

The Mongstad Experience
Facilitating a transition in time, function and space

The Mongstad Experience
Facilitating a transition in time, function and space

Research Report

Elise van Herwaarden

Delta Interventions 2017/2018
North Sea: Landscapes of Coexistence

25-01-2019

Under supervision of

dr. ir. Taneha K. Bacchin
ir. Stefano Milani
ir. Sjap Holst

dr. ir. Hamed Khosravi
dr. ir. Nicola Marzot

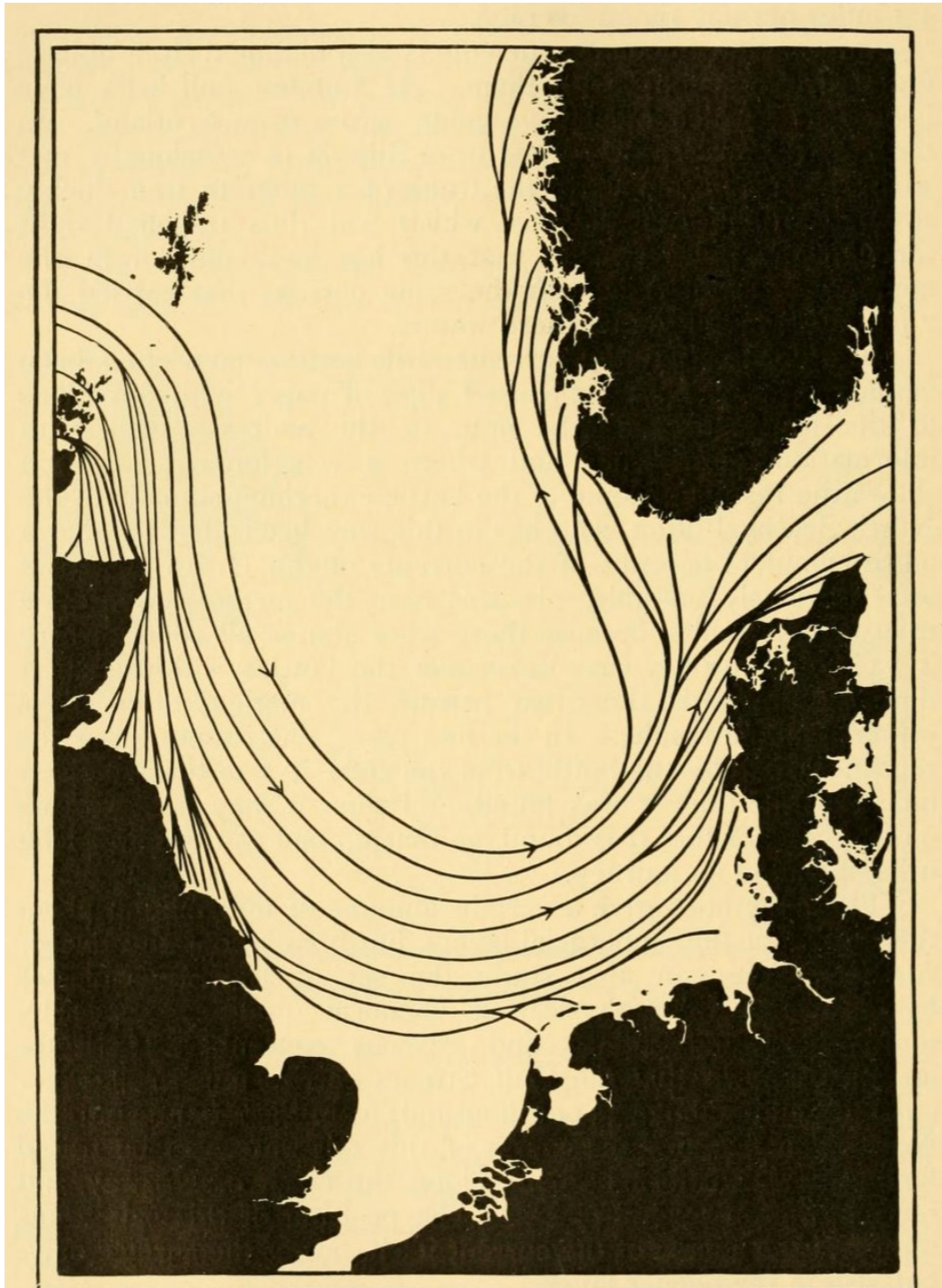


FIG. 176.—RESULTS OF DR. FULTON'S DRIFT-BOTTLE EXPERIMENTS IN THE NORTH SEA.

CONTENT

0

Introduction	7
--------------	---

I

NORTH SEA

Delta Interventions -	9
Landscapes of Coexistence	11
Fishing Industry	13
Resource Extraction	21

II

NORWAY

Economy	25
Oil in Norway	27
Tourism in Norway	29
	33

III

MONGSTAD

North Sea Refineries	35
Geographic Situation	37
The Site	39
Site Visit	45
	47

Problem statement / research question	49
---------------------------------------	----

INTRODUCTION

Before you lies the first of a series of three booklets, presenting to you the story of 'The Mongstad Experience - facilitating a transition in time, function and space'. The Mongstad Experience was designed as a graduation project, done in the Delta Interventions graduation studio as a closing part of the Architecture master of the Faculty of Architecture and the Built Environment at TU Delft.

The project took a total of three semesters, all of which were guided by my supervisory team, consisting of dr. ir. Taneha Bacchin, ir. Sjap Holst and ir. Stefano Milani. During the first two semesters, I had the pleasure of being taught by dr. ir. Hamed Khosravi and dr. ir. Nicola Marzot too.

This graduation project has been a challenging process. In educational terms, but at least as much on a personal level. For obvious reasons it took longer than expected, which definitely enforced the project. But at the same time I'd seen this as a failure that I had to overcome.

I think I did, and I would like to thank Taneha for her support. For encouraging me to continue with the project, and for always keeping the aim at taking the project to a higher level. I'm sure you provided me with the tools I needed to make a complete architectural design out of this project. I'd also like to thank Sjap and Stefano for evaluating my work numerous times, meeting after meeting and P4 after P4.

I would like to thank my parents for their unconditional support in multiple ways. And of course many, many thanks to all of the friends that were (and still are!) there all these months. I'm not sure how I would have been without being able to ventilate my feelings and experiences over all the cottage cheese or beer breaks.

Thank you very much and I hope you enjoy these readings.

Elise van Herwaarden



An aerial photograph of a coastline, likely the North Sea, with a dark, semi-transparent overlay. The land is visible in shades of brown and tan, while the water is dark. The text 'NORTH SEA' is printed in large, white, bold, sans-serif capital letters across the bottom right portion of the image. A vertical white bar is on the left side of the image.

NORTH SEA

DELTA INTERVENTIONS NORTH SEA: LANDSCAPES OF COEXISTENCE

Within the Architecture master at the Faculty of Architecture and the Built Environment of TU Delft, the Delta Interventions graduation studio is a particular case. This interdisciplinary studio focusses on the transformation of delta landscapes and does so by uniting Urbanism, Architecture, Landscape Architecture and Water Management students.

The main distinctive feature of this studio is that different disciplines are brought together, while mutually depending on each others specific knowledge. By doing so, interscalar projects evolve.

During the academic year of 2017/2018 the specific scope of the D-i graduation studio was 'North Sea: Landscapes of Coexistence'. The studio adresses sea level rise as a consequence of climate change. The impact on the territorial waters of the North Sea and its adjacent countries had been researched, whilst considering predictions for extreme future scenario's.

Throughout history the North Sea has been a much disputed area. Surrounded by land, being relatively shallow and reasonable in scale, it has inspired painters with its dramatic skies, was the preferred travel route for vikings and made overseas trade possible. But the more people were able to benefit from its richness, the more tension was caused.

From recent history up to the present day, the situation has been no different. In an attempt to overcome spontaneous disputes, the sea has been strictly divided into 'Exclusive Economic Zones', determining which country has the right to extract resources from the Sea. But also this solution has been a temporary one: we can only try to imagine what the consequences of Brexit will be, or what will happen once the Sea's resources deplete.

While situated in the broader context of a time in which sea level rise is an urgent matter, the specific theme of the studio provided us with a territorial project by nature. To us as urbanism, architecture, water management and lanscape architecture students there has been much more to consider than only spatial issues.

Through an interdisciplinary mapping exercise we managed to research historical and current issues concerning the Sea itself as well as the coastal regions of the surrounding countries, and everything inbetween. While doing so, we looked into systems defining the North Sea as a territory.

The systems of focus are the fishing industry and resource extraction.



FISHING INDUSTRY



Panoramic timeline - 500 years of fishing in the North Sea - 1600 - 2100

The North Sea is a relatively shallow sea, but still it is home to plenty of fish species. For centuries the area has been used for commercial fishing, and nowadays hosts large scale aquaculture farms too.

Fish has been an important source of income for countries surrounding the Sea, but due to temperature- and sea-level rise the industry is being threatened.: fish species migrate with the warming of the sea, which causes the industry to move with it.

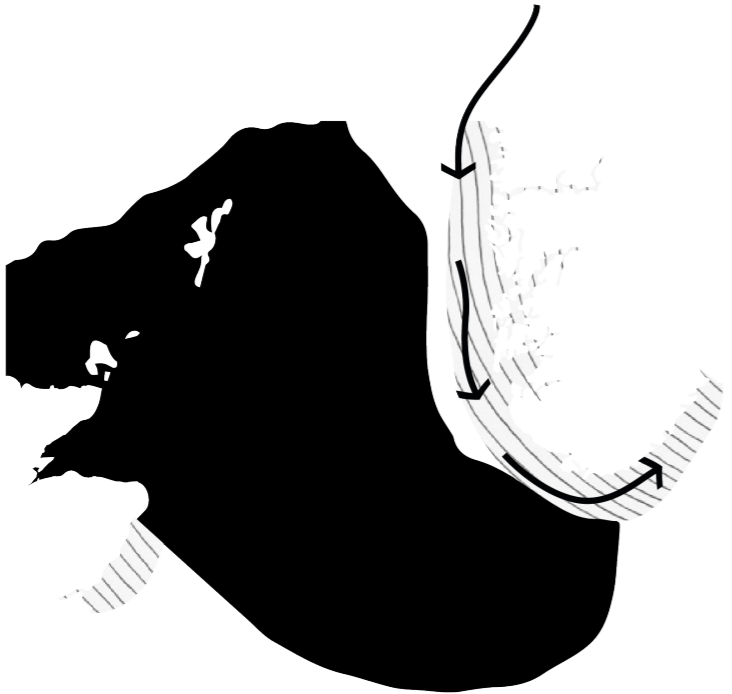
Because of the rapidly changing climate, fish species are moving to areas with a suitable average water temperature. Because many lives of inhabitants of coastal regions around the North Sea are dependent of fish revenue, the industry concerning fish catch is forced to move with them. In some cases this only means a change of route for vessels, however, in other cases people, families and social systems have to migrate.

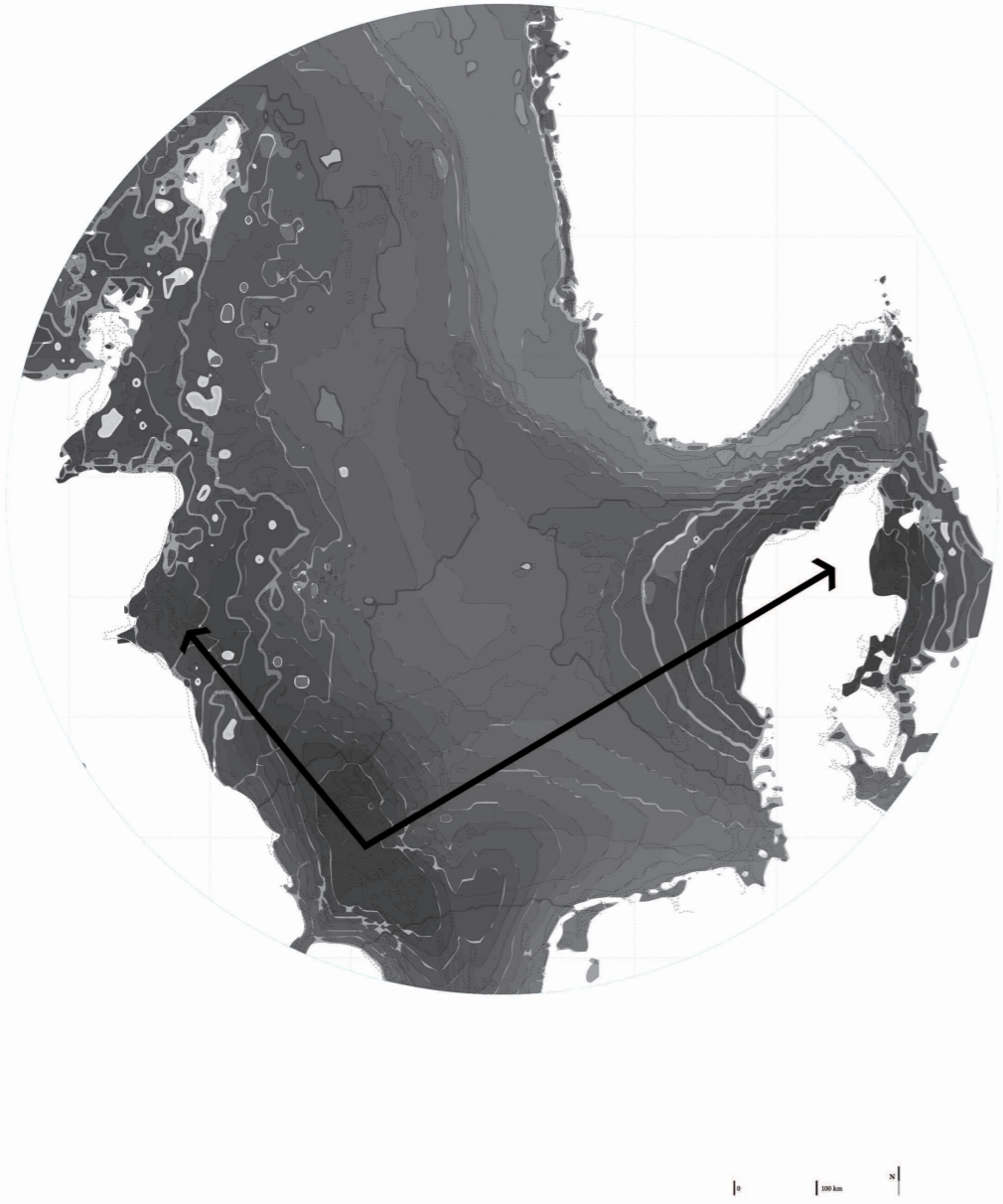


Distribution of Mackerel

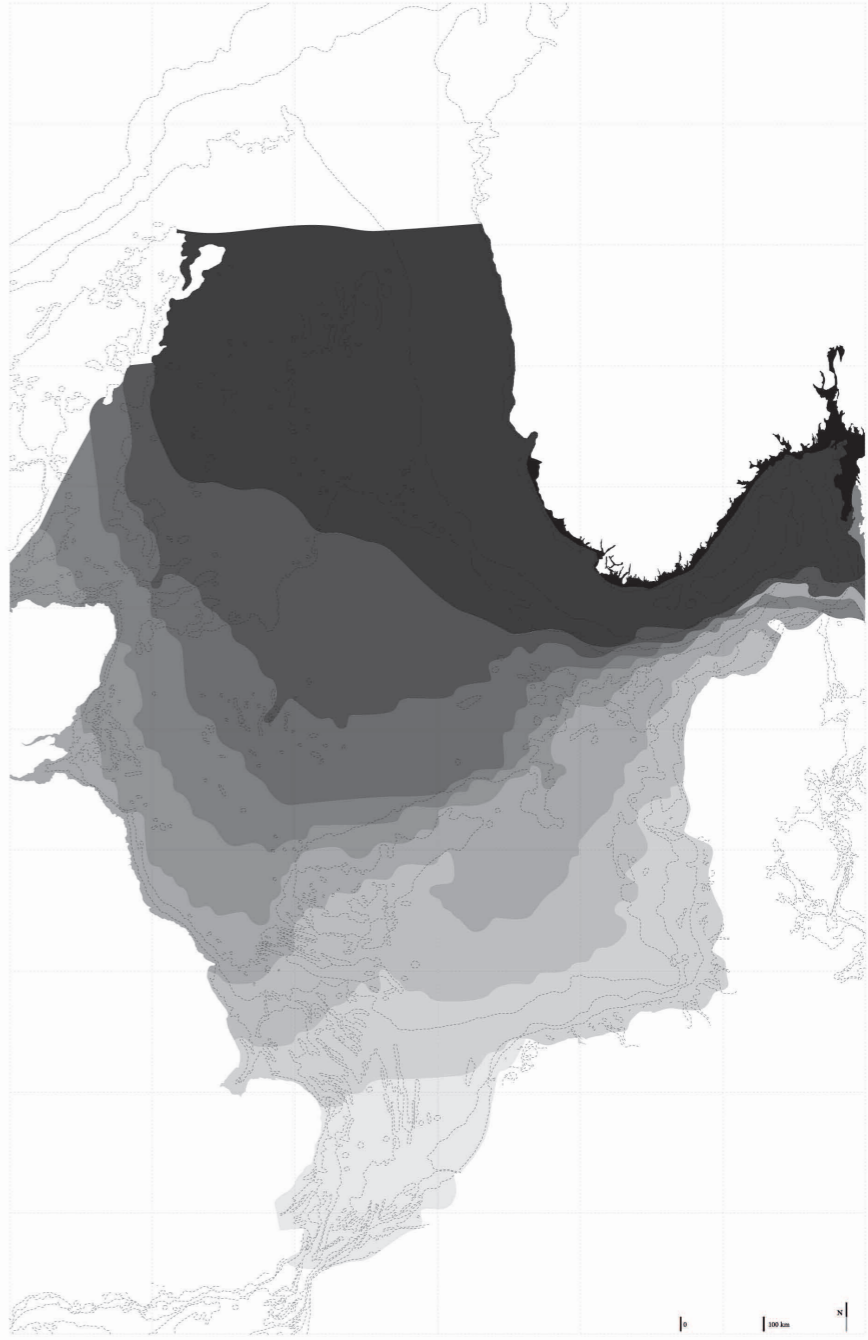


Distribution of Sprat





Rising water temperatures in the North Sea



RESOURCE EXTRACTION

Whereas the North Sea historically provided its adjacent countries with enough resources to become great international trade powers, in recent history this has been no different.

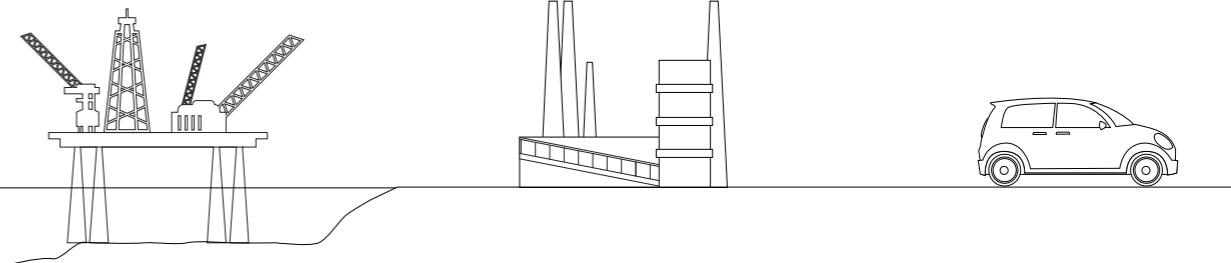
Fish has always been one of the most straightforward sources of income for many countries situated around the sea. But with the invention of modern technology and the shift in mentality eventually people were able to tap into new sources of energy and income.

Since the localisation of gas and oil fields in the North Sea in the beginning of the 19th century, these resources rapidly became an important trade product. Up until today new gas and oil wells are discovered, ensuring relative stability. As of January 2015, the North Sea has been the most active drilling area worldwide.

To prevent from unnecessary tension, and to optimise economic opportunities, from 1982 on the Exclusive Economical Zone (EEZ) was accepted. This law apporitions 200 nautical miles off of the coast of each country as an exclusive area to use for exploration and use of marine resources (united nations article 56).

While the industry revolving around extraction of oil and gas has been a major driver for global wealth, the environmental impact is arguably just as big. In all phases of the process that leads from raw resources to end-use of the products, high amounts of toxic substances are released.

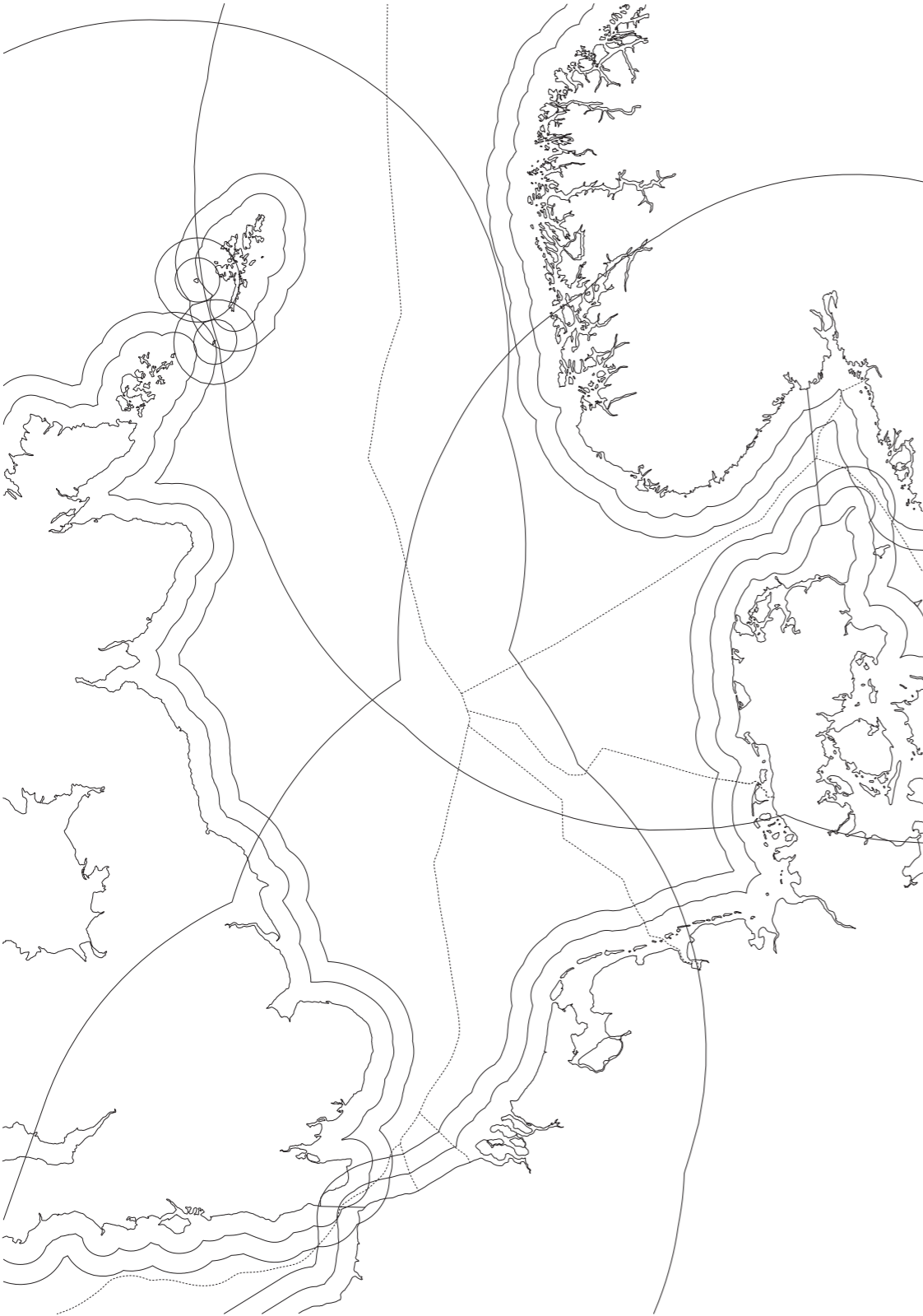
Throughout the supply chain of oil specifically, many toxins are exhausted. From the upstream phase through the downstream phase, most activities related to the extraction of crude oil until the consumption of petroleum cause harm to our environment. Besides oil spills in the sea and soil pollution around refineries, the emission of huge amounts of CO2 as a by-product of petroleum is a big driver of the greenhouse effect, and the warming of the globe.

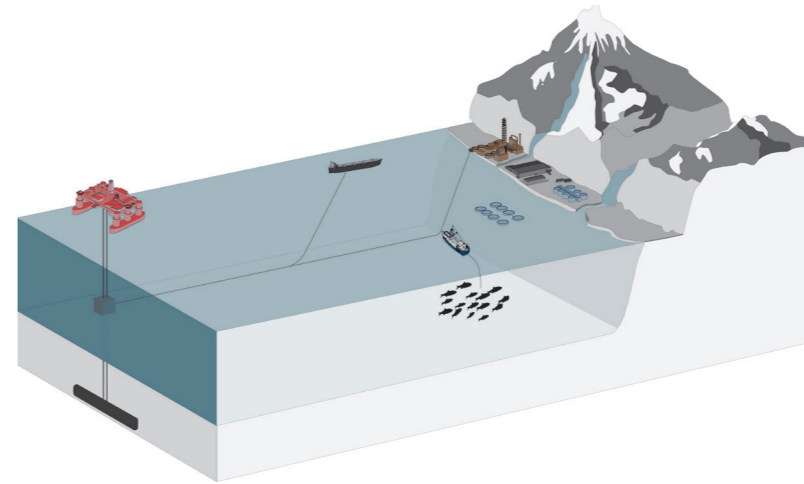
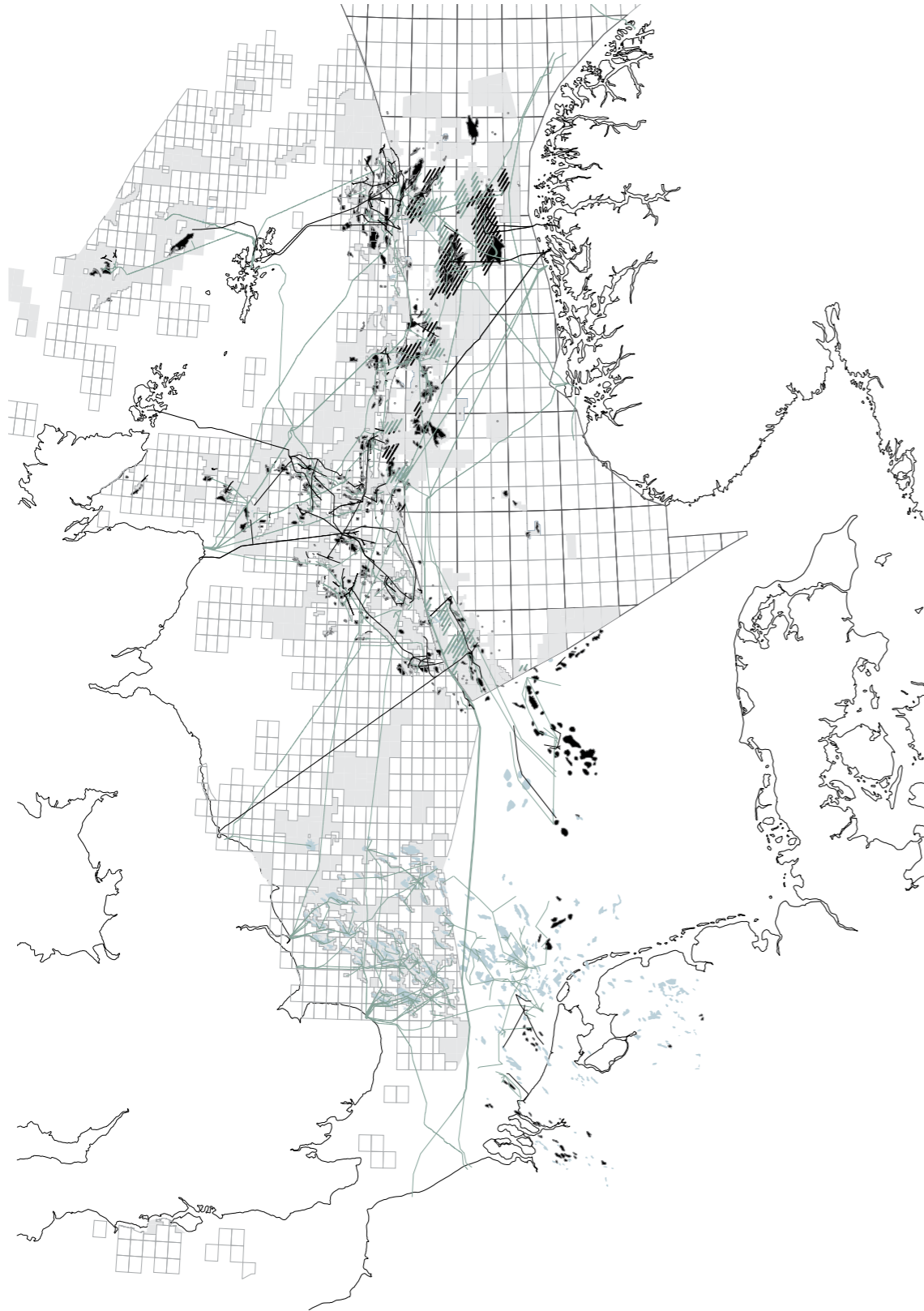


Upstream - localising and extracting oil from underground/underwater fields.

Downstream - processing (refining) of oil into a finished product.

End use - commercial resale and use by companies and individuals.





Fjordic coexistence nowadays - aquaculture + oil extraction

When considering the two systems that both influence many lives in and around the North Sea, being the fishing industry and the extraction and exploitation of resources, it can be concluded that these industries seem to peacefully coexist.

In both cases, specific three dimensional structures and infrastructure serve productivity. The fishing industry is driven by vessels that became larger over the past decades to enable upscaling. Aquaculture farms are another consequence of upscaling, since they enable large-scale fish breeding. On land harbours are designed in such a way that fish can be kept as fresh as possible, and in many countries fish markets serve as a location to bring the daily catch to its final consumers.

The production of petroleum requires a completely different type of spatiality: the construction of oil rigs, pipelines connecting these to the mainland, refineries and eventually roads and gas stations are among the technologically advanced interventions enabling raw material to serve its customers. Since being very efficient, both industries' spatial manifestations barely exclude each other's success.

However: an important paradox can be found. Because where the fishing industry is undergoing a major shift due to climate change, the oil industry is one of the modern-day causes and accelerators of this change. CO₂ emitted damages the ozone layer, which prevents the earth from warming up too rapidly, which on its turn causes fish species to migrate to suitable waters.

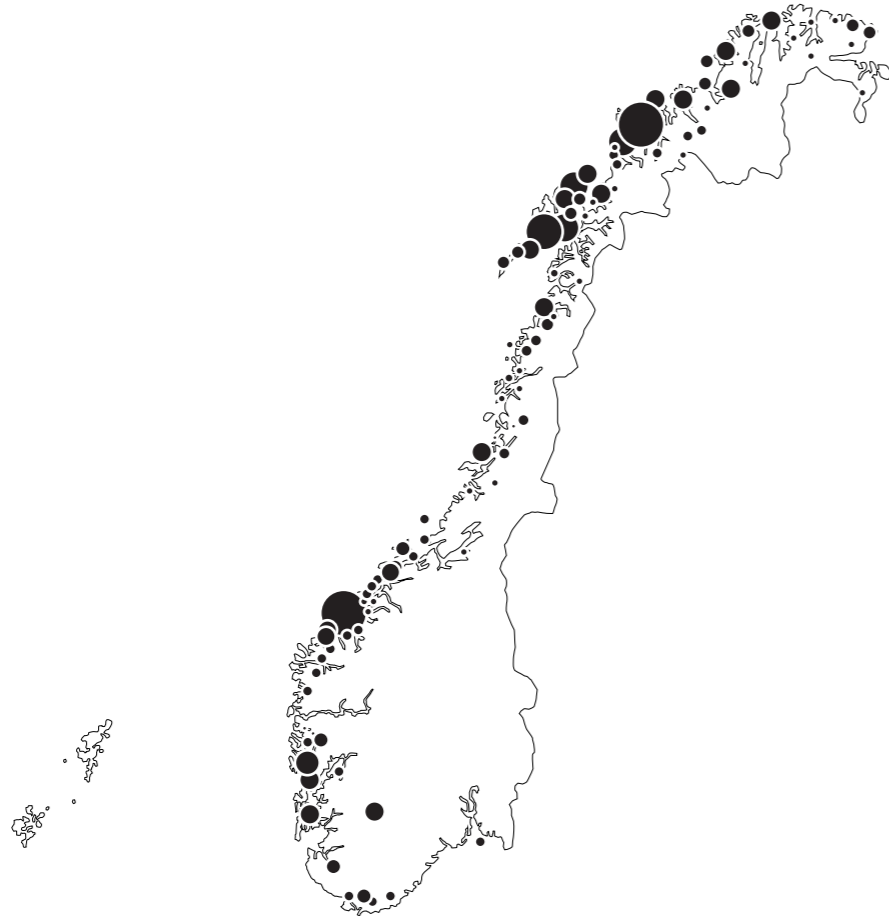
To come up with a project with a positive effect on the world, the problem of the warming of the waters of the North Sea will be taken by the root: the oil industry and its obvious environmental impact.

- Changing fishing industry
- Fish migration
- Global warming
- CO₂
- Oil/gas industry



II NORWAY

Google Earth
© 2014 Google
All rights reserved.



Relative amount of fishermen per capita in Norway

ECONOMY

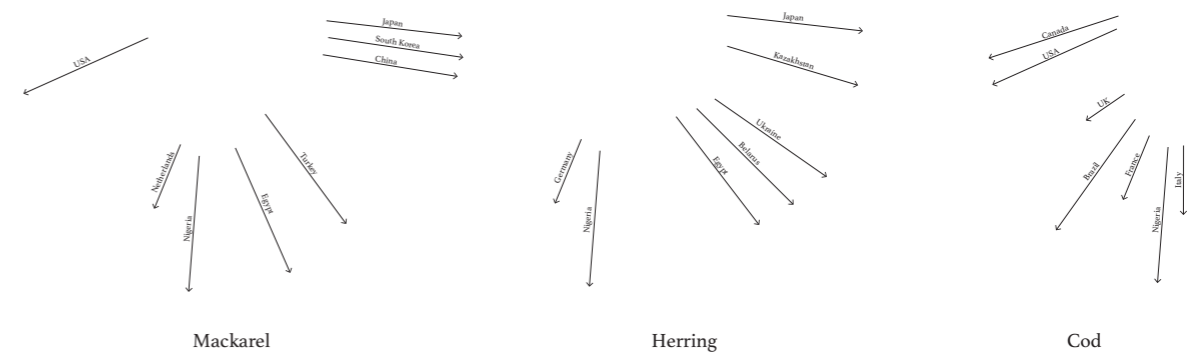
Norway is known as a wealthy and economically stable state. With a Gross Domestic Product per capita of 74,065 USD as measured in the first half of 2018, it's ranked as the seventh richest country in the world. Together with the low crime rate, clear skies and long and healthy life expectancies it is decided on to be one of the best places to live in - globally.

But before the industrial revolution, the country was not that wealthy at all: fishing used to be dangerous and the weather was harsh. Historically seen people used to survive by farming and small scale fishing, benefitting from clear and cold surrounding waters. Later on fish has been caught off-shore on the sea, as well as in the deep inland fjords the country is famous for too.

Upcoming trade possibilities made Norwegian fish popular all around the world, with best selling species such as mackarel, cod and herring. On land and on water the business has ensured many of the state's inhabitants with jobs for over centuries.

Since the discovery of the Ekofisk oil field in 1969, and the start of production of oil from 1980 onwards, Norway's economy grew exponentially. Stavanger and Oslo, that used to host large shipbuilding companies, now started to serve as on-land bases for petroleum related activities.

It is estimated that the Norwegian sector alone contains 54% of the North Sea's oil reserves and 45% of its gas reserves nowadays.



Primary export regions per fish species



Norway

Burundi

OIL IN NORWAY

Together with natural gas, income from Norwegian oil today accounts for around 15% of the country's GDP. Norway only uses about 10% of its petroleum production, which means that around 90% is exported to other countries around the world. Oil money counts up to 40% of Norway's total export value.

Revenue is mainly created by Equinor (previously know as Statoil), a company that is 67% owned by the Norwegian Government. To ensure the stable economic situation of the country, the Norwegian government saves a share of its income from oil export in the so called 'Government Pension Fund Global'. This way the government ensures money from resources is equally spread among its inhabitants now, and saved for future generations too.

Insurance for being economically well-off in the coming decades is of great importance, since the future of the oil industry is very uncertain. Oil sources have already depleted for over 50%. At the same time, international pacts, such as the Paris Agreement, aim at imposing restraints on global warming by indirectly restricting usage of oil and gas drastically.

World's richest countries (2018)

Country	GDP per capita (USD)
1. Qatar	128,702
2. Macao	122,489
3. Luxembourg	110,870
4. Singapore	98,014
5. Ireland	79,716
6. Brunei Darussalam	79,924
7. Norway	74,065
8. United Arab Emirates	68,662
9. Kuwait	6,673
10. Hong Kong	64,533

© International monetary fund

The New York Times

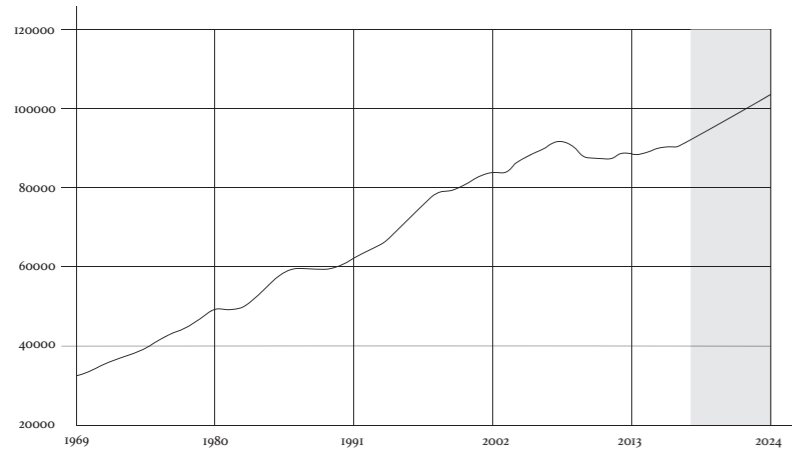
Both Climate Leader and Oil Giant? A Norwegian Paradox

<https://www.nytimes.com/2017/06/17/world/europe/norway-climate-oil.html>

June 17, 2017

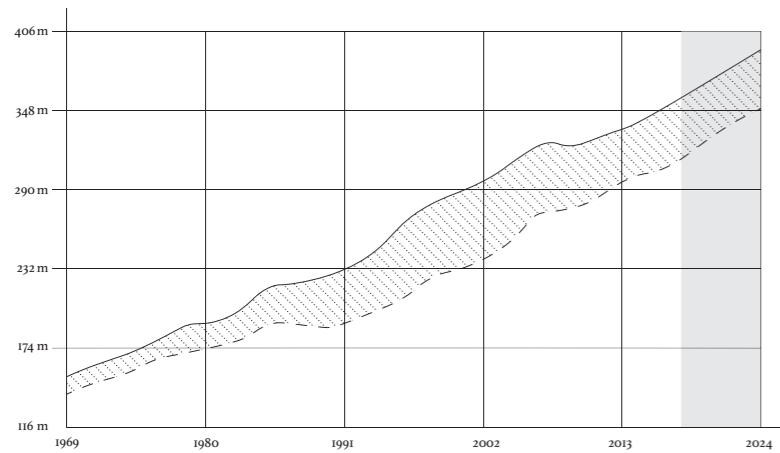
These trends seem to indicate a shrinkage of oil demand, but this is only one side of the story. Because while aiming at less carbondioxide emission by many publicly active actors, different other factors ensure the availability of crude oil for Norway for the coming decades. Among these factors are the discovery of Jon Sverdrup, a huge oil field that will supply the country with crude oil from 2019 onwards, and the melting ice peaks that make transport of oil on sea easier than ever before. And since the income from oil export is so important in keeping Norway as wealthy as it is, it is unlikely that the oil industry will soon reach an end.

Norway: 500 times as rich as Burundi



GDP per capita Norway (USD). Source: World Bank

- GDP per capita
- Predicted

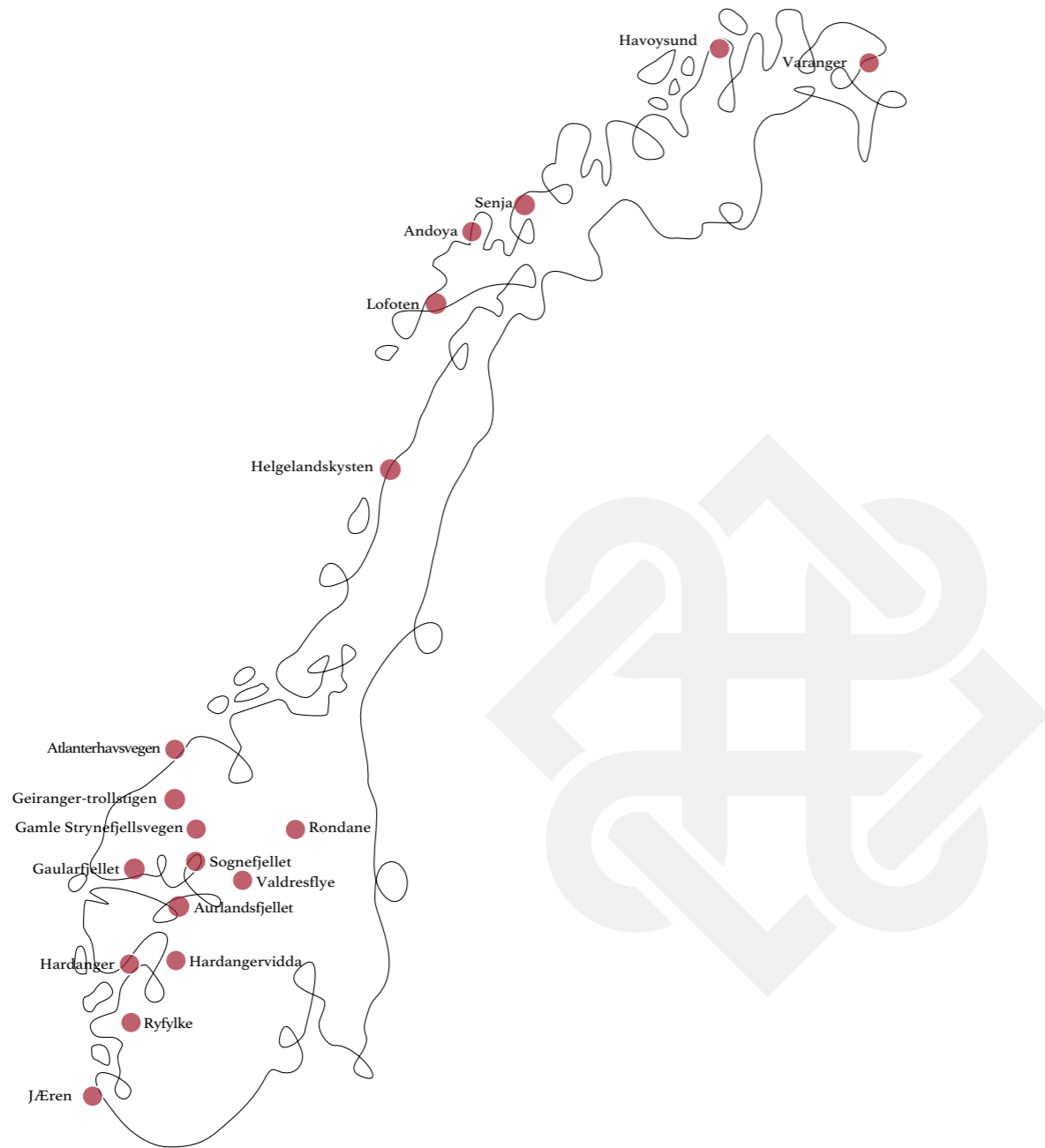


Oil + gas contribution to GDP volume Norway (USD). Source: Norwegian Petroleum Directorate & OECD Economic Outlook 102 Database

- GDP volume
- - Mainland GDP
- ▨ Contribution oil + gas
- Predicted

Even though Norway is such a big player in the oil industry world wide, the country manages to be generally known as one of the world's climate leaders. This is because 97% of its electricity demand is generated through hydropower - one of Norway's other natural energy sources. On top of this, by 2025 only electric cars will be sold, contributing to a cut of 40% off the total CO₂ emission.

The contradiction caused is striking, and makes an interesting case out of Norway's oil industry. By exporting most of its oil, CO₂ emissions are pushed away too. In this way the country doesn't only earns lots of money, but also works on the reduction of its own CO₂ footprint. A good outcome for the Norwegians, who enthusiastically invest in greener sources of energy.



TOURISM IN NORWAY

The current government in Norway encourages tourism, by supporting visiting striking locations throughout the country. The goal is to offer dramatic and interesting views, that have carefully been curated. These views are in most cases emphasized with architectural interventions.

As part of this strategy, 18 routes have been selected that lead the visitor by car along different interesting spots. These are the so-called 'turistvejger', where the journey is more important than the destination itself. Route lengths vary from 20 to 450 kilometers, dependent on the remoteness of the destination.

The emphasis of the route is usually on geographical conditions of multiple kinds. Examples are fjords, waterfalls or glaciers. The architectural interventions highlighting these are done by well known or less well known architects, and usually aim at facilitating a visit, or framing specific views. In other cases these are also highly symbolic and created to commemorate site specific events.

A striking example is the work by Peter Zumthor in Steilneset, located in the very Northern part of Norway. The pavilion is created to commemorate victims found guilty of witchcraft.

Another type of (infrastructural) intervention, is the CorTen steel path along the Svandalsfossen waterfall, designed by Schjelderup Tron Dahl Architects.



Steilneset Memorial by Peter Zumthor



Path along the Svandalsfossen waterfall



III MONGSTAD



NORTH SEA REFINERIES



Mongstad AS as seen from the Fensfjorden

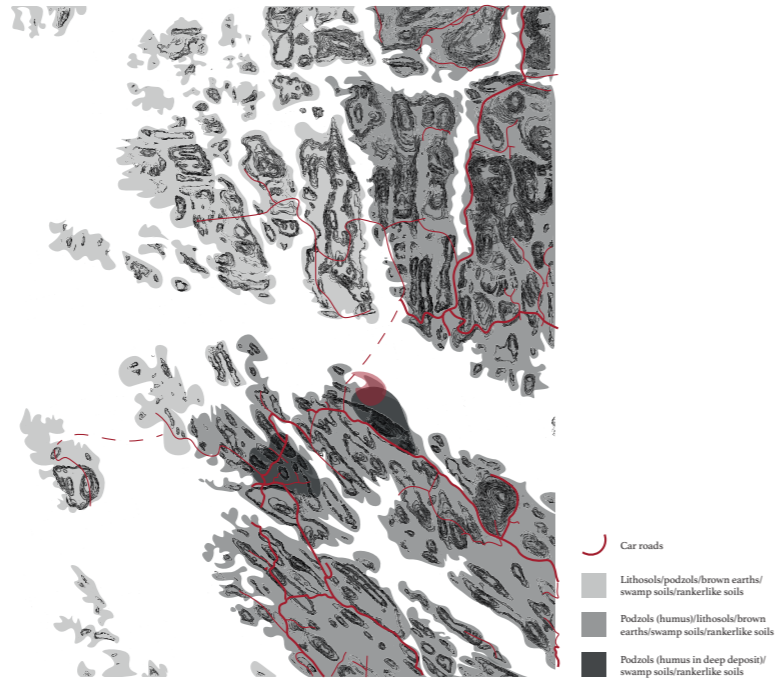
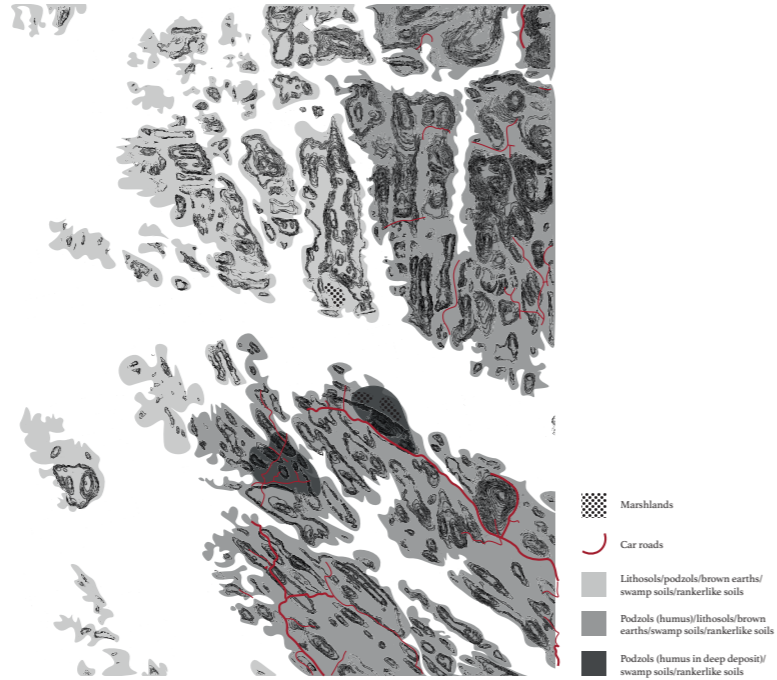
The North Sea is surrounded by multiple refineries. For logistic reasons all of them are located in close proximity of civilised areas. To make sure the sources feeding the refineries within reach, most refineries are located close to the Sea too.

Refineries are industrial sites housing chemical plants, processing a raw product into a 'refined' product, to be used as source of energy. In the supply chain of oil, refineries are part of the downstream phase. Located between water and sea, usually in fragile areas. Areas that are influenced by tides, weather, political regulations and, eventually, climate change.

Refineries are facilities that know great complexity. This causes these sites to have a specific aesthetic. An aesthetic that will not be acknowledged by everyone. A refinery creates a specific landscape, that was not known until short ago. The specific functional, political and aesthetic characteristics of refineries are the reason the proposed project will intervene in one.

The refinery of choice is Mongstad AS. This refinery is of medium size, located in a Fjord in the Southwestern part of Norway. The main reason to choose Mongstad, is its specific aim at being a 'sustainable' pioneer in its field. It does so by investing governmental money in research and testing concerning Carbon Capture and Storage (CCS). The site houses the most innovative CCS research centre, which attracts a lot of attention and international visitors.

1940 - marshlands



2017 - reclaimed land + infrastructure

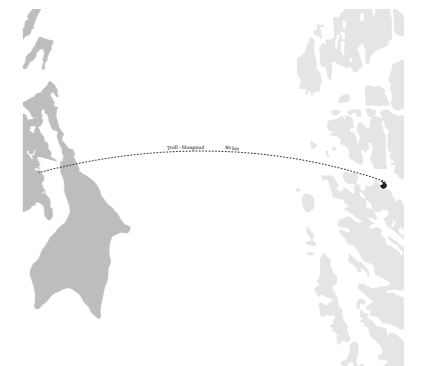
GEOGRAPHIC SITUATION



The Mongstad Refinery is located in a Fjord, approximately 50 kilometers from the city of Bergen. Five kilometers from here, the Fensfjorden debouches in the North Sea.

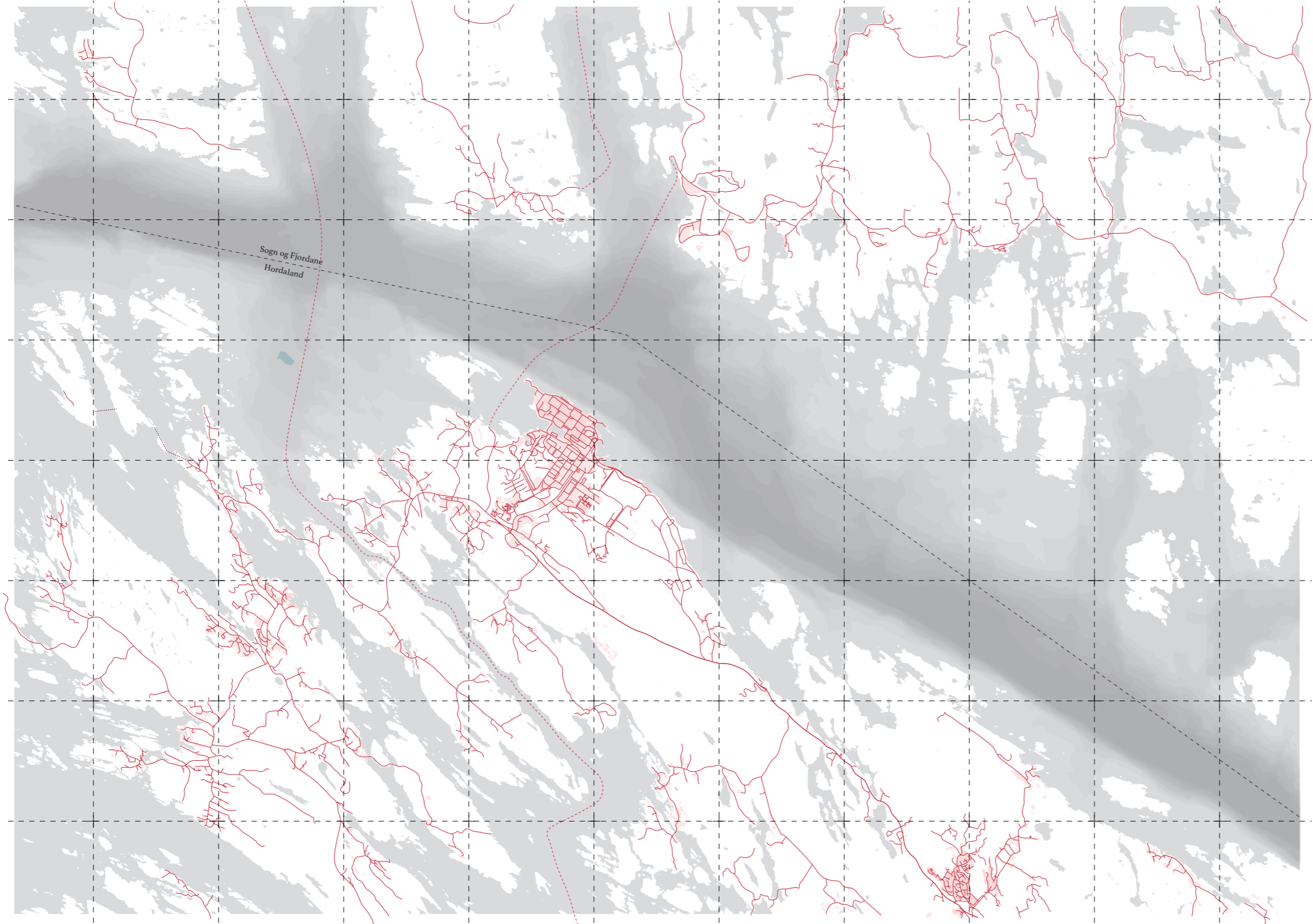
There are several reasons the refinery evolved here. First of all, it's close to the 'troll' oil fields, which has been the main source for crude oil and gas in the past decades. Pipelines connect the refinery directly to these fields. Furthermore, the Fensfjorden is extremely deep and steep so big vessels can easily dock Mongstad's harbour.

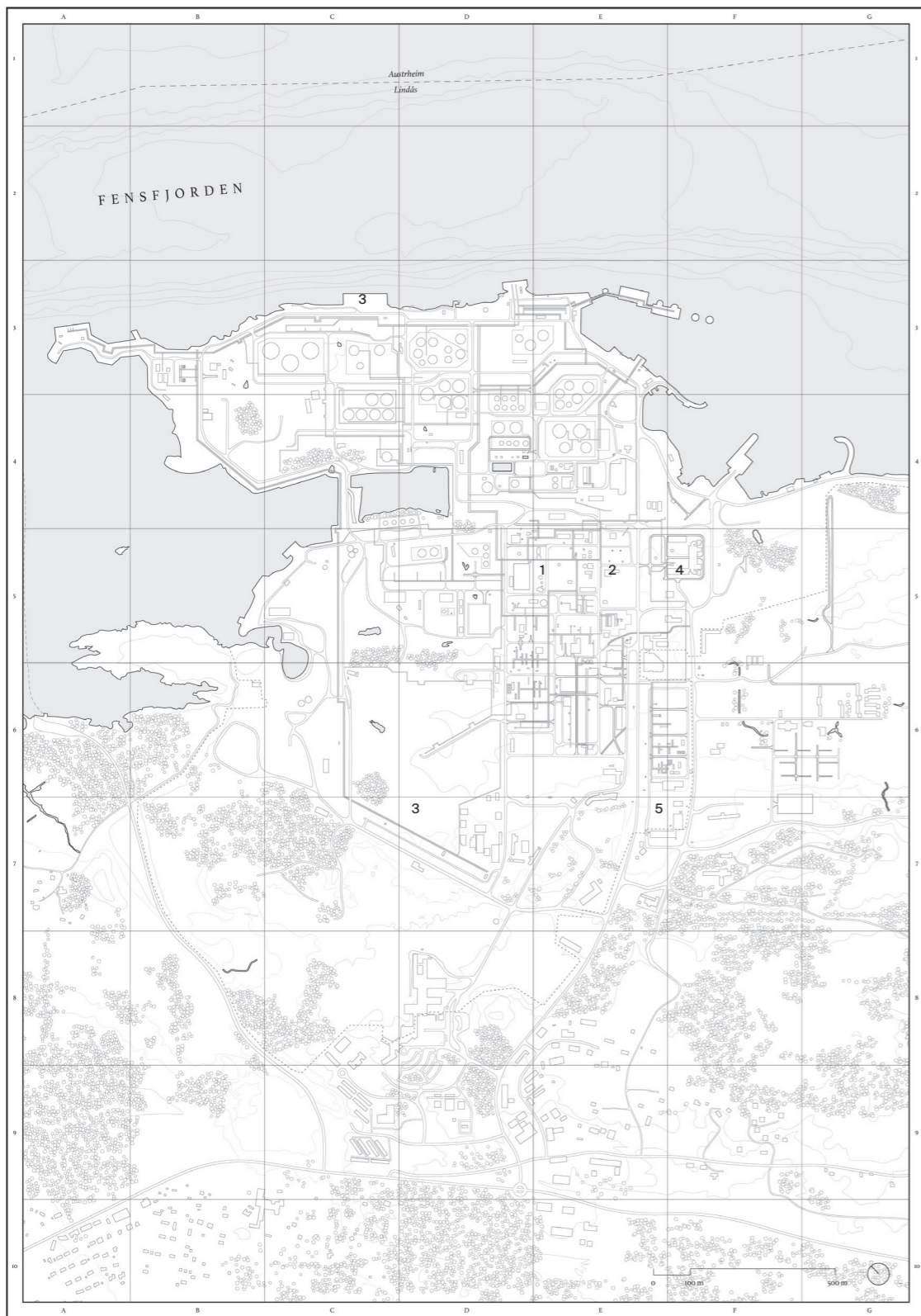
Besides this, Mongstad is located on a piece of land that's relatively flat compared to its surroundings. The size of this land is remarkably big - this has to do with the fact the land hasn't always had this shape. Until the 1960's, the soil of Mongstad consisted of marshlands. After discovery of the Ekofisk field, land has been reclaimed for industrial purposes.



Real distance of Troll oil and gas fields







THE SITE

Mongstad is an industrial site, which has the refinement of oil as main function. Besides the refinery, an NGL (Natural Gas Liquids) processing plant (Vestprosess), a crude oil terminal, a cogeneration plant and world's largest Carbon Capture and Storage (CCS) technology centre (TCM) are located in Mongstad.

1. Refinery (Equinor refining AS) - The main activity on site is the refinement of crude oil. The Mongstad refinery is owned by Equinor, and is the largest of two oil refineries in Norway. Mongstad has a capacity of 12 million tonnes of crude oil per year. Gasoline, diesel and air fuel are the main products after refinement. Around 50% of the production is for export, mainly within Europe.

2. Vestprosess – NGL come to Mongstad through pipelines via Sture from Kollsnes. Here NGL are being split into naphtha, butane and propane. Naphtha is used for petrol production, butane and propane are being exported to petrochemical facilities around the world.

3. MTDA - Mongstad Terminal DA – Mongstad's crude oil terminal holds a large part of all the oil produced by Equinor on the Norwegian continental shelf before being exported. Main customers are in North America, Europe and Asia. Oil comes in through pipelines from Troll B and Troll C. The terminal covers:

- 6 underground halls that can store up to 9.44 million barrels of crude oil.
- Two docks, capable of handling tankers up to 380.000 kg deadweight.
- A separate transshipment vessel capable of handling tankers of up to 440,000 deadweight.

4. CHP – Cogeneration plant – Mongstad heat and power plant was launched in 2010 as an integrated cogeneration system. The plant supplies Mongstad's refinery with energy in the form of electricity, steam and heat. The fuel used in the cogeneration plant is gas extracted from the Troll A platform, which is also led to Mongstad through pipelines via Kollsnes. At maximum utilisation, the cogeneration plant has the capacity to supply 280 megawatts (MW) of electricity and around 350 MW of heat. Because the CHP is not as profitable as expected, it will shut down in the near future.

5. TCM – Technology Centre Mongstad also houses the world's largest technology centre for the development and testing of technologies for CO₂ capture. The facility went into operation in 2013. Nowadays the CCS technique is only tested, but will be applied full scale in the near future .



SITE VISIT

A visit to the site was mandatory to get a grip on the scale of and to become aware of the situation in Mongstad. In the early morning of October 27th, 2017, a guided tour through Mongstad took place.

Starting from the public entrance building, we were guided through the refinery in a Jeep. Jon Halstein Tjore, Equinor employee, served both as supervisor and tourguide. Since we were 5 people concerned with climate change, we started the tour from a quite critical point of view. Our preconceptions were that 1) oil sources would deplete soon, that 2) the area must be very unpleasant to be at and 3) Refining oil is something bad (although we all profit). According to our tourguide we were completely wrong.

As told by Jon, the refinery would serve its purpose for at least multiple decades from now. The main reason is the discovery of a huge new oil field in the North Sea: Jon Sverdrup. This is something Jon was very enthusiastic about. The expectation is that because of extraction of oil from this huge field, at least the next generation of Norwegians can live a wealthy life.

To convince us about the high quality of life in and around the refinery, we were told that crabs from the surrounding waters are edible, and the refinery was home to as many as 20 deer. This was proven when we saw one of them during the tour.

Eventually Jon claimed that, although refining is not very fortunate for the environment, in this area it was done in the most 'sustainable' way possible. The hydropower surplus that Norway has, is being used for Statoil's offshore oil and gas platforms. But what is more revolutionary, is that on site a plant for CCS, carbon capture and storage is to be found, which is in service for CO₂ Technology Centre Mongstad. This centre is a pioneer in the world of CCS and therefore makes Mongstad a place for many important national and international visitors.

From this trip especially the two last arguments made an impression. This got amplified when we continued our trip. We left Mongstad with quite an optimistic feeling: refining oil is not as bad as we thought. If even different animal species can survive in this area..

But the next day we were put with both feet on the ground again when arriving at a beautiful glacier, which was almost melting before our eyes.



PROBLEM STATEMENT / RESEARCH QUESTION

The findings done while researching consecutively some of the most important systems defining the North Sea's territory, the country of Norway in relation to resource management and exploitation and eventually Mongstad as a specific case, can be responded to with an architectural outcome.

In doing so, three main 'problems' should be solved, but it should also be considered that the site has a certain potential.

Problems

- While being of great importance for Norway's economy, Mongstad is still a strictly closed off territory;
- Little to no awareness among inhabitants of the scale of impact to environment;
- A lot of pollution is caused in direct surroundings of Mongstad, and even more worldwide.

Potential

- Mongstad's aim at being a 'sustainable' pioneer;
- Being well connected to sea and mainland;
- Beautifully located in the Fennsfjorden.

When considering these problems, but also the potential of Mongstad, it should be acknowledged that the future of the oil industry is very uncertain. When doing so, the following research question can be posed:

**"How to facilitate a transition in
time, function and space
within the scope of the Mongstad refinery and its potential future?"**

Which can be broken down into the subquestions:

1. How to support a productive, yet more sustainable future for Mongstad?
2. How can different geographical conditions be enhanced within and connected by one infrastructural architectural intervention?
3. How to cause people to critically reflect on oil as an important source of income for Norway?

By answering these question, the aim of the project is as follows:

Creating a flexible building, which bridges the gap between land and water,
industry and nature,
oil and post-oil,
pollution and sustainability,
perception and reality.