EVERYTHING REMAINS TRANSFORMED

I would like to give very special thanks to my tutors Hamed Khosravi and Dominic Stead for their continuous support and feedback, for their understanding and mostly for their positive spirit during our discussions. I hope that this study will shed some light on the potential of the North Sea as a catalyst for the European energy transition and may shift planners' attention to systems and processes instead of using fixed outcomes and traditional planning approaches.

Special thanks also goes to Frank Werner, my mentor in Rotterdam at KCAP, for his substantial guidance and his fruitful comments.

P5 report

TU Delft

Faculty of architecture and the Built Environment
Department of Urbanism

Research group Delta Urbanism

Student	Jan Cyganski (4624319)
First mentor	Hamed Khosravi
Second mentor	Dominic Stead
Delegate	Willemijn Wilms Floet
External mentor	Frank Werner (KCAP)
Date	04.07.2018

BK

TU Delft

Abstract

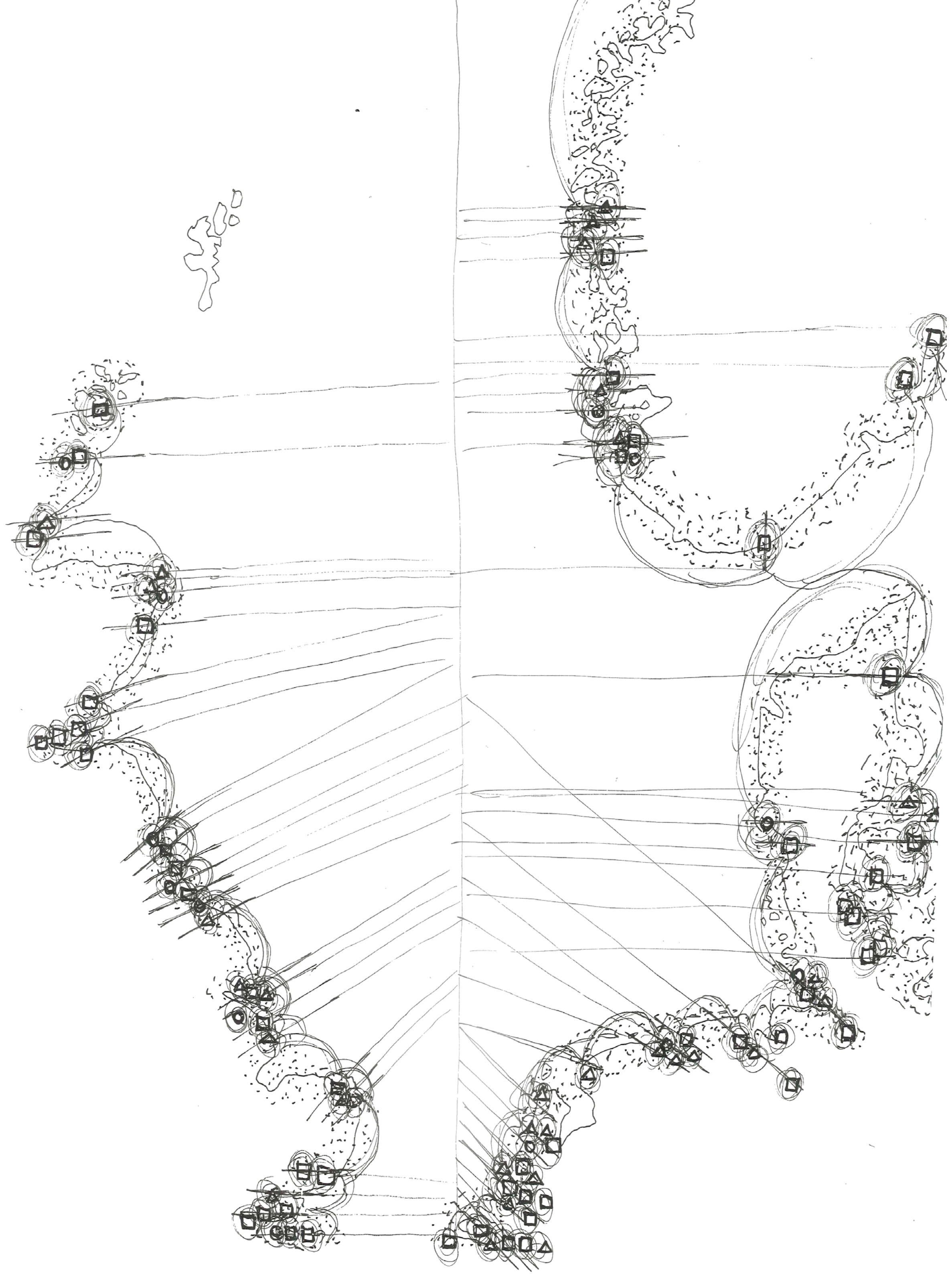
The European climate and energy goals towards 2050 ask for drastic systematic changes in the current European energy system to increase the share of renewable energies and to reduce carbon emissions – from 1990 to 2050 by 90%. The project Everything Remains Transformed intends to highlight how far-reaching the transformative process from fossil energy sources, like crude oil and gas coal, to renewable energies sources actually are. In the marine zone, we will have to decommission platforms and pipelines at immense costs and the coastline will eventually turn into a patchwork of abandoned harbours and refineries. In the terrestrial zone, we will have to pull the plug from coal power plants, while fossil-energy reliant businesses are running down, and citizens will lose their current high-living standards.

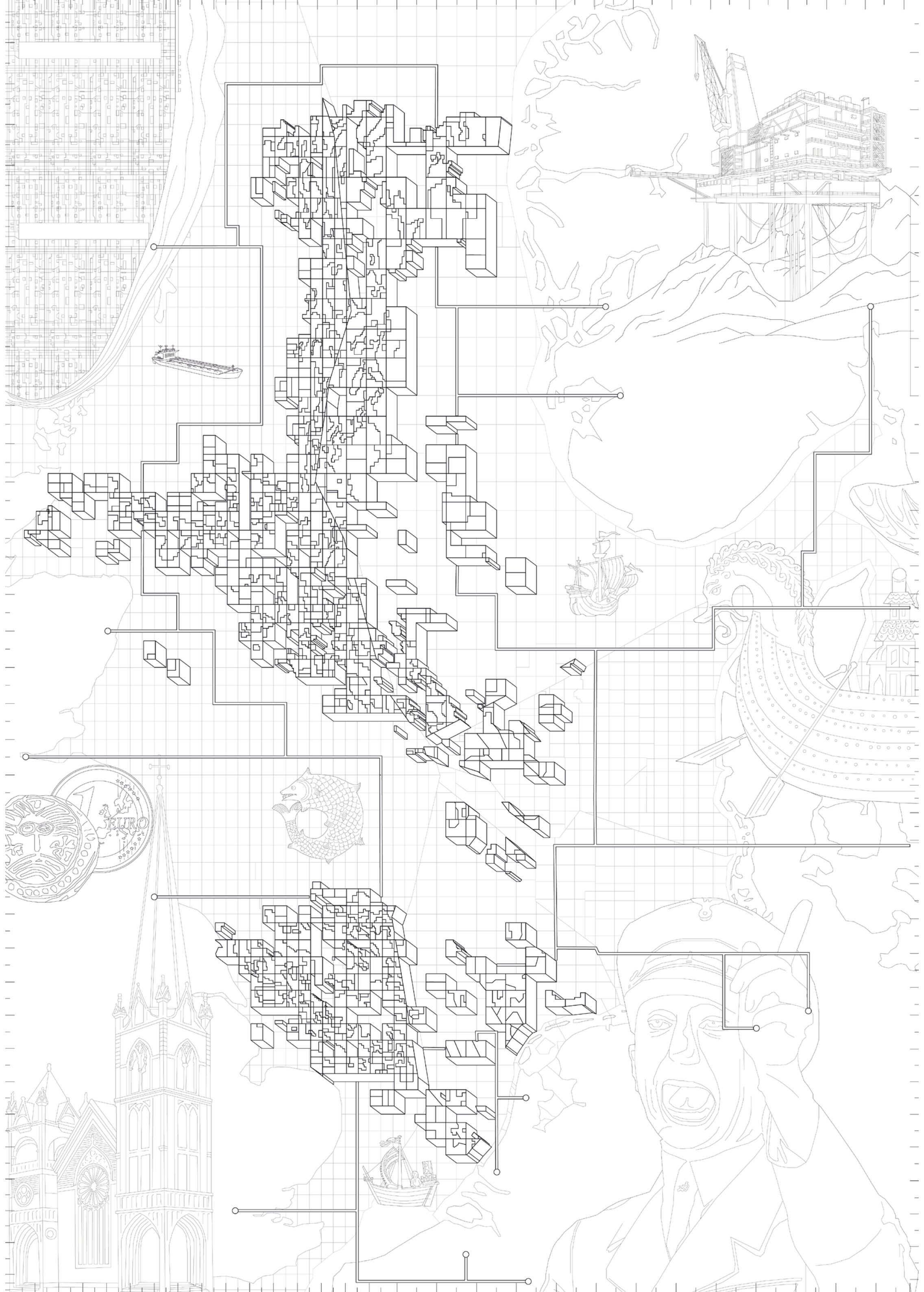
The current energy system adds in this respect to the high ecological footprints of each country in the North Sea territory and requires drastic change in the light of resource management and estimated enormous population growth, according to Eurostat, among the nation states.

Everything Remains Transformed relies on parts of the remaining energy legacy and the potential to transform its components. The project represents a new, energetic system in the North Sea that aims to create one big territory with one low footprint among all adjacent countries through collaboration. It demonstrates on the big scale, that a joint strategy will produce renewable energy to cover the territorial supply, reduces carbon efficiently and brings additional benefits beyond energy production.

A macro-regional strategy for the North Sea builds the overall framework for the strategy. The aim of the European Union's instrument is to jointly target common challenges with actors of various fields. On the small scale, in Aberdeen as a case study, I will showcase what influence big scale principles and spatial guidelines eventually have on the space and the societal and economic structure.

A sketch of the P2 presentation, which is highlighting the low-carbon belt and the collaborative seascape





P0.5 exhibtion: Visualisation of the North Sea as the heart for past, current and future cultural and societal development

INTRODUCTION

Everything Remains Transformed

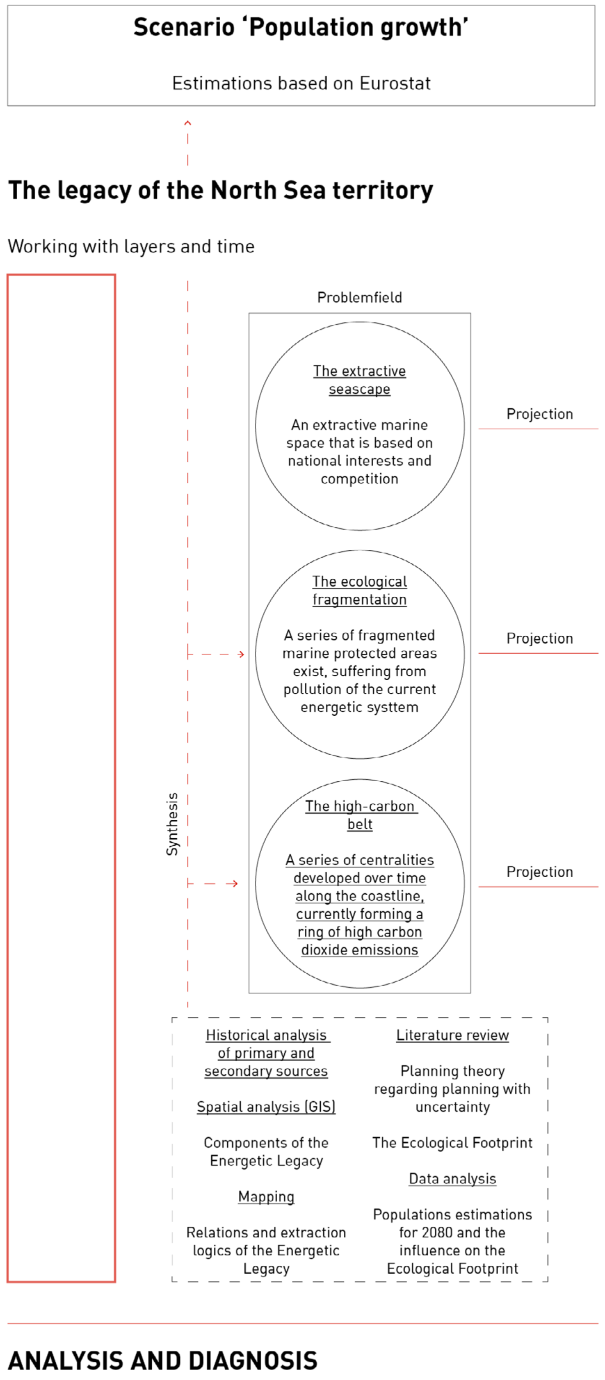
I recently read an interesting paper, 'Ten essentials for action oriented and second order energy transitions, transformations and climate research' by Ioan Fazy et al., which is claiming that the biggest challenge for contemporary climate research is how to facilitate transformative processes rather than research on the actual problems or threads of global warming (2018). My thesis is therefore taking the climate change and its threads, like the rising temperature and water level as well as more frequent extreme weather incidences, as given. I am instead focussing on the question, how we can enable rapid transformational changes in Europe in order to tackle these hazards.

The European Union formulated climate and energy targets for the years 2020, 2030 and 2050 which aim to reduce carbon emissions drastically and increase the share of renewables towards a low-carbon economy. Carbon is one of the main factors for global warming and counts currently as a waste product of the urban regions and industries.

"For every barrel of oil we burn, three times the quantity of CO2 is being produced. This means our actual carbon footprint is almost three times the size of our oil consumption." OMA, Roadmap 2050

TU Delft's graduation studio 'Delta interventions' focused in the academic year 2017/2018 on the North Sea territory. The majority of Europes oil and gas resources are located in this terrain. All adjacent countries extract resources for energy production and two of the biggest petrochemical clusters have huge impact on the national export revenue.
The term 'apparatus' is used throughout the whole project to describe the whole machinery and all components, that are related to or reliant on the infrastructural system. Through time, the infrastructure in the North Sea shaped society and culture of the adjacent countries. Starting with the romans, the sea was a crossroad for culture, language and religion, and was responsible for urban expansion. My thesis is therefore questioning, how the current apparatus of infrastructure will transform towards a prosperous low-carbon future. The different scales of the project are building up this booklet starting from the point of thought, that the North Sea accelerated the spread of society and culture in the adjacent countries. The historical 'look-back' is followed by an analysis of the energy legacy of the North Sea territory and by an urban growth scenario that will challenge future energy and resource supply.

The major focus of my thesis is on the North Sea as a whole system since I state that a collaborative strategy among all adjacent nation states is needed to tackle the challenges arising from climate change jointly. Three principles build up the framework for the structural vision of the strategy: A soft planning approach, that is flexible and adaptive to possible future changes. Aberdeen on the meso-scale acts as a study case and experimental ground to apply and test interventions arising from the macro-scale. The final part of the thesis consists of the design of different objects on land and in the sea as a manifestation of the new multifunctional energy system.



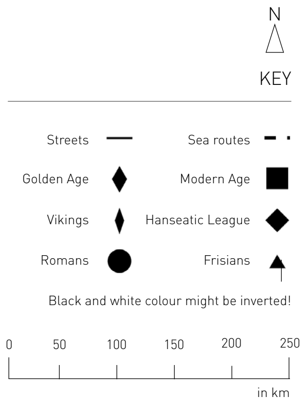
1 PROJECT FIELD

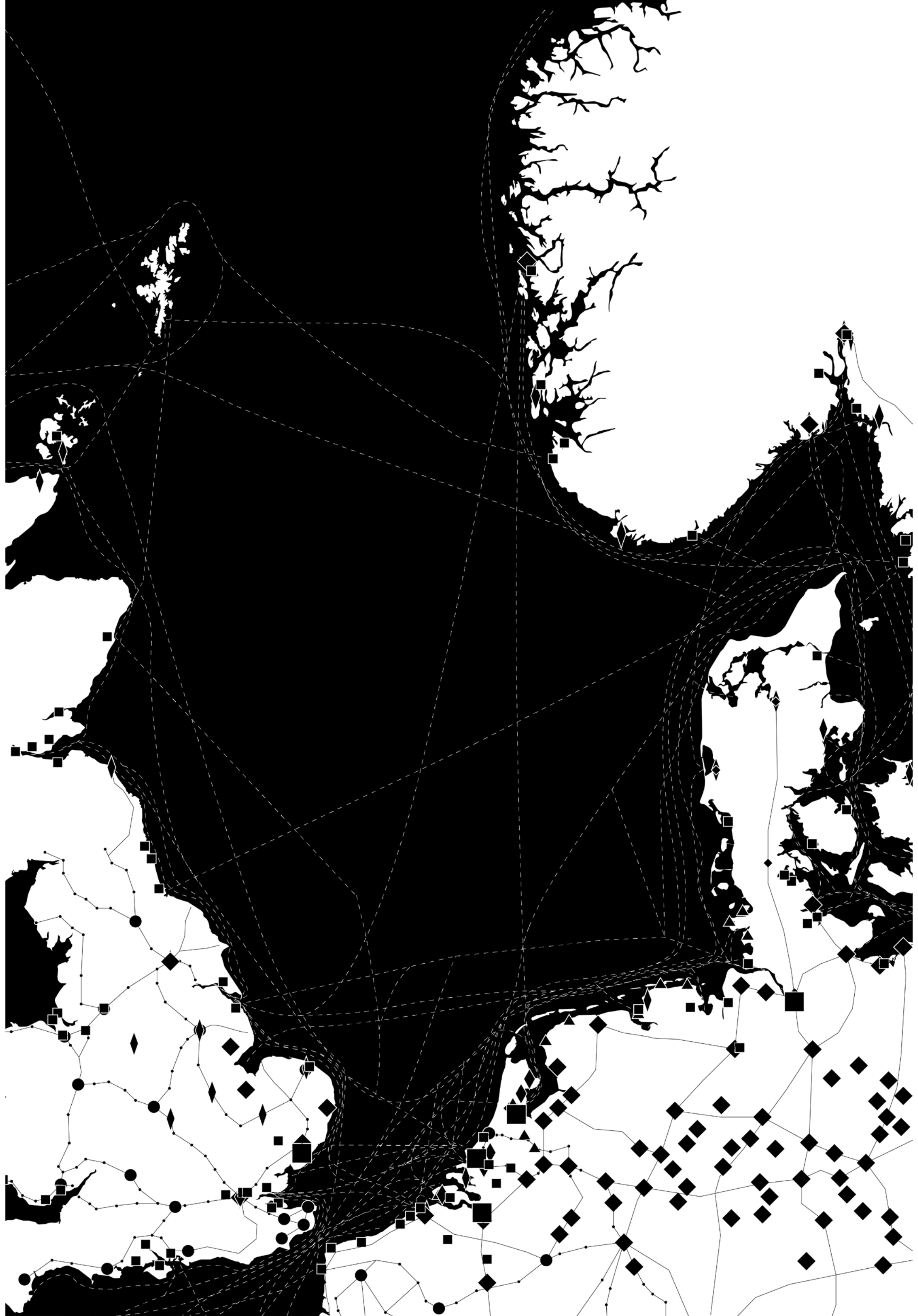
The project field is introducing the different parameters that support the design of an alternative energy system at the North Sea scale.

Starting with a historical look back, in the North Sea as a crossroad, I describe the different problems that the territory is facing nowadays in terms of resource extraction and energy production.
The remaining part of the chapter is following the classic research structure, containing the hypothesis, the method description and the vision. These elements build up the framework for my design project through the scales.

Overview of different centralities that evolved over time in the North Sea territory

Based on Pye, The Edge of the World, 2015; Roding, J. (ed.) and van Voss, L. H. (ed.), The North Sea and Culture (1550-1800), 1996; G-Geschichte Die Nordsee Rand der Zivilisation und Tor zur Welt, 10/2017





HISTORICAL OVERVIEW

The sea as a crossroad for society and culture

'The North Sea made us who we are, so she will determine where we go.'
Pye, The Edge of the World

Since early times, the North Sea is the source of life in the northern part of Europe and plays a key role in the spread of religion, language, culture and economic values. (Pye 2015).
The story of the North Sea begins in the Stone Age. The space, that is nowadays covered by water was a source of life and a pleasant living environment for the people of the stone age until they were confronted with climate change and a rising sea level (Sättler 2017). When a wide range of this fertile land was flooded, it became the crossroad for culture and society for future civilizations until the modern age. The following pages will briefly introduce the different epochs between the first century and the 20th century starting with the romans and ending in the age of globalization and industrialisation. Eventually, the historic development around the North Sea shore line would create one of the densest-populated areas in Europe.

Infrastructure play a key role for the importance of the North Sea as a catalyst for societal and economic development in the past. Men crossed the sea by boats, which intensified trade connections between adjacent nations of the North Sea but also brought violent conquests to the territory. Through the interplay of different types of infrastructure, certain relation to various field emerge, to different industries, economies and society. Infrastructure is, explained by Velikov and Thün, "actively structuring and restructuring the geo- and biopolitical relations between groups of humans, and between humans and the environment" (2017b) and builds up a whole and complex machinery.

To understand all elements, that are involved in this complexity, I want to highlight the work of the French psychiatrist Felix Guattari and the French philosopher Gilles Deleuze. Although they originally come from different disciplines, some of their works can be used to reflect on current planning theory. In their Apparatus of capture they are introducing the term apparatus as a tool to form 'social order' (Purcell 2013).

The apparatus of infrastructure is a complex system with different faces and characteristics over time. In essence, knfrastructure in the North Sea territory fostered the development of a series of centralities developed over time along the North Sea coastline and in the hinterland. These node points were of different nature depending on their location. Nevertheless, these centralities enabled urban growth and societal development in their surroundings. Most of these node points were harbours, that were a point of arrival and departure for ships that crossed the sea and transported goods, culture and values. For instance, the harbour in Aberdeen was first the centre for trade with wool, fish and woods. Later the harbour transformed into a node of the oil and gas industry and transformed the spatial and social structures of the city.

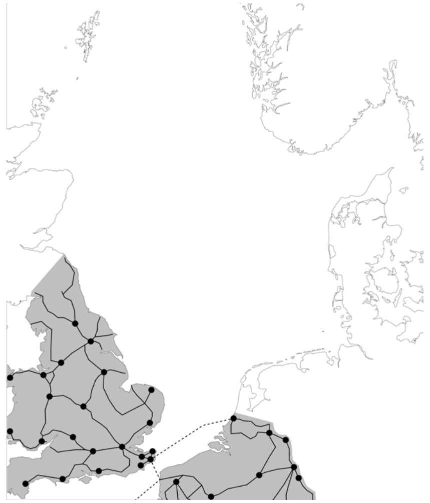
I will further in this report refer to the apparatus of infrastructure. I use this idea as a lens to understand, how different kind of infrastructure shaped the North Sea territory over time, including its urban nodes and society. My design proposal in a later part will deal with the question how we can change this apparatus of infrastructure to cope with future wicked problems, that I will introduce in this chapter.

The sea as a crossroad for society and culture

The North Sea was a crossroad for ships, trade and conquests and enabled the spread of culture and society, starting in the roman epoch. The graphics highlight the emerging centralities along the coastline, streets, shipping routes and as well as battlefields in the golden age and modern epoche.

Based on Pye, The Edge of the World, 2015; G-Geschichte Die Nordsee Rand der Zivilisation und Tor zur Welt, 10/2017; Atlas of European History, in https://upload.wikimedia.org/wikipedia/commons/6/60/Romanbritain.jpg, 1910, London, G. Bell & Sons, (accessed 11 January 2018), Roding, J. (ed.) and van Voss, L. H. (ed.), The North Sea and Culture (1550-1800); Nordzeeatlas, https://www.noordzeeloket.nl/en/, (accessed 08 February 2018)

The Roman discovery

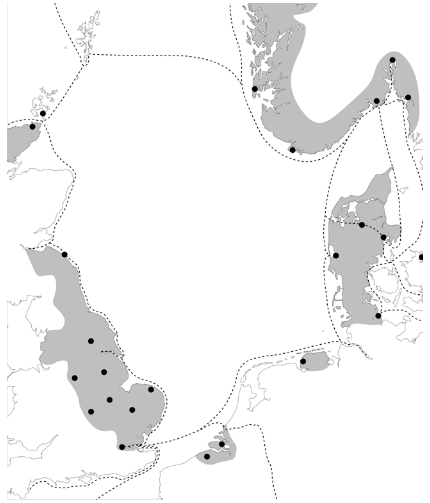


The sea played an essential role for the expansion plans of the roman empire since troops and goods were moved on water faster and more secure than on land. The roman empire accelerated in that way the spread of language as well as the ability of writing and reading. This process manifested in a first network of streets and cities in the southern UK, in the Netherlands and Germany.

The Frisian Sea

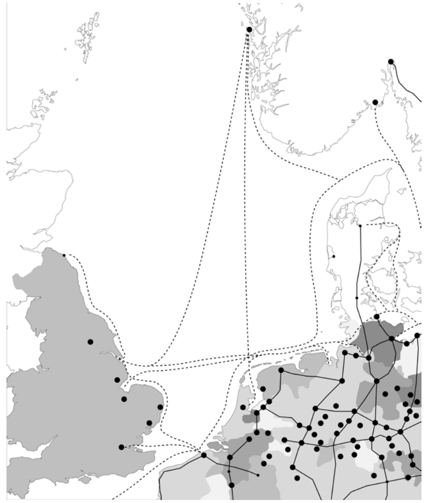
The Frisians stayed at the coast due to the infrastructural advantages the sea. The Frisian society dedicated its life to the water, which is manifested in the Frisian terps and temples as well as in the introduction of coins and the modern understanding of material value.
This small country became the central trade point for goods, reaching to central Europe, Scandinavia and Byzantium.

The Viking's conquests



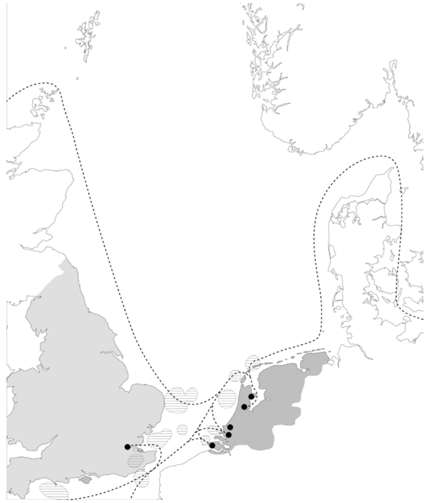
New innovations in shipping technology enabled the development of culture in the North Sea during the Viking age. By boat, the Vikings spread their understanding of technology, architecture, art and language mostly in Denmark and the UK.

The Hanseatic Age



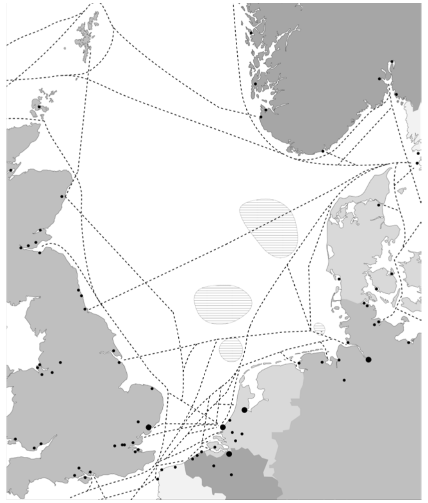
The Hanse established a dense network of cities, sea routes and streets. By doing so, Low German became a first universal language in the North Sea territory. The Hanse generated furthermore a collective network of trade for mutual benefits, trade safety and profit.
Numerous cities, especially in northern Germany are nowadays relying on the Hanseatic tradition.

The Golden Age



The Dutch and British East India Company both established a network of oversea routes in the Golden Age, which affected the people's consumption and the image of cities. Past exotic and luxurious products like fruits, tobacco or coffee are nowadays basic products in every day's life.
These routes were furthermore the reason for first territorial conflicts at the Sea between the Netherlands and England.

Industrialisation and Globalisation

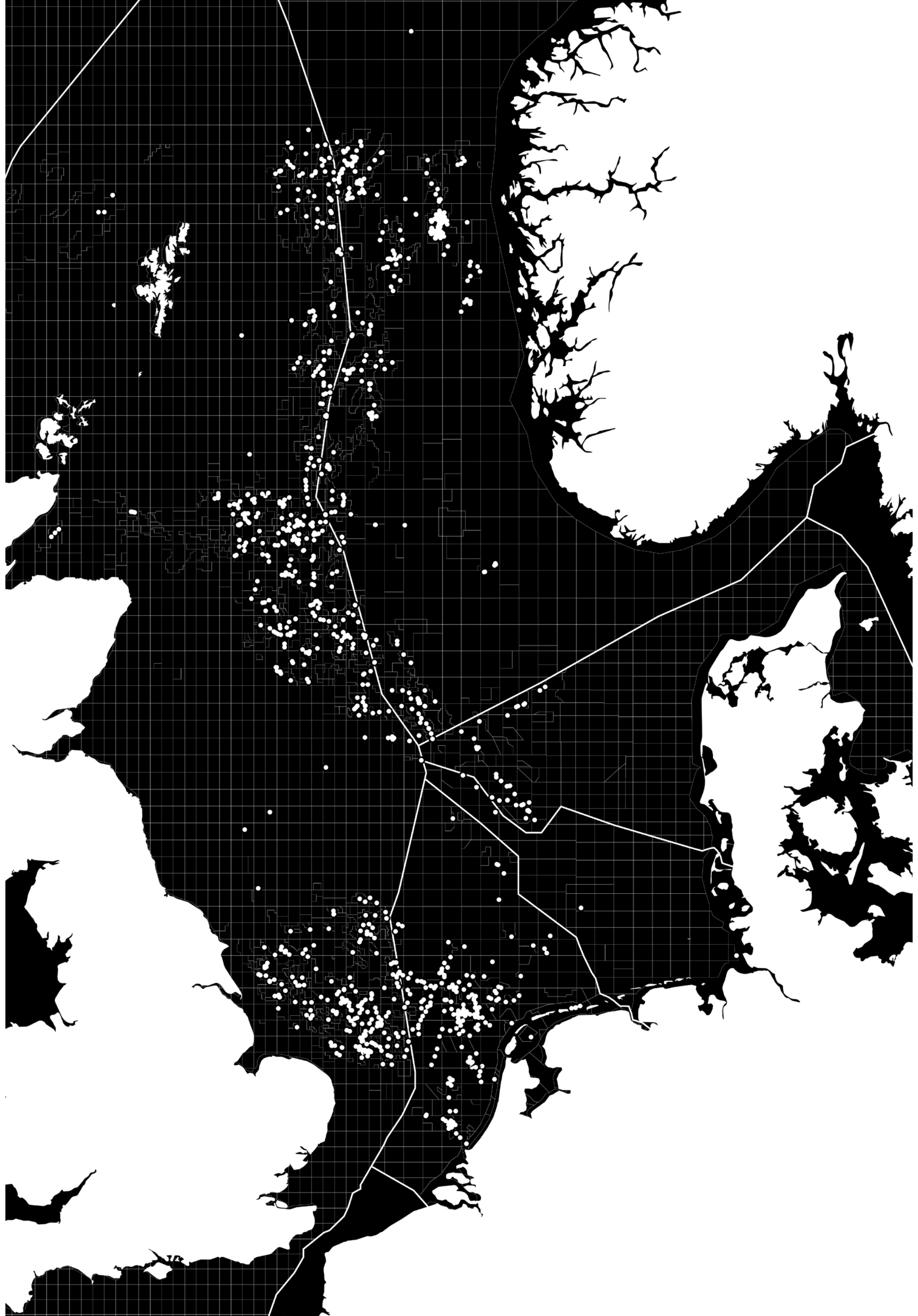


The development of transport and trade infrastructure accelerated during the industrialization due to new technologies and use of new materials. Nowadays, the North Sea is in terms of transport infrastructure, energy production and trade one of the busiest marine areas in the whole world.
This concentration of functions fostered the 'urbanisation' of the sea.

100 400 800 1400 1700 1900

Overview of the Exclusive Economic Zones (EEZ) and oil-license blocks

Based on Nordzeeatlas, https://www.noordzeeloket.nl/en/; Map of North Sea oil and gas fields, pipeline infrastructure, http://www.offshore-mag.com/content/dam/offshore/print-articles/Volume%2073/08/NorthSeaMap2013-071713Ads.pdf



N

KEY

EEZ border

Oil and gas platform

Black and white colour might be inverted!

0 50 100 150 200 250

in km

A conflict of power - regulating the sea

Over time, different nations and centralities evolved in the North Sea territory, which were all facing the sea and competing with each other. These fights over land, goods and politic rights resulted in numerous conflicts, happening on the land and in the sea.
For example, the Golden Age was characterised by politic conflicts between the Netherlands and the United Kingdome. The Dutch and British East India company fought for supremacy in oversea trade routes, which resulted in war and conflicts at the Sea. The North Sea became the stage for numerous big battles in the 16th and 17th century, like the four-days battle in 1667 in the second Dutch-British war (Boxer 1977). The North Sea was furthermore battlefield in the conflicts between the Allied Forces and Germany in the first and second world war. Since various strategically-important centralities during war were located along the shore line of the sea, the fights over the sea played a key role in winning the wars.

These conflicts peaked in the middle of the 20th century in a different way. Oil and resources were discovered and drove the nation's ambitions to regulate the extraction of fossil resources.
The North Sea is surrounded by 6 European countries: Norway in the North, Denmark in the East, Germany in the South, Belgium and the Netherlands in the Southwest and the United Kingdom in the West. All of these countries have a certain interest in the surface water and the sea basin, especially regarding energy.
First legal boundaries on the sea were drawn in 1958 with the introduction of the territorial zone up to 12nm (nautical miles) offshore. This intervention was a direct response to ongoing territorial conflicts, since previous regulations were based on the perception of the horizon line, about 3nm offshore (Couling 2017). The 1960th were determined by the discovery of oil and gas and it brought a major change to the North Sea territory in terms of regulation and division of water space and resources. A 200nm exclusive economic zone was added in 1982 specially to control resource exploitation, to protect the marine flora and fauna and to manage infrastructure activities (ibid.)
.
The object of interest was in this respect apparently the division of resources, since the EEZ boundaries were constructed by consideration of oil and gas field locations. Norway, the U.K. and the Netherlands benefited from rich resource fields while Denmark and Germany were in a bad position apparently because of their geographical location and presumably due to their weaker politic position of power. Each country divided their exclusive economic zones into blocks, based on longitude and latitude, and made license agreements. The operators were allowed to exploit the potential of oil and gas in their block in return of a certain percentage of profit to the state (Mace, Leckie, Gray et al.).

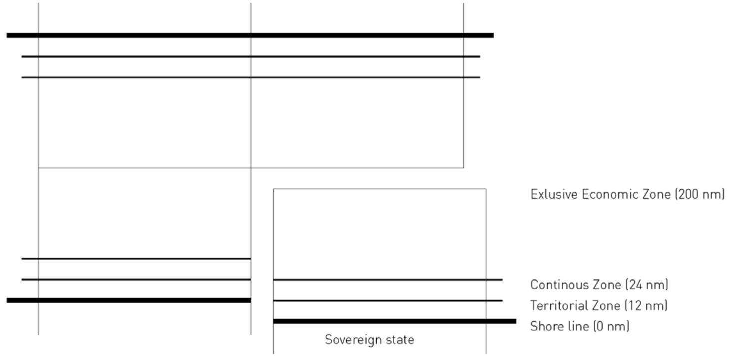
This complexity of power relations is determining the current North Sea territory and is creating institutional and spatial scarceties. The surrounding countries of the Sea are by nature sovereign and have legislative, executive and jurisdictive power on land. The exclusive economic zone still belongs to each country, but in a different state of power since the countries are losing parts of their sovereignty. Each country is holding sovereign rights to exploit resources or to control its extraction. In addition, the countries are sovereign in harvesting in their domain renewable energy. In contrast, they lose power in the realm of pipeline infrastructure, shipping routes and vessel traffic (regulated by international marine law) as well as fishing (EU law and policies). This division of power results in fragmented systems of authority and policy making. For example, decommissioning thousands kilometres of pipeline infrastructure and oil rigs will be one of the future challenges on the international level (Jack 2017). Joined forces instead of separated strategies might bring huge advantages and cut costs immensely.

Dutch and British authorities fight over sea routes and supremcacy in oversea, h ttps://commons.wikimedia.org/wiki/File:Storck,_Four_Days_Battle.jpg

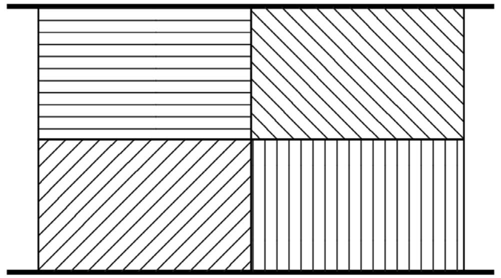
The Exclusive Economic Zones (EEZ) are dealing with various topics

Based on: Barry, M., Elema, I. and van der Molen, P., Governing the North Sea in the Netherlands, 2006

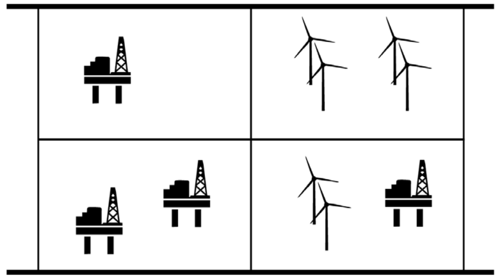
Legal structure of the North Sea



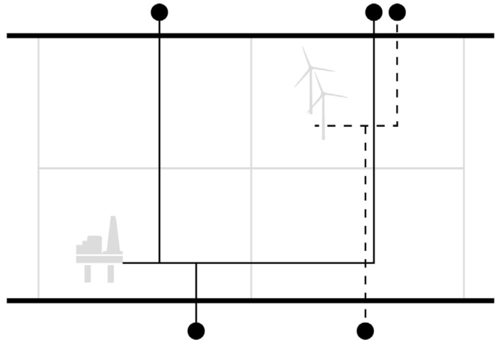
Partially conflicting national policies and laws



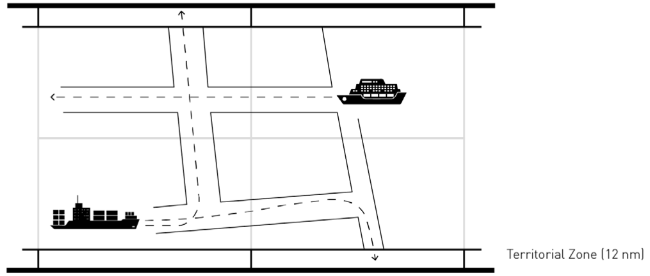
Energy: hard legal boundaries



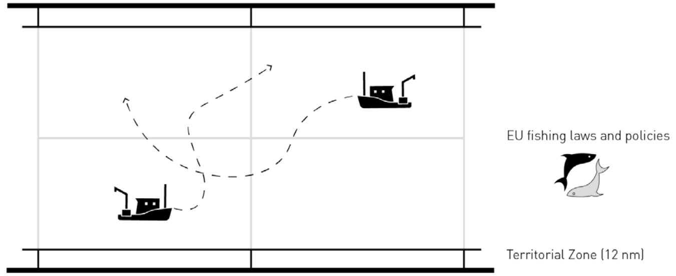
Cables and pipes: soft boundaries



Shipping routes determined by international law



Fishing determined by EU policies and laws



The Energy Legacy of the North Sea territory is devided in 3 zones

Data extracted from EUROSTAT, Thematic Mapping API, NLOG, OGA, NPD, DEA, PETRO-DATA, OSPAR

N

KEY

- Shipping route
- Pipelines
- Cables
- EEZ border
- Oil and gas platform
- Oil and gas field
- Wind turbine
- Coal site
- Chemical industry
- Energy substation
- Refinery
- Coal power plant
- Harbour

Black and white colour might be inverted!

0 50 100 150 200 250

in km

THE ENERGY LEGACY

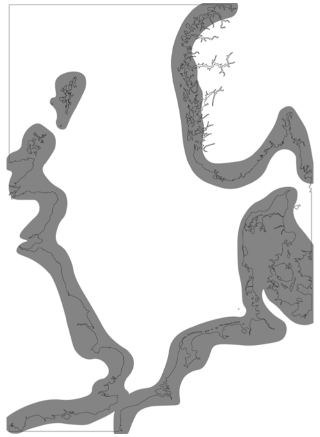
The sea as a space of extraction

The North Sea is one of the most crowded marine areas in the whole world (Bonn Agreement 2018). Next to busy shipping routes and wind farms, the North Sea is nowadays one of the main suppliers for crude oil and gas in Europe. Different sources discuss the question when and why the extraction of fossil resources will stop. For example, a Scottish newspaper is drawing the scenario that the U.K. will run out of oil and gas resources within the next 10 years (Amos 2017). Other sources mention technical obstacles, economic profit and the climate change as major points of consideration towards a post-oil future.

The chapter 'The energy legacy' is highlighting two major problems, that the North Sea territory will face in the future regarding energy and resource supply: The limitations of oil and gas and its dependency as well as the seasonal and diurnal variations of wind energy. These challenges leave the question how the energy system of the North Sea territory will transform towards an uncertain future. Therefore, I will introduce at the following pages potential future brownfields categorized in zones: The marine zone, the coastal zone and the terrestrial zone. Afterwards. I explain the extraction logics of the current energy system, which bind the three zones together and characterise the North Sea territory as a space of extraction.

The Marine Zone

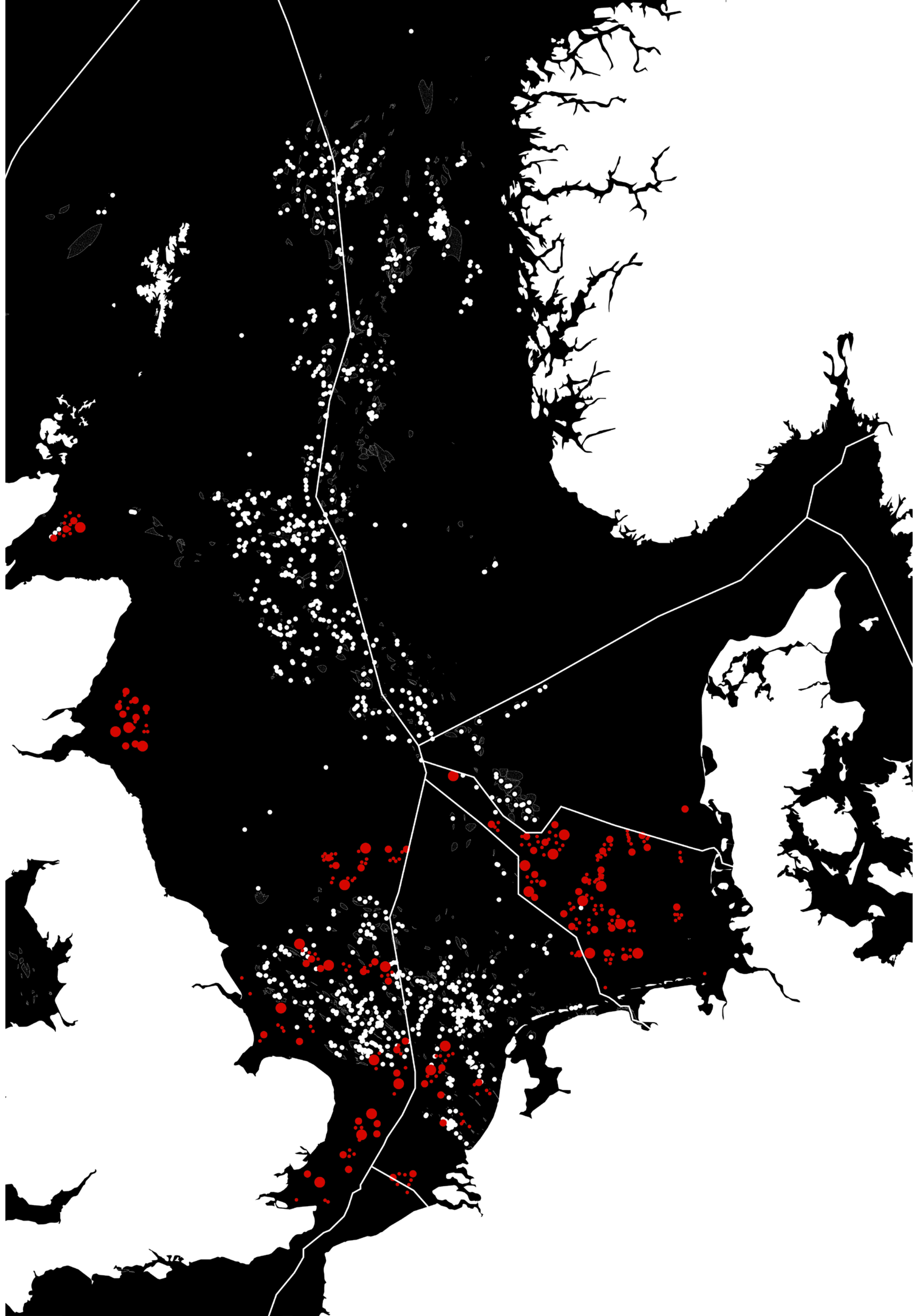
The Coastal Zone

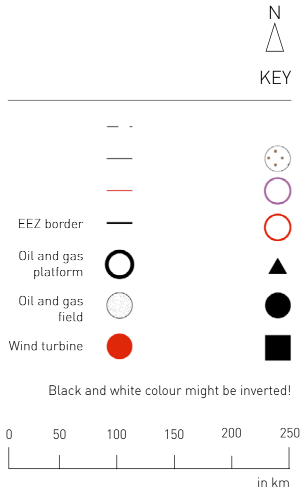


The Terrestrial Zone

Overview of existing oil and gas rigs as well as wind parks

Data extracted from EUROSTAT, Thematic Mapping API, NLOG, OGA, NPD, DEA, PETRO-DATA, OSPAR



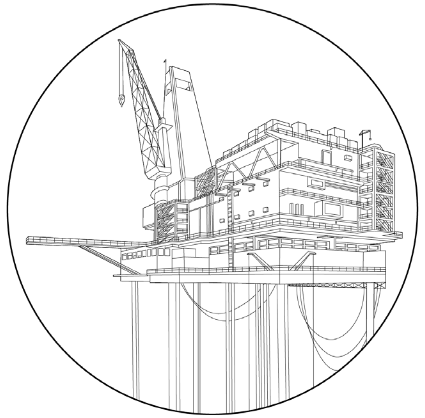


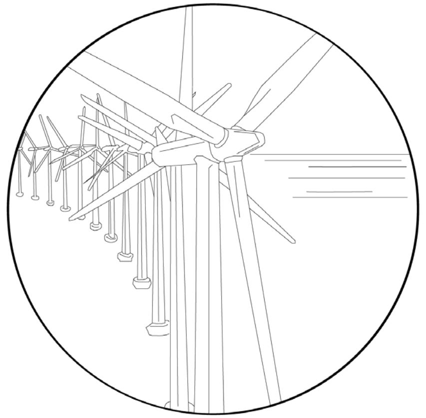
The current energy system in the marine zone

The marine energy system currently consists of two major energy sources: Crude oil and gas and wind power. The map is showing a concentration of fossil energy sources in the North and South of the sea. The northern area is shared by the United Kingdome and Norway, which are the major extracters exporters of crude oil. Norway covered in 2016 12% of Europe's oil supply and 35% of gas supply in 2012 (Statista 2016), which makes Norway the main exporter of oil and gas in Europe.

The major part of the southern resource field is crude gas and is shared by the United Kingdome and the Netherlands. Currently, 184 oil rigs are extracting oil from the basin of the sea (Statista 2018). One of the major challenges will be how to reuse or decommission operating and already abandoned platforms in the future. The Guardian is arguing, that hundreds of oil and gas rigs as well as thousands of kilometres of pipelines need to be eventually removed from the sea (Jack 2018).
Wind energy parks are spread across the whole North Sea and numerous new facilities are in planning phase since the main part of electricity from renewable sources will be produced by wind energy in the future (IABR 2016). The majority of wind turbines currently exist in Germany, which already generate 16% of their electricity consumption by wind (Fraunhofer IS 2018). New wind parks in the North Sea territory are mostly planned offshore since the wind speed at the sea is higher and increases electricity generation by the factor 3 (GENI 2000). All countries surrounding the North Sea invested in to wind energy due to different reasons. First, it is a business and creates thousands of new jobs. This fact is important regarding the fact that jobs in the field of fossil energy sources are disappearing. Second, countries like Denmark and Germany invested a lot in wind energy to be less dependent on other energy sources.

The marine components of the current energy system: oil and gas rigs and wind turbines





The limitations of crude oil and gas resources

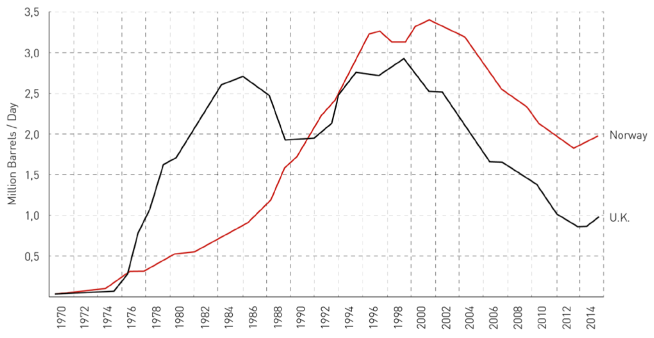
'It's always been said the stone age did not end because we ran out of stones. So, the oil age is not going to end because we are running out of oil.'

Carola Hein

Numerous sources are trying to predict the day of oil and gas depletion in the territory of the North Sea. Research papers differ in the prediction between one decade and the years beyond 2050, depending on the country. Even within certain countries exist different scenarios about the question how many resource fields are left. A Scottish newspaper is arguing, that the U.K. is running out oil and gas within 10 years and is basing the predictions on different academic sources (Amos 2017). Another journal is stating, that the United Kingdom has still a considerable amount of oil resources left, and an end of oil production cannot be foreseen (Nahkle 2016). Norway on the other hand seems to own enough resource potential to exploit oil and gas fields beyond 2050. Even if Norwegian resource fields in the North Sea are running out of oil in the North Sea during the next decades, the country can exploit recently discovered and accessed oil and gas fields in the Barents Sea (Couling 2017).

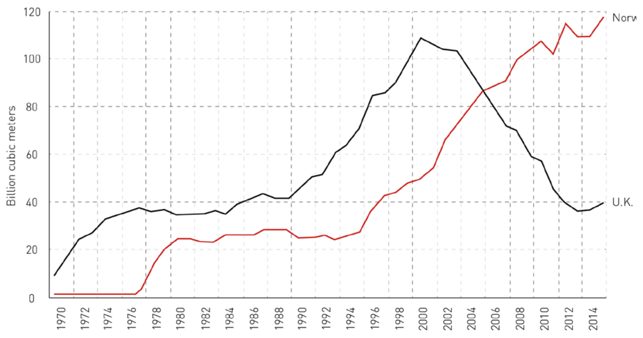
The tendencies of North Sea oil show a clear decline of production rates since the peak time in the 90th and early 2000 in Norway and the UK. A recent increase of production on the other hand might indicate a revitalization of oil and gas exploitation in the North Sea (Nahkle 2016). If and when oil and gas production come to an end will be dependent on different factors since current predictions on the resource depletion seem to have a pure estimation character and an accurate forecast is almost impossible. An indicator might be the question on how profitable new discoveries of oil and gas fields are. New fields need to have a certain size to be profitable for extraction, because infrastructures, like platforms and pipelines, are very expensive to construct (Johnson 2017).
In addition, the politic domain will influence the discussion since the European climate goals for 2020 will be most likely missed (European Environment Agency 2017). Accelerating the process of a society that is not any longer relying on crude oil and gas resources might be therefore on the politic agenda in the upcoming ten years in order to meet the climate goals for the next decade towards 2030. An additional consideration of cost is the decommission of abandoned oil and gas infrastructure. The North Sea demands in the next decades to deconstruct about 470 oil platforms and 10 000km of pipelines (Jack 2017).

Norway and U.K. crude oil production, 1970 - 2014



Source: BP Statistical Review 2015, DECC, Norwegian Petroleum, http://www.crystolenergy.com/assessing-future-north-sea-oil-gas/June 2017

Norway and U.K. crude gas production, 1970 - 2014



Source: BP Statistical Review 2015, DECC, Norwegian Petroleum, http://www.crystolenergy.com/assessing-future-north-sea-oil-gas/June 2017

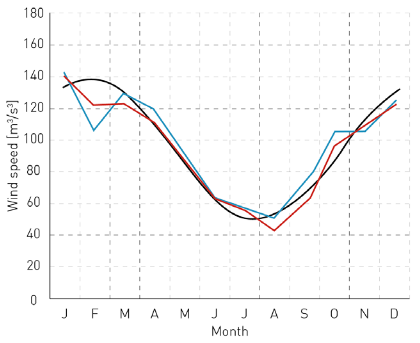
The variations in wind energy production

Wind energy might be on a short term the most valuable source for renewable electricity production, but it brings problems regarding the security of electricity supply in the North Sea territory as a whole.

The main problem with renewable wind energy are the seasonal and diurnal variations in renewable energy production. The figure below is showing the average difference of wind speed on northern latitudes, which correlates directly with the energy production by wind. Both figures are stating, that the North Sea territory is lacking the potential to generate electricity in summer but might bear on the other hand a future surplus in winter (Mulder 2014).
The diurnal differences, the variations of energy production during a day, are described in figureon the bottom right. This calculation derived not from the particular case of Northern Europe. This is a model, that can be applied in a general context, since diurnal variations of sun and wind are both mostly related to the surface temperature (ebd.). These strong daily differences are a challenge since energy security is one of the most important point of discussion and the storage of energy is still problematic (Arnold 2014).

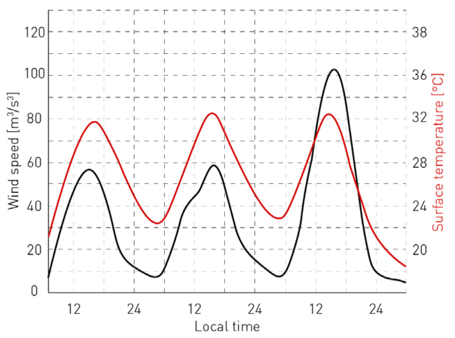
The problem of electricity supply by wind energy is close related to the current extraction logics that is described later in this chapter. With current patterns of renewable energy generation, sudden demands of electricity can not be covered, because there is no centralised renewable electricity grid existing in the North Sea.
This is a critical point, because the demand of electricity can rise forseen and unforeseen caused by different occassions. For example, the British TV show *Eastenders* is causing every week a sudden increase in the electricity demand, because most of the British people tend to drink a cup of tea after an episode is over. The U.K. needs to import additional electricity from France to deal with this problem. Covering this demand with renewable energy would mean, that electricity needs to be imported over long distances from Germany or Denmark.

Average windspeed in the US for shore (blue) and off shore (red) locations and an approximation (black)



Source: Mulder, F. M., Implications of diurnal and seasonal variations in renewable energy generation for large scale energy storage, American Institute of Physics, 2014

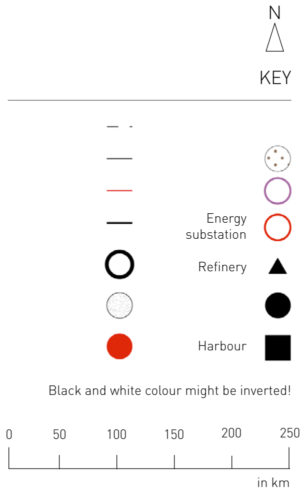
Diurnal variations of wind speed and surface temperature during 3 days



Source: Mulder, F. M., Implications of diurnal and seasonal variations in renewable energy generation for large scale energy storage, American Institute of Physics, 2014

Overview of existing energy centralities along the North Sea shore line

Data extracted from EUROSTAT, Thematic Mapping API, NLOG, OGA, NPD, DEA, PETRO-DATA, OSPAR



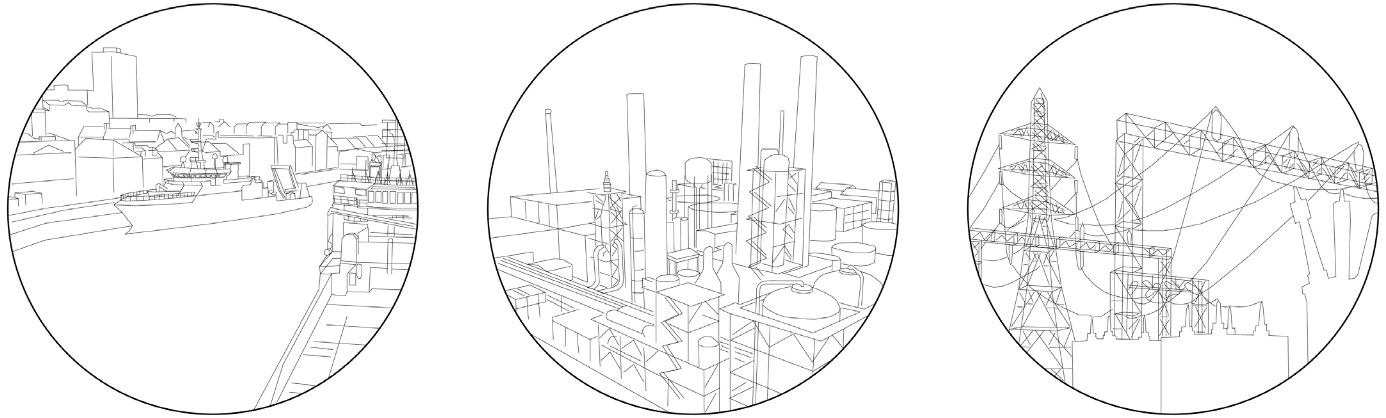
Coastal centralities as potential future brownfields

Over time, a series of centralities developed along the North Sea coast line. These centralities fostered urban and economic growth of the surroundings areas. Later in the reports, I will explain such a process more in depth in the case of Aberdeen harbour.

Nowadays, 3 different kind of centralities can be found in the energy system of the North Sea: Harbours, refineries and energy sub stations. These centralities were formed due to the necessity to produce energy by extracting resources from the sea. The oil and gas industry fostered the growth of harbours in the whole North Sea territory and brought urban growth and economic prosperity to the surrounding regions. For example, Rotterdam harbour and chemical clusters expanded immensely due to the oil and gas industry. This development had a huge influence on the city, since the local government invested heavily in infrastructure instead of the urban quality. It had the effect, that Rotterdam experienced economic prosperity in the 1970th but the inhabitants, especially the wealthy citizens, left the city (World Port Source 2005).

Apparently, these centralities have an influence on the development of the urban areas in the North Sea territory, but most of these nodes will change in the future. The energy transition brings major changes to the structure of the potential future brownfields. Harbours that are relying on oil and gas leave the question on how to transform towards a future which is less dependent on fossil energy resources. Oil refineries are facing the same challenges and create huge areas of potential future desolations integrated in the urban fabric or in rural areas. Energy sub stations are the only spaces of the current energy system that will most likely remain in a low-carbon economy. These structures might even grow, since the future energy system will rely more on renewable electricity production by different offshore sources.

The coastal components of the current energy system: Harbours, refineries and energy sub stations



Overview of existing potential future brownfiels on land

Data extracted from EUROSTAT, Thematic Mapping API, NLOG, OGA, NPD, DEA, PETRO-DATA, OSPAR

N

KEY

Coal site

Chemical industry

Refinery

Coal power plant

Black and white colour might be inverted!

0 50 100 150 200 250

in km

The dependency on fossil resources

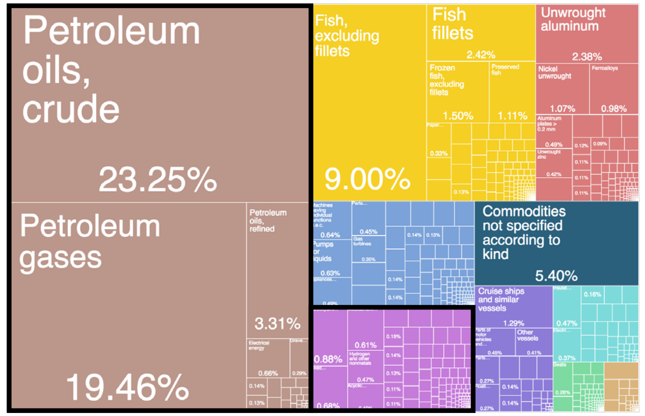
The petroleum industry is one of the key drivers for Europe's economy. Oil and gas fields as well as related infrastructure is occupying big parts of the North Sea's surface water and sea basin. Numerous oil terminals and refineries exist along the coast line to export or import petroleum goods. The countries in the North Sea territory can be roughly divided into two catergories: fossil producers and consumers.

The main producer of oil and gas is Norway, where more than the half of the export revenue is based on oil and gas resources. The U.K. is also a big oil and gas producer but they are exporting less of their resources than Norway since big chemical industry clusters in the country are existing around Hull, Manchester and Liverpool. The main consumer of oil and gas resources in the North Sea territory is Germany, because the Rhein-Ruhr area forms together with the chemical industry in the Netherlands one of the biggest chemical clusters in the world (Deloitte.) A major part of the German export is based on processed oil and gas resources, which makes Germany the leading European country in the chemical sector (GTAI 2017). Nevertheless, the sector is slightly decreasing since 2011 (Ibid.).

Other types fossil resources to produce electricity can be found in the terrestrial zone. Germany and the U.K. are still heavily relying on coal in terms of electricity production (Sandbag 2017). This type of electricity production emits a lot of carbon dioxide and needs to be reduced regarding the European climate and energy goals 2020 and 2030 since the central aim is to reduce greenhouse gas emissions and to increase the share of renewable in electricity generation (European Commission 2018a). The United Kingdome planned the coal exit in 2025 but Germany still did not agree on a date (Sandbag 2017).

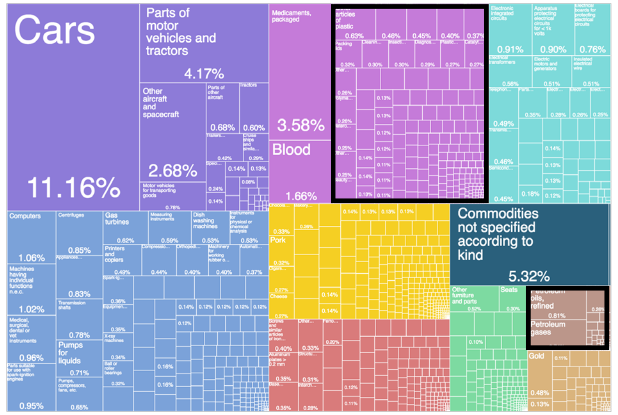
The transformation of the European industrial clusters towards a low carbon economy leaves the questions how to secure the economic prosperity and social wealth regarding the depletion of oil and gas resources. Chemical industry clusters and sites of fossil energy production need to find alternative ways to produce goods and energy. For example, carbon dioxide could be used as an alternative resource for the petrochemical industry to produce different types of fuels and plastics.

Norway as an oil and gas exporter



Source: Harvard Atlas of Economic Complexity, http://atlas.cid.harvard.edu/

Germany as an oil and gas consumer: exporting goods bassed on oil and gas resources



Source: Harvard Atlas of Economic Complexity, http://atlas.cid.harvard.edu/

Carbon dioxide emissions
in the North Sea territory

Data extracted from EU GeoCapacity, EU-ROSTAT, Thematic Mapping API, NLOG, OGA, NPD, DEA, PETRODATA, OSPAR

N

KEY

0 - 2,000
2,001 - 5,000
5,001 - 10,000
10,001 - 32,000

CO_2 emissions in mt/year

0 50 100 150 200 250
in km

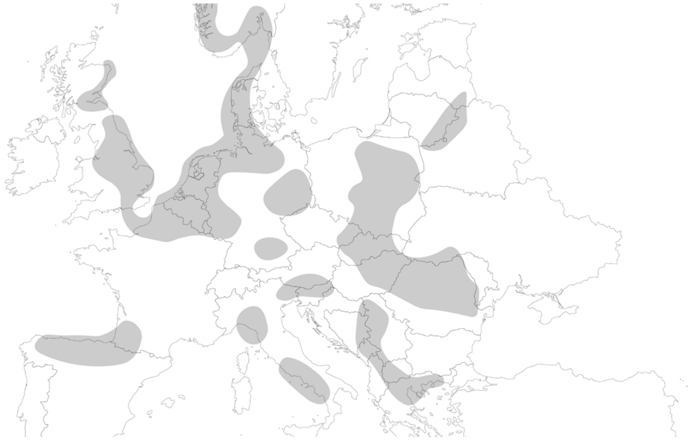
The European high-carbon ring

The adjacent regions along the North Sea coast line form one of the densest-populated areas in Europe. This circumstance, the electricity production through coal in Germany and the U.K. and the concentration oil and gas-related industries are the main contributors to the development of a high carbon ring in the North Sea territory, which emits hundred thousand of megatons of carbon dioxide each year (EU GeoCapacity 2006).

Germany is the main emitter of carbon dioxide in Europe with 778 kton CO_2 in 2015 (European Commission 2015). The major contributor is the Rhein-Ruhr area where coal minining fields, power plants and petrochemical clusters are located. The Netherlands is part of this petrochemical clusters with the major oil harbour in Rotterdam and emits in relation to the country size large amounts of carbon dioxide, 165 kton in 2015 (Ibid.). The U.K emits anually about 399 kton of CO_2, which is as well based on coal mining and petrochemical clusters next to Hull, Manchester and Liverpool. Norway and Denmark emit just little amounts of CO_2 in comparisson to the other adjacent countries of the North Sea territory. Both countries are not as much reliant on fossil energy sources and already show a higher share in renwable energy. As an example, Norway generates more than 90% of their electricity demand through hydropower.

Other regions in Europe also necessarily need to reduce their carbon emissions. Especially the countries in South East Europe contribute a lot to the European carbon dioxide emissions. These emissions need to be reduced regarding the European climate goals for 2020 and 2030.

High-carbon regions in Europe



Based on EU GeoCapacity 2006, http://www.geology.cz/geocapacity/publications/D42%20GeoCapacity%20Final%20Report-red.pdf

The logics of resource extraction
in the North Sea territory

Data extracted from EUROSTAT, Thematic Mapping API, NLOG, OGA, NPD, DEA, PETRO-DATA, OSPAR

N

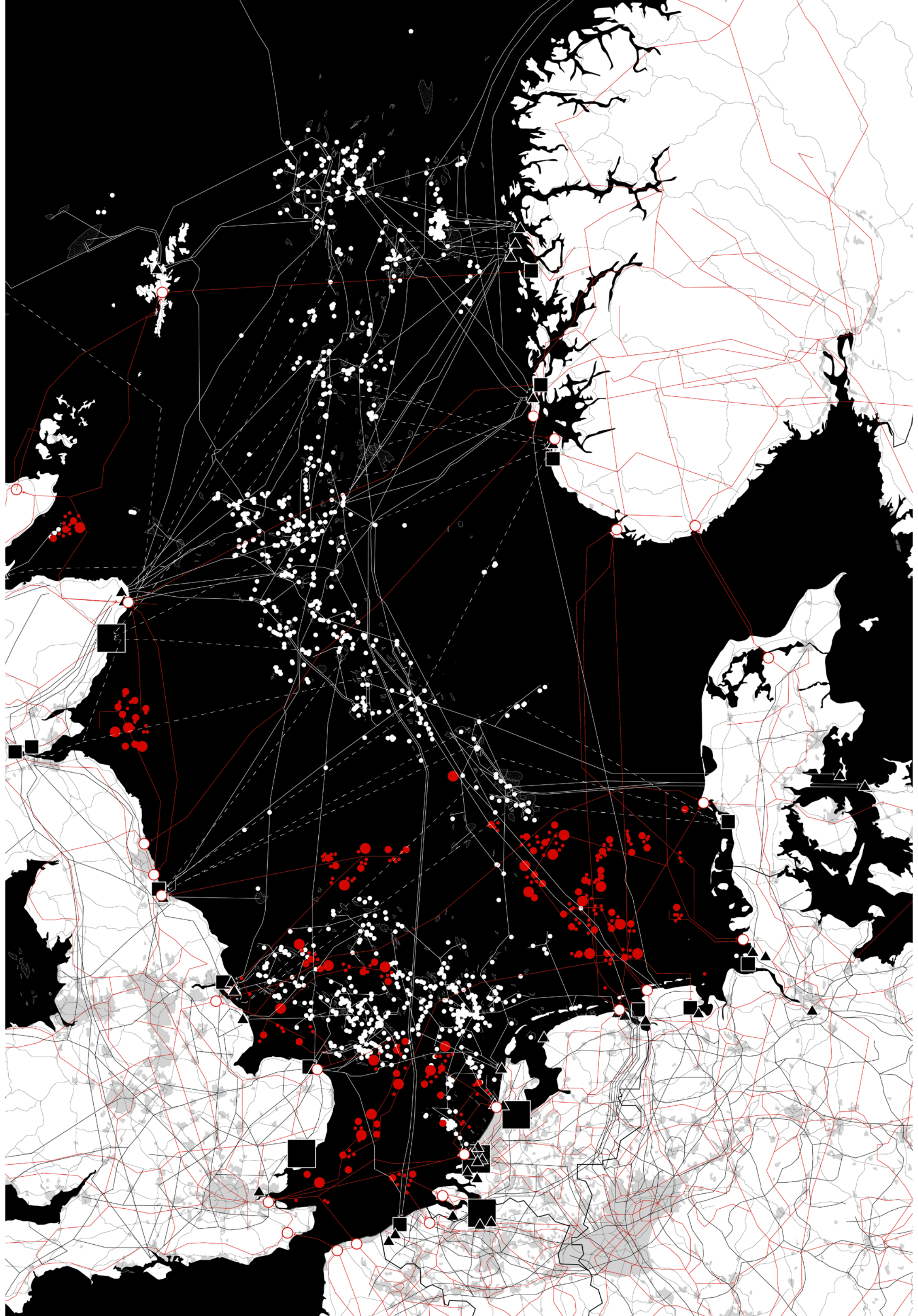
KEY

Shipping route	— -		
Pipelines	—		
Cables	—		
	—	Energy substation	
Oil and gas platform		Refinery	
Oil and gas field		Coal power plant	
Wind turbine		Harbour	

Black and white colour might be inverted!

0 50 100 150 200 250

in km



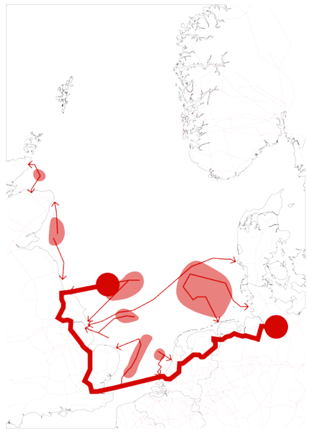
The extraction logics

Currently, two different kind of resource extraction happen simultaneously in the North Sea territory. Oil and gas is transported by pipes and tankers to the oil terminals and refineries and electricity is transported by cables from the offshore wind turbines to the energy sub stations at the coast. Crude oil is transported majorly by tankers to the destinations and partially by pipelines while gas is especially transported by pipelines. Besides to the problems with oil and gas, that were discussed before, the major problems with oil and gas extraction are the environmental threads that derive from the moment of drilling and extraction and from the transport by ships.

The major problem of the current resource and energy extraction is related to the wind energy production. Since high variations exist in the wind energy generation, a flexible and central system is needed to react fast to sudden surplus and shortages in the electricity production. One big problem regarding a surplus of electricity is currently the question of storage (Arnold 2014). In terms of electricity shortage, the biggest problem is that the electricity currently cannot be sent directly to the consumers but needs to be send through various additional electricity grid of different national states and passes multiple exchange points. The problems of long-distance electricity transmissions are next to potential taxations the loss of energy and technological issues in constructing high-voltage cables. Long-distance are in addition more vulnerable to weather and natural surges and are more cost-intense (Edison Tech Center 2018).

Linear extraction of oil and gas from the fields to the receiving terminals and refineries

Problematic transportation of wind energy from surplus sites to demanding areas



Marine sites of natural preservation and pollution in the North Sea territory

Data extracted from EUROSTAT, Thematic Mapping API, European Commission (Environment)

N

KEY

Oil and gas platform

Pollution

Existing ecologicial zones

Planned ecologicial zones

Black and white colour might be inverted!

0 50 100 150 200 250

in km

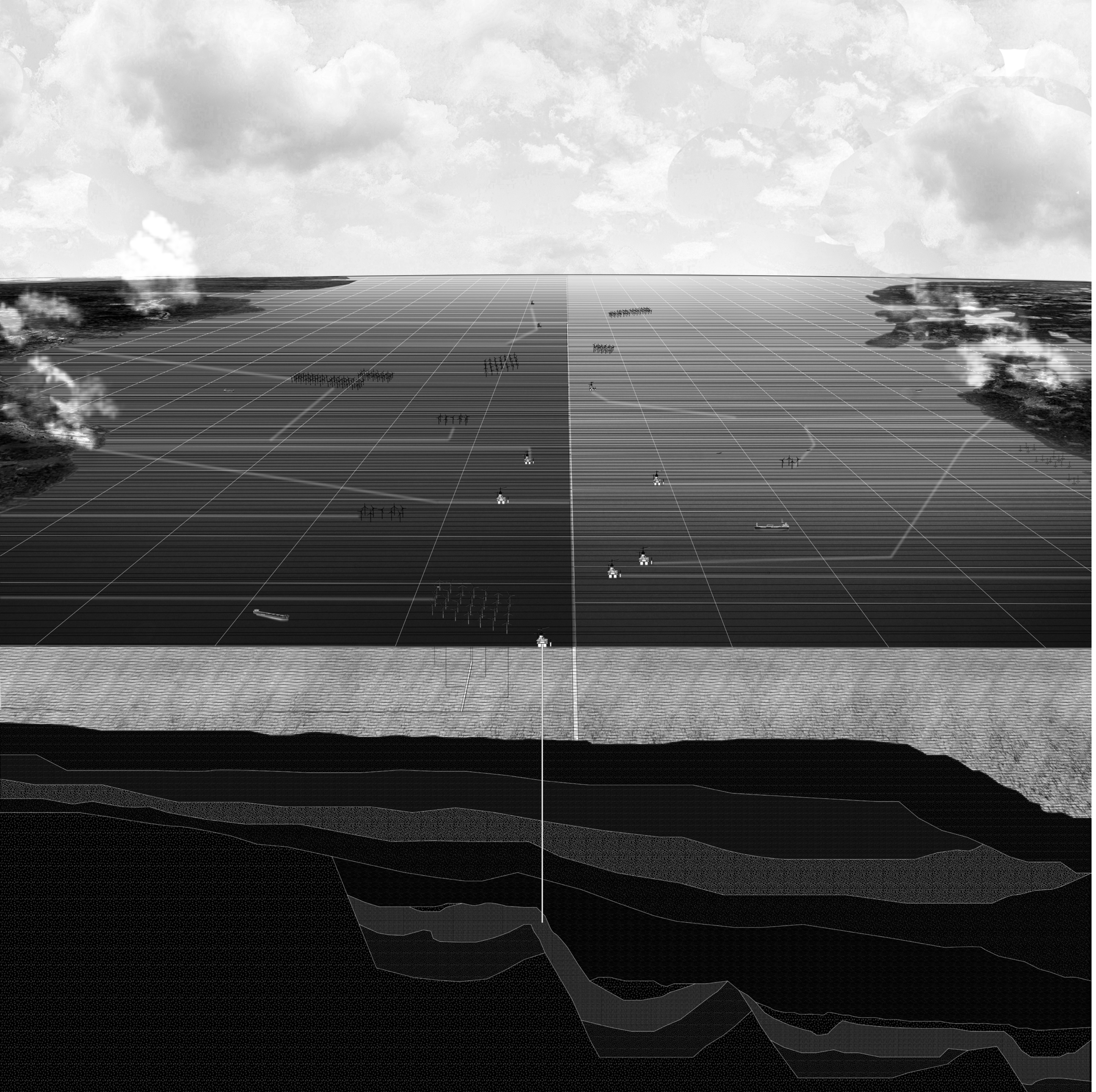
Pollution caused by the current energy system

Different occasions in the production chain of oil and gas, from the discovery and the extraction of resources to the transport are threatening the environmental conditions of the North Sea. The pollution is directly harming the seabed, the air and water quality (Carpenter 2015).

Whenever oil is discovered and offshore drillings begins, the sea basin and its rich habitat and species are affected by dredging ships and pipelines. Tools to discover offshore resources, like seismic waves, are harming ocean mammals. Drilling is furthermore producing toxic mud, which is released in the ocean. It results in a decrease of marine species reproduction and its distinction and small toxic particles can become part of the marine food chain (Horton 2008). Related is the pollution of sediments and the subsoil caused by the oil and gas industry at the oil terminals and refineries. Depending on the location, assessments show that heavy metals, radioactive materials and other toxic substances can be found in soil and in water (Selley 2006).
Oil spills are an additional major thread for the flora and fauna of the North Sea. The toxic character is eradicating marine life. The major source of oil leaks are transport vessels, rather than oil platforms or pipelines. The North Sea is one of the busiest maritime areas in the whole worlds, since one third of global oil shipping traffic is passing through European waters (Carpenter 2015).

Renewable energy has a green and blue image, clean energy without threatening the environment but this position requires further assessment. There are no complete assessments or long-term studies yet about the impact of offshore wind farms on the flora and fauna of shallow seas (Bailey et al. 2014). Some scientists are concerned, that the construction and decommission of wind energy facilities are harming flora and fauna, and long-term damage cannot be assessed yet. Especially shallow waters have high ecological value containing rich habitats of fish and migrating and breeding seabirds (EWEA).

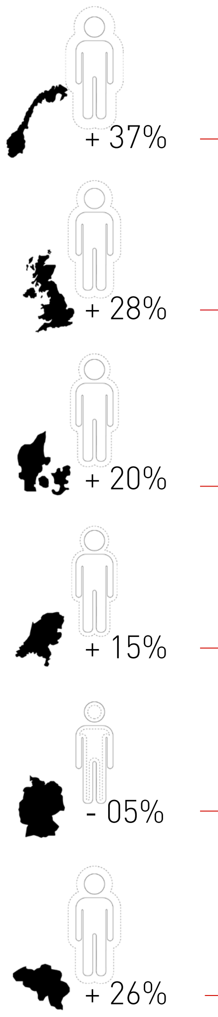
Image 2: Artwork, The destinction of flora and fauna, of recreation and protein, by Tom MacKenzie

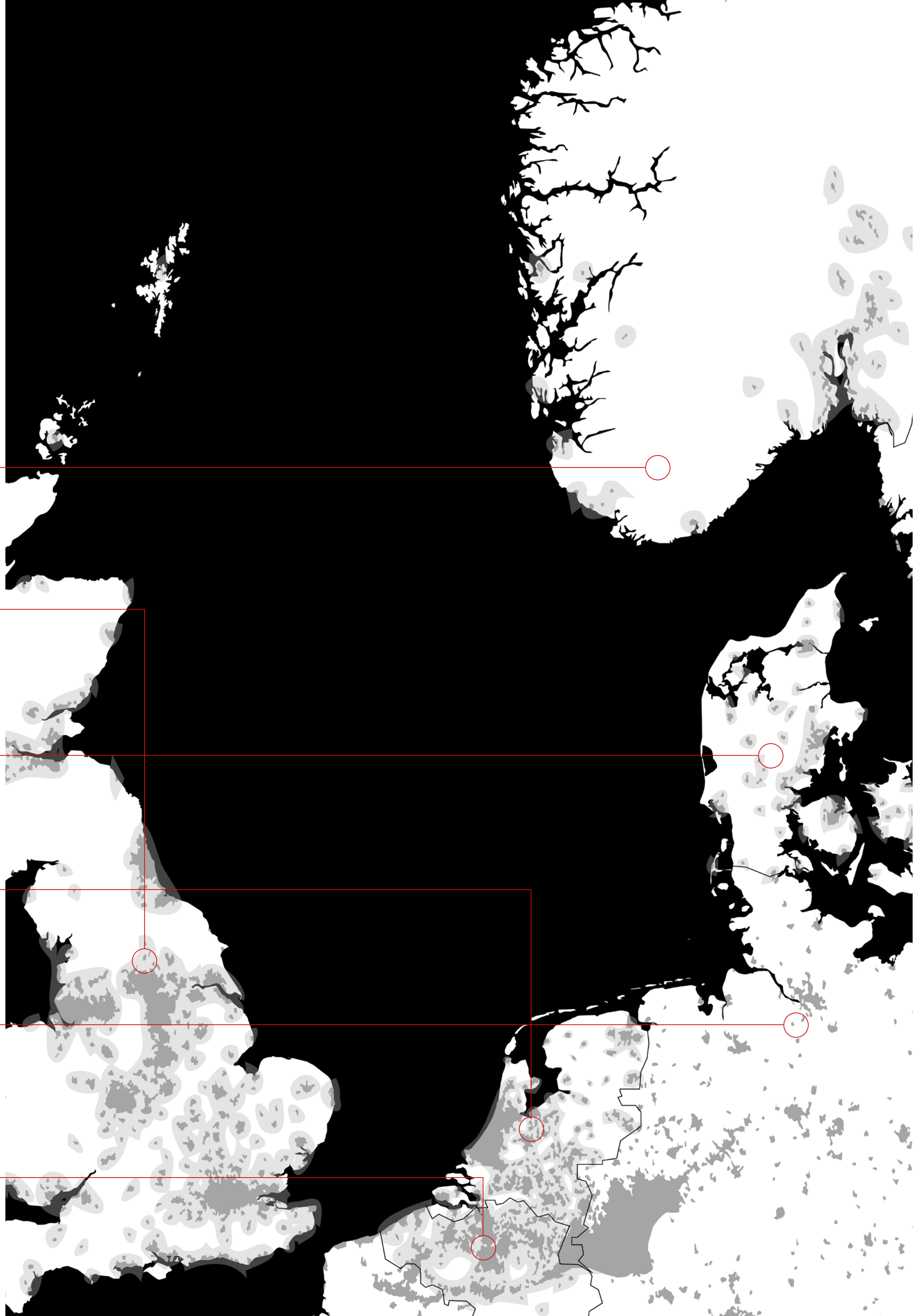


Summary - The Energy Legacy

The marine zone of the North Sea territory turned over time in to a space of resource extraction, which is harming the environment and is causing the terrestrial dependency on fossil resources. Two major challenges arise in this respect: First, the energy system contributes with high carbon dioxide emissions to the climate change. Second, the limitations of crude oil and gas is creating uncertainties for the territorial energy supply, economic prosperity and social wealth.

Estimated population growth by country
between 2016 and 2080





A GROWTH SCENARIO

Population estimates towards 2080

The North Sea territory will grow between 2016 and 2080 enormously, which creates pressure on the existing urban areas to grow and questions the current way how resources are used.
Eurostat developed several growth scenarios, which are based on the weighting of different parameters and trends, like deaths and fertility rates, immigration and emigration on the national as well as regional level (Eurostat 2018). In my thesis I work with the main scenario and the numbers shown in the table below. This scenario predicts an enormous growth in the countries adjacent to the North Sea, which is opposing to the general trends in Europe. The growth rates in the North Sea territory vary between 15% in the Netherlands and 37% in Norway. Just Germany will shrink by about 5% and will be replaced by the U.K. as the most populated country in Europe with 82 Million inhabitants.

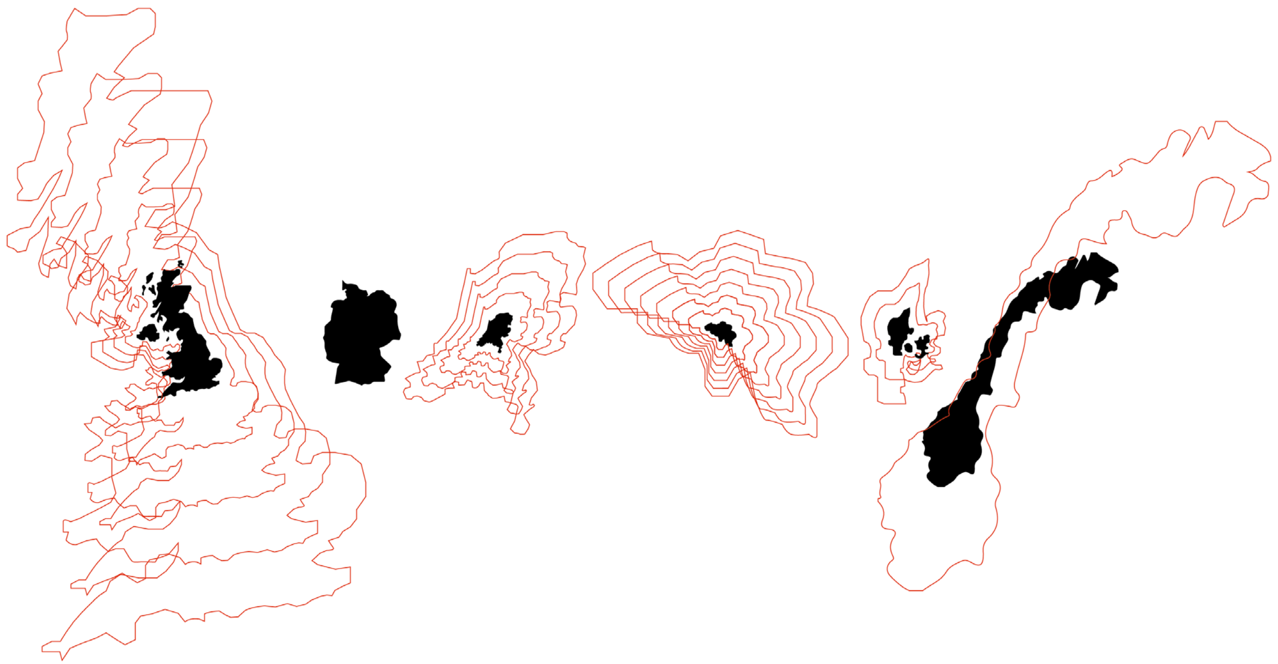
A growing population brings different challenges for the future. In the light of global warming, it is the question how to accommodate this growth in a sustainable way. The declining oil- and gas industry will leave economic and social challenges on how to generate jobs, how to secure economic prosperity and how to produce energy without an increasing use of resources. The following pages introduce the idea of the ecological footprint, which is dealing with the topic how to balance the population growth and resource management.

Estimated population growth between 2016 and 2080, in 1000 capita

	Population 1 January 2016	Cumulative births	Cumulative deaths	Cumulative natural popul. change	Cumulative net migration	Total popul. change	Projected popul. 1 January 2080
EU - 28	510279	327121	383991	-56870	65521	8652	518798
U.K.	65383	53794	47265	6529	10513	17042	82424
Germany	82176	46050	64848	-18798	14441	-4356	77794
Netherlands	16979	12615	12488	127	2621	2748	19728
Belgium	11311	8866	8369	497	2405	2902	14189
Denmark	5707	4324	4304	20	1131	1150	6858
Norway	5214	4380	3797	584	1368	1952	7166

Source: EUROSTAT - People in the EU, http://ec.europa.eu/eurostat/statistics-explained/index.php?title=People_in_the_EU_%E2%80%93_population_projections&oldid=358171

Multiple times of additional space is needed to
produce the required amount of resources
for the consumption of a growing population.



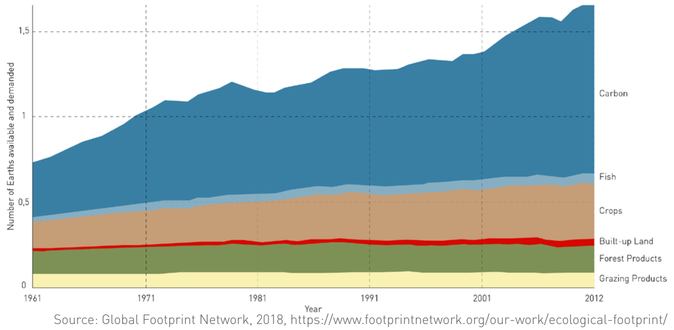
Population estimates towards 2080

The ecological footprint is an instrument to measure the relation between how much nature we 'use' and how much of it we 'have' (Global Footprint Network 2018). On the demand side, it measures natural assets that a number of citizens require to produce the natural resources they consume (Ibid.). On the supply side, the concept introduces the term 'biocapacity', which represents a unit reflecting the productivity of its ecological assists in the given area (Ibid.). The product of this relations is giving information about how much space is needed to provide a particular number of inhabitants in a defined area with the required amount of natural resources.

The majority of European countries is consuming more natural resources, than their space can produce in a sustainable way. In the light of drastic population growth, it leaves the North Sea territory with the problem that the national states will consume even more natural resources than their ecologic assets can provide. For example, the scenario for Belgium predicts a growth of 26%. In order to accommodate this growth, additional space equal to the factor 4 of Belgium country seize would be needed with the current ecological footprint.

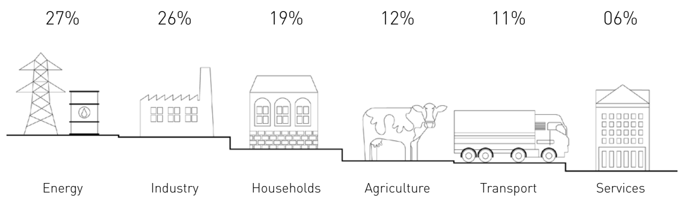
The major source of the Ecological Footprint is carbon, which continuously grew over the last decades since 1960. In essence, in order to reduce the individual high carbon footprints and to sustain the estimated population growth of the nation states carbon emissions need to be reduced. This can happen by reducing the carbon footprint from the energy sector, since this sector is emitting most carbon dioxide. Another option is to increase the marine and terrestrial biocapacity since vegetation can naturally absorb carbon.

World Ecological Footprint by component



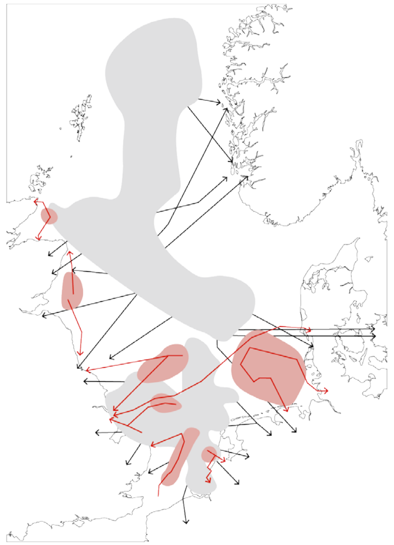
Source: Global Footprint Network, 2018, https://www.footprintnetwork.org/our-work/ecological-footprint/

Carbon sources by sector

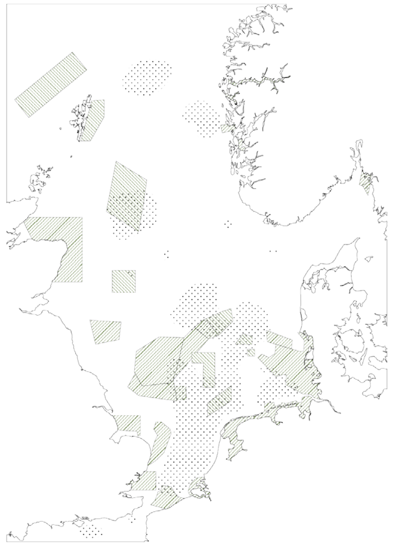


Source: European Environment Agency, 2017, https://www.eea.europa.eu/media/infographics

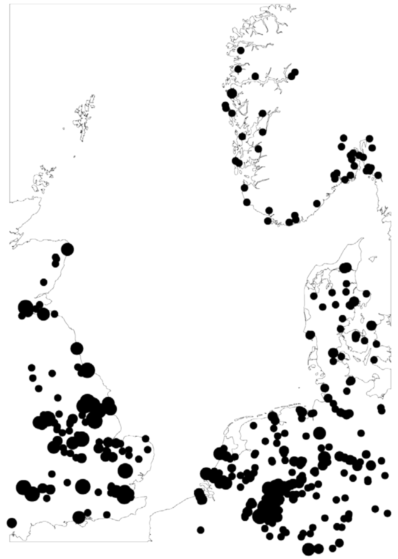
The extractive seascape



The ecological fragmentation



The high-carbon belt



Problem statement

A case of urgency - Resource management VS population growth

The North Sea played a vital role for the development of society, culture and economy of Western Europe. Over time, the North Sea turned from a crossroad for society and culture into a space of extraction.

The current extraction logics of oil, gas and wind result in problems of different dimensions, that the countries cannot solve on their own. All adjacent nations of the North Sea territory are highly reliant on fossil resources and the limitations of oil and gas are threating the societal development as well as the economic prosperity of all neighbouring countries. The current energy extraction is furthermore threatening the environment. On the one hand, the reliance on oil and gas results in high carbon emissions, which is the main contributor to global warming. On the other hand, the artefacts of the current energy infrastructure are polluting the vulnerable marine ecosystem and will be responsible for the distinction of flora and fauna.

Additionally, the current manner of resource management will be challenged by the extreme population growth scenario based on Eurostat. The current way of resource consumption will accelerate the process of global warming and leaves social and economic uncertainties towards the end of the oil and gas age.

6 territories, 6 national states and 6 high footprints: the current way of managing the sea is based on national interests in resource extraction and economic profit

PROPOSITIONS

What if ...

What if we develop **a joint strategy for the whole North Sea territory** where public and private stakeholders cooperate to target the individually high carbon footprints of the nation states. National interests in terms of resource extraction and profit are the major driver for the current management and separation of the marine zone. A cooperation among all adjacent nation states of the North Sea territory could support the idea to target the common challenges of resource management and population growth and to create a low territorial joint footprint.
There are numerous projects exiting that deal with the energy transition on the small scale. For example, the Frisian island Texel in the Netherlands is aiming to be carbon neutral in 2020 (TESO 2018). Nevertheless, the European energy transition cannot be solved on smaller scale but needs to be tackled on the international level. The following chapter CONTEXTUAL OVERVIEW entails a brief summary of theory paper 'Planning and spontaneity', which is dealing with this topic.

What if we design a **multifunctional energy infrastructure** that is contributing environmental, economic or social benefits in addition to the pure sake of energy production. This new infrastructure could on the one hand be based on the current artefacts of the energy apparatus, like pipelines and oil rigs. On the other hand, the system could be based on different sources of renewable energies next to wind power according to natual circumstandes and renewable potentials that can be found in the North Sea territory.

What if the future energy infrastructure is **using the waste material of the current energy consumption** as a resource in the future to diversify energy sources, to create social security and economic prosperity. According to several sources, Carbon dioxide is showing the potential to create electricity and biofuel through algae and hydrogen use as well as it can be used in other industries for protein production, cosmetics and building material. What if carbon dioxide can assist to enrich the marine and terrestrial biodiversity instead of threatening it by accelerating the process of global warming.

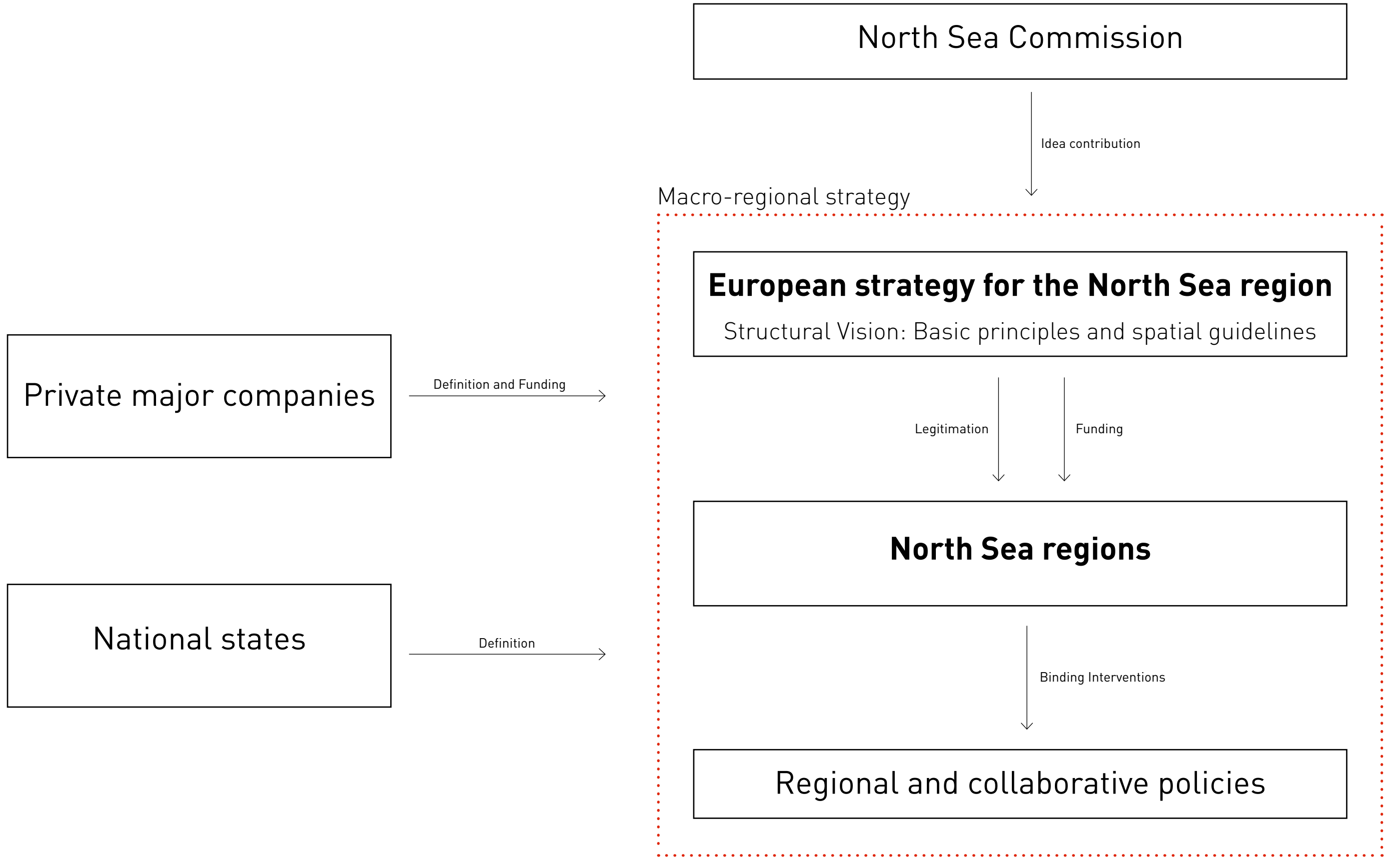
CONTEXTUAL OVERVIEW

The idea of European macro-regions

4 macro-regions already exist or are in development in the European Union: in the Baltic Sea and in the southern part of the continent. Additional 4 macro-regions are under consideration, among others in the North Sea. These strategies are addressing particular challenges of a territory and might accelerate transformative processes in the light of the energy transition.

Therefore, the macro-regional strategies will act as a framework in the further evolvement of my project by building up a framework and basic principles, that will be evaluated and tested on the smaller scales of my project. More detailed information can be found in my methodology.

The process to define a macro-regional strategy is involving various public and private stakeholders



The idea of European macro-regions

A future design for the whole North Sea territory could be based on the idea of macro-regional strategies by the European Union. These strategies aim to create an integrated framework to jointly address challenges in a particular geographical area (COWI 2017). The advantages of macro-regional strategies are the improvement of policy-orientation and a more efficient and coherent way of project and funding programs since the EU provides the regions with a clear development framework and potential funding by the European Structural and Investment Funds (European Regional Development Fund 2017).

Macro-regions can be considered as 'soft' governance approaches, which emerged in the past two decades all over Europe across all scales. Soft space governance is a response to rapid changes in the planning context, which has to deal nowadays with hazards caused by climate change, with the dynamics of globalization and demographic changes. So far, there is just little known about this new way of planning, but a few reference examples especially in the U.K. and in the Netherlands enable planners to reflect on these processes (Waterhout 2010). Soft planning is treating space in a different way compared to the traditional management of space: legal boundaries that sets the boarders for decision-making. Allmendinger and Haughton defined a new type of planning, spaces with 'fuzzy boundaries'. These spaces and boundaries are neither stable in time nor in space, but they form themselves for a certain period of time around certain topics and/or networks in order to enhance the efficiency in policy-delivery (Allmendinger and Houghton 2009). Therefore, soft spaces may emerge on any scale, going beyond any national boundaries and authorities.

Essential for a successful implementation is a cross-national and cross-sectoral thinking: a cooperation of stakeholders of various fields and disciplines to jointly formulate particular problems and strategies. 'Hard' and 'soft' spaces of governance need to work mutually, one cannot work without the other (Waterhout 2010). For example, a 'soft region' which might be established across several municipal boundaries always has to rely on 'hard' institutions, like the municipalities or ministries.

Several of these 'soft' planning models exist already on the European scale, such as EU strategy for the Baltic Sea region or strategies for the Alpine Area and the Mediterranean Sea. The European Union furthermore formulated 6 geographical commissions at the Conference of Peripheral Maritime Regions (CPMR 2016). One of the six commissions is the North Sea commission, which acts as a cooperation platform among the nations around the Sea.
The North Sea commission may act as the point of departure for the development of a governance proposal. Three of the four major focus points are directly relating to the thesis: 'Marine resources', 'Energy and climate change' and 'Attractive and sustainable communities'. The task of the North Sea commission is to promote and to create awareness and to act as a moderator between different private and public actors that are all working together towards one particular vision (CPMR 2016).

Another example for soft planning on a regional scale is the Randstad in the Netherlands, where a a structural vision was implemented in coopporeation between the state, major private stakeholders, different public agencies and municipalities (Waterhoud 2010). A structural vision is a policy instrument, which is only binding on the big scale, but is giving the legitimation to the smaller scales (Ibid). The Randstad 2040 document is proposing 12 spatial guidelines that give legitimation power to the regions and municipalities in order to react flexible to future uncertainties. Actual binding interventions are done by the municipalities in order to deliver particular and collaborative policies efficiently (Ministry of Housing, Spatial Planning and the Environment 2008).

Tackling the energy transtion on the big scale as a neccessity

The following paragraphs are taken from my theory paper 'Planning and spontaneity'.

Territorial Planning as a crucial and necessary discipline to target indeterminacy

'The real opportunities for change', Erik and Ronald Rietveld explain, 'are often found at a higher level of planning (at either a regional, national or international level) [...]' (2011, p. 34). Change is close connected to networks. which are shaping, referring to Castells, the social morphology of society and any stress is modifying the processes of production, experience and culture (1996). Networks cannot be framed by borders of one nation state or by any other legal authority and its boundaries as well as social structures are highly dynamic since they are not just stretching through time and space but also trough scales (Urry 2016). A vision and design principles on the territorial scale can therefore influence even the smallest scale, like local communities, and it can manifest even in single architectural objects.
Territorial impact on society, manipulated by design, can be best described by James Gibson's theory of affordances. It says that a certain action or a change of behaviour is based on details from relevant attributes of objects or on particular elements of the environment (Chemero 2003). Affordances can entail a certain requirement or invitation character, e.g. an armchair means the affordance to sit down as well as a scissor means the affordance to cut. One field, where this theory is applied, is the discipline of environmental planning. The issue is to design the environment in a way that it is stimulating the citizen's perception and is encouraging an environmentally friendly behaviour (Wenninger 2000). The execution of such a project should start with conceptualization and visioning on the big scale. It gives the chance to create a communal framework with one strong vision and well-defined principles, that leaves at the same time space, where the particular can unfold depending on different future directions.

Managing uncertainty: the soft spaces approach as an instrument?

The soft spaces approach is a concept, that was developed in the last decades in the United Kingdome and can be seen as an add-on to hard planning rather than to 'override' the traditional ways of planning. Hard planning is usually understood as the formal actions embedded in 'democratic processes and local political influence' (Haughton and Allmendinger 2007, p. 306). This approach is facing nowadays different problems, like the organization and coordination of policies and of regulative planning tools across all levels of political hierarchy, which is resulting in bureaucratic complexity and delays (ebd.).

Soft spaces are bearing the potential to bridge these problems by reworking and reorganizing legal structures and breaking with the current situation of political boundaries. This approach seems to have an informal character, soft governance is in this respect a term that tends to address new coalitions of stakeholders as well as it aims to 'regain control over territories' (Walsh et al., p. 4). The soft space approach is indeed a tool for territorial management, since both ideas are not based on political geography but tend to overcome these boundaries by orienting towards systems. There are already some references on how to face uncertainty by the help of soft spaces on bigger scale. In the Thames Gateway, a series of soft spaces emerged over the last decades. The problematic situation was caused by a plan from 1995 that foresaw an attractive development for the Thames estuary in the East of London. In 2000, an evaluation stated delay and very slow progress that encouraged the government to move (Haughton and Allmendinger 2007). The Thames Gateway Unit was founded, as a central governmental element bridging all relevant departments like regional planning, transport, housing and economic development. The strategies were detached from current legal boundaries and authorities since just a part of the Thames Gateway was directly involved, including 16 local authorities with their own frameworks and strategies (ebd.).

Existing emission taxations in Europe

In 2003, the European Parliament and the European Union formulated two instruments to target greenhouse emissions from the energy sector and intense-energy industries to fulfil the European climate target 2020 (Kahl and Simmel 2017), the European Union Emissions Trading System (ETS) as well as the European directive on emissions trading.

The EU ETS is a 'cap and trade' system (European Commission 2018), which means that a cap is set on a certain amount of greenhouse gas emissions. The limit is decreasing over the years in order to reduce the amount of emissions and to achieve the short-term and long-term European climate goals. The European commissioner for climate actions is supervising the process and is selling emissions certificates, which allow a certain amount and kind of emissions over a limited period of time (Ibid.). The basic idea is that the limited number of certificates increase their value since companies without allowances or a surplus of emissions await big fines. Currently, the ETS is covering about 45% of the potential European greenhouse gas emitters, which makes a total amount of 11000 facilities from the energy sector and industries (European Commission 2009). This comparably low percentage might relate to technical or administrative difficulties in order to measure the emissions of greenhouse gas producers. For example, it will be easier to evaluate the carbon dioxide emissions of a coal power plant than to measure the carbon emissions of the livestock industry.

The second instrument is European directive on emissions trading, with is setting up a framework legislation of minimum tax rates depending on the resource and its intended use. This directive is seen as an addon to the ETS and provides European states with the freedom in taxation (Kahl and Simmel 2017). Since this kind of taxing is national responsibility, all countries deal with it in a different way. For example. Germany just did first steps towards a carbon dioxide taxation in 2017 (Badische Zeitung 2017) while Sweden already implemented a first tax system in 1991 (Jamet 2011).
These instruments both seem to bring numerous advantages: first, it can influence the competition on the market, since greenhouse gas-intense industries have to deal with higher taxation and therefore higher costs for the consumers. This process might foster technological innovation in order to find alternative ways of dealing with emissions. Therefore, emissions might decrease in the long term and environmental damage could be limited.

Nevertheless, various sources draw a different picture of results. EuroSolar is stating, that the trade with emission certificates does not work due to its low prices (Ziehm 2008). According to Andersen, the European directive does not support well enough the focus on carbon dioxide and thereby the achievement of Europe's energy and climate targets (2017). The given circumstances therefore leave space to rethink the way carbon dioxide is processed in Europe for a technical point of view but also from the policy side.

METHODOLOGY

00 How is the apparatus of energy infrastructure in the North Sea territory changing towards a prosperous low-carbon future?

In this chapter the core methodology, the relation between questions, methods and answers will be discussed (Biggs and Buchler 2008). The central dimensions in this respect are scale and time. Scale and time directly link to the idea of analysis, synthesis, projection and the interrelation of research and design. They are the constant elements in my working progress from the analysis and diagnosis of the North Sea legacy up to the application of the urban design in Aberdeen. Central to my understanding of this context was the work of Jon Habraken, who introduced the dimensions of time and scale as crucial to tackle indeterminacy (Havik and Teerds 2011). I compared the theoretical work of scientists from different fields, like from the British sociologist John Urry and his *What is the future?*, with design insights from practical professionals, like Erik and Ronald Rietveld (2011). The essence that I took from these literature reviews and comparisons stated, that the dimensions of 'Scale' and 'Time' are crucial to tackle future uncertainty and that I will use a series of traditional and non-traditional methods of research and design in order to answer my research questions.

The **concept of scales** plays a key role in the development of my project since indeterminacy and different affordances and consequences for each scale are directly linked. Habraken claimed, that *'wherever you are working, you will be faced with context, that is already created by someone else and your design will be build the context for somebody else'* (1988). The key method for the understanding of the current energy apparatus on the macro scale was the spatial analysis with QGIS in order to get precise information on existing energetic artefacts, extraction logics and natural dynamics. I used data of the different national petroleum agencies, like the Dutch petroleum authority (NLOG), the Oil and Gas Authority U.K. (OGA), and the Norwegian Petroleum Directorate (NPD) to receive reliable information about the current energy system in the North Sea territory.
I used the method of literature review to build up the framework for me design project. Soft planning approaches in planning theory and macro regions, a planning instrument of the European Union, support the structure of my strategic project through the scales. The macro scale creates a communal framework, where particular elements have space to adapt to sudden and abrupt changes on the small scales. *'The real opportunities for change'*, Erik and Ronald Rietveld explain, *'are often found at a higher level of planning (at either a regional, national or international level) [...]'* (2011, p. 34). The analysis and diagnosis of the current situation is resulting in projective goals for the vision and strategic framework on the macro scale. In that way, the big scale is creating 3 basic principles and spatial guidelines, which leaves the freedom to the small scale to adapt more flexible to abrupt changes and specific challenges on the regional scale. In my project, Aberdeen on the regional scale acts as an experimental ground to test and evaluate the principles and spatial guidelines of the macro scale.

The **dimension of time** emerged in the planning and architecture discipline in the 20th century, starting among others with the architecture pioneer John Habraken. He claimed, that it is necessary to understand dynamic processes, how site-specific systems evolved over time and what it needs to anticipate an uncertain future. John Urry discusses in his *What is the future?* different parameters and views on the unit 'time'. In my project, two parts are certainly interesting: What can we learn from the past and what methods exists to design and think about an uncertain future. Therefore, the first important step was to analyse primary and secondary historical sources to understand how certain dynamics shaped the North Sea territory over time.

I furthermore use the methods of a utopian vision and scenarios to project towards the future. My theory paper is discussing both terms more in depth. *'Utopia edifies like a novel, while scenarios are function more like proverbs'* (Hoch 2016, p. 17). Scenarios aim to reveal certain meanings and the significance of particular aspects of change and support in that way the creation of utopias. Among others, I work with the scenarios of rapid population growth and a gradual decline of oil and gas resources to develop my utopian vision on the macro scale: a prosperous low-carbon future that sustains the territorial growth.

In order to answer my main research question, I developed a series of sub-research question according to the structure of my work. A diagram of my work process can be found on the following two pages, which is categorised in the legacy of the North Sea territory, the macro-region strategy for the North Sea, and the smaller scales in order to apply and evaluate my decisions of the macro-scale.
The methods I used are categorized by the usual structure of a design project: analysis, synthesis and projection.

The legacy of the North Sea territory

Key questions:

01 How did the infrastructural apparatus change over time in the North Sea territory and how were these transformative processes reflected in society?
02 What are the components of the energy system in the North Sea territory and what are their future challenges?

Methods:

Literature review, spatial analysis (GIS), mapping exercises, historical analysis of primary and secondary sources, data analysis, relational thinking, visualisation

For the analysis part of my project, the legacy of the North Sea territory, I used a series of methods to understand the dynamics that shaped the territory as a whole and seekd to figure out the components of the current energy system. First, I reviewed various academic papers to define a lens which helps me to understand territorial dynamics through time. Velikov and Thün were a big source of inspiration to understand that infrastructure is the main influence of transformative processes in a territory. I analysed various primary and secondary historical sources, which underlined the impact that infrastructure had in the transformation of the North Sea territory over time. I used GIS for the spatial analysis to find the key components of the current energetic system and I made a series of mapping exercises to understand the interrelations between these components. One example are the extraction logics in the chapter 'The energetic legacy.
An additional point of interest was in that phase to understand the future challenges that the territory will face regarding the energy supply and generation. I analysed data and reviewed literature, among other by EUROSTAT and by the Statoil (Norway), with the outcome that the major challenge will be to rebalance the relation between resource management and the estimated territorial population growth in the future.

Macro-regional strategy for the North Sea

Key questions:

03 Which tools and concepts can be used in our discipline to tackle future uncertain trends of resource management, growth and power?
04 What are the existing components and what are potential elements that eventually form a new territorial energy system?

Methods:

Utopian visioning, scenario making, literature review, spatial analysis (GIS), relational mapping, reference examples, research by design, stakeholder analysis

This phase started with writing my theory paper 'Planning and spontaneity' that revealed the importance of utopias and scenarios in planning with transformative processes. I reviewed literature and reference examples, which deal with transformative processes on the big scale and I decided to use an instrument of the European Union, macro-regional strategies, as a framework to process my approach for the macro scale.

I worked with scenarios to frame and to project possible challenges towards a low carbon future. The scenarios 'population growth' and 'limitations of oil and gas' supported the process of vision-making in order to develop projective goals for the macro-scale. This resulted in my basic principles and spatial guidelines, which build up the macro-scale approach and are evaluated on the meso- and micro scale. The process of research and design helped me to review sources parallel to my design work and to develop efficiently my approach: which elements of the existing energetic system will remain, which new components will be added and what possible synergy effects for the people, the planet and prosperity are created in order to fulfil the goals of the overall vision.

Regional strategy for Aberdeen

Key questions:

05 What is the role of Aberdeen in the current energy system?
06 What is the role of Aberdeen in the future energy system?

Methods:

Spatial analysis (GIS), mapping, input from the macro scale, reference examples, research by design

This phase is the first moment of applying and evaluating decisions, that I made on the macro-scale. I first analysed the context of Aberdeen through spatial analysis and mapping in order to understand the role of Aberdeen in the current energetic system. I furthermore used input from the macro scale, the spatial guide lines and the basic principles, as a base to develop the approach on the regional scale. That basically means, that elements of the bigger scale responded to the regional context and more concrete challenges. Reference examples helped me to deal especially with the question, on how to apply technological aspects into a spatial design proposal. The concept that I developed on that scale furthermore build the frame for the micro scale.

Aberdeen's dualistic character

Key questions:

07 How will the marine brownfield be transformed towards a low-carbon future?
08 How will the terrestrial brownfield be transformed towards a low-carbon future?

Methods:

Reference examples, mapping, spatial analysis (GIS), input from the macro and meso scale, relational thinking, literature review

This phase produces the most concrete outcome of the project and highlights especially the drivers of change that will contribute to the transformative processes on the small scale. I made a series of mapping exercises and I used the spatial analysis to understand the particular spatial context of both future brownfields and worked with reference examples and literature review to deal with technical challenges and its application in the built environment.

Scenario population growth

Key questions:

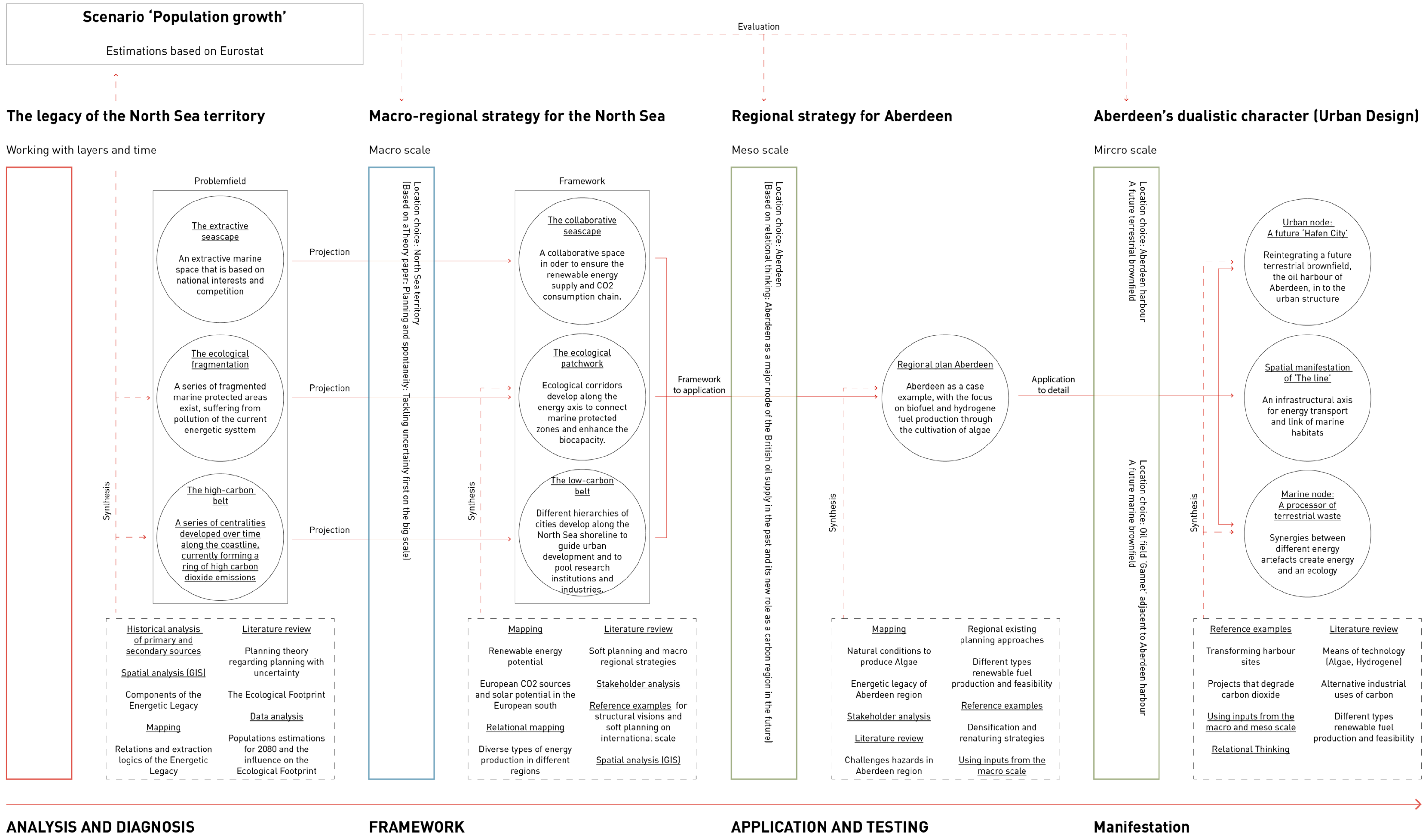
09 How to sustain the strong population growth in the light of limited resources and climate change?

Method:

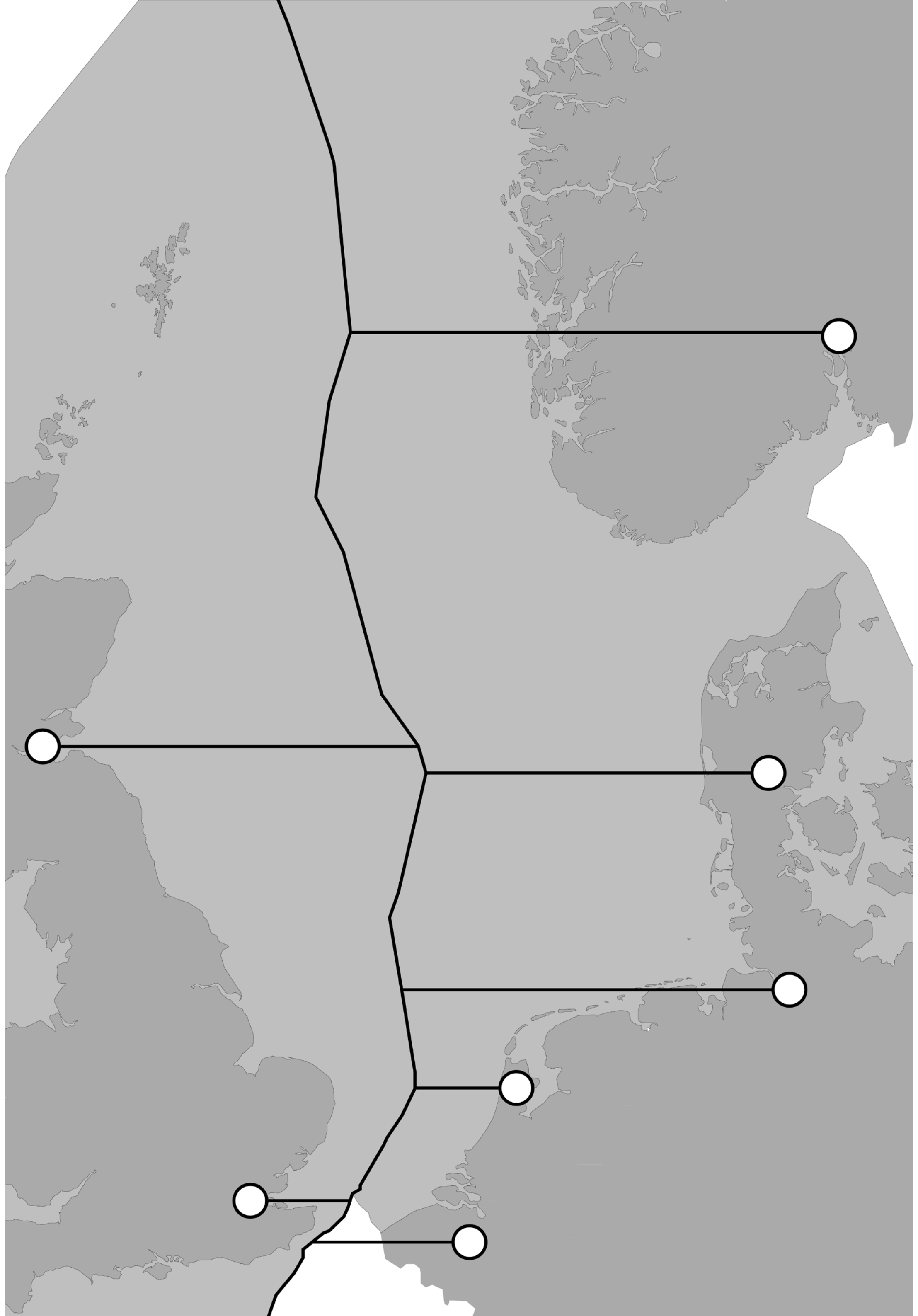
Literature review, calculations, data analysis, relational thinking

The scenario population growth will be used in certain moments of the project to reflect on the strategies and interventions of my master thesis through the scales. I analysed data, among others from the European Commission, to much energy can be produced in a sistainable way through carbon dioxide utilization. Literature review helped me to reveal the Ecological footprint as a change to measure the relation between population and the required space to produce the minimum of the necessary natural resources. Certain calculation

Working process diagramm, a strategic framework on the macro scale
that sets three principles and spatial guidelines
to be applied and tested on the small scales



From 6 territories with 6 high individual footprints to one territory and one low footprint through collaboration



VISION

From a space of extraction to a space of collaboration

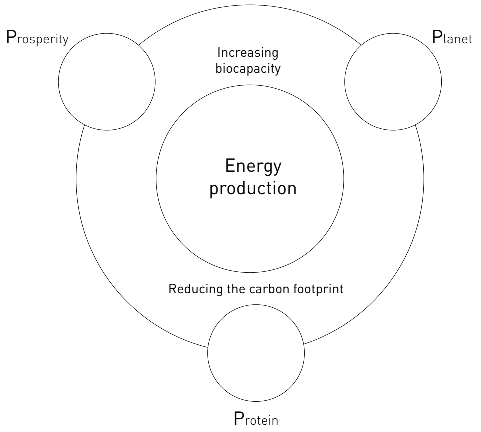
The research and design project investigates a possible transition towards a prosperous low-carbon future of the North Sea territory that is introducing a different relationship between the marine and terrestrial zone: **from a period of resource extraction towards an age of collaboration**, between the adjacent countries of the Sea and between land and water.

The transitional period towards a low-carbon future that facilitates the estimated population growth in terms of resource management will be achieved through collaboration among all adjacent nation states in the North Sea territory: **from 6 nation states and 6 territories with high individual carbon footprints towards one territory** that has one low footprint and brings energy security and independency, social wealth, prosperity and environmental benefits for both the human and natural system in the North Sea territory.

I propose the development of a macro-regional strategy that is dealing with the gradual decommission of oil- and gas artefacts in the sea, with terrestrial brownfields and with the security of the territorial energy supply through diversification of offshore renewable energy and collaboration. Over time, a multifunctional energy system is developing, which is contributing to the '3 P's' prosperity, planet and protein in addition to the initial sake of energy production.

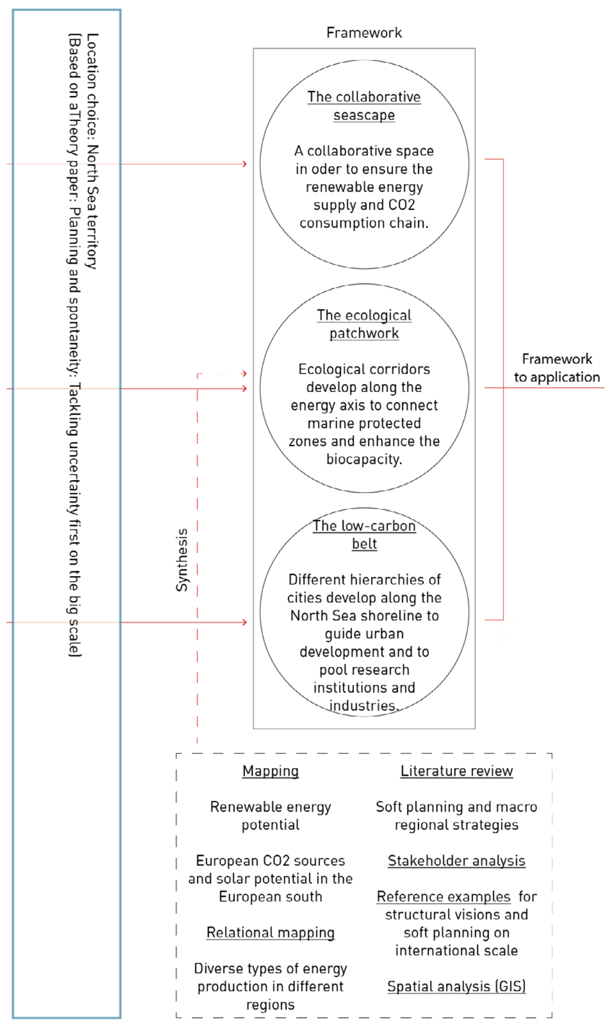
Future brownfields of the oil and gas age will transform into centralities of urban growth and into nodes of environmental, economic and social resilience through a strong R&D sector. The 'line', the marine exchange grid of carbon dioxide and electricity, will strengthen the synergies between land and water. The system will sustain the estimated population growth on land and will secure and strengthen the marine biodiversity due to its ability to reduce the Ecological Footprint.

A multifunctional energy infrastructure: economic, environmental and social benefits



Macro-regional strategy for the North Sea

Macro scale



FRAMEWORK

2 MACRO SCALE

The macro scale is introducing the macro-regional strategy for the North Sea. The approach is based on the 3 principles 'the collaborative seascape', 'the ecological patchwork' and 'the low-carbon belt'.

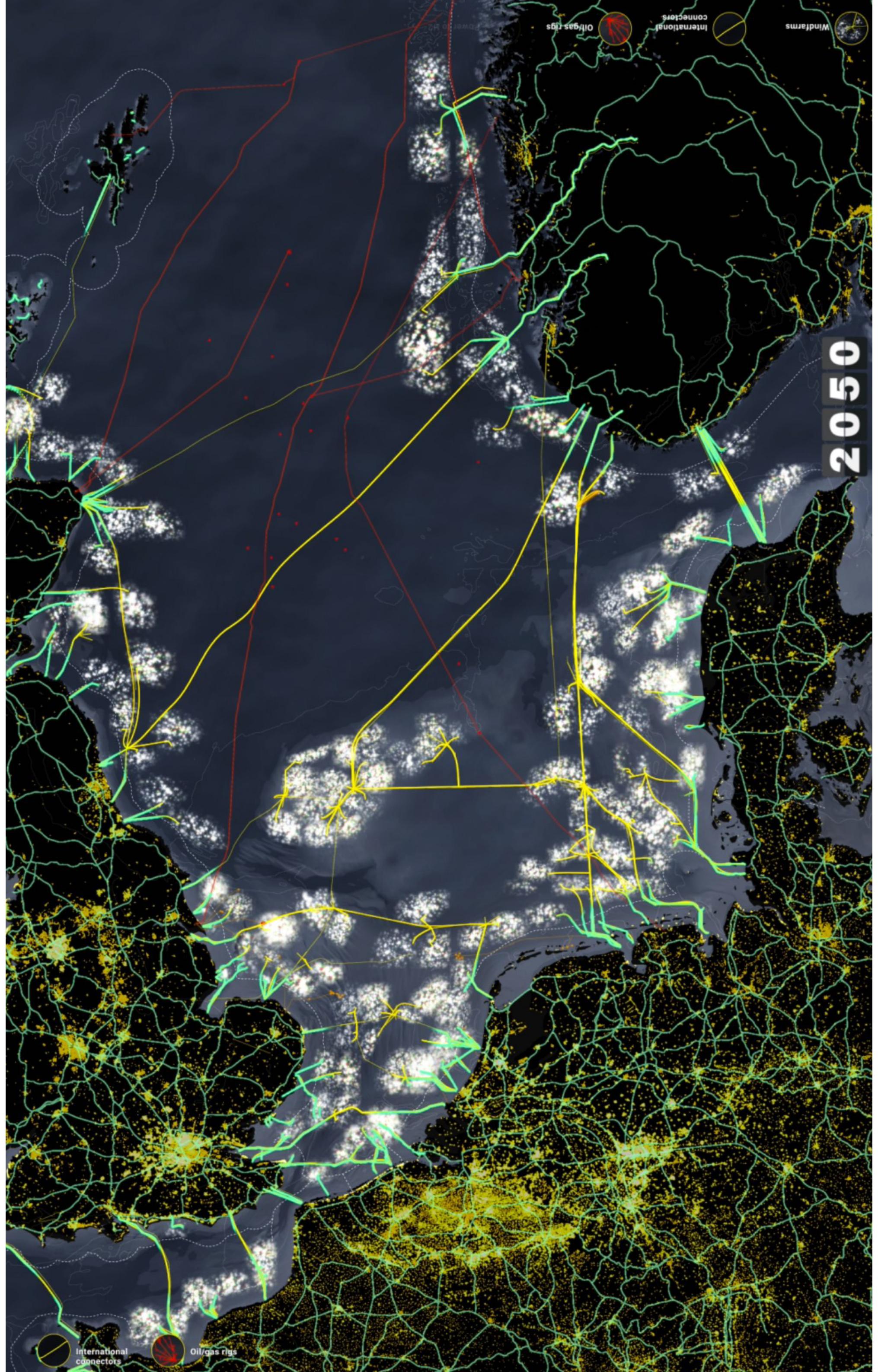
Each of this principles consist of various spatial guidelines, which form the structure of this chapter and the strategic proposal.

References

An Energetic Odyssey

This project is dealing with the energy transition at the North Sea, focussing on the question how to achieve the European climate objectives for the year 2050 – reducing the amount of greenhouse gas emission between 80 and 95% in comparison to 1990. The approach was developed by Maarten Hajer and Dirk Sijmons for the IABR in the year 2016. Sijmons and Hajer are stating, that the energy transition cannot take place exclusively through a large amount of small scale projects, but big scale approaches and drastic changes of whole systems are required (IABR 2016).

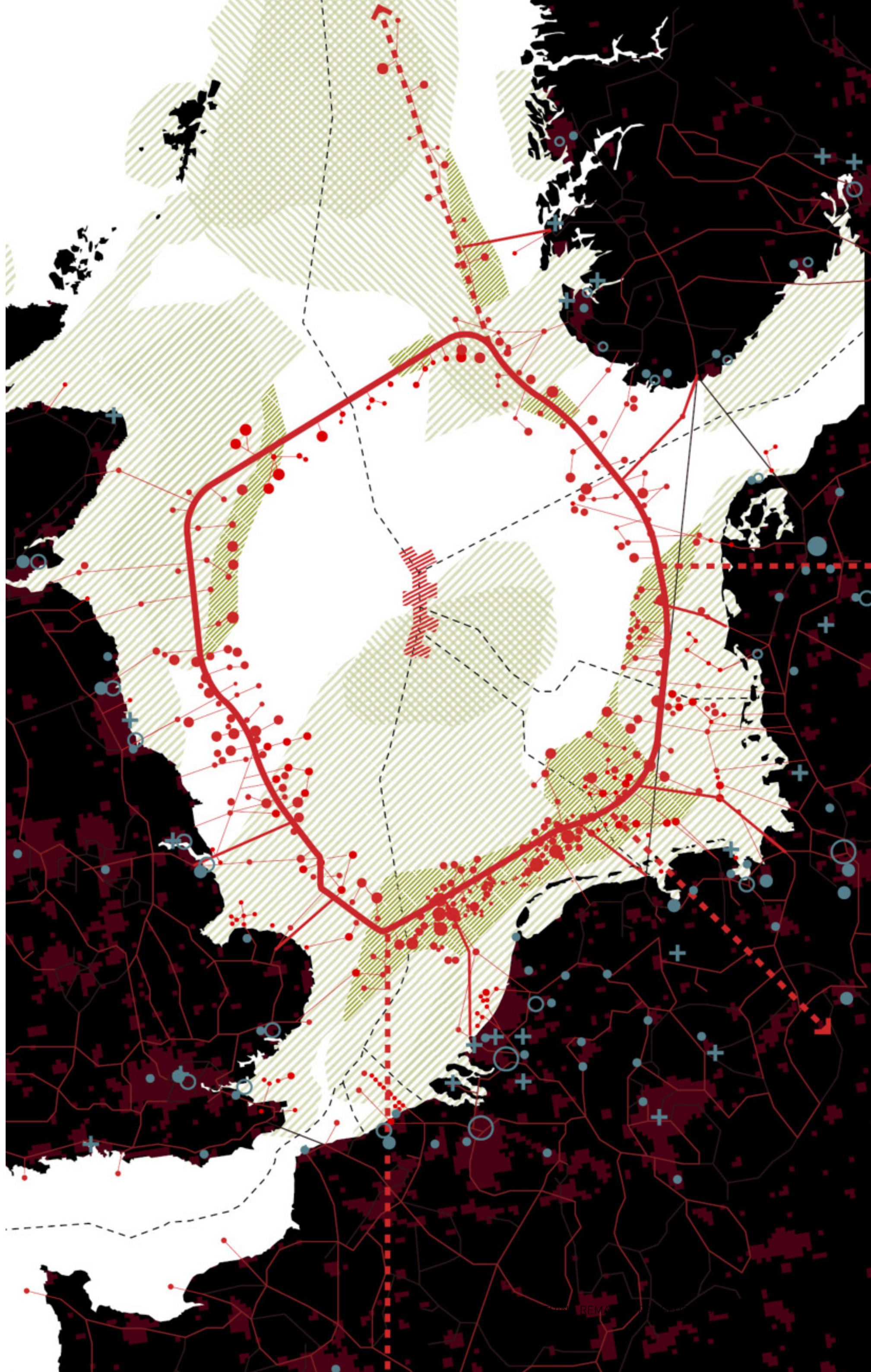
Their idea is focussing on the domain of wind energy generation, which will produce up to 90% of the territorial electricity demand and eventually generate even a surplus (Ibid). I take this project as a point of departure certain arguments as granted, like the point that wind power will produce enough electricity for the territory and that patchworks of electricity-producing objects will generate an even bigger surplus in the long-term as it will secure the energy supply regarding the diurnal and annual variations in electricity generation through wind.



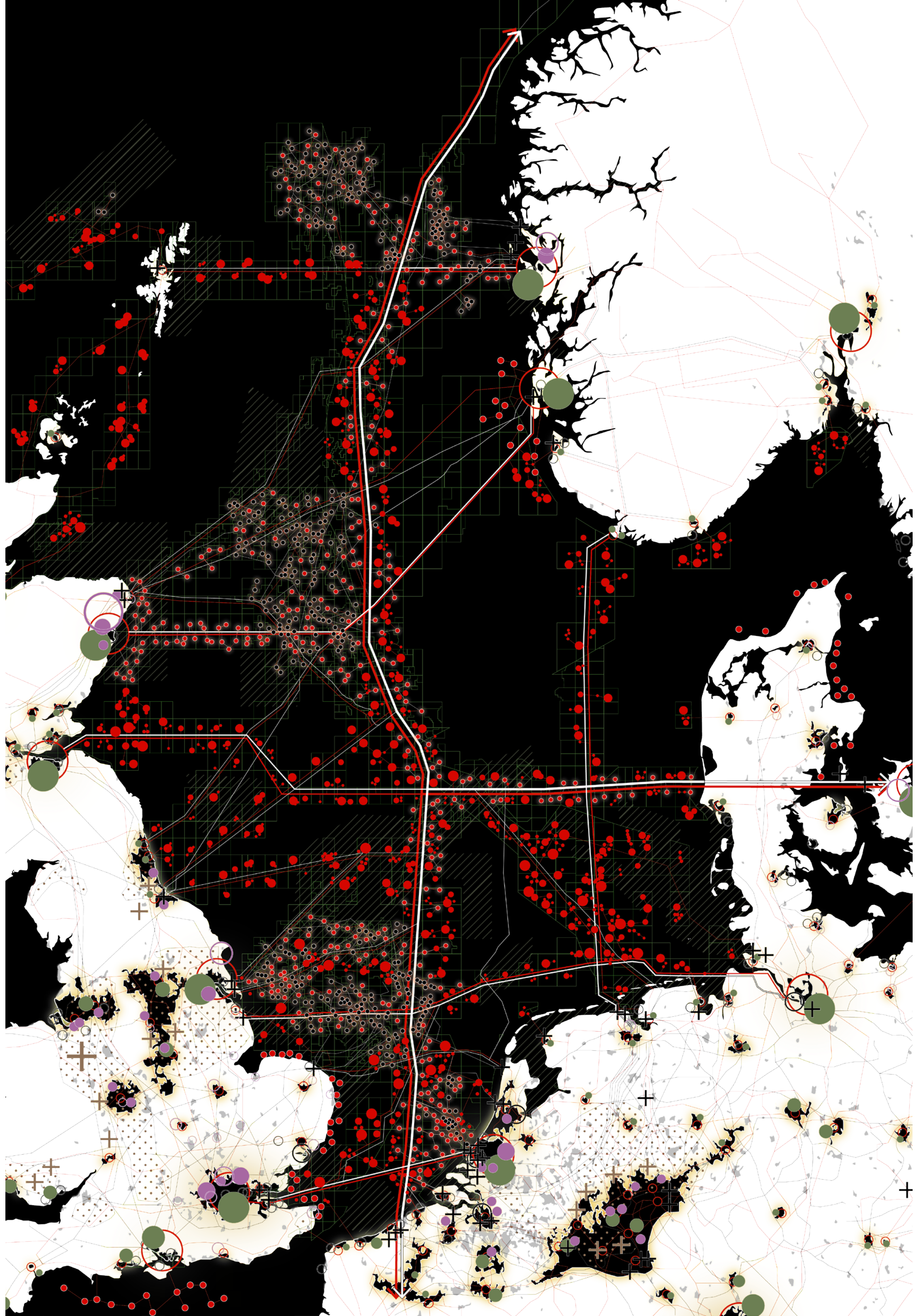
OMA Zeekracht

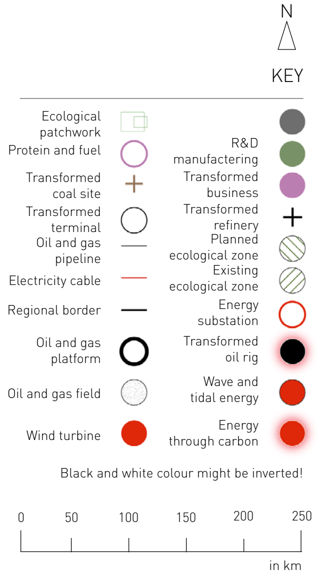
I chose this project as the second reference for the macro scale, because it is proposing another kind of big-scale system to tackle the energy transition in the whole North Sea territory. As does the Energetic Odyssey, OMA's Zeekracht masterplan for the North Sea is proposing a system of offshore wind energy parks, which are the entire electricity demand for the adjacent countries and generate eventually a surplus of power (OMA 2008).

The nature of the project is more design-oriented, since they propose a strong geometric shape, a ring, in the middle of the sea, which is tackling the annual and diurnal variations in wind electricity production. Both projects target the energy transition, from fossil energy sources to renewable energy sources, but both proposals are lacking some information. What will happen to the legacy of the current energy system, like pipelines and platforms? How to secure economic prosperity and social wealth when oil and gas resources deplete. Huge cluster of monofunctional wind parks will not solve the problems, that the North Sea territory is facing beyond the challenge for a renewable electricity source.



Everything Remains Tranformed, a macro-regional strategy for the North Sea territory





SPATIAL PLAN

Everything Remains Transformed

Everything Remains Transformed is introducing a new energy system that is aiming to create one low carbon footprint for the whole North Sea territory through one joint strategy among all actors .

My proposal for the North Sea is based on the idea, that the energy transition just can be tackled through the transformation of the current energy system on the big scale. Furthermore, I propose that the system needs to provide additional advantages for the planet and the people as it needs to create economic prosperity next to the pure sake of energy production.
Building up on the two reference examples explained before that imagine the sea as a space of wind energy production, my approach is based on the three following pillars:

First, the transforming energy system needs to integrate the existing energy legacy of the oil and gas industry. This includes themarine infrastructural artefacts, like oil rigs and pipelines, as well as the future brownfields that will emerge in the transitional process: oil fields, refineries, oil harbours and business areas.

Second, collaboration among all actors of the energy sector is essential to secure the territorial energy supply. Next to an exchange grid, my proposal entails an exchange grid of carbon dioxide, which is reusing elements of the oil and gas age while it generates energy and fuel as it enhances the marine biocapacity and brings economic revenue.

Third, a diversified field of offshore renewable sources is important to secure the territorial energy supply. The North Sea bears huge potential for other means of energy production, e.g. through carbon dioxide and hydrogen, through the motions and the salinity of water or through tidal streams.

These three pillars build the ground for the basic principles, that structure the macro-scale proposal, and for the spatial guidelines.

Key elements of the strategy

1
Integration of the energetic legacy (Infrastructural artefacts and brownfields)

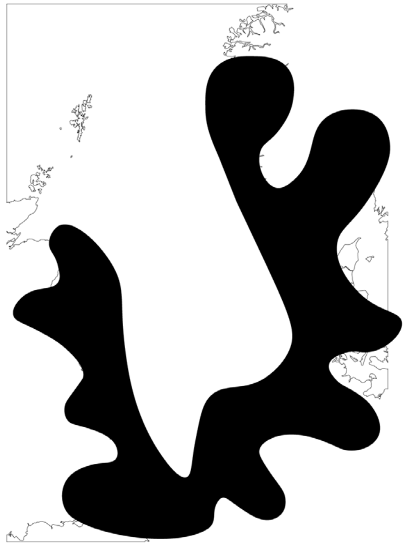
2
Territorial collaboration

3
Diversified energy production

The collaborative seascape

The ecological patchwork

The low-carbon belt



Everything Remains Transformed

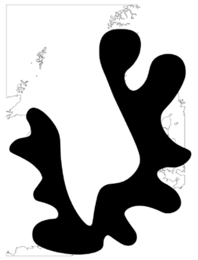
The approach is categorized in 3 basic principles, which can be directly compared to the summarising diagrams in the problem statement.

The sea is transforming from a space of resource extraction into a space of collaboration, symbolised though 'the line' in the sea. Collaboration means, that an exchange grid for of pipelines and cables emerge, that transport and generate electricity, carbon dioxide and fuels.

The second principle is dealing with the ecological threads, that are caused by the current energy system. Through the development of ecological corridors and objects in the sea, the marine zone is transforming from a system of ecological fragmentation to an ecological patchwork. This system will eventually connect marine protected areas, it will increase the marine biocapacity and it will depollute water.

The low-carbon belt will emerge through the transformation of the current high-carbon belt along the shore line. The focus will be on a low-carbon economy, which is based on a strong R&D cluster.

Framework of the macro-regional strategy for the North Sea territory

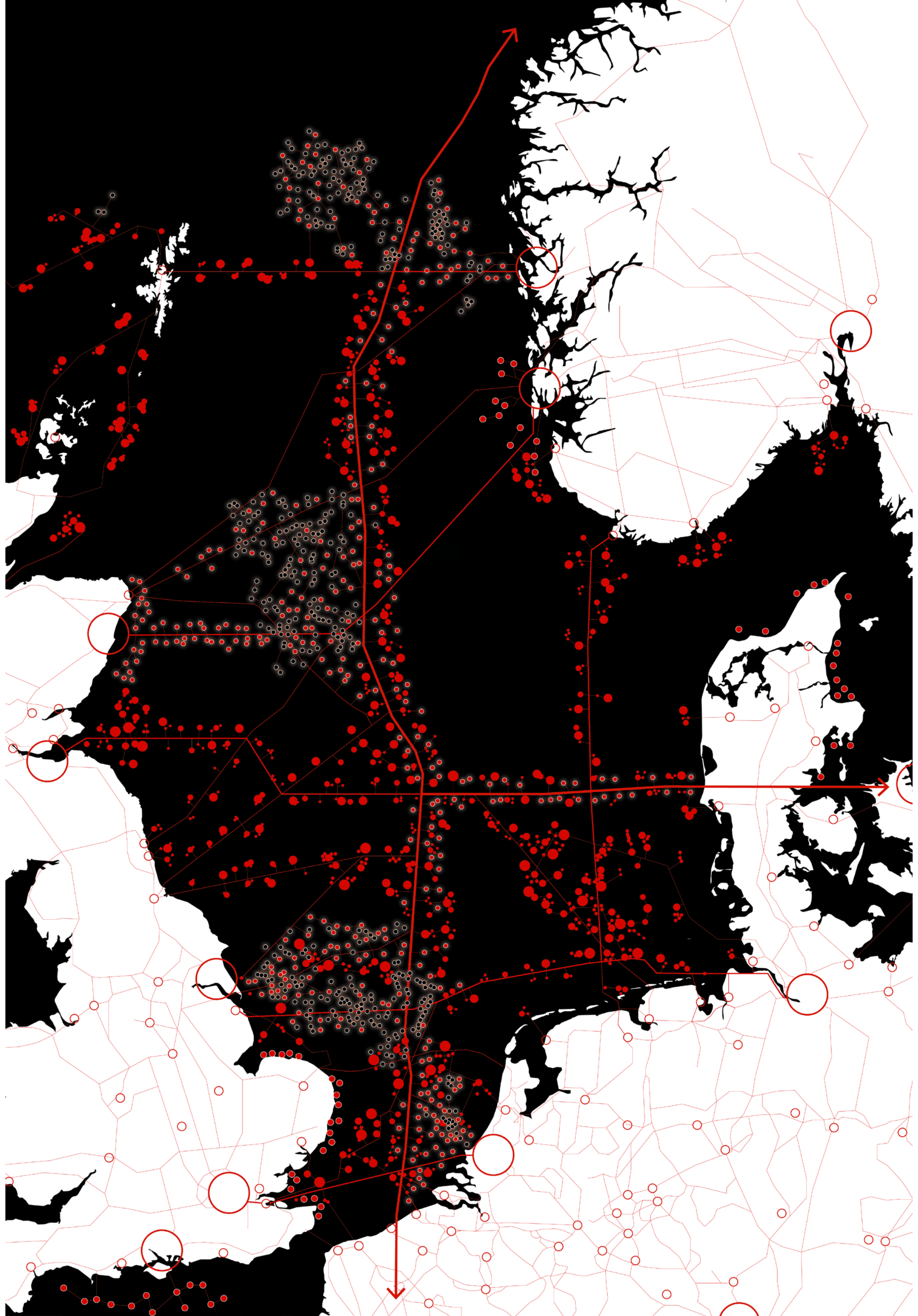
	The Collaborative Seascape	The Ecological Patchwork	The Low-Carbon Belt
Main principles			
Spatial guidelines	1 Energy security through collaboration 2 Energy security through diversification 3 From producer to consumer 4 Reusing what is already there 5 A fair division of resources and revenue	6 Ecological corridors connecting protected zones 7 Engineered artefacts as water purifiers and artificial reefs	8 Independent energy regions with an own identity 9 Centralities for energy supply and urban growth 10 Prosperity and competition through transformation 11 Prosperity and competition through research

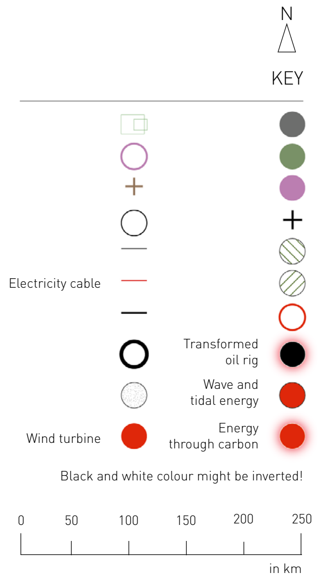
Application at the regional scale of Aberdeen

Principles and spatial guidelines

The ideas of basic principles and more concrete spatial guidelines is derivig from the concept 'macro-region' which is a soft planning instrument of the European Union. Another reference of a soft planning approach is the structural vision of the Randstad in the Netherlands that consists of principles and guidelines as a general framework. This framework leaves planning freedom and the ability to adapt to sudden hazards and particular regional challenges (Ministry of Housing, Spatial Planning and the Environment 2008).

An electricity exchange grid and divese renewable offshore sources to secure the territorial energy supply





THE COLLABORATIVE SEASCAPE

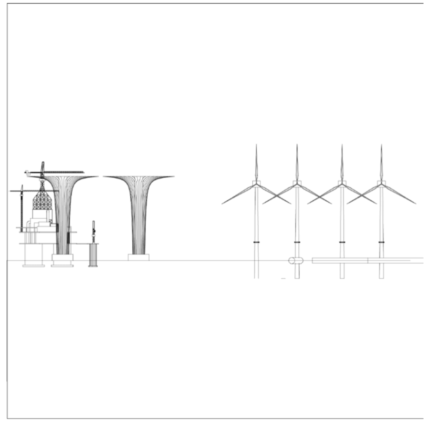
The electricity-exchange grid

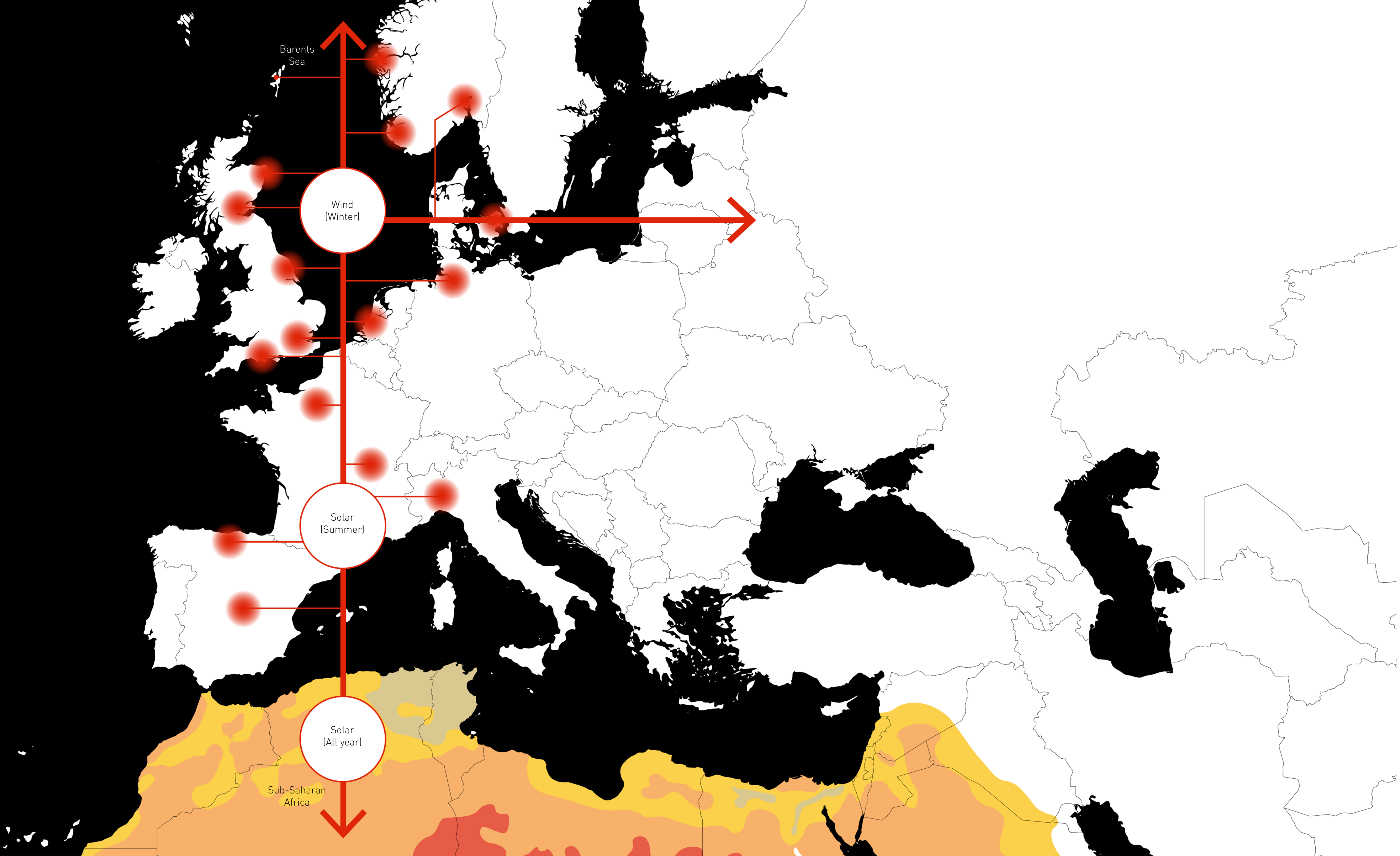
A network of electricity-producing objects will cover the marine space along the infrastructural axis. The majority of the artefacts will produce electricity through wind, but a patchwork of alternative electricity producers will be added. Electricity can be further produced through tidal energy, wave energy, osmoses power plants and through the use of algae and biomass. Carbon dioxide bears the potential to support electricity production through the photosynthesis effect in algae.
Most electricity objects concentrate along 'the line', the central axis of electricity production in the North Sea territory. The form of the axis follows the trace of the existing pipeline structure of the current energy system since synergies between the carbon and electricity grid can be used to generate electricity and produce different kind of fuel. This central system makes furthermore the transport of electricity more efficient since energy can be now send from the producer directly to the site of demand over short distances and through the marine space.

The EEZ borders will eventually disappear, because they were drawn as a result of the oil and gas extraction. Nevertheless, the new system of an electricity and carbon exchange grid can even work under the current circumstances because the nation states do not have any legal power to control the spread of cables and pipelines in the subsea (Barry et al. 2006).

(1) Security through collaboration

(2) Security through diversification

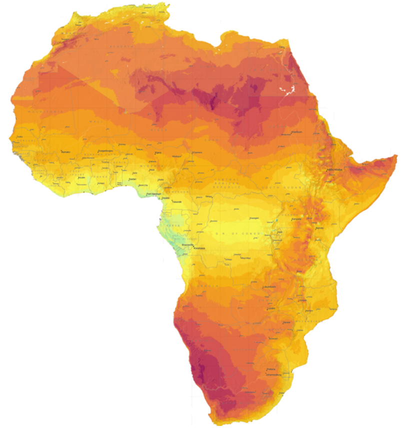




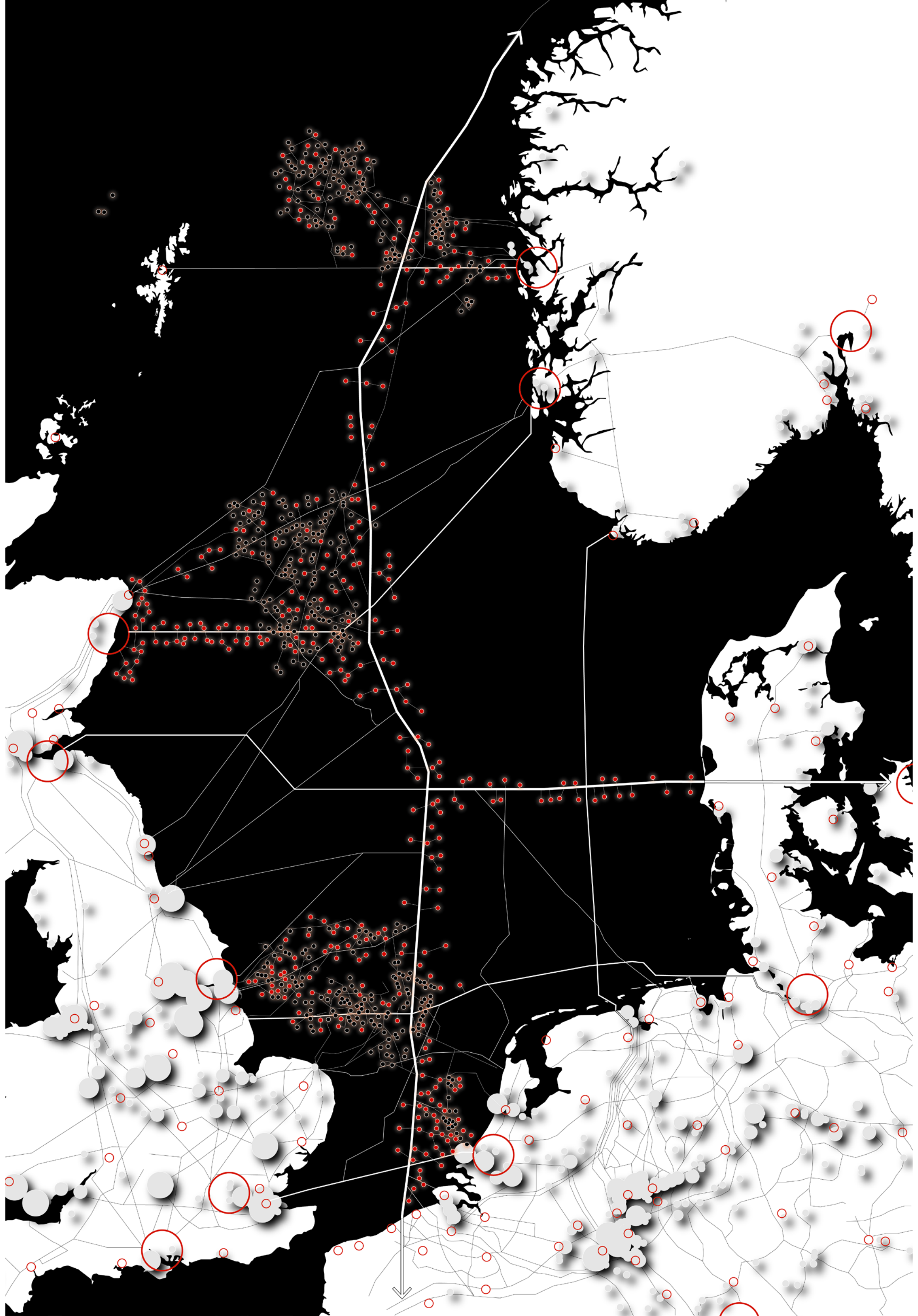
Extending the Electricity Grid

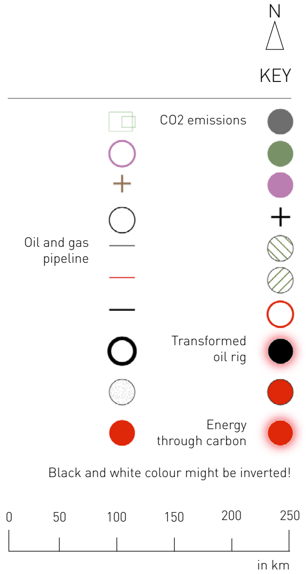
There is the potential to extend 'the line' beyond the borders of the North Sea macro region and connect the electricity grid to the south of Europe and even to Africa. Wind energy produces a surplus of electricity in winter and has a shortage in summer. Solar energy has the contrary problem since a surplus is generated in summer.
An exchange grid of renewable electricity between the North and South of Europe would therefore secure the energy supply for both territories. Africa would even bear the potential to exchange solar electricity over the whole year, which would diversify the sources of renewable energy in the North Sea territory even more.

The African potential of solar power
(The darker the colour the higher the potential)



The urban waste product, carbon dioxide, is consumed in the carbon region in Aberdeen, and in the regions adjacent to Hull, Bergen and Rotterdam



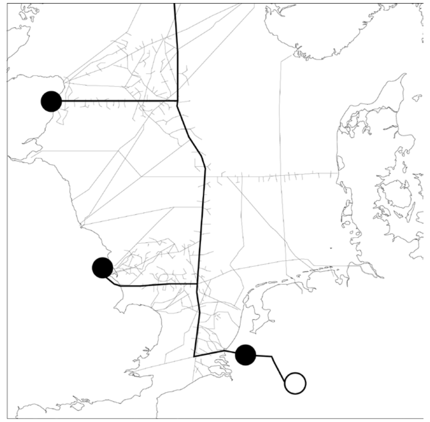


The carbon-exchange grid

The carbon exchange grid is based on the idea that carbon dioxide needs to be reduced efficiently to meet the climate goals in 2030 and 2050. There are already existing studies that research how to reuse pipelines for carbon dioxide transportation and platforms to store this gas in the depleted oil fields (Global CCS Institute 2013). Existing pipelines can be used to transport liquified carbon and both oil and gas field give the opportunity to store carbon dioxide in the basin. Nevertheless, the pressure on the rock formations leaves a certain amount of risk which makes the marine storage sites more valuable than storage sites on land (Ibid.). New pipelines will be eventually added to the system, since the carbon trade might increase, and new pipeline capacities might be needed as well as existing pipelines have to be replaced after a certain lifecycle.

The carbon-exchange grid is connecting the producers of carbon, the energy regions, with the consumers in the carbon regions. The nature of the energy regions will be introduced in the chapter 'Independent energy regions with an own identity'. Along the transportation path and in the carbon regions, carbon dioxide is consumed to produce electricity, bio fuel and electro fuel through different biochemical processes. These objects emit oxygen and clean at the same time the seawater. The carbon regions furthermore develop R&D clusters which are based on the different opportunities to use carbon as a resource, for examples in the cosmetic and chemical industry and as solution to produce construction material.

(3) From producer to consumer



(4) Reusing what is already there

The algae tower

There is a clear relation between the electricity exchange grid and the carbon exchange grid. Electricity can be produced through carbon utilization and will add to the patchwork of renewable electricity sources with the aim to diversify the existing sources of generation.

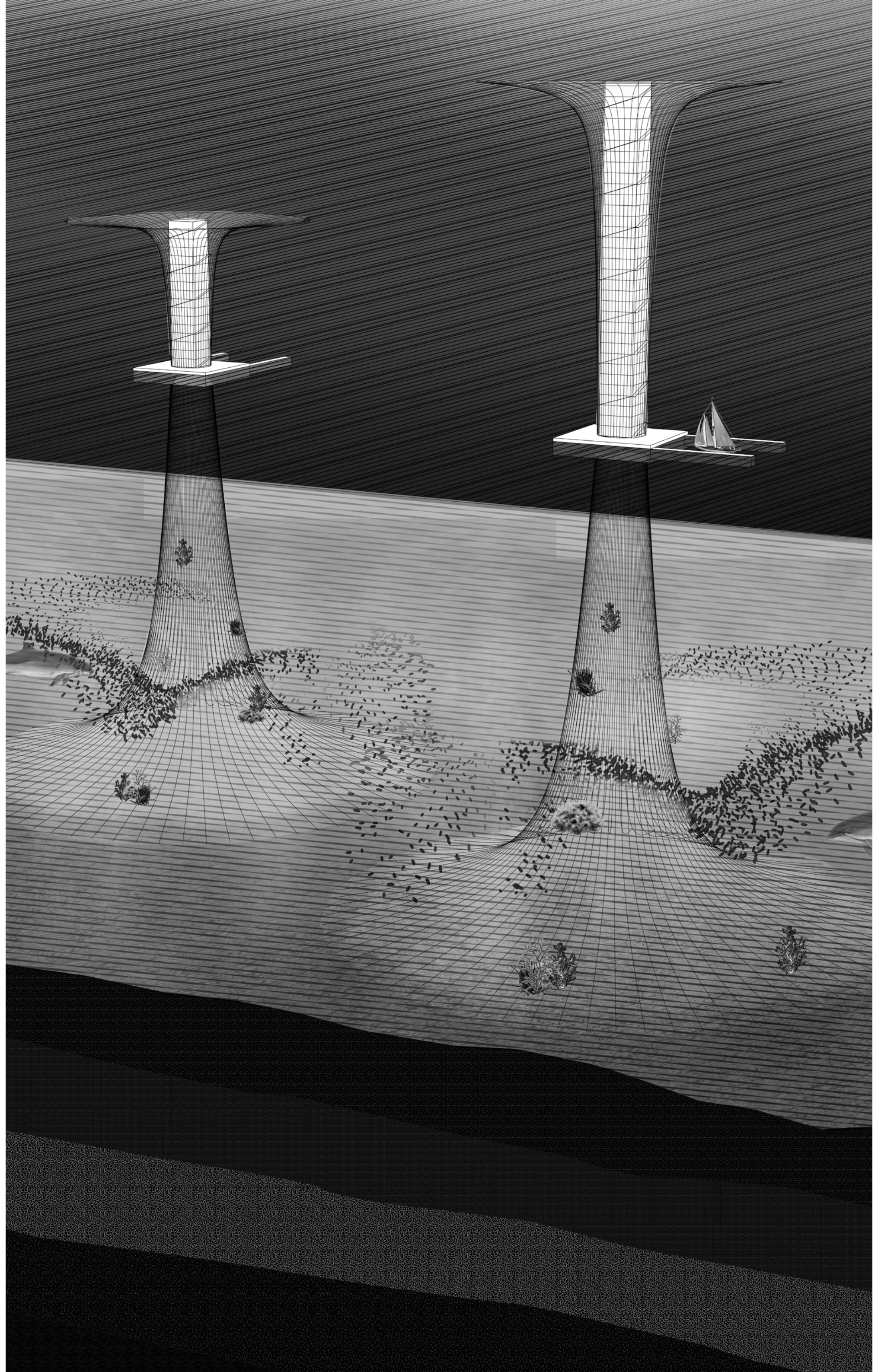
Two different types of power generation are introduced: Algae towers, that grow in the sky, and hydro towers, that are located in the subsea. Both structures create in addition to power generation environmental benefits through algae as a valuable part of the marine nutrition cycle and by turning the new energy artefacts into artificial reefs. More detailed information can be found in the next chapter *'An ecological patchwork'*.

Algae towers produce electricity and biofuels through algae cultivation. Carbon dioxide is used to accelerate the growth in order to reduce the carbon waste of the surrounding territorial urbanisation and to lower the overall carbon footprint.
Electricity is produced through a newly innovated power cell that can extract electrons from algae during their photosynthesis process (Dockrill 2015).

"Both photosynthesis and respiration, which take place in plant cells, involve electron transfer chains. By trapping the electrons released by blue-green algae during photosynthesis and respiration, we can harness the electrical energy they produce naturally."
(Muthukumaran Packirisamy, Concordia University, Montreal)

The architecture of these structures to produce electricity might vary. The form of the objects in the right image is based on the idea to maximize the surface for algae pipes to catch as much sun as possible.

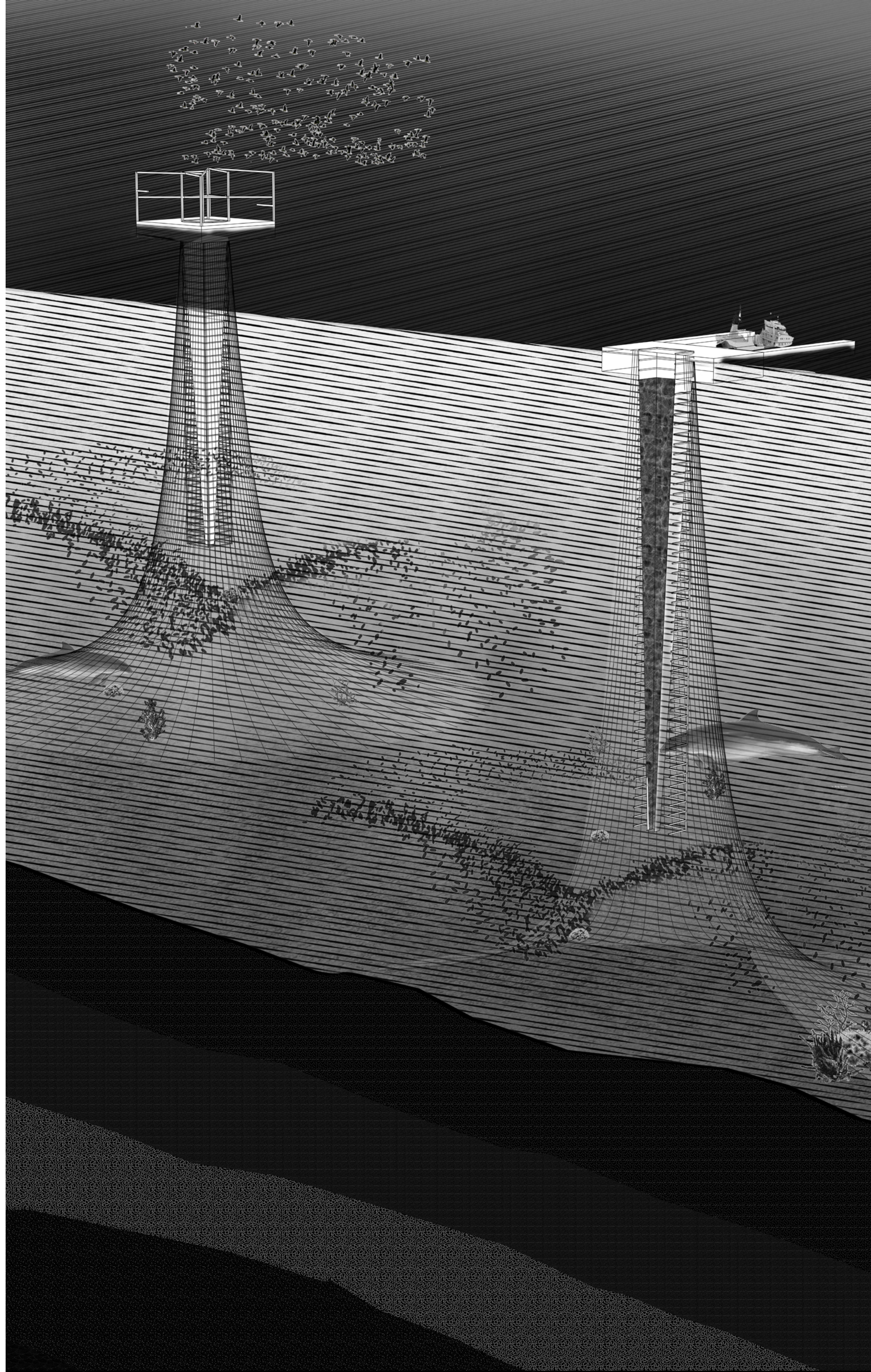
Different kind of biofuels can be produced through biochemical processes. Algae bear the potential to generate 10 up to 100 times more energy than through teh equivalent amount of terrestrial biochemical feedstock (U.S. Department of Energy 2018). These fuels can be used in different ways for transportation or for the production of plastics. Algae can be used in addition in various other fields to produce protein, medication or for cosmetics.

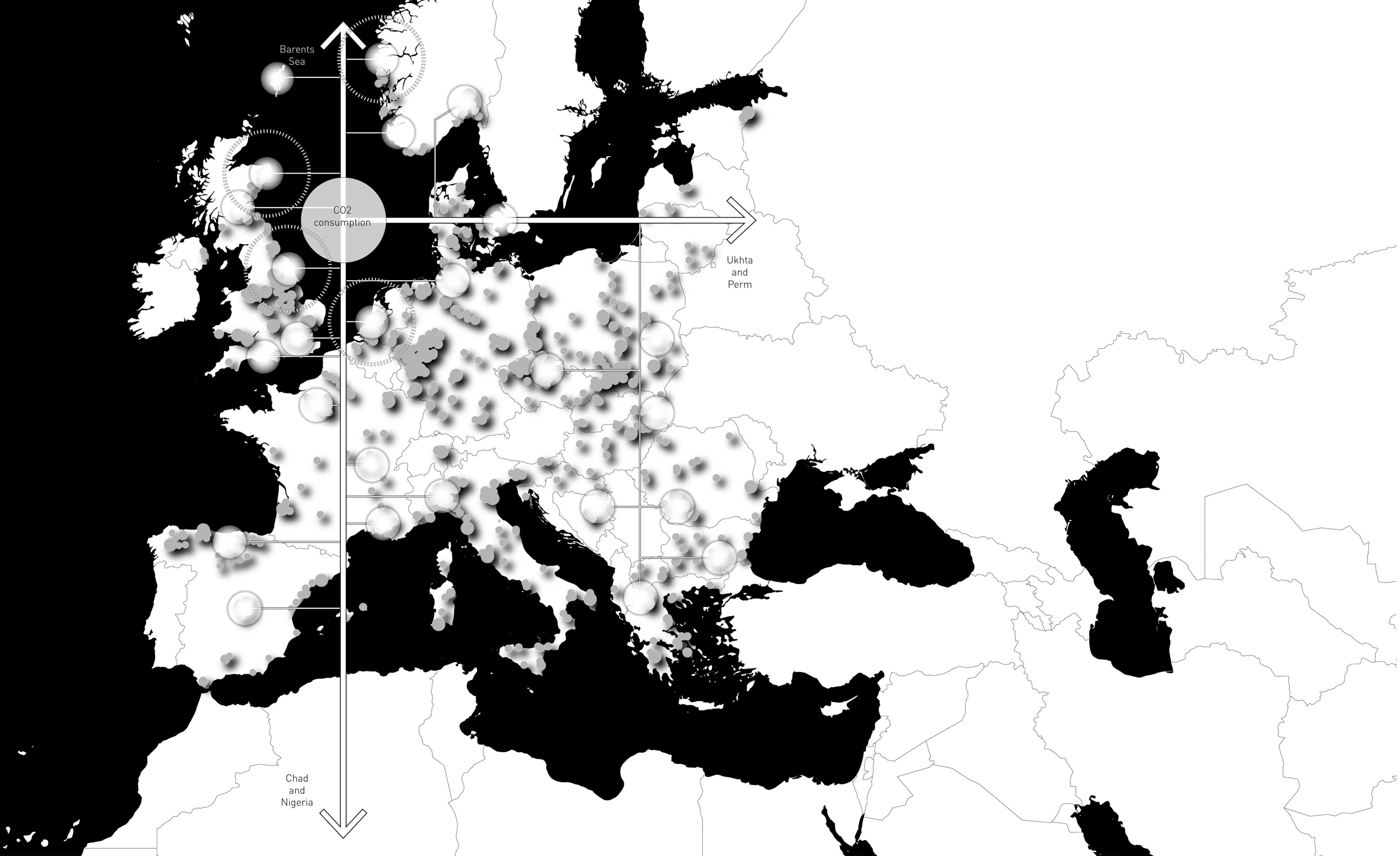


The hydro tower

Hydro towers produce electrofuels through the use of carbon dioxide and hydrogen. Hydrogen is harnessed through a technology, that allows to filter these elements from sea water (Nield 2017). This process might even bear the potential to remove toxic substances from the seawater through filtration. It might be therefore advantageous to locate hydro towers close to oil platforms since these waters are usually polluted due to toxic leakages in offshore drilling.

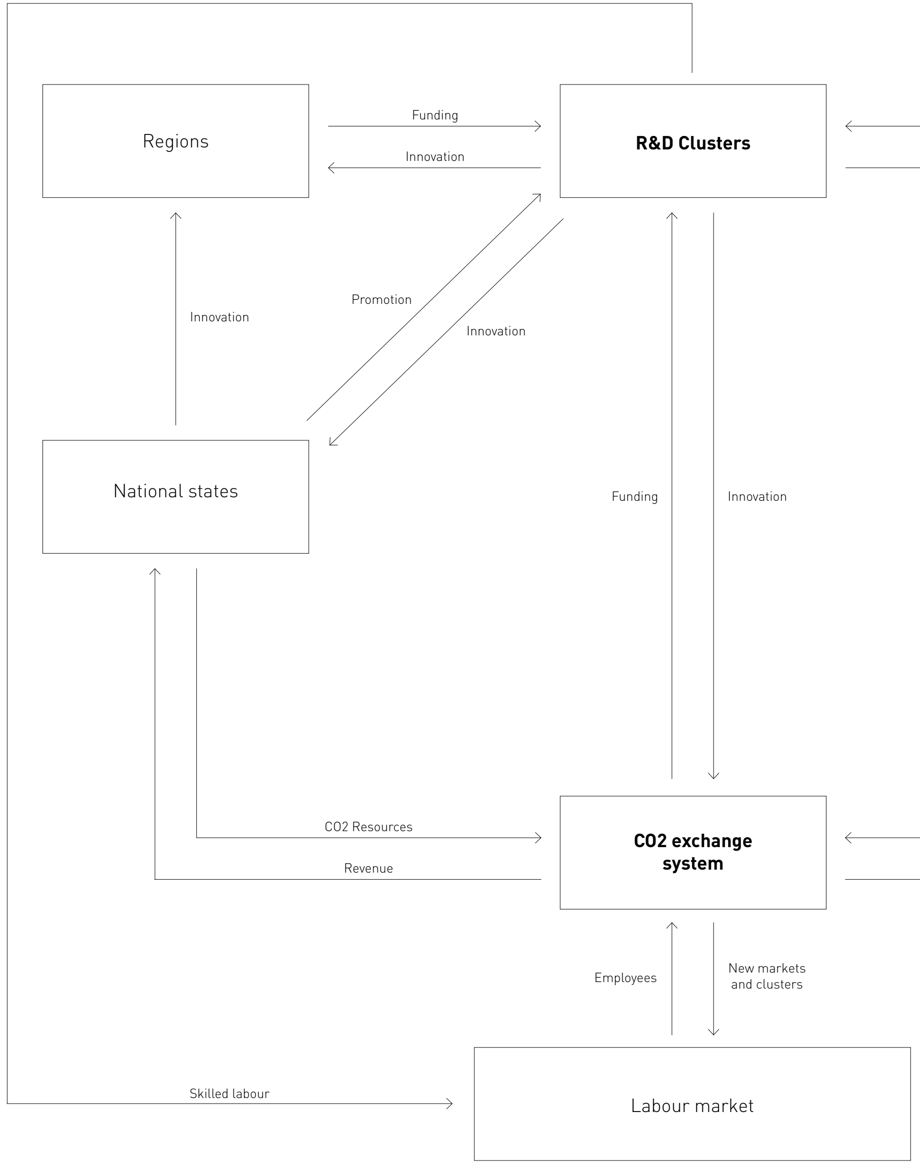
Electrofuels show several advantages in comparison to biofuels. First, they can replace a wider field of products that were formerly produced through the process of crude oil and gas. Furthermore, electrofuel could contribute to one of the major problems in the current energy sector: electricity storage. Liquid electrofuels can be transformed at any time into electricity by help engineered microbes (Hansson et al. 2017)





Extending the Electricity Grid

The former urban waste material, carbon dioxide, could eventually turn into a valuable resource for different fields of industries and for the energy sector.
Therefore, 'the line' could extend towards the south to big oil and gas clusters in Nigeria and Chad. The system could furthermore extend towards the east and connect with major carbon emitters in Poland, the Cheche Republic and with major oil and gas clusters in Russia.



(5) A fair devision of resources and revenue

The sea as a space of collaboration leaves the question how the adjacent countries of the North Sea can benefit equally from the new energy system. So far, countries with a long coast line and a small terrestrial zone yield in comparison big EEZ's in the sea and can extract a lot of resources. Countries, like Germany, with a short coast line and a big hinterland lacked the opportunity to benefit from energy and revenue generated at the sea. The collaborative seascape therefore introduces an alternative governance system in order to equally share the revenue of the new energetic system at sea.

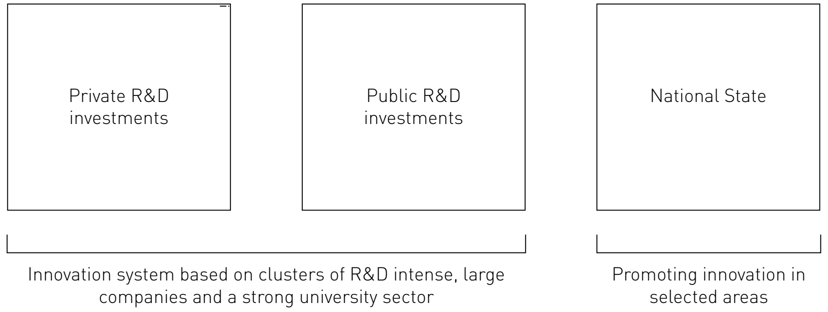
'Welfare represents quality social investments and quality social investments means high quality education, health, housing, employment and social services for the society at all levels.'
Project for democratic Union, 2014
Welfare in Scandinavia acts as a role model for continuous and sustainable economic growth, since it generates revenue for all participants through a strong R&D sector. For example, the Swedish welfare system is built on three pillars: (1) Private R&D investments (2) and public R&D investments, which creates an innovation system that is focused on clusters of R&D-intense, large companies and a strong university sector. The state is promoting innovation in certain selected fields and is thereby influencing actively the social and economic development in cooperation with big businesses and the labour market (Fagerberg and Fosaas 2014).

The wellfare system of the North Sea territory will be as well build around a strong research and development sector funded by private firms, the national states and adjacent regions. The investments in R&D will eventually foster the development of the CO2 exchange grid and related technologies which will accelerate the development of new markets and industries that sustain the long term economic growth and secure social welfare.

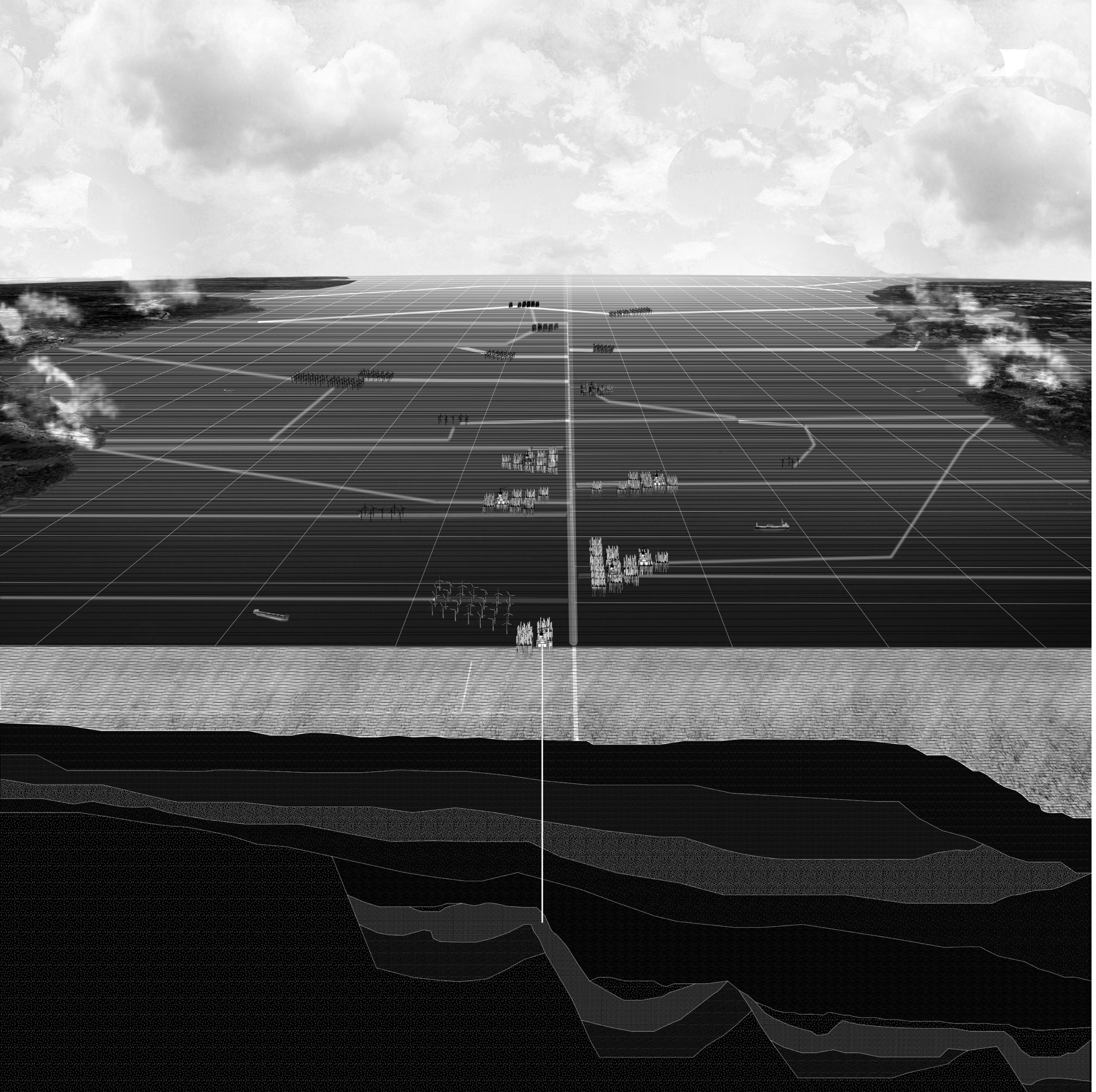
Another advantage of the close cooperation between big businesses and national states is the joint engagement into big infrastructure projects. For instance, the Swedish telecommunication agency cooperated with the Swedish global player Ericsson to improve the electrical infrastructure of the country (Fagerberg and Fosaas 2014). A joint cooperation between public and private stakeholders might therefore bear the biggest potentials to build up such a big and complex infrastructural system like the exchange grid in the North Sea.

How to secure equal revenue for all adjacent countries of the North Sea?

The three pillars of Swedish welfare



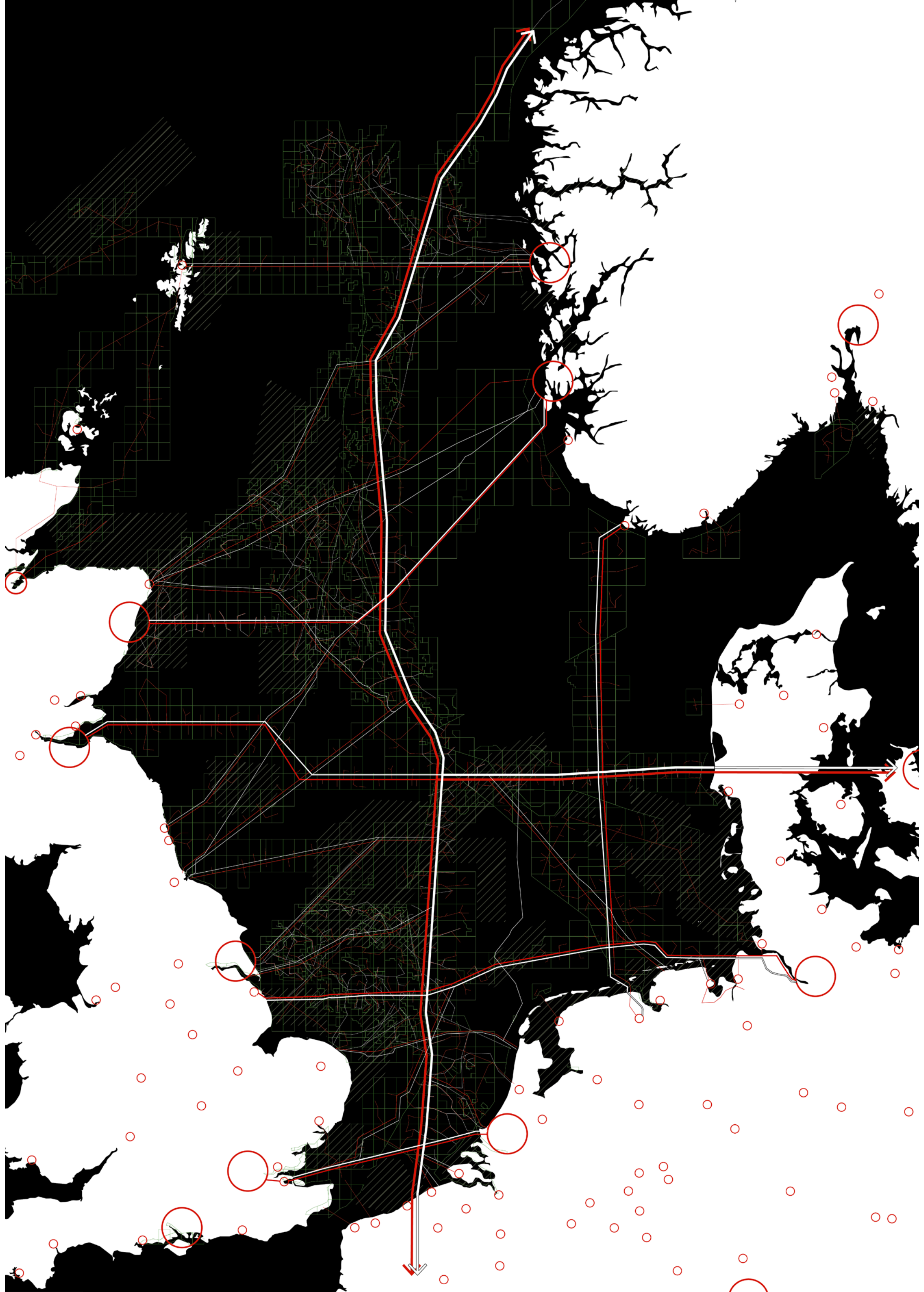
Based on: Fagerberg, J. and M. Fosaas, Innovation and innovation policy in the Nordic region, in Fafo-report 26, 2014



Summary - The collaborative seascape

The marine area is turning from a space of extraction into a space of collaboration in order to diversify the electricity and fuel production and to secure the territorial electricity supply. Carbon dioxide as an urban waste material is transported by pipelines from the areas of production to the spaces of consumption to support the fulfilment of the European climate goals, to create energy and fuel and to foster prosperity and wealth.

Ecological corridors develop along the infrastructural axis to increase the marine biocapacity



N

KEY

Ecological patchwork

Oil and gas pipeline

Electricity cable

Planned ecological zone

Existing ecological zone

Black and white colour might be inverted!

0 50 100 150 200 250

in km

THE ECOLOGICAL PATCHWORK

Increasing the marine biodiversity

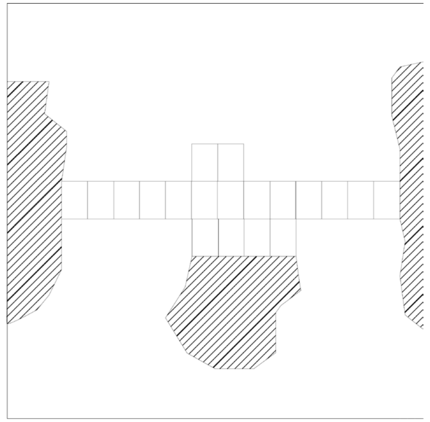
The North Sea is facing numerous environmental threads deriving from the current energetic system, climate change and overfishing. Interventions are urgent in different spheres, like the growth of rich marine habitat, different policies and through more sustainable fishing methods.

70% of the threatened species live near the bottom of the sea. Measurements needs to be taken to ensure the recovery of fish species like cod, herring, plaice or mackerel (Seas at Risk 2017). The future exchange grid will enhance the marine biocapacity through the development of ecologic corridors that connect currently fragmented marine protected zones. This idea is based on 'Landscape ecology principles' by Dramstad, Olson and Forman, who introduce the advantage of natural corridors and the benefits deriving from big ecological habitats: a richer biodiversity and the chance to sustain 'interior species' (1996). Natural habitats are usually divided into interior and edge zones, which both have particular characteristics of flora and fauna. The smaller a habitat is, the bigger is the edge zone and interior species are threatened. Improving the marine nutrition circle might lead to a recovery of the fish stock, which continuously shrank in the 20th century due to overfishing. Nevertheless, since 1960th different strategies were developed to cope with the hazards of overfishing and pollution in European waters. 'Seas at Risk' states, that these strategies so far were not sufficient enough to deal with the threads (Seas at Risk 2017).

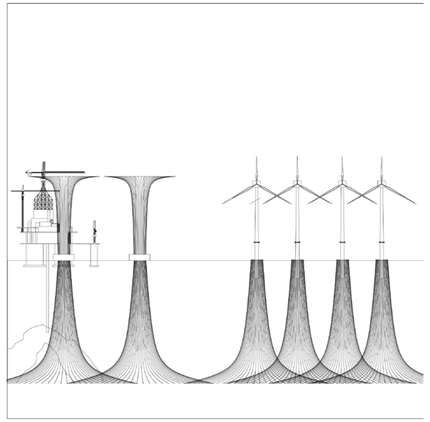
Next to sustainable fishing methods, additional steps need to be considered to deal with the loss of fish species in the sea. Just recently, the European Parliament fishing committee voted for a concept to manage fishing among the member states in a more sustainable way. The outcome had positive and negative sides since the committee decided for a plan but postponed concrete decisions to a later moment (Ibid.). The establishment of a macro-region could therefore create awareness for the urgency of the topic and provide a platform for concrete interventions to cope with the problem. Since the nation states need to work collectively on the topic of the energy transition they would deal at the same moment with environmental themes, like overfishing. Whenever the energy system is transformed and extended, it also increases rich marine habitat in different ways.

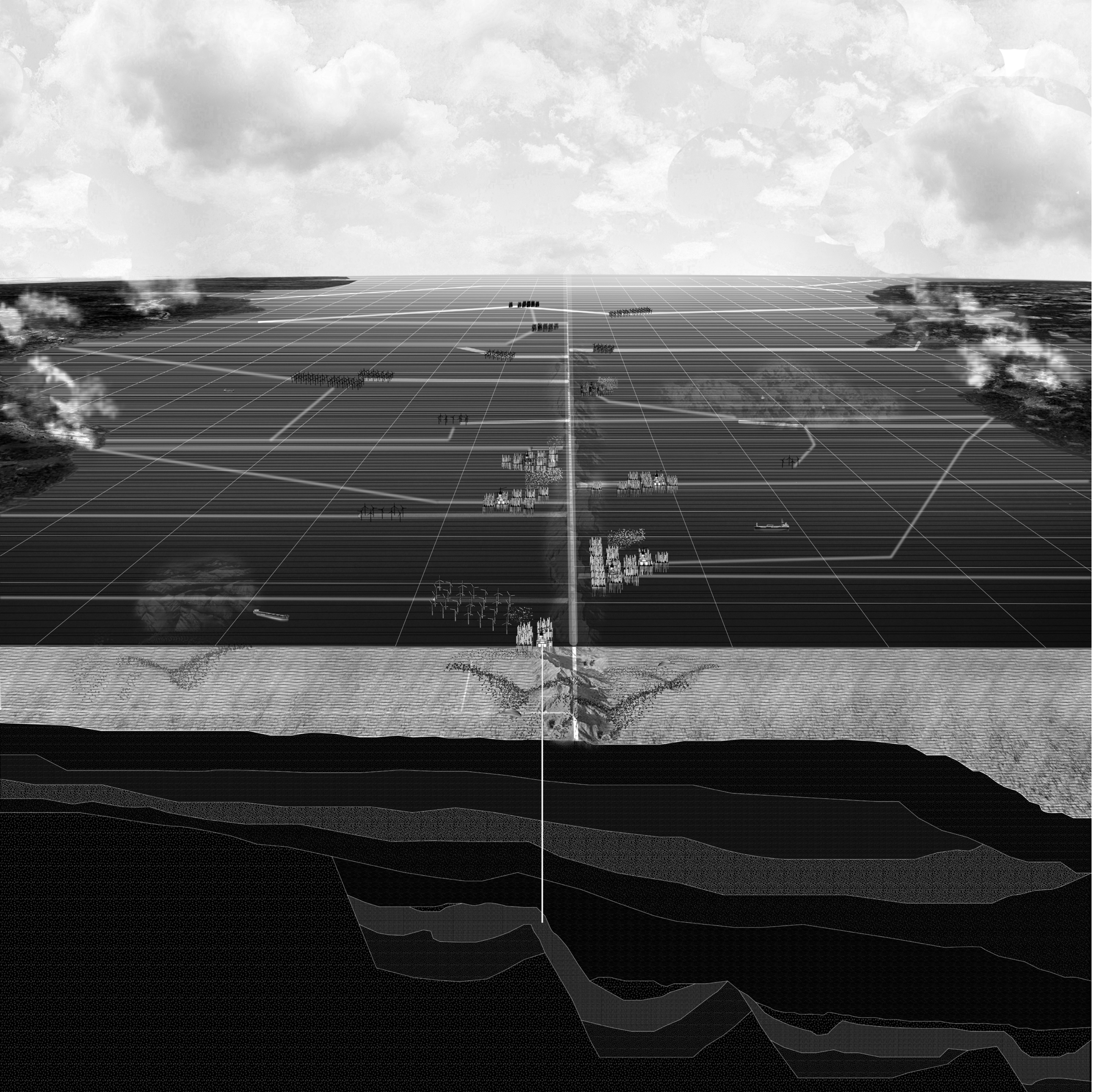
The natural corridors will be created by engineered energy objects and a transformed pipeline and cable system, which act as artificial reefs in the sea. Water purification will be a by-product in the process to produce electro fuel through the use of carbon dioxide and hydrogen, where saltwater will be filtered and processed into hydrogen (Nield 2017). Algae are an additional point of consideration to enhance the marine biocapacity. Besides to their productive utilization of electricity and fuel, algae are one of the main components in the marine food chain and are support the metabolism and growth of marine species, like sea sponges and natural reefs (Chapman 2013). A more detailed image can be found in a later stage of the project in the chapter 'the marine node'.

(6) Ecologic corridors connecting protected zones



(7) Engineered artefacts as water purifiers and artificial reefs

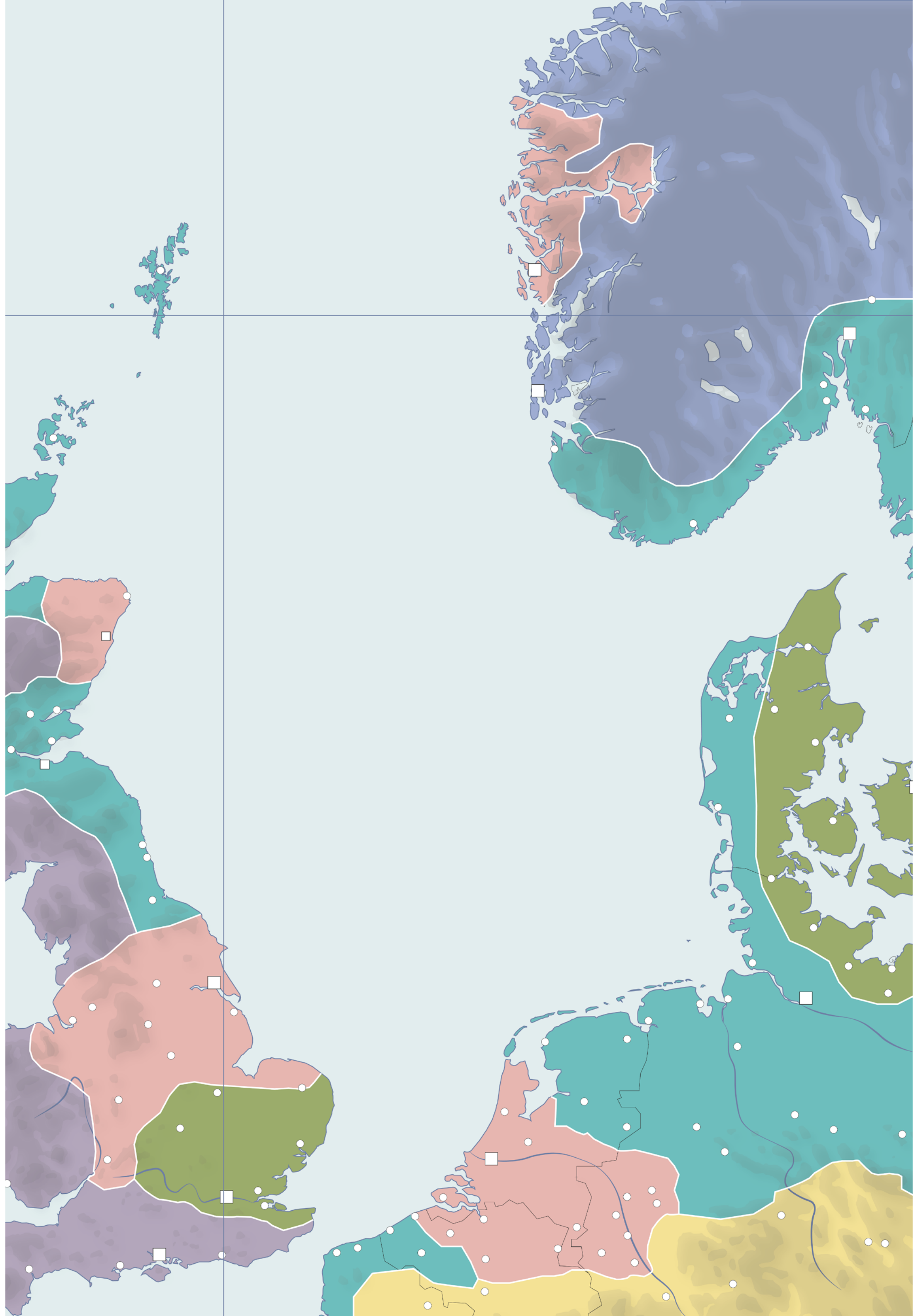




Summary - The ecological patchwork

Ecological corridors develop along the infrastructural axis of electricity and CO2 to connect currently fragmented marine protected areas. The aim is transform the energy infrastructure from a polluter into a structure which is enhancing marine biodiversity and to expand the habitats for ocean mammals and fish.

The formation of 6 kind of energy regions:
Carbon , Wind, Hydro, Biomass, Tidal
and Geothermal



N

KEY

Carbon region
Wind region
Biomass region
Geothermal region
Tidal region
Hydro region

0 50 100 150 200 250
in km

THE LOW-CARBON BELT

(8) Independent energy regions with an own identity

The low-carbon belt consists of 6 different types of energy regions which are on the one hand based on the energy legacy of the North Sea territory and on the other hand on the future potential of renewable energy sources.

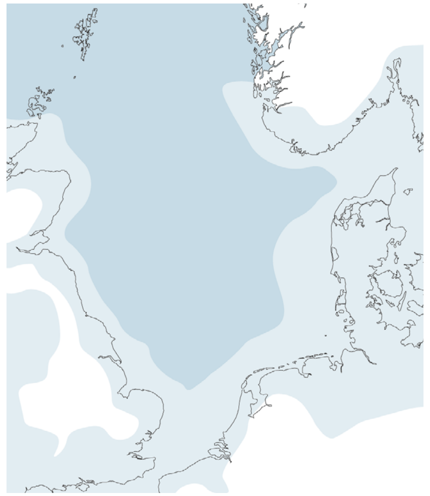
Each renewable energy potential relies on certain natural conditions. The wind regions are characterized by comparably high marine and terrestrial wind speeds, which derives from a flat relief as well as from ruralized areas with less urban settlements. New types of wind energy facilities are linked to already existing patterns of wind parks.
Two biomass regions can be found adjacent to the Thames estuary and in the East of Denmark. These regions are characterized by shallow waters and higher water temperatures compared to the northern seascape. Certain kind of crops require good light conditions, which can be only facilitated in a shallow sea.

The hydro region in Norway has unique conditions to produce electricity by waterpower. The high potential derives from the water flow which is accelerated by the mountainous relief. The country is already generating 99% of their electricity through hydropower (Statkraft 2018). Differet technologies will add up to this high ratio of renewable electricity production.
The energy region in the west of the UK relies on its high tidal potential. The kinetic power of the tides, that is relying on the moon phases, water currents and the level of the bathymetry, is producing electricity.

The carbon regions play an essential role in the collaborative system of exchanging energy and resources. These regions are directly addressing the short term European climate goals and store or process CO_2 in different ways. Carbon dioxide can be used to produce electricity, biofuels and can accelerate the production of proteins and other goods. The locations of the carbon regions were chosen strategically in order to harvest the waste CO_2 of the surrounding energy regions and to generate short distances to potential process and storage sites.

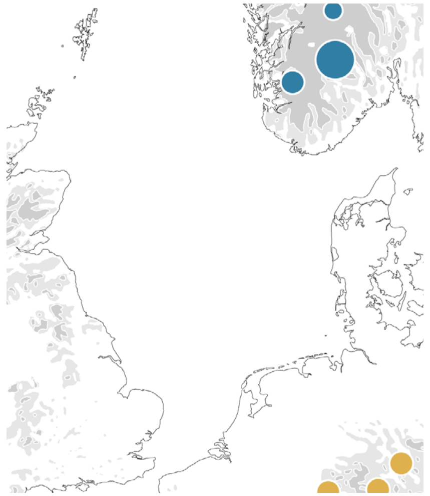
Creating energy regions does not mean to weaken the positions of existing national states. They are giving additional options of planning and governance in coexistence with existing models of nation states and 'hard planning' institutions. The goal is to accelerate decision-making and to be more flexible to different future uncertainties. The following pages are showing an alternative model of governance and policy making, reaching from the international to the urban scale.

The wind energy potential is based on flat relief and sparsely populated landscapes



Shallow waters and high water temperatures for aquacultures

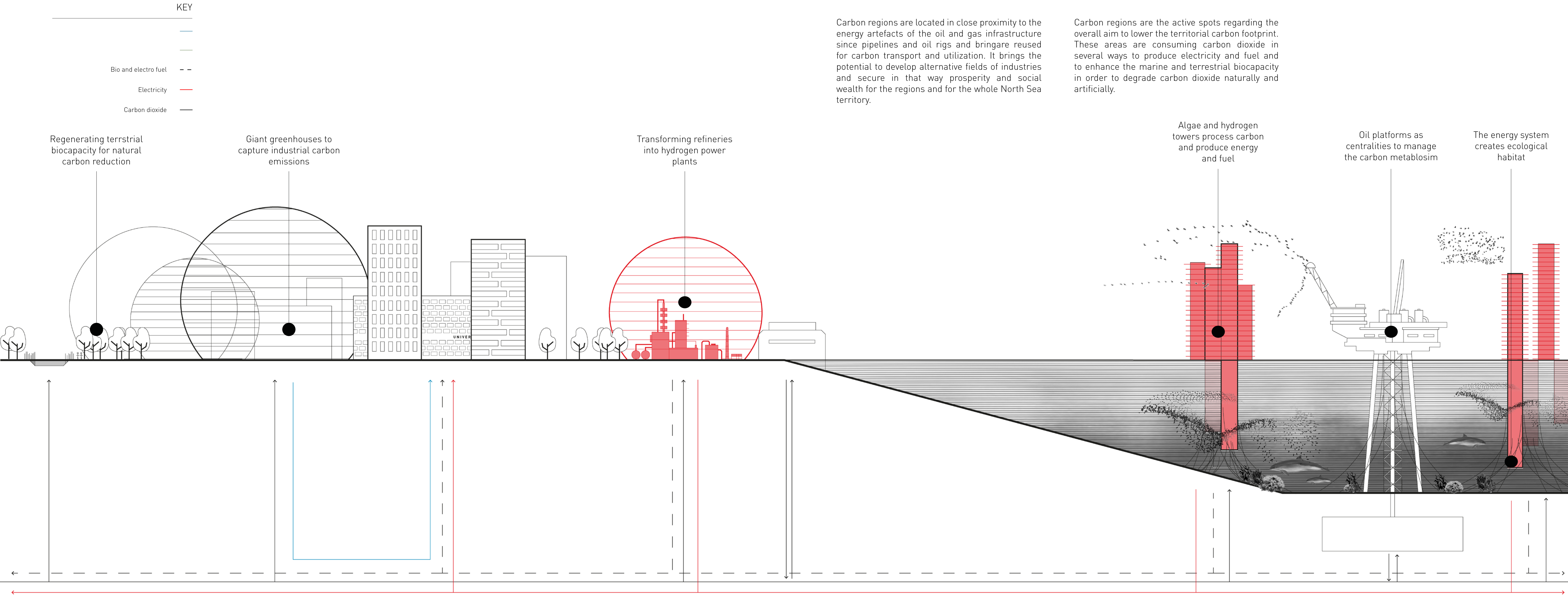
Shallow waters and high water temperatures for aquacultures



The carbon regions: Consumers of urban waste

Carbon regions are located in close proximity to the energy artefacts of the oil and gas infrastructure since pipelines and oil rigs and bringare reused for carbon transport and utilization. It brings the potential to develop alternative fields of industries and secure in that way prosperity and social wealth for the regions and for the whole North Sea territory.

Carbon regions are the active spots regarding the overall aim to lower the territorial carbon footprint. These areas are consuming carbon dioxide in several ways to produce electricity and fuel and to enhance the marine and terrestrial biocapacity in order to degrade carbon dioxide naturally and artificially.



KEY

Bio and electro fuel

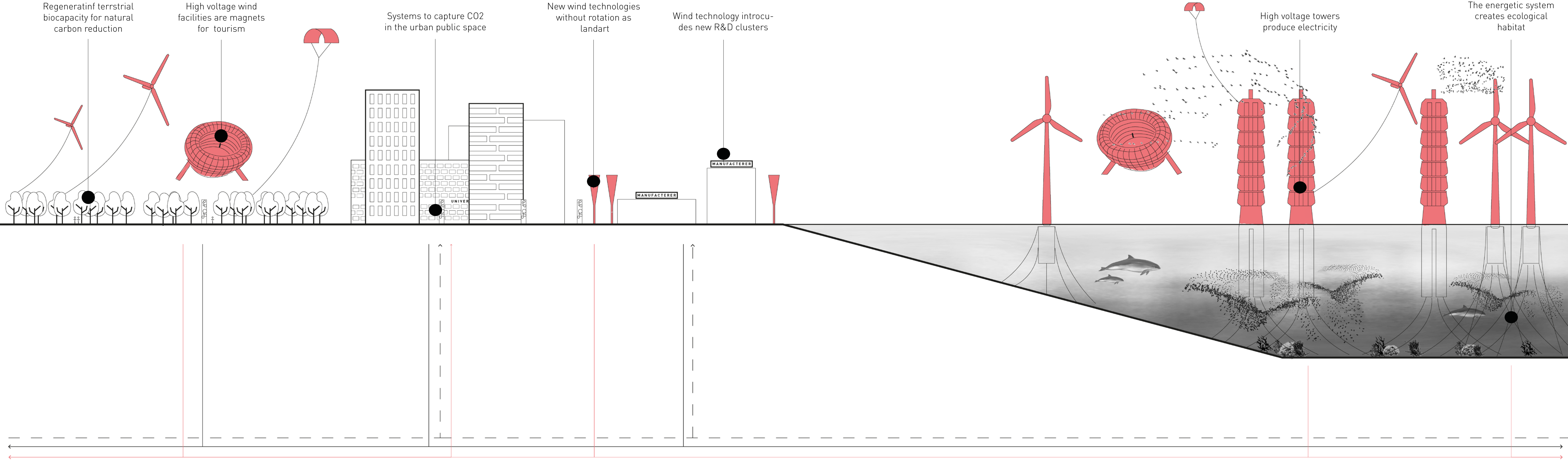
Electricity

Carbon dioxide

The wind regions: Major producers of electricity

Wind regions are located in the spaces of the highest wind speed potential, sparsely populated areas with a flat relief. These regions are the major provider of electricity in the North Sea territory, referring to the reference examples of *'An Energetic Odyssey'* by H+N+S and the *'Zeekracht'* masterplan by OMA.

Wind regions eventually produce a surplus of electricity and contribute to the low carbon future, but the integration in the overall system of collaboration is essential. Wind region require the exchange grid due to the variations in electricity generation and because of the transport of carbon dioxide to the carbon regions.



The hydro and tidal regions: Diversifying renewable electricity sources

Both types of energy regions have the same role in the North Sea territory and work with the motions and the salinity of water. They add to the idea to diversify the sources of renewable energy in the North Sea territory. Hydro regions are located in mountainous areas, since they use the motion of the water, e.g. waves, to produce electricity. Tidal regions use the motions of water through tidal streams to produce electricity. Both regions have the potential to generate electricity through osmoses power plants, which use the salinity differences between ocean water and sweet water.

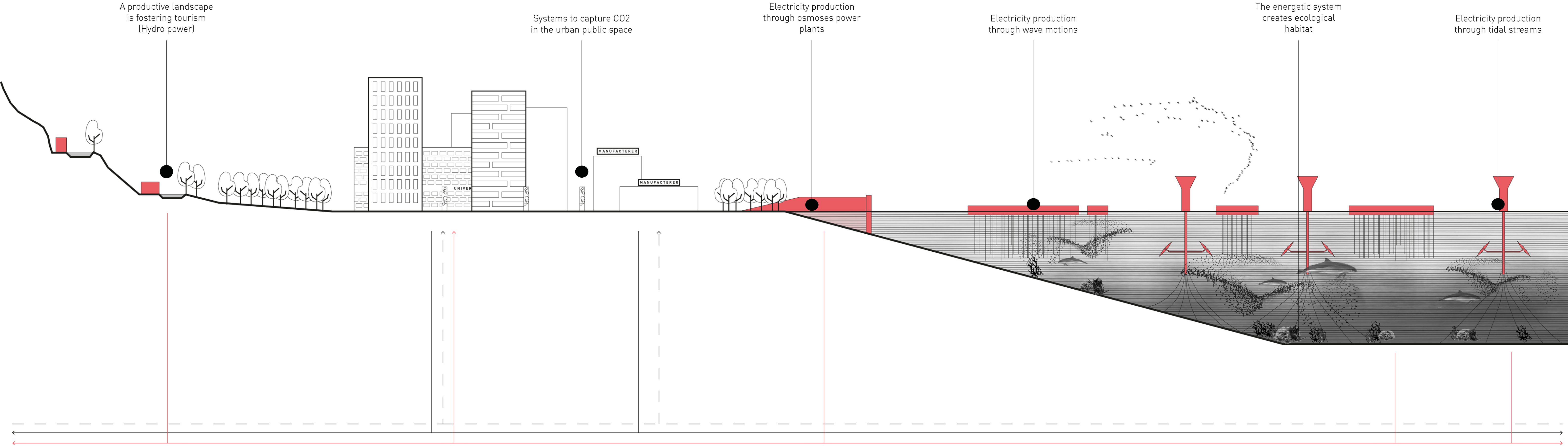
These regions furthermore produce carbon dioxide as a resource that is consumed by the carbon regions. In return, they eventually receive bio- and electro fuels as well as revenue from the carbon welfare system.

KEY

Bio and electro fuel

Electricity

Carbon dioxide



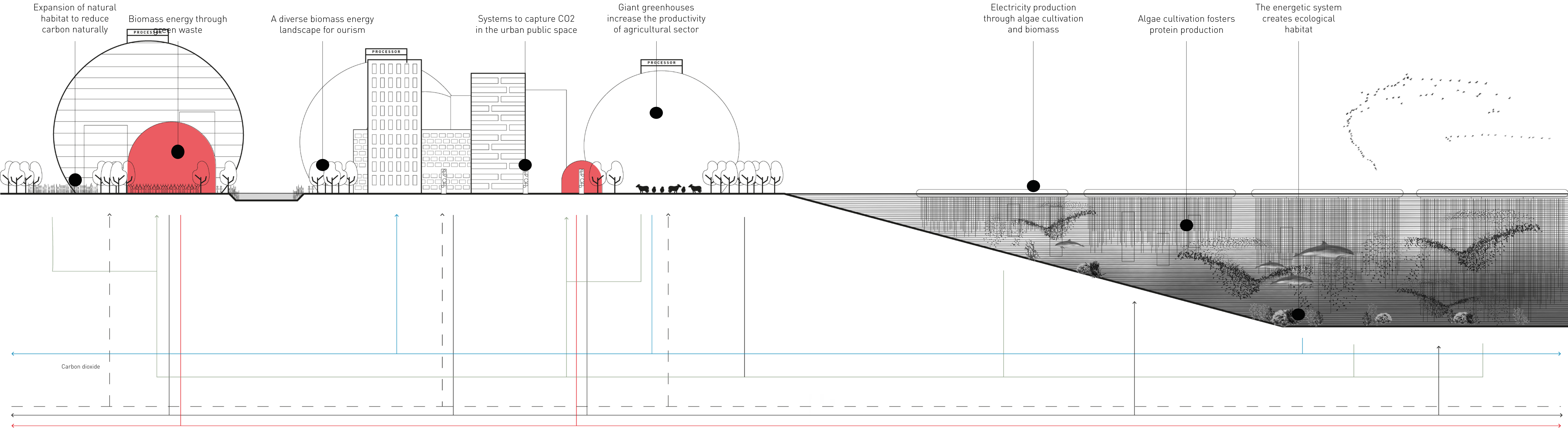
KEY

Protein
Green waste
Bio and electro fuel
Electricity
Carbon dioxide

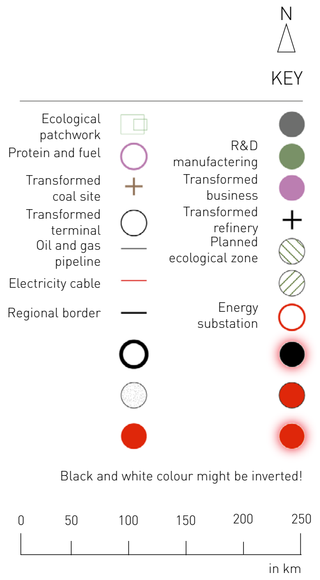
The biomass region: Energy production for the sake of nature expansion

The biomass regions are adding to the patchwork of diverse renewable energy production through the use of green waste, algae and other agricultural disposals. The location factors are on the one hand the terrestrial land use: rural landscapes and agricultural spaces for the generation of green waste. The marine natural circumstandes are shallow waters and a comparably high water temperature to foster the growth of marine algae and seafood.

Biomass regions build a circular system of energy generation and protein production including the partial use of carbon dioxide. The focus of this region is on the expansion of natural habitat both in the marine zone through the cultivation of algae and marine mammals as well as in the terrestrial area through reforestation. These interventions contribute to the overall goal to establish a low-carbon economy by degrading carbon dioxide naturally.



A low carbon belt is developping in the North Sea territory



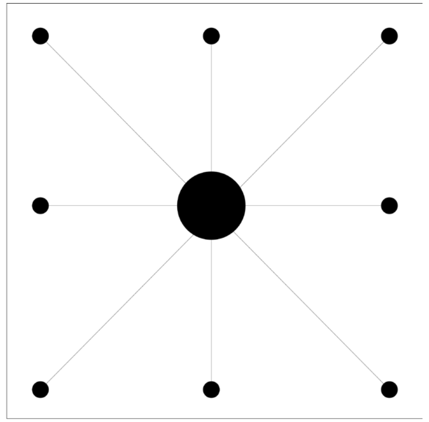
(9) Centralities for energy supply and urban growth

The development of a low-carbon belt is essential since carbon is a major contributor to climate change. Furthermore, the carbon footprint needs to be reduced in order to sustain the estimated population growth in the North Sea territory.

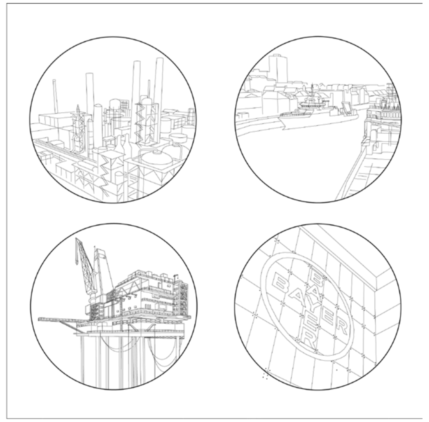
Different hierarchies of cities exist in the belt, depending on the number of infrastructural connections and the number of brownfields since these two factors contribute to the development of a low-carbon economy. Therefore, the biggest nodes also carry the highest rates of growth. The number of infrastructural connections secures the energy and resource supply of renewable and low-carbon sources. The cities (areas of energy demand) are benefiting from the energy exchange grid since the areas of energy production are connected through an exchange grid that creates short and direct links.

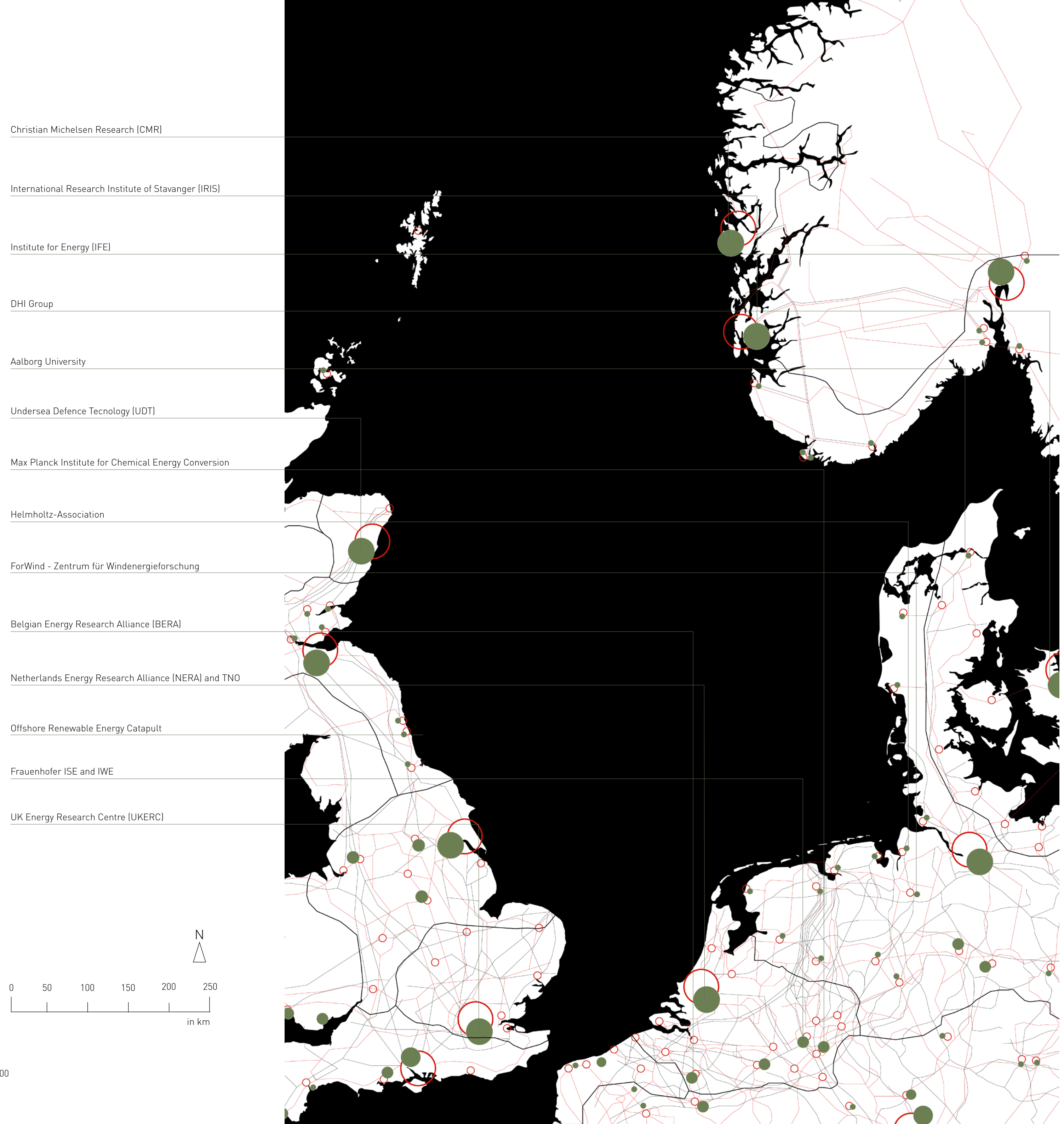
A high number of brownfields generates potentials for urban growth, for alternative industries and research. Future desolated sites, like oil-harbours and refineries, will turn into urban centralities. The drivers for this change are the infrastructural connections, like the resource exchange grid, terrestrial transport infrastructure and water transport infrastructure. Different means of infrastructure will reintegrate in that way these brownfields back into the urban structure. The urban node, Aberdeen as an experimental case, is drawing a more concrete picture in the later stage of this project.

Number of infrastructural connections



Number of future brownfields



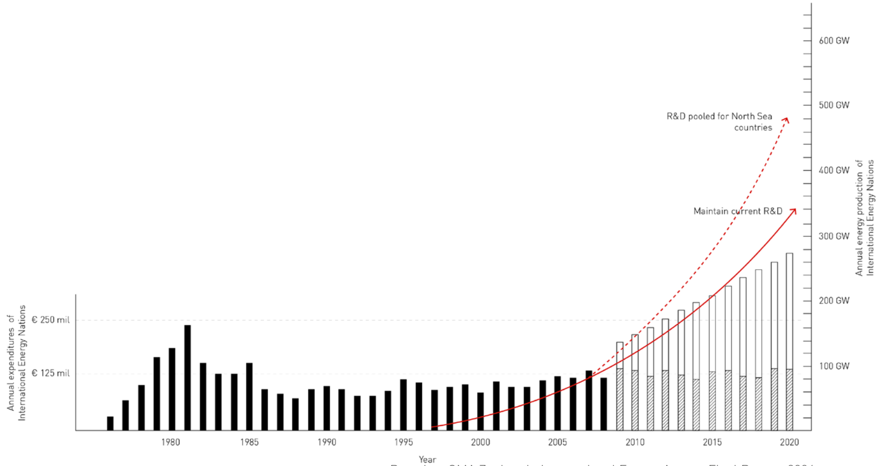


(10) Prosperity and competition through research

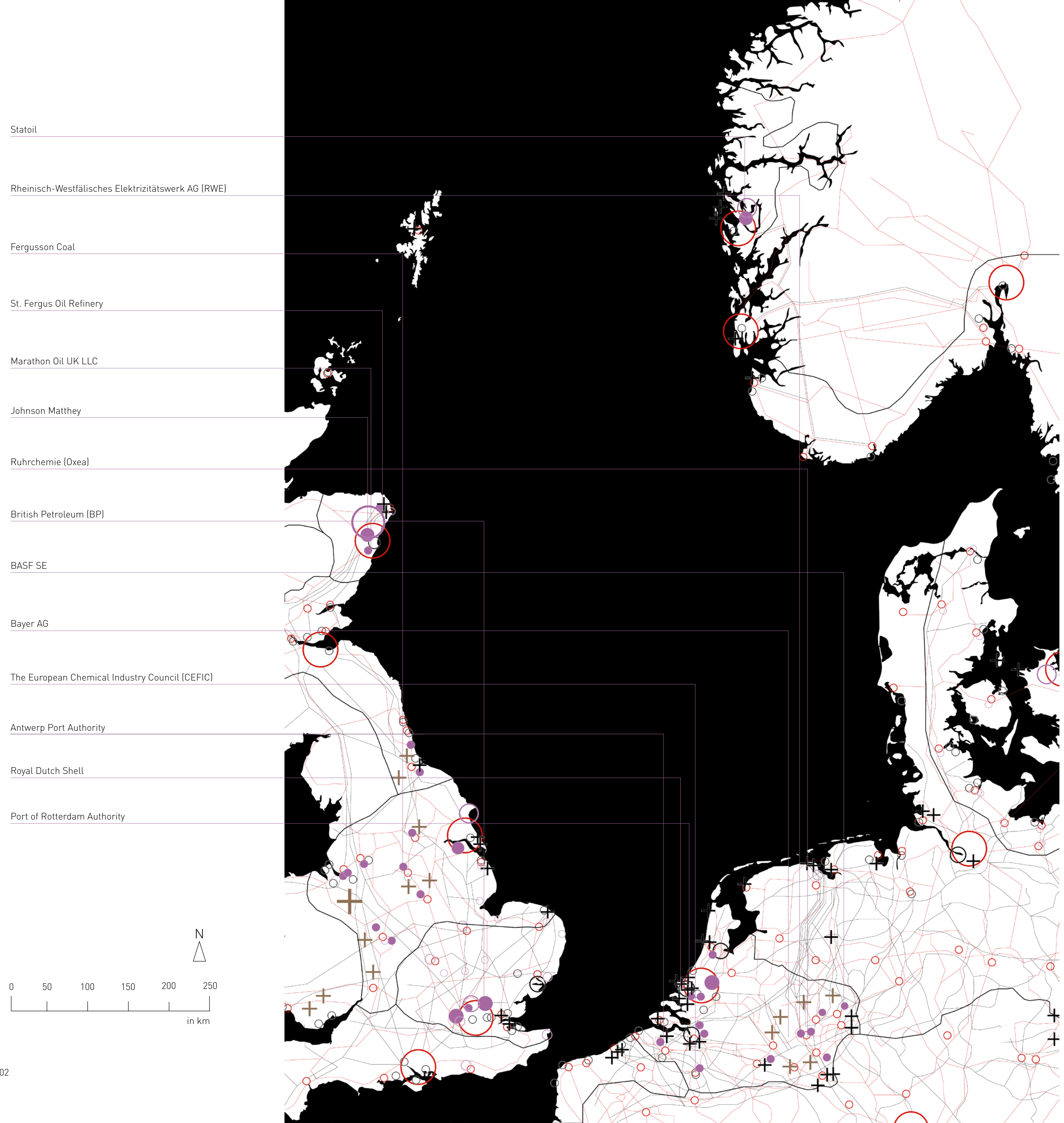
The development of strong research clusters and the integration of research institutions in the process to form a macro-region in the North Sea territory is essential to deal with the transformative processes from an energy system reliant on fossil resources towards a low-carbon future.

First, research is fostering the development of technologies which are important for the creation of the exchange grid. Research furthermore can increase the efficiency of renewable technologies. The figure beneath is showing the benefits that derive from investments into the R&D sector of wind energy. A pooling of R&D clusters in the North Sea territory could increase the outcome and efficency of infrastructural components while keeping the cost at the same level. Each energy region is doing research in their field of expertise in order to create knowledge and innovation in several fields of renewable technologies and carbon reduction.
There are already numerous research institutions existing that deal with innovation in these fields. They all meet in the European Energy Research Alliance which is acting as a platform for networking and to coordinate action towards a low-carbon Europe (EERA 2018). These research institutions played so far a minor role in the spread and location of different energy regions in the territory. In the future strategy they will be a location factore to charactetrise the nature of each energy region. For example, Aberdeen already has several institutions, like the centre of 'Undersea Defence Technology, which are dealing with subsea engineering and will transform into a carbon region,. Another example is the 'ForWind - Zentrum für Windenergieforschung' in Germany, which is located in one of the future emerge regions.

The benefits of research and development in wind energy



Based on OMA Zeekrach, International Energy Agency Final Report, 2004

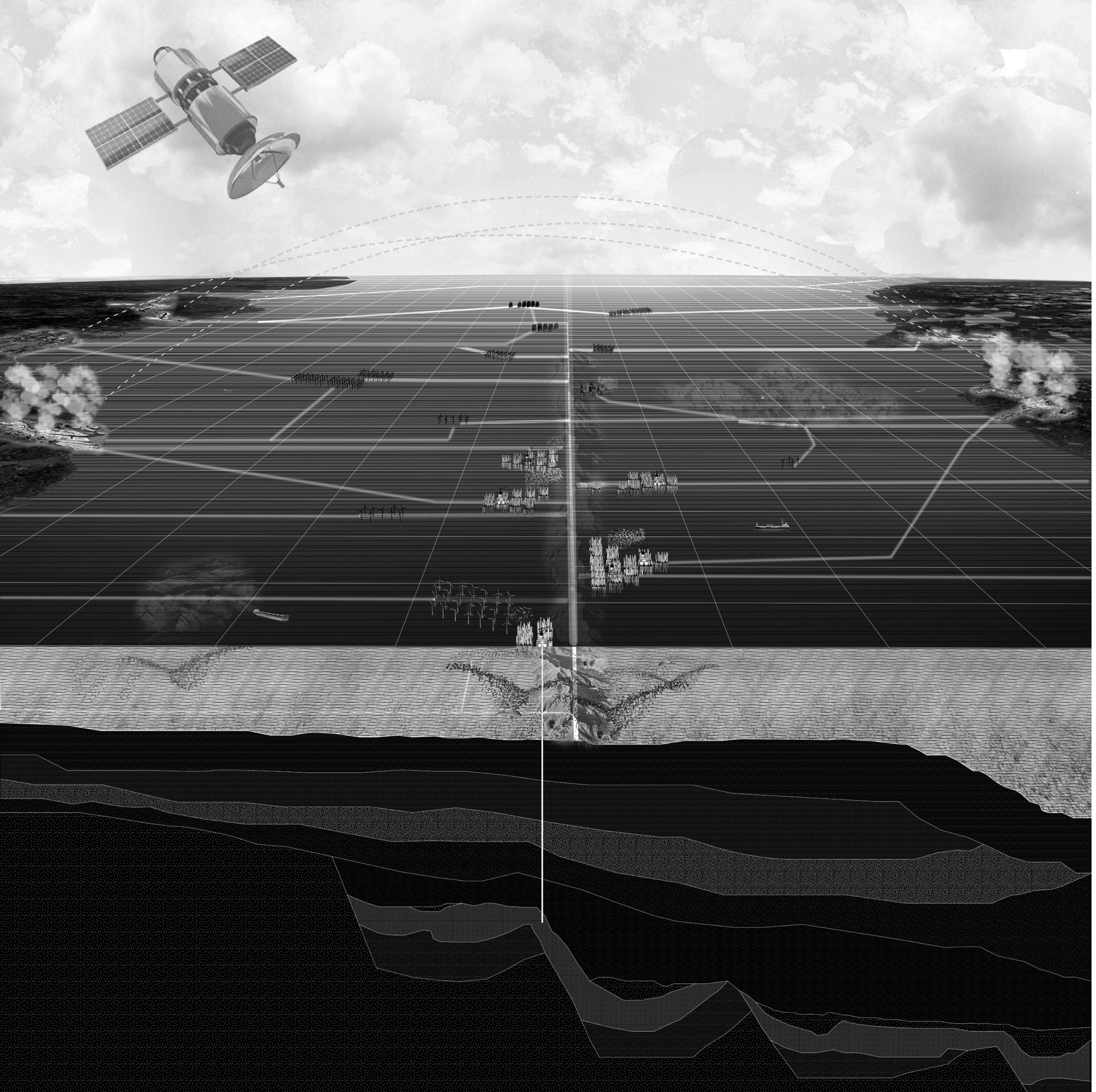


(11) Prosperity and competition through transforming brownfields

Major players and smaller companies of the oil and gas industry, petrochemical industry and from the fossil energy sector need to transform towards a low carbon future. As alternatives, they can invest into renewable technologies or into the carbon business. Global players, like Royal Dutch Shell, are already aware of this challenge, partners with companies of the renewable energy sector and invests into infrastructure and wind parks (OffshoreWind 2018).

Integrating these companies into the strategy-making of the North Sea's macro region is of importance to find strategic partners throughout the whole process that support the approach with funding and knowledge. This strategy, on the other hand, also bears several advantages for the companies to tackle their most urgent future challenges jointly. For example, The Guardian is stating that in the close future hundreds of oil rigs and thousands of kilometres of pipelines need to be decommissioned (Jack 2017). Cooperation will therefore drastically cut costs, companies are from the beginning involved in the strategy and can invest into low-carbon technologies. For example, BASF one of the major players in the petrochemical industry could invest into infrastructure and technology to base their production of goods on carbon dioxide instead of on the use of crude oil. This process would reinforce cooperation among actors of the private and public fields as it would secure the generation of jobs and social wealth.

Nevertheless, some future brownfields, like refineries and oil terminals in harbours need to be transformed and reused in a certain way. These zones give potential space for growing industries in the renewable and carbon sector in order not to further thread the environment and lower the terrestrial biocapacity. Areas, like the oil terminals of harbours already have good infrastructural connections and a building stock that can be reused. In a later stage of the project, I use the oil harbour of Aberdeen as a showcase on how this future terrestrial brownfield could transform.

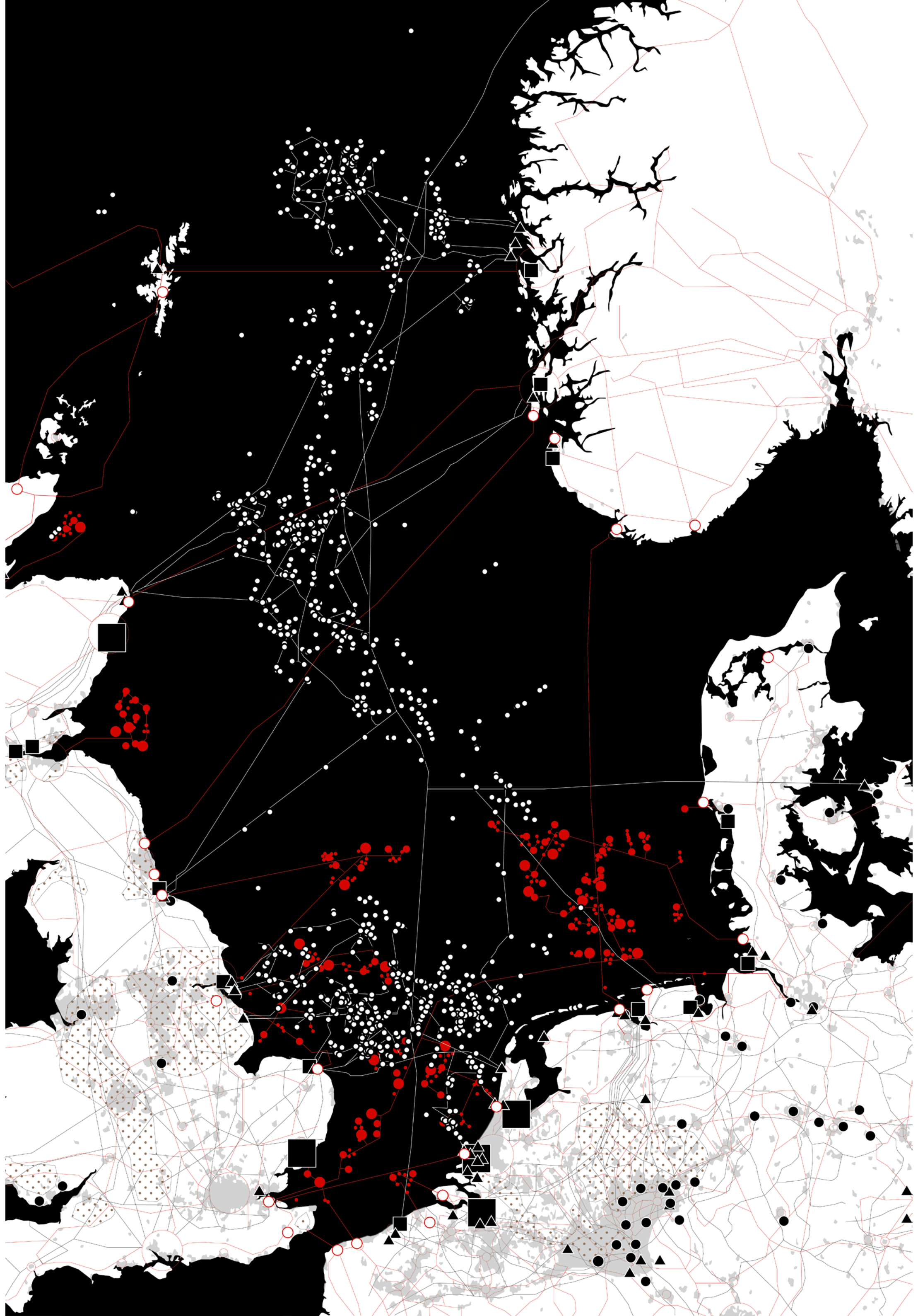


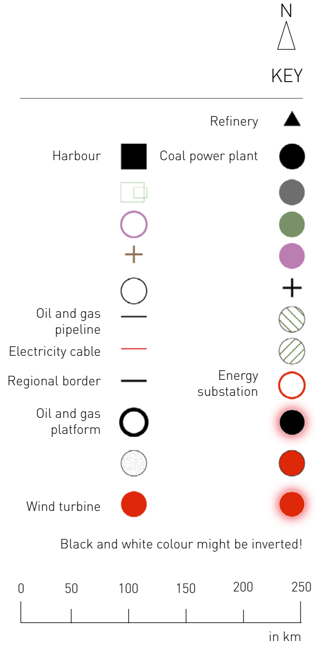
Summary: The low-carbon belt

The function and form of the low-carbon belt varies depending on the kind of energy region, which is based on the natural potential pf renewable energy and the artefacts of the energy legacy. The belt entails a number of future brownfields, which will be transformed according to the logics of the energy region. The overall aims are to develop R&D clusters through the pooling of research institutions and the creation of knowledge-intense industries. This kind of new industries are based on manufacturing and the development of technologies regarding renewable energy and to use carbon dioxide as a resource in order to diversify the industrial sectors, which are based on crude oil and gas.

The hierarchy of cities is based on the number of infrastructural connections and the number of brownfields. The biggest nodes carry the highest increase of population regarding the challenge to accomodate the growth in a sustainable way.

Phasing, Current situation





PHASING

Phase 0: The Energetic Legacy

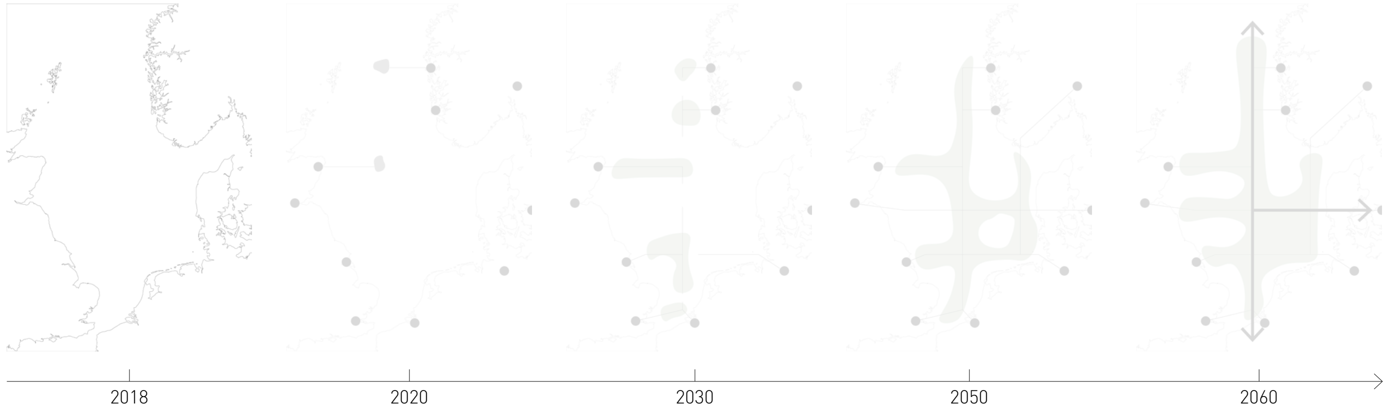
Phase 0 of the project is equal to the current situation, like it is described in the energetic legacy. The North Sea is still a space of resource and energy extraction by exploiting oil and gas resources. Refineries and oil terminals are processing crude oil and gas, which has a strong impact on the national export and import rates. The terrestrial zone is heavily relying on the oil and gas resources from the North Sea and from oil exports from outside Europe. Big chemical clusters in Germany, in the Netherlands and in the U.K. produce fuels, plastics and cosmetics and contribute a lot to the prosperity and wealth of the countries.

At the same time, wind energy is the growing producer for electricity in the North Sea territory since offshore wind power can generate three times as much electricity as onshore facilities (GENI). The adjacent countries invest a lot in R&D of wind power, especially Germany and the United Kingdome already harvest a considerable amount of electricity from renewable wind resources (Frauenhofer ISE). The major problem regarding wind energy, the variations in power generation, does not have a heavy impact yet on the territorial energy supply, since electricity is still produced by other sources, like coal and radiation.

Norway and the U.K. work on strategies how to decommission in the future depleted oil platforms and pipelines. The consuming countries of oil and gas need to search for alternative ways on how to secure the energy supply, prosperity and wealth in the future of their nations.

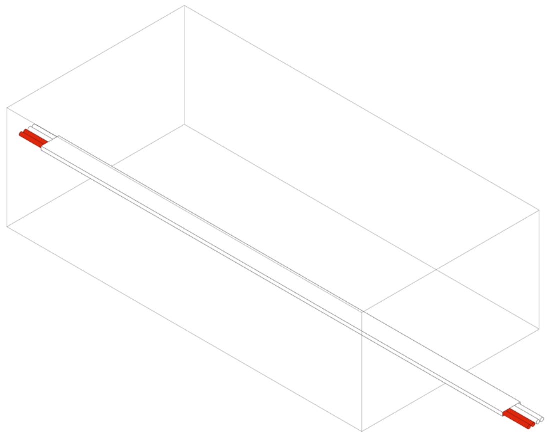
This urgent topic of the energy transition is already on the political agenda. The European climate targets will be failed most likely due to high greenhouse emissions (European Environmental Agency 2017), which fosters discussions and research in the spheres of carbon capture and storage as well as the use of carbon dioxide as a resource. The North Sea commission, one of the six commission for periphery marine areas in Europe, is currently working on key elements and the implementation of a North Sea macro-region to target 'Marine resources', 'Energy and climate change' and 'Attractive and sustainable communities' (CPMR 2016). These first development ideas of a joint strategy for all stakeholders related to the energy sector in the North Sea territory might eventually lead to cooperation and the development of a join strategy.

The following pages show the ideal process of the project, from the extractive seascape towards a territorial system of collaboration. The energy system will grow dynamicly and will respond to uncertain trends, like politic occasions, new technologies or sudden changes in the economic situation.
To guide the development, I defined 4 general rules of growth. The phases will show the ideal development of the strategies followed by 2 scenarios that deal with uncertain trends the adaptive capacity of the system.

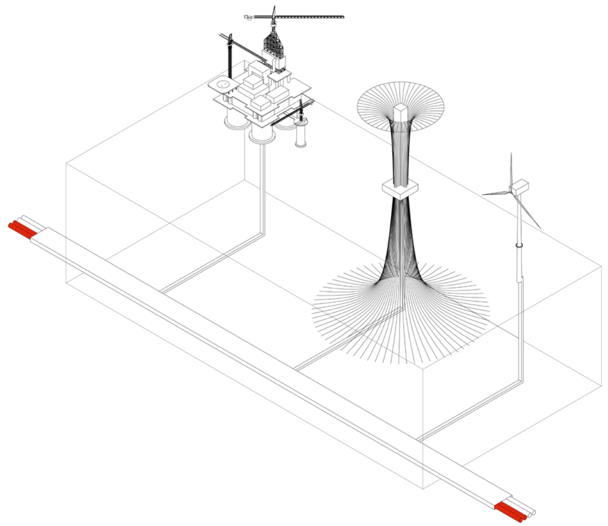


General growth principles

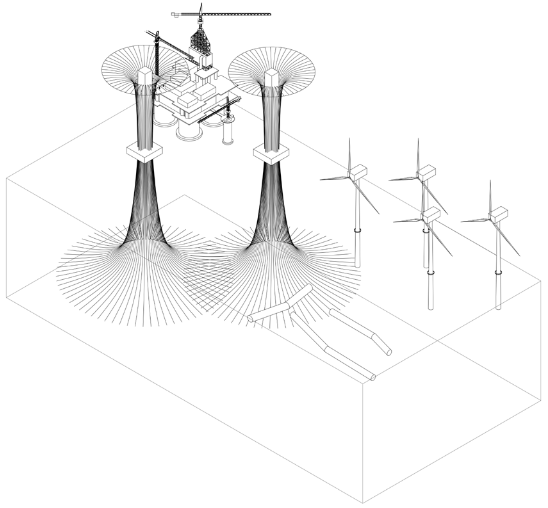
The following pages show the ideal process of the project, from the extractive seascape towards a territorial system of collaboration. The energy system will grow dynamicly and will respond to uncertain trends, like politic occasions, new technologies or sudden changes in the economic situation.
To guide the development, I defined 4 general rules of growth. The phases will show the ideal development of the strategies followed by 2 scenarios that deal with uncertain trends the adaptive capacity of the system.



Principle 1: Reusing
The aim is to reuse existing pipelines for the transportation of carbon dioxide. New cable infrastructure develops along these existing structures. New cables or pipes develop parallel. Different funding sources exist: National states, European Union and private cooperation.

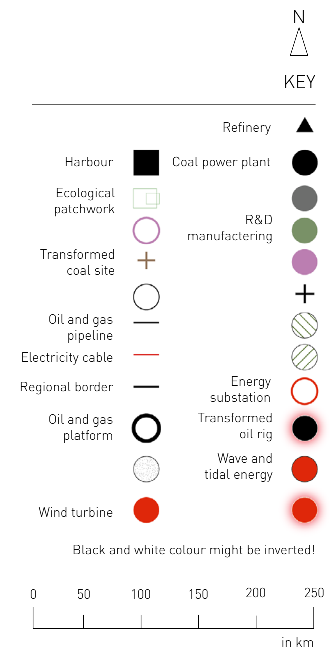


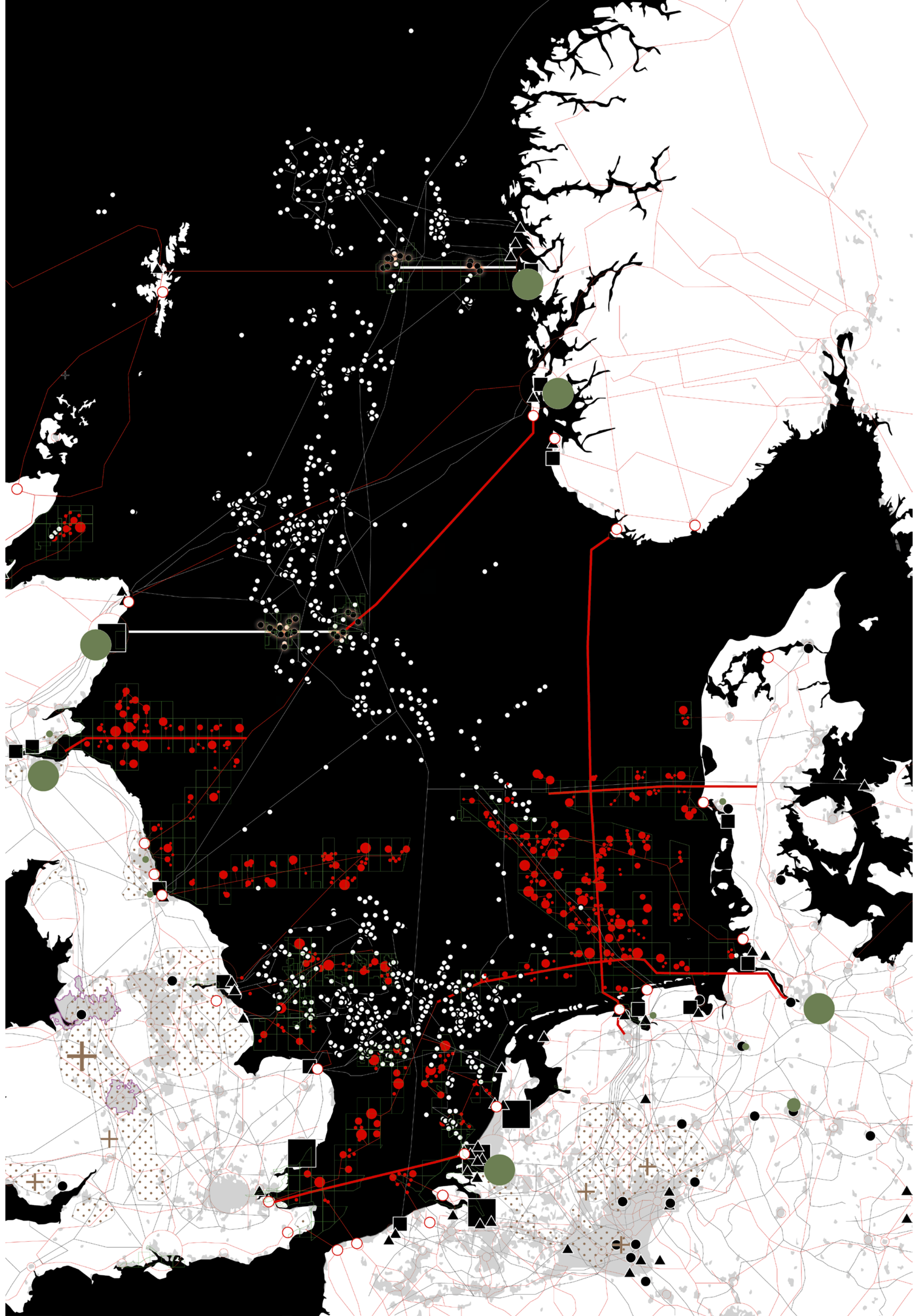
Principle 2: Plugin
Energy artefacts can plug in to the existing or new cable and pipeline infrastructure. These artefacts can be funded by any private or public institution. Certain environmental regulations need to be followed regarding artificial reefs and algae cultivation.



Principle 3: Pooling
Energy artefacts are pooling in certain areas depending on the natural circumstances of an area or the remains of the energy legacy in order to increase the productivity. Furthermore, the aim is to create a strong R&D sector. The sites will therefore be used as experimental ground for new technologies and innovation within a specific frame of renewable energy production.

Phasing, Situation until 2020



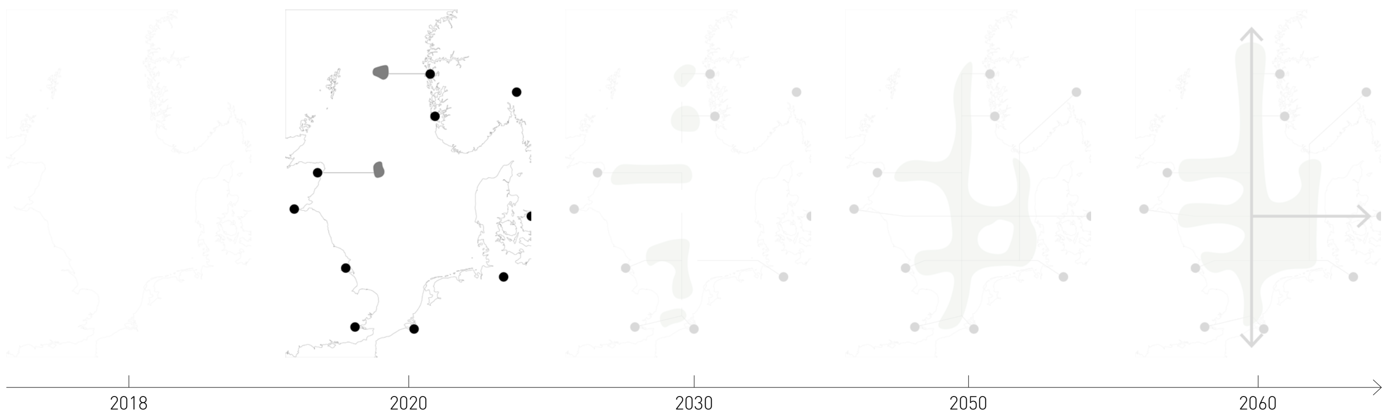


Phase 1: Response to national needs and first showcase projects

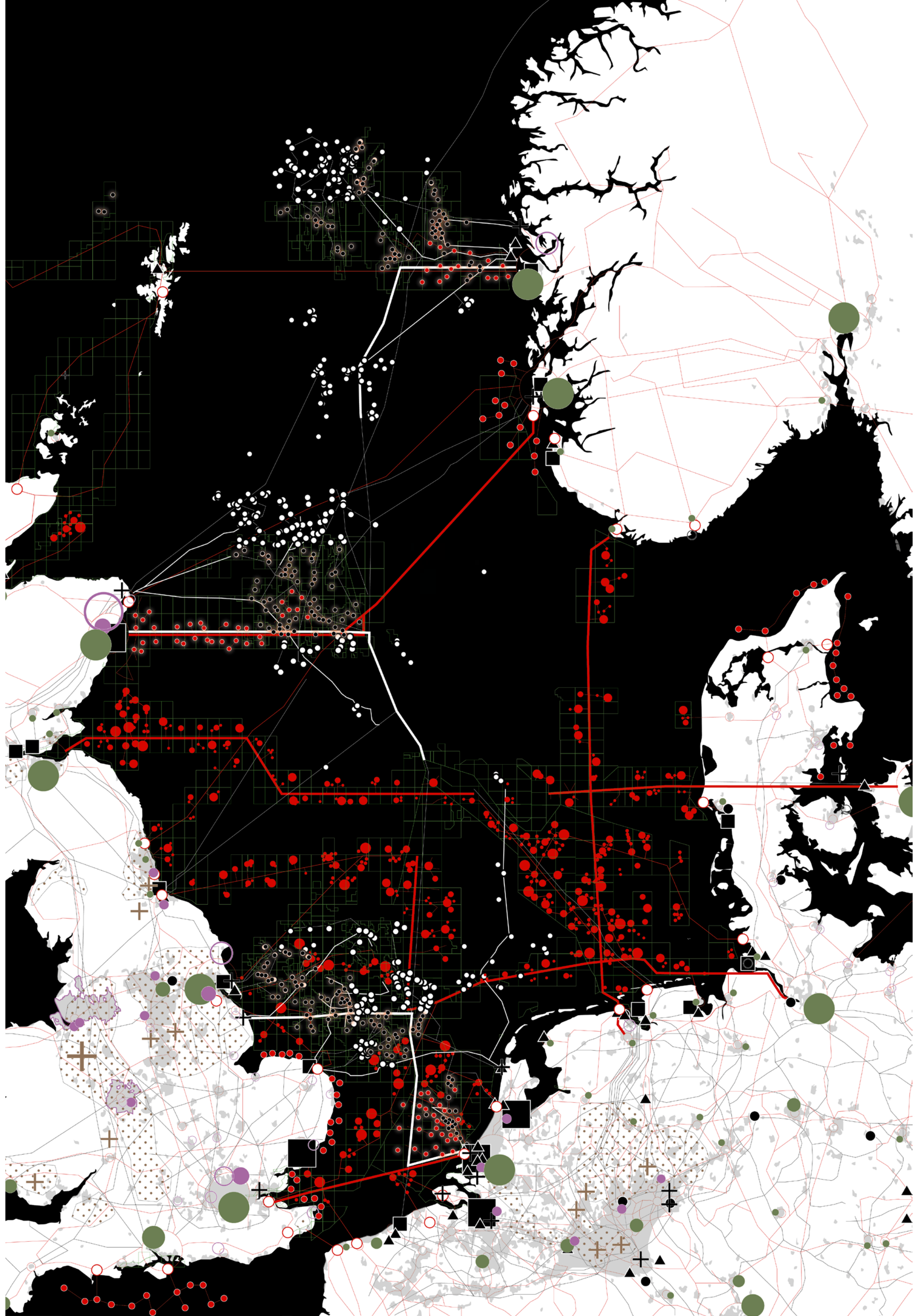
Phase 1 is describing the most recent period until 2020, the year of evaluation if the European Union achieved the climate and energy goals for the year 2020 (European Environment Agency 2017). The development of a macro-region in the North Sea territory will have a high politic priority, since the North Sea might contribute a lot in order to achieve the climate and energy goals for 2030. Among others, the aims are to decrease the greenhouse gas emissions in comparison to 1990 by 40% and to increase the electricity generation from renewable sources by 27% (European Commission 2018a). A North Sea strategy would eventually support these goals by enabling the member states to efficiently decrease CO2 emissions from industries and the atmosphere and by supporting the implementation of different renewable energy sources in the North Sea marine area.

In that stage, the North Sea Commission acts as a moderator to involve major stakeholders from the public and private fields into the development of a macro-regional strategy. Industries from the fossil energy sectors, like Shell and BP, might be as interested into a joint strategy as companies from the renewable energy sector, like Vattenfall and EON. Research institutions are closely involved to foster innovation in the energy sector regarding the huge technological affordances to implement the proposed new system. The motivation for national states, regions and municipalities derives from the role that they play in the current energy system. Nevertheless, all of these actors need change from fossil resource producers or consumers towards alternative ways to produce energy and to create prosperity and social wealth.

Interventions at this early stage are on the one hand aiming to respond to the national energy demand since all adjacent countries still follow their national agenda to produce or export energy and resources. The national states are investing in offshore wind energy and they start to decrease the amount of electricity produced by coal power plants.
On the other hand, the carbon regions in Aberdeen and Norway already start with first showcase and experimental projects to accelerate the process of a CO2 exchange grid development in the later phases of the project.



Phasing, Situation until 2030



N

KEY

Refinery
Harbour
Coal power plant
Ecological patchwork
Protein and fuel
R&D manufacturing
Transformed business
Transformed coal site
Transformed terminal
Transformed refinery
Oil and gas pipeline
Electricity cable
Energy substation
Oil and gas platform
Transformed oil rig
Wave and tidal energy
Wind turbine
Energy through carbon

Black and white colour might be inverted!

0 50 100 150 200 250
in km

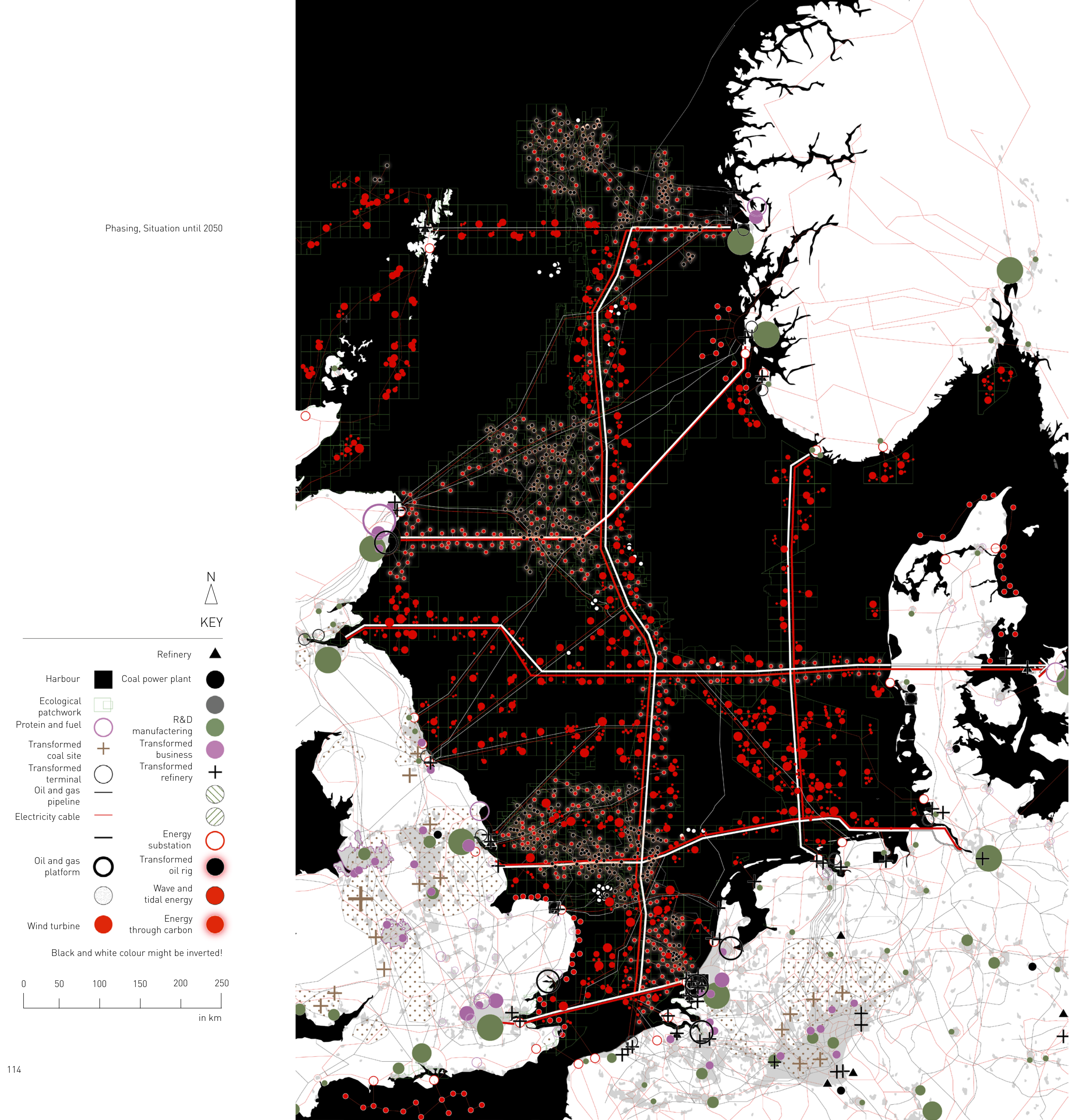
Phase 2: Towards national cooperation

Phase 2 starts with the official foundation of the North Sea macro-region. This instrument of the European Union provides a platform for all involved stakeholders to share experience throughout all project circles and is a potential source of funding. The macro-region is divided in smaller energy regions to accelerate decision-making with the involved regions and municipalities and to adapt easier to uncertain changes and challenges. The macro-region provides a framework and spatial guidelines, where each single energy region has the freedom for individual development.

The energy regions build furthermore areas of expertise in their own field and are responsible for the pooling of R&D within their area. With the establishment of the energy regions comes also a first attempt of alternative renewable energy sources in addition to wind energy, which depend on the overall regional type of energy production. Carbon regions for example produce electricity and fuel through the use of CO2 while hydro regions produce electricity through the motions of waves. In order to unlock the whole potential of the new energy system, all regions start to build infrastructure towards the joint vision of the resource and electricity exchange grid. Existing pipelines, platforms and cables are integrated in order to cut costs of new infrastructural elements and to reduce costs of decommissioning energetic artefacts. Neighbouring countries and regions start to share electricity and resources to ensure greater security of renewable energy supply and to start the establishment of new industrial clusters.

Funding for this whole process should derive first from national states and regions, since this system of reducing CO2 through storage and reuse would contribute a lot to the European climate goals in 2030. The macro region as a platform could in this respect diversify and enrich the funding sources by attracting major private players of the energy sector. An additional way of funding could be an advanced form of the existing European and national CO2 taxation systems. These taxis could be used to build the infrastructure for CO2 exchange, which could transform later into the already proposed CO2 welfare model. The former consuming stakeholders of oil and gas and strongest CO2 emitters could invest in such an exchange system in order to receive financial revenue as soon as the greenhouse gas can be used efficiently as a resource.

Phasing, Situation until 2050

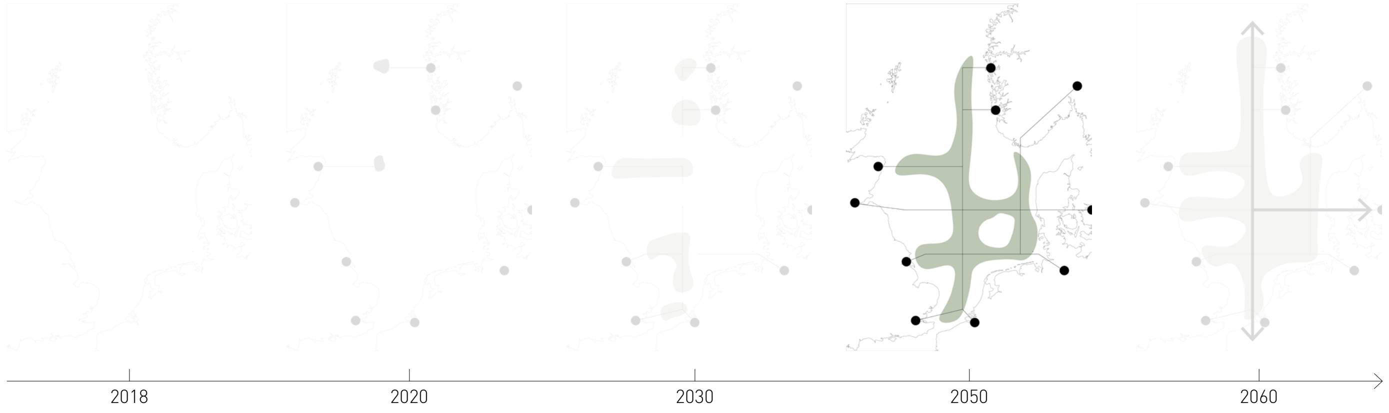


Phase 3: Shared power and resources among the North Sea countries

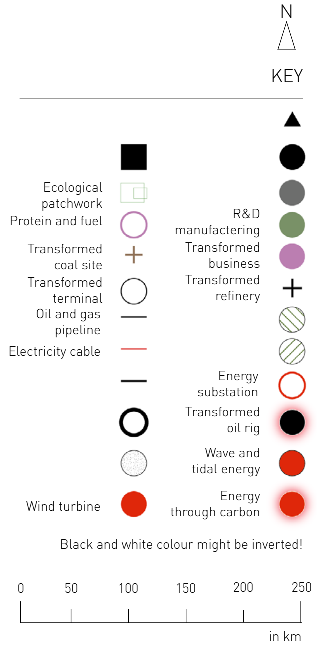
The third phase is aiming to develop the exchange grid among the neighbouring countries of the North Sea territory to its full extent towards 2050. In this year, the European Union set the goals to decrease greenhouse gas emissions by 90% in comparison to 1990 and to turn Europe into a low-carbon economy (European Commission 2018b). The exchange grid will support these aims by establishing an efficient network, that is harvesting CO2 in the whole North Sea territory, which is consumed by the objects in the sea and in the carbon regions in order to produce electricity, fuel and other goods. The carbon-producing countries gain financial revenue through the established welfare system.

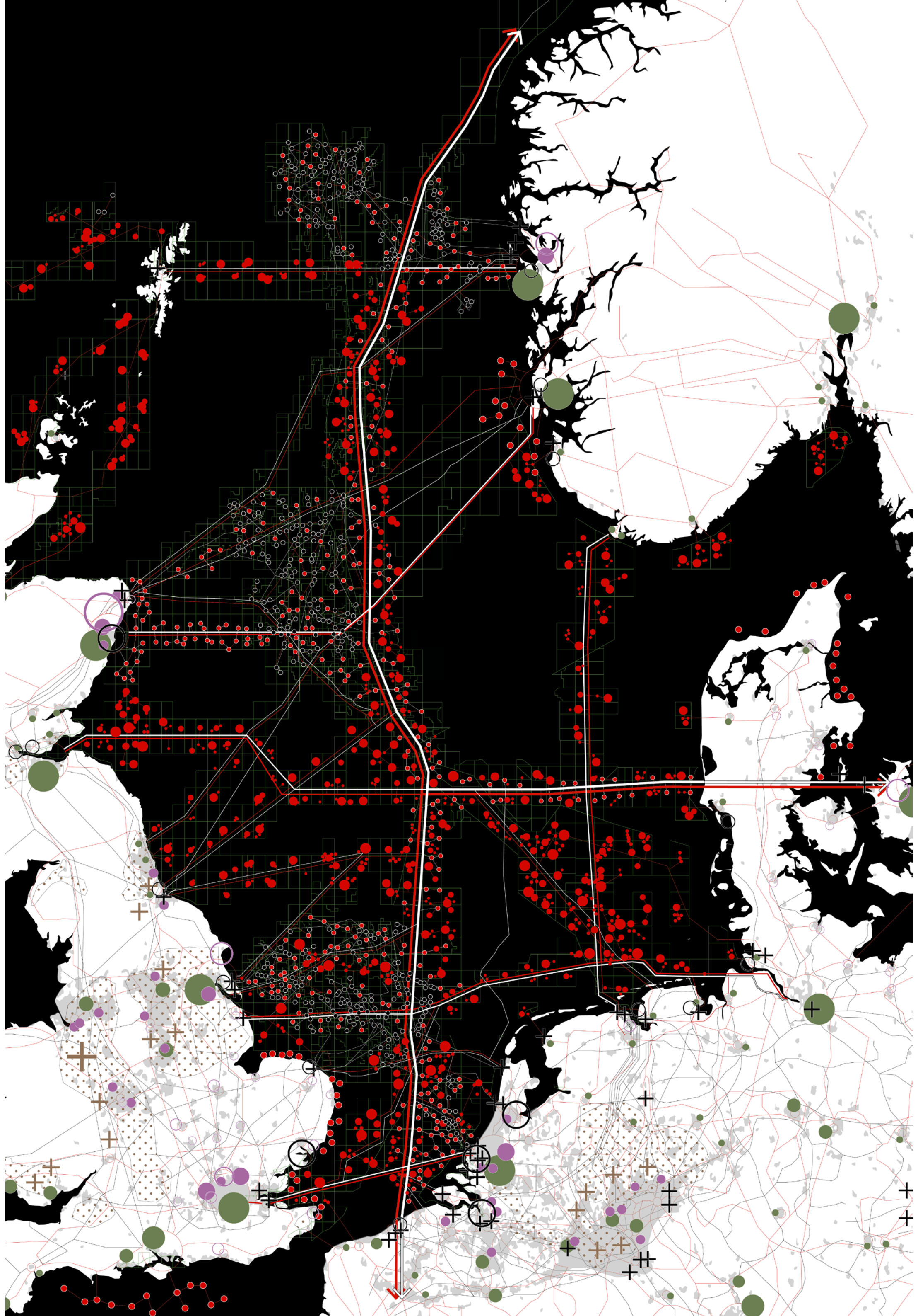
Wind farms and alternative ways of electricity production are established in close proximity to 'the line' to secure the energy supply for the whole North Sea territory. The ecologic reserves in the sea are linked with each other through energy-producing objects in the sea, that act as artificial reefs. The fishing industry can use these grounds for monitored fishing and the extended ecologic habitats are turning into a space with public and recreational functions.

The low-carbon belt is in this phase almost completely developed, which means that the majority of brownfields transformed into new spaces to accommodate urban growth and to secure economic prosperity and social wealth. Research and development clusters in each region foster the growth of new industrial clusters and new manufacturers depending on the expertise of each region. For example, the wind regions might be able through research to introduce new high voltage energy production facilities. Carbon regions could produce goods out of CO2, like buildings materials, cosmetics and plastics.



Phasing, Situation until 2060



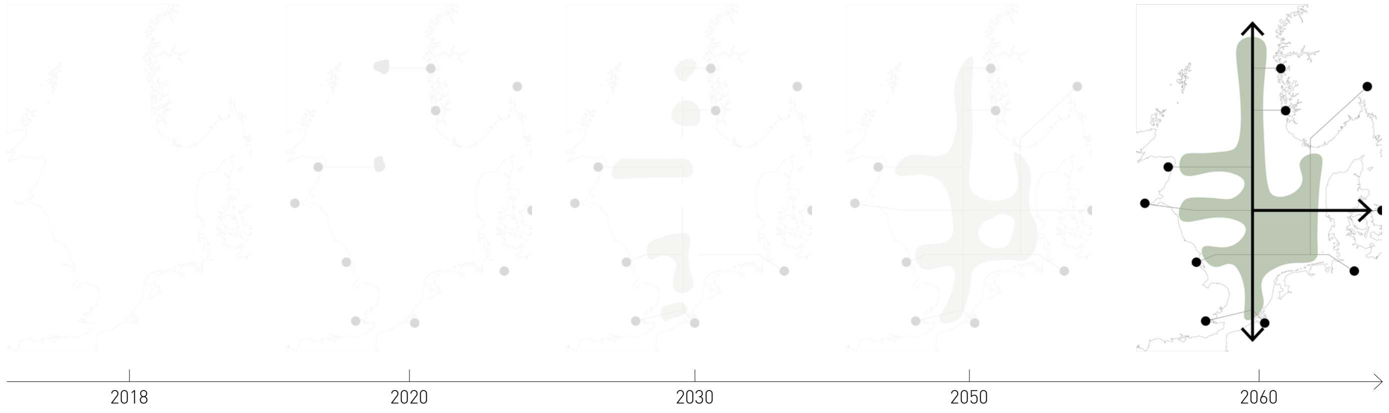


Phase 4: Collaboration beyond the borders

The age beyond 2050 is bears the potential to link the North Sea exchange grid to the remaining European member states and even beyond the European borders to ensure the energy supply for other countries as well as to link the carbon-consuming regions of the North Sea to other big emission areas.

Since wind energy in the future eventually will produce a big surplus, it might be an advantage to export the energy along the new developed infrastructure lines. In times of energy shortage, renewable energies could be imported. For example, a circular exchange system with the south enable the actors in the North Sea territory to export the surplus of wind energy in winter and to import solar energy from southern Europe or Africa in summer.
Connecting the carbon grid to other big CO2 emitters would increase the amount of carbon that the carbon regions could process as a resource. The North Sea has furthermore the advantage, that its oil and gas sites are located in the sea basin, which bears less risk in term of resource storage and extraction for the urban areas.

Another potential source of revenue is the export of knowledge and technologies across the borders of the North Sea. For example, China is mining minerals which are necessary to create different renewable technologies but is lacking knowledge and technology (OMA Roadmap 2050). Collaboration in the R&D sector might be therefore beneficial for both sides.



Brexit scenario: a territorial energy system of collaboration without the U.K.

N

KEY

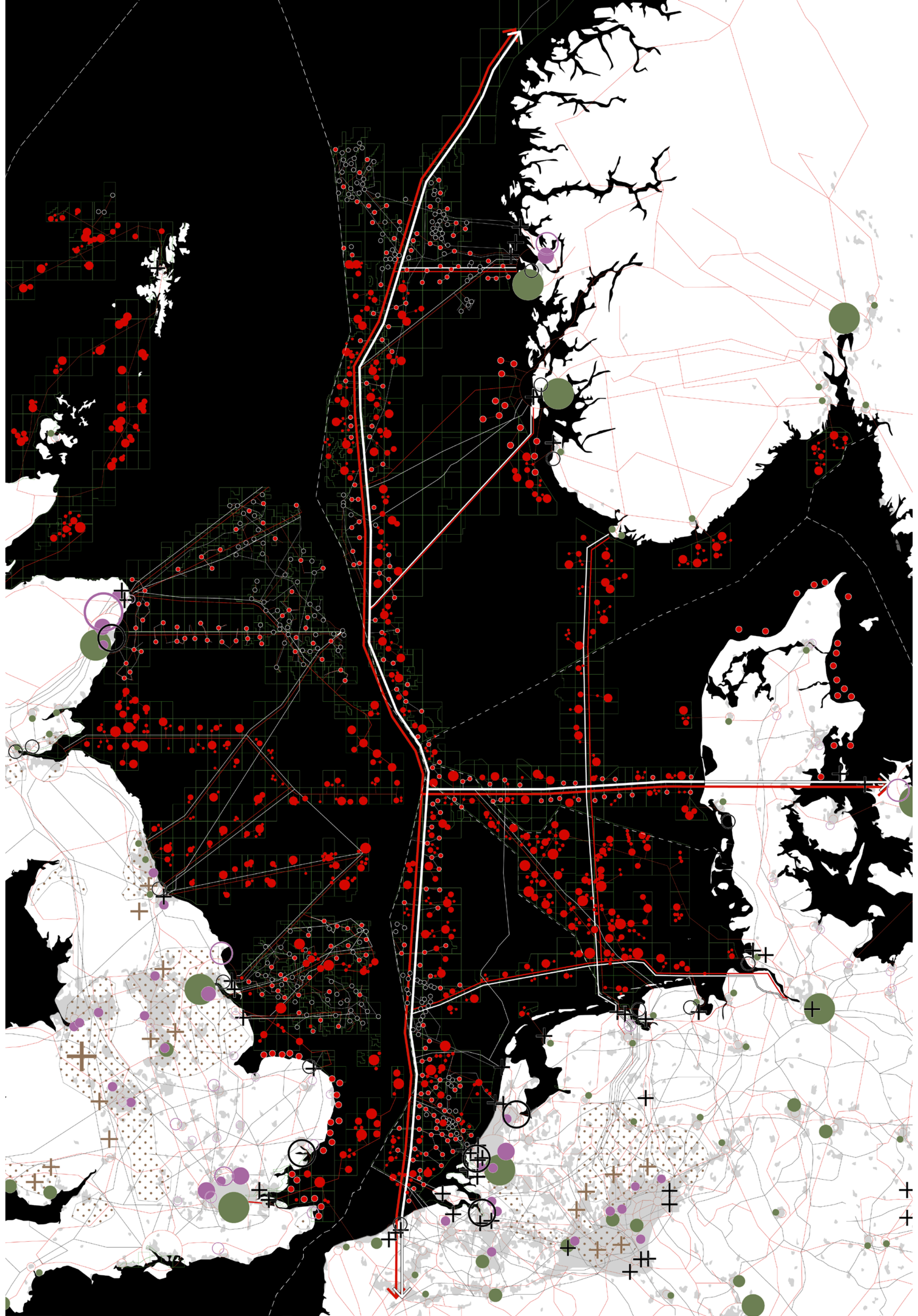
Ecological patchwork
Protein and fuel
Transformed coal site
Transformed terminal
Oil and gas pipeline
Electricity cable
Wind turbine

R&D manufacturering
Transformed business
Transformed refinery
Transformed oil rig
Wave and tidal energy
Energy through carbon

Black and white colour might be inverted!

0 50 100 150 200 250

in km



Politic complexity: The Brexit

This project is facing uncertainty in different spheres, such as the politic dimension. Politic decisions will be an important point of consideration because this project involves 6 national states, each with numerous regions and municipalities.
I took the Brexit as an example to highlight the dynamic nature of the energy system and 'the line'. The future energy system is not a static system that necessarily needs to develop like I introduced in the phasing. The phasing rather shows an ideal process of growth towards a low-carbon future according to the general principles of growth that I defined.

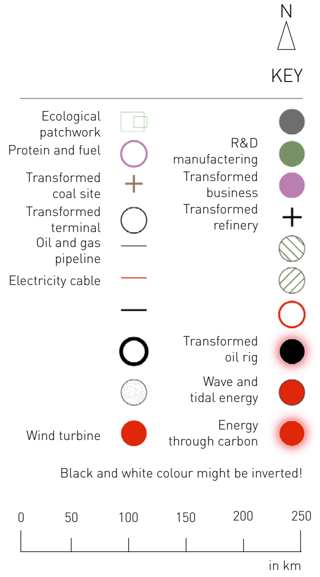
The map is showing a scenario where the line is still the central element in the North Sea but with a detached British energy system.
In 2016, about 60% of the British citizens voted for leaving the EU. Since I work in my project with the concept of a European macro-region, a planning instrument of the EU, I want to shed some light on the question how the strategy might work without the U.K. as an actor.

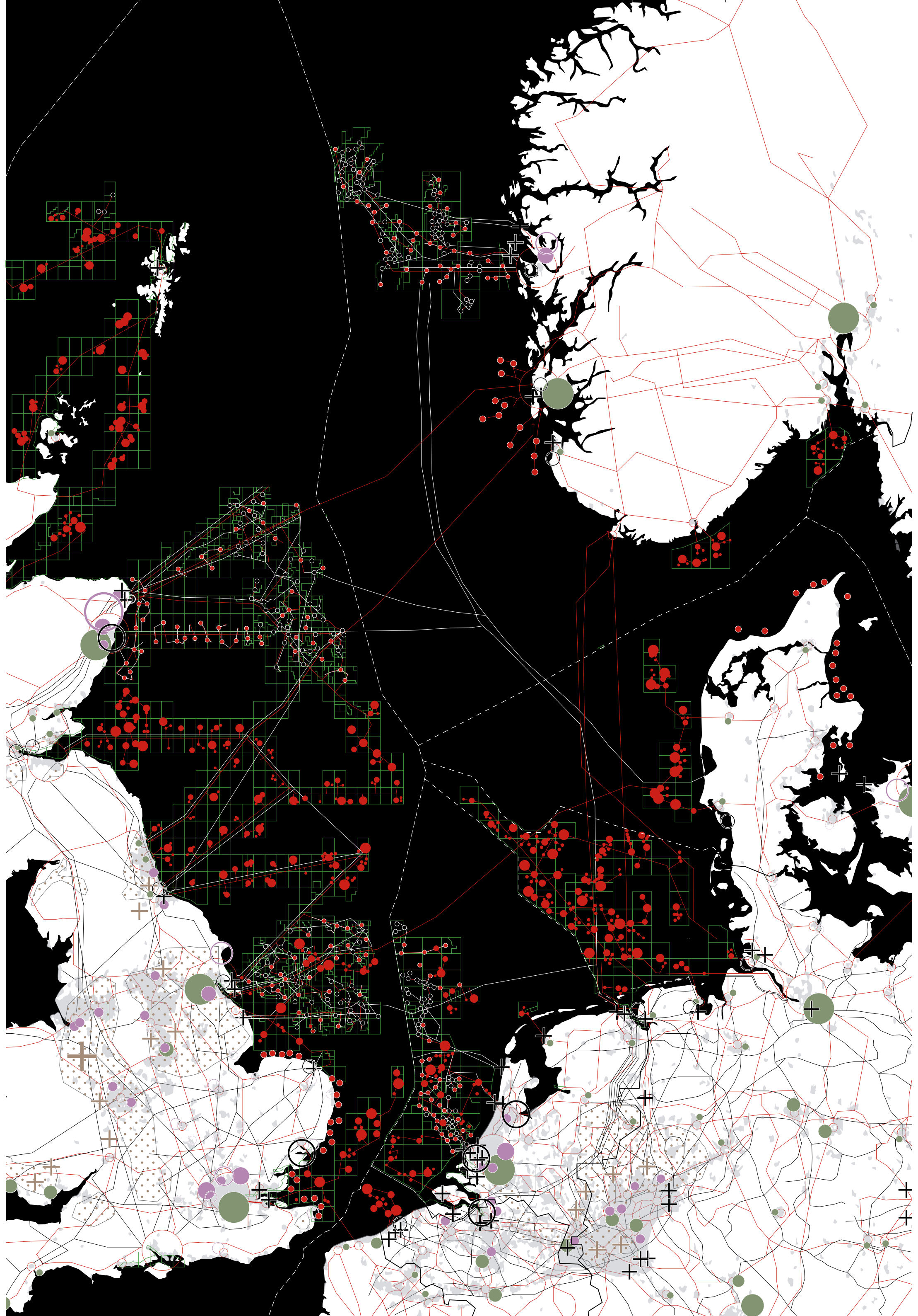
The central element of pipelines and cables is still existing, because the remaining 5 nation states are cooperating, and states do not have sovereign rights in managing the pipeline and cable infrastructure in their EEZ. On the other hand, the energy objects accumulate outside the British EEZ because the energy extraction is the sovereign right of each nation according to contemporary law (Barry et al. 2006).

In this scenario, Great Britain is focussing especially on electricity generation through wind energy and carbon storage in the Aberdeen region and adjacent to Hull. Great Britain would face the problem to be still dependent on energy exports because of the variations in wind energy generation and the parallel exit from coal mining as a fossil energy resource. It is furthermore unlikely that it is economic feasible to invest into carbon utilization without the carbon imports from the other nation states because investments in cables and pipes will be eventually the most expensive interventions in the strategy. Instead, the U.K. might use the existing oil and gas infrastructure to simply store the carbon dioxide in the vacant carbon storage sites.

DPA, Der Spiegel, Brexit Gegner in London, http://www.spiegel.de/politik/ausland/bild-1214412-1304741.html

No collaboration as a scenario: What would be the effects to deal with the energy transition individually on the national level?





AN UNCERTAIN DEVELOPMENT

The neccessity for collaboration

With this scenario I want to shed some light on the question what the results would be of individual, national, strategies instead of the proposed joint strategy to deal with the energy transition.

The map is showing a potential use of renewable electricity sources by each country. Germany is currently heavily investing into wind energy technologies and will most likely proceed in the close future. Belgium will also increase the share in wind energy since they plan to double the amount of power generation through offshore wind after the nuclear power exit (Staff 2018). The United Kingdom and the Netherlands might focus on a mixture of electricity generation through wind and fuel production by utilizing carbon. Norway, on the other hand, invests hardly into wind energy because they already produce the majority of their electricity demand through water power. Denmark is producing electricity through wind and in addition through alternative technologies like biomass because the natural conditions of shallow water with a comparably high temperature support the growth of Algae.

On the one hand, I assume it is feasible that each country can cover its electricity demand through different sources at the long term. Dirk Sijmons stated in his *'An Energetic Odyssey'* that this could be achieved through a patchwork of diverse energy sources in addition to a high share in renewable wind energy (IABR 2016).
On the other hand, if the nation states are all focussing majorly on the electricity generation through wind, all of them are dependent on energy exports due to the variations in wind energy production. A system of collaboration, as proposed in this thesis, would show alternative ways to generate electricity through carbon utilization and would secure the energy supply by introducing a centralised exchange grid. Furthermore, a pooling of research among all actors in the North Sea territory could improve innovation at the same level of costs to introduce new technologies and ways to generate renewable electricity.

A second point of consideration is the exchange and utilization of carbon to reduce emission and produce renewable fuels. From a technical point of view, collaboration and a joint strategy in pipeline decommission or reuse could cut the costs for companies and nation states enormously. Dealing with the energy transition at the national level would mean that the countries without offshore oil or gas sites need to store carbon in the terrestrial zone, to export carbon to foreign offshore storage sites or that they cannot store their carbon dioxide at all.

"Deployment of CCS will not be optional in implementing the Paris Agreement. Indeed, faster deployment of CCS, particularly in industry, must be an integral part of a strengthened global climate response."
(Dr Fatih Birol)

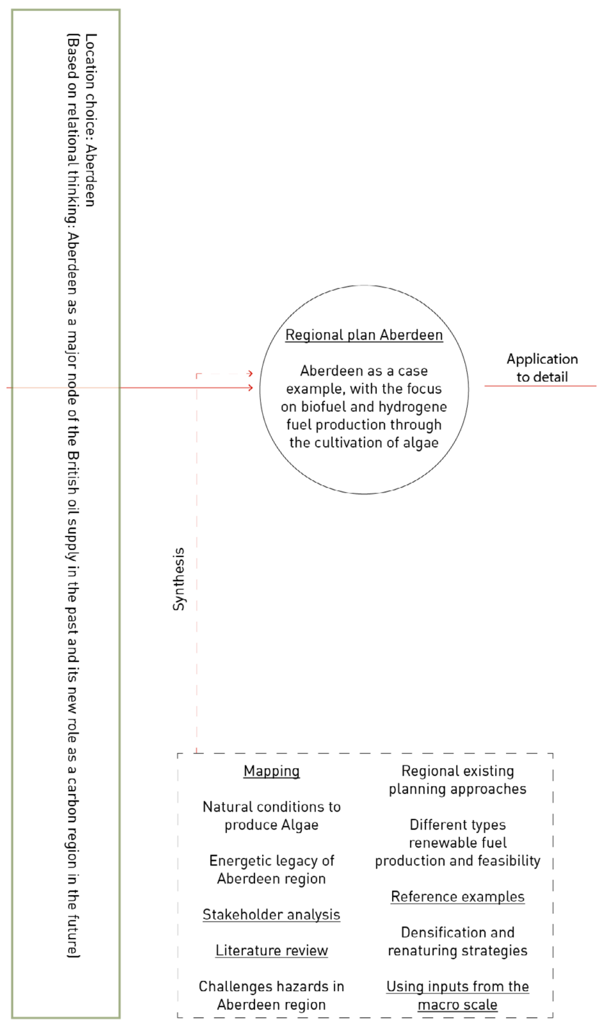
It might not be a problem to individually store carbon or to initiate carbon-export agreements between the nation states. A more critical question is, when the utilization, instead of storage, becomes feasible. I assume that big amounts of carbon as a resource will be needed to make the model profitable. Collaboration among the nation states in the North Sea territory might be therefore the overall requirement to start thinking about such a big infrastructural approach.
Processing huge amounts carbon could bring economic revenue and social wealth to all actors, like I described in the chapter 'A fair division of resources and revenue'.
Earlier, I already described how many thousand tons of carbon each nation is emitting in a year. I took this data (European Commission, Energy Datasets: Eu28 countries, February 2018) and made calculations based on a Swedish case-study (Hansson et al. 2017). In their research they claimed, that 0,21-0.28t of carbon dioxide are necessary to produce an equivalent of 1MWh of electrofuel or 2 MWh of electricity. According to their study, processing 55% of the territorial carbon emissions would cover the entire contemporary energy demand. 20% of the carbon emissions could already provide enough resources to cover the demand of the oil and gas reliant industries.

An additional point of consideration are the environmental assets. In a joint strategy, the infrastructural axis and objects could connect in the long term currently fragmented marine protected zones as it could improve the marine nutrition cycle through algae cultivation. National strategies would leave ecological fragmented zones and the decision making to the national states if and how they want to tackle the environmental threads in the North Sea territory.

Evaluation

Regional strategy for Aberdeen

Meso scale



APPLICATION AND TESTING

3 MESO SCALE

The regional plan for Aberdeen is applying and evaluating the principles and spatial guidelines of the macro scale in the light of regional challenges and trends.

Aberdeen is the current oil and gas capital of the North Sea which leaves space to question the future role of Aberdeen for the North Sea territory and for the United Kingdome.

Aberdeen as the major provider for crude oil in the United Kingdom

N

KEY

Refinery

Harbour

Oil and gas pipeline

Electricity cable

Black and white colour might be inverted!

0 50 100 150 200 250

in km

REGIONAL PLAN

Aberdeen's status quo

Aberdeen is considered the oil capital of Europe since first oil flew in 1969. Since then, the city's population and economy grew strong and a cluster of big oil companies settled in Aberdeen as well as a big number of related industries and research institutions. For example, more than 200 highly specialised subsea companies can be found in Aberdeen, since offshore drilling in the North Sea is one of the biggest drilling challenges in the whole world (Day 2013).

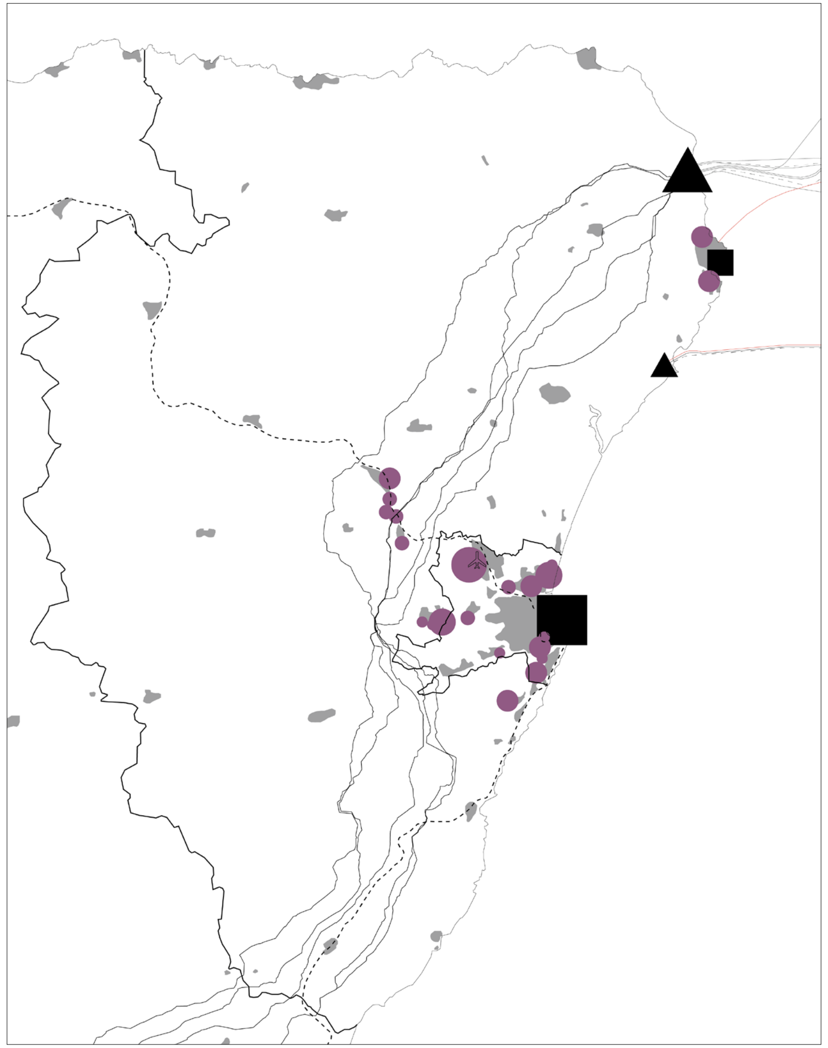
'Tales of oil executives queuing up for food banks or to sell their Rolexes to overwhelmed pawn brokers are breathlessly repeated by cab drivers' (Aberdeen, the granite city in crisis, Ambrose 2016)

The city's dependency on the oil and gas industry had a direct influence on the urban structure and social situation. In the 70th, a big ring of housing was built in the suburbs of the city since a lot of people migrated to the city due to good job opportunities. Even today, Aberdeen has one of the highest employment rates in the U.K. with 97% (Baedeker 2009). Sources regarding the employment rate and social situation are varying. While some sources speak of high employment, others state that hundreds of jobs got recently lost in the British oil industry and in Aberdeen and that the city is facing a crisis (Ambrose 2016).

Aberdeen and the surrounding region Aberdeenshire is nowadays one of the most important oil regions in Great Britain. Next to Peterhead is the largest British oil refinery St. Fergus located, and Aberdeen's oil terminals are the major point of arrival for oil tankers from the northern British oil fields. The oil is transported by several pipelines towards the south, which makes Great Britain highly dependent on the small region of Aberdeenshire. When one of the pipelines broke in 2017, numerous companies were suffering from a cash down for 3 weeks (BBC 2017).

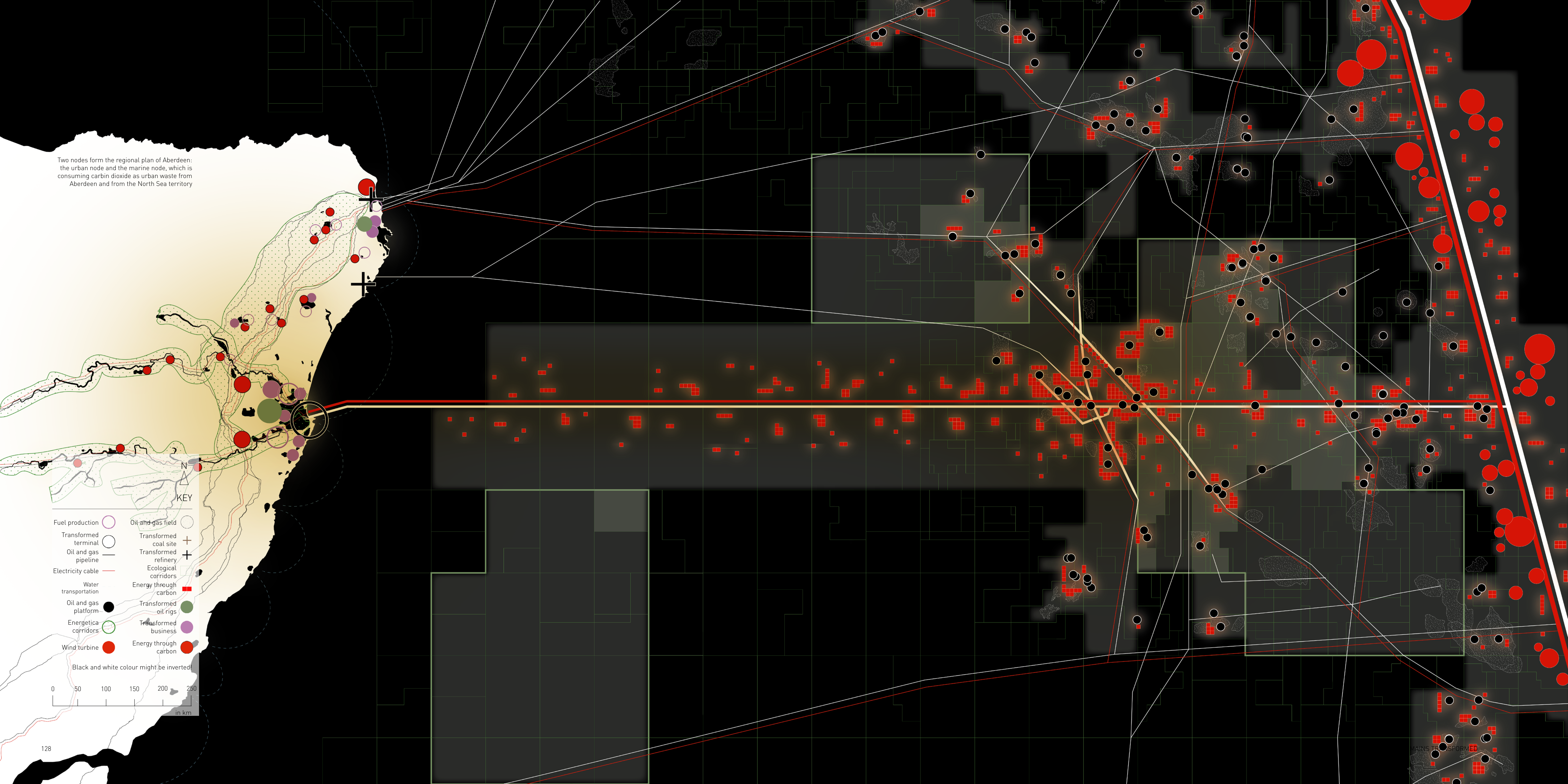
Nevertheless, Aberdeen needs to search and is already searching for alternative solutions. In the past, Aberdeen opened U.K.'s largest hydrogen fuel production and the city developed a vision for hydrogen use towards 2025 (H2 Aberdeen 2015). Another project of interest is the Scottish 'Energetica', an energy corridor that will develop over a length of 30km between Aberdeen and Peterhead (Aberdeenshire council).

Aberdeen is highly relient on the oil and gas industry, stated through the future brownfields: Refineries (triangle), harbours (square) and industrial sites (circle)



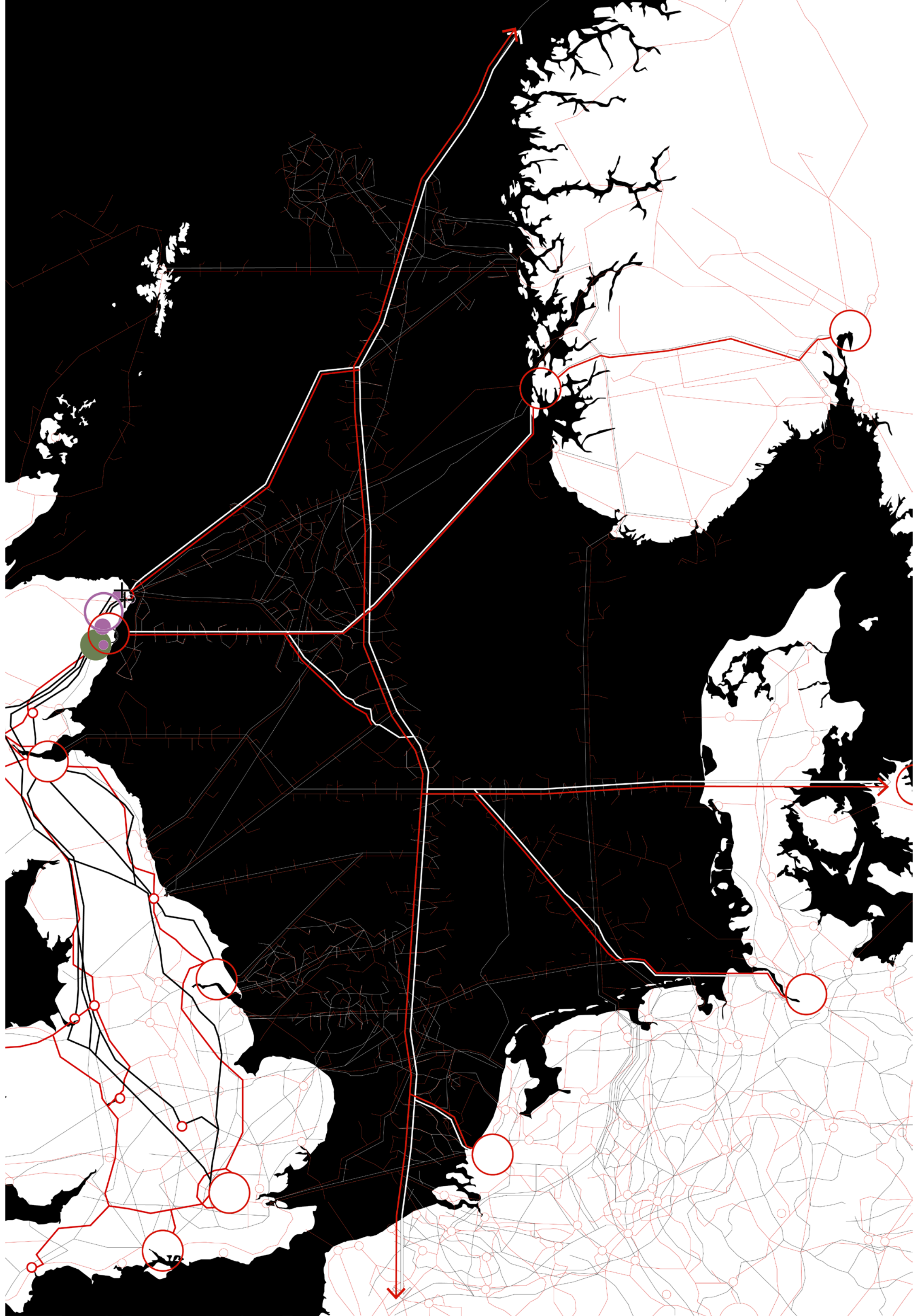
Aberdeens dependency on the oil and gas sector:
A view from a oil terminal towards the city center

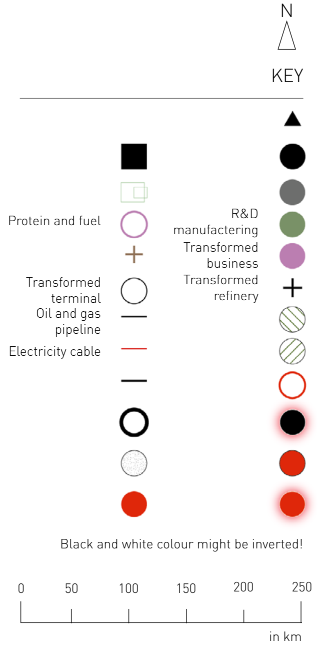
The Independent (8 November 2016), https://www.independent.co.uk/news/business/news/aberdeen-oil-industry-downturn-best-uk-cities-drop-downturn-ranking-scotland-north-sea-oil-a7403676.html



Two nodes form the regional plan of Aberdeen: the urban node and the marine node, which is consuming carbin dioxide as urban waste from Aberdeen and from the North Sea territory

Aberdeen as the major provider for biofuel and electro fuel in the U.K. through the consumption of carbon dioxide





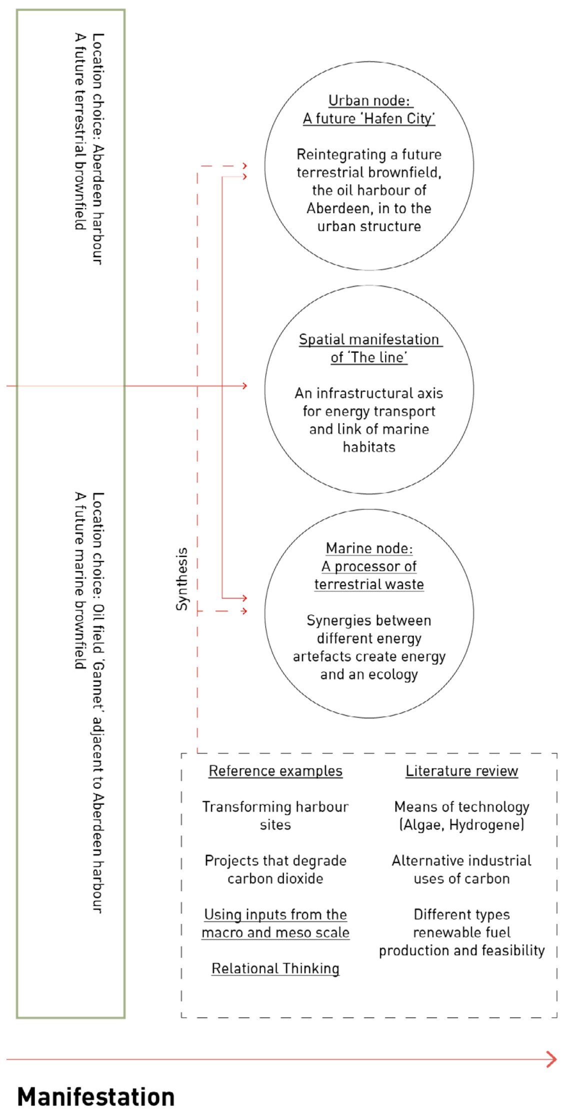
An urban and a marine node

The regional plan was set to apply the spatial guidelines and principles of the macro scale in the light of more particular challenges for Aberdeen and the surrounding region. The major challenges are the strong dependency on the oil and gas industry as well as the polution estimates that Aberdeen will grow by about 20% until 2039 (Aberdeen City Council 2016).
Facing these two challenges, the regional plan for Aberdeen is proposing two nodes, one each in the terrestrial and marine zone. Both nodes are interacting with each other and are jointly using synergies to produce electricity and fuel, to enhance marine and terrestrial biodiversity and to secure the future economic prosperity and social wealth. Both nodes are integrated in the overall system of the resource and electricity exchange grid and function in that respect as a carbon region, that reduce the territorial carbon dioxide footprint.

The urban node is Aberdeen harbour, which is accommodating the major part of the estimated population growth in the territory by reintegrating the harbour as a future brownfield back into the city. The node point is furthermore managing the process of resource and energy flows between the urban node, the marine node and the blue-green corridors of the Energetica.
The Energetica is a concept by the Aberdeen City and Shire Economic Future (ACSEF) who want to transform in cooperation with the Scottish government the Aberdeen city region into a centre for worldwide energy conferences and discussions. They are aiming to create corridors, where major players of different energetic sectors meet, work and create innovation to target jointly the energetic challenges (Aberdeenshire Council 2018). In respect of the function as a carbon region, the 'Energetica' corridors could produce bio fuels through the use of carbon dioxide.
The marine node is as well the consumer of the urban waste product 'carbon dioxide' from the city region of Aberdeen and from the rest of the North Sea territory. Through objects in the sea that use biochemical processes, carbon dioxide is consumed, while electricity, biofuel and electro fuel is produced. The energy and resources are send back to the urban areas. Furthermore, the objects enhance the marine biocapacity and emit oxygen.

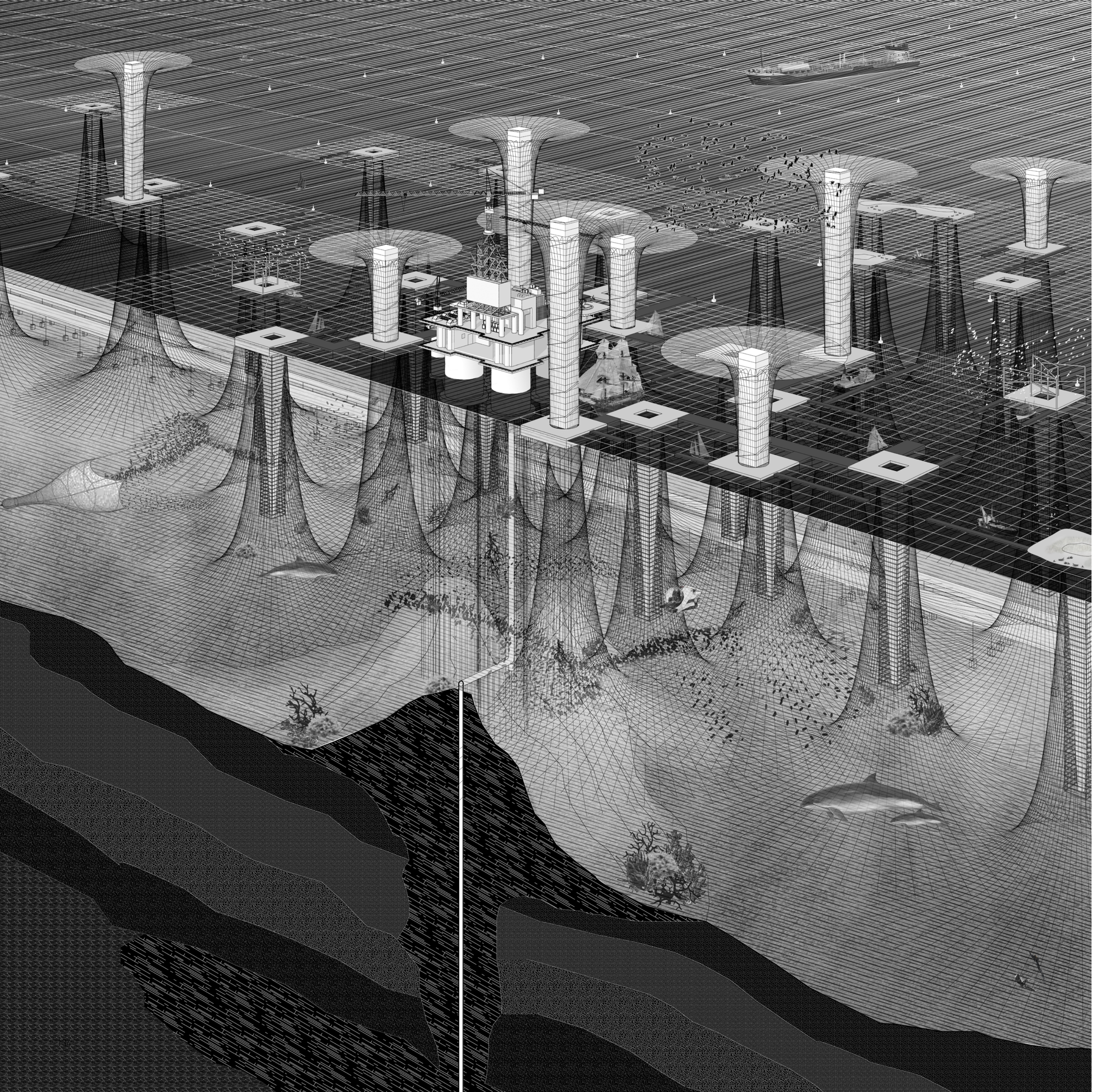
Aberdeen's dualistic character (Urban Design)

Mircro scale



4 MICRO SCALE

The micro-scale is showing the most concrete spatial impacts of my master thesis. I will introduce 3 images that are corresponding with the regional plan: The urban node, a space for urban growth and resource flow management, the marine node, a space for carbon consumption, and a spatial manifestation of the line.



THE MARINE NODE

A space of carbon consumption

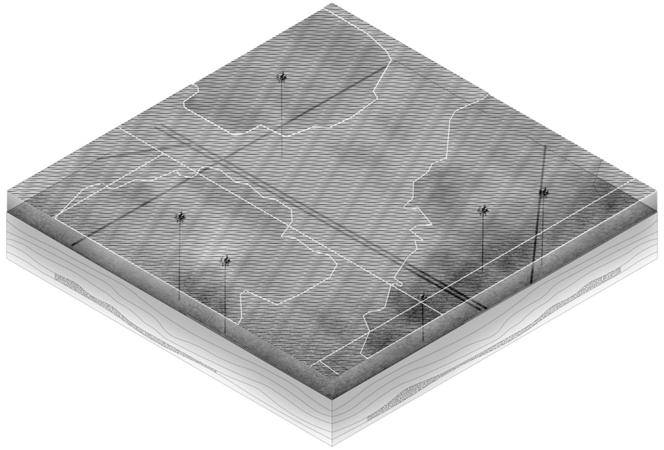
The illustration is showing a part of the Gannet complex, which is laying approximately 180km from Aberdeen's coastline. Royal Dutch Shell and Esso are currently operating there and are extracting oil and gas from 6 fields (Shell 2015). According to Shell, the field still has at least 25% of its original oil and gas capacity (Ibid), but the Scottish oil stock seems to deplete around the year 2030 (PeakOil). The field was first discovered in 1973 and the last satellite field started the extraction in 1999. This field still has a lifespan of about 10 years (Offshore Technology). Nevertheless, the area shows potential for future development since the field is close located to the shore line and several pipelines and platforms build a node.

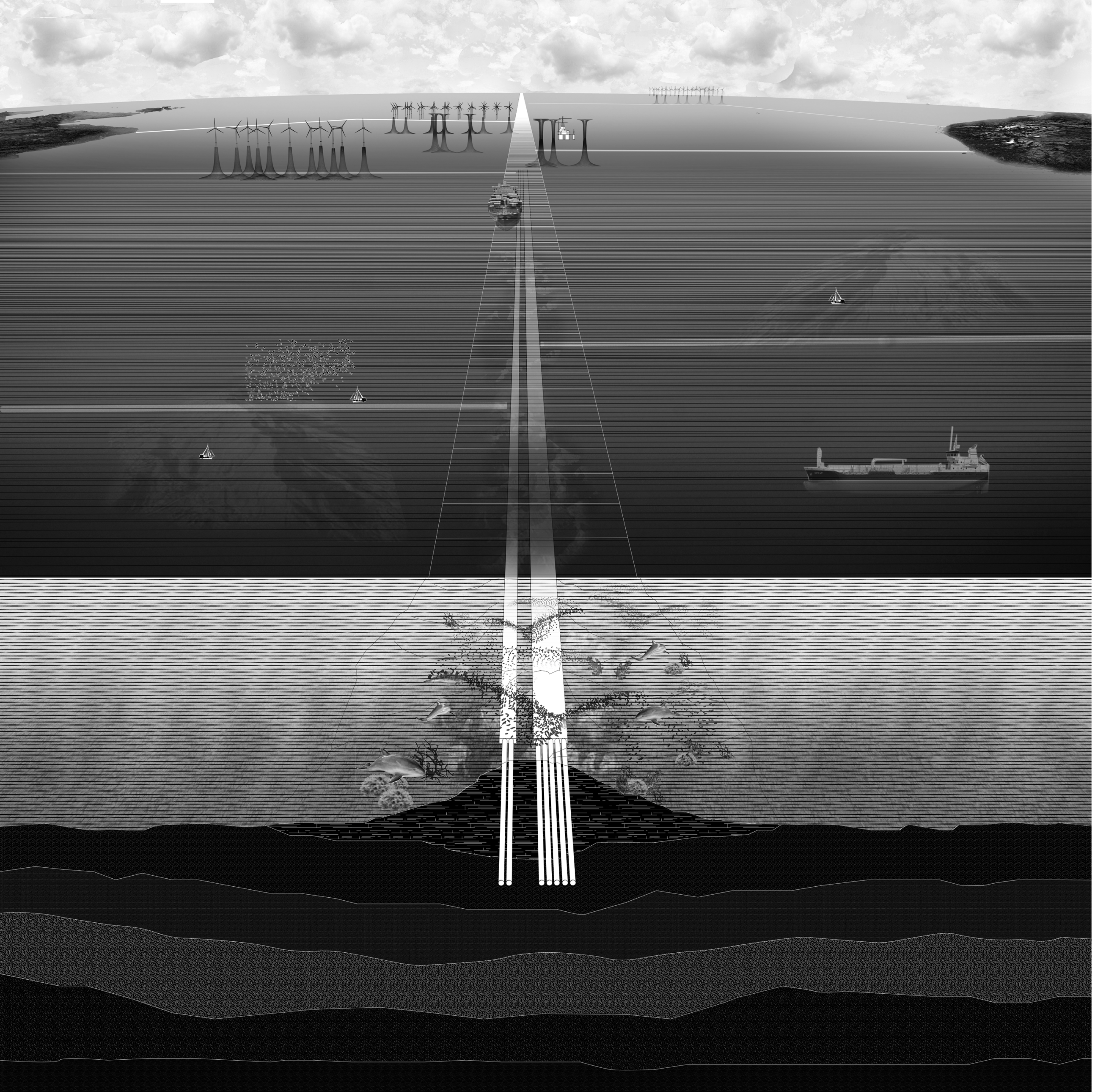
The oil platform is turning into a new centrality both on the surface water and in the sea basin. A new ecology is created through different interventions and synergies between the human and the natural system.

A series of swimming platforms assemble around the oil rig, which can be occupied in different ways. In close proximity to the oil platforms are the algae towers located. They produce electricity and biofuel through different biochemical processes and emit carbon. They can be also potentially used to settle at the sea due to the pressure on the urban areas or as locations for eco-tourism. The pontoons can be furthermore occupied in different ways, for example as docking-stations for ships, as artificial wildlife-islands or as bird-habitat.

The oil platform is building a centrality in the subsea by creating artificial reefs out of limestone. The natural carbon cycle is simulated: Carbon is injected into the ground where it is mixed with water. Over time, the carbon dioxide is turning into a chalky substance and into limestone (Stockton 2016). Shells and sediments are occupying the limestone and form a reef in the former heavily polluted water. Fish and water plants settle in the new marine habitat as soon as the hydro towers started to filter the polluted water and turned it into hydrogen. This habitat gives new opportunities for sustainable and monitored fishing. Cod fish and Herrings are returning since the area is improving the marine nutrition cycle through algae cultivation.

The Gannet complex, 180km from Aberdeen's coast line



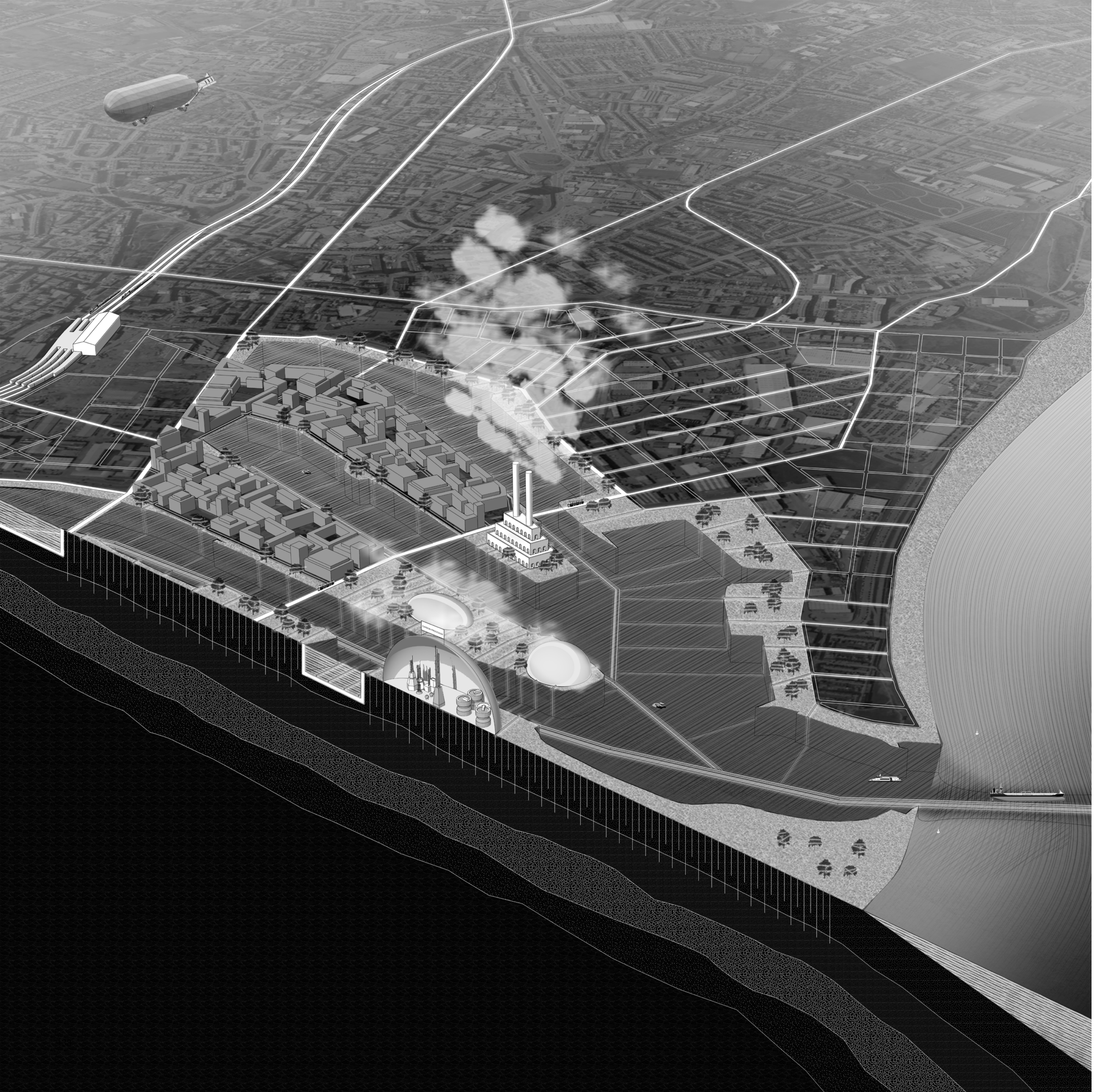


THE LINE

The spatial manifestation of 'the line'

The image shows the spatial manifestation of the line, the central elements in the sea and a symbol of collaboration and cooperation between the actors adjacent to the sea. It as an exchange grid, that transports renewable fuels, electricity and carbon from one energy region to another.
Different components assemble along the line according to the energy region on land. The image is located between the urban node and the marine node in the carbon region of Aberdeen.

The main components are the cables and pipes in the subsea, where the former oil and gas pipelines are reused for transporting carbon dioxide. The pipelines are gradually injecting carbon into the ground, where it is transforming over time in limestone. The line is therefore not just connecting the urban areas in the low-carbon belt but is also linking the former fragmented marine protected areas.
Algae have great conditions to grow in the artificial limestone reefs. They are furthermore most important for the health of the reefs. Certain kind of algae have the ability to cement sand and other sediments and bind it to the surface of the reef. In that way, algae support the reef structure. Algae furthermore are necessary for the marine food chain since they are nutrition for the fish population. Controlled and monitored fishing in these areas is producing food and proteins for the growing population in the North Sea territory.



THE URBAN NODE

A future brownfield

Aberdeen harbour is nowadays one of the major hubs for oil and gas trade in the North Sea territory. A big cluster of industries and logistics developed around the oil terminals. The area is well connected for transportation by rails and by car, but not accessible for the citizens. The harbour is a part of the city but not a part of the city life.

A changing point is not so far away since estimates forecast the depletion of Scottish oil resources for the year 2030 (PeakOil 2014). That means, that a huge part of the city will be a wasteland - in the middle of the city centre adjacent to the main station, the old city centre and the sea.
Aberdeen harbour was not always a zone of exception that was entirely isolated from the rest of the city. The harbour shaped Aberdeen and the node was a vibrant place for trade with wool, wood, fish and agricultural products. Since Medieval times, the port was a major spot of trade with Scandinavia and the Baltics. The fortress and banks were in close proximity to the port (Aberdeen harbour 2018). At a certain point the city stopped to grow when the oil industry was introduced and demanded space for expansion. The declining oil and gas sector can be seen as a change to give this future brownfield back to the city and its citizens.

The harbour area bears excellent opportunities to be reintegrated in the city. The site is adjacent to the central station and the old city and just a few min from the university. In the centre of the proposal is the green heart, which is making the docks complete accessible for the public again. The harbour becomes the new urban centrality of Aberdeen, linking to the cities structure in 3 different ways: Transport Infrastructure, Refunctioning and Reparcellation.

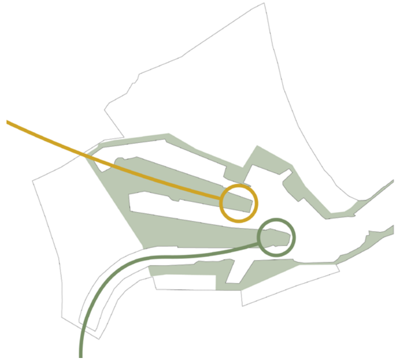
(1) Infrastructure: The main focus is to reintegrate the harbour through infrastructural interventions. A circular street is located around the harbour area and stretches towards the city in all direction. Since Aberdeen had a long traditions with trams before the oil and gas industry entered the city, the tram system is reintroduced along the historical tracks. Partially, the tram lines use the former cargo transport lines of the harbour.

(2) Refunctioning: Two urban anchor points with different themes will be established at the head of the docks: The northern urban dock with a connection to the city centre and the southern green dock connecting to the green spaces along the river.
Both anchors deal with the topics of carbon and infrastructure in different ways. The urban space is a public building, probably of the carbon research directive which is absorbing carbon and emits oxygen through energy generation. The green space is dealing with the topic of pipelines and landart. Different installations showcase the reuse of the pipes. For example, trees and modified absorb carbon dioxide from the air: artificial and natural synergies.

(3) Reparcellation: The future brownfield of the harbour gives the opportunity to introduce dense urban development to the city right next to the central station. Parts of the existing buildings re integrated in the new parcell system. For example, former oil sites, like refineries, are reused for alternative industries that utilize carbon since these sites are already connected to existing pipeline infrastructure.

Reintegration through infrasstructure

Reintegration through functions



Reintegration through density

The harbour as an integrated part of the city, before the oil and gas industry took over, 1892

Source: National Library of Scotland, https://maps.nls.uk/view/82862604

5 CONCLUSIONS

CONCLUSIONS

How is the apparatus of energy infrastructure in the North Sea territory changing towards a prosperous low-carbon future?

'The North Sea made us who we are, so she will determine where we go'
Pye, The Edge of the World

The North Sea played an important role for the development of culture and society, starting with the Romans and lasting until today. The sea turned from a crossroad, into a space of extraction and will eventually transform into a space of collaboration. With these conclusions, I want to highlight certain aspects of my thesis: the urgency of the topic, the necessity to tackle the energy transition on the big scale and the idea of a multifunctional energy system that relies on the legacy of the oil- and gas industry and aims to lower the carbon footprint.

The urgency of the topic

The climate change is the most obvious reason to deal with the energy transition in the North Sea territory. While the hazards and consequences of this topic are broadly researched and part of the public awareness, little research is done so far on the question how these transformative processes through the scales will take place.

I am stating that the key parameters to deal with the transformative processes of the energy transition in the North Sea territory are 'population growth' and 'resource management.'
The urgency of the topic is highlighted by the fact, that the territory is facing rapid population growth until 2080. These predications are very problematic, because a growing population demands an increasing amount of resources with the equal footprint. Resources in the North Sea territory are limited, because the energy system is still heavily relying on fossil resources, especially on crude oil and gas.
This leaves the urgent question on how to accomodate the growth in terms of energy and resources in a sustainable way and how to how to ensure the territorial energy supply, social wealth and economic prosperity towards a low-carbon future.

Tackling the energy transition on the big scale

My master thesis is stating that it is necessary to deal with the energy transition on the big scale. According to the reference example of 'An Energetic Odyssey', this topic can just be solved with drastic changes in a whole system (IABR 2016). Small-scale projects, like the intention to make the Dutch island Texel CO2 neutral, will not contribute to the overall European goals in 2020, 2030 and 2050 to reduce carbon significantly and to ensure a high share of renewable resources.

With my thesis I furthermore want to add to the ongoing discussion on how to integrate soft-planning approaches into existing hard-planning structures. There are already existing examples and planning instruments to deal with systems on the big scale. Macro-regional strategies, a planning instrument of the European Union, is a soft-planning approach that is aiming to add on to existing hard-planning institutions.
Soft-planning and hard-planning approaches show apparently big potential to work jointly towards common challenges, since soft planning is building the framework to deal with hazards more flexible while hard planning institutions and stakeholders are needed to legalize the process. The idea of soft-planning is to build a structural vision and to create principles and guidelines through the involvement of private and public stakeholders and research institutions on the big scale. This overall framework is on the hand coordinating interventions on the small scale to work jointly towards one common goals but leaves on the other hand planning freedom to adapt to regional hazards and specific challenges.

The idea of multifunctional energy infrastructure

'Everything Remains Transformed' - I am introducing an approach, which is proposing to transform the current energy system of resource extraction into a space of collaboration among all actors of the North Sea territory. Through collaboration, big parts of the current energetic system can be reused to produce electricity and fuel and to secure the territorial energy supply for all actors in the adjacent countries of the North Sea. The project is introducing a system which is generating social wealth and prosperity through the generation of new jobs and emerging alternative industrial fields that are not relying on fossil resources.
An important point is the focus on R&D intense sectors since knowledge-based economies create furthermore innovation. Innovation is one of the most crucial features of the new energy system, because it is increasing the efficiency of existing technologies, but it also might result into the invention of new technologies. Knowledge can become an important element of trade next to carbon-based products and manufactured renewable technologies. Nevertheless, some of the technologies that are introduced in this thesis are still in the development or test phase. They can be used for speculations and scenarios of application but the evaluation leaves questions of uncertainty and doubt when these technologies can be commonly introduced.

The overall aim of the project is to reduce the carbon footprint in the territory to facilitate the estimated territrial population growth.
Renewable energy is one of the key elements for the development towards a low carbon economy. The second point of equal importance is, how to deal with the carbon emissions. This thesis is stating that the former waste of urban areas, carbon dioxide, is becoming a resource to ensure the territorial energy supply, as well as the economic prosperity and social wealth.
I made first predictions, that carbon could eventually produce enough energy to cover the energy demand of the entire territory. With this fact, I am not aiming to provide a concrete number since I know that I can hardly make accurate predictions due to the complexity and the amount of parameters. I rather want to highlight, that carbon can become one of the biggest potential in the energy transition as soon as it is embedded in circular processes.

REFLECTION

The Ecological Footprint

I want to use the last chapter of my master thesis as a moment, to reflect on the concept of the ecological footprint. This concept is basically giving information about how much capacity a given area has to accomodate growth in a sustainable way.

The topic of growth and the limitations of growth were first discussed in *The limitis to growth* by The Club of Rome. In their work, they simulated an extreme economic and population growth with an finite amount of resources. The goal was to get insights into the limits of our world society and to shed some light on the main parameters that influence the long-term behaviour of this society.Two of these elements are population and the consumption of non-renewable resources. This report was furthermore stating, that without changing our behaviour in resource management we would reach the limits of growth in the year 2072.

The ecological footprint is as well taking certain parameters into account to define two key aspects: How fast we consume resources and generate waste and how nature can absorb our waste and generate new resources. As a result, two numbers are directly compared to give insights on the question if one society consumes resources in a sustianable way.

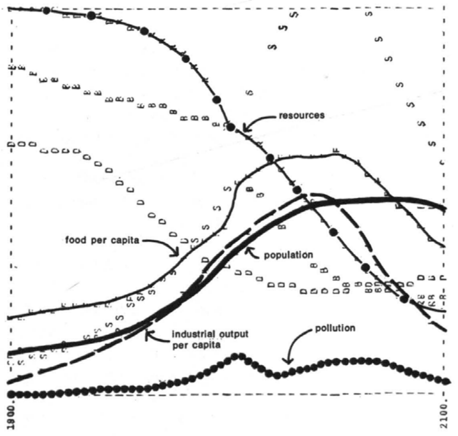
This model is at the same quiet strong as it is very weak. On the positive side, the visualisation and the lvel of reduction makes it very easy to communicate this complex context. Furthermore, you gain insights about the status quo, neither new technologies nor more sustainable ways of consuming resources are consideres.

On the other hand, these strenghts are the same time the weakness of the concept. The level of reduction seems to lead to an incompletness since certain factors and aspects of sustainability are not considered. For example, the global hectar, the unit that measures the ecological footprint, does not take parameters like toxic or non-biologocal waste into account.

Also, not all kind of emissions seems to be consideres in the calculations. The reduction of carbon dioxide played a major role in my thesis in order to lower footprint. But this maked it very hard to compare it to any other project related to the concept of the ecological footprint. While my project lowered the footprint by reducing carbon emissions, projects in other parts of the world migh rather focus on a change in landuse since carbon emissions is in other locations might be of less importance. Comparing these parameters from a methodological point of view is problematic, because carbon emissions as a dominant factor of a calculation can hardly be compared to a project that is based on the transformation of the productivity of a given area. Anyway, comparing the productivity is very difficult because monocultural and intense types of agriculture are more productive by nature than biological types. Therfore, monocultures might score a better result in the calculation even if nobody would consider them more sustainable than biological types of agriculture.

As a summary, I consider the ecological footprint as a way to get an overview on the situation of any region regarding resource exploitation and the capacity for growth. This concept is not made for a detailed evaluation of the status quo of any region.

5 parameters to determine the limits to growth



The limits to growth, Club of Rome, 1972, p. 169

Balancing the natural and the human system

The overall theme of this year's graduation studio Delta Interventions was 'The North Sea - territory as a project', where the students were allowed to choose any architectural or urban project on any scale, I chose to start with the North Sea as a point of departure and to investigate what the role of the marine area is in relation to the terrestrial zone. My P1 group discovered, that two systems exist in the North Sea territory, the human and the natural system. The relation of both machineries changed over time, from an age where both system coexisted in balance to an epoch where humankind manipulated and engineered nature regardless of the outcome. In the light of my project, humans extracted crude oil and gas resources from the basin of the sea accepting the fact, that this system of resource extraction is threatening the marine environment directly as it contributes to climate change.

The group conclusion of P1 questioned the current balance between the human and the marine system and asked for interventions or strategies to rebalance this relation for mutual benefits. I developed my project along the specific studio theme 'Ecologies of power', coordinated by Dr. Hamed Khosravi, focussing on the energy transition at the sea. I propose a multifunctional energy system, which is producing advantages for both the natural and human system through collaboration.

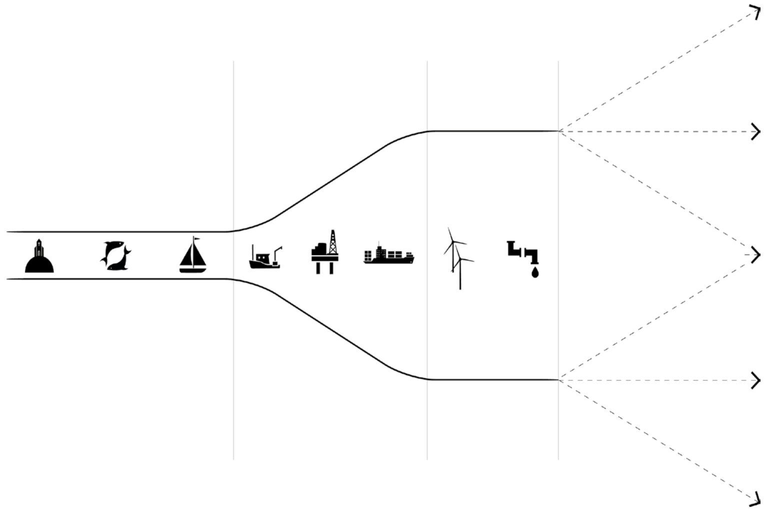
The human system is benefiting from the new energetic system by securing the territorial electricity and fuel demand through the use of renewable energies and carbon dioxide. This system creates furthermore economic prosperity through alternative R&D clusters which are based on renewable technologies or the utilization of carbon. New markets are generated for carbon-based products, manufacturing, and knowledge that ensure social wealth and new jobs.

The natural system is benefiting from the new energety systems, since the future infrastructural machinery will purify sea water and improve the marine biodiversity. First, the engineered marine artefacts form ecological corridors that connected fragmented protected zones through the establishment of artificial reefs and algae production. Second, these objects extract toxic substances from the water by processing sea water into hydrogen and oxygen. If hydrogen is burned at a later stage it releases clean water.

My project is aiming to rebalance the relationship between the human system and marine system by using synergies: energy production through natural forces and enhancing the marine biodiversity through engineered objects. Nevertheless, the technical side of the project is difficult to evaluate out of several reason: Due to the complexity of the project through scales, I focussed on the conceptual and spatial parts of the approach. My methods up to this point were mostly aiming to develop an approach for the macro scale through visioning and scenario-making and literature was used to understand the components and relations between certain technological parts of the project. Data analysis might be a further method to proceed and to evaluate my principles and spatial guidelines referring to the problem statement Resource Management Vs. Growth. The ecological footprint can act as framework for calculations since the numbers of the concept are based on the human footprint and the biodiversity (Global Footprint Network 2018). Nevertheless, data collection will be the most critical part of this calculations because there is no collection of detailed carbon emissions available.

Nevertheless, I intend with this thesis to highlight the following points: (1) Transformative processes regarding the energy transition and the relation between resource management and population growth are an urgent topic and should be part of the European Agenda (2) The energy transition needs to be tackled first on the big scale in order to bring drastic changes to the whole energetic system (3) Beyond the sake of energy production, an energetic system has to bring benefits for the three dimensions: People, Planet, Prosperity.

Group conclusions in P1: The Netherlands and Germany, in cooperation with Julia Holtland and Deniz Üstem



6 BIBLIOGRAPHY

Aberdeen City Council, Aberdeen Key Facts Population, 2016, https://www.aberdeencity.gov.uk/sites/default/files/2018-01/Aberdeen%20Key%20Facts%20-%20Population.pdf, (accessed 20 May 2018)

Aberdeenshire council, Energetica – What is Energetica?, 2018, https://www.aberdeenshire.gov.uk/business/support-and-advice/energetica/, (accessed 21 May 2018)

Aberdeen harbour, How the Harbour has Shaped Aberdeen, 2018, http://www.aberdeen-harbour.co.uk/article/the-history-of-the-harbour/, (accessed 21 May 2018)

Allmendinger, P. and G. Haughton, Soft Spaces, fuzzy boundaries and metagovernance: the new spatial planning in the Thames Gateway, Environment & Planning A41: 617 – 633, 2009

Ambrose, J., Aberdeen: the granite city in crisis, in The Telegraph, 14 May 2016, https://www.telegraph.co.uk/business/2016/05/14/aberdeen-the-granite-city-in-crisis/, (accessed 21 May 2018)

Amos, I., North Sea oil and gas to run out in ten years, experts warn, in The Scotsman, 19 September 2017, http://www.scotsman.com/news/north-sea-oil-and-gas-to-run-out-in-ten-years-experts-warn-1-4564402, (accessed 30 October 2017)

Andersen, M. K., A Comment on "Reforming the EU Energy Tax Directive: Assessing the Options". In: I Parry, K Pittel und H Vollebergh, Energy Tax and Regulatory Policy: Reform Priorities, 2017

Arnold, B., Collecting and Storing Energy from Wind Turbines, in AZO Cleantech, 13 Juni 2014, https://www.azocleantech.com/article.aspx?ArticleID=488, (accessed 8 January 2018)

Badische Zeitung, Initiative gründet sich, 28 March 2017, http://www.badische-zeitung.de/wirtschaft-3/kurz-gemeldet-xtps2nsix--135001054.html, (accessed 8 May 2018)

Baedeker (ed.), Allianz-Reiseführer, Schottland, 9th edition, MairDuMont, Ostfildern, 2009

Biggs, M. and Buchler, D., Eight criteria for practice-based research in the creative and cultural industries. Art, Design and Education in Higher Education, 2008

De Jong, T.M. and van der Voordt, D.J.M, Waysto study and research urban, architectural and technical design, TU Delft, 2002, p. 504

Boxer, C. H., The Dutch seaborne empire, 1600-1800, Taylor&Francis, 1977

Chapman, R. L., Algae: the world's most important 'plants' – an introduction, Springer Verlag, 2013, https://link.springer.com/content/pdf/10.1007%2Fs11027-010-9255-9.pdf, (accessed 20 May 2018)

Couling, N., The Urbanization of the Ocean; Extractive Geometries in the Barrents Sea, in I. and A. Ruby (ed.), Infrastructure Space, Berlin, Ruby Press, 2017, pp. 238-250

COWI, Study on macroregional strategies and their links with cohesion policy, November 2017, http://ec.europa.eu/regional_policy/sources/cooperate/baltic/pdf/eusbr_links_cohesion_policy.pdf, (accessed 24 April 2018)

CPMR, The CPMR North Sea Commission, 2016, http://cpmr-northsea.org/who-we-are/, (accessed 23 April 2018)

Day, P., Aberdeen's central role in the North Sea oil industry, in BBC, 31 July 2013, http://www.bbc.com/news/business-23490586, (accessed 21 May 2018)

Deloitte., The Chemical Industry in the Netherlands: World leading today and in 2030-2050, 2012, https://www.vnci.nl/Content/Files/file/Toekomst%20van%20de%20chemie%20in%20Nederland/VNCI_visie_2030-2050.pdf, (accessed 15 May 2018)

Dockrill, P., Scientists have developed a power cell that harnesses electricity from algae, 27 November 2015, https://www.sciencealert.com/scientists-have-developed-a-power-cell-that-harnesses-electricity-from-algae, (accessed 21 May 2018)

Dramstad, E., Olson, D. and Forman, T. T., Landscape Ecology Principles in Landscape Architecture and Land-Use Planning, Harvard University, Island Press, 1996

Edison Tech Center, Power Transmission, 2018, http://www.edisontechcenter.org/Transmission.html, (accessed 18 May 20187

Elegant embellishments, Made Of Air, 2018, http://www.elegantembellishments.net/made-from-air/, (accessed 21 May 2018)

EU GeoCapacity, Assessing European Capacity for Geological Storage of Carbon Dioxide, 2006, http://www.geology.cz/geocapacity/publications/D42%20GeoCapacity%20Final%20Report-red.pdf, (accessed 17 May 2018)

European Commission, EU-Maßnahmen gegen den Klimawandel: Das Emissionshandelssystem der EU, 2009, http://www.pedz.uni-mannheim.de/daten/edz-bn/gdf/09/KH7809568DEC_002.pdf, (accessed 8 May 2018)

European Commission, EU Emissions Trading System (EU ETS), 2018, https://ec.europa.eu/clima/policies/ets_en, (accessed 8 May 2018)

European Commission, 2030 climate & energy framework, 2018a, https://ec.europa.eu/clima/policies/strategies/2030_en, (accessed 14 May 2018)

European Commission, EU climate action, 2018b, https://ec.europa.eu/clima/citizens/eu_en, (accessed 14 May 2018)

European Energy Research Alliance (EERA), What is EERA?, 2018, https://www.eera-set.eu/what-is-eera/, (accessed 20 May 2018)

European Environmental Agency, Tracking Europe's progress on meeting 2020 climate and energy targets, 15 December 2017, https://www.eea.europa.eu/articles/tracking-europe2019s-progress-on-meeting, (accessed 13 May 2018)

European Regional Development Fund, Added value of macro-regional strategies, February 2017, http://s3platform.jrc.ec.europa.eu/documents/20182/198909/Added+value+of+the+macro-regional+strategies+for+projects+and+programmes/adefa20c-8b5d-48c8-8690-1e8fdd2570cc, (accessed 24 April 2018)

Eurostat, People in the EU, population projections, 11 April 2018, http://ec.europa.eu/eurostat/statistics-explained/index.php?title=People_in_the_EU_%E2%80%93_population_projections&oldid=358171, (accessed 24 April 2018)

Fagerberg, J. and M. Fosaas, Innovation and innovation policy in the Nordic region, in Fafo-report 26, 2014, http://www.fafoarkiv.no/pub/rapp/20373/20373.pdf, (accessed 9 May 2018)

Fazey, I., N. Schäpke, G. Canigclia et al., Ten essentials for action-oriented and second order energy transitions, transformations and climate change research, in Energy Research & Social Science, 2018

Frauenhofer ISE, Electricity production in Germany in week 20 2018, 2018, https://www.energy-charts.de/power.htm, (accessed 15 May 2018)

Global Footprint Network, Ecological, 2018, https://www.footprintnetwork.org/our-work/ecological-footprint/, (accessed 19 May 2018)

GENI (Global Network Energy Institute), North Sea's Wind Resources Could Combat Climate Change, November 2000, http://www.geni.org/globalenergy/library/technical-articles/generation/wind/dewi/north-seas-wind-resources-could-combat-climate/index.shtml, (accessed 15 May 2018)

Global CCS Institute, Research report: hazard analysis for offshore carbon capture platforms and offshore pipelines, 01 September 2013, https://hub.globalccsinstitute.com/publications/research-report-hazard-analysis-offshore-carbon-capture-platforms-and-offshore-pipelines, (accessed 20 May 2018)

GTAI (Germany Trade % Invest, The German Chemical Industry, 26 April 2018, https://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Brochures/Industries/the-german-chemical-industry.pdf?v=5, (accessed 15 May 2018)

H2 Aberdeen, Aberdeen City Region Hydrogen Strategy & Action Plan 2015-2025, 2015, http://archive.northsearegion.eu/files/repository/20150918111637_AberdeenHydrogenStrategy_March2015.pdf, (accessed 21 May 2018)

Hansson, J., Hack, R., Taljegard, M., The Potential for Electrofuels Production in Sweden Utilizing Fossil and Biogenic CO2 Point Sources, 13 March 2017, https://www.frontiersin.org/articles/10.3389/fenrg.2017.00004/full, (accessed 15 June 2018)

Habraken, J., The Uses of levels, Seoul, 1988

Havik, K.M. and Teerds H., Define and Let Go / An Interview with John Habraken, in Productive Uncertainty, OASE 85, Rotterdam, NAi Publishers, 2011, pp. 8-16

Hoch, C., Utopia, scenario and plan: A pragmatic integration, in Planning Theory 2016, Vol. 15 (I) 6-22, Chicago, University of Illinois, SAGEpub, 2014

IABR, Atelier 2050 . An Energetic Odyssey, 2016, https://iabr.nl/en/projectatelier/atelier2050, (accessed 4 May 2018)

Jack, I., North Sea oil is in its death throes. But the industry has one last grand act left, 8 April 2017, https://www.theguardian.com/commentisfree/2017/apr/08/north-sea-oil-death-throes-rigs-decommission-industry, (accessed 7 May 2018)

Jamet, S., Enhancing the Cost-Effectiveness of Climate Change Mitigation Policies in Sweden. In: OECD Economics Department: Working Papers. Nr.841, 2011, p. 9

Johnson, S., UK's oil industry 'entering final decade of production', in The Telegraph, 19 September 2017, http://www.telegraph.co.uk/news/2017/09/19/uks-oil-industry-entering-final-decade-production/#comments, (accessed 30 October 2017)

Kahl, H. and L. Simme,, Europa- und verfassungsrechtliche Spielräume einer CO2-Bepreisung in Deutschland, in Stiftung Umweltenergierecht: Würzburger Studien zum Umweltenergierecht Nr. 6, Oktober 2017, stiftung-umweltenergierecht.de, (accessed 8 May 2018)

Keane, K., Major forties oil pipeline to be closed for repairs, in BBC, 11 December 2017, http://www.bbc.com/news/uk-scotland-north-east-orkney-shetland-42308437, (accessed 21 May 2018)

Mace, P., D. Leckie, L. Gray, D. Blumenthal, I. Desgranges, D. Anthony, Clyde&Co LLP, Oil and gas regulation in the U.K., overview, in Thomson Reuters practical law, 1 October 2017, https://uk.practicallaw.thomsonreuters.com/5-524-5349?transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1, (accessed 3 November 2017

Ministry of Housing, Spatial Planning and the Environment, RANDSTAD 2040 summary of the structural vision, Son and Co B.V. (ed.), 2008

Mulder, F. M., Implications of diurnal and seasonal variations in renewable energy generation for large scale energy storage, American Institute of Physics, 2014

Nahkle (Dr.), C., Assessing the future of North Sea oil and gas, in Crystol Energy, 21 April 2017, http://www.crystolenergy.com/assessing-future-north-sea-oil-gas/, (accessed 30 October 2017)

Nield. D., Awesome New Method Can Pull Hydrogen Fuel from Seawater Using Only Sunshine, in Science Alert, 5 October 2017, https://www.sciencealert.com/new-nanomaterial-can-pull-hydrogen-out-of-seawater-using-sunshine-alone (accessed 20 May 2018)

Offshore Technology, Gannet Oil and Gas Field Project, 2018, https://www.offshore-technology.com/projects/gannet/, (accessed 21 May 2018)

offshoreWIND, Business Guide, 2018, https://www.offshorewind.biz/tag/shell/, (accessed 20 May 2018)

OMA, Roadmap 2050, a practical guide to a prosperous, low carbon Europe, Rotterdam, 2010

OMA, Zeekracht – A Strategy for Masterplanning the North Sea, 2008, http://oma.eu/publications/zeekracht-a-strategy-for-masterplanning-the-north-sea (Accessed 20 MAy 2018))

PeakOil, Scotland Oil stock depletion 'felt by 2030', 2014, http://peakoil.com/geology/scotland-oil-stock-depletion-felt-by-2030, (accessed 21 May 2018)

Project for democratic union, The East's Welfare State: What Model for Growth?, 9 September 2014, http://www.democraticunion.eu/2014/09/easts-welfare-state-model-growth/, (accessed 9 May 2018)

Purcell, M., A new land: Deleuze and Guattari and planning, in Planning Theory & Practice, 14:1, 2013, pp. 20-38

Pye, M., The edge of the world, How the North Sea Made Us Who We Are, London, Penguin Books, 2015

Rietveld, E. and Rietveld, R., The paradox of Spontaneity and Design / Designing Spontaneous Interactions, in Productive Uncertainty, OASE 85, Rotterdam, NAi publishers, 2011, p. 33-43

Sandbag (smarter climate policy), The European Power Sector in 2017, 2017, https://sandbag.org.uk/wp-content/uploads/2018/01/EU-power-sector-report-2017.pdf, (accessed 15 May 2018)

Sättler, S., Das versunkene Paradies, in G – Geschichte, Die Nordsee, 10/2017, Augsburg, Bayard Media GmbH, pp. 22-23

Seas at Risk, European Parliament wants to end overfishing in the North Sea, 14 September 2017, http://www.seas-at-risk.org/16-fisheries/781-european-parliament-wants-to-end-overfishing-in-the-north-sea.html, (accessed 28 July 2018)

Selley. H. A., Biomonitoring of pollution in harbours when multiple pollutants are present, University of Aberdeen, 2006

Shell, Gannet Complex, 2015, https://www.shell.co.uk/content/dam/royaldutchshell/documents/lubricants/gannet-2014-complex-021799-asset-fact-sheets-marketing.pdf (accessed 21 May 2018)

Staff, R., Belgium to double offshore wind energy capacity as it exits nuclear power, 20 April 2018, https://www.reuters.com/article/us-belgium-renewables/belgium-to-double-offshore-wind-energy-capacity-as-it-exits-nuclear-power-idUSKBN1HR1U3, (accessed 28 June 2018)

Stockton, N., A POWER PLANT IN ICELAND HAS TURNED ITS CO2 INTO STONE, 6 September 2016, https://www.wired.com/2016/06/iceland-pumped-co2-underground/, (accessed 28 June 2018)

Stratetic Energy Technologies Information System (SETIS), Carbon Dioxide – turning an enemy into a valuable friend, 2018, https://setis.ec.europa.eu/setis-reports/setis-magazine/carbon-capture-utilisation-and-storage/carbon-dioxide-%E2%80%93-turning-enemy, (accessed 20 May 2018)

Statista - das Statistikportal, Verteilung der Erdölimporte Europas (EU-28) nach Herkunftsland im Jahr 2016, 2017, https://de.statista.com/statistik/daten/studie/172674/umfrage/verteilung-der-oelimporte-der-eu-nach-herkunft/, (accessed 30 October 2017)

Statista – The Statistics Portal, Numbers of offshore rigs worldwide as of January 2018 by region, 2018, https://www.statista.com/statistics/279100/number-of-offshore-rigs-worldwide-by-region/ (accessed 15 May 2018)

STATKRAFT, Hydropower, 2018, https://www.statkraft.com/energy-sources/hydropower/, (Accessed 29 June 2018)

TESO, Texel CO2 neutraal in 2020, 2018, https://www.teso.nl/nl/teso-mainmenu-70/teso-en-duurzaamheid/texel-co2-neutraal-in-2020, (accessed 11 May 2018)

Urry, J., What is the Future?, Cambridge, Polity Press, 2016, pp. 61-103

U.S. Department of Energy, Algal Biofuels, 2018, https://www.energy.gov/eere/bioenergy/algal-biofuels, (accessed 28 July 2018)

Velikov, K. and G. Thün, The production of territory, in I. and A. Ruby (ed.), Infrastructure Space, Berlin, Ruby Press, 2017, pp. 34-36

Waterhout, B., Soft spaces and governance: The transformation of planning, in 24th AESOP Annual Conference, Track 6: Global Challenges and Local Responses, Finnland, 2010

Ziehm C., Eine Kritik am Emissionshandel, in Eurosolar, February 2009, http://www.eurosolar.de/de/images/stories/pdf/SZA%202-08%20Ziehm,%20Emssion.pdf, (accessed 8 May 2018)

7 APPENDIX

APPENDIX 1: THEORY PAPER

Planning and spontaneity

Which tools and concepts can planners and architects use to design with uncertainty?

Abstract

This paper is discussing possible design tools and devices to regulate and guide indeterminacy in an uncertain future and is questioning the changing role of the planners in this process. I will introduce different concepts from philosophy and sociology and connect them to the future major challenge of architects and planners: dealing with uncertainty in design and process management.
As a first step, I am arguing that the aspects of time and complex systems are essential factors for our discipline to deal with all facets of indeterminacy. The second chapter is revealing, how these aspects evolved in the 20th century, starting with the architect pioneer John Habraken. He revealed that it is necessary to understand dynamic processes, how site-specific systems evolved over time and what it needs to anticipate an uncertain future.
The following chapters are investigating the fact, that Utopias and Dystopias can serve as tools to target indeterminacy in planning and that it works apparently certainly beneficial on the big scale. In particular, the soft spaces approach will highlight that the territorial scale is providing a certain communal backbone and a concrete vision, while the particular is fuzzy and more adaptive to change.

Keywords

Designing with uncertainty, Hard and soft planning, Strategic planning, Matter of concern, Time, Complexity

Indeterminacy: From a matter of facts to a matter of concern

Architects and planners usually work among each other within their known context and anticipate an unknown future. Traditional planning tools like master or zoning plans are commonly used to communicate and deliver a final image with a fixed outcome. Nowadays, planning and designing across all scales are still mostly relying on static planning tools and they miss the capacity to tackle indeterminacy and radical change. Haughton and Allmendinger are underlining, that spatial plans are based '[...] around concepts of creating places of equilibrium really rather than creating places of change... So, they're not particularly visionary... what they do is carry with them this element of political authority and community consultation...' (2007, p. 307). Professionals are only confronted with future uncertainty while questioning the future program of a project or discussing the implementation process. They face indeterminacy as a "matter of fact" (Ghosn and Jazairy 2017), as a list of elements that need to be tackled.
Recent economic and politic incidences as well as future uncertainties regarding climate change and the energy transition change the way of planning and the role of the planner within this unstable context. The nature of planning requires nowadays the ability to foresee and to envision certain future paradigm changes. Spatial planners are facing the challenge to predict possible future scenarios while they have to consider and balance possible economic, social and environmental uncertainties. Indeterminacy is turning into a matter of concern. Bruno Latour explains in his What is the style of matters of concern? that 'a matter of concern is what happens to a matter of fact when you add [its] whole scenography, much like you would do by shifting your attention from the whole stage to the whole machinery of a theatre (2005, p. 39). Tackling uncertainty means not just work with single elements of a system, but to understand the whole apparatus of relations and dimensions behind it.
Working in an unknown context is asking planners and architects to enrich their knowledge and skills as well as to diversify their traditional instruments. A sort of system thinking is required, the understanding of interrelated elements forming networks and complexity over time. Complexity and time are therefore the key variables when we start to discuss about how to anticipate an uncertain future (Urry 2016).

Complexity and time as factors for uncertain futures

In his What is the Future?, John Urry is introducing the complexity theory with a focus on the social domain. He is arguing, that future actions are not just relying on individual actors or existing social structures but on the interrelations and organization of systems. His 'sociomaterial' concept claims, that systems should not be reduced to single factors, but they should be conceived simultaneously as 'economic, physical, technological, political and social' (Urry, 2016, p. 66). In other words, it is essential to understand the specific apparatus of a system when the aim is to cope with uncertainty.

For example, systems can be explained as relations of power, which manifests as well material and technological as it does social (Urry 2016). Social institutions and the daily life of people are directly linked to technological improvements, that are accelerating change and determining unknown futures. Change has a non-linear character and entails turning points and thresholds from one path to another. In complex systems, change can therefore have diverse faces; it can be gradual and natural as it can be dramatic. John Urry underlines Axelrod and Cohen position in Harnessing Complexity, that "[...] a complex system consists of cascades, self-restoring patterns, apparently stable regimes that suddenly collapse, punctuated equilibria, butterfly effects and thresholds" (Urry, 2016, p. 66). Complexity and its dynamics, expressed by time, are therefore directly correlated.
Time is an important unit in order to measure and evaluate the dynamics of complexity and its nature is discussed among various philosophers and scientists (Markosian 2016). Newton mentioned time as an absolute entity, while Leibniz described the term as an order of action or events (Urry 2016). Aristoteles is furthermore questioning if there is a beginning and an end of time which could be represented by a single line. Other considerations relate to the assumption, that time has numerous parallel streams where actions are related to each other on a single 'arrow of time' but do not have any temporal connection beyond to parallel time lines (Markosian, 2016).
John McTaggart made an important distinction of different kinds of time, the A and B series, in his The Nature of existence (1927). The B series is easily describing a stringent line of actions, a before and an after. The A series becomes interesting especially regarding the disciplines of architecture and planning. It is introducing the idea of a past- to present- to future relationship. John Urry is referring to George Herbert Mead and is arguing, that '[...] emergency transforms the past and gives sense and direction to the future. This emergence stems from interactions between people and the environment [...]' (2016, p. 70), which enables us to study and to learn from the past and reflect towards the future.
The earliest understanding of the nature of time is related natural sciences in the 20th century. Albert Einstein was introducing in his Special Theory of Relativity the four-dimensional space-time while thermodynamics showed the irreversibility of time (Mastin 2017). Steven Hawking summarized the relation between time and space as " [...] dynamic qualities: when a body moves, or a force acts, it affects the curvature of space and time - and in turn the structure of space - time affects the way in which bodies moves and forces act' (1988, p. 33). Time therefore does not just relate directly to the complexity of a system but also to the perception and development of space, which is a direct connection to the discipline of architecture and planning.
Time and complexity are the key variables in anticipating future development. First attempts towards designing with uncertainty were made in the 20th century by the architects John Habraken. He set the base for numerous, nowadays popular, architecture, landscape architecture and planning offices.

First attempts on integrating time and complexity

John Habraken gave recently in the journal Productive Uncertainty an inspiring interview about his first ideas on the potential of indeterminacy in design. Habraken was one of the first professionals, next to Aldo Rossi, Yona Friedmann and OMA, who introduced the dimension of time in his work. His Supports: An alternative to mass housing argues that it is the inhabitants who are 'making' their environment, that is changing over time (Havik and Teerds 2011).
Instead of traditional planning and architectural approaches, the communal should be shaped, while the particular is given space (Havik et al. 2011). In his work, Habraken claimed to liberate architectural floor plans, because they were a symbol for the static character as for the exclusion of inhabitants from the making of architecture. Participation, in his opinion, was one of the key tools to target uncertainty in the architecture discipline as well as it was a key driver to tackle static processes of Top-down planning.
The idea of 'Communal' elements and particularity can be applied across scales, from territorial or urban infrastructure systems and specific related actions down to buildings, with access areas and individual private zones. Habraken introduced the concept 'uses of levels': Wherever you are working, you will be faced with context that is already created by someone else and your design will build the context for somebody else (Habraken 1988). He set the base for what we are calling nowadays 'strategic interventions', planning tools to give room for change. A planner is creating principles that are based on a vision and a solid concept. The aim is to envision a picture for a desired future. These principles are shaped by the backbones of a bigger system, but leave space for individual procession in different directions depending on particular future factors.
The term 'vision' is dealing with different futures, which can be both positive and negative. The term is differing at a certain extent from, what philosophy calls, Utopias and Dystopias. Utopias are also aiming to provide us with an image of the future, but are, differing by definitions, in contrast to planning visions absolutely perfect and entirely unreachable. Nevertheless, Utopias can help and encourage planners and architects to create extreme scenarios in order to envision a more realistic picture of the future.
Utopia and Dystopia – different views on the future world

John Urry is mentioning several future catastrophes and its cascading effects, that need to be faced, especially economic and societal collapses (Urry 2016) Economy and society were in the past close connected by different utopias and dystopias. For instance, the utopias of globalization and of the internet promised a new age of strong economic growth and changing society by new businesses and industries as well as by new ways of global communication and exchange. This kind of 'global optimism' in the 1990th was blurred by the unforeseen trends of politic instability, like terrorism and migration, as well as the discussions on climate change. These developments left room for several philosophers to think about future dystopias, a more pessimistic view on future turns and challenges (ebd,).

One way of discussing future uncertainty is the development of dystopias as a warning or for reflection on what difficulties might emerge to lead systems and whole societies into a desired future. It can encourage the present to change directions and to rethink usual daily life patterns and structures (ebd.). This kind of 'case studies' could provide planners with insights about development and implementation of technologies, policies, social patterns or other ideas and might enable them to rethink and refine their future visions.

In addition to dystopias, utopias might help spatial planners to prepare for future uncertainty. From a philosophical point of view, a utopia is a place that offers an alternative perfect picture for the current problems of society. This place can be described as an 'active Utopia' (Baumann 1976) where the aim is to reach the most possible outcome, rather than a utopia as a perfect and complete place. In planning theory, the term 'Utopia' is describing 'a future place that reconciles current social, political, and economic problems within a single spatial community' (Hoch 2016, p. 8).
A Utopia is focussing in philosophy especially on social science and social policy, on what will be possible in the future, but is not yet in our current society (Lefebvre 1976). Planning theorists are expanding the definition of the term by the phrases of politic and institutional governance (Hoch 2016).
A utopian vision should therefore not just discuss the question what is impossible today and what is possible tomorrow (Urry 2016), but should also give an indication on how to authorize and govern these actions.
Scenarios are one way to understand and to evaluate different Utopias and Dystopias. They are narratives that are addressing certain stakeholders or future trends, can easily be evaluated based on certain well-defined factors, and are comparable to each other. 'Utopia edifies like a novel, while scenarios are function more like proverbs' (Hoch 2016, p. 17). Scenarios aim to reveal certain meanings and the significance of particular aspects of change and support in that way the creation of utopias. They furthermore bear the potential to discover and study poorly understood interrelations among institutions and actors as well as they can give insights on how to create more public awareness and involvement in a planning

process (Hoch 2016).
Utopias, dystopias and scenarios are supposed to enable planners and architects to think about more refined future visions. Visions should address possible future changes in the complex interplay of systems, its relation of power and the apparatus behind it. The question is on which scale indeterminacy can be targeted best by the help of visions. The territorial scale seems for me the most suitable solution, since a territory's central focus is by definition indeed on (transnational) systems rather than the concentration on actual borders of national states (Velikov and Thün 2017).

Territorial Planning as a crucial and necessary discipline to target indeterminacy

'The real opportunities for change', Erik and Ronald Rietveld explain, 'are often found at a higher level of planning (at either a regional, national or international level) [...]' (2011, p. 34). Change is close connected to networks. which are shaping, referring to Castells, the social morphology of society and any stress is modifying the processes of production, experience and culture (1996). Networks cannot be framed by borders of one nation state or by any other legal authority and its boundaries as well as social structures are highly dynamic, since they are not just stretching through time and space but also trough scales (Urry 2016). A vision and design principles on the territorial scale can therefore influence even the smallest scale, like local communities, and it can manifest even in single architectural objects.
Territorial impact on society, manipulated by design, can be best described by James Gibson's theory of affordances. It says that a certain action or a change of behaviour is based on details from relevant attributes of objects or on particular elements of the environment (Chemero 2003). Affordances can entail a certain requirement or invitation character, e.g. an armchair means the affordance to sit down as well as a scissor means the affordance to cut. One field, where this theory is applied, is the discipline of environmental planning. The issue is to design the environment in a way that it is stimulating the citizen's perception and is encouraging an environmentally friendly behaviour (Wenninger 2000). The execution of such a project should start with conceptualization and visioning on the big scale. It gives the chance to create a communal framework with one strong vision and well-defined principles, that leaves at the same time space, where the particular can unfold depending on different future directions.

At the same time, society does not have an impact exclusively on their close environment but also correlates with the territorial scale. An example for a sudden societal footprint on territorial scale is a case from the U.K. where thousands of households are boiling water for tea at the exact same moment, when the BBC TV show Eastenders is over. The simultaneous energy demand is causing such an urgency to secure the territorial energy supply, that additional electricity from France has to be imported (Raby 2013).
Nevertheless, anticipating future changes on the territorial scale raises the question how to deal with such complex systems and their related apparatus in the social, economic and ecologic dimensions beyond any legal borders. It calls for flexible planning, that can be just achieved when the role of architects and planners is changing from designing towards managing and regulating processes. They have to leave room for unforeseen developments instead of trying to predict the future of complex systems.

Managing uncertainty: the soft spaces approach as an instrument?

The soft spaces approach is a concept, that was developed in the last decades in the United Kingdome and can be seen as an add-on to hard planning rather than to 'override' the traditional ways of planning. Hard planning is usually understood as the formal actions embedded in 'democratic processes and local political influence' (Haughton and Allmendinger 2007, p. 306). This approach is facing nowadays different problems, like the organization and coordination of policies and of regulative planning tools across all levels of political hierarchy, which is resulting in bureaucratic complexity and delays (ebd.). Soft spaces are bearing the potential to bridge these problems by reworking and reorganizing legal structures and breaking with the current situation of political boundaries. This approach seems to have an informal character, soft governance is in this respect a term that tends to address new coalitions of stakeholders as well as it aims to 'regain control over territories' (Walsh et al., p. 4).
The soft space approach is indeed a tool for territorial management, since both ideas are not based on political geography but tend to overcome these boundaries by orienting towards systems. There are already some references on how to face uncertainty by the help of soft spaces on bigger scale. In the Thames Gateway, a series of soft spaces emerged over the last decades. The problematic situation was caused by a plan from 1995 that foresaw an attractive development for the Thames estuary in the East of London. In 2000, an evaluation stated delay and very slow progress that encouraged the government to move (Haughton and Allmendinger 2007). The Thames Gateway Unit was founded, as a central governmental element bridging all relevant departments like regional planning, transport, housing and economic development. The strategies were detached from current legal boundaries and authorities since just a part of the Thames Gateway was directly involved, including 16 local authorities with their own frameworks and strategies (ebd.).

An integrated approach towards an uncertain future?

This paper described different concepts from psychology, sociology and planning in order to bring the discussion about designing with uncertainty forward. Central for the implementation of such concepts and tools is the change of architect's and planner's role in the design and implementation process. I speak in particular about the practical part of our discipline, the academic scene embraced this body of knowledge already with the work of John Habraken. Though, his work always stayed in the academic domain and he was never applying it practically. Habraken wanted to discuss and question past architecture methods and concepts but did not want to become part of the discussion by practicing and celebrating his ideas in the built environment (Havik and Teerds 2011). This phenomenon is showing the basic problem: We have a lot of academic research, but it still lacks the practical application, even if certain offices like RAAAF (Rietveld-Architecture-Art-Affordances) or OMA are dealing with uncertainty since years.
But how to combine the different concepts of this paper to actually integrate them in the practical field of our discipline? I want to highlight Habraken's idea, that I already mentioned earlier: designing and setting a communal frame with a solid concept and a strong vision, while the particular is set free and can adapt to change. This approach can be easily linked to the terms of utopia and dystopia, as well as to scenarios in order to refine the planners vision by developing extreme cases. The TU Delft is contributing a lot to these discussions, since a central element of education in the Urbanism track is research by design and the teaching approach of strategic interventions is strongly influenced by complexity and time.
I was introducing in this paper one example for flexible planning, the soft spaces approach. This idea tends to face the problem of future wicked problems and uncertain development, but is still object of discussion and demands improvement. The theorists Haughton and Walsh are arguing, that it is still not predictable whether the approach will be improved or if the focus will change to different theories in the upcoming years. For example, emerging soft spaces in the Thames Gateway resulted in 'the perception [of several involved actors] that it was 'over-planned', with too many strategies, plans, partnerships and agencies' (Haughton and Allmendinger 2007, p. 307). Nevertheless, after adjustments and the continuous focus on a sufficient framework, the idea seemed to succeed.
The approach of soft spaces was further researched since Haughton's and Allmendinger's conceptualization in 2009 (Walsh et. al). Walsh underlines in this context the importance of socio-spatial relations and asks for further critical research in the fields of regional studies and institutional theory. The link to social dynamics might be indeed an interesting aspect to elaborate on, since society is most affected in terms of change and is shaping the environment across scales, depending on future events resulting in different path directions.
The academic field already developed several theories and concepts that can be used to tackle uncertainty in planning and architecture. Essential is the direct translation

Conclusion

The focus of architects and planners have to change indeed from indeterminacy as a matter of fact to a matter of concern, considering the whole machinery of a theatre rather than just watching the stage. The academic field already developed several theories and concepts to reveal this apparatus and to anticipate future changes of the whole construct. Essential is the direct translation of these approaches into the practical domain, which gives opportunities to experiment and to evaluate the spatial and structural consequences.
My own graduation project might act as such a 'test field' to evaluate the consequences of concepts and theories that deal with uncertainty. During my graduation process, I might discover new insights and ideas to refine these approaches. For instance, soft spaces already deliver a first idea on how to design a flexible framework with the focus on system-oriented processes with flexible boundaries, but still seem to have potential in linking it directly to the dynamics of society.

Bibliography

Baumann, Z., Socialism: The Active Utopia, London, George Allen und Unwin, 1976

Castells, M., The Rise if the Network society, Oxford, Blackwell, 1996

Chemero, A., An Outline of a Theory of Affordances, Franklin and Marshall College, 2003

Ghosn, R. and Jazairy, E.H., Geography and Oil: The Territory of Externalities (Design Earth), in I. and A. Ruby (ed.), Infrastructure Space, Berlin, Ruby Press, 2017, pp. 361-376

Habraken J., The Uses of levels, Seoul, 1988

Haughton, G. and Allmendinger P., 'Soft spaces' in planning, in Town and Country Planning September 2007, 2007, p. 306-308

Havik, K., Patteeuw, V. and Teerds. H., Editorial Productive Uncertainty / Indeterminacy in Spatial Design, Planning and Management, in Productive Uncertainty, OASE 85, Rotterdam, NAi Publishers, 2011, pp. 3-6

Havik, K. and Teerds, H., Define and Let Go / An Interview with John Habraken, in Productive Uncertainty, OASE 85, Rotterdam, NAi Publishers, 2011, pp. 8-16

Hawking, S., A Brief History of Time, London, Bantam, 1988, p. 33

Hoch, C., Utopia, scenario and plan: A pragmatic integration, in Planning Theory 2016, Vol. 15 (I) 6-22, Chicago, University of Illinois, SAGEpub, 2014

Latour, B., What is the style of matters of concern, Amsterdam, University of Amsterdam, 2005

Lefebvre, H., The Survival of Capitalism, London: Allison and Busby, 1976

Markosian, N., 'Time', in Stanford Encyclopaedia of Philosophy, 21 September 2017, https://plato.stanford.edu/entries/time/#TheBThe, (accessed 20 November 2017)

McTaggart, J., The Nature of Existence, Vol. II, Book 5, Cambridge, Cambridge University Press, 1927

Praeger, D., Our Love of Sewers: A Lesson in Path Dependence, in DAILY KOS, 15 June 2007, https://www.dailykos.com/stories/2007/06/15/346883/-Our-Love-Of-Sewers-A-Lesson-in-Path-Dependence, (accessed 24 November 2017)

Raby, M., Tea time in Britain causes predictable, massive surge in electricity demand, in GEEK, 1 July 2013, https://www.geek.com/geek-cetera/tea-time-in-britain-causes-predictable-massive-surge-in-electricity-demand-1535023/, (accessed 22 November 2017)

Rietveld, E. and Rietveld, R., The paradox of Spontaneity and Design / Designing Spontaneous Interactions, in Productive Uncertainty, OASE 85, Rotterdam, NAi publishers, 2011, p. 33-43

Urry, J., What is the Future?, Cambridge, Polity Press, 2016, pp. 61-103

Velikov, K. and Thün, G., The production of territory, in I. and A. Ruby (ed.), Infrastructure Space, Berlin, Ruby Press, 2017b, pp. 34-36

Walsh, C., Jacuniak-Suda, M., Knieling, J. and Othengrafen, F., Soft Spaces in Spatial Planning and Governance: Theoretical Reflections and Difinitional Issues, Hamburg, HafenCity University

Wenninger, G., 'Affordanz', in Lexikon der Psychologie, 2000, Heidelberg, Spektrum Akademischer Verlag, http://www.spektrum.de/lexikon/psychologie/affordanz/320, (accessed 22 November 2017)