowledge that this problem is a global one, the importance of regional actions is valued greatly. Thus, the strategy and pathway drawn up by the project is for the EuroDelta region in Northwest Europe.

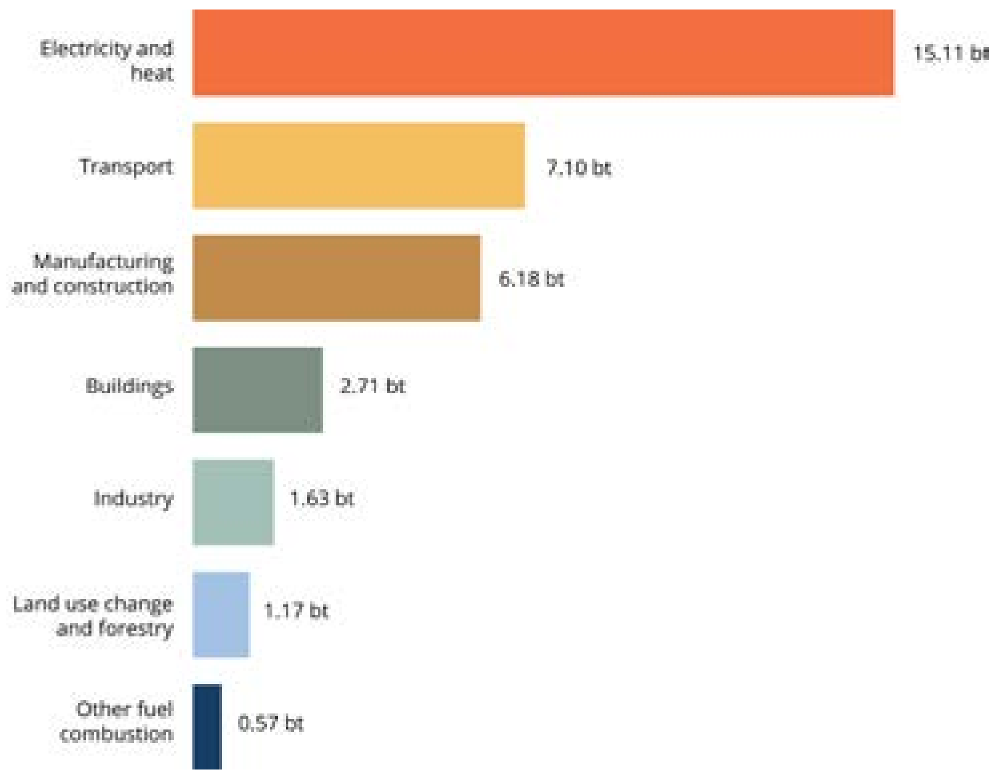


Figure 9. Bar chart of CO2 emissions in billion tons per sector in 2020, showing electricity and heat as the biggest emitter (Ritchie et al., 2023).

C. History of the fossil fuel

1764

James Watt invents the modern steam engine. Industrial-scale use of fossil fuels begins

1784

William Murdoch invents the gas lamp, which quickly replaces paraffin candles as the primary method of lighting

1800s

Coal gas becomes the primary source of domestic energy, used for heating and lighting

1859

The World's first commercial oil well begins production in Pennsylvania, US. The extracted oil is used in boilers and modified gas lamps

1890s

With advancements in the use of explosives, coal mining activities expand into underground mines

1930s

With the spread of petroleum use in transportation and in the petrochemical industry, requirements for the extraction and trade of oil skyrockets

1960s

Until the 1960s Natural Gas was considered a by-product of crude oil extraction, separated and burned away. Natural gas become a viable energy source during the oil crises of the 1970s, when it replaced coal gas and oil in domestic heating and electricity generation

1973

The 1973 Oil Crisis was the main event that shed light on the Western World's energy dependence as a strategic weakness. The resulting energy crisis was the main motive behind first major attempt to move the electricity generation of Western Countries away from fossil fuels

1970s

As a consequence of the oil crises of the 1970s oil exploration and extraction operations are extended onto the world oceans. Areas such as the North Sea and the Gulf of Mexico become centres of the petrochemical industry

1980

Technological advancements allow for the liquification of natural gas. Now, much easier to transport, natural gas replaces oil as the primary electricity source in the Western World

2023

Germany closes its last remaining nuclear power plant, becoming the last Western country to commit to coal usage in the medium term

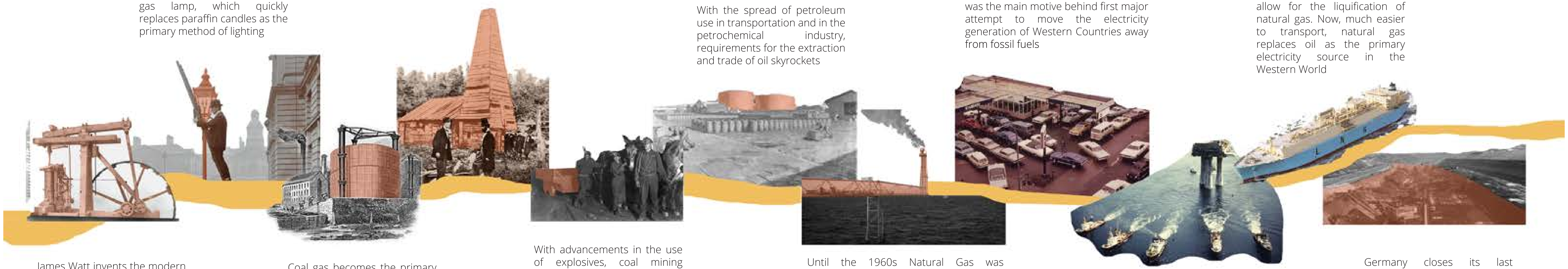


Figure 10. Timeline collage of history of the fossil fuel starting from the invention of steam engine until the nuclear plant power (see sources in Bibliography)

Coal

After the invention of the modern steam engine by James Watt in 1764 a rapid industrialisation began that greatly increased the need for coal. Throughout the late 18th and 19th centuries, many processes, such as transportation, manufacturing, mining, agriculture were motorised using steam engines, rapidly increasing coal consumption. With the invention of the steam turbine generator, it became possible to generate electricity from the chemical energy content of coal - As the result of cheap coal, like with steam engines, the spread of electrification was quick. To this day, coal is the cheapest and simplest way to generate electricity, resulting in the relative popularity of coal-fired power plants, despite the apparent environmental harm (Britannica, no date).

Oil

Ignacy Łukasiewicz builds the world's first rock oil mine in Poland. Following the discovery of liquid oil deposits near Baku in then-Imperial Russia, industrial-scale oil extraction begins. Petroleum products were used primarily for lighting, but owing to breakthroughs in industrial chemistry, many products of petroleum refining were started to be used. After the First World War, a rapid economic recovery had begun that led to the rapid spread of automobile use, which resulted in increased demand for refined petroleum products, such as petrol and diesel oil. Improvements in industrial chemistry enabled the development of the first plastics and synthetic rubber products. As the most advanced militaries underwent rapid motorisation before and during the Second World War, oil became the most important war material - Taking control over oil extraction and refining became a primary objective of major powers (Vasillou, 2018).

Natural Gas

Natural gas is the latest addition to the widely used fossil fuels. The first commercial use of gaseous hydrocarbons was in the form of coal gas, a substance released from coal when heated up. Coal gas - also called town gas - was first used in the UK from the late 17th century for domestic heating and street lighting purposes. In the 18th and 19th centuries natural gas was used in small local energy grids in the US and Western Europe as a fuel for heating, but due to the limitations of pipeline technology its widespread use was not possible then. Improvements in pipeline technology and oil shortages during the Second World War triggered developments towards wider use of natural gas. Until the 1960s Natural Gas was considered a by-product of crude oil extraction, separated and burned away. Natural gas become a viable energy source during the oil crises of the 1970s, when it replaced coal gas and oil in domestic heating and electricity generation.

In the 1970s, utilising advancements in pipeline technology and developments in maritime transportation, the global distribution of natural gas became possible, finally enabling the widespread use of natural gas as a cheaper, less pollutive and more abundant fossil fuel alternative to oil and coal (Britannica, no date).

D. Climate crisis

According to the World Meteorological Organization (WMO), "*2011 to 2020 was the warmest decade on record by a margin for both land and ocean*" and each successive decade has been warmer that all previous ones (WMO, 2023b). 2023 had the highest average global temperature since we first started recording temperatures, 174 years ago and 2024 is on track to break last years records (WMO, 2023a)(Science Friday, 2024). More specifically, the annual mean global near-surface temperature for each year between 2023 and 2027 is predicted to be between 1.1°C and 1.8°C higher than the average over the years 1850-1900 (WMO, 2023a).

The current warmer world is already affecting human and natural systems and some of the key risks are already being identified. Europe faces four primary risks, which are projected to escalate at 2°C Global Warming Levels (GWL) compared to 1.5°C GWL under scenarios with low to medium adaptation (high confidence). Even with high adaptation, severe risks persist across multiple sectors in Europe at 3°C GWL and beyond (high confidence) (IPCC, 2022). In Europe, its predicted that the number of deaths and people at risk will be doubled to tripled at 3°C compared to 1.5°C (IPCC, 2022). At the same time, warming will decrease suitable habitat space for both terrestrial and marine ecosystems, changing their composition. Additionally, heat and drought impose stress on crops as substantial agricultural production losses are projected for most European areas, which will not be offset by gains in Northern Europe. In Southern Europe, more than a third of the population will be exposed to water scarcity at 2°C GWL (IPCC, 2022). Lastly, above 3°C GWL, damage costs and people affected by precipitation and river flooding is possible to double (IPCC, 2022). Coastal flood-related damages are projected to surge by at least tenfold by the end of the 21st century, and potentially even earlier or to a greater extent given current adaptation and mitigation efforts.

Global mean sea level rise is accelerating, largely because of ocean warming and the loss of land ice mass. From 2011 to 2020, sea level rose at an annual rate of 4.5mm/yr (WMO, 2023b) and it represents an existential threat for coastal communities and their cultural heritage, particularly beyond 2100.

A variety of adaptation options are available to address future climate risks. These may include behavioral changes, building interventions, urban planning to manage heat risks, as well as changes in farming practices, and early warning systems. However, challenges such as limited resources, lack of engagement from the private sector and citizens, and insufficient financing delay effective adaptation efforts (IPCC, 2022). "*Closing the adaptation gap requires moving beyond short-term planning and ensuring timely and adequate implementation*" (IPCC, 2022). It's crucial to develop inclusive, equitable, and just adaptation pathways for climate-resilient development and the success depends on identifying feasible and effective options tailored to local contexts.

Figure 11. Picture showing birds migrating as a metaphor for climate migration, (see source in Bibliography)

Climate change has also contributed to increased human migration, which is expected to increase significantly.

Figure 12. Extreme weather events impact coastline development (see source in Bibliography)

In 2023, in the United States alone, climate-related disasters like hurricanes, droughts, and wildfires caused nearly $92.2 billion (NOAA, 2020).

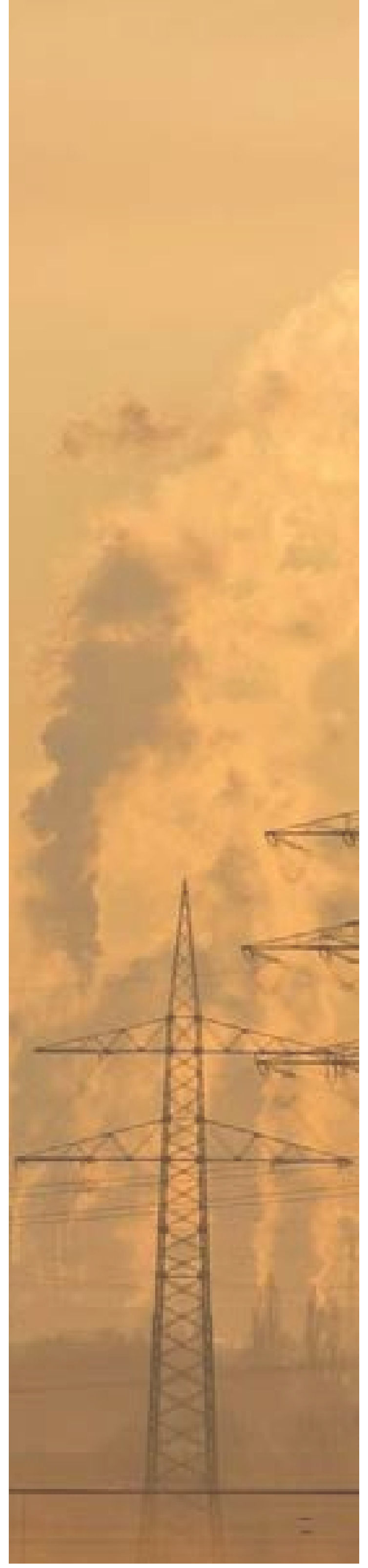


Figure 13. Fossil fuel energy production landscape (see source in Bibliography)

In private and academic circles since the late 1970s and early 1980s, ExxonMobil predicted global warming correctly and skillfully (Supran et al., 2023).

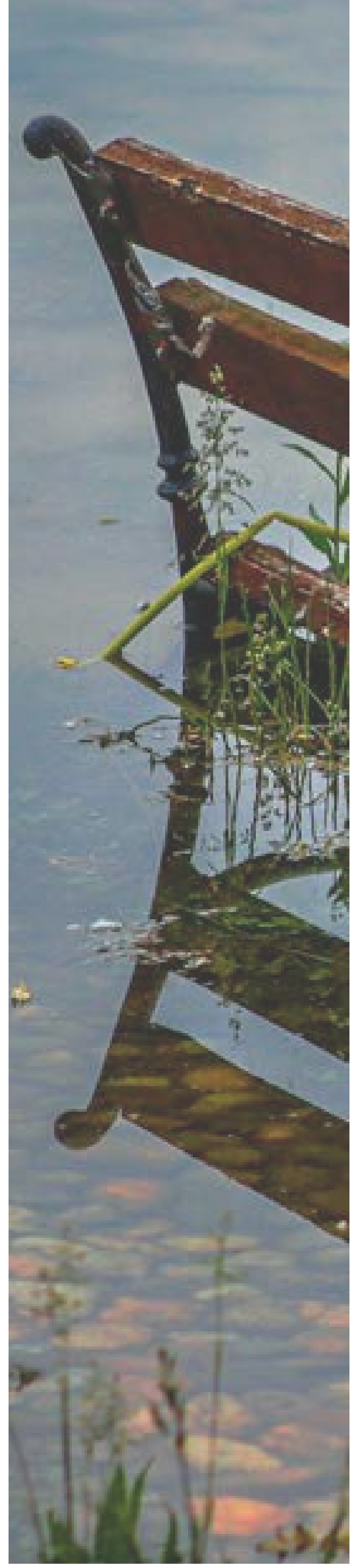


Figure 14. Flooding extremes (see source in Bibliography)

Rising sea levels have also increased the risk of flooding because of storm surges and high tides.

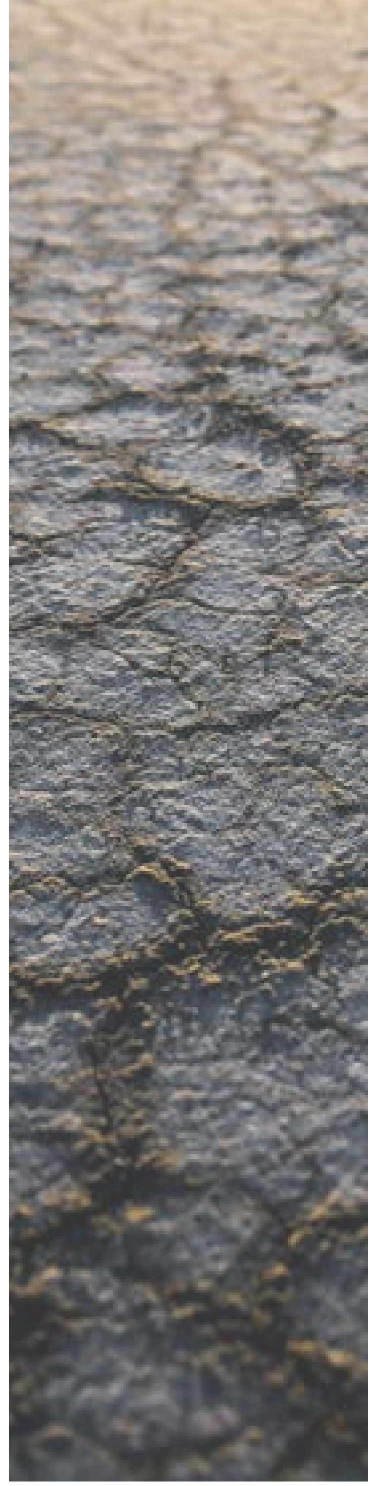


Figure 15. Another key result of climate change is severe drought (see source in Bibliography)

The drought that afflicted the American Southwest from 2000 to 2018 was almost 50 percent more severe because of climate change (WMO, 2023b).

Figure 16. Icebergs in Antarctica (see source in Bibliography)

Greenland and Antarctica lost 38% more ice between 2011 and 2020 than during the 2001-2010 period (WMO, 2023b).

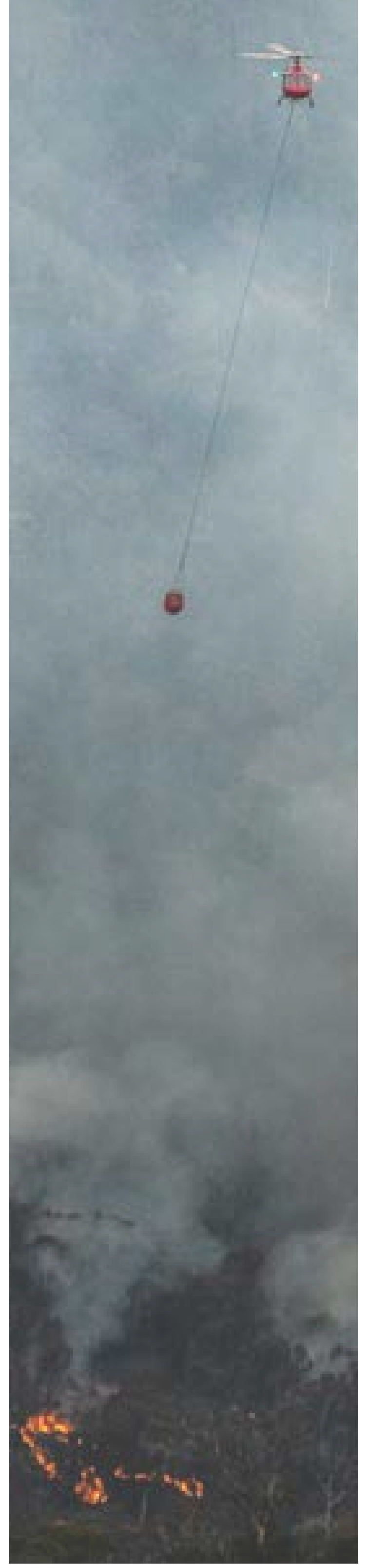
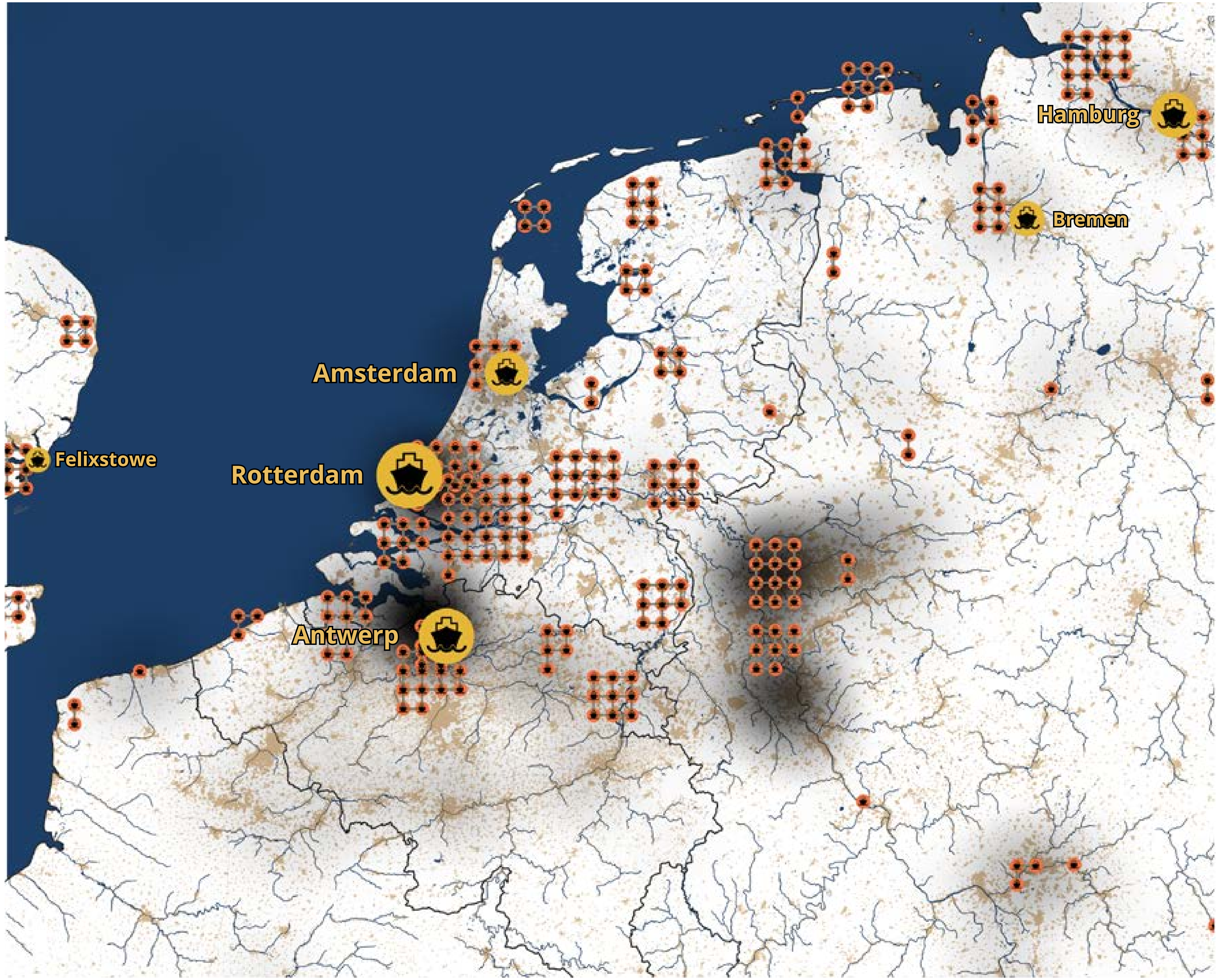


Figure 17. Wildfires and fire retention activities (see source in Bibliography)

Climate change plays a major role in wildfires by heating and drying forests, turning them into tinderboxes.

3.2 Ports: Between Energy and Pollution



A. Polluting ports in Eurodelta region

Ducruet et al. (2024) examined that densely populated Port Regions emit more greenhouse gases than port-free regions, with specifically industrial ports having the worst health and pollution ratings. Well-connected ports become attracting nodes for fossil fuel industries for their efficient and large bulk transportation capabilities. These industries not only pollute by refining these fuels, but they also require large power plants to power the industry as they have large of electricity and heat requirements. (Ducruet et al., 2024)

This port pollution claim is supported and analysed by figure 18, layering the largest ports in Northwest Europe as well as inland ports together with CO2 emissions from the energy sectors. Two areas stand out: the Ruhr industrial region and the Eurodelta port region. While the Ruhr area is notorious for its extensive coal use, the largest ports, such as Rotterdam and Antwerp, largely focus on oil refining and petrochemical industries. These ports are vast industrial complexes that are not only supplying hydrocarbons for their local regions, but they also act as a fossil fuel gateway for the European continent (Engelke & Webster, 2023).

Legend

Waterbodies
Urban Fabric

Main Ports
Largest Eurodelta Ports
Ports
CO2 Pollution Concentration

0 50km 100km

Figure 18. CO2 pollution concentration in Eurodelta region's ports map (see sources in Bibliography)

B. Fossil fuel infrastructure in the ports

As depicted in Figure 18, the country has an extensive infrastructure system associated with the fossil fuel sector, extending to neighboring countries. The Port of Rotterdam alone features 1,500 kilometers of pipelines (Port of Rotterdam, n.d.), facilitating the transport of various liquid products, mainly crude petroleum, to other parts of Europe. In general, the country's pipelines span a total length of 2,500 kilometers connecting oil fields, refineries, and major consumers (AENERT, 2022).

More specifically, the main oil fields are situated in the west and northwest of the coastal shelf, redominantly offshore (AENERT, 2022).The country's largest oil refinery is located in Pernis, owned by Shell, and has an installed capacity of 416,000 barrels per day (AENERT, 2022).

The ARA region, encompassing Amsterdam, Rotterdam, and Antwerp (ARA), features historic medieval trading cities and stands as a pivotal historical site for the storage, transportation, and utilization of petroleum from its earliest days (C. Hein, 2021a).

Today, the area hosts the ARA oil spot market, including Amsterdam for refined petroleum products, Rotterdam as the hub for crude oil, and Antwerp serving as the petrochemical hub (C. Hein, 2021a). Notably, Antwerp ranks as the second-largest petrochemical industrial complex globally, following Houston (C. Hein, 2021a).

Legend

Offshore oil extraction
Heavy oil extraction field
Key oil storage
Natural gas processing plant
Key natural gas extraction fields
Key fossil terminals
Fossil infrastructure hub
Fossil related pipeline

0 5 10km

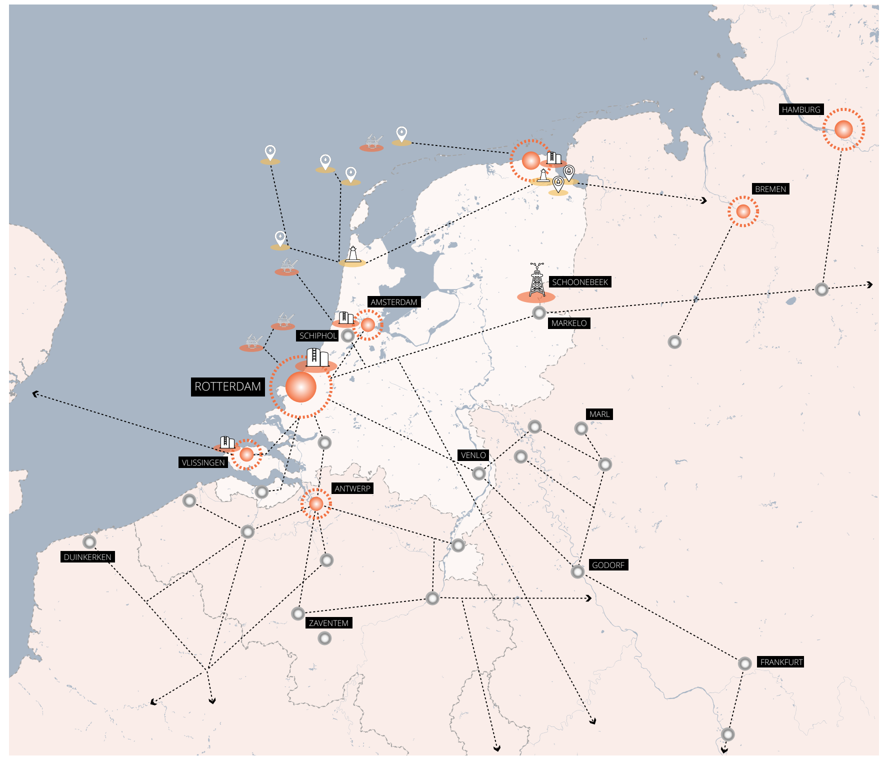


Figure 19. Fossil fuel-related infrastructure in the Eurodelta focusing on ports as oil terminals redrawn by the authors with data from (Maritime Museum, 2024), (AENERT, 2022)

C. Port typology study

Western Europe contains some of the biggest ports of the world, which are of high importance for international trading routes. In order to compare, we took a closer look at the three biggest ones. These are the Port of Rotterdam, which is 10th of the One Hundred Ports (Lloyd's List, 2023), Antwerp, which takes the 12th place, and Hamburg, on place 21. For this research we are also including the Port of Amsterdam as it is part of the Eurodelta region.
As trading and fuels go hand in hand, these ports combined host one of the most significant hubs for oil refinery and petrochemical activity in the world, making them part of the most polluting places as well. Rotterdam being the biggest port in Europe shows the highest pollution rates of European ports, which is why we will be our focus on this region for the report.

The ports of Antwerp, Rotterdam and Amsterdam (ARA) are located in relative proximity, so that they serve partly the same hinterland. This is called a multi-port gateway region (Notteboom, 2010) and this leads to competition for the same throughput and investments.

However, one could argue that a multi-port gateway can also be looked at as a polycentric region, which underlines more the connectivity and complementarity between different closely-located centres (Van den Berghe et al., 2022). Zooming in on these three ports, it becomes visible that they have taken on different specialisations. Rotterdam is focused on oil refining, Amsterdam mainly revolves around fossil fuel storage and Antwerp hosts above all petrochemical industries. Van den Berghe et al. (2022) show that these ports are "connected through flows and specialization in processing and trading oil (products)". Rather than intended spatial planning, this is the result of the oil industry's self-organisation, stressing the power that the companies have over our built environment.
Hamburg, being location further from these ports and serving a predominantly different hinterland, shows less specialization and is more diversely equipped. Still it has been taken into account in this study to be able to compare numbers with the other ports.

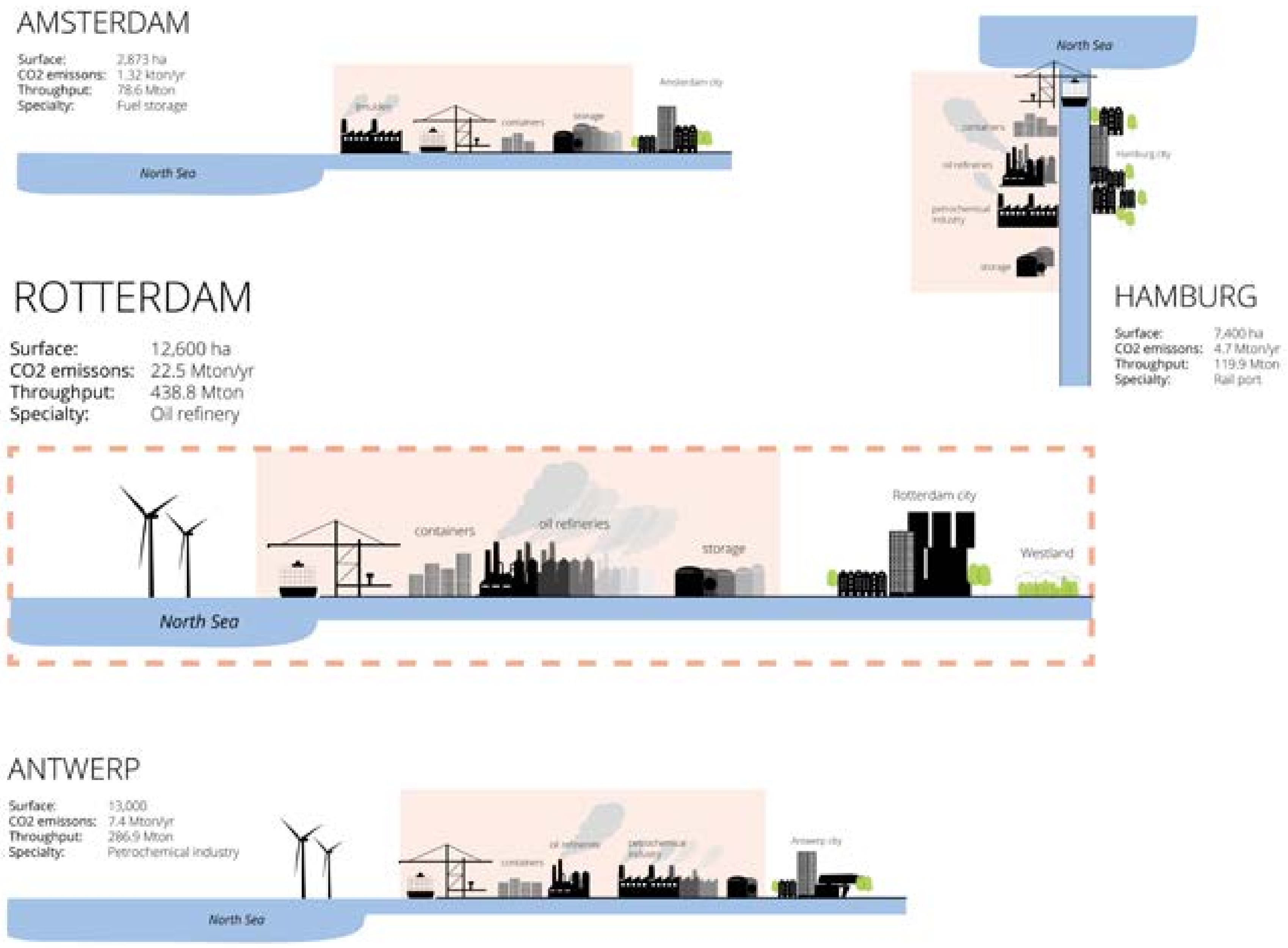


Figure 20. Four case studies of different port typologies from Amsterdam, Rotterdam, Antwerp, and Hamburg ports.

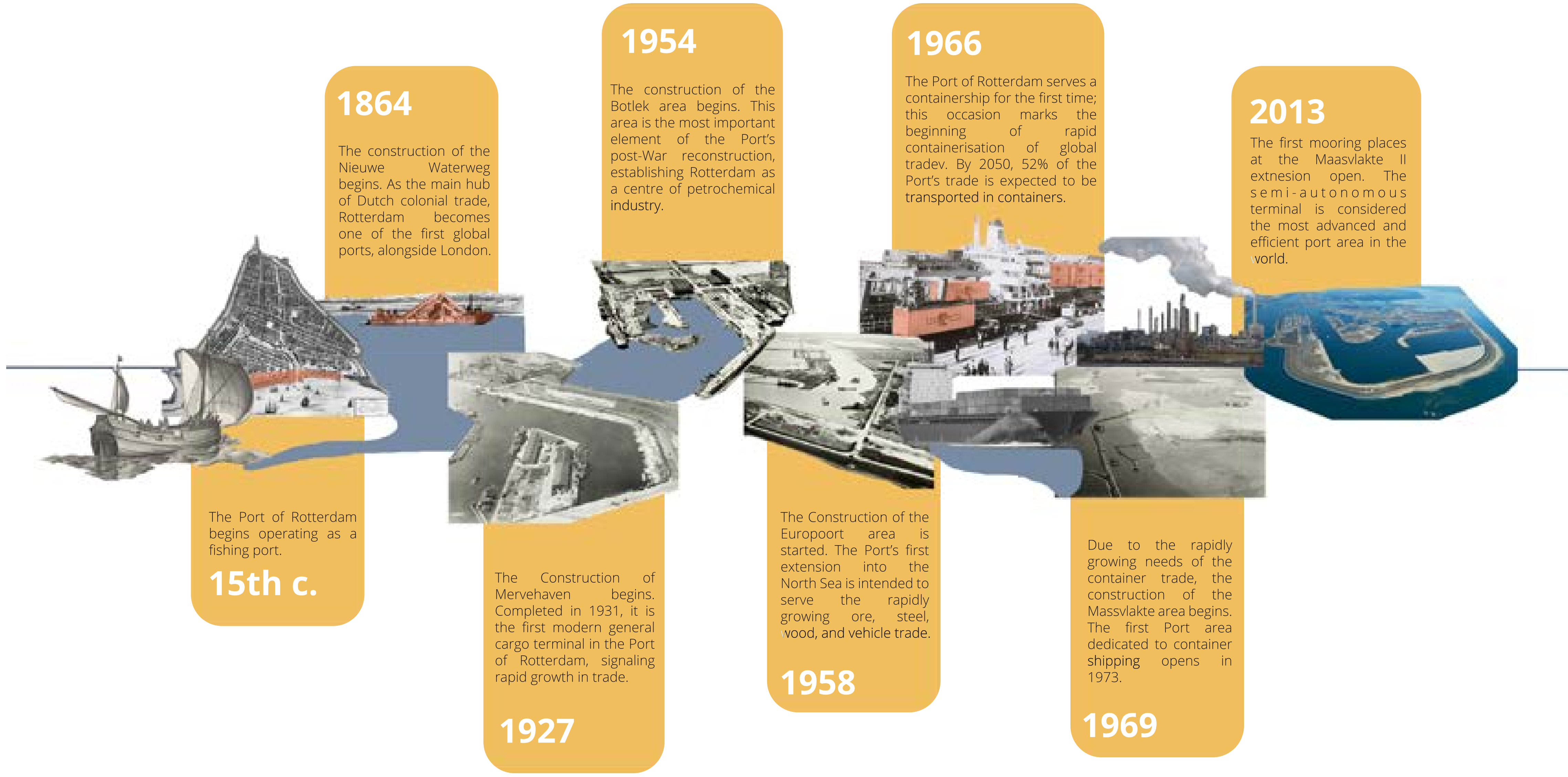


Figure 21. Timeline collage of history of the Port of Rotterdam starting as a fishing port from the 15th century until the Maasvlakte development in 2013 (see sources in Bibliography)

D. Port of Rotterdam's history

The history of the Port of Rotterdam dates to the early 15th century, when the area was used as a fishing port. The port gained significance in the 19th century when it became the main hub of Dutch colonial trade. The large amount of goods arriving from the Dutch East Indies and other colonies transformed Rotterdam - alongside London - into one of the first global ports. During this time, the Port of Rotterdam also assumed the role of primary maritime gateway to Western Europe; its location at the mouth of two significant rivers - the Rhine and the Maas - made it an excellent hub where ocean and inland water trade could interact.

With the rapid industrialisation of Northwest Europe in the late 19th and early 20th centuries, especially the Rhine-Ruhr area, the port expanded westwards along the Rhine-Maas-Scheldt delta area. Bulk shipment facilities were added in the 1920s, while the petrochemical industry appeared in the 1930s. As a result of extensive reconstruction following the Second World War, the port became the world's largest petrochemical complex, a role it still holds to this day.

In the 1950s, the port proposed the extension of the petrochemical facilities North of the main waterway, facing strong local opposition - this opposition led to the development of the Europoort complex on reclaimed land south of the river. In 1962 the Port of Rotterdam surpassed the Port of New York-New Jersey to become the largest in the world. In the 1970s massive containerisation efforts were carried out to accommodate growing containerised cargo traffic. Container terminals were initially built with the conversion of existing sites, however, in the 1980s the construction of Maasvlakte I on reclaimed land was started to add more container capacity. In the meantime, improvements in cargo distribution were also carried out, transforming the port into a vital logistics centre as well. To cater for further container capacity needs, Maasvlakte II was proposed in the 1990s, but due to strong public opposition, construction only started in 2008 with the first terminal opened in 2015. The Maasvlakte II Project is expected to finish in 2030, but with few other options left for expansion, the main focus will be the reconversion of facilities.

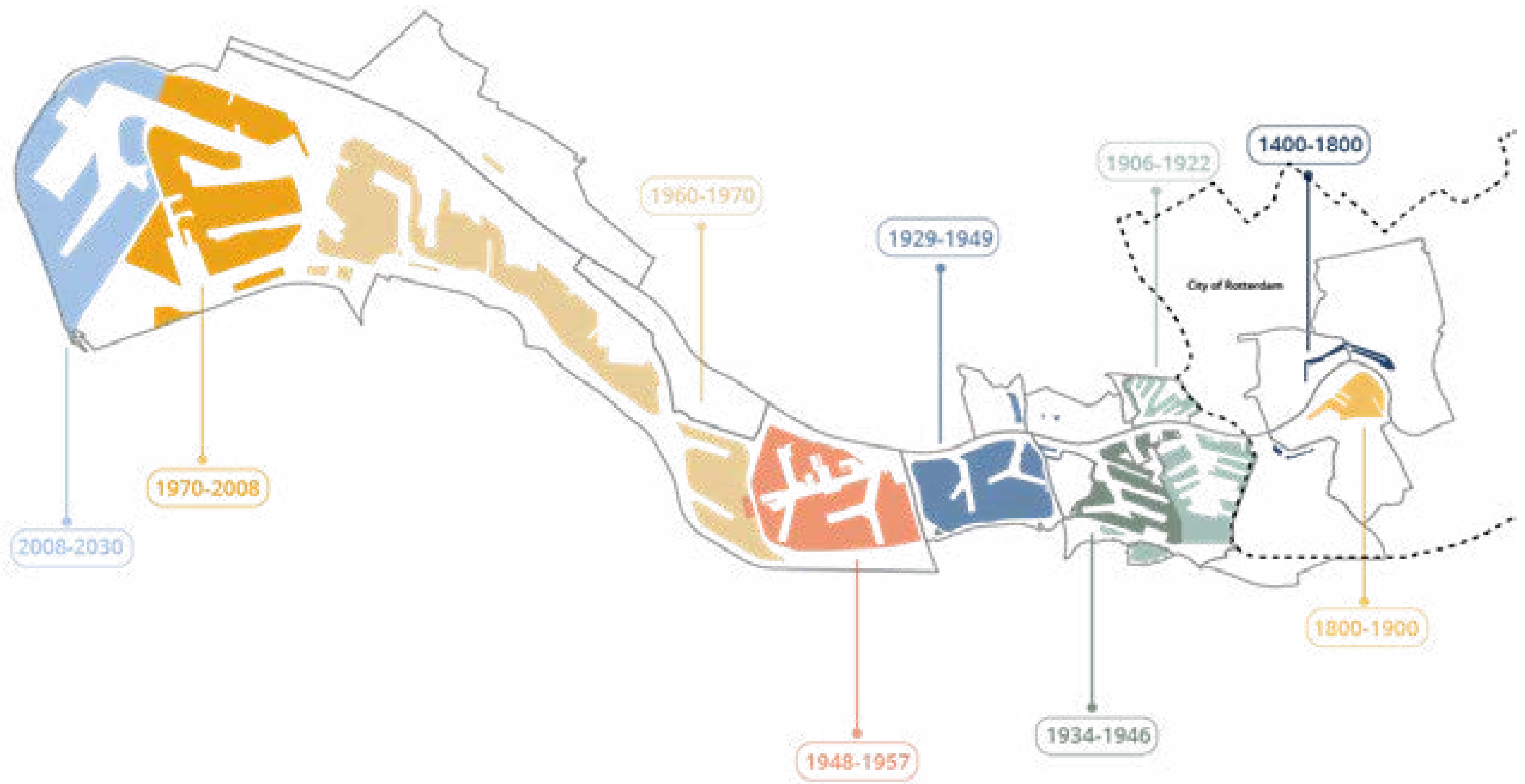


Figure 22. Rotterdam's port development, from small docks in the city center to expansive facilities towards the sea, (Port of Rotterdam, 2017) (Al-qadhi, 2020)

E. The port and the city

"*To many citizens, the port and city of Rotterdam are happily married*" (Aarts et al., 2012).
The relationship between Rotterdam's port and the city has been a significant focus for development in recent years. Aarts et al. (2012) highlight the intertwined growth of the port and the city over time, as depicted in Hoyle's port models (Figure 23), tracing the evolution from small docks in the city center to expansive facilities towards the west (Figure 24) (Aarts et al., 2012). This westward shift in port development, driven by economic demands for larger, modernized areas and improved coastal accessibility, has resulted in a geographical separation between the city and the port. This separation underscores Rotterdam's extreme example of port-city detachment (C. M. Hein & van de Laar, 2020).

Stage	City / Port	Period	Characteristics
I.Primitive port/city		ancient/medieval to 19th century	close spatial and functional associations
II. Expanding port/city		19th - early 20th century	Rapid commercial/industrial growth forces port to develop beyond city confines, with linear quays and break-bulk industries
III. Modern industrial port/city		mid - 20th century	Industrial growth (especially oil refining) and introduction of containers / require separation/space
IV. Retreat from the waterfront		1960s - 1980s	Changes in maritime technology induce growth of separate maritime industrial development areas
V. Redevelopment of waterfront		1970s - 1990s	Large-scale modern port consumes large areas of land/water space, urban rewenal of original core
VI. Renewal of port/city links		1990s - 2000s	Globalization and intermodalism transform port roles, port-city associations renewed, urban redevelopment enhances port-city integration.

Figure 23. The port moves away from the city, (Aarts et al., 2012; Hoyle, 1998)

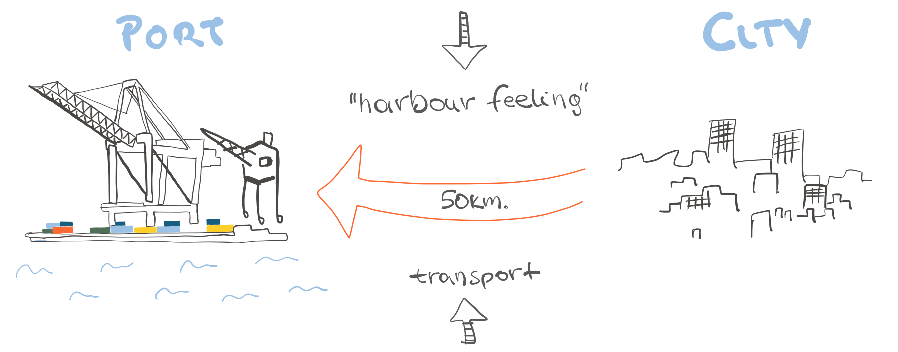


Figure 24. Sketch illustrating the decreasing maritime mindset of Rotterdam, (Hein & Littlejohn, 2021)

Following World War II, Rotterdam transformed into an industrial port cityscape, leading to a 'city without port' (C. M. Hein & van de Laar, 2020). Major industries, including iron and steel, oil refineries, and petrochemicals, relocated to new industrial zones, further deepening the divide between the city and the port. After 1970, Rotterdam lost its primacy as economic engine of the Netherlands, but remained an important port, thanks to the oil and petrochemical industries (C. M. Hein & van de Laar, 2020). However, the port's noise, pollution, and other environmental problems impacted the relationship with the city.

F. Port of Rotterdam Facts and Figures

The port of Rotterdam is Europe's largest deepsea port and the primary import facility for petrochemicals and fossil fuels. It is mainly and importing facility, meaning that there is significantly more cargo exiting the port towards the inland, than towards the open sea; an attribute related to the port's importance in Europe's fossil fuel trade. Visible on figure xx, the two primary import commodities entering the port and continuing towards mainland Europe are crude oil and natural gas. Apart from this, the port also handles significant containerised trade and dry bulk shipments, but here incoming quantities also representing a majority.

Owing to the large amount of fossil fuels and dry bulk shipment, the port has built up a sophisticated infrastructure for the handling, processing, and storing of these types of cargo. The main elements of these infrastructures are shown on figure xx. As the port also functions as a large industrial area, the safety and reliability of its energy supply is also crucial, hence the substantial number of energy generation facilities within its premises, also summarised on figure xx.

Figure 28. Fossil fuel infrastructure in the Port of Rotterdam, photographed from the field trip

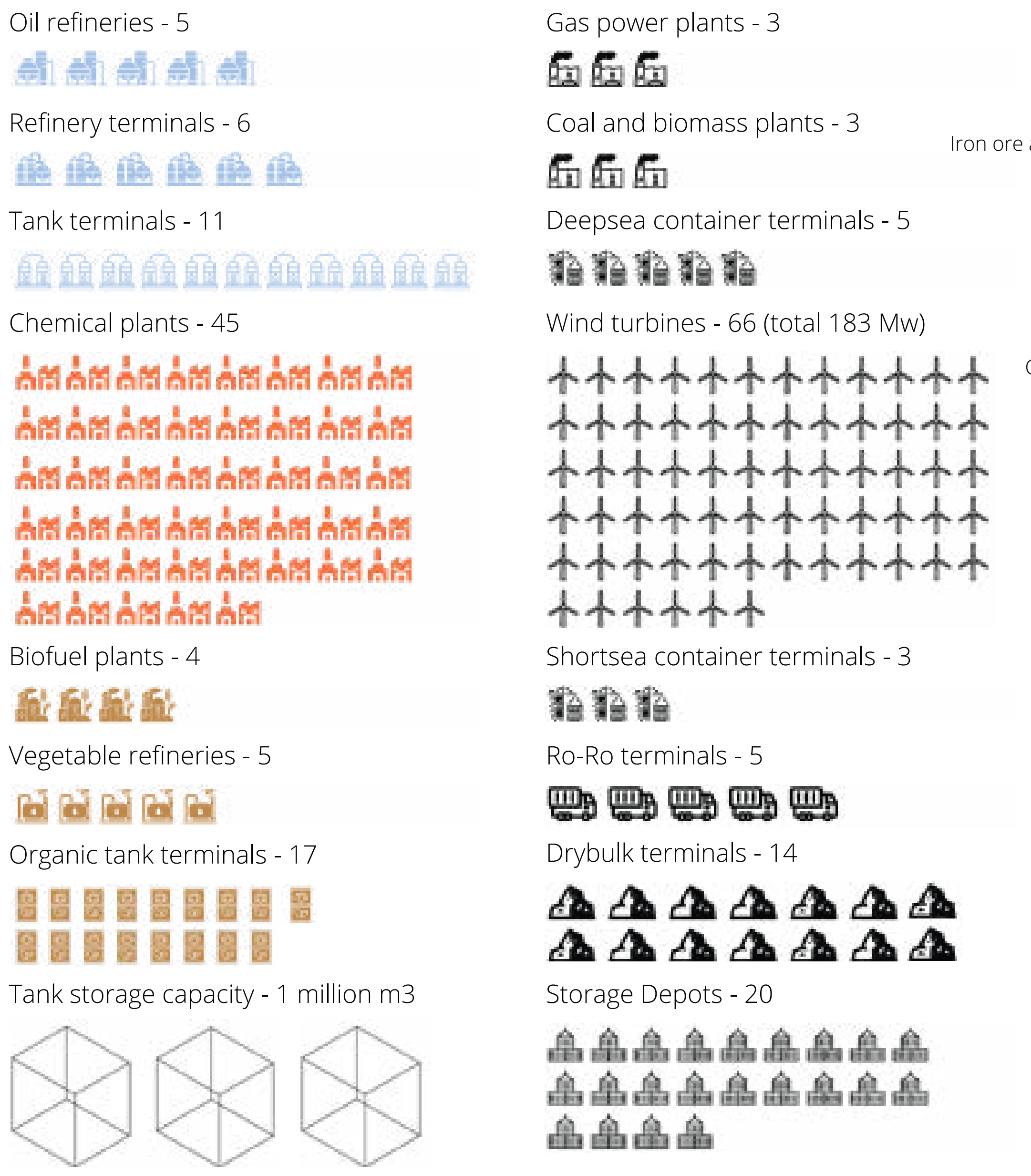


Figure 25. Graphic data showing the numbers of infrastructures provided in the port (Port of Rotterdam, 2020)

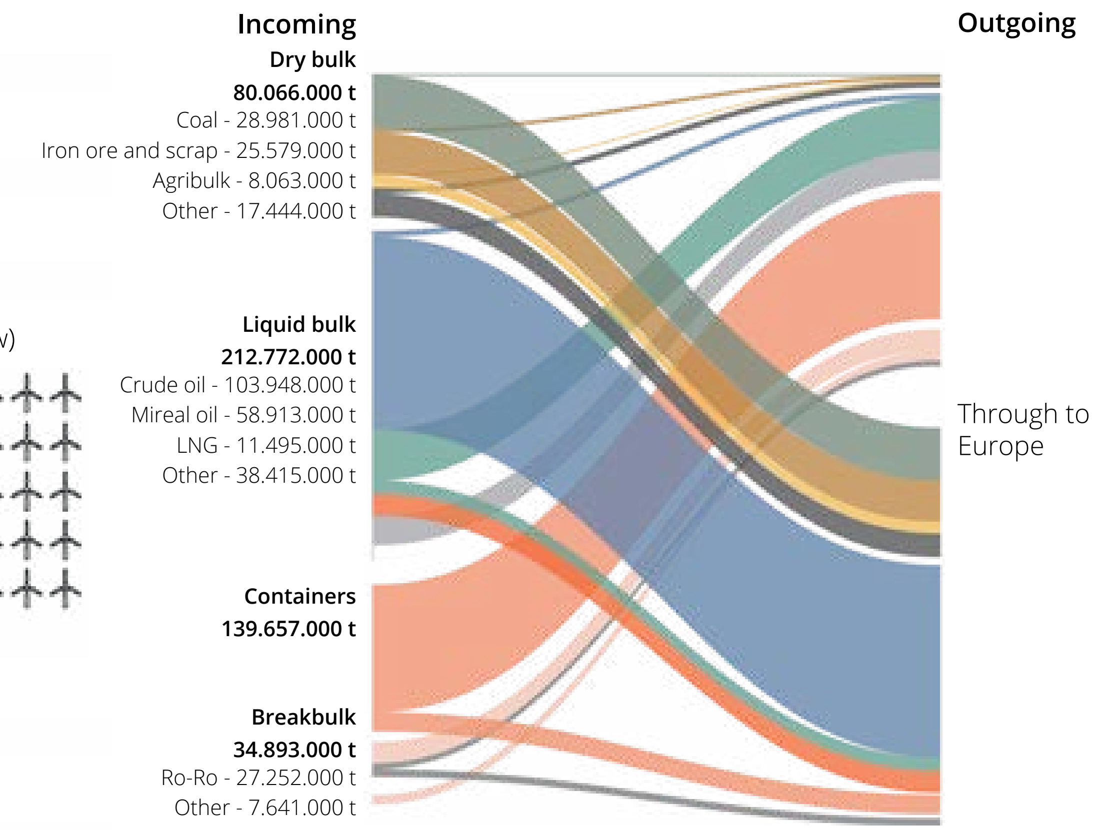


Figure 26. Sankey diagram of throughput of Port of Rotterdam (Port of Rotterdam, 2022)

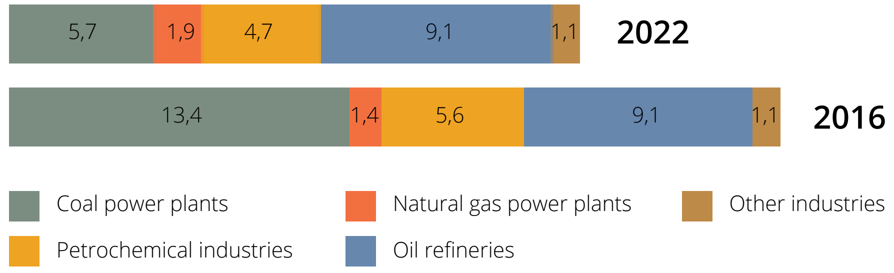


Figure 27. Graph explaining comparison data of CO2 emission from Port of Rotterdam, showing significant reduction between 2016 and 2022 (Port of Rotterdam, 2023)

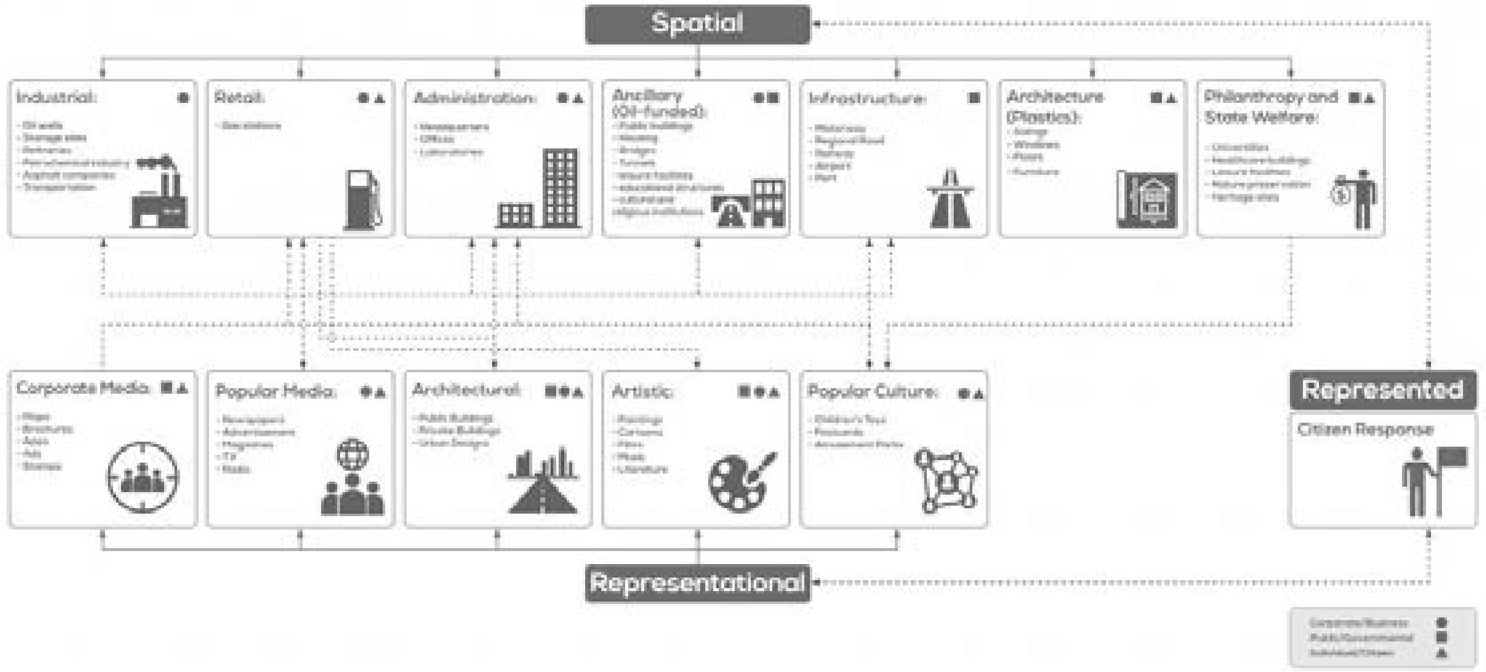


Figure 30. The Global Petroleumscape (Hein, 2021)

Legend

- Waterbodies
- Urban Fabric
- Airports
- Industry
- Oil Based Industry

Petroleum Connectivity

- Oil Product Pipelines
- Motorways
- Main Roads
- Fuel Station
- Petroleum Headquarters

0 10km 20km

Figure 29. (Left) Petroleumscape in the Port Region of Amsterdam-Rotterdam Map (see sources in Bibliography)

3.3 Energyscapes

A. Petroleumscapes around Port of Rotterdam

When analysing fossil fuel landscapes, such as petroleumscapes, it is important to understand that these spaces are not only limited to the fuel extraction, transportation and transformation flows, but also define consumption patterns that determine the spatial elements of our built environment (C. Hein, 2021b). As seen in figure 29, Hein (2021) determined the socio-spatial extents of how '*global petroleumscapes*' have an effect and have already influenced specific interventions concerning administration and industrial distribution, infrastructure connectivity and concentration.

This petroleumscape development also has implications on spatial justice, for regions that are devastated by the extraction industries and for deprived people living next to expansive and polluting energyscapes (Aspen Global Change Institute, n.d.).

The extensive petroleumscape between Rotterdam and Amsterdam is defined by vast highways and their supporting fuel stations, oil-based companies situated further away from oil refining industries and by oil product pipelines which are hidden spatially but having large impactful connections to other areas such as airports and neighbouring countries.

B. Energy flows around ports

Since the introduction of the petroleum industry, ports had been an integral part of the energy production chain. They did not only become a hub for the transportation, but also fossil fuel producing and processing ones. However, to understand the whole chain it is important to address the energy flows around the port itself. In the current energy landscape where the vast majority of the energy comes from fossil fuel, raw materials are extracted and shipped through ports. The oil refineries and power plants located in the port then process these raw materials. There are also industrial factories that process the raw materials into everyday commodities and spare parts for different utilisations, such as vehicles, heavy equipment and machinery, and renewable energy infrastructure spare parts. As one of the main products, gasoline is shipped out of the port to different stations as fuel for internal combustion engine-based vehicles. The other product, electricity, can be shipped directly for consumers outside of the port or stored if the production exceeds the demand.

Throughout this fossil-based process, including the energy distributions, carbon emission (CO_2) are released into the atmosphere, not to mention the other byproducts in forms solid, liquid, and other gaseous waste. In the current situation, there are still minimum treatment or prevention. On the other hand, on the smaller scale, renewable energy production also takes part in the port to support energy generation with less carbon emission.

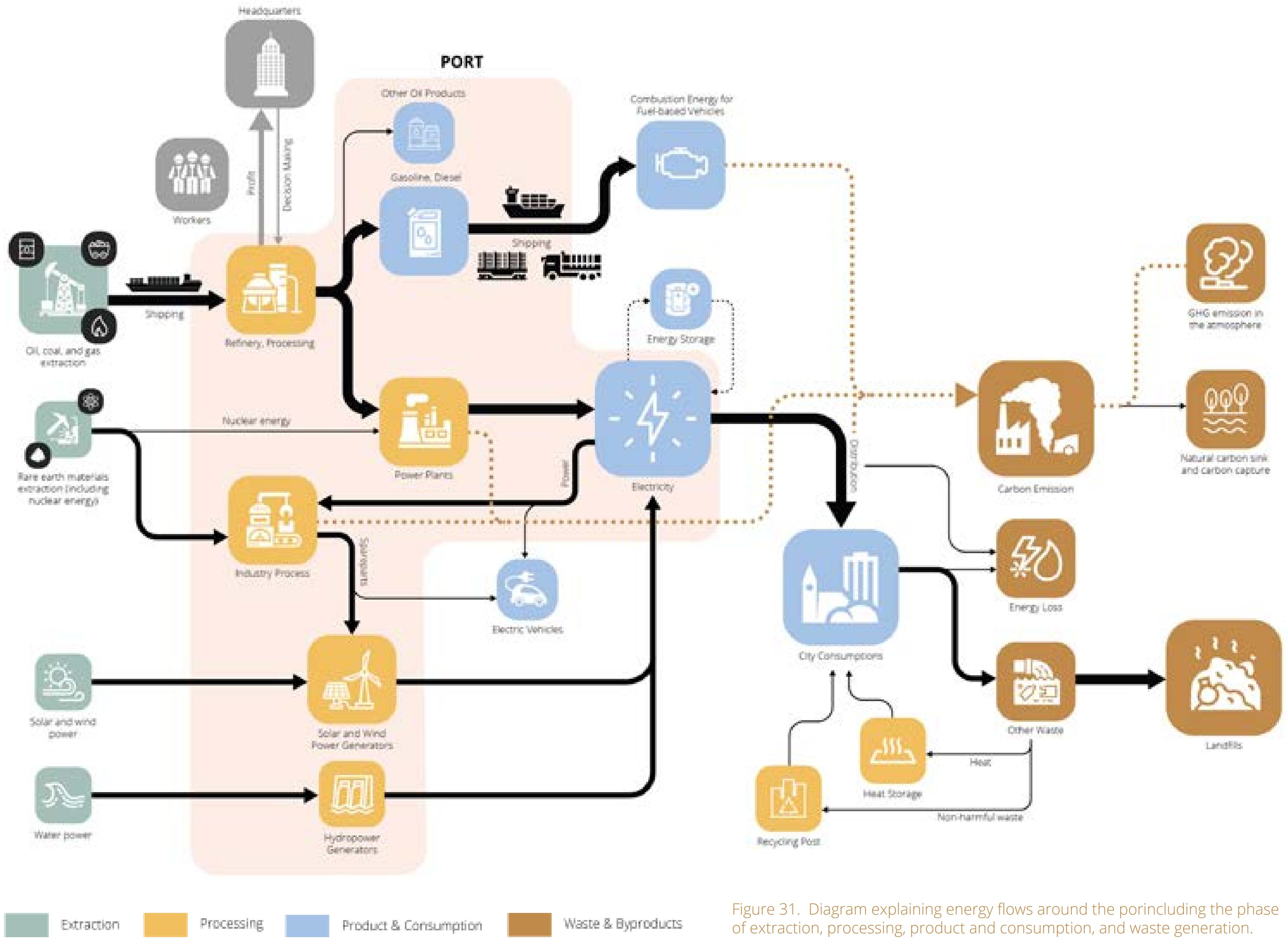


Figure 31. Diagram explaining energy flows around the porincluding the phase of extraction, processing, product and consumption, and waste generation.

C. Energy profile

In order to understand the extent of necessary interventions into the Dutch energy system, an examination of current energy generation and consumption trends is necessary. As visible on figure x, there are three important trends in the Dutch energy sector that require consideration from the project's perspective. First, the vast majority of the Netherlands' energy needs are met by fossil fuels, mainly natural gas and crude oil; second, almost 60% of the total energy use of the Netherlands are met by imported energy sources; third, the majority of energy is used in the form of heat, while only about 12% of the total energy use is in the form of electricity.

In order to reach the main goals of this project, the following alterations in the energy system will be necessary: First, fossil fuels would have to be eliminated from the energy mix, and replaced with renewable energy sources; second, the share of electricity in within the total energy use would have to be significantly increased to aid the total phase-out of fossil fuels; third, all energy needs will have to be met from domestic energy sources to guarantee the energy safety and security of the Netherlands.

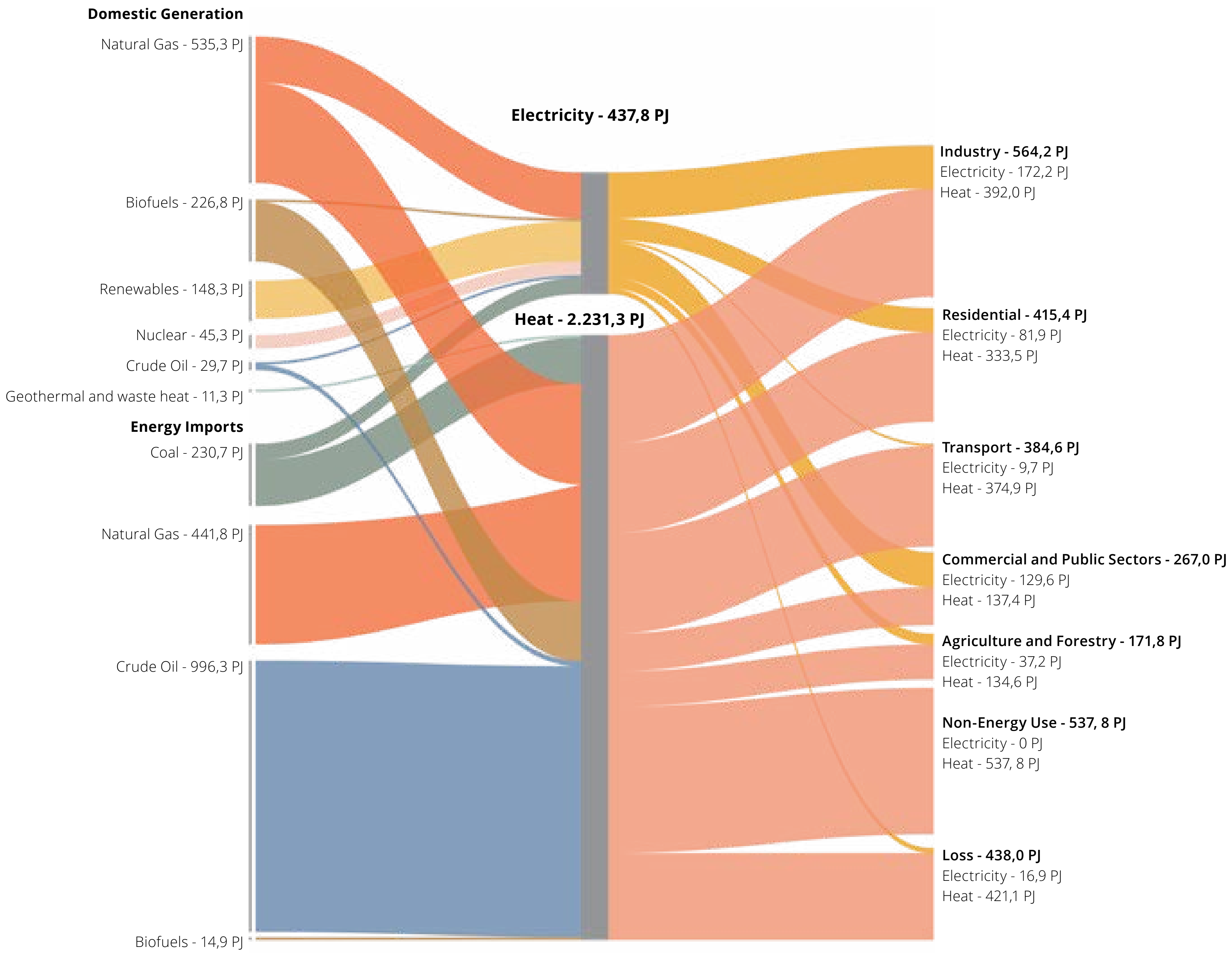
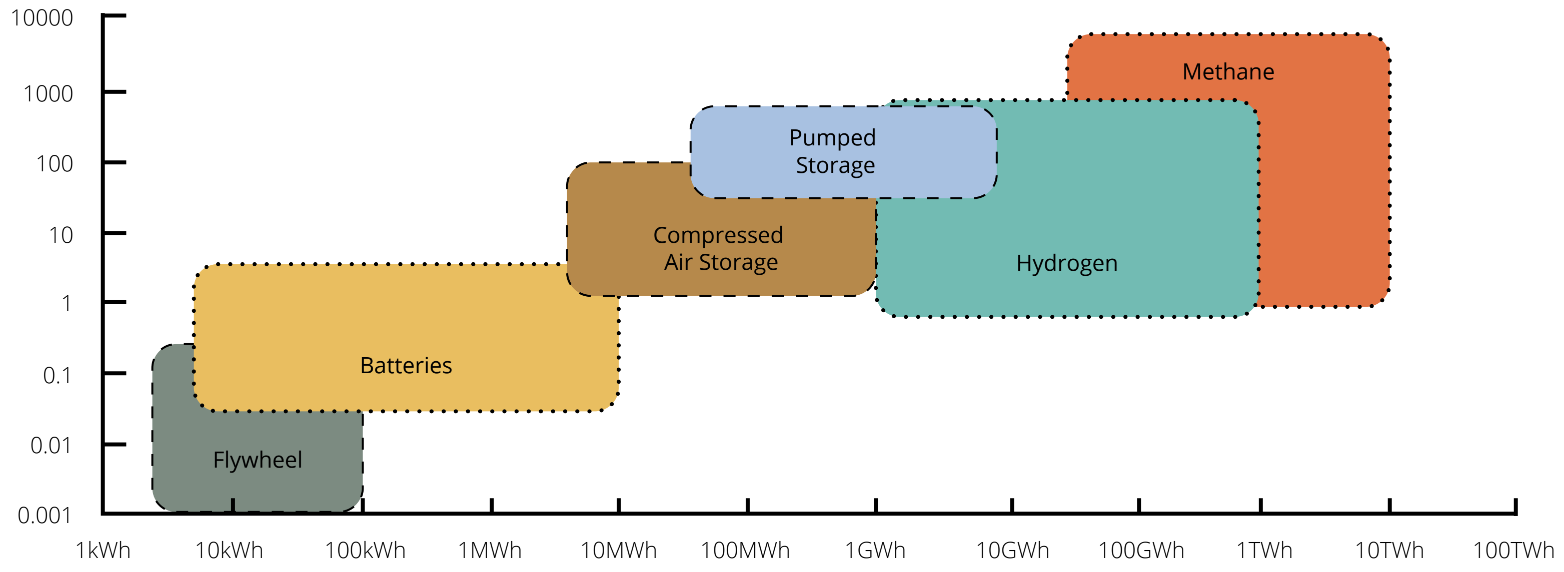


Figure 32. Sankey diagram showing data about energy profiles of the Netherlands in 2022, consisting of electricity and heat generation using different energy source (Advanced Energy Technologies, 2022).



Electro-mechanical energy storage
Electro-chemical energy storage

Figure 34. Storage Capacity and discharge time of various energy storage techniques, adapted (Akash et al., 2023)

Legend

Waterbodies
Urban Fabric
Electricity Grid Zones that will face Overloading until 2030

Energyscape

Natural Gas Pipelines
Power Plants

0 10km 20km

Figure 33. (Left) Map illustrating an interconnected and centralised Energyscape in the Port Region of Amsterdam-

D. The Overloaded Centralised Grid

Today's electricity grid can also be considered as a fossil-fuelscape. In the Netherlands case, electricity energyscape is sustained and effected by natural gas, as extensive pipelines intersect and provide constant fuel storages for the electricity and heat generating power plants.

It can be hypothesised that high energy concentrated energy fuels, such as natural gas, coal, and petroleum, define the electricity grid as a centralised energy system to efficiently control the supply of energy to fluctuating demands. This creates a strong reliance on, usually polluting, high potential fuels and makes the system low in flexibility and resilience as integration of alternative energy generation can easily overload the grid (Vezzoli et al., 2018). Today the large incorporation of renewable energy into the grid is straining the grid and requires improvements (Pascoe, 2023) To transform the energy system into a more inclusive decentralised energy generation (DEG) system a redevelopment of energy storage is required. There are many types and energy storage as seen in figure xx with Hydrogen and Methane being able to contain a large amount of energy as fuel (Akash et al., 2023). One problematic aspect of these fuels is that to produce and use them emits pollution. Today the biggest percentage of hydrogen created is from non-renewable energy sources called 'grey' and 'blue' hydrogen, while 'green' hydrogen generated from renewable energy is completely carbon-free and has the potential to support the systematic change towards a decentralised system (Akash et al., 2023).

E. Systemic Section

The current worldwide energy system relies heavily on ports. Fossil fuels go from the extraction places to processing areas through ports. In the port, the materials are processed in refineries, manufacturing, and stored in fossil fuel tanks. The produced energy is then transported to the city for consumption. In some cases, cities also produce energy with renewable energy technology such as solar panels and wind turbines.

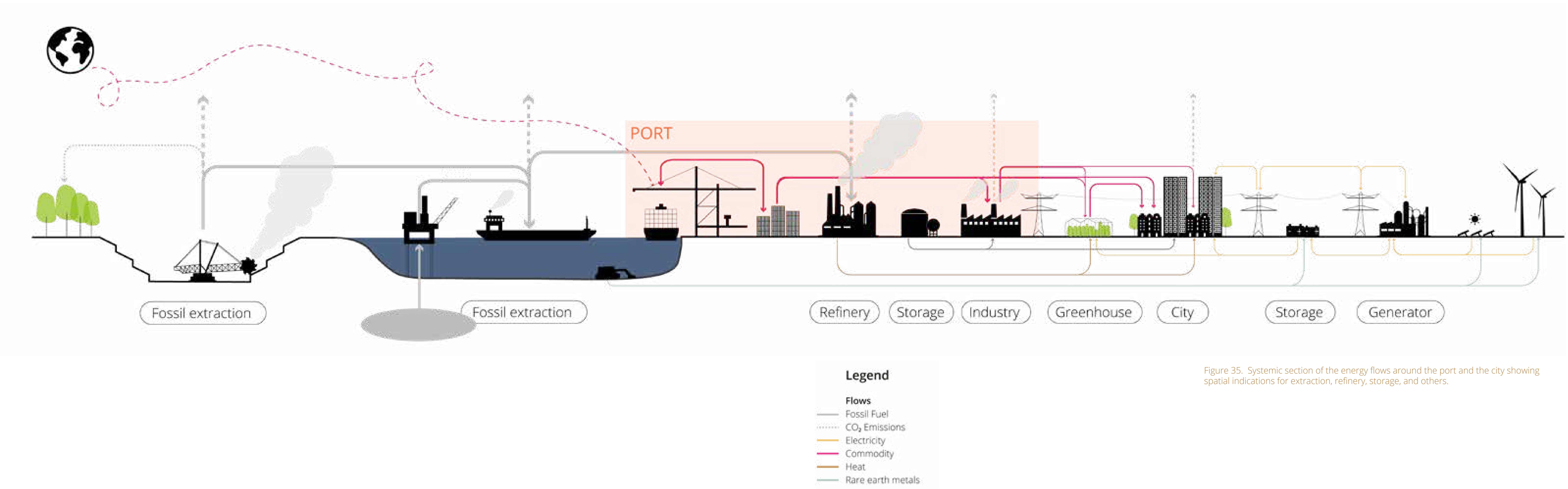


Figure 35. Systemic section of the energy flows around the port and the city showing spatial indications for extraction, refinery, storage, and others.

F. Energy footprint

When examining energy systems and different energy sources in relation to a spatial plan, the carbon- and land intensity is a crucial factor. Figure 36 contains information about these aspects of different energy sources that were considered for the project area.

Many important considerations can be drawn from this data. First, it is important to note that although renewable and nuclear energy sources do not directly emit carbon during their operations, their lifetime carbon footprint is not zero; Carbon emissions coming from the material processing, manufacturing, transport, and construction activities related to these energy sources need to be considered into the lifetime carbon footprint. Second, most renewable energy sources, especially biomass and wind power are highly land-intensive energy sources, an aspect that is highly relevant from a spatial planning perspective. An important notion in relation to these two sources, however, is that their land-use is a 'gross' value; unlike in the case of fossil fuels or nuclear power, the land used by them can also fulfil multiple functions simultaneously, for example, wind turbines can be deployed onto agricultural land, while energy forests can host healthy ecosystems.

Another important consideration is that renewable energy generation can be dispersed into rural, urban, and peri-urban areas, while nuclear and fossil generation needs to be centralised in order to retain economies of scale. This difference also holds a challenge for the project; this great difference between the technicalities of the existing and proposed energy systems, a fundamental paradigm shift is necessary. The specific process and the challenges this shift itself holds are summarised in figure 36.

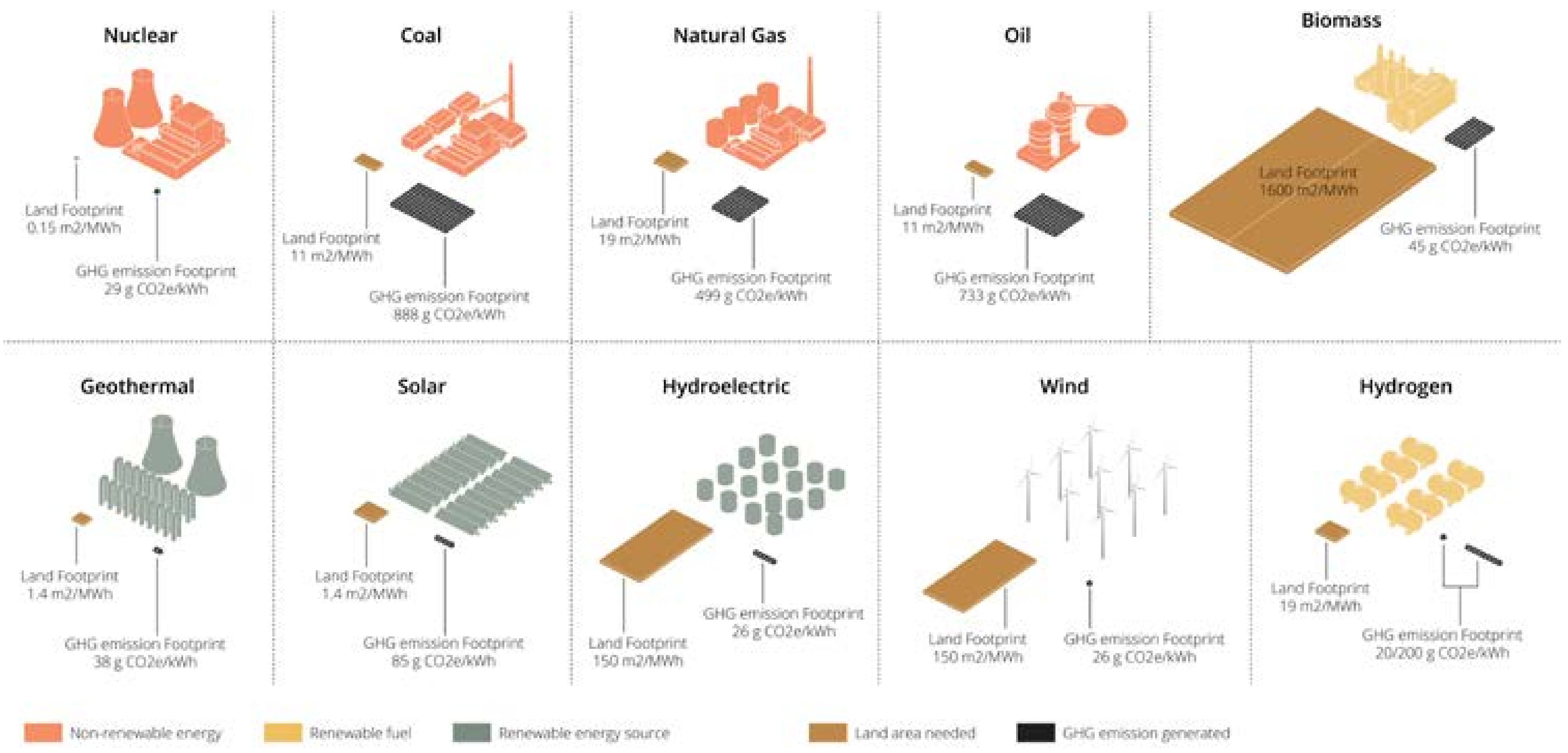


Figure 36. Diagrams showing comparison between different energy source, considering the area of land they will require and the amount of emission they will emit in producing the same amount the energy.

G. Shifting Paradigm

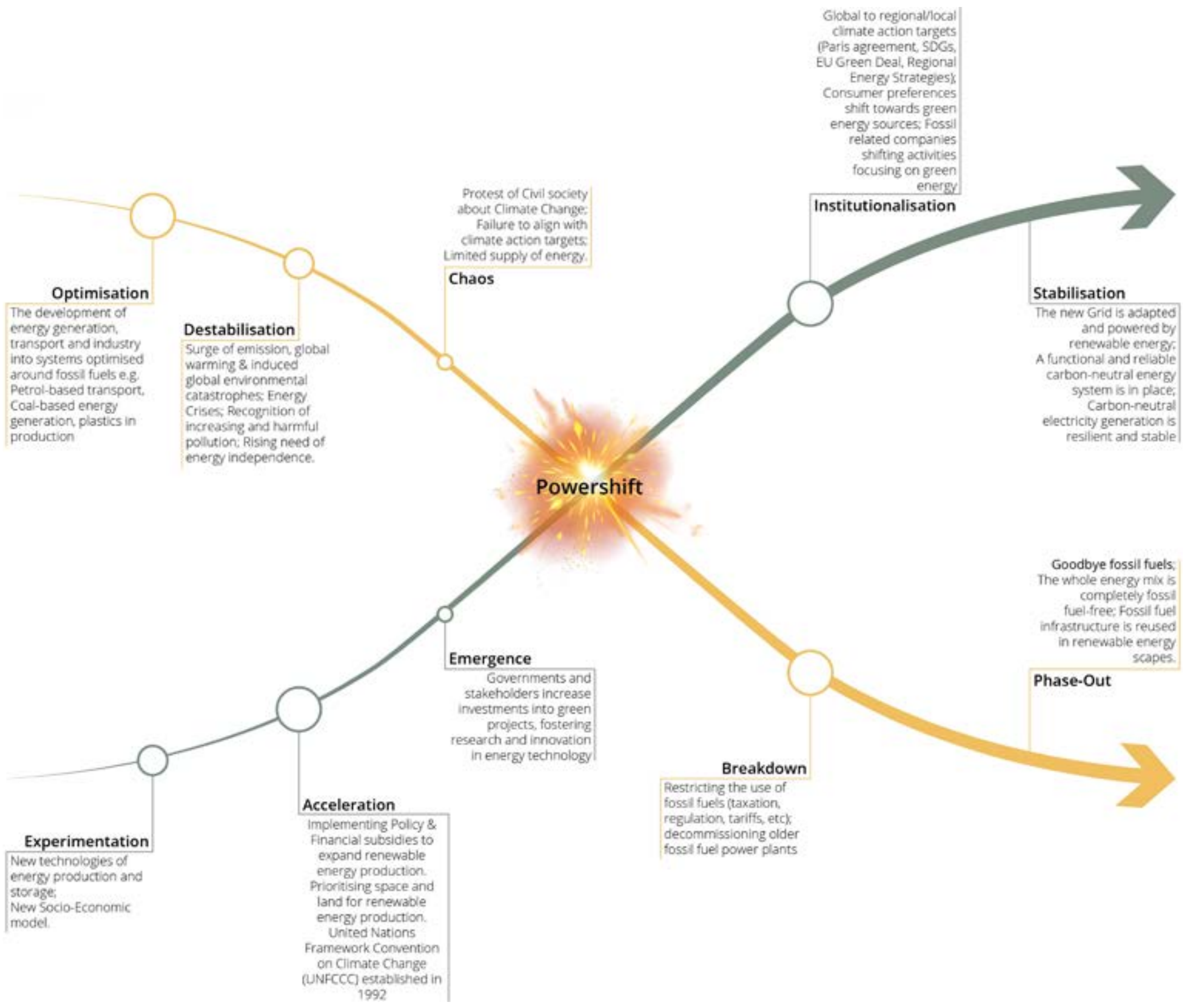


Figure 37. The X-Curve diagram explaining shifting paradigms in the energy transition process.

Figure 38. Sea-level Rise Flooding Map (see sources in Bibliography)

Figure 40. Groundwater Flooding Probability Map (see sources in Bibliography)

Figure 41. Fluvial Flooding Probability Map (see sources in Bibliography)

Legend

- Waterbodies
- Urban Fabric
- Reinforced Protection Lines
- Groundwater and Sea Flooding
- Fluvial and Pluvial Flooding

0 50km 100km

3.4 Threats and Potentials

A. Water risks

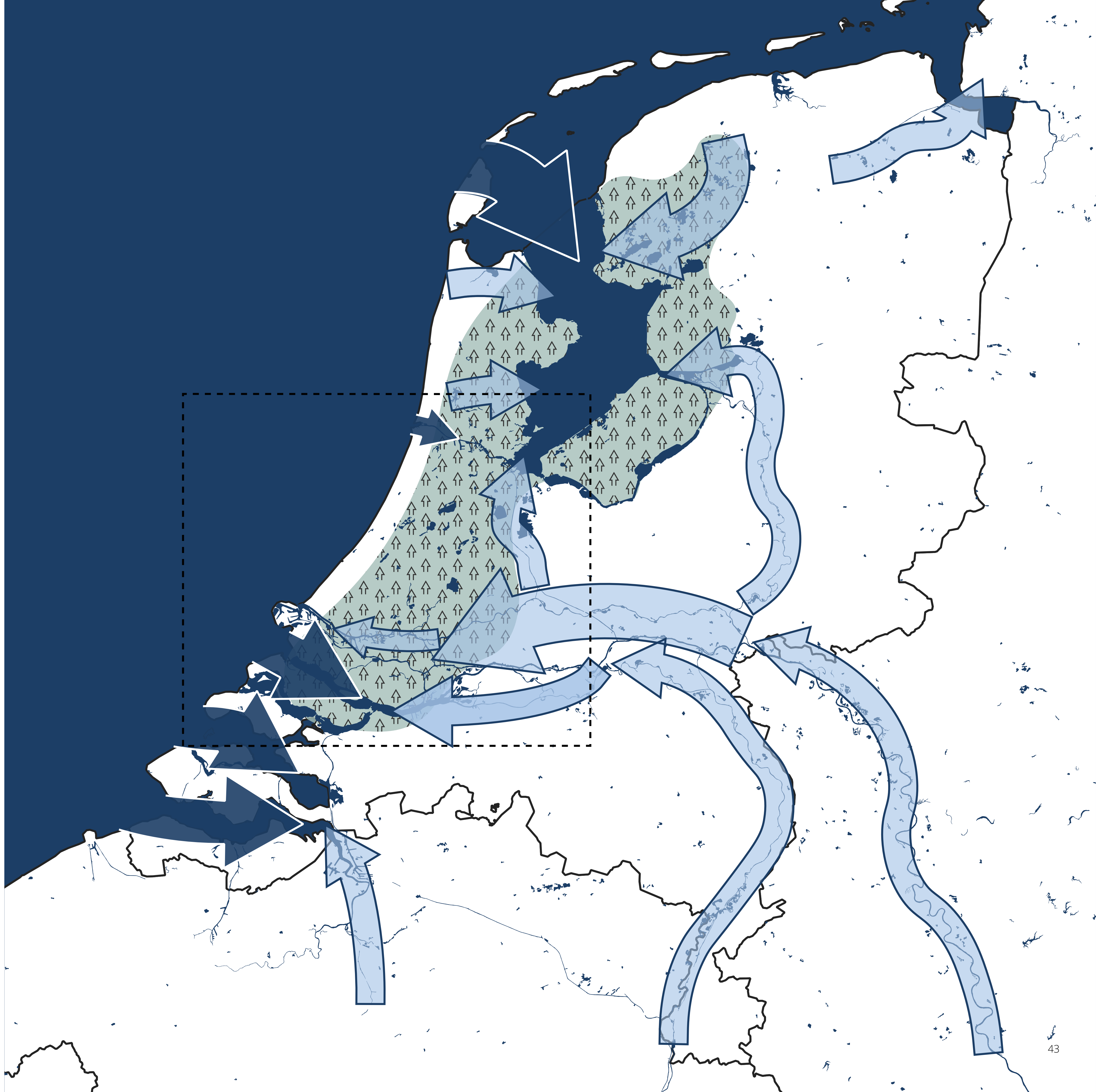
The biggest climate change threat that concerns the Netherlands is increasing flooding problem and accelerated Sea level rise, in all future scenarios, a successful and an unachieved carbon neutrality (van Alphen et al., 2022) (Moore, 2019). To situate ourselves in the future cone, we took the worse but very likely situation of a +2 metre sea level rise. To understand the regional water threats, different types of flooding, such as groundwater, coastal, pluvial, and fluvial, mappings were made. The coastal western part of the Netherlands is a high-risk area due to high probability of devastation and high amount of possible harm as this is the most densely populated urban area in the Netherlands. To manage these threats a stronger decision has to be made for approaching future scenarios. We provide two alternative solutions how it can be handled.

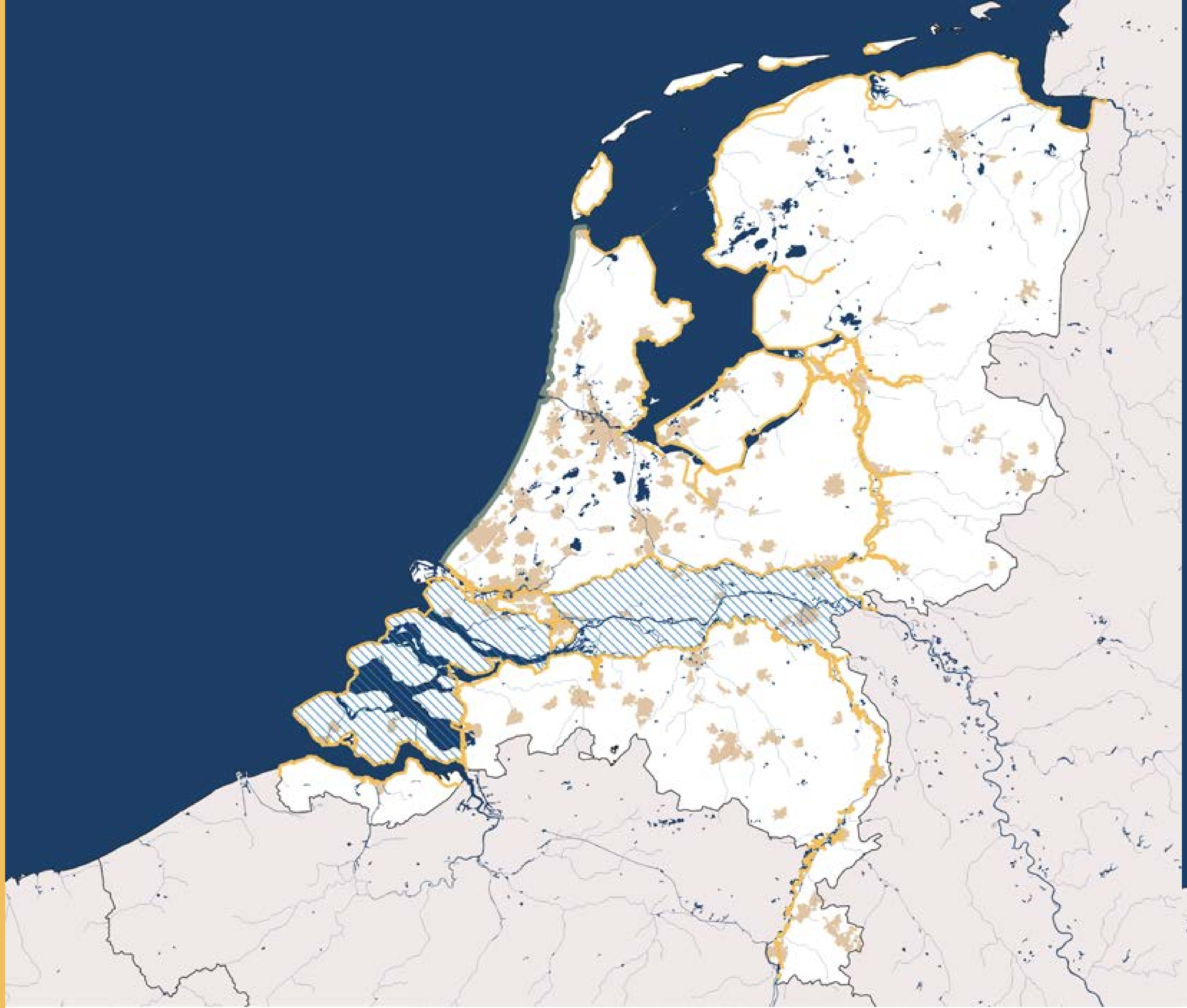
Figure 39. Conclusional Flooding Map (see sources in Bibliography)

Legend

- Waterbodies
- Urban Fabric
- Reinforced Protection Lines

0 20km 40km





Fighting the Water

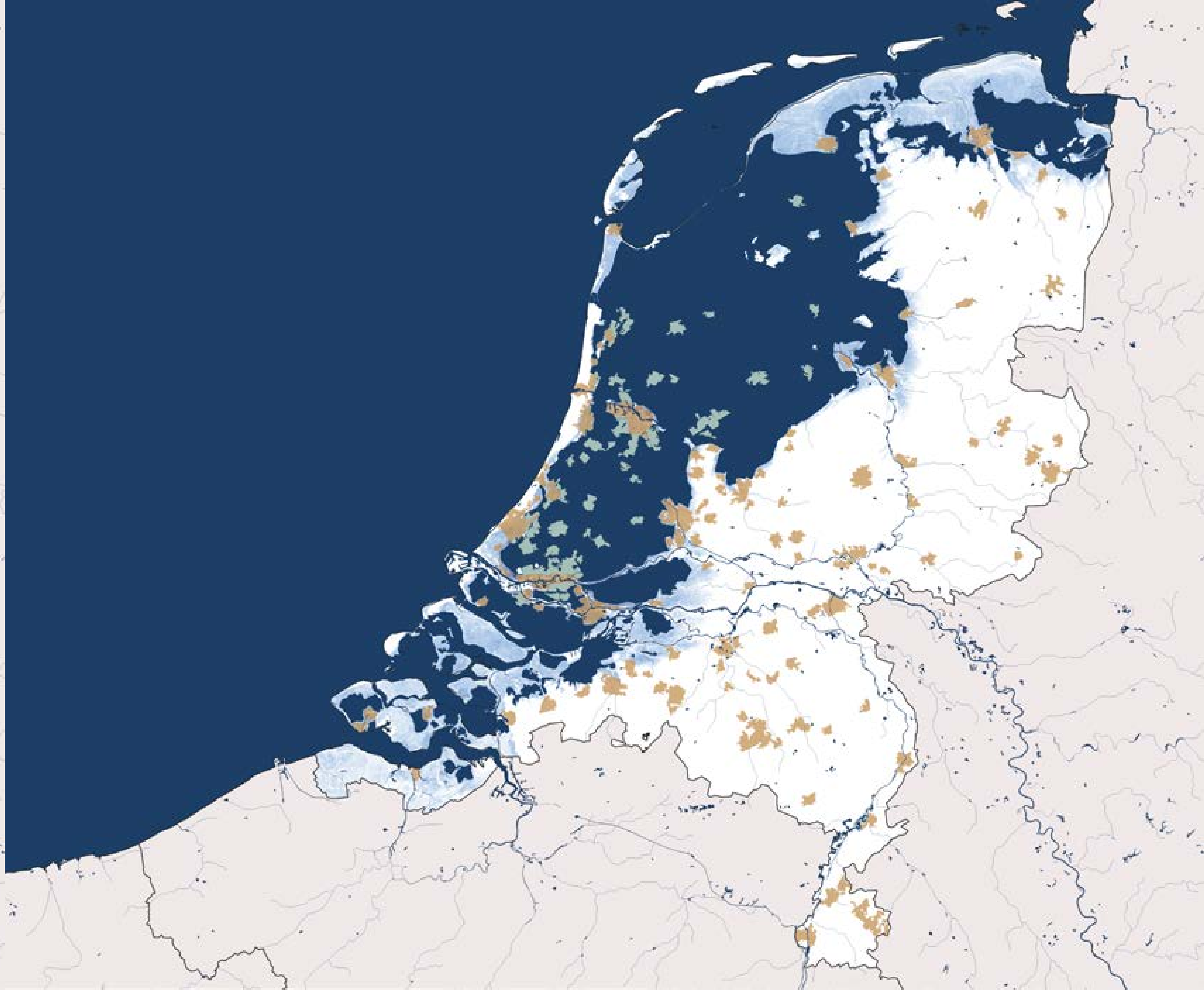
By continuing the Dutch water management approach outlined in the National Water Programme 2022-2027, the main flood defence systems would have to be reinforced to fulfil tightened statutory norms (Ministry of Infrastructure and Water Management et al., 2021). One possible alternative approach would be to create room for the river to overspill.

Legend

- Waterbodies
- Urban Fabric
- Reinforced Dikes
- Natural Landscape Protection

0 25km 50km

Figure 42. Protected Landscape (see sources in Bibliography)



Room for the Water

An alternative water management approach would be to not to manage the water at all. Inspired by LOLA's research project 'Plan B: NL2200', an exploratory examining of how the Netherlands could cope by embracing the new waterscape of +2 metres sea level rise could be managed was undertaken (LOLA Landscape Architects, n.d.).

Legend

- Waterbodies
- Urban Fabric
- Water adapted Urban Fabric
- Floodplain

0 25km 50km

Figure 43. Natural Landscape (see sources in Bibliography)

B. Energy potentials

Wind Power

At the time of this research, 50% of the current renewable energy sources used for electricity production is generated by offshore and onshore wind turbines (Netherlands, 2024). Considering the countries climate, wind power is the biggest generating source compared to other renewable energy sources.

By mapping the high wind speeds regions, large potential zones following the coast and the main waterways and estuaries. The North Sea is also a large potential zone for offshore wind power as there are no obstacles blocking the wind. The situation of the current wind turbines also illustrates the large potential areas while also showing the exclusion of turbines from the urban fabrics.

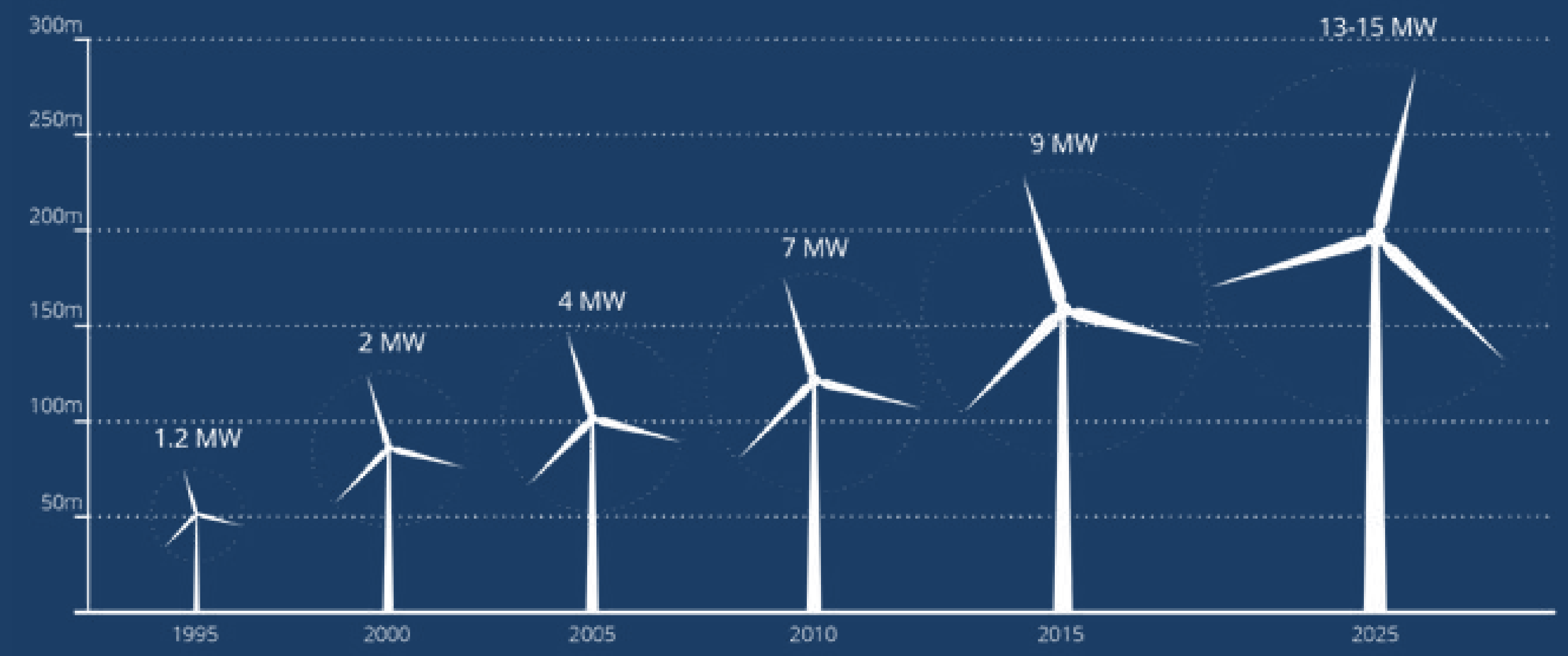
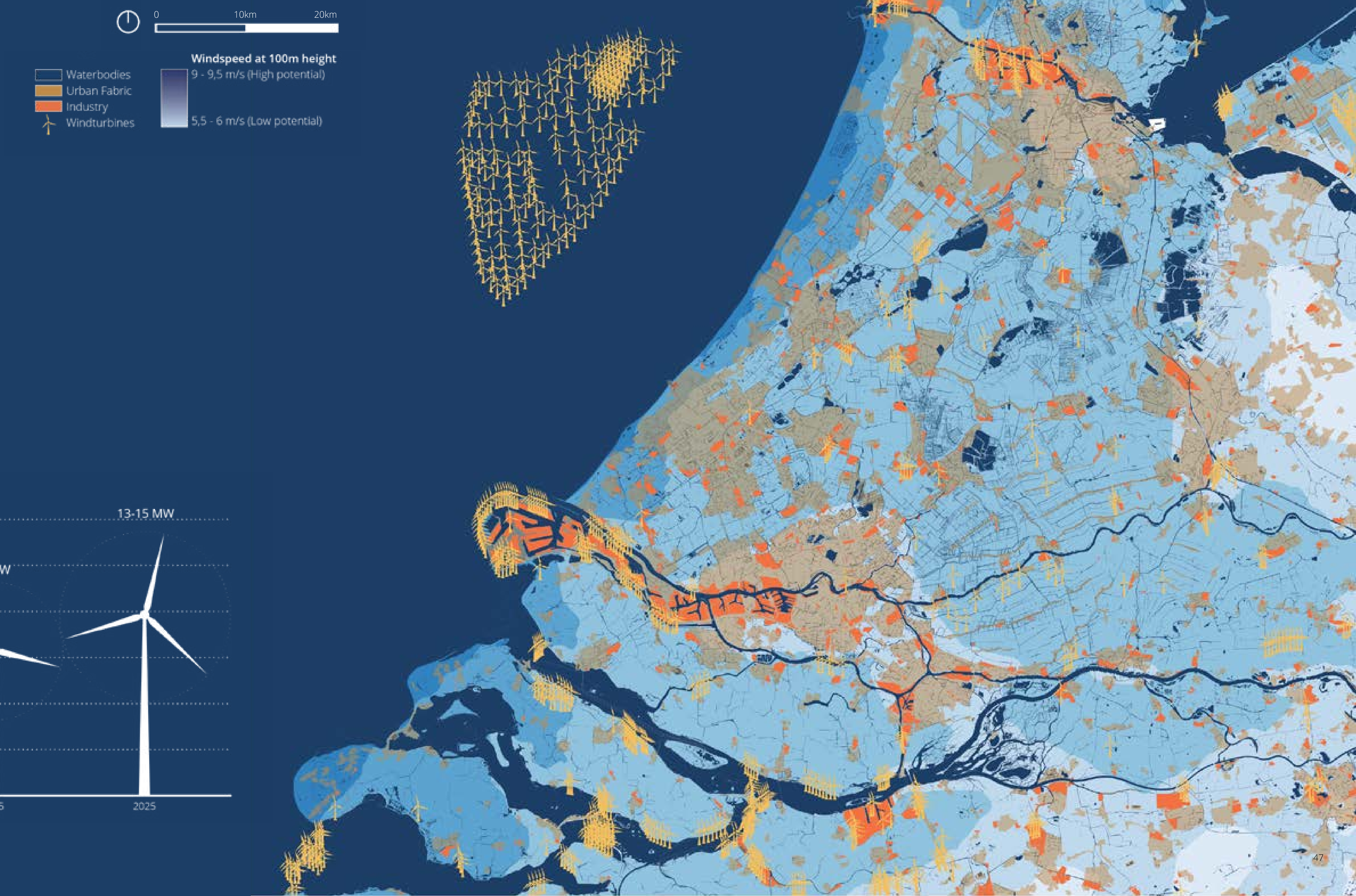


Figure 45. Wind turbine innovations, adapted (Pisano, 2019)

Figure 44. Wind power potential & current generating wind turbines map (see sources in Bibliography)



Solar Power

At the time of this research, 37% of the current renewable energy sources used for electricity production is generated by solar panels (Netherlands, 2024). Considering the countries northern global position, solar power does not have that much energy potential as countries closer to the equator and especially the tropic lines. Apart from this solar power generation is still a very attractive power source as it allows residents to produce their independent energy and with new innovations the prices of photovoltaic panels has dropped considerably (Carbon Brief, 2020).

By mapping the highest solar intensity regions, southern areas and similarly to the wind potential map – the coastline illustrates the biggest solar energy output. The vast and equal distribution in the of solar farms in the delta region illustrate the positive and inclusive outlook towards this renewable energy.

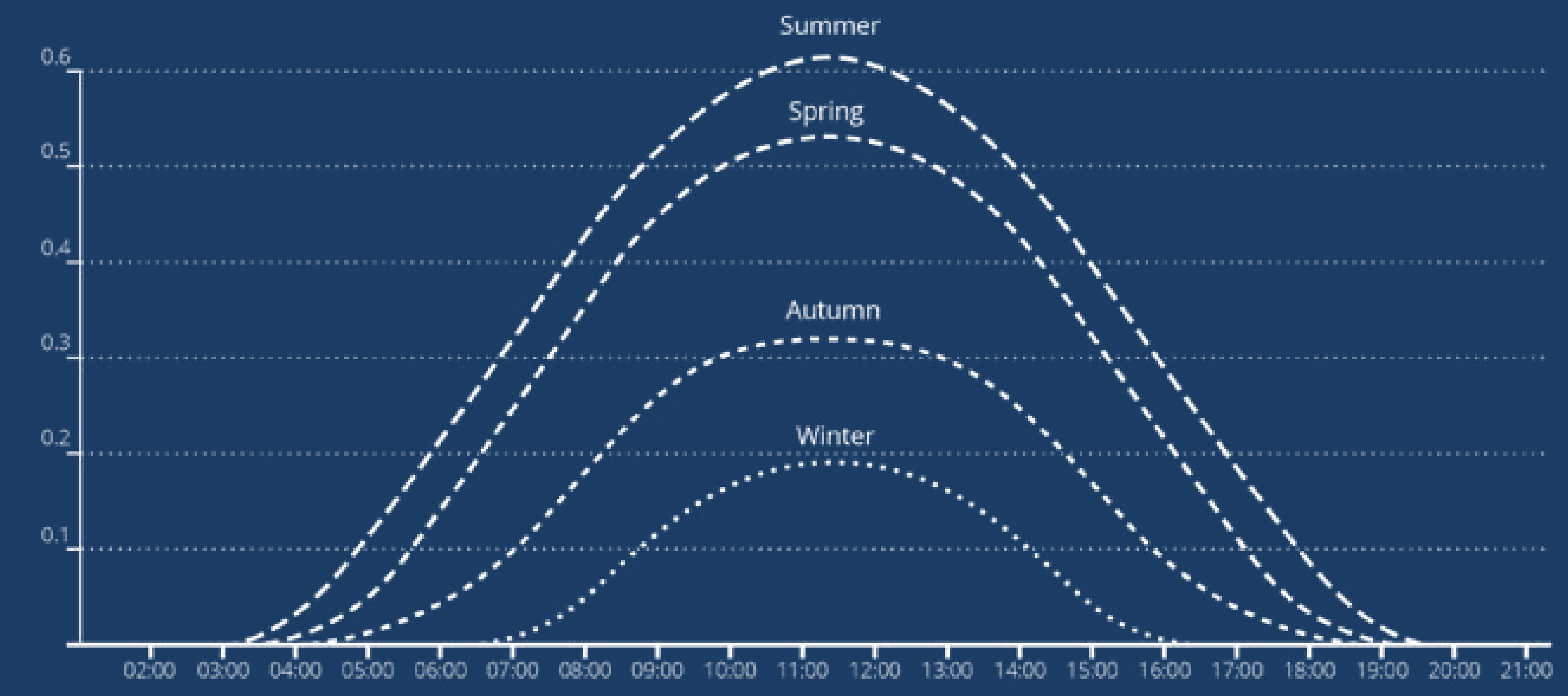


Figure 47. Hourly average kWh electricity output per kW of solar PV by season, adapted (Robinson, 2019)

Figure 46. Solar power potential & current generating solar farms map (see sources in Bibliography)

Geothermal Power

When considering energy consumption heat requires much more energy than electricity. For the energy transition to be feasible a renewable heating source has to be introduced into the energy mix. Geothermal together with district heating perfectly fills this missing link in the transition. While the sector is still undeveloped, the government is showing its interest in this energy source by providing permits for geothermal heat explorations and investing in expanding the geothermal industry (Ministry of Economic Affairs and Climate Policy, 2017).

By mapping the currently explored geothermal heat potential zones, two parallel strips overlaying Rotterdam and on above Amsterdam show the biggest potential heat extraction zones. Today geothermal heat is mainly used for greenhouse horticulture industries, but future plans are being to scale up the renewable energy to incorporate also densely populated neighbourhoods, non-residential construction and industry sectors into the this type of heat consumption (Platform Geothermie et al., 2018).

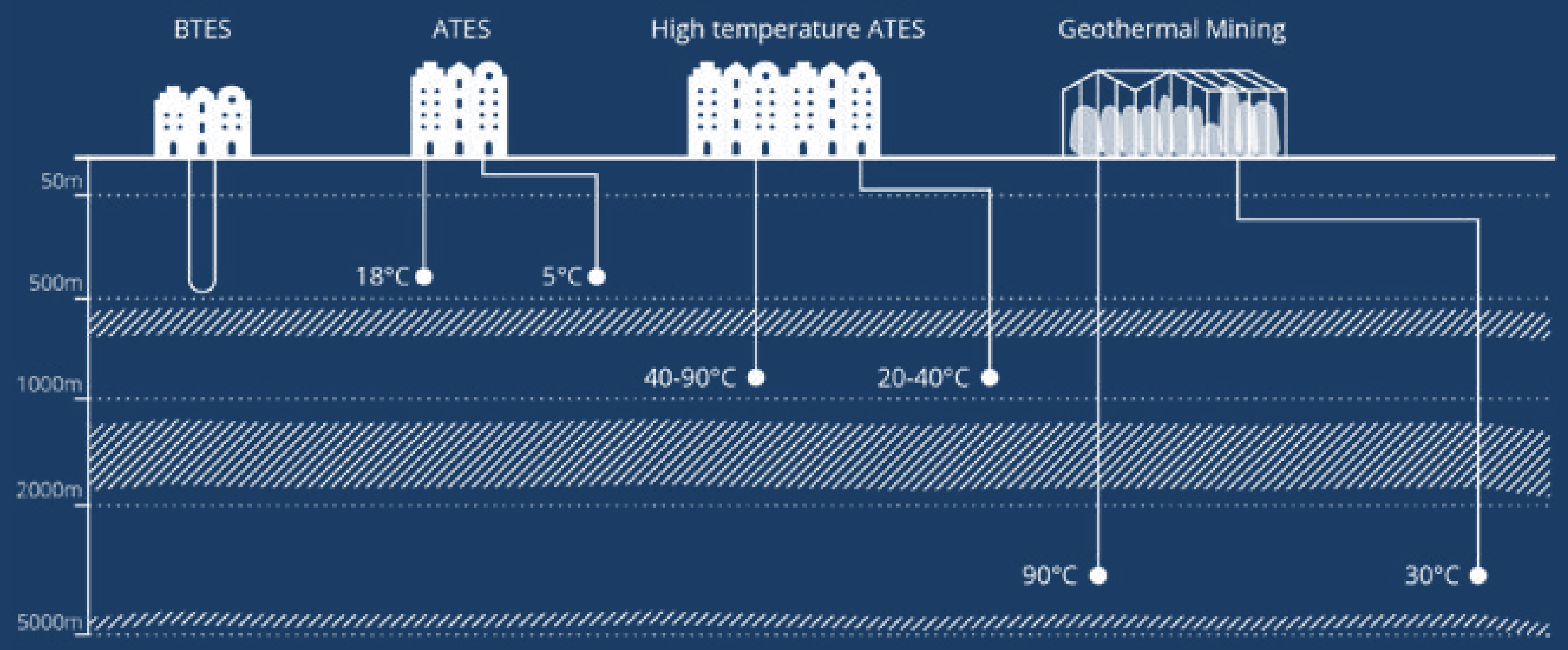


Figure 49. Various types of Geothermal power, adapted (Godschalk et al., 2019)

Figure 48. Geothermal power potential & current geothermal generators map (see sources in Bibliography)

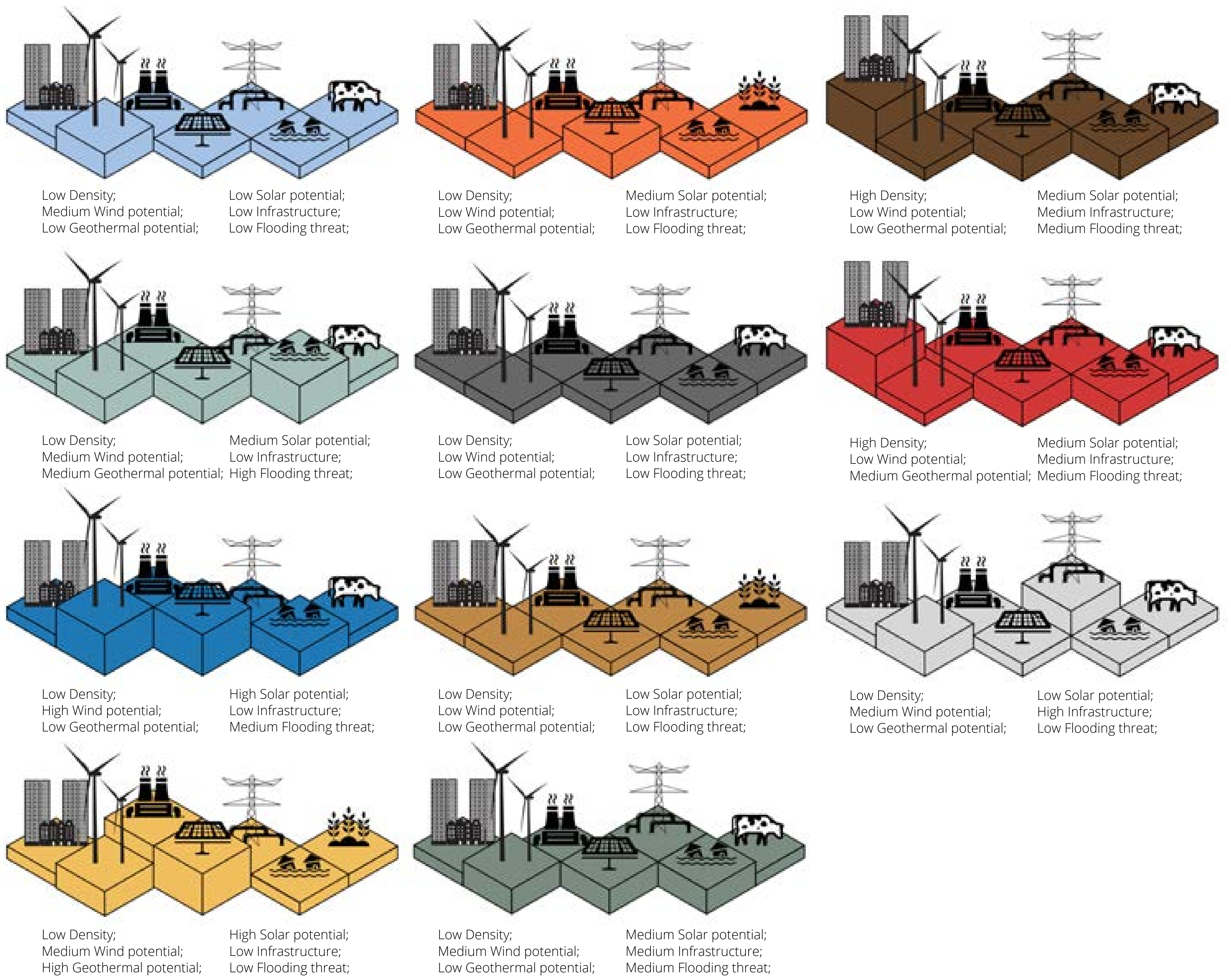
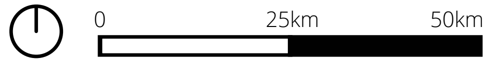


Figure 50. Diagrams explaining combination of potentials and also threats for typology making

C. Threats and Potential Typology

By layering the renewable energy potential areas, flood risk areas together with the urban and peri-urban land-uses a final conclusionary typology was created. Mapped out data was combined and divided into 2 by 2 km. square EEA reference grid for Europe. With the help of software GeoDa, the individual squares were analyses and clustered into similar 11 types of threat and potential zones. These regions show similar traits that can help to distribute particular interventions in each of the zones. The particular west side of the Netherlands: Zeeland, South and North Holland, has both high opportunities for renewable generation and high flood risks, requiring a balanced approach.



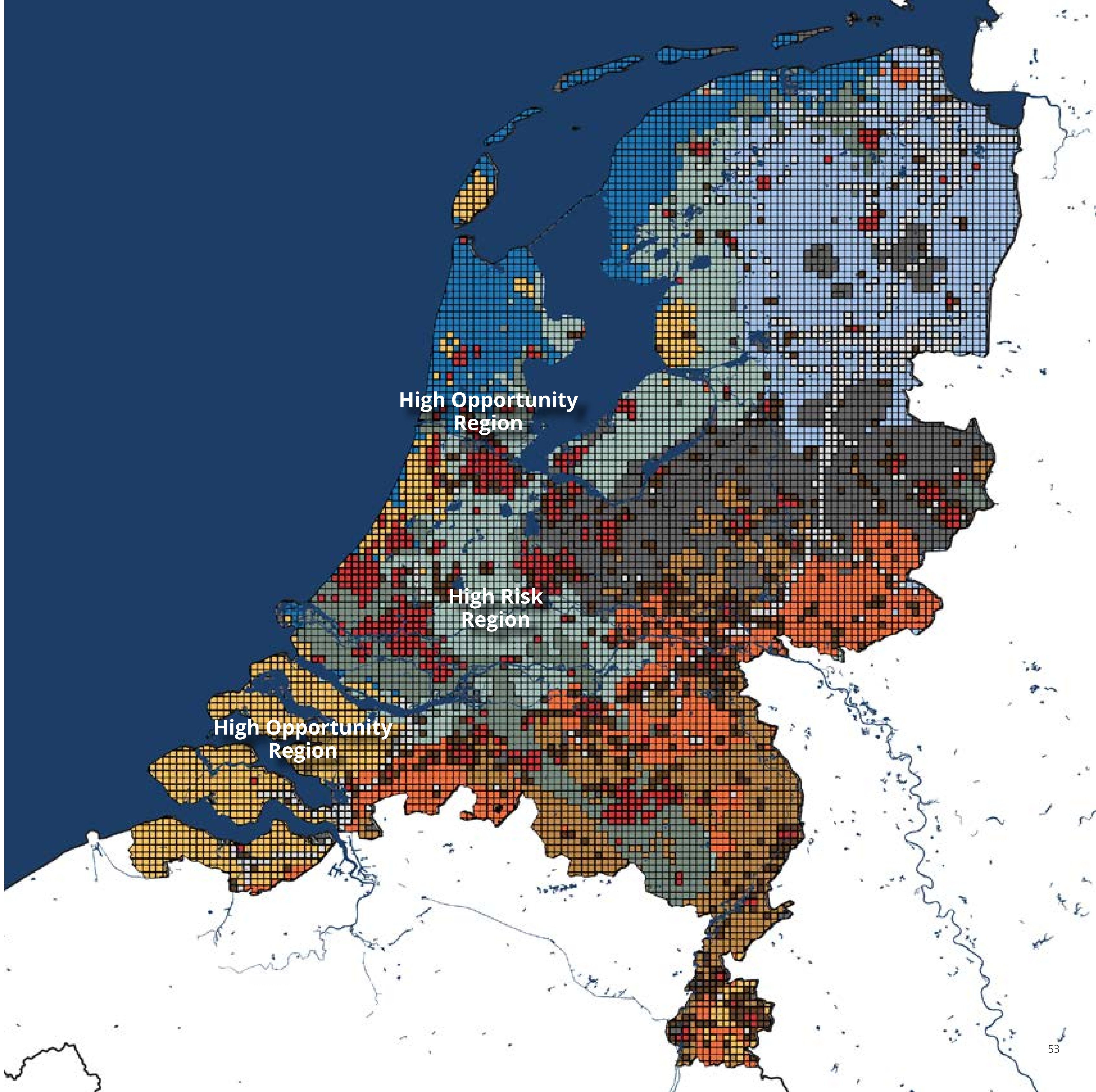


Figure 51. Threats and Potentials Typology Map
(see sources in Bibliography)

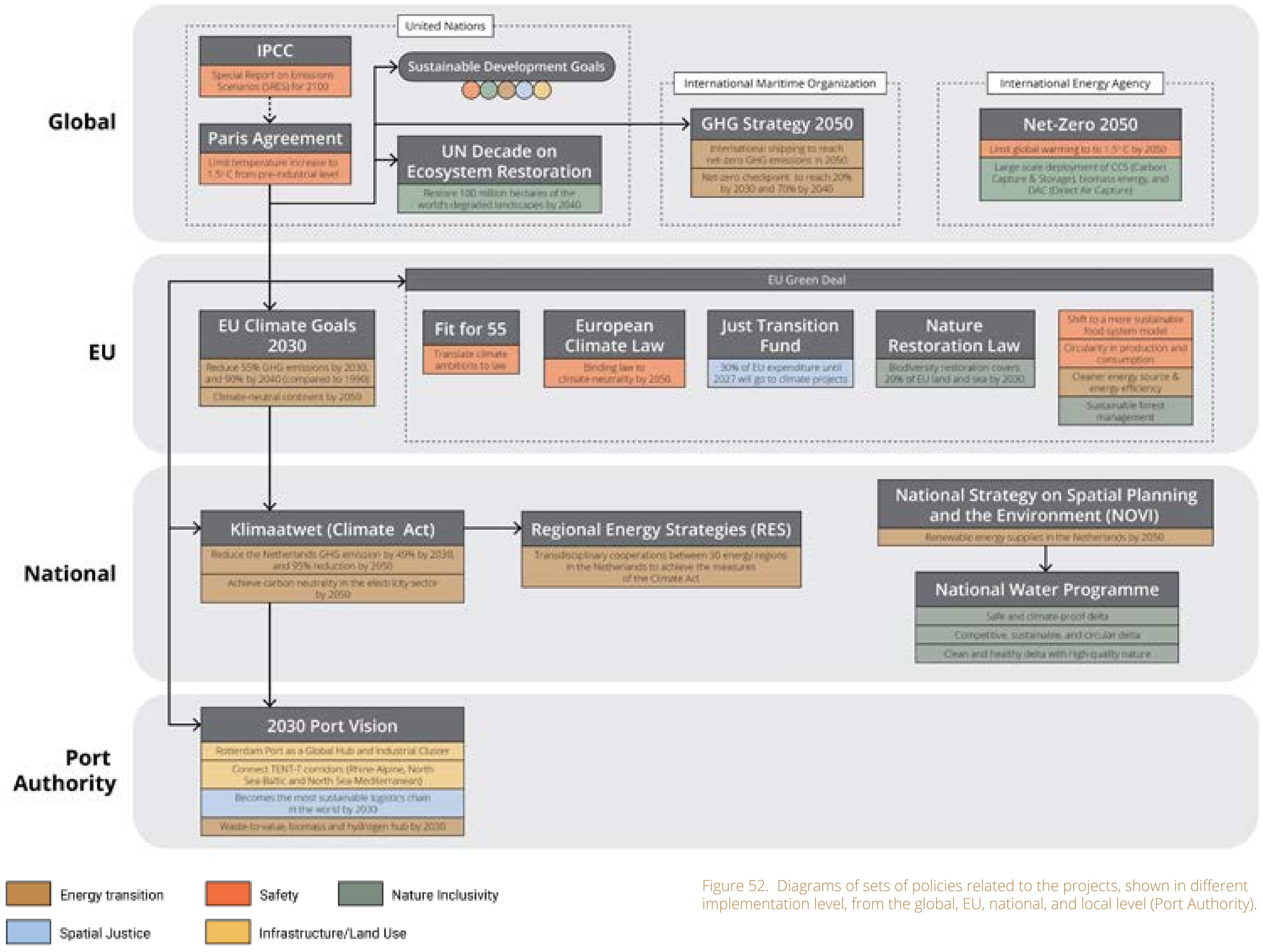


Figure 52. Diagrams of sets of policies related to the projects, shown in different implementation level, from the global, EU, national, and local level (Port Authority).

3.5 Policy Analysis

After the rise of petroleum industry in the 19th century, the 1974 oil crisis led to the establishment of International Energy Agency (IEA), focusing on ensuring oil security (International Energy Agency, 2024). Fourteen years later, the United Nations created the Intergovernmental Panel on Climate Change (IPCC), following the state of knowledge on the science of climate change, the social and economic impact of it, and potential response strategies and elements for inclusion in a potential future (Intergovernmental Panel on Climate Change, 2024). Since its creation, the IPCC has produced six comprehensive and scientific assessment report addressing different trajectory known as the Representative Concentration Pathway (RCP). These pathways considered different climate models shaped by potential future level of greenhouse gas emissions, population growth, economic development, and else. With each model as input, the scenarios covered projections far into the future of 2100, 2200, and even more.

Considering the scenarios by the IPCC, the United Nations Framework Convention on Climate Change (UNFCCC) held an international treaty on climate change called the Paris Agreement. The main goals of the treaty were to have the increase in the global temperature to below 2°C above pre-industrial levels and to limit the temperature increase to 1.5°C above pre-industrial levels (United Nations Framework Convention on Climate Change, n.d.). Looking towards 2030, the Paris Agreement created the Sustainable Development Goals (SDGs) as a part of global sustainable development agenda. These goals set targets and indicators to address various global challenges, such as poverty, inequality, climate change, environmental degradation, and justice.

These prior climate actions set examples and even became scientific bases for other initiatives, translated into different levels of policies. In the context of the Netherlands, these documents cover the global level, including the IPCC scenarios, the SDGs of the Paris Agreement, and similar climate strategies by the International Maritime Organizations called GHG Strategy 2050. Following the Paris Agreement, the European Union (EU) released EU Climate Goals and EU Green Deal with ambitious goal of becoming the first climate-neutral continent by 2050.

In the national level, the Netherlands adopted prior climate goals and generated the Climate Act, Regional Energy Strategies (RES), and the National Strategy on Spatial Planning and the Environment (NOVI). For the context of the project, we also investigated smaller scale policy documents by the Port of Rotterdam. Called the 2030 Port Vision, it imagined the Port of Rotterdam as a Global Hub and Industrial Cluster, considering the currently happening energy transition.

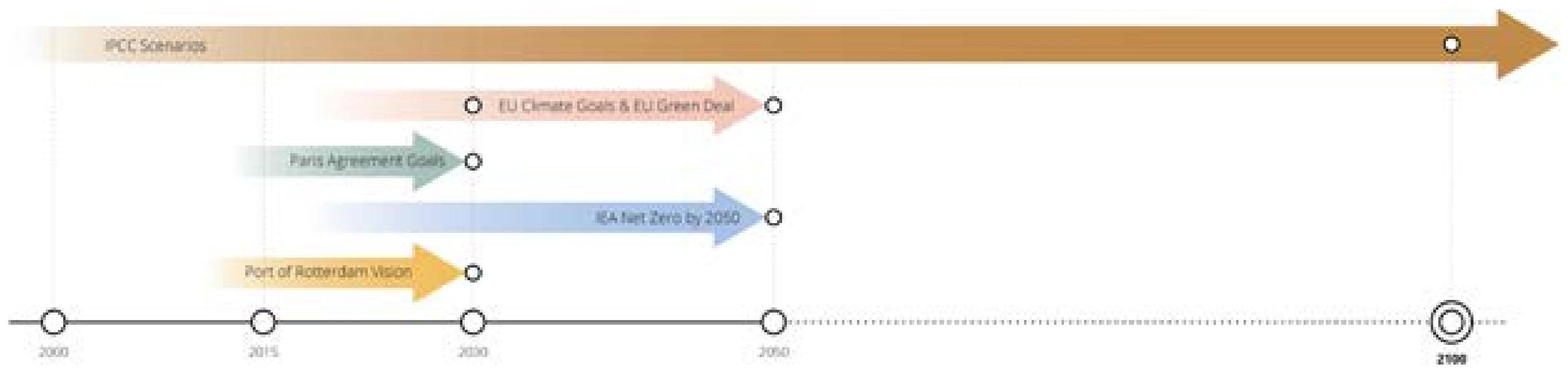


Figure 53. Simplified diagram of roadmaps of the policies in relation to the year 2100.

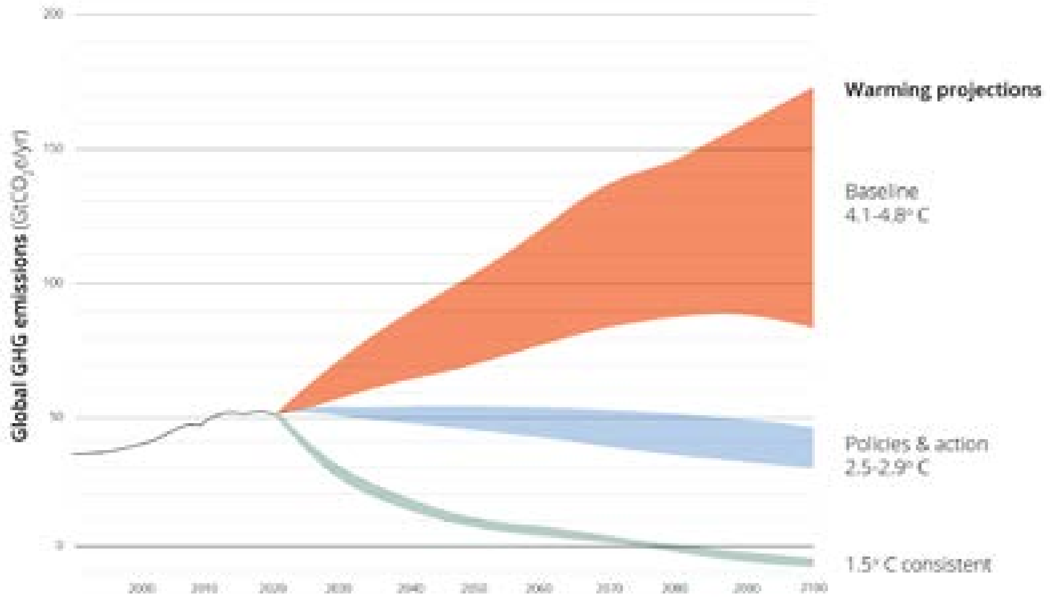


Figure 54. Graph explaining global warming projections in relation to the global GHG emissions level (adopted from (Ritchie et al., 2023)

04

Future Scenarios and Uncertainties

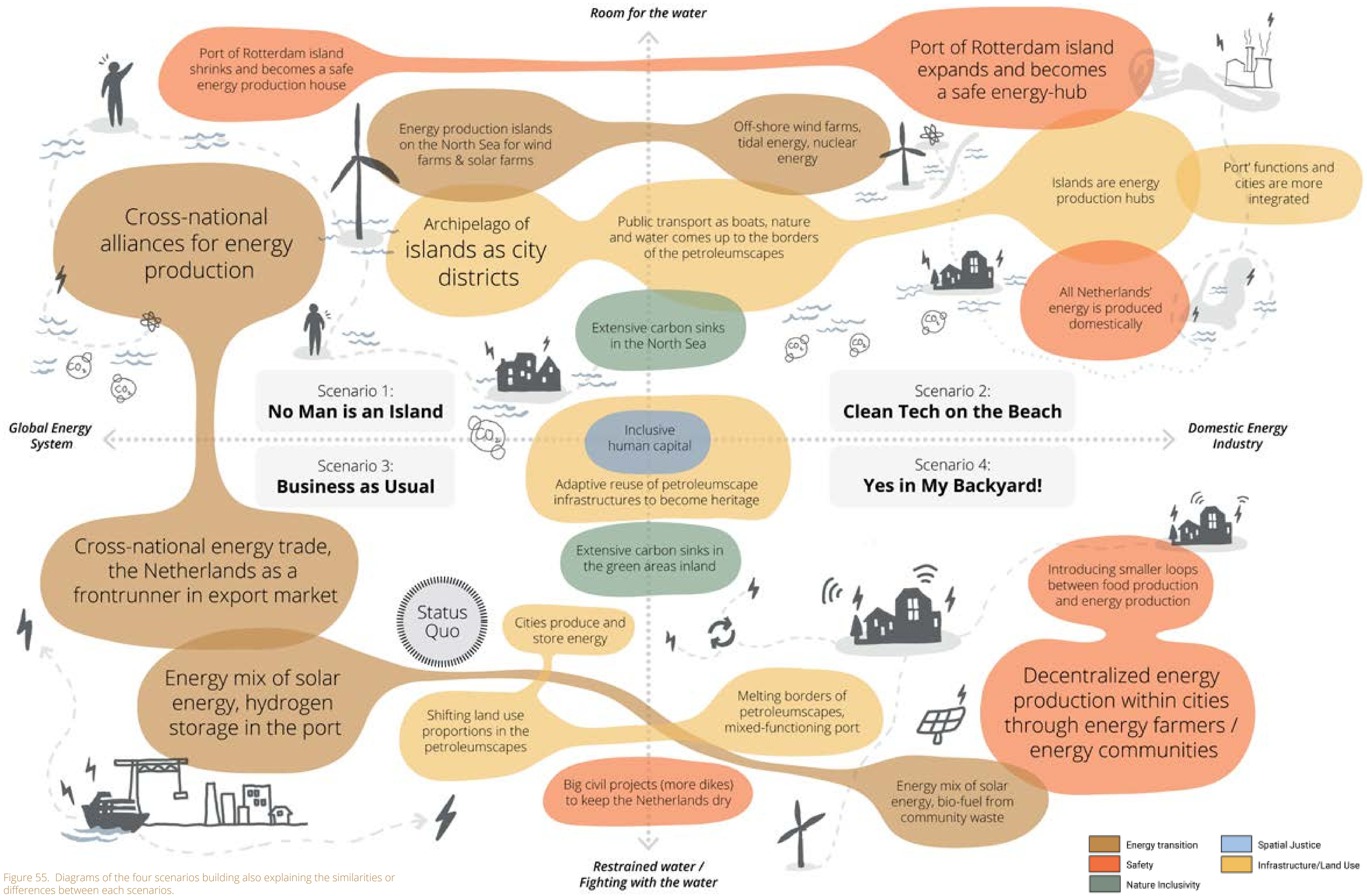


Figure 55. Diagrams of the four scenarios building also explaining the similarities or differences between each scenarios.

4.1 Scenario Building

Creating "what if" scenarios is one research tool in planning, allowing designers and planners to put into words and images of how the potential future can look like (Rocco, 2024). This project considered trends of climate events and its impact to water level, crossed with the trends of geopolitical trades and alliances. In the first scenarios, where the global sea level rises by 2 meters, parts of the western side of the Netherlands are submerged, with energy demands covered by international trade through the North Sea. In the second scenario with the same extreme water level condition, the port expanded and became a safe energy hub with an important role in producing all the country's energy domestically. In the third and fourth scenarios, the Dutch landscape kept restraining the water by continuing the reinforcement of its water defences. Cities play a role in producing their own energy, but in the third scenario the Netherlands also exports the energy and stores it as hydrogen in storages in the port. The fourth scenario emphasizes on decentralized energy production in cities by empowering local energy communities.

The diagram on the left explains aspects in each scenario and how they interlinked each other, demonstrating similarities and differences between different four scenarios.

Figure 56. Diagram explaining the four different scenarios within two axis.

SCENARIO 01

4.2 No Man is an Island

In this scenario, water safety is taken as the highest value and by anticipating the worse predictions (Moore, 2019) an alternative approach must be taken to deal with ever-increasing floods and sea level rise. By stepping away from constant water pumping and monitoring, the areas below sea level and areas once reclaimed must be given back to the sea. This rearranges the current urban fabric towards higher safer lands, clustering smaller settlements to form new urban agglomerations. The East of the country is seen to grow exponentially as large number of people would relocate to safe, waterproof areas. Larger settlements within the flooded zone are transformed to floating and water adaptive settlements.

With the loss of land to the sea, the importance of cross-national energy production is emphasised. The North Sea is utilised as a mediator for collective power generation for North-Western European countries. A large amount of solar, wind and tidal energy production is positioned on floating energy islands, leaving as much land for people.

The port's position completely changes from energy production to electricity transmission. Ports act as transformers connecting high voltage cables and distributing energy to their cities. Areas used for fuel storage are taken by commerce and cargo trade and are integrated back into the cities. The Port of Rotterdam together with Rotterdam and the Hague will become one island port city.

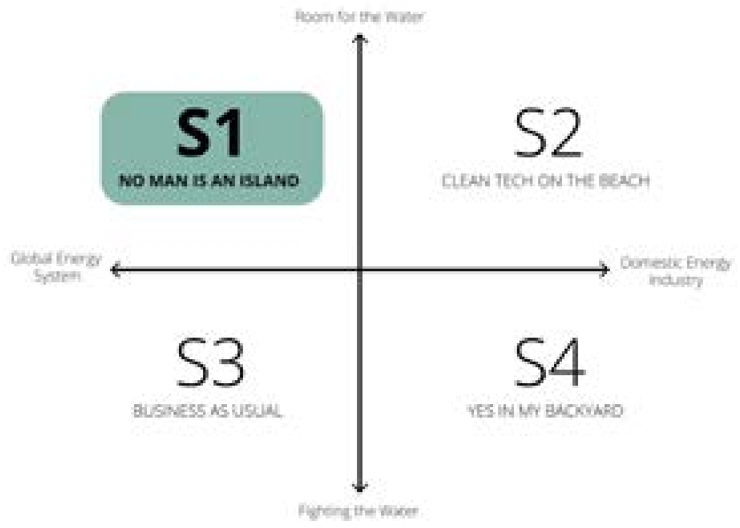


Figure 58. Diagram highlighting the first scenario within two axis.

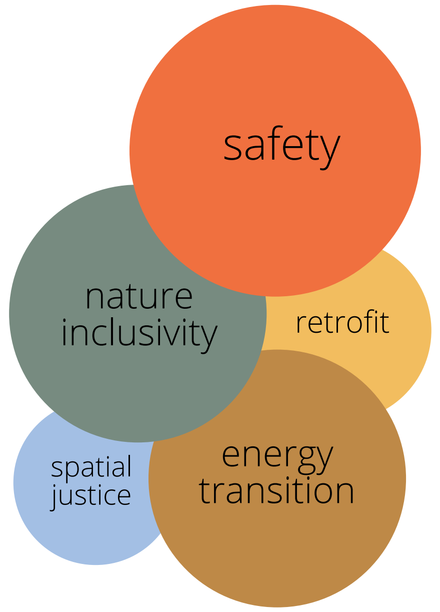


Figure 59. Prioritization context in Scenario 01 with safety concept as the utmost focus

Energy mix

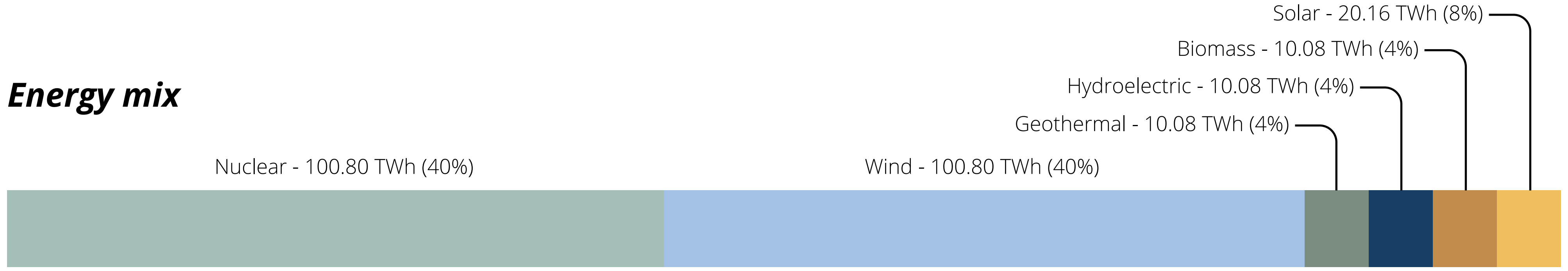


Figure 57. Energy mix of the Scenario 01 showing the percentage of each energy source for production

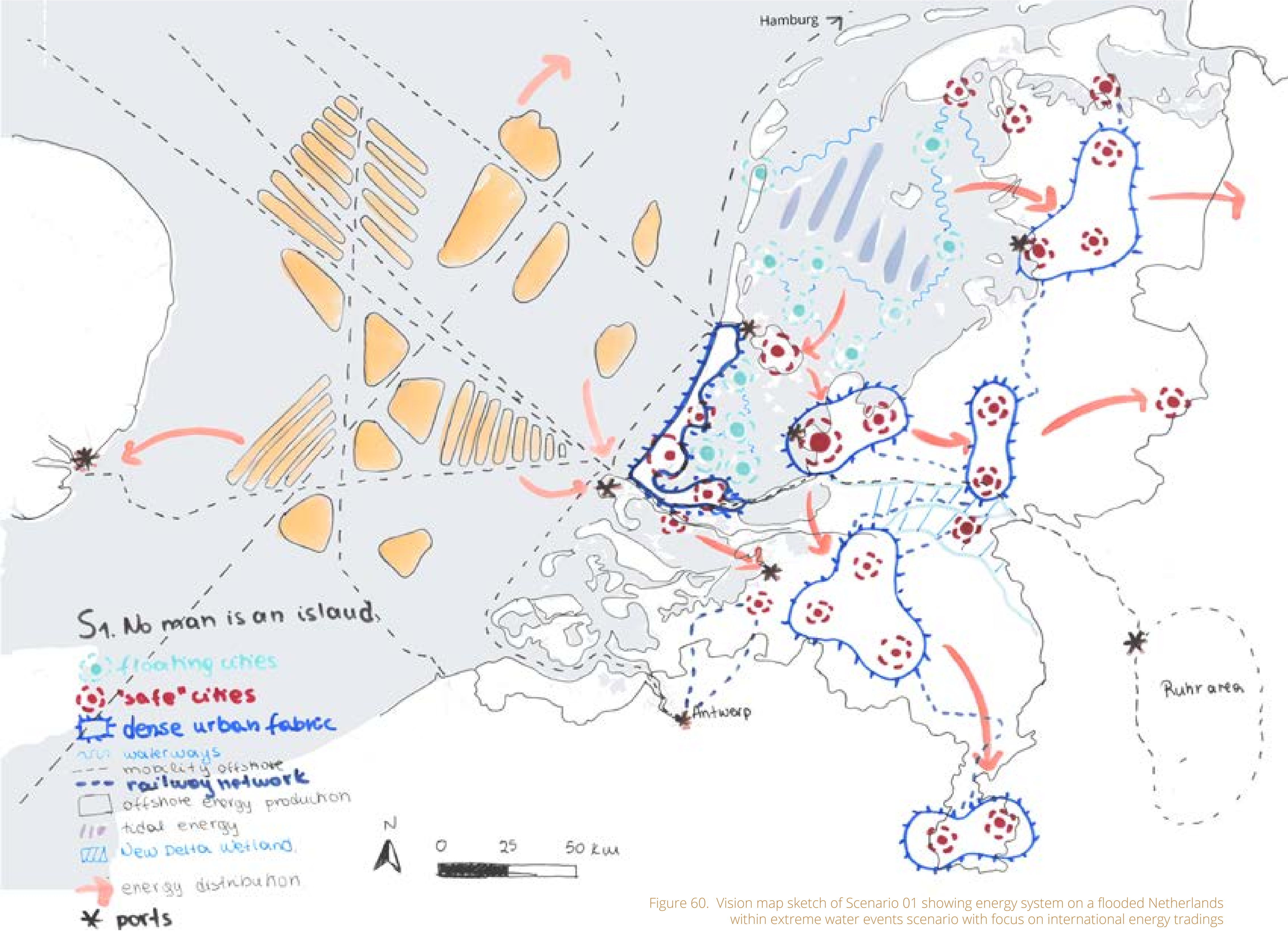


Figure 60. Vision map sketch of Scenario 01 showing energy system on a flooded Netherlands within extreme water events scenario with focus on international energy tradings

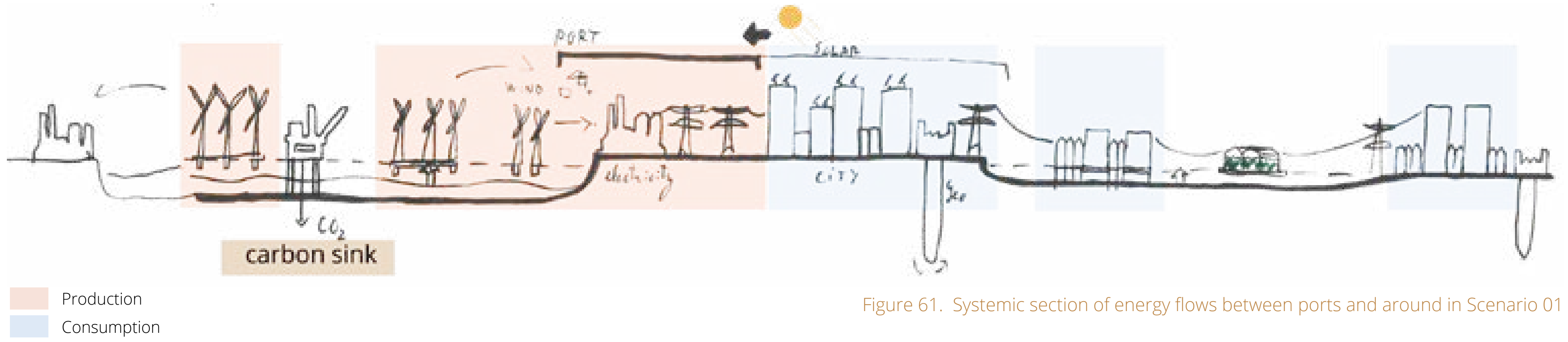


Figure 61. Systemic section of energy flows between ports and around in Scenario 01

SCENARIO 02

4.3 Clean Tech on the Beach

In this scenario, water safety and nature inclusivity are prioritised equally. Similarly to scenario No. 1, areas currently 2 metres above sea level would be taken by the sea as greater storms and a higher sea level would constantly threaten to break through protective dikes. The new dense urban fabric would relocate towards the 'second coastline' situated in the higher Eastern lands. Some settlements situated in the floodplain are transformed into floating and water adaptive settlements. Old mobility lines are changed to water transportation, such as public transport ferries.

To ensure that the North Sea ecosystem is not wrecked by outsourcing all the energy production to it and covering all the surface with turbines and panels, there is a need to locate energy production in-dustry within the country's borders. The perfect zone is the 'first coastline' – the dune strip that is natu-rally higher is safe from flooding and has the biggest potential for renewable energy. With this industri-al zone, the country becomes energy independent. The Ports position shifts towards renewable energy industry, connecting material routes and empha-sising the trade between industries. The port area expands to cope with the centralised energy industry sector.

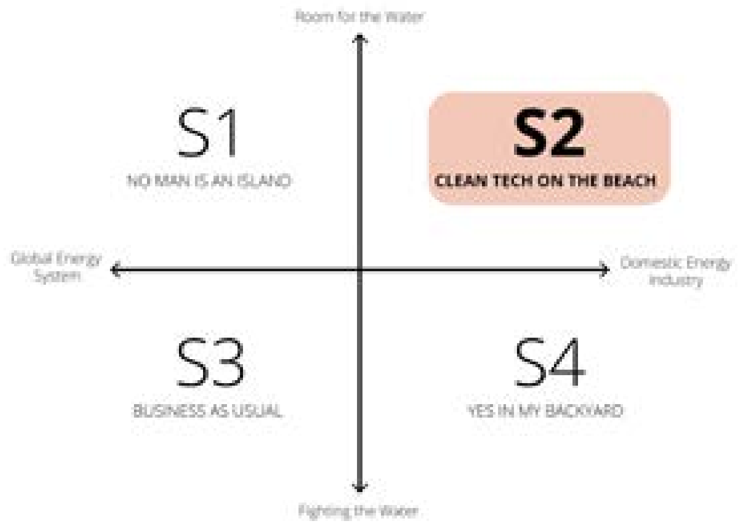


Figure 63. Diagram highlighting the second scenario within two axis.

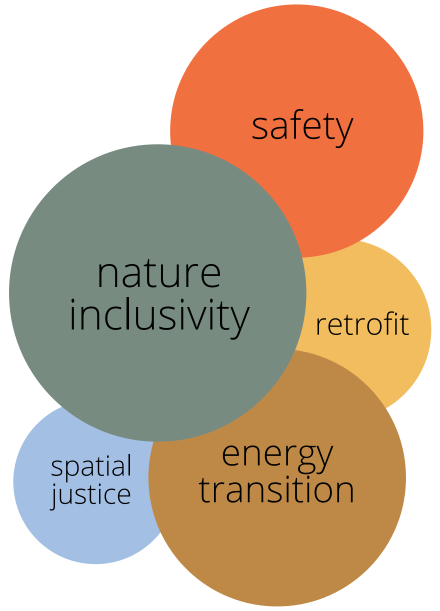


Figure 64. Prioritization context in Scenario 02 with nature inclusivity concept as the utmost focus

Energy mix

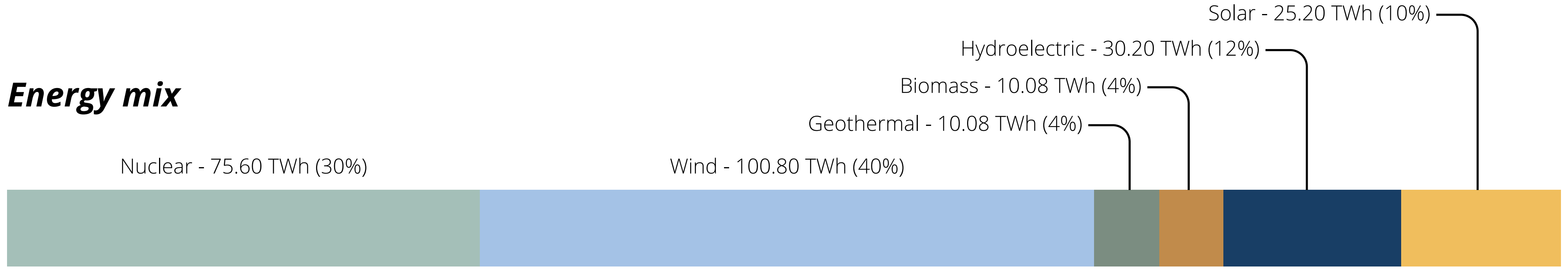


Figure 62. Energy mix of the Scenario 02 showing the percentage of each energy source for production

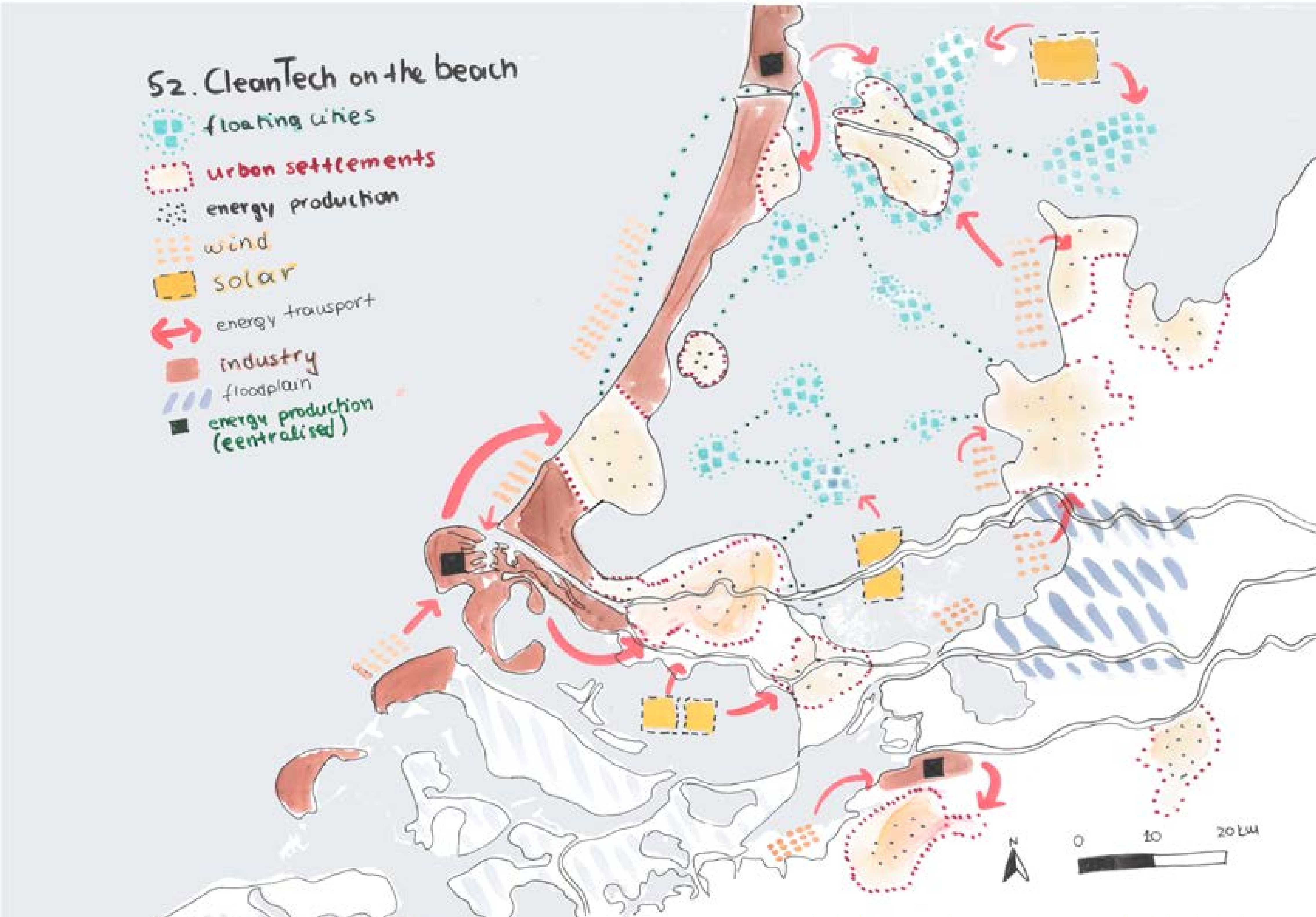


Figure 65. Vision map sketch of Scenario 02 showing energy system on a flooded Netherlands within extreme water events scenario with focus on national energy production

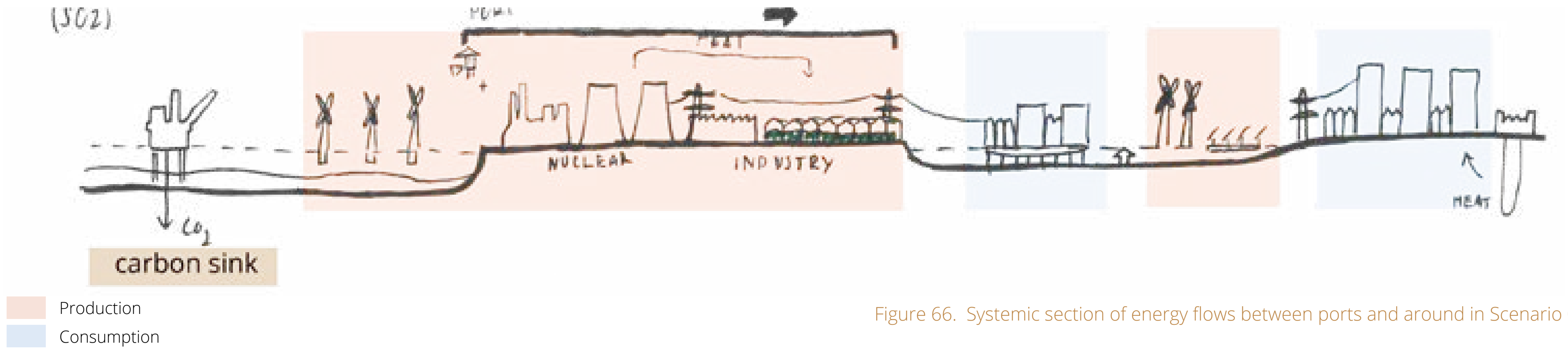


Figure 66. Systemic section of energy flows between ports and around in Scenario 02

SCENARIO 03

4.4 Business as Usual

In this scenario, energy transition is accelerated to achieve carbon neutrality as soon as possible. To cope with higher sea level and severe storms, the current Dutch water management approach is enhanced by strengthening the main protective dikes, constructing larger pumping stations but also integrating natural river flood plains to manage the pluvial flooding as well.

To achieve the energy transition as quickly as possible an international cooperation is needed. By generating energy and trading the excess with countries and regions that are in higher demand than supply, insures an efficient use of energy without any losses. Energy trading by high voltage lines is exchanged by trading with hydrogen fuel for its long-lasting and concentrated energy storing capabilities (Akash et al., 2023). This trading is established by reusing old fossil fuel pipelines and tanker ship to move substantial amounts of hydrogen fuel. By creating zones for the Rhine delta to overflow, this allows more ships to move towards inland ports, shipping energy by rivers deeper into Europe.

The ports position stays similar to the status que as a fuel transportation and processing hub. The only change is the fuel itself, moving from fossil fuel refining to hydrogen production and storage. This means that the port itself does not create energy and only keeps and transports the energy created by other sources, such as renewables and nuclear.

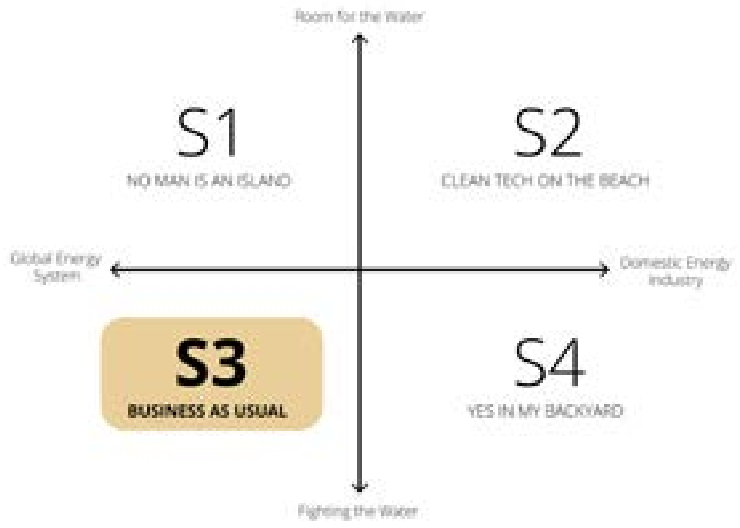


Figure 68. Diagram highlighting the third scenario within two axis.

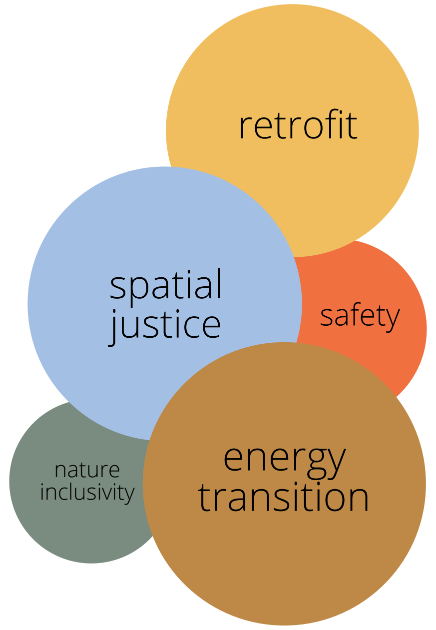


Figure 69. Prioritization context in Scenario 03 with energy transition concept as the utmost focus

Energy mix

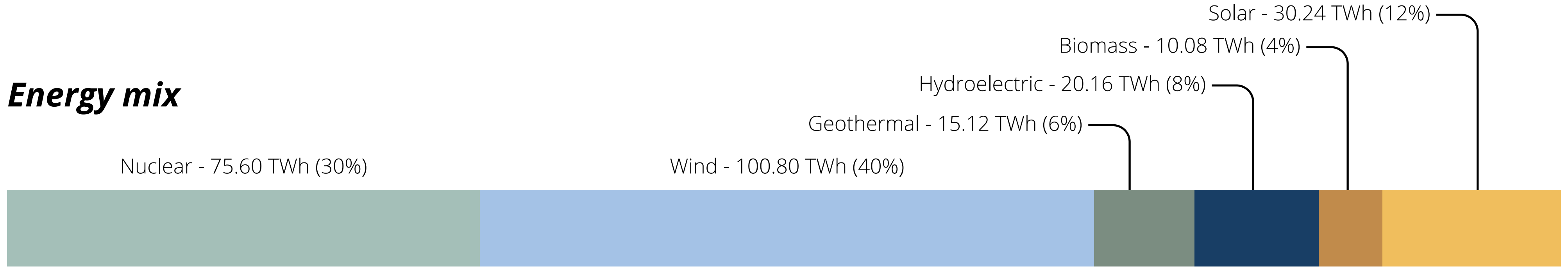


Figure 67. Energy mix of the Scenario 03 showing the percentage of each energy source for production

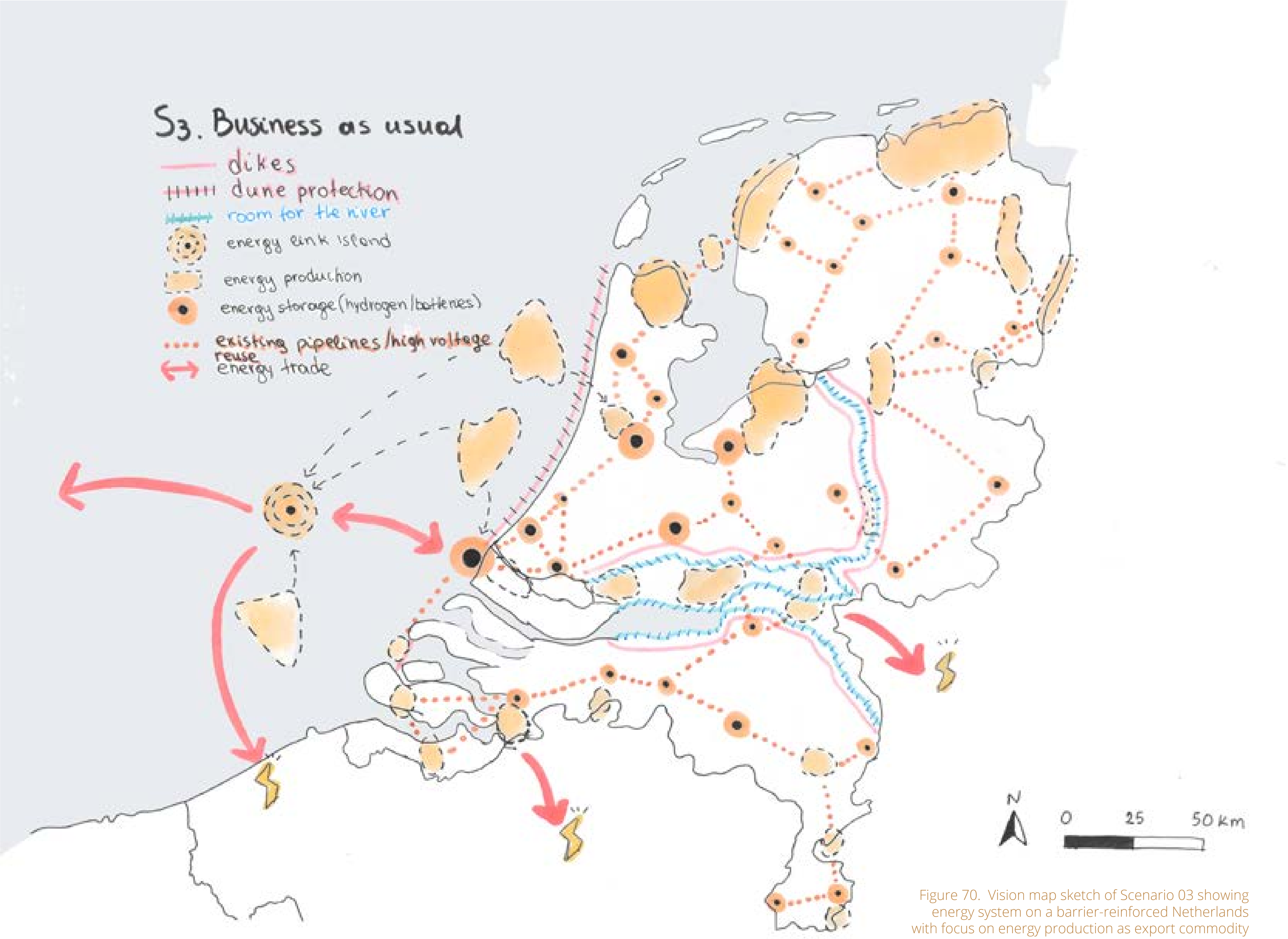


Figure 70. Vision map sketch of Scenario 03 showing energy system on a barrier-reinforced Netherlands with focus on energy production as export commodity

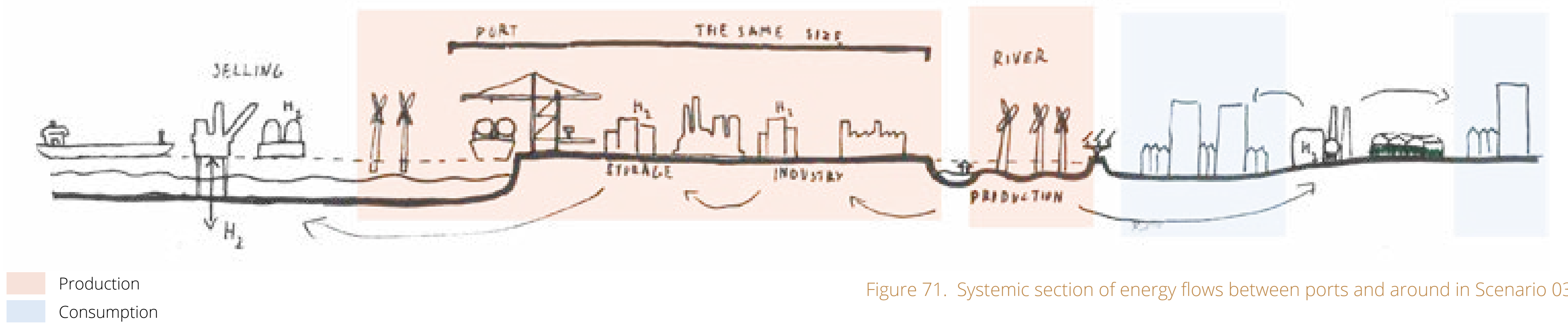


Figure 71. Systemic section of energy flows between ports and around in Scenario 03

SCENARIO 04

4.5 Yes in my Backyard

In this scenario, spatial justice and a just energy transition is sought out. The water problem is approached similarly to scenario No. 3, by increasing the current water management strategies and incorporating floodplains around the delta. By giving more room for nature and rivers, some groups such as farmers and rural residents are directly affected by this reshaping of land-use. To achieve a just transition, people must be included in the transitioning decisions, meaning the governments focus on local relations instead of international affairs.

To empower people to produce energy themselves requires a systematic shift from a centralised system to a decentralised energy production system. This allows people to produce and consume local electricity and heat. This modifies and separates the grid into smaller independent structures lowering the amount of wasted energy while also encouraging smaller consumption patterns.

Peri-urban areas and residents are at the forefront of this transition as large open areas, such as unoccupied land, pastures, and agriculture zones, become integrated with energy production.

The ports position and power decreases drastically as cities and industries are not dependant on fossil fuels and power plants positioned within the ports. Finance and power are shifting towards peri-urban areas, while the port is left with only cargo transportation and fully integrated into the city.

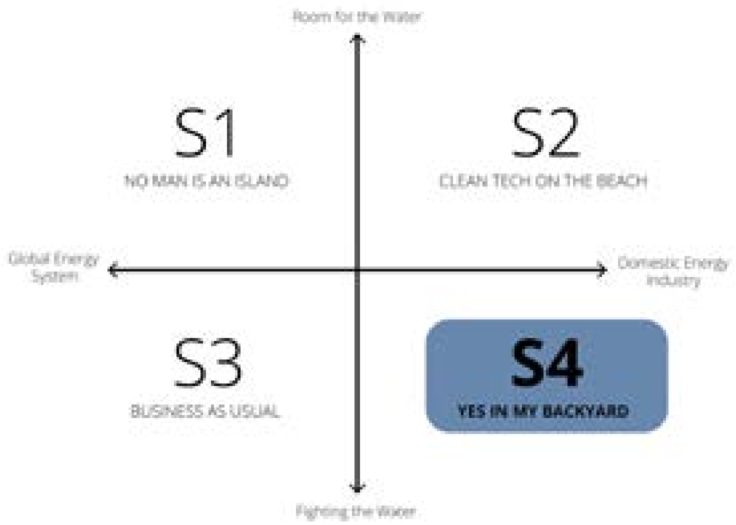


Figure 73. Diagram highlighting the fourth scenario within two axis.

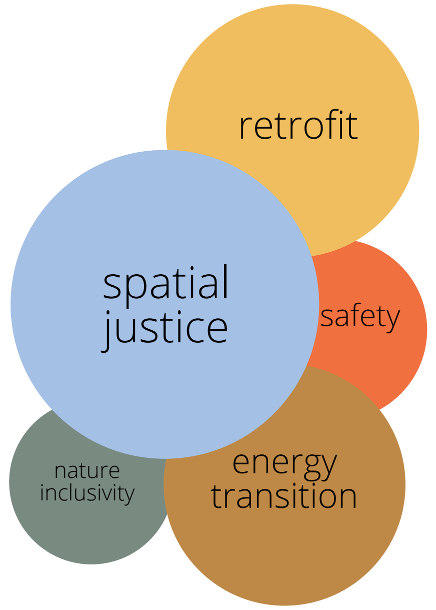


Figure 74. Prioritization context in Scenario 04 with spatial justice concept as the utmost focus

Energy mix

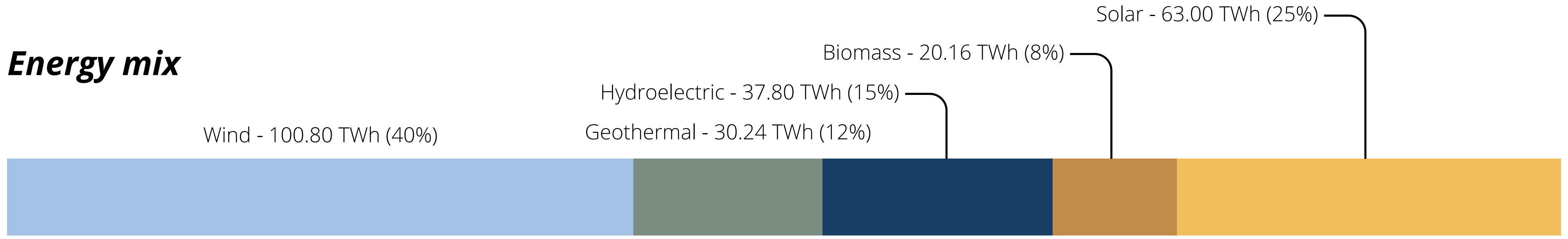


Figure 72. Energy mix of the Scenario 04 showing the percentage of each energy source for production

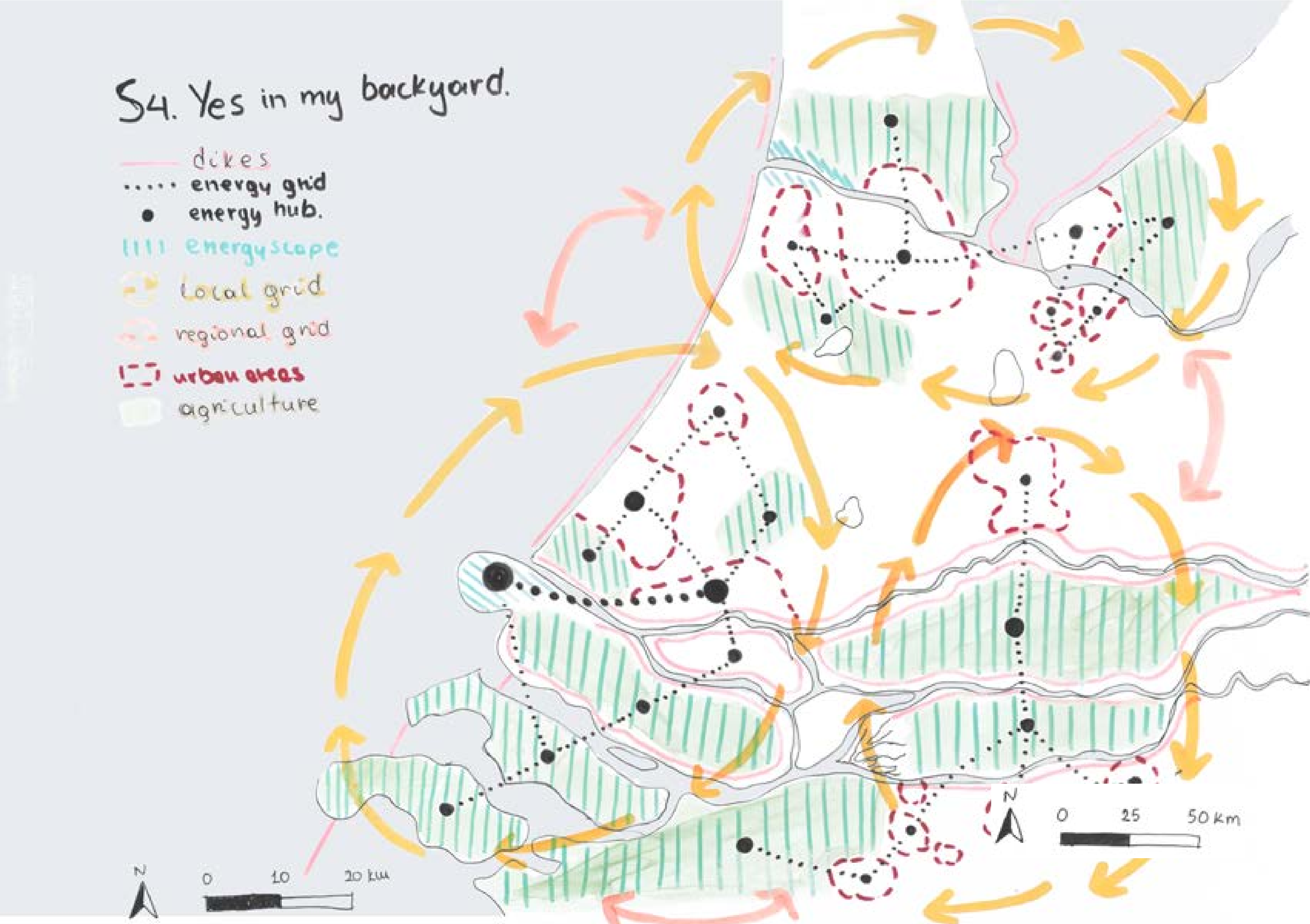


Figure 75. Vision map sketch of Scenario 04 showing energy system on a barrier-reinforced Netherlands with focus on local energy produce

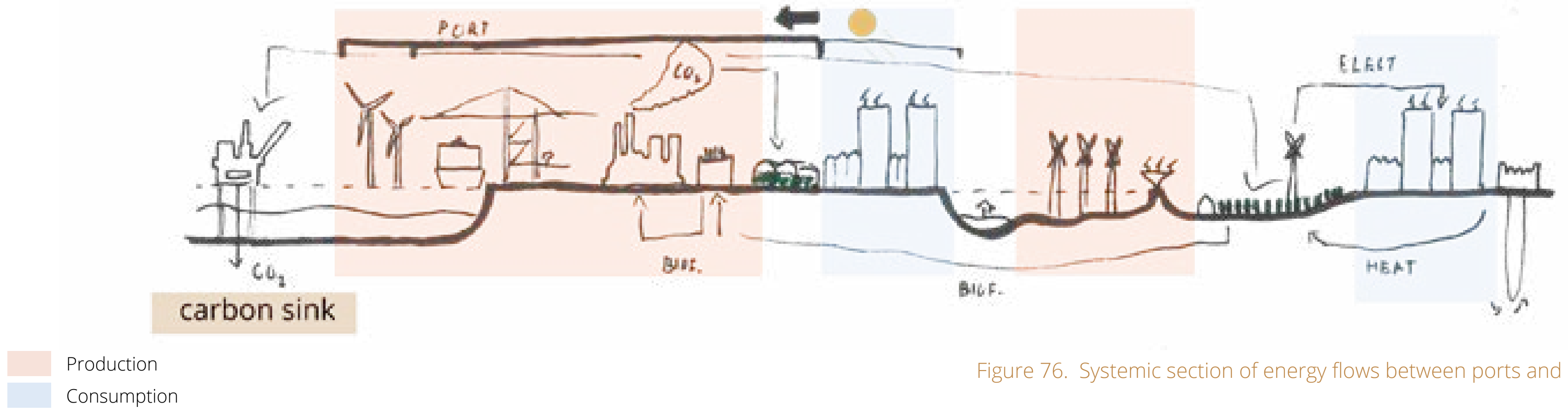


Figure 76. Systemic section of energy flows between ports and around in Scenario 04

4.6 Evaluation of the Scenarios

The next step was to find the strengths and weaknesses in the four previously illustrated scenarios. We set up an evaluation, weighing the importance of different criteria. The point of the evaluation was to support the vision-making, so we gave more weight to criteria that were deemed of higher importance in this project following the conceptual framework. The criteria are divided into three categories, following the Triple Bottom Line of Sustainability: Planet, People and Prosperity. We ranked the importance of the three P's for the project in said order. We will now clarify what is meant with the different criteria.

a. Planet

- a1. How fast a carbon neutral country is achieved

The faster, the better. Big projects take time and are less predictable in the outcome.

- a2. Impact on existing ecosystems

Less impact is favourable. Big civil projects on sea or changing the landscape have a bigger impact on the ones existing now.

- a3. Impact on biodiversity

Increasing biodiversity is desired. In S1 and S2, where more room is given for the water, there is also more room for biodiversity to blossom.

- a4. Degree of circularity

When more circularity is applied – and more locally – less energy is needed. In the project we want to close the loops and treat waste like a new opportunity.

- a5. Decrease of consumption

The greenest energy is the energy that you do not use. This is more likely in a scenario with very local energy production, where there is more awareness.

- a6. Degree of sustainable land use

Giving room to nature, more sustainable agricultural practices, fixing water issues locally.

- a7. Degree of nature-based solutions

Preferred over engineered solutions we know today. Examples of nature-based solutions ale carbon-capture with trees, carbon sinks in the North Sea and the 'Room for the River' program.

- a8. Clean water supply

Due to climate change, The Netherlands will know more times of drought. At the same time, sea level rise causes salinization of the soil. Both can endanger our access to drinking water.

b. People

- b1. Displacement of people

Although future-proofing The Netherlands for a new climate is a project which benefits multiple generations, we must try to keep the impact on the current citizens as small as possible. The displacement of people should be avoided.

- b2. Degree of participatory action

Big plans can only be realised with support of the population. Participation provides for awareness.

- b3. Conservation of heritage

Culture and remembrance of our history is important to be aware about ourselves. When we are giving room for nature, water or energy generation, heritage is to be considered.

- b4. Water safety during transition

There is a period before, during and after the transition to a new landscape that is resilient to the sea level rise. During the construction, safety must be safeguarded.

- b5. Water safety after transition

However well people and cities are adapted to the water, floods are still less safe than no floods. Water safety here means least chance of floods.

- b6. Energy supply resiliency

Shortage of energy can be catastrophic. In the scenarios where we are dependent of other countries for our energy supply, there is less security.

- b7. Employment opportunities at the port

Currently the Port of Rotterdam provides thousands of jobs. Scenarios with good employment opportunities are graded positively.

- b8. Energy poverty

This consists of the accessibility and price of energy. Overall, long transportation of energy is more expensive than local generation.

- b9. Spatial justice along the new energy supply chain

Renewable energy also has downsides. Solar panels and wind turbines contain rare earth metals that are mined on the other side of the world, more often than not under difficult conditions and is bad for the local environment.

c. Prosperity

- c1. Surface of agricultural land that is lost

The Netherlands is the second biggest food exporter in the world. This is favourable for our economy and a lot of people work in this field.

- c2. Conservation of the Randstad economic district

A lot of money is generated in the Randstad, where big companies are located. To keep the business climate of The Netherlands attractive, the Randstad is indispensable.

- c3. Reuse of existing infrastructure

The reuse of existing infrastructure saves a lot of money. Also a part of circularity.

- c4. National economy resiliency

A more independent country, not so much relying on other countries for the economy, means more resiliency.

- c5. Functional links with other countries

In contrast to c4, having relationships with other countries can also be beneficial in working together to achieve carbon neutrality.

- c6. Socio-economic importance Port of Rotterdam

The Port of Rotterdam, as stated before, is the largest seaport in Europe and therefore of high importance for trading inside and outside of this continent. Rotterdam and the whole country benefit from this position. In the scenarios the function of the port changes and therefore grows, shrinks, or stays the same.

- c7. Port and city interactions

The Port of Rotterdam has since the start moved outwards to the sea, with increased distance from the city. It is now a secluded place with no reason to go to except for work. We would like to imagine a future where the Port becomes a part of the city again, bringing the two closer together and mixing functions.

Concluding the evaluation

The evaluation gives the highest rating to S4: Yes In My Backyard. This scenario scores highest on all 3 P's, showing strength on different topics. The evaluation also shows high scores which are important to the project, circled in red. The vision will be a combination of the strengths of the different scenarios.

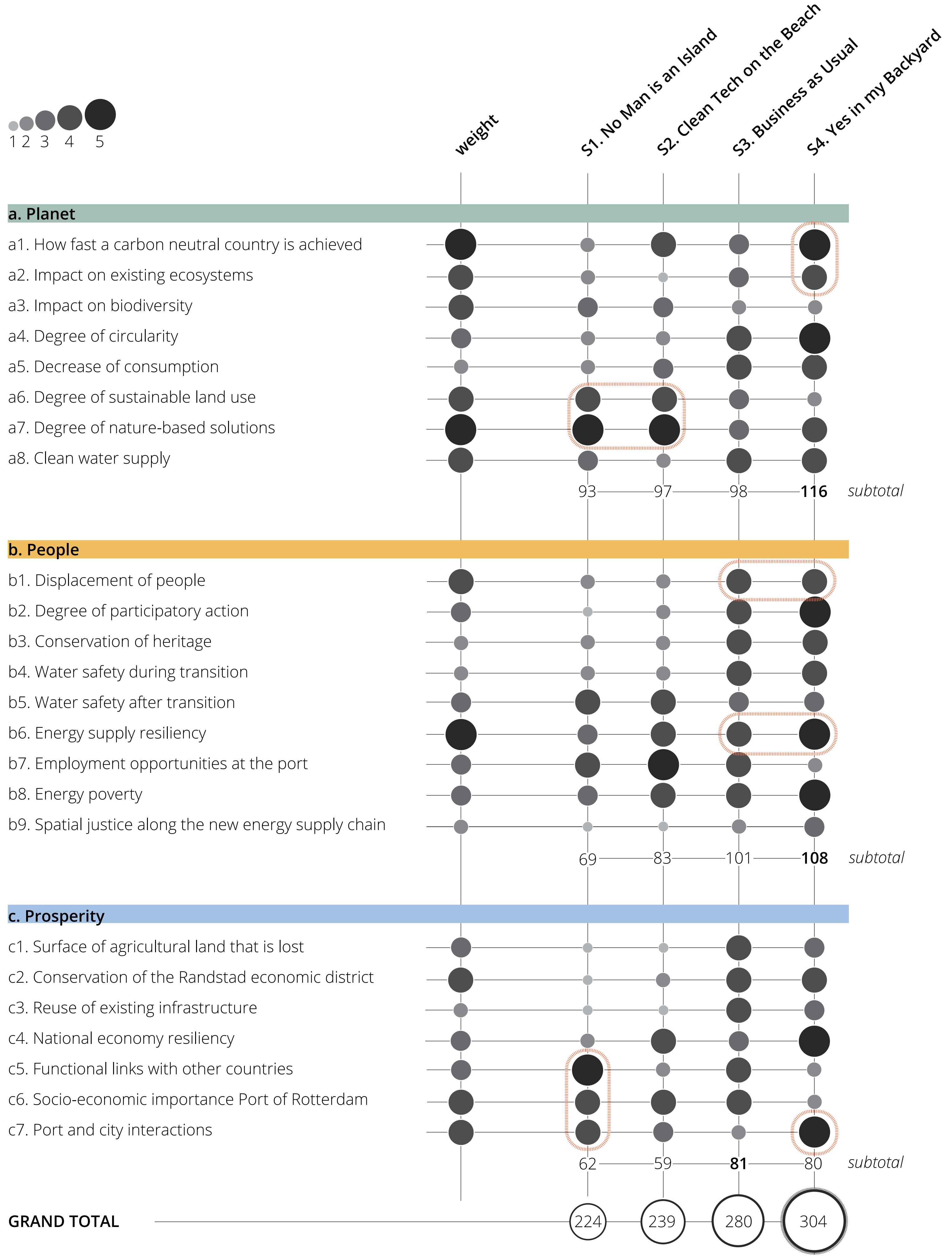


Figure 77. Evaluation sheets for the four scenarios

05

Envisioning the Port of Rotterdam Region in 2100 | Vision

5.1 Project Vision

In 2100, the Port Region of Rotterdam has found a way to live with the +2m sea level rise powered by carbon-neutral energy, ensuring inclusivity, while transforming its energy landscapes to coexist in harmony with nature.

Figure 78. Visualizations of the project's vision

A. Vision Map by Day

The Netherlands will be a frontrunner in the energy transition by having a green, independent energy system. To provide all energy inside the country's own borders, the energyscape will be extended to be incorporated into all kinds of landscapes. Energy will be generated inside cities with solar panels and geothermal heat. But the biggest part of energy production will take place in peri-urban areas, where renewable energy technology is fitted into agricultural landscapes and greenhouse waste is used as biomass. On sea, wind turbines generate a large amount energy which is directly converted into hydrogen on location.

While geothermal and biomass sources are steady during the full 24 hours of a day all year round, solar and wind are fluctuating throughout the day and seasons (figure 79). This results into an energy surplus during the day when the sun is shining, and wind is stronger/more powerful. During the day, the energy is divided inside urban clusters of cities and smaller settlements working closely together in a decentralized system. The surplus is stored in the form of hydrogen, so no energy is lost.

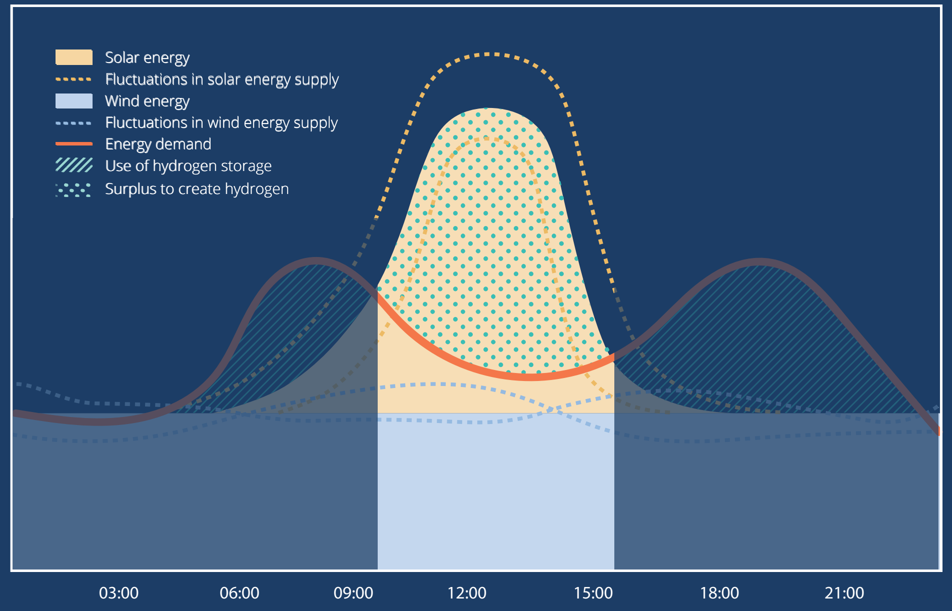


Figure 79. Renewable energy supply and demand are not aligned, therefore surplus energy has to be stored so it can be used on a time there is not enough production. In this figure, the energy surplus time is highlighted (Chen et al., 2022).

Following the evaluation, the emphasis for the landscape will be on keeping important economical and social districts and minimizing the displacement of people, all the while adopting a more natural relationship to the water. Some areas will be transformed to fit the future climate, two risks specifically. First is the increase of pluvial water because of more and heavier rain storms, putting pressure on the rivers. Therefore, more room will be given to the rivers by applying broader river banks, functioning as sponge.

The second risk is freshwater shortage, which is used for drinking water and cooling. Because of the rising sea level and the decision to let more seawater into the country via Zeeland, combined with more frequent and longer periods of drought, the freshwater supply is in danger. This issue is tackled by extending the IJmeer, a closed-off inland bay, towards the Green Heart.

In the strategic sites in chapter 6 the relationship between landscape and energy production is further illustrated.

Figure 80. Day vision map

Legend

Urban fabric
- High density city
- Water-adaptive settlement
- Port gradient
- Schiphol

Energy
- Electricity network
- Renewable energy production
- Urban clusters
- High wind energy potential
- H2 production plant
- H2 storage facility
- Solar potential

Water system
- Sea water
- Fresh water
- Tidal fresh water zone
- Seasonal floodplain
- Dune/dike protection
- Delta works

B. Vision Map by Night

At night, the energy system changes. The majority of the nights, there will not be enough energy because of less wind and no solar energy that is produced real-time. This is when hydrogen facilities will distribute the stored energy, now also between the different urban clusters. The hydrogen storage facilities are located on industrial grounds such as port regions, reusing old fossil infrastructure.

The national hydrogen storage space should be abundant so that energy generation setbacks can be compensated, in times of crises or disasters. Therefore, it is vital that although The Netherlands is independent of other countries in terms of energy supply, we will keep international energy infrastructure intact in case we do need to import energy. The other way around, in the case our surplus grows greatly, we can export this energy overseas or via pipes to other countries.

The Port of Rotterdam plays a central role in our envisioned post-fossil future as it does today but in a transformed way. Instead of serving primarily as an oil terminal and extended oil-centric landscape, it now functions as a renewable energy and storage hub. Current fossil-related infrastructure is repurposed or reused for hydrogen production or storage, while new renewable energy projects are being introduced. Historically, pollution led to the detachment between port and city (C. M. Hein & van de Laar, 2020), but as polluting activities diminish, room for diverse activities is being created. The Port has involved into an extension of the city, accommodating people as well. A gradient of activities is, therefore, implemented, from mixed-use in the eastern port area, transitioning to energy and hydrogen-related activities, and "pure" port activities in the western area and Maasvlakte. Additionally, there is a shift in the importance of inland ports, as they now play a more prominent role in the maritime trading network.

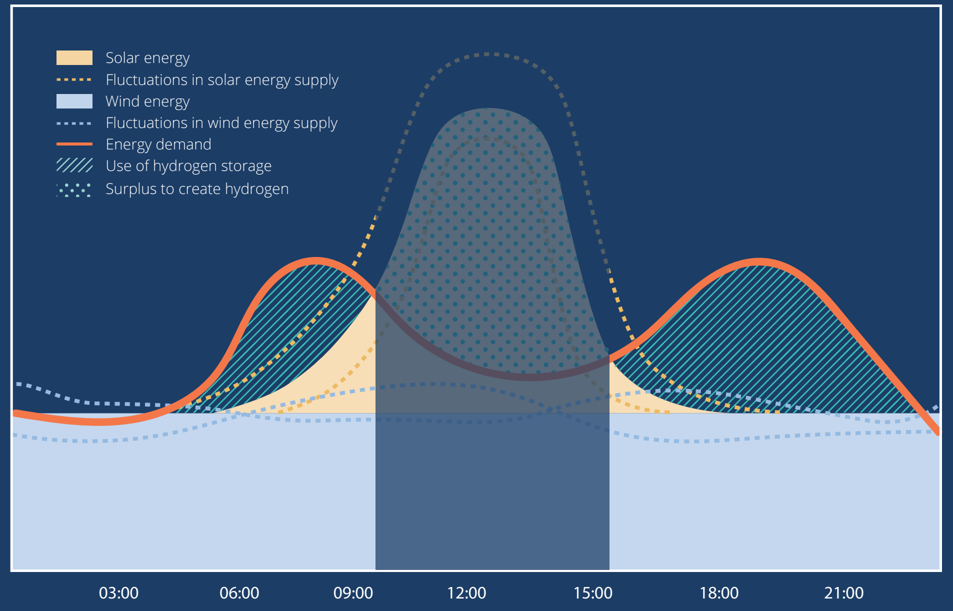
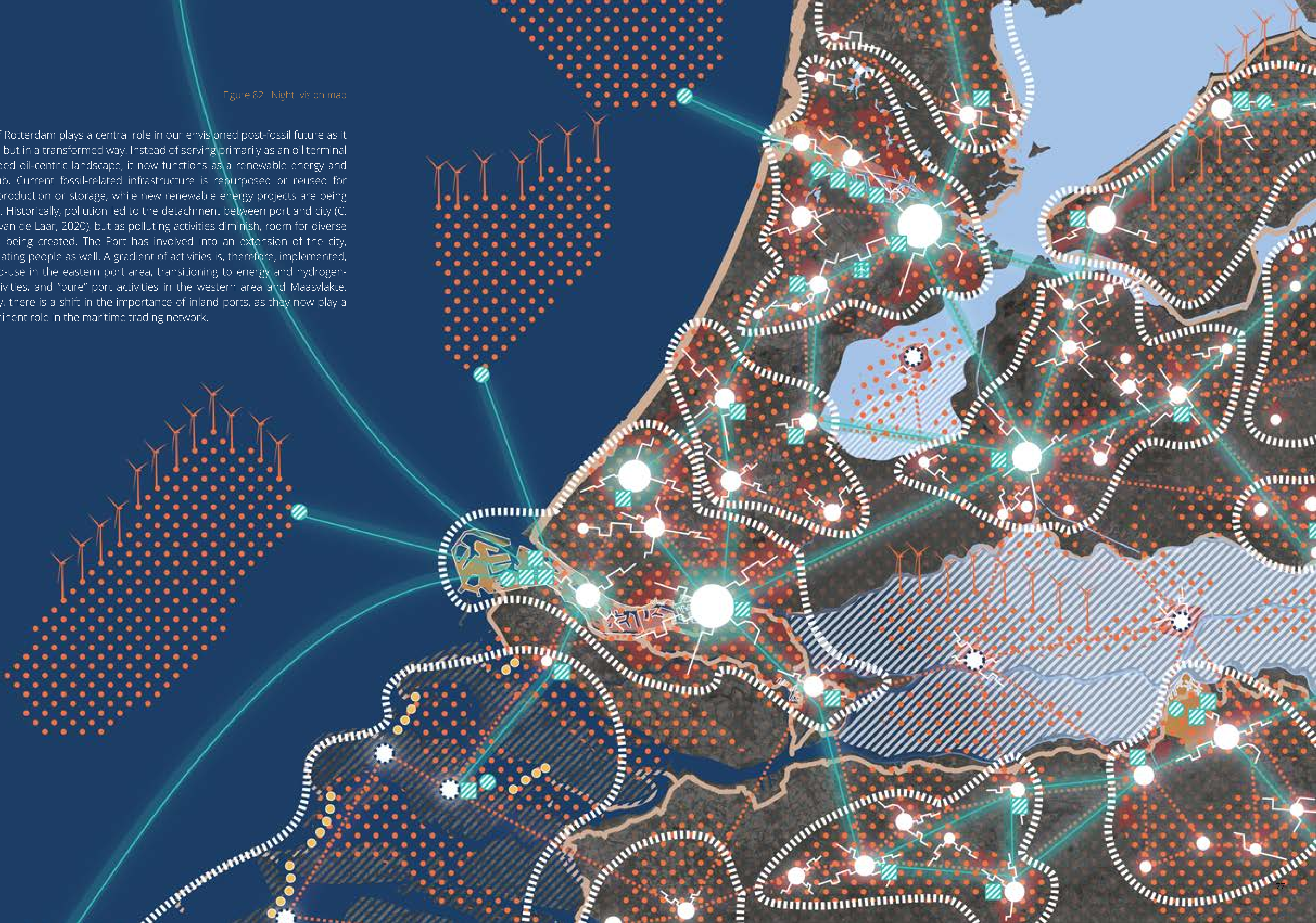


Figure 81. Renewable energy supply and demand are not aligned, therefore surplus energy has to be stored so it can be used on a time there is not enough production. In this figure, the storage use time is highlighted (Chen et al., 2022).

Figure 82. Night vision map



Legend

Urban fabric
- High density city
- Water-adaptive settlement
- Port gradient
- Schiphol

Energy
- Electricity network
- Renewable energy production
- Urban clusters
- High wind energy potential
- H2 production plant
- H2 storage facility
- Hydrogen connection

Water system
- Sea water
- Fresh water
- Tidal fresh water zone
- Seasonal floodplain
- Dune/dike protection
- Delta works

High Energy Supply

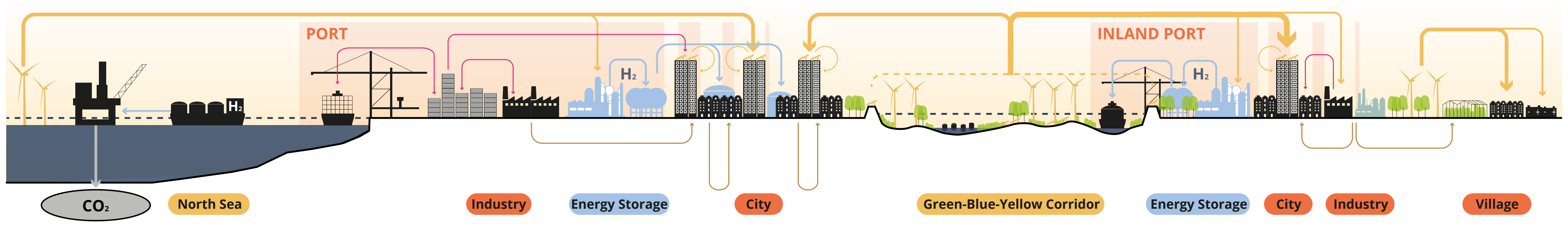


Figure 83. Sectional Diagram illustrating relationship flows during time of high renewable energy supply.

High Energy Demand

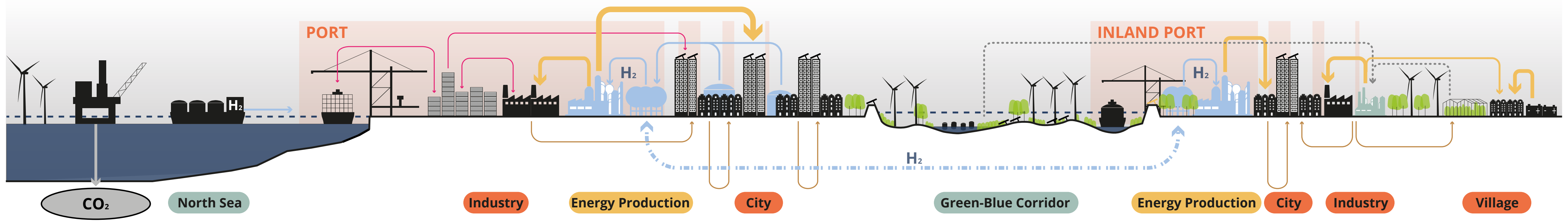


Figure 84. Sectional Diagram illustrating relationship flows during time of high consumer energy demands.

C. The New System | Systematic Sections

As shown in both sections, the new energyscape system introduces a dichotomy into the day and night timeframe. This separates the activates two different systems: a localised decentralised systems during times of high renewable energy supply and a regional connected centralised system during times of high demand, when collected and stored energy in the shape of hydrogen has to be brought back into the electricity grid and the heating system.

Legend

Flows
- Electricity
- Commodity
- Hydrogen
- Geothermal
- Biomass

Districts
- Port Area
- Energy Producers
- Energy Consumers
- Energy Storage

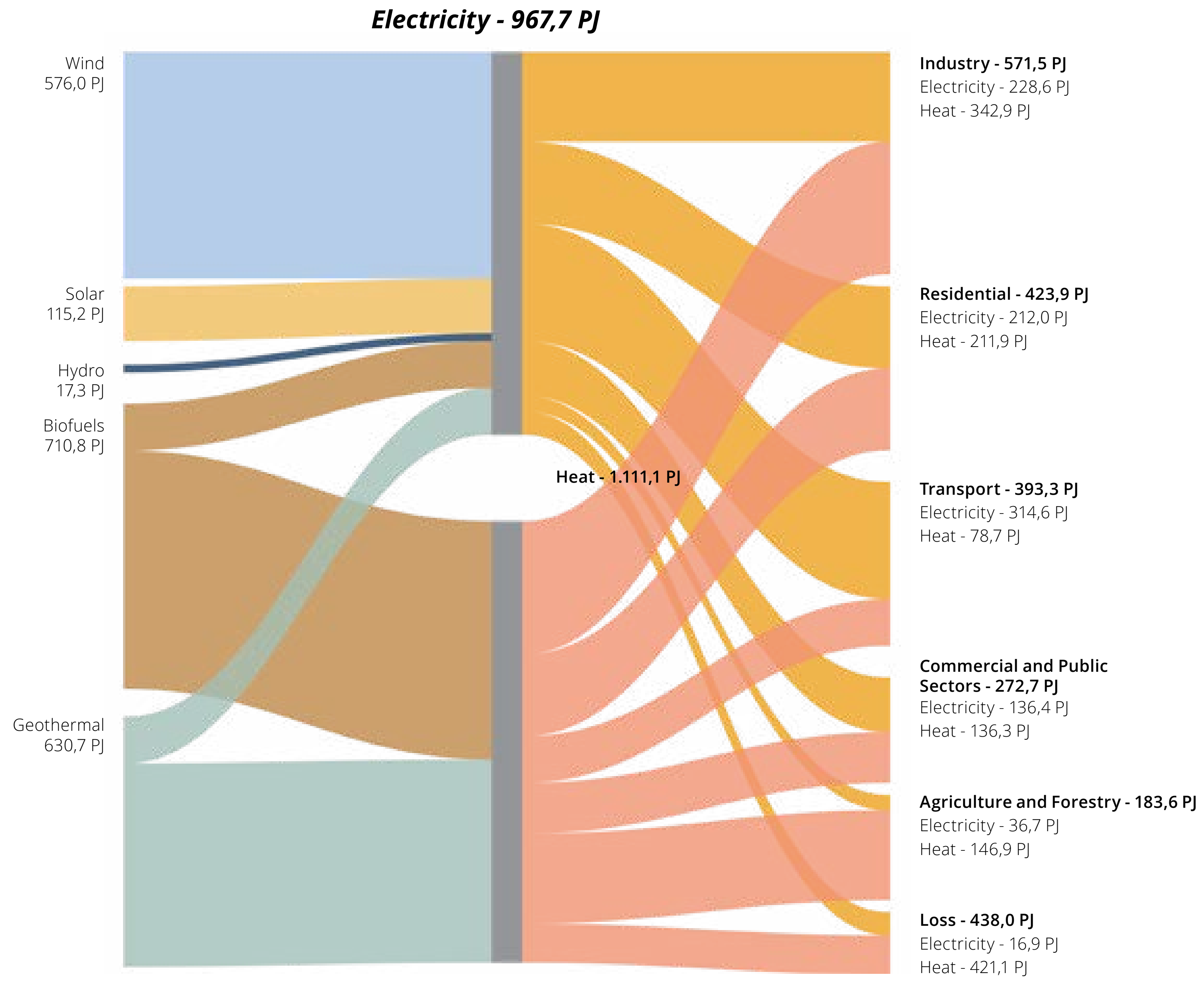


Figure 85. Sankey diagram showing data about future energy profiles of the Netherlands, consisting of electricity and heat generation using different energy source

New energy mix

The Netherlands will be a frontrunner in the energy transition by having a green, independent energy system. To provide all energy inside the country's own borders, the energyscape will be extended to be incorporated into all kinds of landscapes. Energy will be generated inside cities with solar panels and geothermal heat. But the biggest part of energy pro Figure xx shows the envisaged energy mix for the Netherlands by the year 2050. A significant notion is the different deadline from other parts of the project. In line with the Paris Climate accord, the deadline for the carbon neutral energy sector was moved from the project's 2100 end date to 2050, hence the difference. In terms of the new energy mix, two important aspects need to be discussed. As identified in relation to the current energy mix diagram, a significant issue with the Netherlands' current energy sector is that the vast majority of the energy is used in the form of heat, which is significantly harder to generate using renewable energy. To solve this issue, the policies of the project suggest widespread electrification across sectors and spatial areas, leading to electricity accounting for almost 50% of the total energy use by 2050. The second important aspect is the realisation of the Netherlands' energy independence.

Based on calculations contained in appendix x, the project concluded that the Netherlands could become energy independent, if it relies heavily on offshore wind power, domestic solar and wind power generation, and the large-scale utilisation of biomass- and geothermal-based heat energy. duction will take place in peri-urban areas, where renewable energy technology is fitted into agricultural landscapes and greenhouse waste is used as biomass. On sea, wind turbines generate a large amount energy which is directly converted into hydrogen on location.

While geothermal and biomass sources are steady during the full 24 hours of a day all year round, solar and wind are fluctuating throughout the day and seasons (figure xx). This results into an energy surplus during the day when the sun is shining, and wind is stronger/more powerful. During the day, the energy is divided inside urban clusters of cities and smaller settlements working closely together in a decentralized system. The surplus is stored in the form of hydrogen, so no energy is lost.

5.2 From Uncertainty to Visioning

During the scenario-building, each scenario provided a unique lens through which we could envision plausible future for the energyscape in The Netherlands. With a thorough evaluation process, we analysed the implications, challenges and strengths within each scenario. Instead of taking the one with the highest score, we saw the value in combining the best parts from each scenario. After showing the vision on the previous pages, we are unfolding it scenario by scenario.

S1. No Man Is An Island

From the first scenario, the offshore energy focus was adopted, although not in a shared system with other countries. Therefore, the urban clusters working together was also taken from this scenario. Finally both are tackling the housing crisis by densifying the cities.

S2. Clean Tech on the Beach

In the vision, more land is retained. Still, the concept of floating cities is adapted in some parts of the region where water can move more freely. Second, ports take on a new function as circularity and green industry hub.

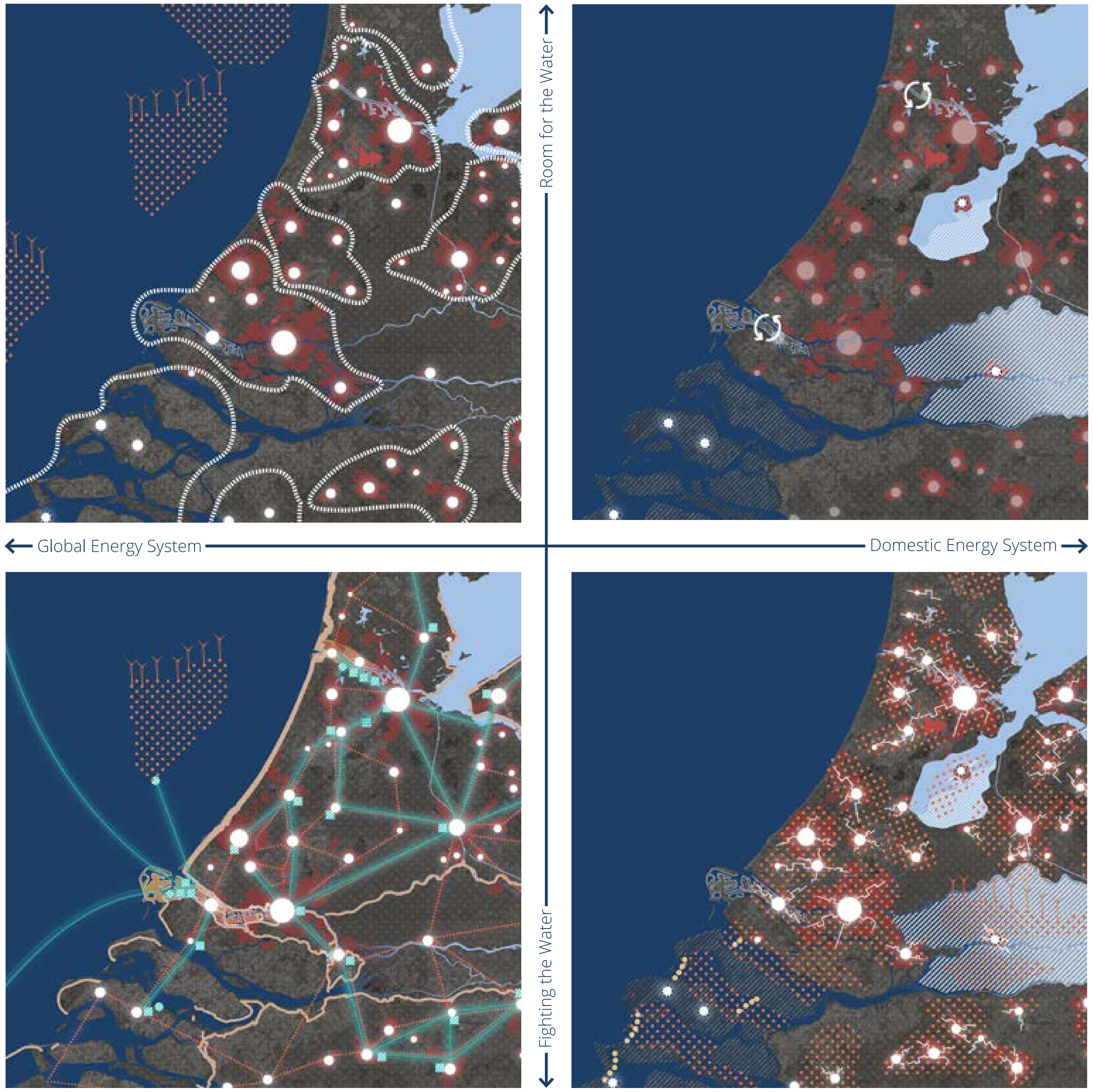
S3. Business as Usual

This scenario was all about hydrogen storage. This has inspired us to differentiate in a vision during the day, when more energy is produced than consumed, and the night when it's the other way around. Hydrogen storage facilities will be located in the larger cities and close to the energy production sites, such as the off-shore wind farms. Just like in this scenario, existing gas pipes are reused to transport the hydrogen.

S4. Yes in My Backyard

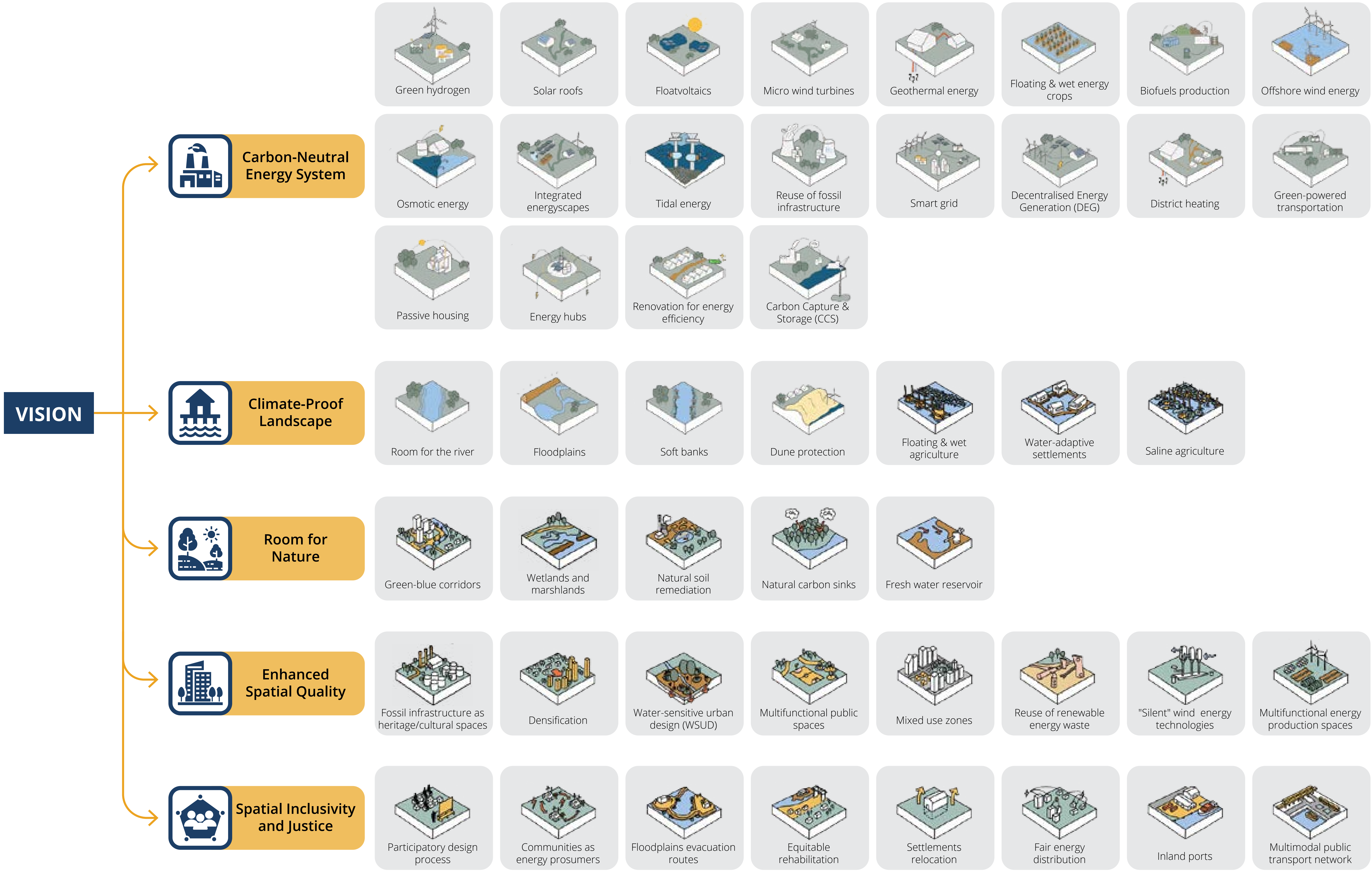
Having been graded the highest, naturally the vision has taken most from this scenario. A decentralised system accounts for the country's independency of energy supply. Energy is mostly produced in the peri-urban fabric, where energy communities are introduced. Finally, we will create floodplains around rivers for seasons of flooding.

Figure 86. Four different scenarios within two overarching axis with maps explaining excerpts we take from each scenarios for the project.



06

The Way Towards 2100 | Strategy



6.1 Development Strategy

Formulating strategies is important in order to guide measures towards the realisation of the project vision. It allows planner to identify concrete actions to be taken in the light of a vision and consists of 1) Spatial interventions; 2) A timeline; and 3) An inventory of actors and organizations (Balz, 2024).

As mentioned in the Methodology chapter, this project formulated five goals as principles in achieving the aforementioned vision. Each of the goals consist of toolkits as applicable strategies in the spatial interventions.

The first goal, Carbon-Neutral Energy System, involved toolkits for different current and potential sources of energy generation, its supporting infrastructure, and the trends of energy consumption. The second goal, Climate-Proof Landscape, included toolkits about safety measurement towards water events, and resiliency strategies responding to the possible water scenarios. The third goal, Room for Nature, focused more on water-related issues triggering different problems. The fourth goal, Enhanced Spatial Quality, emphasized strategies towards high-quality environment, including housing quality, public spaces, and acceptance of society towards renewable technologies. The fifth goal, Spatial Inclusivity and Justice, talked about the inclusion of the wider public throughout the planning process and the effort to minimise negative impact out of the entire transition.

Figure 87. Diagrams of goals and toolkits

Carbon-Neutral Energy Systems

This goal of our project is fundamentally related to SDG N.7; Providing clean and affordable energy is one of the main focuses, and the project addresses all targets of this SDG, including 100% **renewable** energy supply, research and improvements in **energy efficiency**, and ensuring **affordability** and **accessibility** to energy.

The creation of carbon neutral energy systems requires extensive **research and development** efforts, **innovation**, and **infrastructure** improvements. These objectives overlap greatly with SDG N.9, especially in terms of policies related to **regional** infrastructures, repurposing and **retrofit** efforts, and industrial research and development.

Climate-Proof Landscape

This project goal is primarily concerned with the development of urban, peri-urban, and rural environments that are **climate-neutral** and **resilient** to the effects of climate change that will be perceivable by 2100. This project goal is greatly in line with SDG N.11's target to reduce the negative effects of climate change on urban areas.

Protecting our landscapes and habitats is not only about **adaptation** to the effects of climate change that are already happening; It is just as much about **mitigation** of said effects to the greatest possible extent. The project's aspiration to stop and reverse the processes causing climate change is in line with SDG N.13, which aims at strenghtening resilience and adaptive capacities against climate change-related hazards as well as slowing down and ultimately stopping the process of climate change.

Room for Nature

The **protection** and **rehabilitation** of natural habitats and the improvement in **biodiversity** should be a crucial element of all spatial planning strategies concerned with long-term goals. Our project places emphasis on the protection of existing natural habitats and the creation of new ones. This goal reasonates with SDG N. 15. which is concerned with the **conservation, restoration, and sustainable use** of natural habitats, and the reversal of **biodiversity** and habitat loss.

Currently, one of the greatest problems with renewable energy generation is the **resource-intensity** and **lack of recycling** methods related to renewable energy sources. Our project intends to create a renewable energy system that has **circular** support industries and **material flows** in order to not only generate clean energy, but also eliminate all waste-related environmental harm. This goal is closely related to SDG N.12, concerned with efficient resurce use and management, and reduction in waste generation, through various levels of circularity.

Enhanced Spatial Quality

Improving the **quality** of urban and peri-urban spaces and **integrating** them with the new energy infrastructures is a primary goal of the project. We imagine **denser** settlements with high-quality and energy **efficient** housing, abundant and quality **green spaces**, and accessible **public transport**. This goal is closely related to SDG N.11, which also advocates for quality housing and public transport within urban areas.

Spatial Inclusivity & Justice

In relation settlements and communities, **accessible, inclusive and just** spaces are of crucial importance in the project. We thrive to provide the necessary amount of housing, green and public spaces that are accessible for everyone, regardless of **social status or disabilities.** This goal of ours overlaps with SDG N.11, which sets the target for **adequate, safe and affordable** housing and accessible, inclusive public spaces.

In terms of spatial justice, the project also considers the **social consequences** of spatial alterations it causes within the project area. The elimination of whole sector is proposed, which would result in large-scale job termination; other proposals of the project would also mean that many job types would be significantly transformed. Multiple policies place heavy emphasis on the **retraining of workers** who are already on the job market, and the **updating of training** for future generations. Such **protection of employment** and economic growth is very much in line with SDG N.8.

6.2 Aligning the Goals to the Sustainable Development Goals

This goal of our project is fundamentally related to SDG N.7; Providing clean and affordable energy is one of the main focuses, and the project addresses all targets of this SDG, including 100% renewable energy supply, research and improvements in energy efficiency, and ensuring affordability and accessibility to energy.

The creation of carbon neutral energy systems requires extensive research and development efforts, innovation, and infrastructure improvements. These objectives overlap greatly with SDG N.9, especial-ly in terms of policies related to regional infrastructures, repurposing and retrofit efforts, and industrial research and development.

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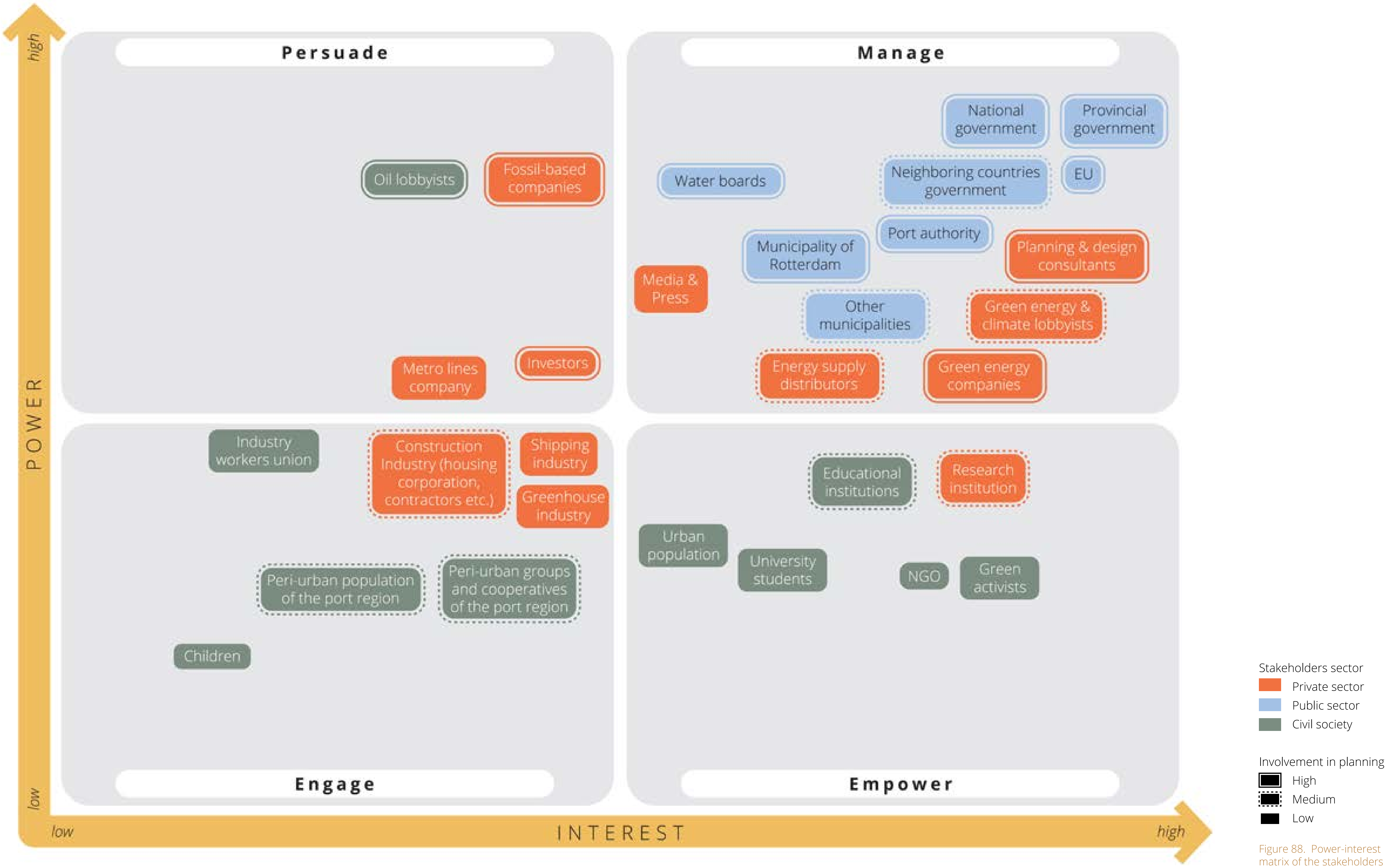


Figure 88. Power-interest matrix of the stakeholders

6.3 Stakeholder Analysis

A. Power-Interest Matrix of the Stakeholders

High interest - High power
In the public sector, governments taking part in the project belong to this group, such as the ministries of the national government, provincial government of the South Holland, and the municipality of Rotterdam along with the Port of Rotterdam's authority. They possess not only higher power to control the society with considerable influence in the planning process, but also higher interest in sustainability projects that are aligned to the policies and laws they produced, such as the EU Green Deal and the Netherlands' Climate Act.

In the private sector, climate lobbyists and companies with focus in green energy have the utmost interest towards the project, along with planning and design consultants with higher power with a big planning role for the project. Actors with lower interest and power in this group, such as the energy supply distributors and the media & press, need to be managed in order to be aligned to the project.

High interest - Low power
Research institutions and educational institutions, especially with focus in engineering and sustainability, will have great interest towards the project but with a rather low involvement and power in the decision making. It is important for this group to be subsidized as an encouragement and empower them to produce more evidence-based impact for the project. In the current situations, NGO and green activists also have high attention towards sustainability projects but often ignored and rarely involved, along with urban citizen although they will the most impacted actors before, through, and after the projects.

Low interest - High power
In this group, large fossil-based companies that have influence in energy sectors, such as Shell, BP, Exxon Mobile, and Total Energies currently hold a large interest in keeping their business as usual, therefore they possess low interest towards costly sustainability projects. However, it is important to address these stakeholders properly and persuade them to contribute into the green energy shift in order to sustain their company. Investors, on the other hand, hold a rather neutral position in the axis.

Low interest - Low power
Stakeholders belonging in this group are mostly the population living the area impacted by the project. They often have low power in the decision-making process; therefore, it is important to do community engagement to also increase their interest towards the project which might impact their general lifestyle. Industry workers possess little interest for the project, as their jobs will be impacted with the shift in petrol-based companies.

B. Power-Attitude Diagram of the Stakeholders

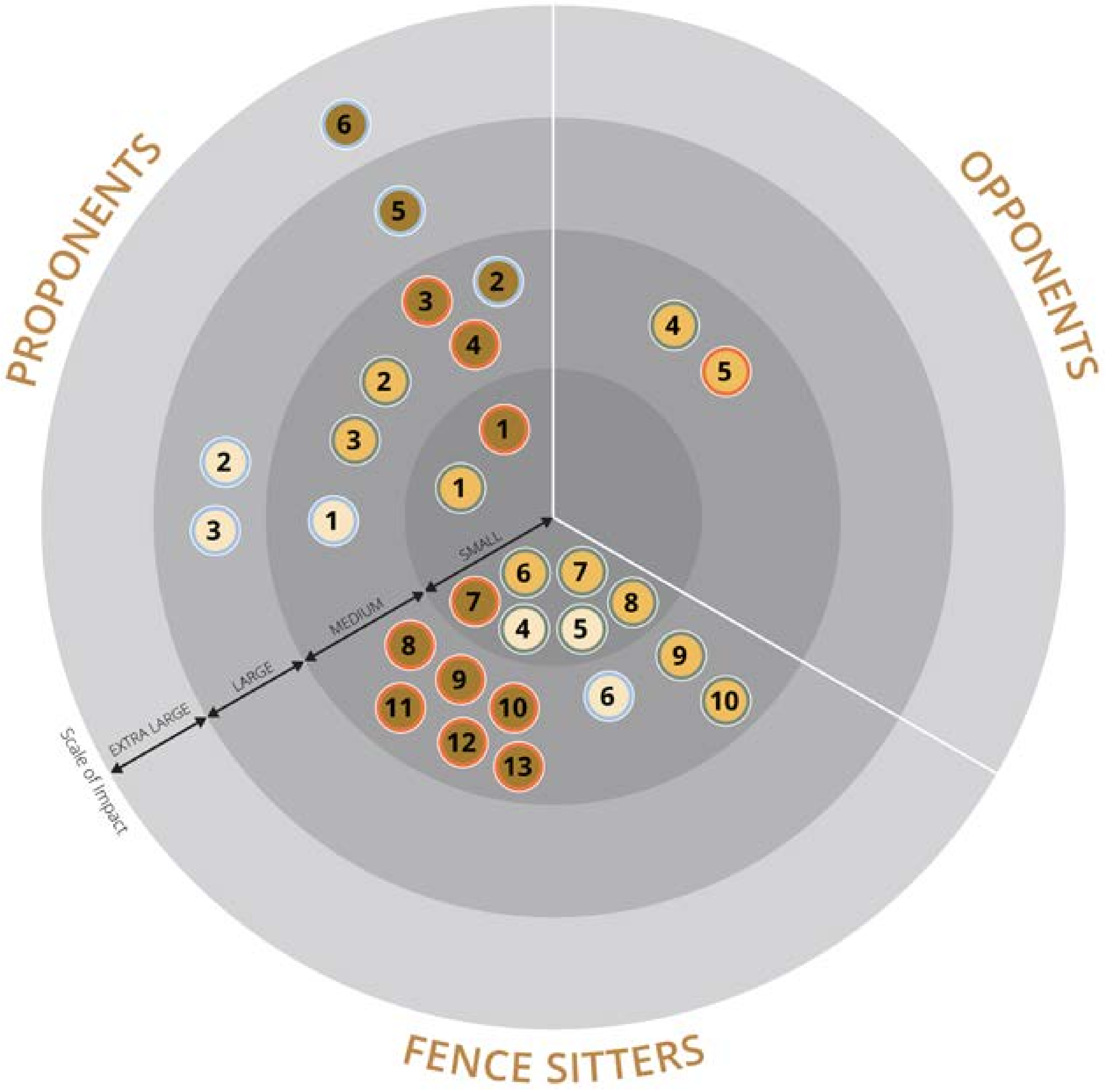


Figure 89. Power-attitude diagram of the stakeholders

Stakeholders sector
- Private sector
- Public sector
- Civil society

Actors with production power:

1. Planning & design consultants
2. Water boards
3. Green energy companies
4. Shipping industry
5. Port authority
6. EU
7. Greenhouse industry
8. Research institution
9. Media and press
10. Construction industry
11. Development banks & creditors
12. Energy supply distributors
13. Metro lines company (RET)

Actors with blocking power:

1. NGO
2. Green energy & climate lobbyists
3. Green activists
4. Oil Lobbyists
5. Fossil-based companies
6. Industry workers union
7. Urban population
8. Children
9. Peri-urban population of the port region
10. Peri-urban groups and cooperatives of the port region

Actors with diffuse power:

1. Other municipalities
2. Provincial government
3. Municipality of Rotterdam
4. Educational institution
5. University students
6. Neighboring countries government

Proponents

Actors with production power

Most of the actors supporting the project come with production power, including the governments and international organizations (e.g. EU). They have big influence in the energy transition process within policy-making domain, and have steering power to control and influence private sectors and the civil society.

Actors with blocking power

Organizations and/or actors with high interest in sustainable energy transition have power to do blocking if the project is altered and not in alignment with sustainable principles anymore.

Actors with diffuse power

The Province of South Holland and Municipality of Rotterdam, along with other municipalities support this project, but they can also do restrictions in the policy level if the project is not aligned to the existing policies.

Opponents

Actors with blocking power

The oil lobbyists and fossil-based companies will oppose the project as it will jeopardize their position, especially at the start of the project. Sustainable energy transition will lessen their power, impact, and benefit from the large industry of petrochemicals.

Fence sitters

Actors with production power

Most of the existing production private sectors (greenhouse industry, construction industry, transportation company, media, research institution) are included as fence sitters, as their reaction to the project depends on the impact affecting their respective companies.

Actors with blocking power

Industry workers along with citizen of urban and peri-urban areas included in the project can be the most impacted actors. They are able to express disagreement through protests, for example the renowned farmers protest in the Netherlands following perceived unjust government regulations towards nitrogen emissions.

Actors with diffuse power

Other actor groups that are still parts or impacted by the project in a smaller scale often have neutral position.

6.4 Policy Framework

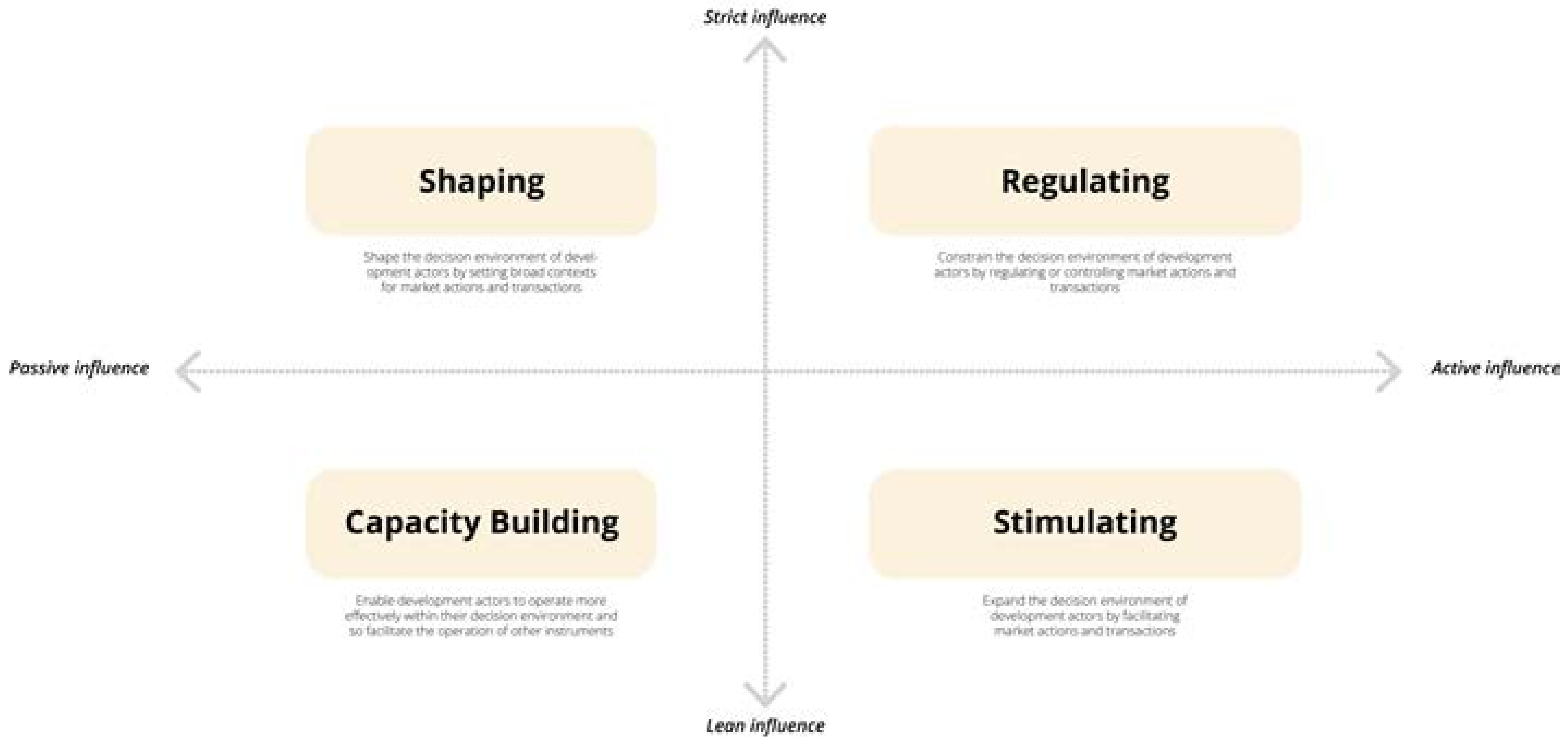


Figure 90. Planning instruments and markets (Adapted from Fred Hobma's lecture on March 18th, 2024 at TU Delft Urbanism)

Policy as a planning instrument

Policy is one of the planning instruments that can affect the 'decision-environment' of market actors to achieve desirable societal objectives, in this case, to implement certain governmental-level's visions (Heurkens et al., 2015). There are four basic types of planning tools or instruments, characterised by how it is intended to affect the market actor's decision environment: (1) Market shaping provides context or guide of how the project is intended; (2) Market regulating aims to control and restrict market actions; (3) Market stimulating attracts the development of the intended growth or change; and (4) Capacity building facilitates better delivery of the other planning tools.

In the case of each policy included in the project, it is necessary to determine the type of influence the policymakers have over the subject of the policy. The policy building uses the four main types of planning tools, taking into account the influence of each main category.

On the horizontal axis, **Active Influence** means that the policymakers have direct control over the characteristics that are subject to the policy. **Passive Influence** on the other hand means that policy makers can only influence characteristics that are in terms related to the characteristics subject to the policy itself; policymakers do not initiate the change, but passively create circumstances that will in turn lead to said change. On the vertical axis, **Strict Influence** refers to cases of policies where agency in relation to the subject of the policy remains largely in the hands of the policymakers.

Strict influence allows for more thorough and fundamental changes, with few to none subject characteristics being outside of the policymakers' control. On the contrary, **Lean Influence** is the type of influence in which policymakers outsource most of their agency to external actors. In such cases policymakers retain just enough agency to steer the direction of change through the policy itself; the actual effects of the policy are exerted by external actors leveraging agency from the policymakers.

The two different metrics with two possible values each determine the four main types of policy. When Active and Strict Influences are combined, the resulting policy will become **Regulating**; Policymakers retain most or all agency, while actively influencing the subject characteristics. Active and Lean Influences result in **Stimulating** policies; Policymakers release a considerable amount of agency but retain an active participatory role in the processes influenced by the policy. The sum of Strict and Passive Influences is a **Shaping** policy; Policymakers retain most agency in relation to the subject process, but do not actively participate in said process. Lastly, Lean and Passive Influences will result in **Capacity Building**; Policymakers release nearly all agency at their disposal, while also giving up active participation in the process initiated by the policy. In such cases, policymakers only initiate the build-up of new agency, which in turn will act according to the policy, although independently from the original policymakers.

Policy category: Shaping

SH1: Offshore Wind Power

Areas of the North Sea close to the Netherlands are idea for large-scale use of offshore wind power, due to shallow waters and optimal wind conditions (Government of the Netherlands, 2017). Offshore wind power is also effective in eliminating noise pollution concerns. Calculations concerning the Netherlands' energy and electricity demand by 2050 call for a total 40 GW of wind power, about 75% of which would be installed offshore in the North Sea. In line with existing plans by the Dutch government, the project proposes the realisation of all existing offshore wind plans, with an additional 10 GW of capacity by 2050.

SH2: Green Hydrogen in Shipping and Aviation

Hydrogen is widely considered as the best possible replacement for liquid fossil fuels in transportation, especially in shipping and aviation. Creating policies so that they favour the use of hydrogen, namely tax breaks and public subsidies for hydrogen fuel and related e-fuels would help accelerate the spread of such fuels in the shipping and aviation sectors

SH3: Floating Solar Power

The use of water surfaces, such as reservoirs, artificial lakes, and bays to generate electricity using floating solar panels is not a new concept. However, the project proposes legislation and building codes that simplify the planning, development, and approval of floating solar farms.

SH4: Power from the Sea

Osmotic and Tidal energy are only experimental technologies at present, but there is good chance that within the project's time scope they become technologically and economically feasible energy sources. As such, the policy framework must consider them as potential future energy sources. In delta areas where tides are high, tidal power will be a potential energy source. These are where Delta Works is located as a part of the water-management system and an energy generator infrastructure. Some of the delta areas are also a tidal-fresh water zone (TFZ) where salty water is mixed with fresh water, in which osmotic processes happen. Within a large scale, osmotic energy is possible to utilize. This policy outlines the intent to excessively use these energy sources in the Zeeland region, as part of the Delta Works Infrastructure upon their availability.

SH5: Emphasis on District Heating

In larger urban areas, district heating systems are efficient tools in distributing heat to homes from power plants and industrial facilities, that would otherwise go to waste. Although, multiple Dutch cities, such as Amsterdam, Rotterdam, and Den Haag already have district heating networks, these are not universally accessible, and much of the heat in them comes from carbon-intensive activities. This policy offers the necessary legislative and financial background to transform existing district heating networks into universally accessible and carbon-neutral, as well as to create new systems based on the same principles.

SH6: Integration of Geothermal Infrastructure

In close relation to the SH5 policy, the utilisation of geothermal energy in urban district heating networks is an essential element of this project. The Netherlands has excessive known potential geothermal resources that could be utilised to transition district heating networks into carbon neutral ones, by replacing carbon-intensive heat coming from natural gas plants and carbon-intensive factories with geothermal heat. The reuse of former natural gas pipelines and distribution infrastructure for geothermal energy would rapidly accelerate and better integrate the heat transition process.

SH7: Climate-Proof Settlements

The Netherlands is one of the countries most threatened by the rising sea levels, thus, the mitigation of- and adaptation to this is crucial. One of the pivotal aspects of the project is to develop settlements that are adapted to the risks of water events in flood-prone areas, and flood-proofing certain protected urban environments.

SH8: Expansion of Natura 2000 Areas

As part of the efforts to renaturalise some areas within the project boundaries, this policy proposes a cooperation with the European Union to extend Natura 2000 areas onto rehabilitated former industrial land and water areas. The inclusion of rehabilitated nature into a supranational protection scheme could serve as a pilot project for other countries future.

SH9: Soft Riverbank
This policy aims to extend the renaturalised areas by transforming riverbanks that are formerly using hard edge infrastructure (concrete walls or piles) into more soft, natural riverbanks. Similar method is used as one of the main principles of Sponge City project (Rau, 2022). Naturalising these river edges will improve soil permeability.

SH10: Natural Carbon Sink
Carbon Capture and Storage is one of the crucial elements of nearly all climate protection plans. Active and technical forms of CCS are available technologies and are included in the project, however, these are too small scale to work on the short and medium term; thus, natural passive carbon capture is needed. This policy proposes to achieve passive carbon capture by designating natural carbon sinks: large areas with intensive ecosystems composed of fast-growing plant species that are efficient in capturing CO_2. Protected seawater vegetation, such as brown algae could also act as an efficient carbon sink.

SH11: Safer, Environmentally Sound Electricity Infrastructure
Very-high voltage (>50 kV) transmission cables pose a great threat to insect and avian (bird) life, notwithstanding their negative visual effect on natural areas. Fortunately, there is technology readily available to move these cables into underground tunnels; thus, this policy provides the planning incentive to transform electricity transport infrastructure into an underground one in and around environmentally sensitive areas and close to human settlements.

SH12: Designated Energy Crop Production
Although the recycling of food and organic waste is a green and efficient source of biofuels, it is insufficient for the scale of bioenergy production our project proposes. As such, this policy outlines an incentive for the agricultural and forestry industries to cultivate and grow designated energy crops and tree species.

SH13: Plan for People-Friendly Wind Power
The primary issue with wind power technology is noise pollution. In the Netherlands, there is no current regulation in effect that protect settlements from the noise disturbance. In order to ensure the spatial justice and liveability near existing wind farms infrastructure, a buffer zone of 2.000 m is advised as a noise insulation to new development of residential areas.

SH14: Integrated Energy Generation
The project places heavy emphasis on the decentralisation of energy generation. By producing most or all the required energy on the place of use, infrastructure needs and losses coming from long-distance energy transportation can be eliminated. From a spatial policy perspective, it is important to ensure the integration of such decentralised energy generation and distribution systems into the urban fabrics of settlements within the project area.

SH15: Densification and Redevelopment of Cities
With a growing Dutch population and a decrease in the overall land area of The Netherlands, a more efficient placemaking will be necessary. This policy proposes that large urban areas should be densified with mixed-use neighbourhood and their brownfield areas including former fossil fuel landscapes should be redeveloped. As a result, the policy aims for urban population densities of around 8000 people per km2.

SH16: Integration of Spatial Inclusivity and Justice with Planning
Although, spatial planning is a process done on the large scale, planners must not forget about the importance of individuals and the inclusion of their needs and desires in the planning process. All contemporary planning systems must consider such inclusion and strive for the most just and inclusive planning system achievable. This policy explicitly calls for the integration of inclusivity measures and the desire for spatial justice into the planning process.

SH17: Ensuring Connection Lines with Water Disconnected Settlements
As the spatial strategy of the project calls for multiple settlements to be transformed into 'floating' ones, providing sufficient infrastructure and access to these settlements becomes an issue. This policy sets out planning incentives for Dutch road and rail authorities to modify their infrastructure to fit the new landscape conditions; in certain areas elevated or floati[...] lines and roadways will be necessary.

SH18: Floating and Wet Agriculture
With the development of technologies such as aquaponic and floating agriculture, floodplains and permanent freshwater surfaces will become useable 'farmland.' By integrating the needs of such land use into the Dutch planning system, the project enables the extension of agricultural activities onto suitable water surfaces improving the productivity of food and biofuel production in the project area.

Policy category: Regulating

RE1: End of Fossil Exploration (G1, G3)
It is important to note that the exploration and extraction of fossil fuels is also very energy intensive, highly polluting, and extremely harmful to the environment. In order to alleviate the damages done by the fossil fuel industry, the project proposes the prohibition of exploration efforts for new fossil fuel reserves as well as the construction of any new extraction infrastructure for known reserves.

RE2: Waste into Power (G1, G2)
A compulsory purchase scheme would be introduced requiring public and private actors to collect and provide their organic waste suitable for use as biofuels to energy companies to generate electricity and heat.

Policy RE3: Carbon Capture Quotas (G1, G2)
The primary criticism about the issue and trade of carbon emission quotas is that the system can be played easily and is just another form of greenwashing. This policy offers a different approach; instead of quotas on carbon emissions, it issues quotas on carbon capture. Every private and public company over a certain carbon emission threshold would be held liable for actively capturing a certain share of their emissions. In contrast to emission quotas, capture quotas would be non-tradeable, meaning that all major carbon emitters would be required to develop their own carbon capture infrastructure.

RE4: Environmental Clean-Up (G3, G4)
Our project proposes the redevelopment or rewilding of multiple existing industrial areas. In these areas, soil and groundwater pollution is already apparent, thus, environmental clean-up processes would need to be carried out before redevelopment or rewilding. This policy would ensure that said clean-up processes indeed happen to a satisfying extent as well as hold the industrial companies currently occupying and polluting these areas liable for the costs of these processes.

RE5: Urban Greening Efforts (G3, G4, G5)
New local policy frameworks would be created to ensure that the per capita green space in densified urban areas is increased. The policy sets out the goal of having at least 32 m2 of green space per capita within city limits; for reference, Oslo has the most green space per capita in any city with 39.05 m2 (Statista,2018).

RE6: Energy-Efficient Buildings (G1, G2, G4)
The greenest form of energy is energy that we do not have to generate; thus, energy efficiency is in the forefront of this project. All newly built buildings within the project area would be subject to much stricter energy efficiency standards, while the existing building stock would fall under the requirements of energy efficiency-improving refurbishment works.

RE7: Silent Wind Power Technology (G1, G4)
Anticipating rapid technological advancements in wind power technology, new noise regulations would be put in place regarding the noise levels of wind turbines. According to the new regulation, noise levels coming from wind turbines must not exceed 20db in the nearest inhabited area.

RE8: Sustainable Power Generation (G2)
One of the most pressing issues regarding renewable energy generation is the life-cycle waste and pollution generation. There are no incentives for reusing or recycling decommissioned solar panels and wind turbines, which become waste at the end of their useful life. The aim of this policy is to compel energy companies operating solar and wind farms to draw up plans outlining life-cycle carbon neutrality and circularity of their operations, including the complete recycling of decommissioned generating units.

Policy category: Stimulating

ST1: R&D Subsidies for Green Energy Technology (G1, G2, G4)
The continuous advancement in green energy technology is vital for the success of the green energy transition and the subsequent achievement of a carbon-neutral future. However, on a purely market-based model research and development of these technologies would not be efficient and fast enough. To solve this problem, this policy sets out public subsidy schemes for the R&D of green technologies. These technologies would include ones related to the green production, storage, and use of hydrogen energy. The policy would also support research related to other energy sources, such as silent wind turbines, greener solar panels, and more efficient and environmentally friendly battery technology. Subsidies for the research and development of green agricultural technologies would be included too.

ST2: Subsidies for Green Energy in Public Transport (G1)
Transport is one of the primary sources of energy-related carbon emissions, thus, its transition towards carbon-neutrality is crucial for the success of the project. As a public service, this sector would never be able to transition on a purely market-based approach, so once again, public subsidies would be employed to accelerate and streamline the transition process. In accordance with policy ST1, hydrogen technology, such as Fuel Cell Electric Vehicles (FCEVs) would enjoy a priority over less efficient battery-electric and hybrid technologies.

ST3: State Subsidies for the Redevelopment of Fossil Fuel Landscapes (G1)
In order to alleviate the housing shortage in The Netherlands, our project imagines the redevelopment of fossil fuel landscapes as predominantly composed of affordable housing and services. To ensure that said affordability is indeed realised, state subsidies would once again be used to prevent the housing market from driving real estate prices up in the newly redeveloped areas – a rather undesirable process that has happened in port redevelopments such as in London's Docklands, or Hamburg's HafenCity.

ST4: Tax Breaks for SMBs and Households on Green Energy Technologies (G1, G4, G5)
A further control over market processes aiming at accelerating the green energy transition would be in the form of tax breaks and household subsidies also targetting the SMBs (Small and Medium Businesses). Efficiency improving housing retrofits, and compulsory housing improvements would be eligible for subsidies, while tax breaks would apply to investments made into the deployment of green energy and agricultural technologies.

ST5: Rehabilitating Nature (G3)
Natural rehabilitation processes mentioned in earlier policies are a necessary, but expensive and cannot be conducted using private capital. State subsidies would be employed to pay for the clean-up and rehabilitation of former fossil fuel and industrial landscapes that are not redeveloped as affordable communities.

ST6: Compensation for Displaced People (G5)
Providing space for nature and water inherently means that some human settlements would need to be abandoned and rehabilitated. People that would be displaced from these settlements would be eligible for financial and/or material compensation in order to ensure socio-spatial justice.

ST7: Food Waste Reduction and Reuse (G5)
In connection with policy RE2, financial incentives for the reduction and reuse of food and organic waste products would be put in place. These would include negative subsidies – fines – on producing excessive food waste as well as tax breaks on the trade of organic waste for use as biofuels.

Policy category: Capacity Building

CP1: Raising Awareness (G1, G2)
The involvement of the civil society and the initiation of public's action during spatial transition are important. This policy proposes to do this by offering help with legislation and bureaucracy to raise awareness about the importance of green energy transition. Workshops, educational programmes, and the support for accessibility of information are tools to be used in this process. This policy hopes to successfully get farmers, landowners, and other stakeholders actively involved in the proposed decentralised energy system.

CP2: Collaboration to Deliver New Capacities (G1, G2, G3, G4)
Collaboration between state actors, NGOs, and universities would be a very efficient way of capacity building. Combining this intellectual capacity with public-private partnerships between companies, local and state actors delivering physical and financial capacities would enable a swift and efficient transition process.

CP3: Employee (Re)Training for Sustainable Energy Jobs (G1, G2)
The transition towards carbon-neutral energyl systems will inherently result in the loss of thousands of jobs, especially in the fossil fuel and related sectors. By offering retraining for existing workers with a heavy emphasis of port workers as well as new career paths for people newly entering the energy labour market, the operating capacity of advanced high-quality energy systems could be significantly increased in a relatively brief period of time.

CP4: Sustainable Agriculture Training (G1, G2, G5)
Similarly to policy CP3, the new, technologically advanced agricultural industry proposed by the project would also require skilled and well-trained workers. By training current as well as future farmers to work with innovative technologies, such as adaptive crops, salinisation, energy crops, and biowaste recycling the necessary workforce could be provided on the highest levels of efficiency and social justice.

CP5: Citizen Participation in Planning (G2, G3, G5)
As mentioned earlier in policy SH16, inclusivity and spatial justice are crucial elements of all desired planning systems. An efficient tool to create such a planning system is the initiation of participatory planning and community engagement during planning processes. Facilitating participation in spatial planning through co-design and ensuring the continuity of citizen participation through platforms to enable community feedback and input on spatial planning and development.

CP6: Public Initiative for the Development of Prosumerism in Energy Capacity (G1, G5)
The creation of a prosumerist, integrated and decentralised energy system is one of the primary objectives of this project. However, the importance of public participation and initiative in achieving this goal needs to be acknowledged. This policy proposes initiatives for both household-level prosumerism using rooftop solar panels, micro wind turbines, and domestic energy storage capacities, and on the community level, with localised grids, community energy sharing processes, and so on.

6.5 Project Roadmap

A. Phasing Framework

By situating the project within the currently established policies of the Paris Agreement and the EU Green Deal it becomes clear that the energy transition and the phasing out of fossil fuels to become carbon neutral is at the most importance (United Nations Framework Convention on Climate Change, n.d.) (Fetting, 2020). With this in mind the project timeline can be separated into two phases: one being 'before 2050', which focuses on carbon neutrality in the energy sector, and the other 'before 2100', which adapts the landscape to be ready for the worsening climate situation. While cities and settlements are gradually implementing climate proof changes in their structures, the large-scale interventions in the peri-urban area pushed into the last phase as numbers stating temperature rise and sea level height are still unpredictable and will be determined by the years to come.

The carbon neutrality phase stretching before 2050 is in itself a condensed period of many changes to come. To better understand this transitionary phase the sensemaking tool 'X-curve' can be used to breakdown the phase into more understandable fractions (Silvestri et al., 2022). By taking the 'patterns of build-up' line, the energy transition can be broken down to Acceleration and Stabilisation. The Acceleration phase must incorporate a lot of new renewable energy sources into the current energy grid to be able to reduce and dismantle the current fossil fuel energy power generation. The Stabilisation phase focuses on mediating the renewable energy output supply and the energy consumption patterns. Renewable energy production and citizens usage of energy timelines do not overlap. This requires an element of energy storage to hold and transfer the energy from excess production periods to higher demand periods during the day. This also requires storing the produced energy outside the current electricity grid, as to prevent the whole grid from overloading and collapsing (Stekker, 2023).

This means the project can be divided into 3 phases, that are considered from the beginning to ensure that first design steps do not contradict future decisions but have a separate emphasis period for decision and budget makers to ensure the feasibility of the project:

Figure 91. Phase 1 diagram drawing

Phase 1 - Deployment of renewable energy production & system

By focusing on peri-urban areas to incorporate renewable energy production, such as solar, wind, tidal and biomass, this decouples the energy production from fossil fuel power plants and empowers areas that are usually neglected and forgotten.

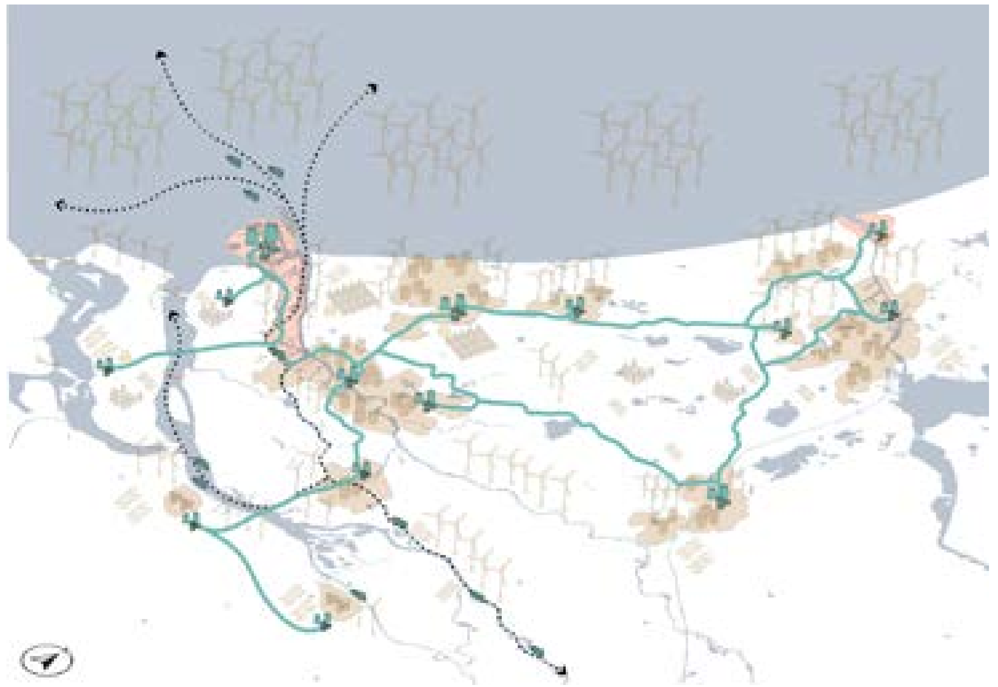


Figure 92. Phase 2 diagram drawing

Phase 2 - Infrastructure repurposement and hydrogen system application

By focusing on larger urban areas that require a large amount of constant power sources to construct a hydrogen power network being capable of storing and transferring the produced renewable energy from Phase 1, this softens the spikes between the supply and demand curves while also distributing the energy equally to every resident.

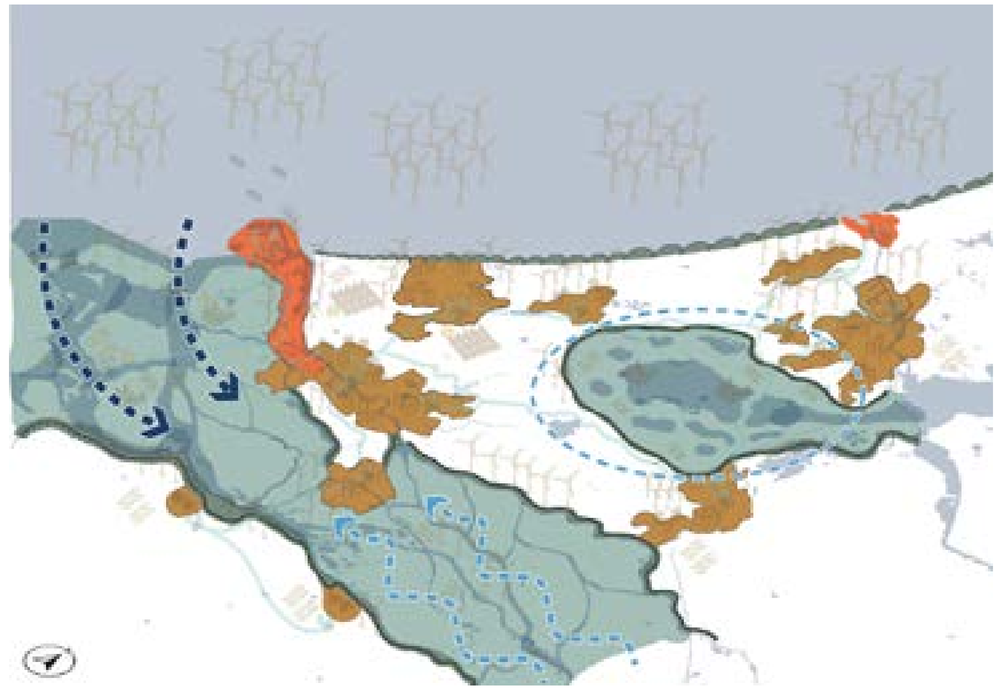


Figure 93. Phase 3 diagram drawing

Phase 3 - A transformation into an adaptive landscape

By focusing on both urban and peri-urban areas to adapt the built environment, such as cities, small settlements, and farms, to the upcoming worsening flooding situations. This ensures that the transformed energy system is not susceptible to natural disasters and can be operating during times of climate crisis.

B. Project Timeline

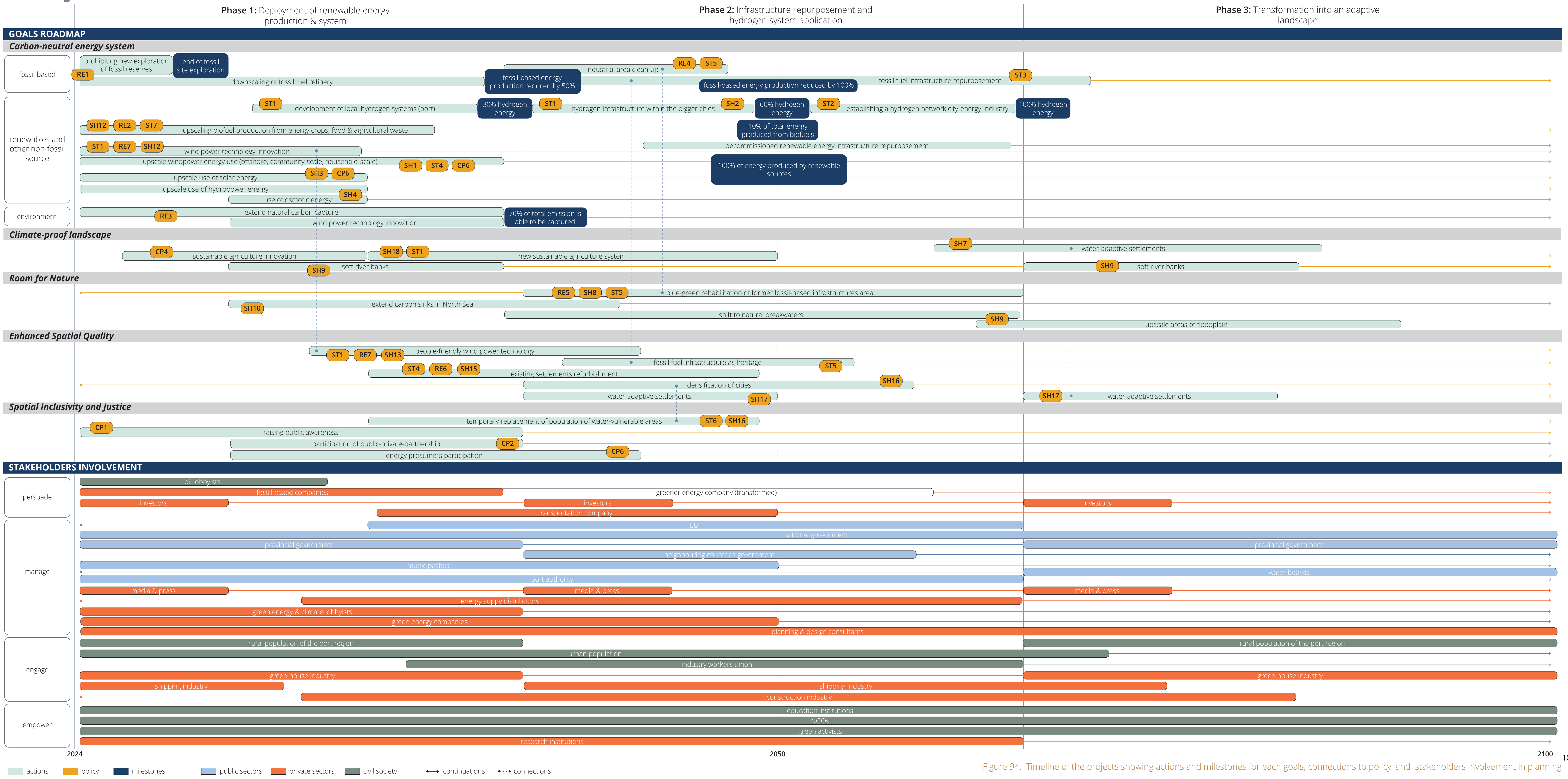
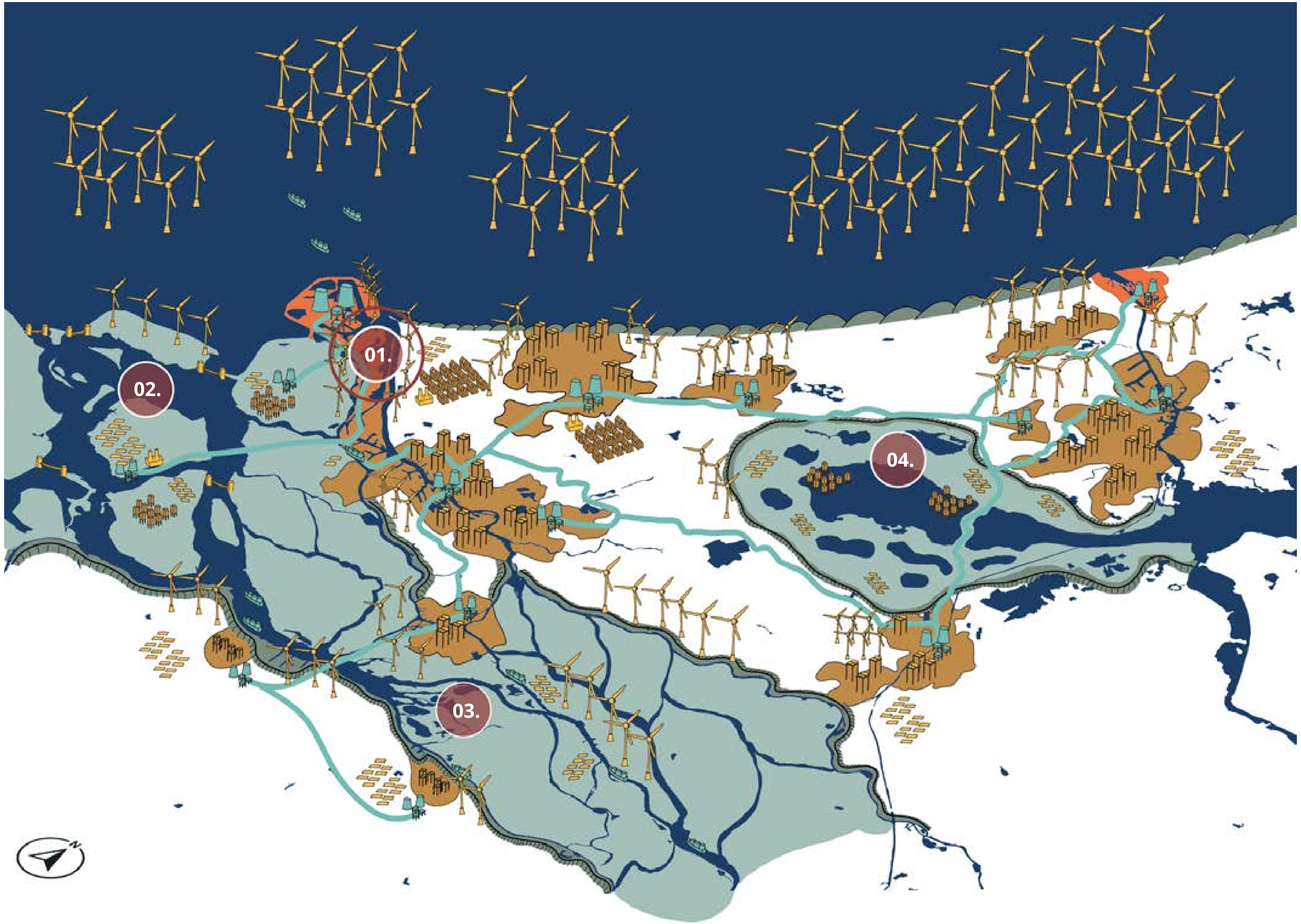


Figure 94. Timeline of the projects showing actions and milestones for each goals, connections to policy, and stakeholders involvement in planning

6.6 Strategic Sites and Pilot Projects



To implement the general post-fossil fuel energyscape strategy in the Rhine-Meuse Delta region, 4 strategic sites are chosen to illustrate how this systemic transformation can countries landscape.

The key strategic site of – Port of Rotterdam is an integral part of the current polluting energyscape problem and addresses our research question and future vision. The port and its surroundings offer a strategic position and a perfect testing ground for decentralised carbon-neutral strategy. While there are common problems in many of the North West Europe ports, by limiting ourselves to the Port of Rotterdam, a more in-depth analysis can be complete for the local challenges, phases, policies, and actors. The key strategic site illustrates the implementation of the final vision and acts as an example project for other fossil fuel dependant European ports.

The additional 3 exemplary strategic sites incorporate many pilot projects that together form the final spatial vision for the western part of the Netherlands. These large-scale sites illustrate how can these peri-urban spaces can become water adaptive, nature inclusive and clean energy producing landscapes.

- 01. Key Strategic Site | Port of Rotterdam
- 02. Exemplary Strategic Site | Zeeland's Osmotic and Tidal Power
- 03. Exemplary Strategic Site | Connecting the New Inland Ports
- 04. Exemplary Strategic Site | The New Blue Heart

Figure 95. Birds-eye view sketch showing the spatial interventions of the vision with the chosen strategic sites.

A. Port of Rotterdam | Key Strategic Site

Current landscape under transformation

The current port's landscape is going under a major transformation. In 2100, the fossil fuel-related activities have phased out and new activities have developed in the port area. The dunes now serve as a protection zone but also recreational areas. Huge piles of coal are not needed anymore. Storage infrastructure is being reused as housing, heritage or hydrogen storage. Cargo is concentrated in Maasvlakte. River banks are no longer hard and enhance connection to water. Disconnected residential areas are now connected.

Figure 96. The dunes area in Maasvlakte

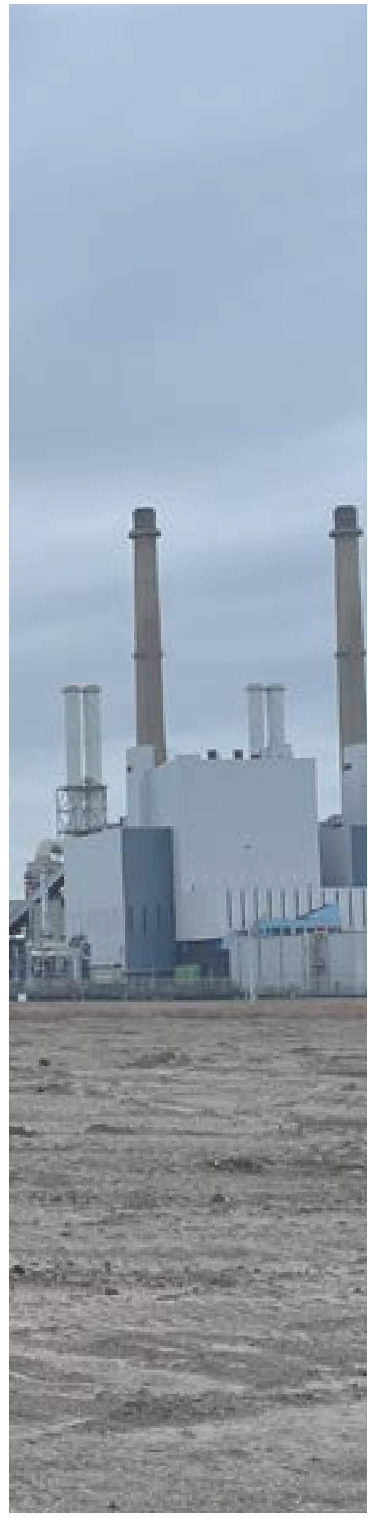


Figure 97. Industries in the western area of the port

Figure 98. Dry bulk storage in the port

Figure 99. Coal power plant

Figure 100. Cargo shipping in the port, the port as a transshipment hub

Figure 101. Hard river banks in Rozenburg

Figure 102. Rozenburg: a disconnected settlement in the port

Phase 1

In the initial phase of transforming the Port region, the main focus is on integrating additional renewable energy projects in the port area and the territory around, including offshore. This involves expanding existing solar, wind, and geothermal energy production systems considering the different potential typologies and where they are located. Additionally, biomass energy production is being introduced promoting symbiosis between greenhouses areas and energy industries. All the above, contribute to the decoupling of fossil-related energy production and promotes spatial justice as now all areas, including peri-urban ones that are usually overlooked, play a role in the transition. Additionally, in the beginning of port's shift cargo activities expand in Maasvlakte area, giving room for new urbanization around the docks located in the eastern port area. As a result, mixed-use areas start to develop gradually.

Legend

Urban fabric
- High density city
- Low density city
- Water-adaptive settlement
- Airports
- Port
- Cargo
- Cargo movement

Landscape
- Pastures
- Agriculture
- Greenhouses
- Soft river banks
- Floodplain
- Tidal park

Energy
- Electricity network
- Existing hydrogen piping
- Hydrogen piping
- Repurposed natural gas piping
- Hydrogen facilities
- Solar farm
- Wind turbines
- Tidal turbines
- Geothermal
- Circularity hub

Water system
- Water
- Dune protection
- Slow boats area

0 2,5 5 km

Figure 103. Port of Rotterdam - phase 1 (PDOK, 2024) (CLC, 2024) (EU, 2024)

Phase 2

Along with creating a new efficient renewable energy environment, focusing on areas that require large amounts of constant power, an extended hygrogen system is being introduced to store and transfer energy and ensure that none of it is wasted. At the same time, the energy system becomes resilient and the constant power flow is not impacted by climate conditions. This moderated the different spikes in supply and demand curves during day and night, while ensuring that energy is distributed equally to all communities. For this network, existing hydrogen distribution infrastructure of the port is being used, alongside with repurposing natural gas pipelines and storage facilities to accommodate the extended hydrogen network. Hydrogen plants grow near high demand and production areas with minor distribution expansion needed to facilitate them. During this phase of transformation, new urbanization takes place north of Hoogvliet, where dense fossil-related activities were taking place before. Fossil infrastructure is being repurposed, creating industrial parks, commercial zones and residential areas. Additionally, circularity and refurbishment hubs are introduced in the port, facilitating the upcycling and repurposing of renewable energy-related, and other materials.

Legend

Urban fabric
- High density city
- Low density city
- Water-adaptive settlement
- Airports
- Port
- Cargo
- Cargo movement

Landscape
- Pastures
- Agriculture
- Greenhouses
- Soft river banks
- Floodplain
- Tidal park

Energy
- Electricity network
- Existing hydrogen piping
- Hydrogen piping
- Repurposed natural gas piping
- Hydrogen facilities
- Solar farm
- Wind turbines
- Tidal turbines
- Geothermal
- Circularity hub

Water system
- Water
- Dune protection
- Slow boats area

0 2,5 5 km

Figure 104. Port of Rotterdam - phase 2 (PDOK, 2024) (CLC, 2024) (EU, 2024)

Phase 3

As climate change accelerates, water related risks are getting worse and the need for more adaptive landscapes. Therefore, the third phase of port region's transformation focuses on transformation in both peri-urban and urban areas that will ensure the safety of communities and the resilience of the human and natural systems. Although most of the focus on transitioning to an adaptive landscape takes place during phase 3, implementing water adaptive principles in planning starts from the very beginning of the transition, especially when new areas are being developed or others being retrofitted. As key interventions for this phase, tidal parks appear around rivers to enable water infiltration and prevent flooding, as well as soft riverbanks. Additionally, the west coasts are given back to nature to grow and thrive, with an expanded natural reserve. Furthermore, to promote the city's relationship with water, a slow boat area is being introduced so cargo ships do an alternative route toward the inland ports and the area is now promoting citizens slow traffic modes and recreation.

The above-mentioned interventions support local natural ecosystems, promote biodiversity, while enhancing the spatial qualities of the areas transformed. During this stage, water adaptive settlements grow, while areas around Rozenburg densify, creating a smooth transition to the higher and more dense structures of the port.

Legend

Urban fabric
- High density city
- Low density city
- Water-adaptive settlement
- Airports
- Port
- Cargo
- Cargo movement

Landscape
- Pastures
- Agriculture
- Greenhouses
- Soft river banks
- Floodplain
- Tidal park

Energy
- Electricity network
- Existing hydrogen piping
- Hydrogen piping
- Repurposed natural gas piping
- Hydrogen facilities
- Solar farm
- Wind turbines
- Tidal turbines
- Geothermal
- Circularity hub

Water system
- Water
- Dune protection
- Slow boats area

0 2,5 5 km

Figure 105. Port of Rotterdam - phase 3 (PDOK, 2024) (CLC, 2024) (EU, 2024)

Land Use Map

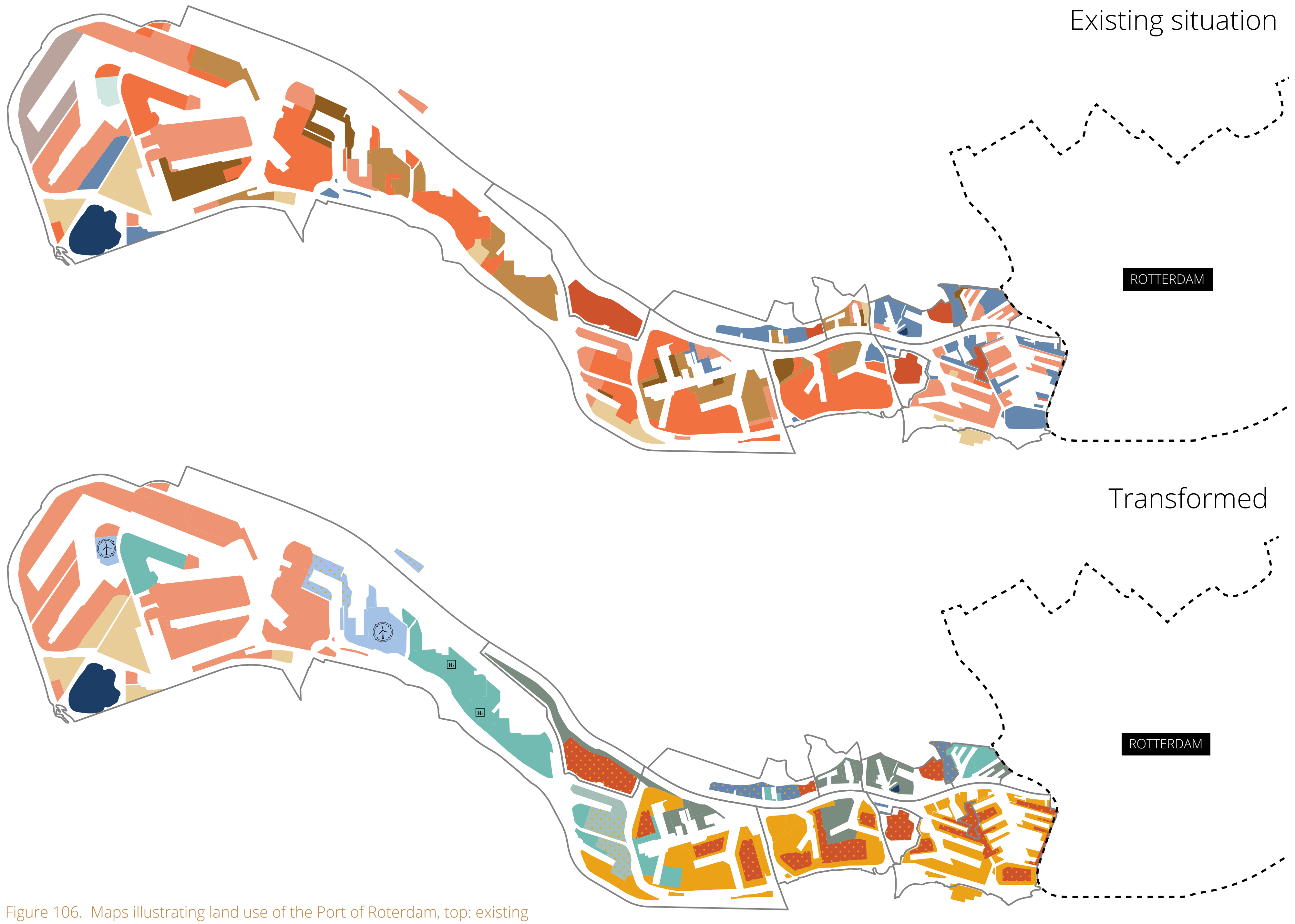
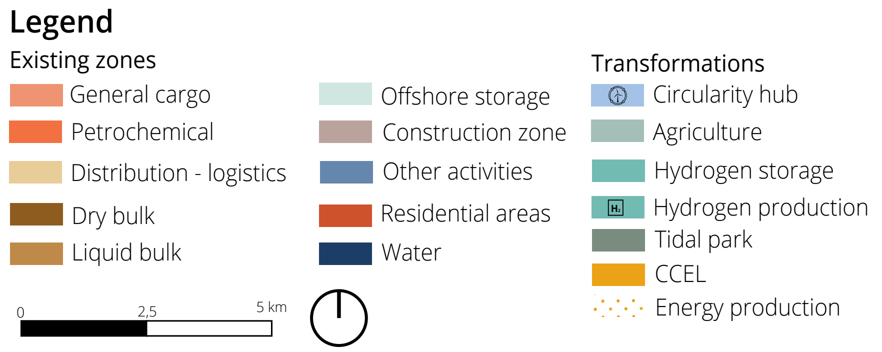


Figure 106. Maps illustrating land use of the Port of Roterdam, top: existing land use, bottom: transformed zoning plan, (Port of Rotterdam, 2017)

Historically and into modern times, the Port of Rotterdam has been defined by its fossil landscape primarily serving activities related to petrochemical and fossil fuel industries (Figure 106.). Furthermore, it operates as a hub of cargo transshipment, hosting extensive storage and logistics infrastructure for both general cargo and bulk goods. However, as fossil-related undergo transformation, paving a renewable energy path, a shift towards a less polluting environment is ongoing. Therefore, opportunities are opened up for more human-scale activities, fostering mixed-use energyscapes that accommodate renewables, agriculture, residential areas, education facilities, commercial zones, and natural ecosystems.



Main focus of transformation

As illustrated in figure 107. the main focus of land use transformation circulates around fossil and petrochemical-related activities, cargo, and bulk. The zones under transformation give room for new urbanization, hydrogen activities and Commerce Culture Education Leisure (CCEL) zones. More information on the main additional land use – CCEL - will be given in the next pages.

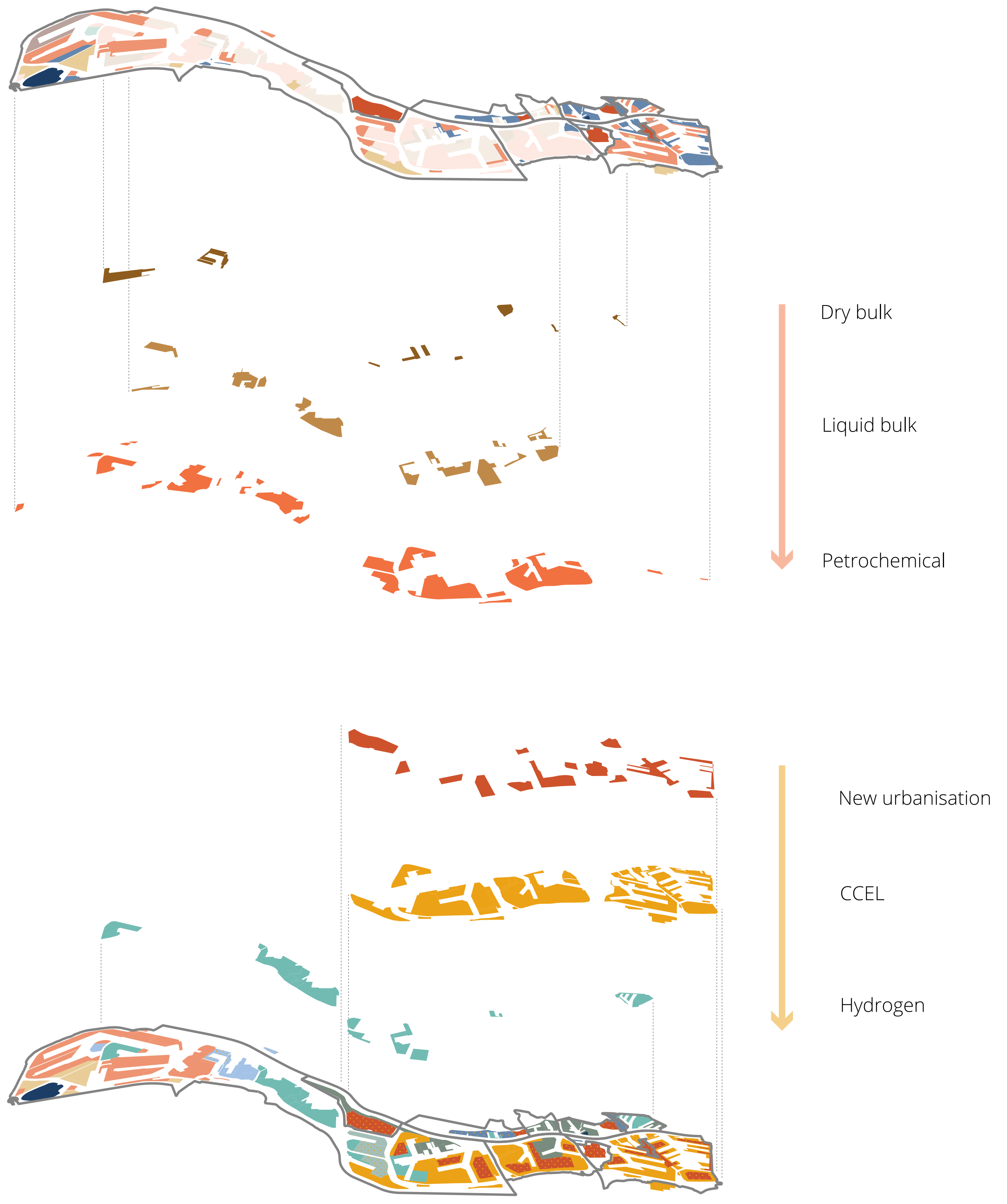


Figure 107. Diagram illustrating the main focus on land use transformation, top: transforming, bottom: adding

Toolkit used

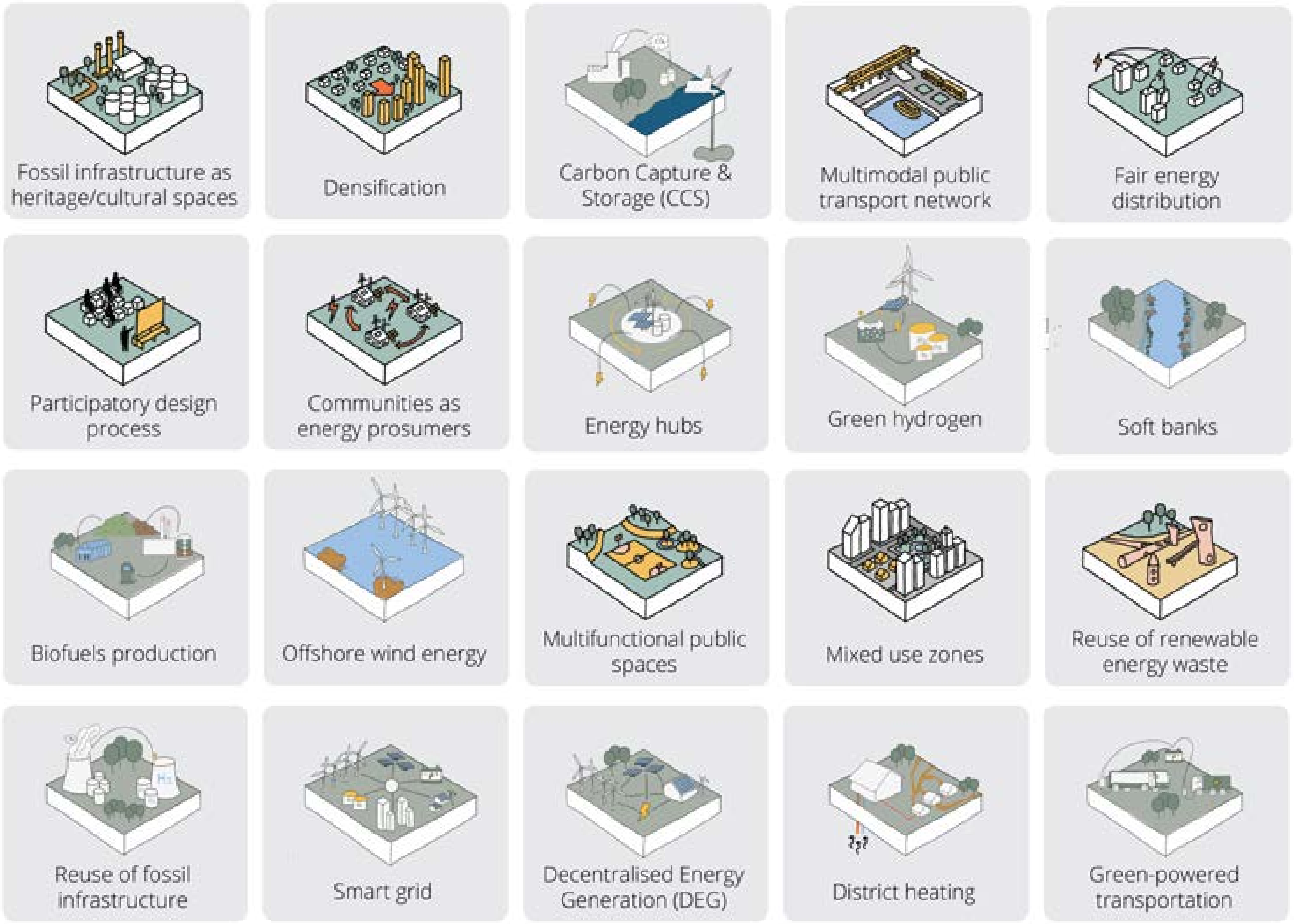


Figure 108. Toolkits used in Port of Rotterdam strategic site.

Reference projects

Figure 109. Ruhr area de-indusrtialization process

The Emscher Landcape park in Duisburg-nord, located in the Ruhr Area in Germany, is a key example of de-industrializated landscape that included methods like ecological reconstruction of the river, reusing industrial structures, and use of art as a creative tool to give new character to former industrial areas (Amenta, 2019). The conceptual approach was to "re-interpret and reconnect fragments of former industrial structures" to create a brand new landscape. The project allows us to see an alternative to leaving fossil-fuel landscapes as plain brownfields as the energy transition accelerates.

Figure 110. Stadshaven project in Amsterdam, (Gemeente Amsterdam, n.d.)

The area of Haven-stad in Amsterdam undergoes a big transformation by changing 650 hectares of industrial port territory into an urban district. This ambitious vision is at the forefront of the municipality of Amsterdam's development strategy for Port-City. In the plan new commercial and residential zones will develop, accommodating up to 70,000 residences and 58,000 employment opportunities, all combined with essential amenities such as educational facilities, recreational spaces, public transportation, healthcare services, and green spaces (Gemeente Amsterdam, n.d.)..

Mobility

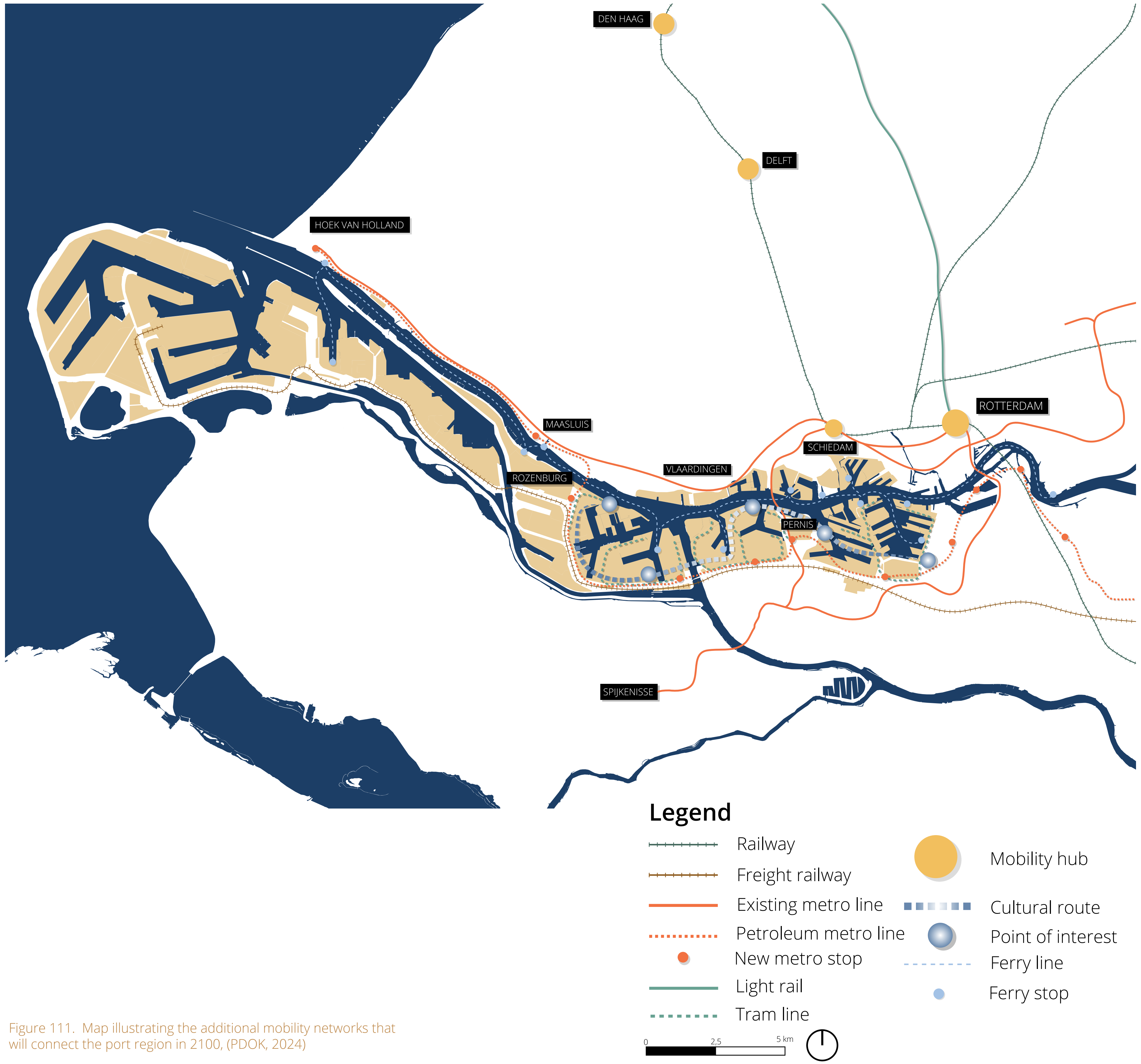


Figure 111. Map illustrating the additional mobility networks that will connect the port region in 2100, (PDOK, 2024)

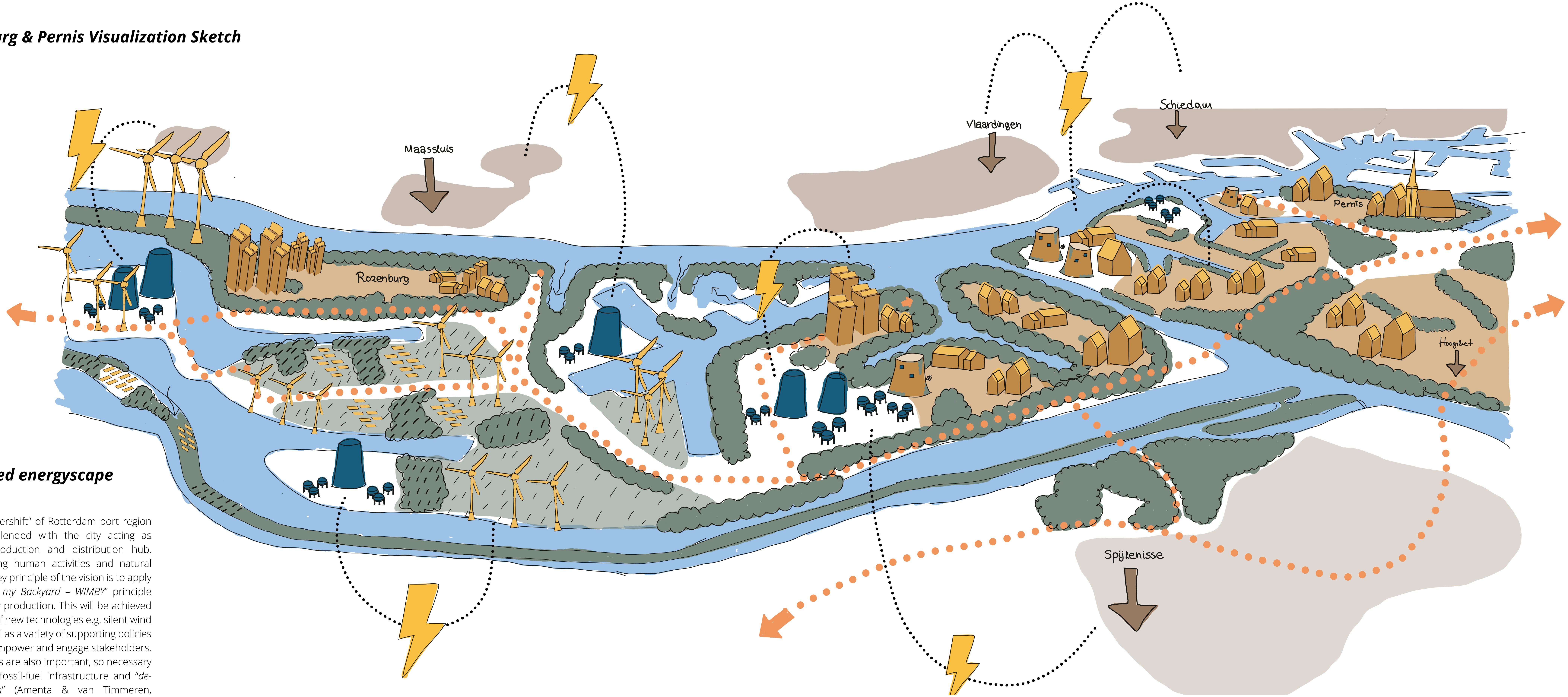
To improve the connection of new urbanization areas in the port and the city, additional fixed track means of transport are being introduced by repurposing existing freight infrastructure and develop new connections, both on land and along the river. To facilitate mobility needs multiple tram lines are created, along with one new metro line, connecting Hoek van Holland and Rotterdam. The so called "Petroleum line" facilitates mobility, through the port while acting as a cultural route through oil heritage areas. At the same time, the disconnected Rozenburg is now well connected with the rest of the territory. With a new robust mobility system, more investments and interest will grow facilitating a gradual transformation of the whole territory.

Alongside the metro line, another cultural pedestrian and bike route is proposed connecting key heritage areas, new integrated energyscapes, and river banks. The route goes through the "fingers" of the ports eastern area and ends in Rozenburg with potential extensions going till Maasvlakte.

Hoek van Holland now becomes a clean dunes recreational area and new attraction zone where citizens go and enjoy a clean, multifunctional landscape.

Figure 112. Sketch illustrating part of the cultural route highlighting the boat culture

Rozenburg & Pernis Visualization Sketch



Integrated energyscape

After the "powershift" of Rotterdam port region the port is blended with the city acting as an energy production and distribution hub, while facilitating human activities and natural processes. A key principle of the vision is to apply a "*Welcome in my Backyard – WIMBY*" principle relating energy production. This will be achieved with the help of new technologies e.g. silent wind turbines as well as a variety of supporting policies to stimulate, empower and engage stakeholders. Spatial qualities are also important, so necessary retrofitting of fossil-fuel infrastructure and "*de-industrialization*" (Amenta & van Timmeren, 2018) (Amenta, 2019) processes will happen as well and some of them will be repurposed as housing, heritage areas, along with ecological reconstruction.

Figure 113. Bird eye sketch illustrating the integrated energyscape and the "welcome in my backyard" principle for energy production

Stakeholders in Port of Rotterdam

Fossil-based companies and oil lobbyists
Both fossil-fuel companies and the oil lobbyists need awareness (Policy CP1) about the importance to shift into green energy in which they hold power to make impact. Fossil companies will be prohibited to do exploration of new fossil reserves (Policy RE1), and with the awareness they possess, oil lobbyists will not promote new site exploration anymore. During the transition, collaboration can be offered to these companies (Policy CP2) with Public-Private Partnerships scheme.

Industry workers
As one of the most impacted actors due to the major shift in industry trends, the workers including the port workers need to be engaged through discussions (Policy CP1) to raise awareness about the shift itself. Without knowing the importance of the transition, the workers will have less knowledge as of why they are losing their jobs and can potentially arise blocking power. During the transition, it is also important to involve these workers through capacity building by doing training for sustainable energy jobs (Policy CP3) to shape high quality, adaptive, and competitive labours.

Port region's peri-urban and urban population
The involvement of local residents in the impacted project area is important and can be done by raising people's awareness (Policy CP1) through socializations, and increase their impact in planning by including them in the planning process (Policy CP5) through workshop for co-design, and maintaining their participation by creating platform in which the people can give inputs and feedbacks. This project also encourage the establishment of energy communities (Policy CP6).

To stimulate this participation, several funding scheme can be given, such as the tax breaks for complying with green energy regulations (Policy ST4). In the process of adapting to the water scenarios, several groups of residents will be displaced from their water-vulnerable settlements. Fundings can be given as compensation to these group of people (Policy ST6).

Research institution
The create projects with scientific base, the role of research institution is significant. It is important to provide fundings for research and development (Policy ST4) to stimulate evidence-based measurements throughout the planning process, and to empower the research environment.

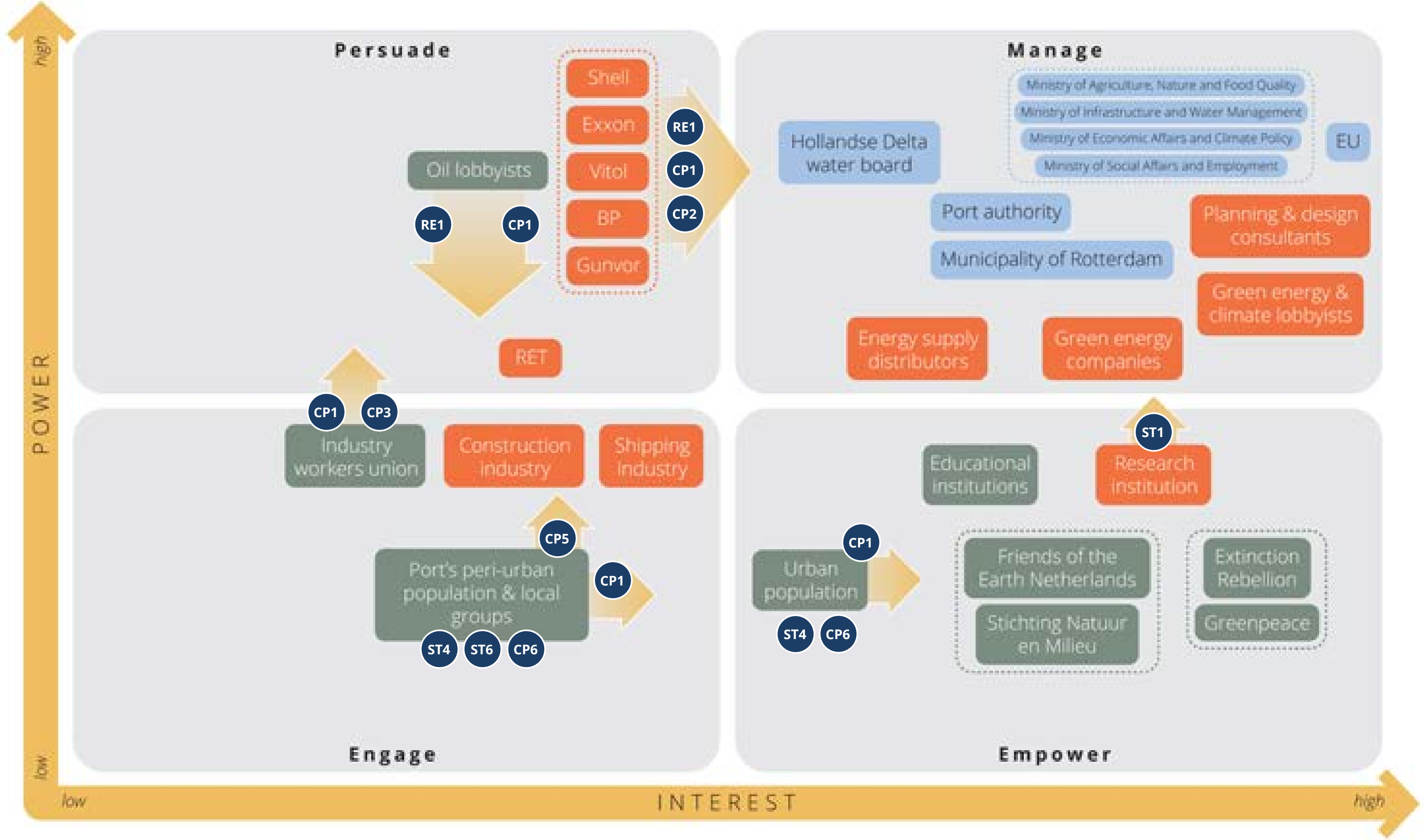


Figure 115. Petrochemical and peri urban areas mapping in the Port of Rotterdam

Policy:

- RE1 End of Fossil Exploration
- CP1 Raising Public Awareness
- CP2 Collaboration to Deliver New Capacities
- CP3 Employee (Re)Training for Sustainable Energy Jobs
- CP5 Citizen Participation in Planning
- CP6 Public Initiative for the Development of Prosumerism in Energy Capacity
- ST1 RnD Subsidies for Green Energy Technology
- ST4 Tax Breaks for SMBs and Households on Green Energy Technologies
- ST6 Compensation for Displaced People

Stakeholders sector
- Private sector
- Public sector
- Civil society

Plans to shift

RE1 Policy code

Figure 114. Power-interest matrix of the stakeholders in the Port of Rotterdam

Petrochemical company
1. BP
2. Gunvor
3. Koch
4. Exxon
5. Shell

(Port of Rotterdam, n.d.)

Peri urban areas
1. Maasluis (population: 35.000)
2. Rozenburg (population: 12.460)
3. Vlaardingen (population: 75.000)
4. Pernis (population: 4.940)

(Overview of the municipality of Rotterdam, 2023)

Community Engagement

To ensure a Just Energy Transition, community engagement and empowerment is a necessity. Recognising vulnerable groups in the energy transition, such as communities living around polluting powerplants, communities that are divided by large infrastructure lines and remote communities that do not receive the required amount of energy, is the first step to engage them (Aspen Global Change Institute, n.d.).
Many interviews and talks would have to be conducted to fully understand these communities, but an overall narrative can be understood by critically analysing the media. To understand the current problems and miscommunication happening around the renewable energy discourse, a qualitative research approach was taken to understand the subjective responses from different points of views (Fossey et al., 2002).
With our project, we want to inspire civil society and local communities to not reject the energy transition and its sources but to claim them and use them to empower themselves and take ownership of their energy rights (Wade & Rudolph, 2024). By bringing the three different sectors, public, private, and civil together for meeting of placemaking sessions, co-creation studios and overall transparent discussions about this transition, can better convince local communities to come together and embrace renewable energy production in their backyard (Peinhardt & Storring, 2019).

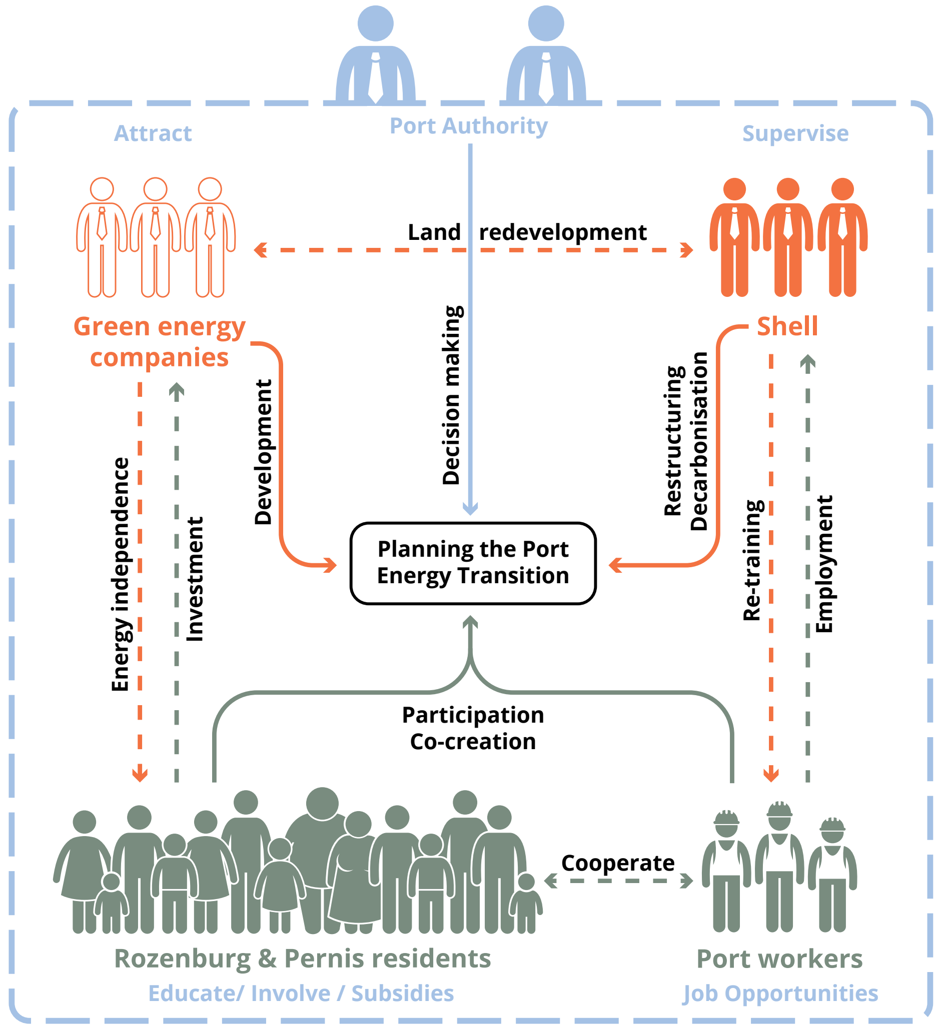


Figure 116. Diagram showing collective stakeholder engagement.

'Qualitative Research' tools for current discourse analysis
The topic of wind power was chosen to represent the discourse around renewable energy. By analysing the subjective attitudes expressed in the articles with the help of ATLAS.ti programming, a reoccurring contrasting narrative emerged.
The private sector companies expressed a positive outlook towards renewable energy, although focusing on numbers and quantities, innovations in the field and completed projects without mentioning people or negative aspects of turbines. While the civil society groups focus specifically on the negative effects and how they are impacted without mentioning the necessity for this technology in future's sustainability.
5 diverse media articles were taken as the analysis – 2 communicating the civil society voice, 2 corresponding the position of the private sector and one mediating research article, that explains both sides of the arguments. The articles used:
· Article 01 (Private Sector) – 'Shell and Eneco to build third unsubsidised Dutch offshore wind farm' (Klimaat, 2020);
· Article 02 (Private Sector) – 'Whiffle and Shell are working on the wind park of the future - using game technology' (Bakker, 2023);
• Article 03 (Research) - 'A lot of hot air? Controversy grows about wind turbines' impact on health' (Pascoe, 2022);
· Article 04 (Civil society) – 'Doctors concerned about noise pollution caused by wind turbines' (NL Times, 2024);
· Article 05 (Civil society) – 'Living in hell because of Wind Park N33' (National Wind Watch, 2023).

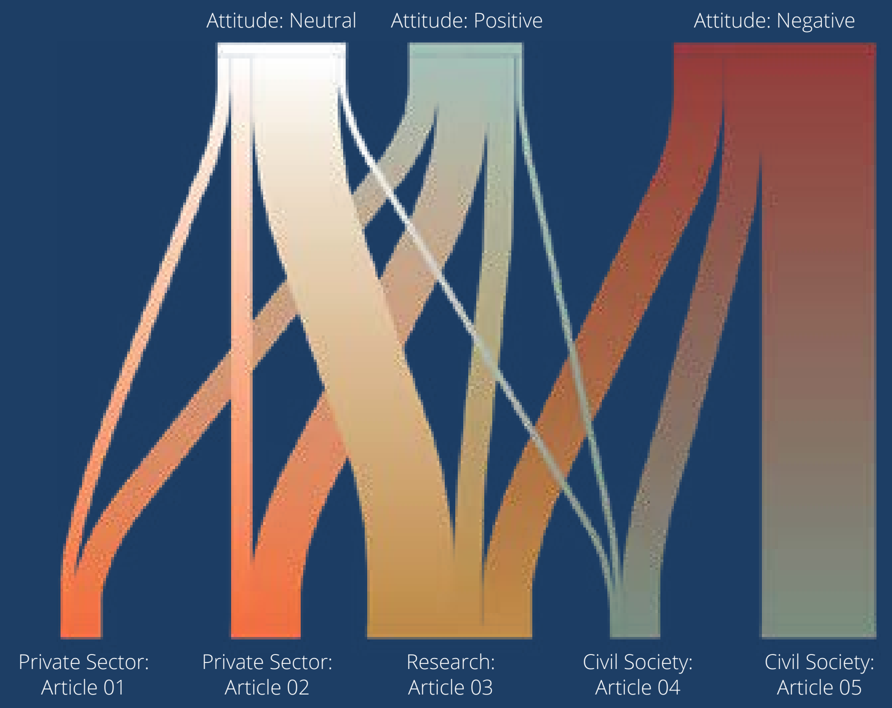


Figure 117. Attitude analysis towards renewable energy (Wind) in current media discourse.

Port Authority's Interests

In order to get a better understanding of the position, future perspectives and sustainability plans of the Port of Rotterdam, we conducted an interview with Hans Nagtegaal, responsible for Costumer Sustainability since March 2024.

The Power of the Port
The Port of Rotterdam Authority is an unlisted public limited company. The shares in the Port of Rotterdam Authority are held by the Municipality of Rotterdam for 70% [and by the Dutch government for 30%]. It can decide which companies it leases their ground to. Before the main question was, does it attract more cargo? Now they are looking for sustainable growth. This means they want to attract more companies with specialisation in green technologies or which can add to a circular system with the other companies, using each other's waste flows. The Port doesn't want to grow spatially but rather use the current grounds more efficiently [e.g. taller warehouses]. That being said, for the energy transition in the coming years we temporarily need more space. When fossil fuel is phased out, the current landmass should be big enough again.
The Port leases their ground to companies with contracts of 20 years. During that time they have limited power over the companies, if agreements have not been made upfront. The execution of the various companies processes are the responsibility of these companies. The port can have a bigger influence over the logistics surrounding the facilities. The Port can facilitate the necessary technologies and infrastructure to help them work more sustainably. An example is the Porthos project, to pump back CO2 in the North Sea that is emitted by companies from among others Shell and Exxonmobil. Infrastructure for CO2 towards the Westland greenhouse region and residual heat towards nearby cities have been in existence for some years. Next to this, the Port is investing in hydrogen infrastructure as the fuel of the future.

The Polycentric System of Ports
Cooperation with other ports is not very common (yet), Aathough more and more green corridors are being formed. Before, we were mainly competing for volume with other ports like Antwerp and Hamburg. Now we realised that we all benefit if we collaborate as well. Other ports are facing the same transformation challenges as Rotterdam. Fuel availability should not be competed about but instead communicated so more efficiency is achieved. By agreeing on standards, we can use the same systems for technologies like onshore power [so ships can turn down their engines when they are plugged into an onshore power source].

> *"World trade is a necessity."*

The Future of Energy Trade
According to Hans, world trade is a necessity. In The Netherlands we will only be able to generate 10% of the power we need, this means that we will not be importing less, just a different form of energy such as hydrogen.

Figure 118. Collage illustrating features of the new land use - CCEL, (see sources in Bibliography)

From SHELL to CCEL

What if the post-fossil landscape was a combination of commerce, culture, education and leisure areas, instead of polluting infrastructure?

Reimagining the landscape for a post a post-fossil environment entails an integration of vibrant commercial areas, with industrial heritage, education facilities, recreational areas with residential zones. These elements harmoniously coexist with natural ecosystems. Focusing on a gradient approach, it unfolds from the east side of the Port with the Rotterdam cityscape (right in collage) and grows towards the west area (left in collage) where "pure" port functions take place.

Stakeholders emerge as protagonists in our transformation narrative. Civil society, private and public sector are active participants in creating this new future. Stimulating their engagement and collaboration can serve as a solid foundation for realising "powershift" and create an inclusive and thriving future where no one is left behind.

EXEMPLARY STRATEGIC SITE 01

B. Zeeland's Osmotic and Tidal Power

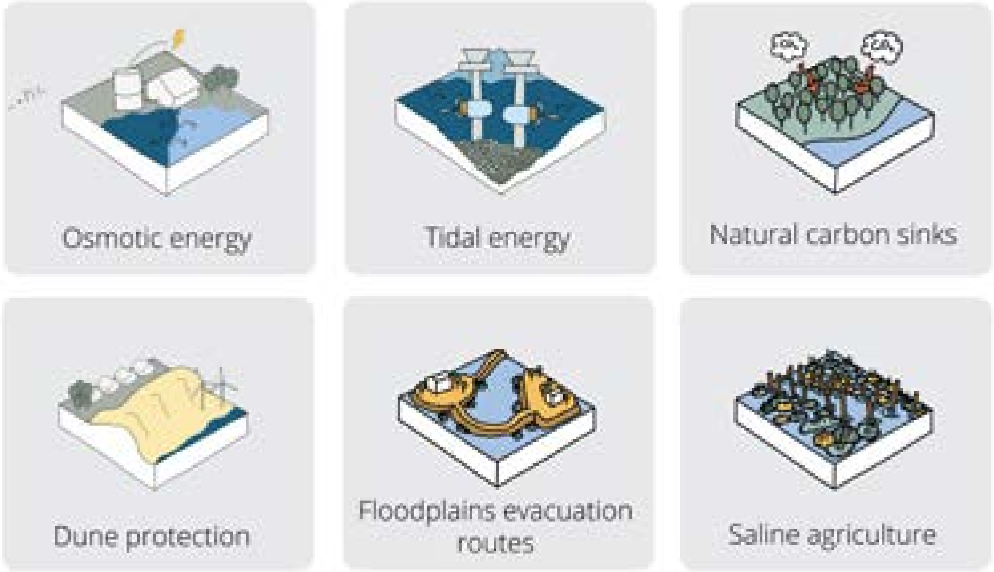


Figure 122. Diagrams of main strategies used in the site.

Legend

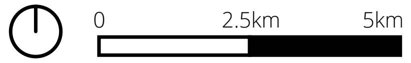
Urban fabric
- Low density settlement
- Settlement expansion
- Water-adaptive settlement
- Ports
- Evacuation routes
- Settlement relocation

Landscape
- High-ground dunes
- Floodplains
- Nature reserve
- Agriculture
- Regional Park

Energy
- Electricity network
- Hydrogen piping
- Hydrogen Plant
- Solar farm
- Wind turbines
- Tidal turbines
- Osmosis Plant

Water system
- Sea water
- Dune protection

Figure 119. Zeeland Project Site Map (see sources in Bibliography)



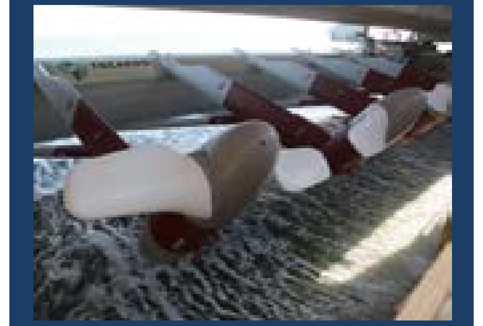


Figure 120. Image of tidal turbines installed on the Delta Works (Deltares, n.d.).

In 2015, Developer Tocardo Tidal Turbines installed five-turbine array onto the existing Eastern Scheldt Storm Surge Barrier. The turbines are fitted with bi-directional rotor blades, enabling them to generate power in both directions (during ebb and flood).

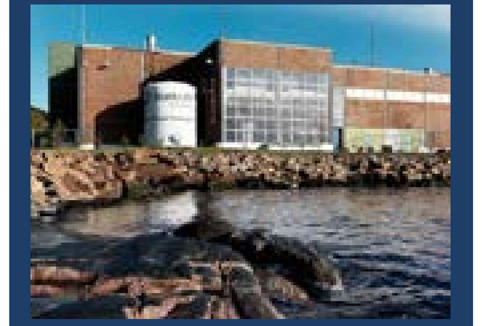


Figure 121. Image of the world's first osmotic energy plant in Tofte, Norway (Clark, 2013).

Osmotic power, also known as "salinity gradient power" or blue energy, is a form of renewable energy obtained from the difference in salt concentration between two bodies of water, typically freshwater and seawater, and their controlled mixing. Salty water molecules tend to move into freshwater, creating energy in the form of heat and pressure. By harnessing this movement, electricity can be produced without emitting greenhouse gases or other pollutants.

Zeeland province will be most affected by sea and storm floodings in the future, with it being the distinctive Rhine–Meuse–Scheldt River delta. We see this as an opportunity to step back from the controlled water management of the Delta Works and embrace the tides coming from the sea.

The adaptation of the current agricultural landscape to cope with the rising sea level will transform the land into vast water absorbing energyscapes. The new floodplains infiltrated with sea water would shifts its production from agriculture to energy crops such as algae, which not only would remediate the CO2 pollution but would also allow current farmers to adapt their occupation for the flooding future. The mixing of salt and fresh water also brings out new opportunities for power generation. Farms. Industry zones and even independent settlements could construct osmotic power plants, which would empower the smaller communities to become prosumers.

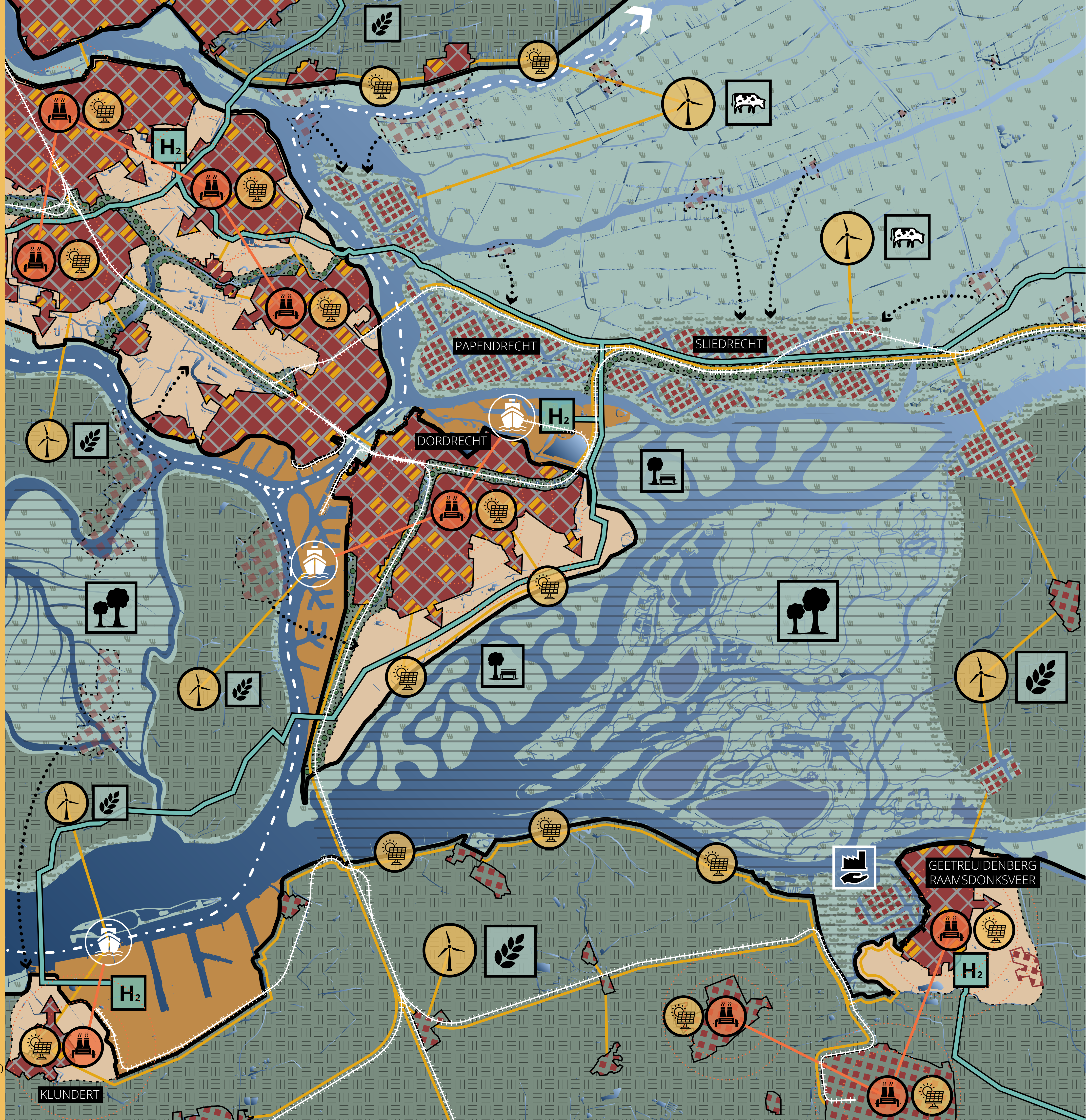
The transformation of the Delta Works from a protective infrastructure that consumes energy to a tidal power generating one would create a steady energy source for the local area with the excess transported towards further Netherlands regions.

Settlement safety from water would be the biggest challenge. Villages laying low to water would have to be adapted with water infiltration strategies, allowing water to overflow without devastating the built environment. Additional precautionary measures such as evacuation routes would have to be enforced by governing actors. Naturally, high dunes, closest to the sea would become safety zones and for this we predict growth and relocation in these settlements.

Figure 123. Collage illustrating the new Zeeland floodplain (see sources in Bibliography)

Spatial Quality

The strategic site focuses on balancing natural aspects together with energy production. The area has a large Natura 2000 zone situated in the North Sea and in the Meuse and Scheldt rivers estuaries. For this reason, the new flood plains act as an additional protective buffer zone for current ecosystems to restore themselves. Areas that are already developed will be retrofitted and improved to include carbon neutral energy production. With the coastline having the biggest renewable energy potential is adapted with solar, wind and tidal energy, while the area past the coastline is left as a nature reserve allowing people to visit and study it without changing it.



EXEMPLARY STRATEGIC SITE 02

C. Connecting New Inland Ports

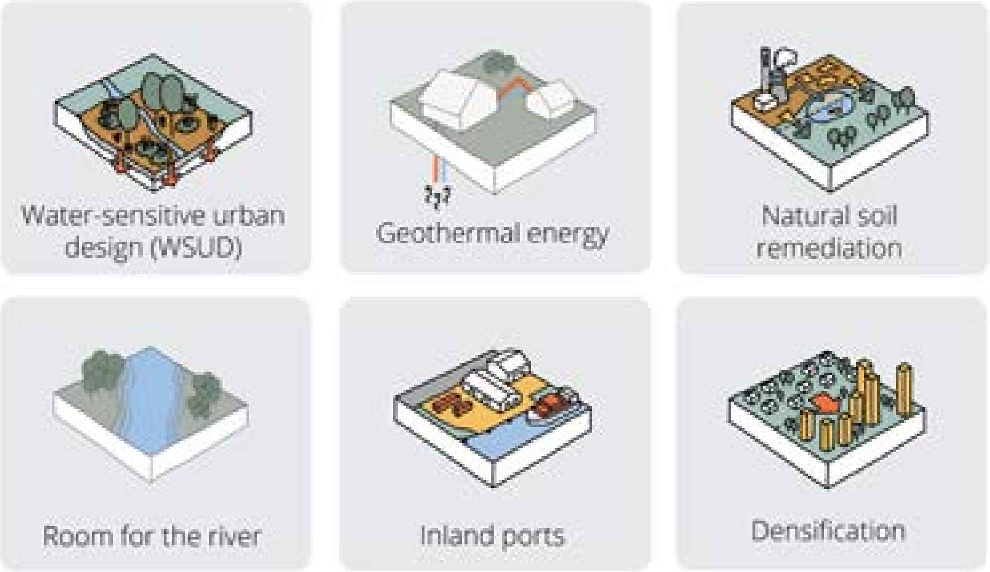


Figure 127. Diagrams of main strategies used in the site.

Legend

Urban fabric
- High density city
- Low density city
- Water-adaptive settlement
- Floating city
- Ports
- Evacuation routes
- Settlement relocation
- Railways
- Boat routes

Water system
- Fresh water
- Sea water
- Tidal fresh water zone
- Reinforced dikes

Energy
- Electricity network
- District heating
- Hydrogen piping
- Hydrogen Plant
- Solar farm
- Wind turbines
- Geothermal plan

Landscape
- Green Corridors
- Floodplains
- Nature reserve
- Agriculture
- Pastures
- Regional Park

Figure 124. Dordrecht Project Site Map (see sources in Bibliography).

0 2.5km 5km

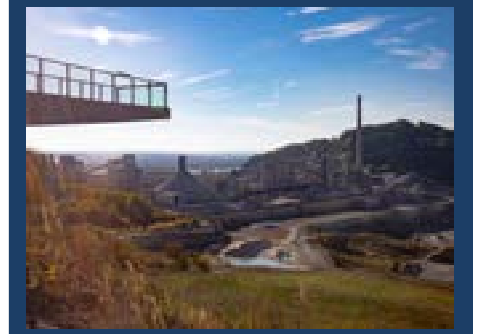


Figure 125. Image of ENCI quarry nature reserve in Maastricht (Sint Pietersberg, above Ground | Zicht Op Maastricht, n.d.).

A former ENCI quarry and the nearby old cement factory has been closed and has been transforming to be integrated into a new natura reserve. The old fossil-fuel scape has not been demolished but kept as heritage, while the nearby excavation grounds are being given back to nature. The company that managed the factory, together with the municipality have been transforming the area to become a new leisure space.

Figure 126. Image of Sanya City's sponge landscape (Campbell, 2022).

While the concept of a "sponge city" is primarily aimed at managing urban flooding caused by heavy rainfall. The principles behind sponge cities can be adapted and extended to address sea water flooding in coastal areas. The large green patches around the flooding coastline can absorb the currents power and reduce the direct impact from the water surge.

As the port of Rotterdam is merged back into the city with new city functions are taking the space of industry, other ports such as Amsterdam and especially inland ports such as Dordrecht emerge and experience new developments. Frequent floodings and widening waterways grows the shipping industry and overtakes large trade and transportation needs in the delta region.

With constant pluvial and fluvial floods, main protective dikes are reinforced. This demands the cities to densify in safe protected zones around the floodplains. Areas around the protective barriers are softened with water absorbing landscape which acts as large natural parks for the dense urbanised islands.

Some settlements caught in the middle of the floodplain will redevelop to be adapted with water infiltration strategies. Existing railways are the main commuter connection between the major urban centres.

Green energy production is dispersed across the region, with cities and their borders focusing on solar energy, while peri-urban farmlands and pastures integrate local wind power across their land. To reduce the demand on electricity, urbanised areas implement district heating by utilising the areas geothermal potential and the residual heat from dense cities and port industries.

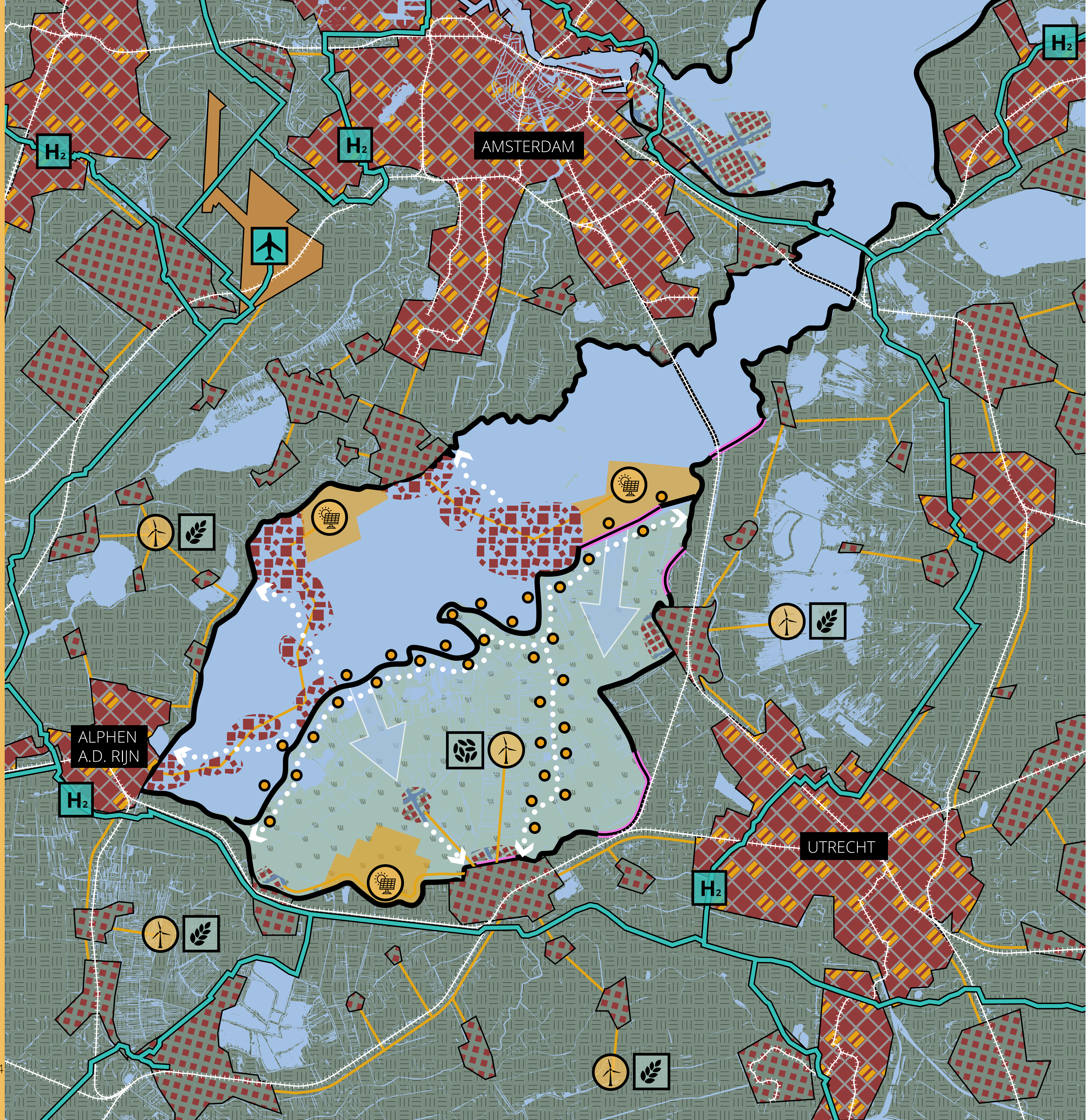
Some fossil fuel power plants, such as in Klundert and South of Rotterdam, are retrofitted and transformed into hydrogen sharing powerplants. Other, heavily polluting coal power plants such as in Geertruidenberg, are closed and preserved as cultural heritage, while the polluted landscape is remediated by vegetation.

Figure 128. Collage illustrating the expanding Inland Ports (see sources in Bibliography).

Spatial Quality

River cities in the Netherlands will have three distinct new qualities. First, settlements will densify around their protective barriers. Secondly, port infrastructure will expand cargo and commercial trading while also including energy storage and trade. With the ports transitioning away from a polluting energyscape, residential and commercial function will be integrated in ports as well. And lastly, to anticipate harsher water conditions more room for water will be allocated, creating larger environmental areas.

Green energy production will be expanded in the peri-urban landscape next to smaller water adaptive settlements to ensure these communities are an important voice and contributor to the new energy system.



EXEMPLARY STRATEGIC SITE 03

D. The New Blue Heart

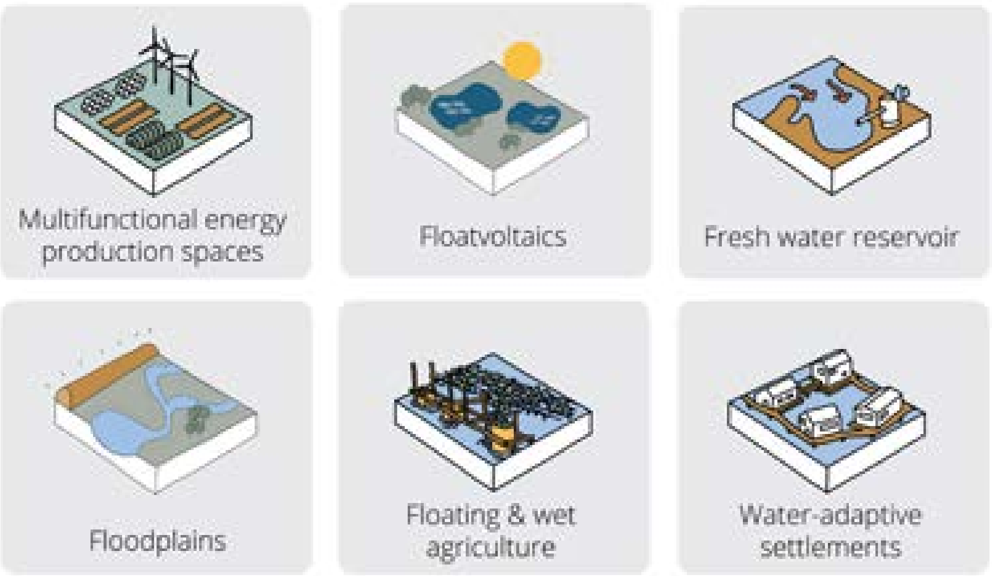


Figure 132. Diagrams of main strategies used in the site.

Legend

Urban fabric
- High density city
- Low density city
- Water-adaptive settlement
- Floating city
- Airports
- Evacuation routes
- Railways

Landscape
- Floodplains/ Water agriculture
- Agriculture

Energy
- Electricity network
- Hydrogen piping
- Hydrogen Plant
- Solar farm
- Wind turbines

Water system
- Fresh water
- Reinforced dikes
- New dikes
- Seasonal Flooding

Figure 129. Green-Blue Heart Project Site Map (see sources in Bibliography)

0 2.5km 5km

Figure 130. Image of floating city project 'Rijneburg' (PosadMaxwan, 2023)

Floating houses have been built on a small scale, but Posad Maxwan has conducted a research about floating cities as an answer to the challenges of the future: 'To ensure that the floating city doesn't become an exclusive enclave, we prioritize establishing strong connections with the existing city, promoting diversity and inclusivity in the housing and work programs, and creating a lively public space with abundant greenery and access to the water for everyone. In short, a complete city.' (PosadMaxwan, 2023)

Figure 131. Image of a farmer is planting risotto rice in a polder near Leiden (NOS Nieuws, 2023).

Because the reclaimed land (droogmakerijen) in the area, mainly used for agriculture, are a big part of the salinization problem, new ways have to be found to grow food. Paludi culture is a viable option for the land that is flooded during parts of the year. Students from Wageningen and Leiden University are currently researching the feasibility of growing rice on peat lands, as an alternative to pastures (Wageningen University & Research, n.d.)

One of the challenges regarding climate change for The Netherlands is freshwater shortage, used for drinking water and cooling. This is because of the rising sea level and the decision to let more seawater into the country via Zeeland [strategic site 03], combined with more frequent and longer periods of drought. In this strategic project, the freshwater supply will be extended by enlarging the IJmeer.

The Green Heart is a relatively thinly populated peat landscape area surrounded by Rotterdam, Den Haag, Zoetermeer, Leiden, Haarlem, Amsterdam and Utrecht. In the National Strategy on Spatial Planning and the Environment (NOVI), the Green Heart is designated as 'NOVI-area', which means that a big transition is necessary because of the big challenges the area currently faces. These challenges are subsidence, soil drought and salinization in a landscape where urbanization is also pressing by the surrounding cities (Vereniging Delta Metropool).

The national and local challenges combined lead to the transformation of part of the Green Heart to become a Blue Heart. Here, part of The Netherlands turns back into the original state of Dutch landscape by ceasing the pumping of water, much like the Biesbosch. The consequence is a new waterbody because of the extreme low grounds. This way, the IJmeer, a closed-off inland freshwater bay, will be extended with an opening between Muiden and Muiderberg. The waterbody will stretch until Alphen aan de Rijn and Woerden.

To create this new lake, the existing dike system is used and reinforced with new dike parts. In the West the water storage is present year-round. In the East, the storage possibility is used in seasons when deemed necessary. In the far future this might also become permanent, dependent from the state of affairs.

Figure 133. Collage illustrating the new freshwater reservoir in the Green-Blue Heart (see sources in Bibliography).

Spatial Quality

The existing settlements in this area are due to be transformed towards resiliency for the water, developing floating neighbourhoods of existing cities such as Alphen aan de Rijn and Uithoorn. Others become independent floating cities altogether, which is the case for among others Mijdrecht and Vinkeveen. This gives new qualities to living environments, being surrounded by flourishing ecosystems.
This new way of building on a large scale brings innovation. For example, floating houses can be disconnected from the sewer system if it filtrates its own wastewater. The surrounding water can be used for cooling and heating.

6.7 New Flows and Relationships

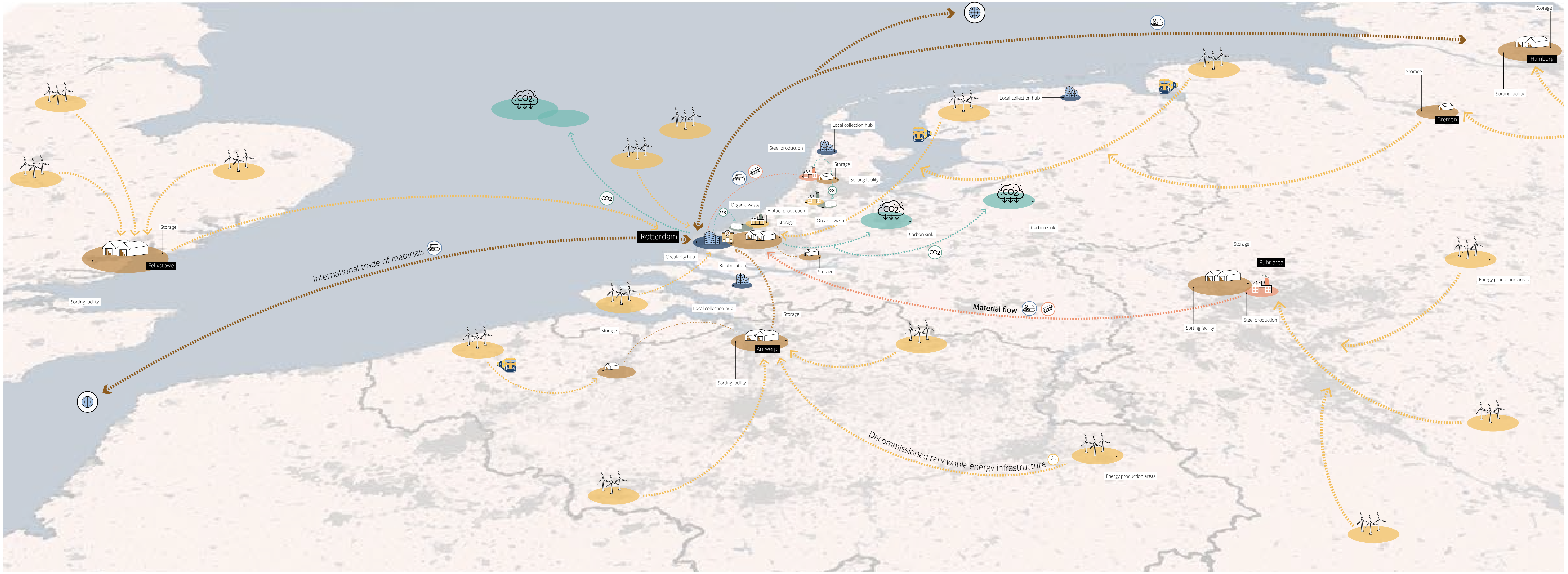


Figure 134. Map illustrating the new relationships between the Port of Rotterdam and other port cities

Legend

- Carbon sink
- Port cities
- Greenhouses
- Renewable energy production zone
- Circularity hub
- Steel production

As we observe the larger scale of a Eurodelta in transition, potential new relationships and flows can emerge between main port city regions and their local clusters creating a complex cross-border structure of networks and systems. The emerging flows system integrates systemic solutions, envisioning a robust raw materials system that supports trade and implements sustainable processes to reduce waste and resource consumption, while maximizing raw materials recovery and minimizing value destruction (Tillie et al., 2014).

The imperative to reconsider our systems stems from the climate crisis, reduced availability of raw materials, and overreliance on third-party nations (SMV, 2021). Meanwhile, global trends are being developed around circular economy and at the same time, new trade opportunities are opening up due to Arctic ice melting (World Economic Forum, 2020). While transitioning to a sustainable energy system, the transition to renewable materials is sometimes neglected. A question then arises concerning the substitution of fossil raw materials and their sourcing (just transition).

Therefore, we propose the development of "smaller supply chains" emphasizing on circular flows of materials and more. The different ports have different transshipment typologies focusing on goods, oil, hydrogen, CO2 etc. For instance, the Port of Rotterdam serves as a main refurbishment and circularity hub where the majority of materials are repurposed through recycling or upcycling procedures. The Port of Antwerp on the other hand serves a key role as a storing facility in the chain.

At the main intersections of transport and energy flows significant local clusters are being developed. CO2 captured from local industries is transported and then stored in vacant gas fields on the mainland and the North Sea. Additionally, the concept of industrial symbiosis is being introduced, where an industry's output, such as CO2 or steel, serves as another's input, like greenhouse heating fuel or wind turbines manufacturing.

Crucial to this future is coordination and cooperation to create business strategies, policies and regulations that boost such efforts. This vision remains flexible and is not meant to be a rigid plan but provides a framework of "metabolism" integrated in a new Eurodelta region, along with possible focal areas in the system. Additionally, it is critical to highlight that as the system scales up, ensuring sufficient storing and processing capacity will be essential for a resilient system. Scaling up often "leads to a more robust and efficient system (economy of scale)" (SMV, 2021), potentially paving the way for new revenue models for the port cities of the Eurodelta region (Tillie et al., 2014).

Figure 135. Diagram illustrating the increasing demand of raw materials from the Circular Mainframe research, SMV, 2021)

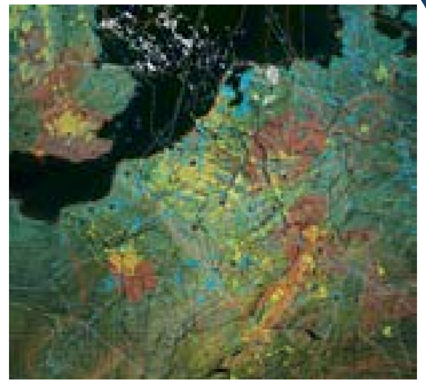


Figure 136. Map illustrating the extended energy networks in the broader Eurodelta region, (Tillie et al., 2014)

Figure 137. Picture illustrating the concequences a changing Arctic can have for the world, , (World Economic Forum, 2020)

07

Conclusion

7.1 Conclusion

In conclusion, this report approaches the issue of CO2 emissions from the perspective of the energy industry, while also taking changing water landscapes into consideration. The overarching vision of the is built on these two perspectives; the energy industry is imagined as being carbon-neutral by 2050, while there is enough space to accommodate the challenges of sea level rise by 2100.

Current Energyscape

The current energyscape is centred around the Port of Rotterdam, and other portscapes in the Eurodelta that are also characterised by their fossil landscapes, especially Antwerp and Amsterdam. Such importance of the port areas was enough justification for designating port areas as the focus of the project; Ports are focal points on the intersection of energy and transportation flows so they can therefore play a key role in the transition. Including portscapes in the energy transition has crucial spatial implications as well; Good urban design and spatial planning can prevent these areas from becoming post-fossil brownfields. This good urban design also includes considering the transformation of landscapes with minimum interventions, by reusing existing infrastructure to fit the changed reality of energyscapes. The main challenge, however, also comes from the fact that fossil-fuel systems are very integrated and interconnected ones, in order to transform them, many aspects of the "fossil chain" need to change. Further justification for choosing energy and portscapes as the main problem is the fact that the Netherlands is a big importer of energy and overtly reliant on third-party nations for energy and materials.

Energy System Profile

The report acknowledges the fact that climate action and energy transition have to go hand in hand. The process of energy transition has to incorporate local urban and peri-urban communities to ensure a just transition and should not prioritise the only involving the private sector. There is great importance to stimulate bottom-up initiatives for this transition, people being included more deeply and extensively in the planning process. The project aims at achieving this by delegating agency and governance to local interest groups and communities, giving them the opportunity to protect themselves against private and corporate interests.

Room for Water

With climate change influencing future spatial realities, changing the Netherlands' approach to thinking about water is an integral part of the project. Taking on a more natural way of living with water instead of the usual Dutch engineered way is emphasised. A fully integrated system transforming water related threats and challenges into opportunities for sustainability was developed for the country, including solutions such as energy production and coexistence with water. The imminent climate extremities will change the dynamics alongside which manmade and natural systems will be working together in 2100. This requires a much more balanced solution approach. Multiple types of infrastructures, such as grey/hard and green/soft infrastructure, policy frameworks and other, interrelated tools and solutions will be needed to tackle challenges arising from water in the future.

The Role of Ports in the Energy Transition

Various stakeholders from public sector, private sector, and the civil society will be involved in the planning process, with different treatments toward each stakeholder regarding their current position. The involvement of the civil society is important, needs to be empowered to have more impact through planning and stimulated with fundings. The Port of Rotterdam can take the lead in changing the role of the port area, to make it a greener, more integrated part of Rotterdam. By sharing knowledge, technology, and smart solutions in a framework working together with other ports, this transition can act as a potential pilot project for other stages of the climate transition.

Post-Fossil Future

The project the transition away from fossil fuel infrastructure can be an opportunity draws up a strong vision towards transforming current fossil-fuel related land use to welcome mixed use areas of housing, culture, commerce, and so on. The possible future scenarios envisaged by the project include "melted" borders between ports and cities.

7.2 Limitations and transferability

A good urbanist is capable of questioning and criticising themselves and are able to acknowledge the limitations of their work; in the essence of this thought, we now take the opportunity to discuss the most important limitations of this project.

By and large, the creation of a site-specific conceptual and stakeholder framework is possible anywhere and at any scale. The methodology and tools used to create this project are applicable to all European port-regions, and most international ones that do not have extreme deviations from most of the assumptions that were made during the project.

Although, Healey (2011) already established extensive theoretical background for planning and design as a highly context-dependent, relational, and territorial profession, there are certain theoretical elements, policy frameworks, and spatial interventions that are highly transferable. With our project containing a large number of such 'universal' policies and interventions, it can be considered a highly transferable framework, achieving our original goal of creating a 'pilot project' for other port-regions in Europe. When it comes to outside of Europe, however, it needs to be acknowledged that the project was created in a developed-country context, with high sustainability values, and uses advanced technologies and innovative solutions. This implies that some measures may be difficult to implement or transfer in economically less developed areas or assumes sustainability as a less vital concern.

The rather ambitious vision that is aligned with EU and international policies should still be considered ambitious due to extensive and radical changes that have to happen in an energy and climate context that are simply too complex to wholly understand and build a comprehensive and empirical project on. In order to still be able to come up with reasonable forecasts, assumptions were made for the long-term future that are based on 'best-case scenarios' continuous research, development, and technological advancement in most of the cases.

7.3 Societal Relevance and Ethical Reflection

During the Methodology part of this quarter, our group was asked the question what makes a good urbanist. Discussing such a question is always beneficial when thinking about social effects and ethics; Every professional, who aspires to be considered 'good' needs to strive towards certain principles in all their projects. A good urbanist knows the potential consequences of their decisions and actions and can communicate about these potential consequences to the public while outlining possible options; They heavily emphasise social issues and recognise that the health and well-being of the community they design for is above all else; and they are a capable decision maker, also able to substantiate why their decisions were made the way they were. Reflecting on their own work, and stressing its societal relevance is also an important aspect of being an urbanist; thus, section three of this conclusion will be such.

As already mentioned in relation to the project's limitations, the project only focuses on the Southwest of the Netherlands; the project does not consider the adverse effects of potentially leaving other parts of the country behind by initiating governmental and supra-national actors to divert resources towards the costly interventions the project proposes.

The deployment of renewable energy technology on such a large scale also brings its own ethical questions. It is a well-known fact that all commercial feasible renewable energy technology is highly resource-intensive, especially in terms of rare-earth metals that are primarily mined in developing countries amongst treacherous conditions. On a more positive note, our project proposes a cross-border metabolism framework for such materials that supports trade and implements sustainable processes to reduce resource intensity, while maximising raw materials recovery and minimising value destruction. It is also important to note that considering long term effects, non-polluting energyscapes will remediate our climate and global ecosystems, potentially preventing even worse conditions in countries that are not wealthy enough to adapt to climate change.

The interventions proposed by the project include mass displacement of people and communities from areas that will be designated for climate-proofing and energy generation. Although, a policy framework was created to minimise the social injustices suffered by said people and communities, the negative societal and ethical relevance needs to be acknowledged. On the same note of individual- and small community-level social injustice, the question of future labour markets also needs to be touched upon; our project contains proposals that would fundamentally change how labour markets work in Southwest Netherlands, essentially laying off thousands of fossil industry and port workers. Again, measures for the prevention and mitigation of social injustices were inserted into the policy framework of the project, with such large-scale interventions, the complete prevention of social injustices on an individual level is almost impossible.

Issues regarding the mindset adaptation of affected social groups also need to be addressed; The extraction and use of fossil fuels is not only a technical necessity but can also be a part of the identity of social groups, while the acceptance of the changed energyscapes can also take time. Although, enhanced built environment, future technologies can not only power the areas, but they can also become parts of the accepted cultural landscape, this process is slow and by nature cannot be fully inclusive. The project, however, plans with a process during which gradually as renewable energy technologies are more and more integrated in space, more people will become aware of their importance, while new technologies will make them more acceptable, ultimately resulting in a mindset shift.

The question of just transition needs to be addressed as well. The project recognises the need for equally distributing the burden of the energy transition and climate adaptation, however, as in the case of most projects concerned with the far future, this is more just a 'given', than a socio-spatial, socio-economic, and socio-technical consideration.

08

Reflection

8.1 Collective reflection

We are happy to say that despite our differences and some bumps along the road, we managed to come together and produce a report whose content and quality all of us are proud of.

In the beginning we communicated to each other how we saw our own strengths, weaknesses and learning objectives for the course. With all team members coming from different backgrounds, it was a challenge to work together efficiently, but these differences also presented a great learning opportunity for all of us. In order to take full advantage of this opportunity, we had several discussions about the group dynamics and sometimes we "made a step back" from the project and reflected on our individual issues and tried to find solutions that satisfied everyone's needs and desires.

Throughout the whole quarter, we worked together intensively, doing almost all tasks while working alongside each other, instead of every member having their tasks and doing them remotely. Group members helped each other obtain new knowledge and skills, while having a strict '9-5' work schedule, we could also better grasp the importance of our work and obtain a sense of duty, while being non campus and working together towards a quality submission. Besides trying to spend as much time working together or alongside each other, we invested time in getting to know each other by doing extracurricular activities together such as a fun meal in the city centre of Delft. This had a very positive impact on teamwork. After discussing the half-time peer review, all group members showed improvements on the feedback they had received from the others.

Due to the complexity of our project and the group's ambitious plans we were "forced" to do more research and make decision making rooted in the scientific method.

8.2 Individual reflection

Kristupas Kadys (6056849)

Quarter 3 was an insightful period that consisted of a large-scale research-based design proposal, that mirrors a final thesis project, and valuable supporting ethics lectures and exercises, which in my opinion are still disregarded in the broader academic teaching discourse.

The regional scale of urbanism was completely new ground for me, coming from an architectural background. The beginning steps were the most difficult, trying to collect and process context, data, and theories on the larger scale. As the scale is unfamiliar, it was difficult to limit myself to a specific area and to narrow down the research, as there always seemed to be more information that was crucial to have the full picture. But after focusing our narrative as a group and started designing scenarios, vision, and strategic interventions, it became more tangible and approachable. Jumping through different scales helped me to understand the different importance of features in each scale and their patterns, spatial interactions. The course's Capita Selecta lectures worked well for our inspiration and background research, especially the 'Petroleumscape' lecture. Together with SDS workshops, I explored many different methods to understand and visualise our narrative. By using scenario building techniques (which in itself has a different theoretical background, which we adjusted to create something similar to action perspectives) qualitative research to understand the prevailing discourse, systemic section and flow analysis helped me narrow down the importance steps of the system, x-curve exercise to understand the linearity and the transitional challenges and lastly stakeholder analysis to comprehend how our profession has to empower, manage, persuade and engage them, I started to comprehend regional planning.

We integrated all of these methods to create a cohesive narrative, building upon a final vision from available scenarios, which was then 'back casted' to develop a strategy. The creation of a strategy was not a linear process in a beneficial way. The two different sides of researched-backed policy creation and explorative strategic sites and pilot projects went hand in hand to compliment and adjust one another. The strategy making also developed the final vision to include aspects that were missing in the beginning.

I believe that the project is an inspiring and extensive concept for the upcoming energy transition. To fully realise our decentralised energy future project would require a widespread citizen engagement, which the limited time of our project prevented us to explore. By literal community engagement with workshops and interviews can drastically enhance the project's relativeness but also set a factual research base.

Overall, this challenging project taught me the complexity of regional design and regional planning and the importance of accurate vision and narrative building to be able to design our future together.

Sebestyen Pfisztner (6054587)

We are at the verge of climate disaster; the issues of energy transition and climate change mitigation are more relevant than ever before. Simultaneously, the socio-economic, socio-spatial, and socio-technical processes within cities, and relationship between cities are becoming increasingly complex - Whenever we, planners and designers interact with and intervene into these spaces and their relations, we have to consider and cater for this complexity. Urban Design and Planning - especially in a cross-border and regional setting - is becoming more interdisciplinary.

An increasing share of people live in urban areas, while most human activities and their emissions are concentrated in and around cities. In my opinion, this is not only an issue, but also represents a great opportunity; By making our cities and peri-urban areas carbon-neutral, we can tackle most issues that cause climate change with interventions that are relatively limited in a spatial sense.

Coming from a predominantly urban planning background, I have been looking forward to this Quarter, with a studio whose approach is much closer to my previous education, and the methodology course that touched upon topics that are very close to my personal interests and I am sensitive about them.

The greatest takeaway from this project was that for the first time during my studies I was required to actually employ an interdisciplinary approach, and interact with all fields of study that are related to our project topic. Although, I was familiar with most of the concepts that we used during the quarter, I had many opportunities to engage with them on a much deeper level, than ever before.

In terms of group dynamics, despite the challenges and issues at the beginning of the project, I believe that we have become an efficient and well-oiled team, which, in my opinion, is visible on the quality and scope of the final submission we made. Becoming part of a team where every team member had different previous qualifications as well as fundamentally different work culture and work ethics was a challenging, but also exciting and valuable experience for me. I started the quarter with the explicit goal of trying to improve my patience towards my teammates, and putting more effort into adapting to organically developing team dynamics - I believe that in this sense, I have superseded my expectations, and I consider this a great learning experience during the project.

Nikita Ham (4882091)

Looking back, this quarter I have once again learned a lot about an urbanistic topic, about a specific region and above all, about myself. Starting off working on the regional scale for the first time I was nervous but soon I found that I liked the big picture thinking a lot: talking about energyscapes feels very high up and at the same time so close to home.

In the first weeks the lecture about petroleumscapes by Carola Hein inspired me a lot. Being interested in climate activism and action, I never had the context explained to me in a spatial way. Víctor Muñoz Sanz's lecture about the farming context, Lely milking robot technology included, made me excited for my role as urbanist to dive into a new niche subject on every project.
Choosing for the CO2 topic, I was mainly interested in energy flows and circularity. For this, Alex Wandl's lecture about analyzing flows and creating maps and sections about it was useful for me. This project was also the first time that I wrote an academic report with a group including a vision, strategies and policies. I was surprised to find that I enjoyed researching the physical environment and innovation part of the project a lot.

As I was the only Dutch student in our team, I was useful for finding the correct documents, translating QGIS map titles but what I enjoyed the most was being able to use my Dutch social network to obtain information about topics we were not familiar with. This way we learned more about the Port Authority and offshore engineering. I would have liked to conduct a street survey for a day, unfortunately we didn't have the time.

Every team project my biggest priority is the group dynamics. I find it very important that every person feels part of the group and is heard, therefore I put stress on reflecting informally or formally every week on how everyone was doing. In the midterm peer review I got positive feedback on this, so I kept working on this the second part of the project. I think the teamwork got better every week, just like the products we made together!

Evgenia Vamvakousi (6082556)

This quarter was a surprise and a challenge for me, as we had to deal with the very complex scale of regional planning and at the same time focus on a topic that I'm very interested in, which was energy transition. Coming from a spatial planning background I was excited for this quarter and my expectations were high. Throughout the course, I not only deepened my understanding of energy transition but also sharpened my skills in methodology of research, interdisciplinary approaches, and systems thinking. As an overall comment, the transition to a carbon-neutral future depends on our ability to built synergies and embrace a collective mindset of willingness to redefine our habits and perceptions. We just need to be open for constructive discussions.

One highlight was Carola Hein's Capita Selecta lecture on petroleumscapes, highlighting how integrated fossil fuels are in our daily lives, shaping landscapes and consumption patterns. This lecture also acted as a starting point that sparked our research regarding historical context of fossil fuels in the Eurodelta, post-oil landscapes, and port-city relationships. Another very enlightening lecture was that from Alexander Wandl on systems thinking, which for us gave light to the complexity of energy transition across the distribution, production and consumption chain, involving various stakeholders in all levels, from local to international scales.

Both SDS and capita selects sessions introduced us to a plethora of tools to support our narrative. I found particularly valuable the sessions on systemic sections, typology analysis, and clustering. And while we did not utilize all of the tools introduced, I'm sure that they are going to be very valuable for my graduation project, where experimentation with a broad range of tools will be essential. Personally, I was very intrigued by the introductions on AI tools. Till this quarter I was missing this discussion which is highly debated globally. Additionally, along with the studio, the lectures and workshops of the Methodology course, especially the sessions about governance and stakeholders were very important to our process as well. They provided a small taste of how working with such complex stakeholder network is and offered ideas on how to navigate through it. However, it would have been delightful to have more time and put actual learnings into practice with interviews or other tools. Other than that, many theories and frameworks were introduced and were very helpful in the theoretical back-boning of the project.

As for my personal development, a new thing for me was my need to explore how those regional scale plans can look on a human scale and research on tangible spatial qualities. I think this shift of mine signs my personal evolution over the past quarters as well, revealing a bigger delight in design that I initially though I had. However, this scale and its complexity, which I think requires a lot of research, evidence-based decisions and stakeholders engagement will remain my love and passion.

As for the group dynamics, while we encountered serious issues in the early, they were overcomed enough after the Midterm presentation. I think facing the tied timeline of the project and its complexity some of my teammates' motivation skyrocketed, and it was the same for me. Collaborating in a group in such a complex issue was a big challenge. Our long discussion sometimes led to exhaustion, but I am grateful that these discussions served as the main tool that aligned everyone with our narrative and goals. As for me, I think I grew together with the team, and I think I am a better and more supportive team member after this.

Frithasya Jeniardina Purba (5991617)

I started the Q3 with a nervous feeling, knowing the challenges I will need to encounter due to my unfamiliarity with this quarter's theme. Despite my prior experience working as an urban designer, regional-scale spatial planning was not my strongest suit. Throughout my struggles during brainstorming discussions, I put blame on my background as the only non-European in which I did not have a deep understanding or knowledge towards spatial planning in the context of European countries including the Netherlands. In addition to that, the culture and language barriers, to some extent, kept me from actively participating in discussions and perceived group work as exhausting. However, I appreciated that the other team members had been nothing but helpful and always put effort into allowing me to express my opinions. We came from similar academic backgrounds, but oftentimes we still had different opinions which required long discussions to find a common ground. As time went by, as team members we constantly evaluated and reflected on each other that as an individual I grew and learnt a lot about communication and teamwork. In the end, I valued that this quarter's studio put emphasis on group work.

On the other hand, as mentioned, regional-scale projects were not familiar to me. Furthermore, this quarter's studio required scientific and evidence-based methodology in conducting the research. However, the studio lectures and the methodology lectures provided were useful and thorough in guiding the students through the project. Our group project is about shifting fossil fuel landscape, hence throughout the project we heavily made use of Carola Hein's lecture from the beginning of the quarter about petroleumscapes. From this project, I gained a plentiful amount of new knowledge, especially the ones relating to ports and their importance. Energy and sustainability are familiar topics for urban designers, but through this project I learnt in more detail about energy flows, energy infrastructure, and how they impact the degradation of the environment.

The energy system also touched the social realm, in which we knew the terminology of energy poverty and energy communities in the context of energy generation. Throughout the project, I was aware that some vulnerable groups would be impacted the most within the notion of climate change and the energy shift itself, for example, the population of peri-urban areas that are prone to flooding—at some point—will face displacements from their homes. However, I then realized the complexity of a regional-scale project that it involved a large number of different actors and stakeholders with different stances and responses towards the project where each of them required different treatments. In the context of sustainability projects, I gained a lot of new insights from current climate actions at the global to local levels. It made me aware that such ambitious goals can only able to be achieved through well-integrated cooperation between these complex relationships of different interdisciplinary stakeholders. All in all, I think the core of this quarter's studio—the team works—was in relation to how regional-scale projects are usually conducted; where communications are needed between stakeholders in order to achieve the common objectives.

09

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Figure 14. Flooding extremes, source: https://www.pexels.com/

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10 Appendix

Energy Calculations

Current Energy Generation

Total Energy Supply

Energy Source	Annual Generation	Share
Oil	1 026,02 PJ	38,44%
Natural Gas	977,09 PJ	36,61%
Biofuels and Waste	241,67 PJ	9,05%
Coal	230,69 PJ	8,64%
Renewables	148,29 PJ	5,56%
Nuclear	45,34 PJ	1,70%
Total	**2 669,10 PJ**	

Fossil-based	Non-fossil
83,69%	16,31%

Domestic Energy Generation

Energy Source	Annual Generation	Share
Natural Gas	535,25 PJ	53,71%
Biofuels and Waste	226,76 PJ	22,75%
Renewable	148,29 PJ	14,88%
Nuclear	45,34 PJ	4,55%
Crude Oil	29,72 PJ	2,98%
Heat	11,26 PJ	1,13%
Total	**996,62 PJ**	

Consumption by Sector

Sector	Annual Consumptio	Share
Non-Energy use	537,75 PJ	22,95%
Industry	564,20 PJ	24,07%
Transport	384,58 PJ	16,41%
Residential	415,38 PJ	17,72%
Commercial and Public	266,97 PJ	11,39%
Agriculture and Forestry	166,03 PJ	7,08%
Fishing	5,75 PJ	0,25%
Unspecified	2,91 PJ	0,12%
	2 343,57 PJ	

Current Electricity Generation

Generation Mix

Energy Source	Annual Generatio	Share	
Natural Gas	47,84 TWh	39,34%	172,224
Wind	21,62 TWh	17,78%	77,832
Coal	17,41 TWh	14,32%	62,676
Solar	16,83 TWh	13,84%	60,588
Biofuels	7,44 TWh	6,12%	26,784
Waste	4,21 TWh	3,46%	15,156
Nuclear	4,16 TWh	3,42%	14,976
Oil	1,53 TWh	1,26%	5,508
Geothermal	0,53 TWh	0,44%	1,908
Hydro	0,05 TWh	0,04%	0,18
	121,62 TWh		437,832

Fossil-based	Non-fossil
54,91%	45,09%

CO2-Emissions by Source

Energy Source	CO2-Emissions	Share
Natural Gas	21,20 MToE	49,19%
Coal	17,40 MToE	40,37%
Other	3,40 MToE	7,89%
Oil	1,10 MToE	2,55%
Total	**43,10 MToE**	

Electricity Use by Sector

Energy Source	Electricity Use	Share	PJ
Commercial and Public	36,00 TWh	33,59%	129,59 PJ
Industry	35,39 TWh	33,02%	127,39 PJ
Residential	22,76 TWh	21,23%	81,92 PJ
Agriculture and Forestry	10,34 TWh	9,64%	37,21 PJ
Transport	2,70 TWh	2,52%	9,71 PJ
Total	**107,17 TWh**		

Current CO2 Emissions from Energy

CO2-Emissions by Energy Source

Energy Source	CO2-Emissions	Share
Oil	42,00 MToE	35,87%
Coal	21,40 MToE	18,27%
Natural Gas	50,10 MToE	42,78%
Other	3,60 MToE	3,07%
Total	**117,10 MToE**	

CO2-Emissions by Sector

Energy Source	CO2-Emissions	Share
Electricity and Heat	43,20 MToE	32,14%
Transport	25,10 MToE	18,68%
Industry	22,20 MToE	16,52%
Residential	17,00 MToE	12,65%
Other Energy	12,80 MToE	9,52%
Commercial and Publi	7,20 MToE	5,36%
Agriculture	6,30 MToE	4,69%
Fishing	0,40 MToE	0,30%
Other End use	0,20 MToE	0,15%
Total	**134,40 MToE**	

Future Energy Generation

Energy Generation Mix

Energy Source	Annual Generation	Share	
Wind	576,00 PJ	27,71%	
Biofuels (Heat-only)	590,40 PJ	28,40%	710,80 PJ
Biofuels	120,40 PJ	5,79%	
Geothermal (Heat-only)	400,30 PJ	19,26%	630,70 PJ
Geothermal	230,40 PJ	11,08%	
Solar	144,00 PJ	6,93%	
Hydro	17,28 PJ	0,83%	
Total	**2 078,78 PJ**		

Fossil-based	Non-fossil
0,00%	100,00%

Electricity Generation Mix

Energy Source	Annual Generation	Share	PJ
Wind	160,00 TWh	59,52%	576,00 PJ
Solar	40,00 TWh	14,88%	144,00 PJ
Biofuels	32,00 TWh	11,90%	115,20 PJ
Geothermal	32,00 TWh	11,90%	115,20 PJ
Hydro	4,80 TWh	1,79%	17,28 PJ
Total	**268,80 TWh**		

Fossil-based	Non-fossil
0,00%	100,00%

Energy Consumption by Sector

Energy Sector	Annual Generation	Share
Industry	571,50 PJ	30,98%
Residential	423,90 PJ	22,98%
Transport	393,30 PJ	21,32%
Commercial and Public	272,70 PJ	14,78%
Agriculture and Forestry	183,60 PJ	9,95%
	1 845,00 PJ	

Electricity Consumption by Sector

Electricity Sector	Annual Consumption	Share	PJ	Share of total energy
Industry	63,50 TWh	24,63%	228,60 PJ	40%
Residential	58,88 TWh	22,83%	211,95 PJ	50%
Transport	87,40 TWh	33,90%	314,64 PJ	80%
Commercial and Public	37,88 TWh	14,69%	136,35 PJ	50%
Agriculture and Forestry	10,20 TWh	3,96%	36,72 PJ	20%
	257,85 TWh		**928,26 PJ**	

Future Electricity Infrastructu

Electricity Source	Cogeneration?	Unit Capacity	Unit Heat Capacity	Unit?	No. of Units	Total Electric Capacity	Peak-equivalent Generation (hr/yr)	Annual Generation	Annual Generation - Heat	Annual Heat Generation	Total Energy Generation
Wind	NO	10 MW	-	1 Turbine	4.000	40 000 MW	4.000	160,000 TWh	576,00 PJ		576,00 PJ
Solar	NO	10 MW	-	1 ha of panel	4.000	40 000 MW	1.000	40,000 TWh	144,00 PJ		144,00 PJ
Biomass	YES	200 MW	5,76 PJ	1 Turbine	20	4 000 MW	8.000	32,000 TWh	115,20 PJ	115,20 PJ	230,40 PJ
Geothermal	YES	200 MW	5,76 PJ	1 Turbine	20	4 000 MW	8.000	32,000 TWh	115,20 PJ	115,20 PJ	230,40 PJ
Hydro	NO	100 MW	-	1 Turbine	12	1 200 MW	4.000	4,800 TWh	17,28 PJ		17,28 PJ
								268,800 TWh	**967,68 PJ**		**1 198,08 PJ**

Innovative Technologies

Floating Photovoltaic Panels

Floating Photovoltaics, source: https://www.euronews.com/green/2023/11/13/float-ovolta-ics-how-floating-solar-panels-in-reservoirs-could-revolutionise-global-power

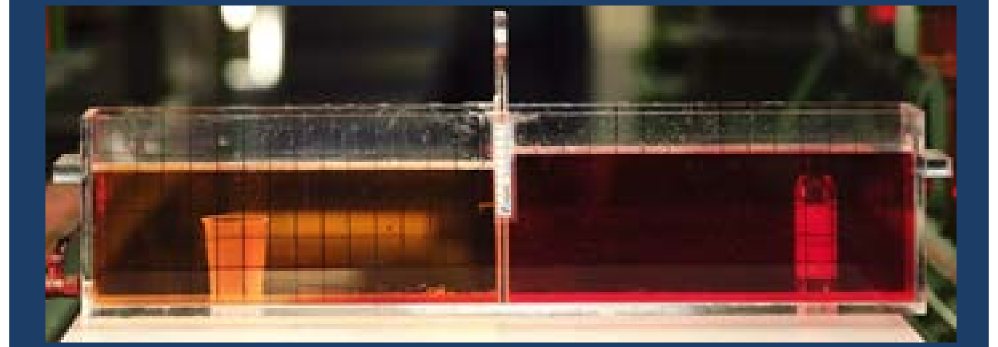
Carbon Capture and Storage

Carbon Capture and Storage (CCS) process, source: https://www.globalccsinstitute.com/re-sources/ccs-101-the-basics/

Bladeless 'Silent' Wind Power

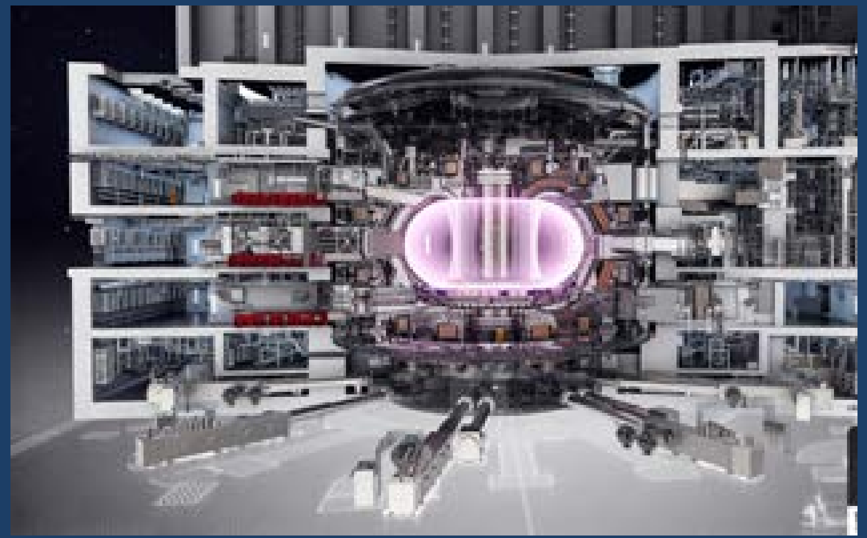
Vortex Wind Turbine, source: https://www.euronews.com/green/2022/12/02/it-may-look-rude-but-this-vibrating-wind-turbine-is-producing-clean-energy

Salt intrusion solutions



source: https://www.tudelft.nl/en/ceg/research/stories-of-science/sweet-solutions-to-a-salty-problem

Fusion Energy



Tokamak-type Fusion Reactor Cutout, source: https://www.iter.org/album/Media/7%20-%20Technical

Hydrogen as Intermittent Energy Storage

Hydrogen Electrolysis, source: : https://www.un.org/africarenewal/magazine/july-2022/green-hydrogen-viable-option-transforming-africas-energy-sector

Tidal Power

Vertical Tidal Stream Turbines, source: https://www.thecooldown.com/green-tech/tidal-ener-gy-how-works-advantages/

Solar bike lane

source: https://www.vox.com/2014/11/11/7193737/solar-power-bike-path-netherlands-so-laroad