Harbour in Transition
A Landscape design for a harbour beyond oil
Master Thesis Landscape Architecture 2017
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Introduction
During my graduation year it took quite some time before I found a project that I considered worth working on. I have a strong urge to work on projects with relevance; projects that really add to the public debate. With climate change and the related problematique I found a topic that is capable of doing so. Climate related problematique is one of the two pillars my fascination in this thesis is built on. The other one is, what I consider landscape architectures biggest power; the capacity to generate new tangible perspectives for wicked problems.

Climate Change and Its Related Problematic

Climate Change and its related problematique is the key assignment for landscape architecture the coming century. The IPCC\(^1\) points out that the consequences of climate change cannot be stopped anymore; we have to adapt. Their definition of adaptation just points out how closely related the core activities of landscape architecture are to the climate problematique. The IPCC defines adaptation as the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”.

Climate change comes accompanied with a wide range of spatial assignments. For the Netherlands probably the most discussed consequence [and assignment] of climate change is sea level rise. In the coming decades the effect of sea level rise will however not be dramatic; quick sea level rise is expected from the start of the twenty second century\(^1\). A climate assignment that asks for more urgent attention of landscape architecture is the energy transition. Especially with the Paris Climate Agreements the urgency of this became very obvious. The European Union committed its selves to a cutback of \([\text{CO}_2]\) emissions of 80-95% by 2050\(^2\). If this commitment is taken seriously, it means a radical transformation of our European energy landscapes, in a matter of decades. In order to realise this ambition action is needed\(^3\). Although there are a few inspiring projects, the field of landscape architecture is relatively silent on this matter\(^3\).

The Power of Landscape Architecture to Generate New Perspectives

Landscape architecture is a discipline of generalists; integrators. Knowing the fundamental principles of many fields landscape architecture is capable of challenging the complex and the wicked by developing new tangible perspectives. It is exactly this integrating and visualising power that is needed to bring the challenging energy ambitions a step closer to realization. The places most impacted by the energy transition are our current energy hubs. The harbour of Rotterdam is one of the biggest global hubs in the distribution of oil\(^4\). A place of high complexity; where economic, social, hydrological and ecological systems are strongly intertwined. A place where transition will hit hard and no specialized discipline can give one single answer. It is here where I as a landscape architect find my perfect thesis assignment.

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The harbour of Rotterdam as a landscape of oil.
(Source photo: unknown)
The harbour of Rotterdam started as a small city harbour, located about 30km of the coast on a branch of the river Meuse. From around 1850 the harbour started to develop rapidly in the direction of the North sea. Nowadays the harbour covers the complete area from the centre of Rotterdam, to the North sea. Making Rotterdam for a short moment the largest harbour in the world. That the harbour of Rotterdam could develop so rapidly is due to its strategic location in the mouth of the Rhine-Meuse delta. In this way connecting the North sea with the vast European hinterland. Especially from the 1950’s onwards the oil sector developed well in the harbour of Rotterdam. The oil sector is currently the most important driver of the harbour of Rotterdam; it is the sector that made the harbour the giant it is today. This success of the oil sector has also a downside. With the energy transition the complete functioning of the harbour of Rotterdam will come under increasing pressure. In the coming decades the harbour has to transform from an oil based harbour to a new kind of harbour, in order to prevent an inevitable downfall. The harbour of Rotterdam is highly invested in. This makes structural transformations expensive. With the coming energy transition historic investments in oil infrastructure will lose (part of) their value. This gives the unique opportunity to rethink the spatial structure of the harbour and its function in the bigger delta, creating a large transformation assignment that forms the basis of this thesis.

THE PARIS CLIMATE AGREEMENTS
For decades now it is known that human emitted greenhouse gasses are the central driver of climate change. A process that probably will cause major disruptions all around the globe. Parallel with this knowledge the understanding developed that the process of climate change can be stopped or slowed down by a reduction in human emitted greenhouse gasses. However until 2015 no serious steps were taken to reduce human emitted greenhouse gasses. With the Paris Climate Agreements of 2015 almost all nations of the world made strong commitments to reduce human emitted greenhouse gasses. Especially the European Union made strong commitments. The European Union promised that by 2050 the member states will cut back their greenhouse emissions with 80-95%, counted from 1990 levels. This commitment will have strong implications for the harbour of Rotterdam, Europe’s largest oil hub. A 80-95% cutback in greenhouse gasses leaves no place for an oil sector of a size that is remotely close to the current oil sector.

A general happiness after the historical Paris Climate agreements were signed (source photo: un.org).
A STEERING POWER IN WATER MANAGEMENT

The harbour of Rotterdam is a steering power in the water management of the Meuse-Rhine estuary. After the floods of 1953 the Dutch government decided to dam the branches of estuary. The plan, known as the Delta werken, provided an almost complete control over the flows of water in the estuary. Due to the importance of direct connection with the sea, the Nieuwe Waterweg, the branch of the estuary that the harbour of Rotterdam is located on, was the only branch not to be closed off. As a result the relatively narrow branch is almost completely responsible for the discharge of the entire river system. It is predicted that in the future this will cause increasing problems, when the water flow will show more extremes. It is very probable that measures have to be taken that increase the control on the water in the estuary at the location of the harbour of Rotterdam. These measures will almost certainly mean a decrease in the connection of the harbour with the river system and the sea.

A LONG HISTORY OF POLLUTION

Soil pollution is especially in the older harbour parts a huge barrier for redevelopment. Until 1987 there was no specific legislation banning soil pollution. Through this absence of legislation in the decades after the development of the harbour soil pollution could build up to extreme levels. The pollution was however not only developed after the realization of the harbour. During the construction of major harbour parts highly polluted dredging silt was used to heighten harbour areas. Resulting in severe pollution up to many metres below surface level.
Oil is the current driver of the largest harbour in Europe; the harbour of Rotterdam. In order to visualise this importance of oil, tracing oil flows is a very effective means. On the next pages you will find three maps visualising the connections between the global oil flows and the harbour of Rotterdam. In size the harbour of Rotterdam is one of the biggest oil hubs in the world and by far the biggest in Europe.

Legend
- Main [oil] harbours
- Ship intensity
- Oil flows [source-destination] *In million tons

*Sources: BP Oil University of California (2008)
INTERMEZZO: Rotterdam as oil hub
Map visualising the crude oil flows on a regional scale. Rotterdam clearly stands out as the central hub.
Map visualising the oil industry in the harbour of Rotterdam. It is clearly visible that the industry covers most of the central harbour area.

Legend
- Yellow: Oil pipelines on land
- Orange: Oil pipelines on sea
- Blue: Pipelines

*Sources: The Port of Rotterdam Statistics (2015)
The energy transition and the impact it will have on the harbour of Rotterdam is the main problem of this thesis. Developing a smart strategy to use the transition to strengthen the future of the harbour is the main purpose of this thesis. One might think, why is this a job for a landscape architect? Harbour areas are highly complex and functional in character. Landscape architects only have basic knowledge of the complex economic, hydrologic and technical processes that make the harbour. This complexity is exactly the reason why a landscape architect can make difference here. Landscape architects are generalists, integrators by nature. And it is exactly this integrative power that gives landscape architecture the capacity to deal with highly complex areas, constantly under pressure of changing dynamics. In the past years there have been countless reports expressing their concern on the functioning and vitality of the harbour and its related systems. Examples of this are publications of the province of South-Holland, declaring the chemical [oil] industry in the harbour ‘at the end of its life-cycle’. Another example is a report by hydrologist labelling the bigger delta as not sustainable. What all of these studies have in common is that they only address one specific scientific field, making them hard to integrate in a spatial strategy for the harbour.

I think landscape architecture is needed to draw a combined picture to start a constructive discussion that is desperately needed. As a landscape architect I have the ability to:
- Make complex problems understandable;
- Look from different lenses;
- Deal with the aspect of time, dynamics and uncertainty;
- Look for solutions that physically work;
- Use design as a way to explore, inspire and break through impasses.

The purpose of the thesis is thus to confront the transition as a landscape architect. I call this a landscape architectural approach. Ultimately finding a working mix between future, existing, ecology, economy, nature, culture, vision and realism. I believe that such a mix is needed in the anticipation of the coming transition. And that I as a mediator can provide the positive and realistic perspective that is needed to start a discussion to keep the harbour the source of life that it is.
1.4 Problem statement and research questions

PROBLEM STATEMENT
The harbour of Rotterdam is one of the biggest global hubs in the distribution of oil. Almost seventy percent of the total surface of the harbour is covered by oil and oil related industry. Due to the Paris-agreements this landscape of oil will change dramatically in the coming decades. The European commission agreed that the CO$_2$-emission of the member states should be reduced by 80-95% in 2050, cutting away the foundations of viable fossil industry. In order to prevent an inevitable downfall, the harbour of Rotterdam should anticipate the coming transition, by developing a necessary spatial strategy to structure the transition.

RESEARCH GOAL
The main goal of this research is to design the coming transition of the harbour of Rotterdam as a landscape architect. This implies that I focus on the spatial implications of the transition. And that I approach the problem statement from a natural and system perspective as well as from a social economic perspective. To achieve this, the goals of this research are:

- Get a grip on the impact of the oil industry on the harbour of Rotterdam and get a grip on what the consequences of the energy transition are on the harbour of Rotterdam.
- Understand how the harbour landscape functions as a system and what the relations of this systems are with its context.
- Create a design for the harbour that anticipates the coming energy transition and incorporates system interests on the regional scale, using the ecological and economic dynamics.

RESEARCH QUESTION
How can the harbour of Rotterdam anticipate the coming energy transition in such a way that the regional scale system interests are incorporated and that the harbour will be ecologically and economically healthier, using a landscape-based approach?

The following sub-questions help to answer this question:

1. How should the transition of the harbour of Rotterdam be handled argued from a landscape perspective? [Ch2]
2. What is the impact of the energy transition on the development of the harbour of Rotterdam? [Ch3]
3. How can a strategy be designed in such a way that it deals with the uncertainty of the landscape system and fits within the harbour landscape? [Ch 4-5]
#H2

Theoretical framework
2.1 Introduction

Summarising from the first chapter it can be concluded that the problems/assignment of
the Rotterdam harbour area resolves around the following statements:

- The coming decades most [fossil] energy related industry will disappear from the har-
  bour as an effect of the energy transition. This will create major vacancies across the
  complete extent of the harbour. A spatial strategy is needed to structure this process.
- Due to the negative predictions a decades long decline and stagnation is looming for
  the harbour area. Radical new perspectives are needed to turn the tide.

This chapter discusses how we as landscape architects can deal with the statements above.
Sub-question one stands central to this purpose: **How should the transition of the harbour
of Rotterdam be handled argued from a landscape perspective?** This chapter aims to setup
a theoretical framework to guide the quest to formulate an answer to the problematique of
the harbour area. The framework in this chapter is sketches along three questions:

- What can we learn from previous [energy] transitions? [2.2]
- How can we use a landscape-based approach to develop a spatial strategy? [2.3]
- How can landscape architecture be used to help create new perspectives? [2.4]
2.2 A short history of [energy] transitions

Transition is one of the central words within my research. But what is the nature of transitions? And what can we learn from previous (energy) transitions?

TRANSITIONS AND SPATIAL IMPLICATION
Vaclav Smill describes energy transitions as a ‘long-term structural change in energy systems’. Energy transitions are not something new. In the Netherlands we experienced several energy transitions. Transitions that always transformed the complete landscape. The first energy landscape was a landscape of peat and coppice woods. After 1900 this changed into a landscape based on coal. With this transition the complete landscape changed. Mines where dug and forests where planted. In the second half of the twentieth century another transition was made towards an economy based on electricity, oil and gas. This again had great implications for the landscape. The mines where no longer needed, together with the wood of the forests that was used as support material in the mines.

With the energy transition that we face today, again, the landscape will change dramatically. Especially since this transition features a shift from a centralized energy production to a more decentralized energy production. This shift will put extra pressure on current fossil hubs like the harbour of Rotterdam. An infrastructure based on a centralized energy production.

LEARNING FROM PREVIOUS TRANSITIONS
The energy transition from coal to electricity, oil and gas in the second half of the twentieth century, resulted in the closing of the coal mines in South-Limburg. An event that we can learn from with regards to the transition of the harbour of Rotterdam. The coal mines where really important for the region South-Limburg as a source of employment.

This is similar to the function of the harbour of Rotterdam for the region Rotterdam.

The Limburg coal mines
The production of coal in the Netherlands dates back to the twelfth century. After the nineteenth century the production started to increase rapidly, with a peak in the twentieth century. All the Dutch coal mines where located in a relatively small area in South-Limburg. At the end of 1965 approximately 53.000 people were employed by the Dutch coal mines and another 30.000 jobs were directly related to the coal industry.

Because of the intensity of the mining in the Limburg region, the complete economy was strongly related to the mining industry. In 1974 the last mine would however close. In 1965 the Dutch national government made the decision that in a period of ten years the coal mines had to be closed, rendering virtually 36% (75.000 people) of the total population jobless. In order to deal with this problem the government adopted a three step strategy:
• Gradually limit the coal production, by closure of mines;
• Support the mines during the process of closing;
• Restructure the industry in South-Limburg.

Especially this last point was very important. In order to make the industry more divers, the government developed a whole set of subsidies for company’s employing former miners. Next to this several governmental offices where assigned to the area. This strategy was so successful that the mines that where still open after 1970 had to attract foreign workers in order to keep the mines open. After an apparent swift solution of the employment problems, the area today, still deals with the social problems as a result of the closing of the mines.

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What can we learn from this
Although the scale of the impact of the closing of the mines on the Limburg region is of another magnitude as the impact of the energy transition on the Rotterdam region, there are similarities between the two cases. One aspect is a long term strategy. We already know that the oil industry will shrink in the coming years. Now is the time to develop plans for a harbour after oil. With the oil industry the harbour will lose an important means of existence. In order to keep up the relevance of the harbour a new ingredient should be added to the area. The government is the party that is capable of creating such large new incentives.

Miners working in one of the Limburg coalmines that closed between 1965 and 1974. (Source: Klein, A. Nederlands Fotomuseum)
2.3 The idea of landscape-based design

This third paragraph discusses the idea of landscape-based design, and how it can be used to build a spatial transition strategy for the harbour of Rotterdam.

THE HARBOUR AS A COMPLEX LANDSCAPE SYSTEM
In order to be able to design with the complexity and the dynamics of the harbour landscape it is crucial to consider the landscape to be a complex system. A system consisting of subsystems with their own dynamics and speed of change. The landscape system is a physical space that is structured as a configuration of networks and locations. All these networks have in turn different levels of organisation on multiple spatial dimensions. In this it is crucial to understand the landscape as a long-term structure that is changing slowly. Within the landscape three levels of dynamics can be distinguished. The first level is related to the natural environment and is characterised by slow processes and natural cycles. The next level is related to long-term social economic and cultural layers. The last level exists out of short-term events, related to people and politics. The transition of the harbour is mainly related to the last two levels of dynamics.

LANDSCAPE-BASED DESIGN
In the past century the landscape has become increasingly complex, dynamic and uncertain. Societal and environmental processes put in an ever increasing pace pressure on our landscapes to change. This pressure results in a strong uncertainty on the direction of development. A method to deal with this increasing complexity and uncertainty in the landscape and a tool to get grip on the processes that initiate change is landscape-based design. A landscape-based (design) strategy could be described as “an open-ended strategy, aimed at protecting resources, guiding developments and setting up future conditions for spatial development by means of landscape planning and design” (Nijhuis, 2017). In landscape-based approaches the goal is to determine the most beneficial action for sustainable development of an area. Within landscape-based design local and regional landscape conditions form the bases on which the strategy is build.

THE LANDSCAPE AS INFRASTRUCTURE
A relatively new approach within landscape-based design is the concept of landscape infrastructures. In this concept “[landscape] infrastructures are considered to be armatures for urban development and for facilitating functional, social and ecological interactions” (Nijhuis & Jauslin, 2015). When it comes to harbour landscapes the concept of landscape infrastructures is a powerful tool for analysis and for the development of an inclusive strategy. Harbour areas are landscapes where developments can be very obvious related to the conditions created by landscape infrastructures. The very reason that the harbour of Rotterdam could grow out into a world harbour, is because of the conditions created by the river Rhine, that connects the North Sea to the vast European hinterland. In fact a harbour could be considered to be a constellation of infrastructures on different scales and with different relations towards each other and towards places inside and outside the harbour. This constellation of flows and spaces is indicated by Nijhuis & Jauslin as ‘flowscape’. The real power of the concept of landscape infrastructures for harbour areas is that it allows us to see, to understand and to deploy the formative powers of the infrastructures that make the harbour. In the concept, through the means of infrastructure, ecological and economic processes are employed as design tools for


the transformation of territory⁶. The formative power of infrastructures is found where they overlap and conditions for development are created³. A landscape infrastructural design could be described as a framework created by [landscape] infrastructures that direct and facilitate urban development and stimulate social and ecological interaction. This framework establishes a distinctive relation between form, process and content through the scales of the landscape⁷. Within this thesis the concept of landscape infrastructure stands central as a landscape based approach.

STRATEGIC PLANNING
Landscape-based approaches always involve aspects of strategic planning and they often result in strategic projects. According to Stouten (2010)¹⁴ strategic projects can be described as projects “that aim to make a larger-scale impact on the transformation and innovation of spatial, economic and social development in a wider context than the project itself.”

Landscape infrastructures: European harbours developed as a result of the conditions created by rivers; namely connecting seas with hinterland.
(Own illustration)
Basic landscape conditions determine directly or indirectly where activities take place. Landscape architecture has the unique capability to alter these conditions, ultimately allowing a different use of the landscape. This fourth paragraph discusses the power of landscape architecture to create new perspectives.

LANDSCAPE CONDITIONS
As discussed in the third paragraph most developments can be directly related to the basic properties of the landscape. Large harbours develop on the crossroads of waterways, cities develop along transport infrastructures and office clusters develop near train stations. By altering one or two of these basic properties an area can become suitable for a new type of use. In the Ruhr region in Germany the altering of basic conditions of the landscape was the basis to revitalise a complete region. In the continuation of this paragraph the case of the Ruhr region is discussed as an example of how landscape architecture can be used to create new perspectives for a troubled region.

CASE EMSCHER PARK

Historical background
The Ruhr region, is a polycentric urban area, located in the state North Rhine-Westphalia. The region developed around the river Ruhr. For decades the Ruhr region functioned as the industrial heartland of Germany. The growth of the Ruhr region started in the nineteenth century. Through its richness in coal and its strategical location along water roads it could attract major industries. With the growth of the industries also the adjacent cities grew. This growth continued until the 1950’s. From the 1950’s onwards the growth started to stagnate, as a result of increasing competition caused by cheap oil and gas and globalisation. What followed was a decades long economic and social decline, in which the population of the region dropped sharply.

The IBA Emscher Park
As a result of more than a hundred years of heavy industry the landscape was completely fragmented by infrastructure, brownfields and polluted creeks. Also the urban quality was poor. In the end of the 1980’s the state government initiated the International Building Exposition (IBA) Emscher Park. The idea of the plan that came with the exposition was to turn the battered region into a huge landscape park. In the next decade, brownfields where purchased, forest was planted, the river was cleaned, parks were made and bicycle paths where developed. In total the effort costed billions in public and private money. Next to an upgrade of the landscape also programs where setup to improve housing and programs to attract work.

The effects
Although the region today still has social and environmental problems as a result of (the loss of) industry. The Emscher Park project was a huge step for the region to regain proud and with it perspective for the future. After the adoption of the strategy new companies where attracted to the region and the population started growing again after decades of decline.

WHAT TO LEARN FROM IT
A main conclusion for this thesis that can be drawn from the case Emscher Park is that changing the landscape image and quality can generate a broad impulse for development of an area. In the Ruhr region the troubled landscape became a burden, standing in the way for new development. By turning the landscape into something positive, the perspective changed and the landscape became a unique selling point.

Photo taken in landscape park Duisburg-Nord, part of Emscher Park. In the park an old industrial site is turned into a unique landscape park (source photo: Wohlrab, M.).
In the third paragraph the idea of landscape-based design was introduced. This last paragraph proposes a research method based on the principals of the landscape-based approach. During my research I used the method as a guide. In this thesis the phases that I distinguish are however not directly translated into corresponding chapters. The method allowed me to reflect on the problematique of the harbour in a very inclusive way. For reasons of clarity and directness I decided however that it would not be effective to structure this thesis in the same way.

THREE CRUCIAL PHASES
When analysing key-notions of the landscape-based approach at least three necessary phases for a design method can be distinguished\(^\text{10}\). The first phase is about getting familiar with the landscape [object] of research, its actors and its future developments. In the second phase synchronization stands central; divers interests and principals are prioritised and translated in a common assignment. In the last phase an inclusive landscape-based strategy is formulated. Figure 2.5.1 gives an overview of the complete methodology used in this thesis.

THE ANALYSIS PHASE
Landscape-based approaches are very inclusive in character. They incorporate interests of all sub-systems and guide these interests into the most sustainable\(^\text{13}\) and beneficial developments based on the local landscape characteristics\(^\text{4}\). For this reason of inclusiveness the initial analysis of a landscape-based strategy is quite broad. The first step of the analysis consists of an analysis of the development of the landscape system of which the harbour is a part (retrospective or historic design research). In the following step the main landscape infrastructures are identified and is researched how they developed and how they relate to each other. The third step identifies the main actors in the landscape and what their plans and interests are. Next to this the probable future developments are investigated (scenario study).

THE SYNCHRONISATION PHASE
In every congruent design and spatial strategy there is a central motive or goal that gives direction to the rest of the design or strategy\(^\text{11}\). For a landscape-based strategy this means that synchronisation of interests is needed; one main assignment for the transformation of the harbour area should be formulated. Next to this central assignment secondary assignments, opportunities and threads can be formulated, that need to be addressed in the spatial strategy and that can help build the strategy. In my thesis this is translated to a central assignment posed in the problem statement of chapter one and the selection of the program used in the strategy.

THE DESIGN PHASE
In this phase the concept of landscape infrastructure becomes the central theme. Now that there is a clear common assignment and landscape infrastructures are selected that relate to the main assignment program. With these selected infrastructures an intervention is made, in such a way, that the main assignment is solved and a durable\(^\text{13}\) framework is created that sets up conditions to solve the related assignments.


\(^\text{12}\) The method use in this step is tracing historical maps in three layers, related to McHargs (1966) layered-approach: the sub-strate, infrastructures and land-use patterns. After a broad initial analysis relevant landscape infrastructures are analysed more in-depth.

\(^\text{13}\) Sustainable and durable: The words durable and sustainable are often incorrectly used as synonyms. The word durable should be used in a context of materials and structures and sustainable in situations that have social and environmental aspects to it. For this reason things can be (material) durable but not sustainable at het same time.
Figure 2.5.1
Methodology overview

**Theoretical framework**
- Reference study
- Landscape-based strategies
- Method

**SYNCHRONISATION**
- The type of strategy
- Program of the strategy
- Spatial characteristics strategy

**ANALYSIS**

**Theoretical framework**
- Reference study
- Landscape-based strategies
- Method

**Site analysis**
- Harbour area
- Context

**Analysis future**
- Scenario study harbour area

**Other analysis**
- Analysis spatial characteristics
3.1 Introduction

In the second chapter a theoretical framework was sketched on how to deal with the transition of the harbour of Rotterdam. The idea of landscape-based strategies was introduced as the way forward. In the last paragraph it was combined into a method.

This chapter contains a crucial step introduced in the method; the landscape analysis. In the analysis the harbour area and its context is analysed on a wide range of topics. The second sub-question stands central to this purpose. The question is addressed in the following steps:

- In the second paragraph the harbour landscape as a landscape architectonic object is discussed.
- The third paragraph analysis the working of the harbour machine.
- Paragraph four focusses on that assignments that face the harbour from a regional perspective.
- In the fifth paragraph the impact of the energy transition for the harbour is discussed through a scenario study.
- The chapter concludes with a spatial diagnoses of the harbour area and its future development.
# H3

Landscape analysis
3.2 The harbour landscape

The landscape can be described as a collection of system with each their own dynamics and speed of development. In every landscape this unique collection of landscape systems is reflected in a characteristic spatial layout and in unique landscape architectonic characteristics. In this paragraph the unique landscape architectonic characteristics of the harbour landscape are discussed.

3.2.1 A HISTORY OF RAPID GROWTH

It is important to study landscape systems over time. A landscape system is never finished, they are always in development. This paragraph starts with an overview of the development of the harbour landscape as a whole.

**From 1850-2015**

Around 1850 the harbour of Rotterdam was just a small city harbour, located about 30 kilometres inland. A good one hundred and fifty years later that same harbour extends almost ten kilometres into the sea; stretching out over approximately forty kilometres. During this one and a half century of growth
the former polder landscape was completely erased. The original landscape of polders and dikes was covered with a five metre layer of sand and clay, in which huge harbour reservoirs were dug. The main map shows this process of growth with a series of transparent layers.

The oil boom
From about the 1950's the harbour as we know it now developed. Especially between 1950 and 1975 the harbour expanded rapidly, establishing the areas of the harbour currently in use by the oil [related] industry. That the harbour could grow so rapidly was mainly based on the growing demand for oil and oil products in Germany and Belgium.

Legend
- River transformations (>1850)
- Old dikes (>1850)
- Current dikes

*Sources: Tapotijdreis.nl
3.2.2 STRUCTURE OF THE LANDSCAPE

**Infrastructure and underground**
The typical landscape form of the harbour of Rotterdam is a product of an interplay between the underground, water infrastructure and road/rail infrastructure. When the harbour was created the surface level was raised five metres, creating a new landscape without any historical traces. On this blank paper, water and road/rail infrastructure was superimposed.

**Villages as islands**
With the construction of the harbour existing villages where not raised. As a result the villages lay like islands in the harbour tissue. This island-effect is emphasised by the superposition of large road infrastructure around the villages.

**Barriers and edges**
All the rail and road infrastructure is concentrated in one belt in the south of the harbour. Creating a strong border with the adjacent landscapes.

**A lobed structure**
Because of the interplay between water infrastructure in the north and road and rail infrastructure in the south the harbour has a characteristic lobed structure.

4. **Water dictates**
Image showing the main water and road edges. Clearly visible is that the water bodies carve into the harbour landscape.

3. **Water and roads**
The water and road infrastructure is highly intertwined.

2. **The underground**
The harbour area was raised 5 metres, creating a blank new underground. The existing villages where not raised.

1. **The basic landscape structures**
that make the harbour landscape
Abstraction of space and mass in the landscape (mass is black).
The spatiality of the landscape

The map on the left shows an abstraction of the space and mass in the harbour and the adjacent landscapes.

In general two things can be stated regarding the spatiality of the harbour landscape. First, the harbour landscape is spatially quite dense. And second, in general the eastern parts of the harbour are denser than the western parts of the harbour.

In the east the harbour connects to the spatially dense urban landscape of Rotterdam. In the middle and the west the harbour borders spatially open polder landscapes. The northern peat-polder is however getting spatially denser by the expansion of the greenhouse area the Westland.
Pernis as a spatial island in the harbour landscape (source photos: Port of Rotterdam).

The infrastructural belt that marks the edge of the landscape (source photos: Port of Rotterdam).
The contrast between the open polders and the spatially close harbour (source photos: Port of Rotterdam).
Conclusion

A contrasting landscape

Overall the harbour can be described as a landscape of contrast; contrast with the bordering landscapes. When the harbour was constructed the surface level was raised, leaving the existing villages like spatial islands in the harbour tissue. The harbour landscape contrast the bordering landscapes in height and spatial density. The contrast is emphasised by clear borders of the harbour landscape formed by water and road infrastructure.
Five different spatiality’s

The harbour of Rotterdam extends along the river Meuse for almost forty kilometres. Within this stretch of land there are many different uses, resulting in different landscape forms and spatiality’s. It does for this reason not make much sense to describe the complete harbour as one landscape type although the harbour landscape as a whole is very distinct in the landscape of South Holland. In fact, based on spatiality at least five landscape types can be distinguished.

This are the following landscape types: the river landscape, the container harbours, the oil harbour, warehousing landscapes and the new harbour. For these five landscape types in general can be said that the oldest harbour parts are the spatially densest parts. The eastern parts of the harbour are the oldest and the western parts are the youngest.
The river landscape: The river and the connecting harbour basins are wide and open. The story they tell is about the opposite site, far in the distance.

The container harbours: An older part of the harbour that can be described as a mosaic of open asphalt surfaces, dense container fields, cranes and train tracks. The landscape type is generally spatially dense.

The oil harbour: A grid-like landscape consisting of rhythmic placed storage tanks, pipelines, chimneys and small dikes. The landscape type is in generally spatially dense, the eastern parts are the densest.

Warehousing landscapes: landscapes consisting out of a mix of warehouses and road infrastructure. In typology this landscape type resembles archetypical Dutch business areas. The areas are spatially dense.

The new harbour: Recently constructed parts of the harbour. A majority of the land is still barren, the developed parts are huge in scale. The landscape can be described as spatially open.
Map showing an abstraction of the most important forms of the landscape.
The morphology of the landscape
A landscape of objects

The drawing on the left describes the morphology of the harbour and the adjacent landscapes. The zoom in show the finer texture of the different landscapes.

What we can learn from this exercise is the distinctness of the character of the harbour landscape. Where the other landscapes consist of a complex mix of different landscape layers that interact and influence each other, the harbour landscape seems like a field with objects placed on top of it.

This has much to do with the difference in development history between the harbour and the adjacent landscapes. The adjacent landscapes developed during many ages in which the landscapes were changed and tweaked. Creating a complex mix of new and old landscape structures. The harbour area on the other hand was developed at once. The existing landscape was covered in a thick layer of sand and clay. On top of this blank paper functional objects and connecting infrastructure were super imposed. Creating a functional landscape with the aesthetics of a circuit board.
The objects of the harbour

Everything is a landmark

As stated on the previous page, the harbour is a landscape of objects. And almost every object in the harbour would if placed in a different context function as a landmark. A large oil tank is 80 metre in diameter and 20 metre high; in volume larger than the faculty of architecture (Tu Delft). Every industry has its own landmarks (see pictures); the oil industry has refineries and oil tanks, there are large office buildings, large warehouses, chemical plants, powerplants, cranes for transhipment and large structures that support harbour functions, for instance bridges.
In the harbour every structure is a landmark.
(source photo: P. Nijhuis).
**Conclusion spatial analysis**
The analysis in this sub-paragraph showed that the spatiality and the structure of the harbour is strongly distinct from the structure and spatiality of the adjacent landscapes. Although that within the harbour several sub-landscapes can be identified, there are certain characteristics that are typical for the harbour landscape.

**A landscape as a circuit board**
The main characteristic is the idea of the surface as a field with objects super imposed on it; a landscape as a circuit board. Functional object connected by material flows in between them. The spatiality as a negative of the objects and infrastructure placed on the field.
Contrasting conditions

Soil and groundwater conditions are the main influencers of the flora and fauna that naturally would develop in a certain area. For vegetation this is often pointed out as the ‘potential natural vegetation’. The potential natural vegetation of the harbour area is quite different from the adjacent landscapes. The section below shows the typical landscape south from the harbour, the harbour itself and the landscape north of the harbour. When the harbour was developed a layer of 5 metres sand and clay was put on top of the existing clay soil, creating a dryer and more drained soil. As a result a dryer vegetation of for instance oak, birch and lime tree can develop here.

This in contrast to the wet polder landscapes around. In the clay polder south of the harbour the soil is a bit dryer, here a vegetation of elm and ash can develop. Where the northern peat polder is much wetter. Here the vegetation is limited to species as willow and alder.
On Landtong Rozenburg, the high and dry conditions, in combination with sea influence resulted in a dune-like vegetation. (source photo: R. v/d Waal).
3.3 The harbour machine

The scenario study of paragraph 3.3.1 shows a detailed spatial translation of the harbour area. A thorough analysis of the harbour ‘engine’ formed together with the written scenario the basis of this. This intermezzo introduces the basics of this harbour engine; the system that makes the harbour function.

FOUR MAIN INFRASTRUCTURES
Four main infrastructures are responsible for the functioning of the harbour; roads (highway), railways, waterways and pipelines. In cargo volume waterways and pipelines are by far the most important infrastructures. The railways, highway and pipelines are all combined in a thick infrastructural belt on the south side of the harbour. The main waterway (Maas) generates excess to the north side of the harbour, creating a highly intertwined network of infrastructures, enabling a rapid transhipment of goods. When in the future the importance of oil declines in the harbour, also the importance of pipelines will decrease.
THE TRANSHIPMENT
Modern harbours are infrastructures developed for the transhipment of goods, from one infrastructure to another. In the images on this page two important transhipment ways are visualised. The first way [1] shows the transhipment of goods from sea vessels to smaller inland ships. This transhipment happens in special transhipment zones. For this type of transhipment direct connection from the river to the North sea is important. If this connection is blocked this important transhipment movement gets more difficult.

Two [2] shows the process of crude oil transhipment. In this process crude oil is pumped from a ship, through pipelines, to a refinery terminal [storage]. Next it is pumped to a refinery. After the oil is refined the new products are pumped through extensive pipeline systems to other destinations in Europe.
Transhipment zone

Oil terminal

Crude oil storage

Refinery
The harbour landscape stands not on itself. Landscape systems of the harbour and the adjacent landscapes are highly intertwined. A structural change in the harbour can have negative consequences in adjacent areas and vice versa. For this reason it is important to get an overview of the most important transformation assignments in the harbour and the regional landscape systems that relate to the harbour.

3.4.1 WATER MANAGEMENT AND HARBOR ACTIVITIES; A FRICTIONAL RELATIONSHIP

The harbour of Rotterdam is positioned in the mouth of the Meuse-Rhine delta. This position gives the harbour a direct connection to the North sea and the vast European hinterland. It is due to this strategic position that the harbour of Rotterdam could develop into one of the largest ports in the world\(^2\). From this argumentation it doesn’t come as a surprise that the harbour of Rotterdam is a steering power in the water management of the Meuse-Rhine estuary (Friocourt, Kuijper & Leung, 2014)\(^3\). After the floods of 1953 the Dutch government decided to dam the branches of estuary. The plan, known as the Delta werken, provided an almost complete control over the flows of water in the estuary (Meyer & Nijhuis, 2016)\(^4\). Due to the importance of direct connection with the sea, the Nieuwe Waterweg, the branch of the estuary that the harbour of Rotterdam is located on, was the only branch not to be closed off. As a result the relatively narrow branch is almost completely responsible for the discharge of the entire river system\(^3\). It is predicted that in the future this will cause increasing problems, when the water flow will show more extremes\(^3\). Taking in account the effects of climate change, many experts expect that it will be necessary to close off the Nieuwe Waterweg with a (half open) dam\(^3\). For the long-term planning of the harbour it is necessary to take in account the placing of this dam.


The harbour area itself is relatively high, but the areas north of the harbour (Rotterdam) lie very low, making them vulnerable for divers water problems\(^3\) (source image: AHN).
The water dynamics in the delta between 1950-2017. All branches are closed off, except for the Nieuwe Waterweg. Now almost completely responsible for the discharge of the river water. (map: edited from Nijhuis, 2010)

The water dynamics in the delta between 1850-1950. The complete delta has a function in the discharge of river water. (map: edited from Nijhuis, 2010)
Map showing the water discharge of the Meuse-Rhine river system. Most of the water is flowing through the harbour of Rotterdam, a situation that is not sustainable in the light of climate change (source map: own).
3.4.2 THE URBAN

The development of Rotterdam

Today Rotterdam forms an almost uninterrupted urban tissue with neighbouring towns as Schiedam and Vlaardingen, covering vast areas of land. It was not always like that. In 1850 Rotterdam was just a relatively small city along the banks off the Meuse, it was in fact not much larger than the city of Den Brielle, south west of Rotterdam. From 1850 onwards Rotterdam and adjacent towns started to develop rapidly, fuelled by the growth of the harbour. Especially after world war two Rotterdam grew exponentially. The figure at the right shows the growth of Rotterdam in different shades of grey (the darker the older).

Tight municipal borders

As a result of the fast growth of both the harbour and the urban tissue of Rotterdam there is not much space for Rotterdam to build within its municipal borders. In its search for space Rotterdam looks now more often to the existing urban tissue then trying to expand. In a recent referendum Rotterdammers could vote on the redevelopment of old city parts. Part of the plans was also to densify the area (increase the amount of houses)⁵.

Harbours have space

In the search for space Rotterdam has also increasing attention for the redevelopment of old harbour areas. Harbour areas lay often relatively central in the city, making them ideal for redevelopment into urban functions. For now Rotterdam focusses most on the harbour areas closest to the city, such as the Keilehaven and the Lekhaven but in the longer future Rotterdam might also have to look to the harbours near Pernis and Heiplaat. Especially since the Dutch CBS expects that the Netherlands and in particular the Randstad will see strong population growth until at least 2040⁶.

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Map showing the dense urban tissue of Rotterdam and the restraining municipal borders (source map: own illustration).

The development of Rotterdam from 1850 to 2015, the darker the grey the older the urban tissue is (source image: own illustration).
3.4.3 GREEN AND RECREATION

A scattered landscape

Rotterdam is part of a highly urbanised region. The rapid urban growth in the last decades consumed most open natural space between Rotterdam and adjacent towns. What is left is a rest-landscape; a scattered landscape consisting of open polder landscape and urbanisation. These scattered pieces of green have little natural and recreational potential. Since a few years Rotterdam has more attention for the lack of nature in and around the city. As a result the recreational potential of several polder areas are improved, with the creation of new parks.

No large landscapes of quality

Next to a relative lack of urban green Rotterdam lacks also excess to large scale nature of quality. The closest landscapes of natural and recreational quality are the Biesbosch and the coastal zone along the North Sea. In the current situation Rotterdam is separated from these landscapes by dense urban and industrial tissues.

From this an assignment can be deviated for the harbour area. How can the harbour be used to improve the recreational possibilities of the landscape?


Photo of a rest-landscape that is difficult accessible for recreation. The photo is taken towards Rotterdam (source photo: Lennard Peters).
3.4.4 INFRASTRUCTURE: IS THE HARBOUR WELL CONNECTED?

**Infrastructure based on car and boat**

Harbours are in itself infrastructures; infrastructures for transhipment. Harbours are nodes where infrastructure of different kinds come together. For the harbour of Rotterdam these infrastructures are pipelines, railways, roads and waterways (see also chapter 3.3). The infrastructural model of the harbour of Rotterdam is quite straightforward; there is a waterway, south of the waterway there is a belt with road and rail infrastructure and in between it there is the harbour (see image below).

**Infrastructure as barrier**

The downside of these strong east-west running infrastructures is that they have a strong working as barrier in the south-north direction. There are only a few crossings that allow access to the harbour area or through the harbour area. This lack of access is especially valid for slow traffic (bicycle).

**No public transport**

It is an ambition of the harbour company to attract more [high] skilled work to the harbour. It is known that these kinds of businesses need a high quality work environment. Good public transport and a well-functioning cycle infrastructure is an important condition for this. As the map at the right shows, the public transport infrastructure in the harbour is poorly arranged. It takes one hour and several means of transport to reach the centre of Rozenburg from the centre of Rotterdam. Next to this Rozenburg is the furthest one can get into the harbour with public transport.

A clear assignment that can be deviated from this is that if the harbour wants to upgrade its working environment, the introduction/improvement of public transport in the harbour is necessary.

*Maps showing the structure of the infrastructure in the harbour (source map: own illustration).*
Map showing the connectivity between the centre of Rotterdam and the harbour for bicycles and public transport (source map: own illustration).
SOIL POLLUTION: A MAJOR RESTRICTION

Two parts
Soil pollution is a major factor in the redevelopment of the harbour. Without intervention major harbour areas cannot be used for any new purpose. For soil pollution the harbour can roughly be divided into two parts; the area east of Rozenburg that is highly polluted and the area west of Rozenburg that is lightly polluted (see map below).

A long history of pollution
Soil pollution is especially in the older harbour parts a huge barrier for redevelopment. Until 1987 there was no specific legislation banning soil pollution. Through this absence of legislation in the decades after the development of the harbour soil pollution could built up to high levels. The pollution was however not only developed after the realization of the harbour. During the construction of major harbour parts highly polluted dredging silt was used to heighten harbour areas. Resulting in severe pollution up too many metres below surface level.

Type of soil pollution
Soil pollution is always related to the type of industry that used soil. For the harbour of Rotterdam this is often oil related industry. See figure at the right for an overview of industry types and contaminations.

Assignment
Dealing with the soil pollution is a major factor in the long-term planning of the harbour. Polluted areas have to be cleaned. Cleaning pollution takes time. Making the redevelopment of the most polluted parts of the harbour problematic.

Maps showing the intensity of soil pollution on various depths. (Own illustration, based on information DCMR)

Legend
- Heavily polluted
- Moderately polluted
- Lightly polluted
- Very lightly polluted
- Not polluted
- No data available

Section showing the typical soil pollution in the harbour. The section shows the original underground (light), the layer on top of it built-up out of polluted material and the pollution drained in as a result of industrial activities.

(Own illustration)
That the factor oil is important for the Harbour of Rotterdam is clear, but what is the exact impact of the energy transition on the harbour? Are active interventions necessary or will the problem solve itself?

VISUALISING DEVELOPMENTS
Next to the energy transition (that is the most important development) there are several other potential future developments that can have impact on the harbour. In a recent report Kuiper et al. (2017) describe four possible scenarios for the harbour of Rotterdam in the year 2045. The scenarios are developed along two axes: the degree of globalisation in the world and the speed of transition. From the perspective of these two variables ten global trends are examined on their impact; generating four different scenarios for the harbour of Rotterdam. What all the scenarios describe is a loss of fossil related industry and a harbour that consumes less space. This common trend gives a clear direction. However to really utilise the power of these scenarios I have to translate the written (abstract) scenarios into a concrete spatial scenario. The figure at the right shows my spatial translation of the scenario ‘disaster’. The spatial translation is approved by the authors of the scenario study. The reason why I chose to visualise the scenario ‘disaster’ is because this scenario shows the most extreme change of the harbour. From spatial perspective the other scenarios are just milder versions of this scenario.

WHAT WE CAN LEARN FROM THE SCENARIO STUDY
The figure on the right page shows the spatial translation of the scenario, showing subsequently; the current harbour, the harbour in 2045, the industries that leave and new industries that will come to the harbour. If we start with the current situation (also printed in a bigger version on the next two pages) we see a fossil sector that is highly connected through material flows. The sector consumes most of the central harbour. Because of the rapid transition quickly the first oil storage units will be closed, followed by refineries that on their turn drag down connected chemical companies. Resulting in a loss of almost the complete fossil sector [third step from bottom]. On the other hand quickly new ‘green’ industries will appear in the harbour [fourth step from bottom]. These new industries will however consume far less space than the old fossil industry. An important reason for this is the decentralized character of the global energy system. The combined image for the year 2045 [second step] shows for this reason a highly scattered harbour landscape, consisting of a patchwork of abandoned industrial sites and new ‘green’ industries.

Ten global trends that can influence developments (Kuiper et al., 2017)

<table>
<thead>
<tr>
<th>Global trends</th>
<th>Home made</th>
<th>Disaster</th>
<th>Asia Rules</th>
<th>Scarcity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate: increasing global temperature, sea level rise</td>
<td>+</td>
<td>++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy: sustainable energy central, hydrogen and LNG</td>
<td>+</td>
<td>++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources: rare earth metals key-material, circular economy</td>
<td>+</td>
<td>++</td>
<td>++</td>
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</tr>
<tr>
<td>Technology: IoT, robotization, autonomous sailing, 3D printing</td>
<td>++</td>
<td>+</td>
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</tr>
<tr>
<td>World economy: low growth global economy, growth Asia, local growth</td>
<td>++</td>
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<tr>
<td>Urbanisation: strong growth, especially in River delta’s</td>
<td>++</td>
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<tr>
<td>Demography: greying, 3 billion people extra, immigration</td>
<td>++</td>
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<tr>
<td>Logistic/transport: fragmentation e-commerce, regional ground form</td>
<td>++</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety: growing unsafety, increasing security</td>
<td>+</td>
<td></td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Leisure: health, prosperous elderly, sustainable</td>
<td></td>
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</tr>
</tbody>
</table>
The current harbour

The harbour in 2045

Industries that leave the harbour

Industries that come to the harbour
NEW SITUATION

THE NEW HARBOUR
- The harbour is a patchwork of empty and used sites
- The current leased out sites are used for recycling metals and plastics
- The former oil-plants are abandoned, because of the costs for cleaning them up

CURRENT SITUATION

COMPANIES/ CONNECTIONS
- In the current situation a large share of the surface is covered by food-related industry
- The lines indicate connections (material flows) between companies
The harbour of Rotterdam as a landscape of oil.
(Source photo: unknown)
In the first half of this paragraph the question what the impact of the energy transition is, was addressed through an scenario study. In this second half of the paragraph we discuss the question whether an active intervention is necessary and whether the current strategy of the parties in charge is sufficient.

AN ACTIVE STRATEGY IS NEEDED
The scenario study shows clearly that the coming transition will have negative consequences for the harbour of Rotterdam. A scenario of a scattered harbour landscape with major vacancies is very realistic. These problems don’t solve itself. An Active spatial strategy is needed to mitigate the negative consequences of spatial scattering. Next to this new ingredients need to be added to the harbour in order to create new economic perspectives.

THE OFFICIAL STRATEGY
As stated; the problems will not solve itself. So what is the strategy of the official parties in the anticipation of the energy transition? The municipality of Rotterdam and the harbour company are the parties that are in charge of the harbour. The municipality is implicitly ambitious with the harbour, namely wanting a 100% energy neutral harbour by 2050. This ambition is however not translated in legislation and concrete plans. The idea of the municipality and the harbour company is that the oil harbour can make the transition from fossil to bio-based itself, without strong official intervention. This strategy however dangerous. The official parties trust on the transformative power of individual companies. With the knowledge that the new bio-based industry will use less space (Kuipers et al., 2017) the strategy will lead in any scenario to vacancies throughout the whole former oil harbour. Without an active spatial strategy only individual plots and companies will make the transition to the bio-based industry, resulting in very scattered harbour.

CONCLUSION: AN OFFICIAL SPATIAL STRATEGY IS NEEDED
As we have seen the spatial and financial impact of the factor oil on the harbour of Rotterdam is huge. The central part of the harbour is almost completely consumed by the oil industry. Studies show that the energy transition will likely cause vacancies in the oil harbour, that now forms the spatial hart of the harbour. Although these expectations, there is no official spatial strategy on how to deal with the effects of the energy transition. For two reasons this lack of strategy is a missed opportunity. First; the harbour is heavily invested in. With the energy transition historic investments in oil infrastructure will lose (a part of) their value. This is a unique opportunity to make necessary spatial transformations to the harbour and to rethink the position of the harbour in the bigger system. Second; without a spatial strategy the heart of the harbour will become a patchwork of vacant and occupied plots. This scenario will be very negative for the vitality of the harbour.

In this last paragraph conclusions stand central. This paragraph gives an overview of the most important conclusions from chapter two and three [see the figure on the right combines all conclusions in one simple scheme]. The goal of this thesis is to develop a spatial strategy for the transition of the harbour of Rotterdam. To develop such a strategy one needs at least three ingredients; one needs to know what kind of strategy to use, one needs programmatic input (goals) for the strategy and one needs to have a vision on desirable spatial/visual outcome of the strategy. The conclusions in this paragraph are related to these ingredients.

3.6 Diagnoses

3.6.1 CONCLUSIONS INFORMING THE TYPE OF STRATEGY
Chapter two discusses the idea of landscape-based strategies and what the properties of these strategies are. As stated in chapter two landscape-based strategies should have the following properties:

- The strategy should allow uncertainty, only a framework should be fixed;
- The strategy should connect developments in the plan area with developments in the context. In chapter two it is referred to this as 'synchronisation of developments in landscape systems';
- The strategy should be focused on creating conditions for development;
- The strategy should be focussed both on the short and the long-term;
- If a crucial ingredient is removed from an area it is important to bring in new ingredients.

3.6.2 CONCLUSIONS INFORMING THE PROGRAM OF THE STRATEGY
Next to the main assignment there are several sub-assignments that should be taken in account in a strategy for the transition of the harbour of Rotterdam. At least the following developments/conditions should be taken into account:

- The oil industry will disappear from the harbour. New industries that will come to the harbour will (probably) use less space. As a result there will be a strong shortage of program in the harbour on the long-term;
- The soil of half the harbour is heavily polluted. Technical measures are necessary to make the land suitable for redevelopment;
- The harbour has almost no public transport infrastructure;
- Because of effects of climate change, on the longer-term it is necessary to close off the Nieuwe Waterweg with a dam
- Until at least 2040 there is a strong demand for new housing in Rotterdam. The harbour is a logical place to look for space for this building assignment.

3.6.3 CONCLUSIONS INFORMING THE SPATIAL/VISUAL PROPERTIES OF THE OBJECT OF DESIGN
Chapter three concludes the following that gives direction to the spatial/visual qualities of the new harbour landscape:

- The harbour is a sand mountain in a low clay/peat polder landscape;
- The harbour is spatially dense, in contrast to its context;
- The harbour connects city and sea;
- The harbour is a landscape of objects.
INFORMING STRATEGY:

LITERATURE STUDY:
• The strategy should allow uncertainty, only a framework should be fixed
• The strategy should connect developments in the plan area with developments in the context
• The strategy should be focused on creating conditions for development

REFERENCE STUDY:
• A long term strategy is needed
• To do so you need a stable party to take charge (government)
• If an industry leaves it is important to bring in new ingredients (this can be landscape, Ruhr area)

SCENARIO STUDY:
• The oil industry will disappear. New industries will (probably) use less space.

HARBOUR AREA:
• Soil of half the harbour is heavily polluted; the soil value is a heavy minus
• The harbour is very bad connected through public transport

CONTEXT:
• The river probably needs to be closed off with a dam in the future
• Until at least 2040 there is a strong demand for new housing

INFORMING DESIGN:

LANDSCAPE ARCHITECTURE:
• The harbour is a sand mountain in a low clay/peat polder landscape
• The harbour is dense, in contrast to its context
• The harbour connects city and sea

Scheme combining all conclusions.
# H4

The Strategy
Summarizing from the previous chapters, it can be stated that the transformation assignment resolves around three statements:

• The harbour of Rotterdam is highly invested in. With the coming transition historical investments in oil infrastructure will lose most of their value. This is a unique opportunity to make structural transformations in order to make the harbour more synchronised with related landscape systems; such as the water system.

• During the transition the central part of the harbour will become a patchwork of active and inactive industrial sites, creating a decline of the spatial quality of the harbour landscape.

• After the transition the harbour has to deal with a shortage of program, causing large scale abandoned territory.

This chapter discusses how the statements above can be addressed in a spatial strategy. Sub-question three stands central to this purpose: How can a strategy be designed in such a way that it deals with the uncertainty of the landscape system and fits within the harbour landscape? The question is addressed in the following way. In the second paragraph the program of the strategy/design is introduced. In the next paragraphs the strategy is worked out in several steps.
4.2 The solution

THE PROGRAM
With the conclusions from the literature review on transitions and landscape-based approaches, the conclusions from the landscape analysis and insights on the impact of the energy transition through the scenario study, we now can formulate a program for the strategy. The strategy should address the following points and should have the following characteristics:

The type of strategy:
• A fixed spatial framework, the conditions of the zones are fixed, the program of the zones is determined later
• The strategy should both inform on the short term (the process of companies leaving) and on the long term (attracting new activities)

Program of the strategy:
• The soil pollution is the biggest problem in the harbour. It needs to be cleaned in an extensive way. The type of pollution is informing for the zoning in the strategy
• In the zoning the strategy should anticipate the damming of the river
• The improvement of the landscape quality and the improvement of public transport connection are the most important factors that will allow new (high quality) program to develop

Program design:
• The unique contrast in height, spatial density and soil conditions with the context are the basis for the spatial characteristics of the design
• The connecting nature of the harbour city-sea should be utilised

THE SOLUTION: LANDSCAPE QUALITY AND CONNECTIVITY
As the introduction already summarizes, the transition of the harbour exists out of two phases; phase one where companies gradually leave the harbour, and phase two where there is a lack of program. In this strategy two ingredients are introduced as a [spatial] solution in both phases; landscape quality and connectivity. In the first phase the declining spatial quality, as a result of companies leaving the harbour, can be mitigated by smart improvements of the spatial quality. In this way allowing active companies better business conditions. In the second phase there is a lack of program in the harbour. Here an improved landscape quality and the introduction of public transport can attract new program to the harbour.

2. Spatial and landscape quality: here used as synonyms, both indicating the ‘spatial quality of the landscape’.
Paragraph 4.3 introduces a strategical masterplan [or strategy] for the harbour of Rotterdam. The strategy is worked out as a timeline of interventions and developments. Two phases of the strategy are isolated in masterplan maps.

4.3.1 A PHASED STRATEGY

The strategy timeline at the right shows two phases and an ‘intervention’ in-between. In the first phase the foundation for the later developed framework is laid. Next to this a few short-term measures are taken to deal with transitional problems. The next step is an external intervention; namely the placing of a dam in the Nieuwe Waterweg. The last step sketches a finalised framework.

Phase one
Phase one, during the transition, addresses the short-term assignment of spatial scattering and lays the foundation for later developments. Solutions in this phase are active relocation of business, a strategy to improve the spatial quality that forms the foundation of the framework in the second phase and the introduction of new public transport connections and recreative routes.

Intervention
The landscape system that is most intertwined with the harbour landscape is the water system. And it is this system that has to undergo a major transformation in order to deal with the effects of climate change. As discussed in paragraph 3.2.2, it is necessary that the Nieuwe Waterweg is closed off with a dam in the further future. This has a strong impact on the functioning of the harbour. For this reason it is crucial to take this into account as a given condition in the long-term planning of the harbour. In the strategy the two systems are synchronised by implementing the dam in the second phase. The dam creates new conditions in the harbour; namely a part of the harbour with direct connection to the sea and a part of the harbour without. These new conditions are an important reason for the relocation of activities in phase one.

Phase two
Phase two sketches a harbour directly after the transition. This phase is a conclusion of the foundations laid in phase one, featuring a robust landscape framework, strong public transport connections and an clear but flexible zoning of functions.

The exact program of the eastern harbour area is determined, new designs are made.

A new equilibrium is reached.

Time line of the planning process, eastern harbour area
4.3.2 PHASE 1

Phase one dual function, on the one hand dealing with the specific assignment of this phase; spatial scattering. And on the other hand, laying the foundations for the ‘final’ image sketched in the second phase. The first phase of the masterplan contains the following components:

**Fighting spatial scattering**
Spatial scattering is a visual problem that needs a visual solution. Based on the zones indicated in the second phase, two strategies are adopted. When a company leaves and there is no new, green business to replace it, the plot is cleaned of objects and [temporary] left to the forces of natural vegetation development. In the areas in the masterplan indicated as permanent green structure these areas are planted with trees. On the next page this is illustrated in an example. The specific zones and the type of vegetation is based on the pollution of the soil. The goal of the strategy is to improve the spatial quality in the harbour during the transition and build on healthy conditions in the harbour after the transition, by having a cleaner soil and a lasting green structure.

**Relocation of businesses**
In about thirty years time the harbour will look quite different. Not all current companies fit within the harbour we will have over thirty years. For this reason companies slowly [within a few decades] have to move to parts of the harbour where they fit. This is the western part of the harbour.

**Connections**
Public transport connections and cycle connections are an import enabler of new high quality developments in the harbour. In the first phase the improvement of these connections start by transforming old rail roads and roads into metro tracks and bicycle paths.

**Campuses**
In order to improve the investment quality in the harbour for high quality businesses three innovation campuses with specific themes are created, directly related to the metro line and the lasting green structure.
Industrial area in the harbour that is likely to get abandoned the coming decades. If this happens the harbour is left with a deteriorating, messy looking industrial plot, polluting the spatial image. Resulting in a decreasing business climate in the harbour.
(Source: maps.google.nl)
A photomontage showing the proposed strategy against spatial scattering. All objects are removed and recycled, natural processes are encouraged to create temporary natural areas. On the one hand purifying the polluted soils and on the other hand creating a high, ‘green’ spatial quality.

(Edited form: maps.google.nl)
4.3.3 PHASE 2

The central objective in this phase is to create conditions in the harbour that allow a healthy, long-term development of the harbour landscape. The strategy aims to reach the objective with the following interventions:

Clear zoning
A clear zoning is a basic ingredient of the strategy. Two future developments make this necessary; the placing of a dam in the Nieuwe Waterweg and a strong reduction of the harbour industry. These developments make the current harbour layout not suitable for the future harbour demands. In the strategy this issue is solved by moving activities requiring an open harbour to the west part of the harbour. In this way making space for new developments in the eastern part of the harbour. Where there are zones for urban development and mixed development (industry and/or urban).

A strategy that allows uncertainty
The masterplan allows uncertainty. It does so by providing a fixed framework and zones that can be programmed according to future demands.

A high quality green landscape well connected to the city
The main objective in the second phase is to create conditions for high quality [business/urban] developments. Missing ingredients for this are landscape quality and good public transport. In the strategy this is addressed by introducing an extensive public transport network [on former railroads] and by introducing a landscape park of quality.
A GRADUAL CHANGE
The perspectives on this spread describe the phased spatial development of the harbour landscape during the transition [1 = start, 4 = finished].

In the perspectives it is clearly visible how the harbour landscape slowly transforms from a uniform landscape to a landscape structured by a green framework.
5.1 Introduction

The strategy divides the harbour basically into two parts. The western part where almost no real structural transformations are necessary and the eastern part of the harbour that undergoes significant transformations.

This chapter zooms in on the eastern part of the harbour, to clarify the strategy for this key-area within the overall strategy. To this end first the design as a whole is explained and after this central elements are discussed.
The Harbour Forest
5.2 The design

A WORLD CLASS PARK
The harbour forest is the future park that in the masterplan is indicated as the green framework, spatially structuring the harbour area. The harbour forest is the central ingredient that has to make the harbour ‘great’ in the future. After a history in which a world class oil industry gave the harbour quality, now a world class landscape has to take over this function.

INGREDIENTS AND NARRATIVE
The harbour forest consists of an extensive forest with in it a series of thematic parks, built around former industrial complexes. For every industry type one site is selected and transformed into a unique park. The park is designed around a daytrip with the metro from the centre of Rotterdam through the harbour forest and back to Rotterdam with a waterbus. During this trip visitor travel by metro through the harbour forest. The metro stops at [almost] every theme park. From several of these theme parks the visitor can take a waterbus back to Rotterdam.

AN IMPULSE FOR DEVELOPMENT
De goal of the harbour forest is to structure the harbour and to generate together with the new metro conditions for high quality developments in the adjacent areas (grey in the map).
The story of the park... Organised around a day-trip

... the story of the park
A chronological story of industrial landscape pearls...
THE CONCEPT

A new hart for the region ...
In the current situation the harbour is completely excluded from the landscape and urban tissue; it is another landscape. With the introduction of the harbour forest and the lake around Heiplaat the harbour will change from a back-side to a front.

Nature as attracter of development
With the harbour forest the harbour area becomes the greenest area within Rotterdam, and with it losing its negative connotation as polluted, open and noisy. In this new positive environment high quality program can develop.
... The harbour is structured through a robust, natural looking forest. The metro line that runs through it is the most important connection to the harbour. On the metro there is a healthy mix between foreign tourist and employees of the offices and high-tech companies located in the harbour. During the metro trip diverse forest landscapes are displayed. Natural forest, old overgrown industrial sites and high-tech campuses that are located around metro stations take turns in the display ...

Vision
BASIC TIMELINE
The figure at the right shows the basic development timeline of this part of the harbour. It shows the following steps:

- The current situation
- Companies stop or are moved to another harbour part, the unnecessary structures and infrastructures are removed, trees are planted/ natural vegetation can develop
- In the forest zone bicycle paths and a metro line is developed
- First strategical business clusters are opened near metros stops
- The parks and the harbour forest is finalized
- The remaining harbour area is developed
If the economy develops well, business areas can develop from this stage. Active soil remediation may be required in this stage.
This paragraph discusses in more detail essential parts of the design. Subsequently the following layers will be discussed; the harbour forest, the new business/urban areas, infrastructures and the thematic parks.

5.3.1 THE HARBOUR FOREST
The harbour forest is the natural backbone of the new harbour. In fact the harbour forest does not only exist out of forest. As the image on this spread display, the harbour forest also includes an island with a dune landscape and a tidal area. On the next pages the different landscape types and there development are discussed.
THE FOREST
The sections on this page display a typical section of the harbour forest in the future. The forest itself consists of a wide forest zone with park program. The forest zone enables the development of high quality business program and urban program in the zone next to the forest. Forest is a strong tool to organise large areas. Through its property as a spatial mass forest has the ability to organise and structure large areas and the ability to neutralize noise created by infrastructure and industry.
THE FOREST

Species
The forest will be completely unique in the western part of the Netherlands. Due to the location of the forest on heightened harbour grounds a dryer and more divers vegetation can develop. Species as lime, beech, oak, prunus and birch will be planted.

Planting
To guarantee a rapid development of the forest the forest will be planted.

Time
On this page the envisioned development curve of the forest is displayed. After a company leaves the harbour the site is cleared of built structures and [underground] infrastructure. After this the site will be mechanically planted. After about ten years the planted area gets spatial impact. After thirty years the area is really experienced as a forest.

Pollution
The area where the forest is planted is polluted with organic contaminants, because of many years of oil (related) industrial activities. Trees and other vegetation have the ability to break down organic contaminants into less polluting elements; in this way cleaning the soil they are planted on.
THE ISLAND AND THE TIDAL AREA

The new island and adjacent tidal area form the unique environment for a new urban development. The Waalhaven is heavily polluted. In order to make the complete area suitable for urban development a huge investment has to be made. Instead in the design is chosen to concentrate the urban developments, in this way saving money and creating space for much needed green and recreational opportunities for Rotterdam. The Waalhaven is transformed into a large lake with an island in the middle (Heiplaat). Parts of the current harbour are excavated until the mean water level, creating tidal areas with a high ecological value. The island itself is heightened with a two meter layer of sand, creating a ‘life layer’. On top of this layer the housing program can developed. The additional raise of the island with sand will create a unique dune like landscape.
5.3.2 ROUTING

An extra bicycle path and metro line are an important carrier for the redevelopment of the harbour. On the drawings on this page the specific routing is worked out in more detail.

**Bicycle path**
The landscape around the harbour of Rotterdam is highly urbanised with little recreational possibilities (see paragraph 3.2.4). With the development of the harbour forest this has to change. The new bicycle path is an important tool in this. The path is designed in such a way that it connects adjacent towns and villages to the harbour forest, allowing inhabitants to bike routes of different lengths through the harbour landscape.

**Metro line**
The proposed metro line connects to the current metro line De Terp-De akkers. The metro line connects to this line at stop Pernis. From Pernis the line runs through the harbour along Rozenburg to the new metro line Hoek van Holland-Beurs (see image). The new metro line runs for most length through the forest. In total there are six stops on the metro line. The stops are located at new parks, near Rozenburg and near new business clusters.

A new metro line is a huge investment. Due to a smart choice of the trace the cost can be reduced significant. In the proposal the metro line is built on existing (rail) infrastructure. In this way no large structures as bridges and tunnels need to be developed. From the start, even without real program in the harbour the metro will have a function as a connection between Rozenburg and Rotterdam. In the current situation Rozenburg is hard to reach with public transport (it takes about an hour to reach Rozenburg from the centre of Rotterdam).
5.3.3 THEMATIC PARKS

An important quality generator in the harbour forest are the sixteen thematic parks. In the zone where the harbour forest is projected sixteen interesting sites are selected, that are turned into special parks. The selected sites show all industry types, practised in the harbour, from the huge oil tanks to rail yard. The exact program and design of all the sixteen parks will be determined in a later stadium. Depending on the demand and available budget, the parks can be developed into extensive or more intensive parks.

- The island
- Quay and cranes
- Warehousing
- Esso
- Shell storage
- Visitor centre
- Tanks and trees
- Trainyard
- Storage tanks
- Aluminium factory
- Shell refinery
- Storage tanks
- Coal storage
- Gas factory
- Concrete forest
- Trainyard
5.3.4 BUSINESS AND URBAN DEVELOPMENTS

For the harbour area the development of the harbour forest has two main goals. The first goal is to create an environment that is suitable for the development of high quality business and urban areas. The other goal is to structure the harbour area.

The images at the right show a projection of the harbour development as guided through the strategy (paragraph 4.3). The following steps can be seen:

- The current situation
- Companies left this harbour part, excess infrastructure is removed
- The harbour forest developed, dividing the harbour in pieces of territory, that can be cleaned and programmed separate or together
- Step three; the harbour is ready for redevelopment, the harbour is well structured and well connected through public transport and road infrastructure.

In a later stadium the exact program of the harbour will be chosen. This program will determine what additional infrastructure is needed, and what the relation between harbour parts will be. See also principal drawings in the top right corner.
Current situation

The site is cleared of superfluous structures and infrastructure

The harbour area is restructured through the development of the harbour forest

Depending on the chosen program areas can develop together or separate.

Through existing and new infrastructure the harbour can be redeveloped
Soil pollution is a problem for the redevelopment of the harbour. The scheme on this page shows the steps that need to be taken in order to build on the polluted soil. There are two possible routes:

- The program is industrial; short term remediation of the soil with the help of vegetation is sufficient.
- The program is urban; short term remediation, using vegetation is not sufficient. A two metre ‘life layer’ of sand needs to cover the polluted soil. On top of this layer the urban program can be developed.
Soil preparations for development

The remediation strategy is based on the program type that is chosen. If the program is industry, no additional steps are necessary. If the program is urban, a two metre ‘life layer’ of sand needs to be added.

Finished situation
Within the harbour forest there are 16 thematic industrial parks with each a different industrial background and park program. In this paragraph one symbolic park is elaborated further to illustrate how the industrial sites can be transformed into vibrant parks.

5.4.1 THE DESIGN

Every park is based on a set of fixed principals and site specific ingredients. In all parks the metro stop and the main bicycle path are the programmatic centre of the park. These two infrastructures enable access to the park. From here site specific routes begin.

The program is added to the parks in several phases, starting from the centre of the parks. In the Shell Storage Park the storage tanks form containers for activities.

In this detail design also business program is included as an example of how the park and metro line generated conditions for new business program. In the design the central axis is extended to the north side of the metro line. Along this axis a new office cluster is projected. Creating a high quality, green working environment.
Infrastructural scheme of the office area

Towards the centre of the park the vegetation density drops.
5.4.2 COMPOSITION SCHEME

Design ingredients
The site of Shell Storage Parks offers, like many of the other selected sites, many unique ingredients for a design. One very interesting aspect is height. The Netherlands is a very flat country. Especially here it is interesting with this aspect of height. The analysis at the right shows the artificial topography of the site, created by large constructions.

The scheme
In the composition scheme the aspect height stands central. Through thematic routes one can walk over dikes, through dikes and on top of giant oil tanks. Next to this there is a route over an old rail road track and there are routes through oil tanks.

The composition scheme: height as central theme.
5.4.3 TIME LINE
Also on the park scale a phased strategy is used. The scheme on the right shows the development of the park related to the phasing in the masterplan. The process is as followed:

Current situation
The site is still actively in use for the storage of crude oil.

Phase 1
Shell abandoned the facility. In this process the site is stripped of all dangerous materials, unnecessary pavement is removed. After this trees are planted and succession gets space to develop a healthy vegetation. In this process the soil is remediated over a period of at least 10 years.

Phase 2
After 10 years the vegetation remediated the polluted soil. Now phase two starts; the building of the park. A metro stop is created and the central cycle path is developed. From the programmatic centre several site specific routes are developed and a few of the abandoned oil tanks are transformed with specific park program.
Phase 1
5.4.4 BUSINESS AND RECREATION
The visualisation on this page shows a zoom in of the area around the metro stop. Showing both the entrance of the business area and the entrance of the park.

Functions deeply integrated
The main purpose of the development of the harbour forest is to use the conditions that the forest creates to redevelop the harbour towards more high quality functions. In this detail the forest conditions are used to develop a business campus directly related to the metro stop. This business campus can on its turn attract other business activities.

Development axes
Perpendicular to the metro line a square-like axes is developed. When the program in the park, or in the business area expands the axes can be extended.

Re-use of materials
For the development of the infrastructure in the park, current pavement is re-used.
5.4.7 CONTAINERS FOR DIVERS PROGRAM
Storage tanks are unique objects that can be appropriated for divers and interesting program. In this sub-paragraph a short visual study on the possibilities.
Storage tank without program after a few years of succession.
A storage tank as an interesting container for a campsite.
A storage tank as stage for an exciting festival.
6.1 Introduction

Chapter six functions as an elaboration of the main spatial drivers of the new harbour landscape; the metro line, the bicycle path and the forest. In this chapter the focus lays on the landscape architectonic qualities that are created by the proposed interventions. To this end the first paragraph discusses synergy between the bicycle path, the metro line and the forest in a spatial sense. In the second paragraph the metro line stands central. The last paragraph zooms in on the bicycle path and its materiality.
Elaboration
A PEARL NECKLACE
As the composition scheme on this page displays the harbour forest is designed as pearl necklace. The bicycle path and metro line are the necklace and thematic parks and landscape elements are the pearls; only when one move along these lines the full richness of the landscape can be experienced.

THE LINE AS IDEAL
The landscape park [Harbour forest] tells the story of the harbour; the openness through the lake around Heiplaat, the biotic and a biotic conditions through the specific vegetation and the story of the history through the many thematic pearls. To tell a coherent story also a story line is needed. In the park this is achieved through a staging of the landscape around a route; the story line. In this way the landscape and all its impressions can be read and experienced in one fluent movement.

A VIEW FROM THE ROUTE …
The next pages describe in four images the specific atmospheres and qualities one will experience when taking a trip through the harbour forest.
A view from the bicycle path south of the Heiplaat lake. The view displays an intimate landscape with industrial relics, vegetational succession, ecology, and views that open towards the lake.
A view from the metro displaying the rich mix between vegetation and industrial relics.
The harbour forest attracts high quality developments that sometimes during the metro trip will pop up in between the green landscape ...
A combined impression of the rich landscape created by the metro line, the succession, nature and the industrial heritage.
6.3.1 THE TRAJECTORY

The drawing on this page shows in more detail the trajectory of the metro line and the most important interventions to create the metro line.

**Based on old rail lines**

In the design for the metro line the use of existing infrastructure is a central theme. In major parts of the trajectory old railways are used as a foundation. Also existing tunnels and bridges are used in the design.

**Space reservation**

Although the metro line is an important ingredient of the masterplan, it is not yet sure in which stage of the strategy the metro line will be implemented. In order to realise a metro line sufficient program is needed. In a post-transition situation the program is in the beginning limited. In this stage a space reservation can be made on the trajectory of the metro line. The reserved space can in this phase be used as an extra bicycle path.

**Mainly above ground**

The whole trajectory of the metro line is above ground. In this way the metro serves its purpose in experiencing the landscape better. Only at crossings and metro stops the metro drops below surface level.
6.3.2 THE METRO LINE

The metro line is the life line of the harbour forest and for the business and urban areas in the harbour.

A basic design

The metro line is next to a means of transport, also a means of experiencing the area. For this reason the metro line is almost everywhere above the ground. Only near stations and large crossings the line drops below surface level. For the design of the metro track simple and natural materials are used. Old concrete slabs from the current harbour are used to build the walls of the deepened metro stops. After time the walls will be covered by (rare) wall ferns. The stairs to the platforms are made from re-used steel from old storage tanks.
Walls made of re-used concrete slabs, that over time will be covered with rare wall ferns.
6.4 Bicycle path

6.4.1 THE ROUTE
The bicycle path is designed as a continuous element in the harbour forest. The route of the bicycle path follows the main directions of the harbour forest.

Divers routes
Next to the central path that goes through the centre of the harbour forest, there are several loops and connections that allow users to make different routes [see also 5.3.2].

Connects with the metro line
The trajectory of the metro line and the trajectory of the bicycle path are designed as one. Around metro stops the path and the metro line converse in order to get maximum interchangeability.
6.4.2 THE PATH

The bicycle path that runs through the harbour forest, it is a constant factor, that gives the forest unity. For this reason the path has a strict design. The path is made of concrete. The path is clear of objects. Objects like benches and information desks are placed on a floor of re-used concrete, on strategical locations. Creating, small square like plots along the path. There is no signage along the path, notes are written on the path in a prescribed way [see image previous page]. Light armatures along the route are designed, inspired on the chimneys in the harbour.
7.1 Introduction

This chapter reflects upon the thesis, its questions, its answers and the process that lays behind it. In the first paragraph the research question posed in the first chapter is answered. In the second paragraph the most important design conclusions are summarized. In paragraph three I discuss specific reflection topics that are obligated by the faculty of Architecture. I conclude this chapter with a general discussion on the usability and the feasibility of my solutions.
#H7

Conclusion and Reflection
The harbour of Rotterdam is one of the biggest global hubs in the distribution of oil. Almost seventy percent of the total surface of the harbour is covered by oil and oil-related industry. Due to the Paris-agreements this landscape of oil will change dramatically in the coming decades. The European commission agreed that the CO\textsubscript{2}-emission of the member states should be reduced by 80-95% in 2050, cutting away the foundations of viable fossil industry\textsuperscript{1}. For the harbour of Rotterdam these expected developments create a large transformation assignment that can be dissected into a short- and a long-term assignment. On the short-term the problem focusses mainly on dealing with the negative effects on spatial quality by companies leaving the harbour. On the long-term the assignment focusses on giving new use to abandoned harbour territory and on creating new conditions for development.

My main goal with this research is to address the transformation assignment of the harbour of Rotterdam as a landscape architect. To this end I formulated the following goals:

- Get a grip on the impact of the oil industry on the harbour of Rotterdam and get a grip on what the consequences of the energy transition are on the harbour of Rotterdam.
- Understand how the harbour landscape functions as a system and what the relations of this system are with its context.
- Create a design for the harbour that anticipates the coming energy transition and incorporates system interests on the regional scale, using the ecological and economic dynamics.

I translated these goals into the following research question and sub-questions: 

- How can the harbour of Rotterdam anticipate the coming energy transition in such a way that the regional scale system interests are incorporated and that the harbour will be ecologically and economically healthier, using a landscape-based approach?

Sub-questions:
1. How should the transition of the harbour of Rotterdam be handled argued from a landscape perspective?
2. What is the impact of the energy transition on the developments of the harbour of Rotterdam?
3. How can a strategy be designed in such a way that it deals with the uncertainty of the landscape system and fits within the harbour landscape?

In the following part of this paragraph I first answer the sub-questions, followed by the answering of the main question.

1. How should the transition of the harbour of Rotterdam be handled argued from a landscape perspective?

The method used to answer this question is a literature study into landscape-based approaches in strategical planning and design [chapter 2]. From this study it can be concluded that landscape-based approaches are “open-ended strategies aimed at protecting resources, guiding developments and setting up future conditions for spatial development by means of landscape planning and design” (Nijhuis, 2017)\textsuperscript{2}. Further characteristics of strategical landscape-based planning are that the goal is to determine the most beneficial action for sustainable development of an area and that local and regional landscape conditions form the bases on which a strategy is build\textsuperscript{2}. The landscape-based design type that stands central in this thesis is that of Landscape Infrastructures. In this theory landscape is considered to be an infrastructure, able of setting up conditions


for new developments.

To answer the sub-question with these findings the following can be stated: In order to deal with the effects of the transition in a ‘landscape’ way, an open-ended strategy should be created that addresses short-term problems while building a lasting landscape framework capable of organising the landscape and setting-up conditions for new developments.

2. **What is the impact of the energy transition on the developments of the harbour of Rotterdam?**

In order to answer this question I made a spatial translation of a scenario study conducted by Kuiper et al. In this study Kuiper et al. describe four possible scenarios for the harbour of Rotterdam in the year 2045. In order to get grip on the possible magnitude of the transition I made a precise spatial translation of the most outspoken scenario [Ch 3]. From this study we can conclude that the energy transition will impact the central part of the harbour severely. Without a strong spatial strategy the central part of the harbour will transform into a patchwork of abandoned and active facilities. In the longer-term resulting in a strong shortage in program.

3. **How can a strategy be designed in such a way that it deals with the uncertainty of the landscape system and fits within the harbour landscape?**

The strategy can be designed in such a way by synchronising the strategy with interests of related systems and by building on the local environmental and spatial conditions of the harbour landscape. In the long-term zoning of the masterplan the integration of system interest is realised by carefully placing the permanent sea harbour, areas of divers development and areas for urban development based on the on soil pollution in the harbour and the placing of a necessary future dam for the water management of the bigger river system [Ch 4]. The shape and vegetation type of the harbour forest, the main spatial framework in the design, is based on the local soil conditions and spatial characteristics of the harbour landscape, making the intervention fit within the landscape [Ch 5].

The complete design shows that by adopting a landscape-based approach the transition can be structured in such a way that short-term spatial quality issues are converted to new qualities that grow to a permanent spatial framework capable of creating new perspectives for the harbour. With this in mind the main question can be answered:

**Main Question: How can the harbour of Rotterdam anticipate the coming energy transition in such a way that the regional scale system interests are incorporated and that the harbour will be ecologically and economically healthier, using a landscape-based approach?**

First off all by recognising how fundamental the transition assignment is. The coming decades the harbour has to change to something completely different in order to stay relevant. With entire new relations to the city, the regional and national economy, the water system, the national energy supply and the regional landscape. All this requires a fundamental rethink of the harbour landscape and its function. This enormous endeavour cannot be solved by one discipline with a blueprint design or vision. It requires a multidisciplinary approach with a long-term strategy that allows uncertainty. Landscape architecture as a holistic discipline can provide this connection between disciplines with its capability of making hybrid designs.

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The strategy that is needed should be built on the basis conditions of the landscape; the conditions that ultimately determined that the harbour developed on this very spot and not fifty kilometres north or south. On these basic conditions of the landscape a strong framework needs to be built. A landscape framework capable of organising the harbour landscape and a landscape framework that by its beauty [spatial quality] is able of pushing the landscape into a new direction of high quality developments. Generating ultimately a harbour that is ecologically and economically healthier.
Central in this thesis stands the transition of the harbour of Rotterdam as a result of the energy transition. Next to this main assignment this thesis addresses also several other spatial assignments. In this paragraph an overview of the different assignments addressed in this thesis and how the strategy deals with these assignments.

THE ENERGY TRANSITION

**Assignment:**
With the energy transition most fossil related industries will leave the harbour [Ch 3.5] new industries will likely consume less space than the current fossil industry. As a result about half of the harbour will be vacant [Ch 3.5]. Without an intervention there will be major vacancies throughout the complete harbour.

**Solution:**
Viable industries are [during several decades] moved to the west part of the harbour. This is the best part of the harbour. The soil is not polluted and this part will also in the future have direct connection with the sea. As a result the east part of the harbour will be empty. With investment in landscape quality [harbour forest] and connectivity [metro] new types of program [housing, offices, high-tech agriculture etc.] are attracted to this part of the harbour.
WATER SAFETY

Assignment:
The Nieuwe Waterweg is the only branch of the Rhine-Meuse river system that has an uncontrolled access with the North Sea. Because of effects of climate change this direct access causes already considerable water quality and water safety issues. Experts say that in the longer future a dam in the Nieuwe Waterweg is needed in order to deal with the increasing effects of climate change [Ch 3.4]. If a dam is placed in the Nieuwe Waterweg the harbour of Rotterdam loses direct access to the North Sea. This is negative for the harbour.

Solution:
In the strategy the dam is placed in such a way that about half of the harbour will lose direct access to the North Sea. In the decades before the dam is placed, companies that require a direct access to the North Sea [such as container terminals] are relocated to the west side of the dam. In this way the placing of the necessary dam causes minimal negative consequences to the functioning of the harbour.

URBAN GROWTH

Assignment:
Until at least 2040 Rotterdam will have a strong demand for new housing [Ch 3.4]. The city harbours close to the city centre are naturally the first harbours that will be transformed into urban areas. On the longer term the municipality will however [probably] also have to look to harbours a little more distant from the city centre. The harbour areas east from Pernis are in the longer future logical areas for urban redevelopment.

Solution:
The masterplan provides two zones for urban development. The most eastern part of the harbour [east from Heiplaat] is reserved for urban development. The larger area east from Rozenburg is reserved for a mixed development. In this zone also the development of urban program is possible.
PUBLIC TRANSPORT

**Assignment:**
In the current situation the harbour of Rotterdam almost completely lacks public transport infrastructure. Nowadays strong public transport is seen as an important driver of high quality program, such as housing and offices [Ch 3.4]. In the future the harbour will have a shortage in program. In order to attract more program to the harbour good public transport can function as a strong catalyst.

**Solution:**
In the masterplan viable [heavy] industries are moved to the east part of the harbour. As a result the east part of the harbour is empty and needs to attract new program. Here an extra attractiveness through strong public transport would be very positive for the attraction of new program. In the masterplan a new metro line is developed on top of existing rail ways from Pernis, along Rozenburg to the metro line Hoek van Holland-Rotterdam. This projected metro line would increase the attractiveness of the eastern harbour as settlement location for a diverse program.

SOIL POLLUTION

**Assignment:**
The eastern part of the harbour is heavily polluted [Ch 3.4]. In order to develop new program in this part of the harbour, first the soil needs to be cleaned [to some extent].

**Solution:**
Cleaning polluted soil is very expensive. Especially if all parcels are cleaned separately. For this reason the masterplan proposes to clean the complete polluted area at once using phytoremediation [using vegetation to clean soil pollution]. In this way the top soil is cleaned to levels that most program can develop. Only for the most sensitive program types [urban functions] additional technical measures are necessary.
ACCESS TO NATURE

**Assignment:**
Rotterdam has relatively little urban green. The green areas around Rotterdam are spatially scattered and lack a high recreational capacity. Also Rotterdam lacks a direct connection to a large landscape of quality [Ch 3.4]. This general lack of access to nature is negative for the overall attractiveness of Rotterdam as a city.

**Solution:**
In the masterplan the harbour forest is introduced as a solution to this. The goal is to develop the harbour forest into a large landscape park of quality; a new icon for Rotterdam. The combination of nature, industrial heritage and thematic parks should create a landscape with regional or national attraction. Through the direct connection of the harbour forest with the centre of Rotterdam and several adjacent towns, the harbour forest has the potential to become a major recreational asset for Rotterdam. On top of this the harbour forest links Rotterdam to the larger coastal landscapes.
The faculty of Architecture requires a short reflection to account for the [preliminary] results of the research and design in the of the graduation phase. In this paragraph the required reflection themes are discussed in the prescribed order.

What is the relation between research and design in my project?
Research forms an important connection within my project. Both within my theoretical framework and in the project as a combined endeavour. In the theoretical framework I use known theories to build a method for the transformation of harbour areas in the light of the energy transition. My complete design is a test of this method; the process is guided by this method. Looking back I can conclude that the proposed method resulted in a congruent design fitting within the boundaries of the theoretical framework. The process that lead to the design was however less congruent as envisioned in the method.

What is the relationship between the theme of the graduation lab and my chosen theme?
The theme of the Flowscape studio is imbedded in the theory of landscape infrastructures. In this theory landscapes are considered to be infrastructures or flowscapes which have the power to setup conditions for development. When designing with this consideration of the landscape as an infrastructure, conditions become the main design tool. The coordinating team of the Flowscape studio suggested to pick a design site and topic that fits within the theory of the Flowscape studio. As a geographic demarcation for the area from which we could select a site, the watershed of the Rhine and Danub river was selected. For the selection of a topic it was suggested to select a theme related to infrastructures. My site, the harbour of Rotterdam, meets these criteria perfectly. Harbour areas are very obvious infrastructures, strongly related to the conditions of the landscape. The harbour of Rotterdam is located on this spot because of the conditions created by the river Rhine and the North Sea.

What is the methodical relation with the graduation lab?
The theory of landscape infrastructures stands central within my thesis. This was possible because the site and topic of research have a strong relation with theory as pointed out in the previous subsection.

What is the relation between my project and the wider social context?
A last reflection topic that I have to address is the relationship of my project with the wider social context, or as I prefer to translate it; the societal relevance of my project. I think that this relevance is quite strong. In my project I address the issue of energy transition. The energy transition will transform our landscapes severely the coming decades, so much is known, but how and what is still unclear. A vast body of knowledge is needed on how to deal with the spatial consequences of this transition. With my project I contribute a little piece to this urgently needed body of knowledge.
Reflecting is an important step in a research process. In this last paragraph I discuss the general usability and feasibility of my solutions. At last I give my recommendations on how to proceed from here.

USABILITY OF THE SOLUTIONS
Looking back, how usable are my solutions and what part of the enormous transformation assignment does my strategy address? The proposed strategy is a spatial strategy, it is not an all-inclusive business plan. The strategy provides the basic conditions for the development of a healthy harbour landscape. It provides these conditions through a structural transformation that makes the harbour landscape more robust and equipped for uncertainties. The strategy creates the conditions on which new businesses cases and activities can develop. So with the implementation of the strategy basic conditions for development are created. Not the developments themselves.

FEASIBILITY OF THE SOLUTIONS
How feasible are my solutions? The direction of my proposals is founded on the direction indicated by scenario studies. On this direction the strategy is built with a high tolerance for uncertainty. The main uncertainty factor in the strategy is the extent of the energy transition and the extent of sea level rise. Only when the energy transition will have very little impact on the harbour and the sea level rise is minimal the effectiveness of the strategy is compromised. These scenarios are however unlikely. In a technical sense the strategy is relatively uncomplicated in executional possibilities. The whole purpose of the strategy was to create a plan that fits the characteristics and qualities of the harbour landscape. For this reason the construction ingredients are cheap or common available in the harbour. Also the scale able and phase able properties of the plan make the strategy technical feasible.

MINIMAL INTERVENTION
An effective way to reflect upon the effectiveness of the strategy is to answer the question, what the minimal intervention would be to make the strategy work? In my strategy I introduce two ingredients to attract new program to the harbour; landscape quality and connectivity. The precise question would be how much can be eroded of these strategical ingredients to make the strategy as a whole work? First of all it is quite difficult to make a precise quantification of what can be left out of the strategy to make it work. In abstract to make the strategy work, the harbour needs to be a healthy green landscape with spatial quality. In order to reach that goal at least major parts of the harbour forest need to be developed, including major parts of the bicycle connection and some of the thematic parks. The proposed metro connection can be left out. But of course, this is not ideal.

LOOKING FORWARD
If you would visit the harbour today or even the coming years, you will encounter a busy harbour full of activities. It will be hard to imagine that this liveliness will disappear from major parts of the harbour. This reality does raise the question how one should implement and start building a strategy that envisions such fundamental transformations? First of all; we are still early, the energy transition still has to start, or just started. Expectedly the first real effects of the energy transition will begin to be really visible after a decade. In this in-between time the strategy can be sharpened, adjusted and be made more specific. Next to this the time can be used to build a clear vision preparing stakeholders and the public for the new direction of the harbour. With the ultimate goal to enthuse both public and stakeholders with the opportunities of the new green harbour.
For my thesis I had several meetings with specialists in many different disciplines. Below summarized transcripts of the most important meetings with external specialists.

Meeting 1
Specialist: Dirk Koppenol | Port of Rotterdam
Date: 02-03-2017
Summarized transcript:
• Costs to clean up pollution are significant, the value of this soil is negative;
• The harbour is very large. Too large to transform completely to urban functions;
• The harbour is a Landlord port, they own the land;
• The harbour company is 66% owned by the municipality and 34% by the central government;
• Quay walls are for 80% outdated, to restore them is very expensive;
• 80% of the income of the harbour comes from oil (related) industry;
• Wind energy is a big thing, 80 GW possible. The harbour uses 8 GW > production of biofuels.

Meeting 2
Specialist: Bart Kuipers | harbour professor Erasmus university
Date: 03-03-2017
Summarized transcript:
• The harbour or the industrial area is larger than the extent of the properties owned by the harbour company; there are also significant industrial complexes in shipping etc. near Werkendam and Spijkenisse;
• We need a entrepreneurial government to deal with challenges like the energy transition;
• Shell and Exxon will be around for 20+ years. These big companies build often different branches that can take over the main branch;
• There needs to be a shock in order to get a fast change, otherwise it will more or less continue [energy transition];
• The harbour of Rotterdam is emitting ever more CO2 – the harbour is very weak on this subject, they have a lot of ambitions, but no actions, the municipality/harbour company should do more concrete things;
• The refineries in Rotterdam are relatively strong through the integration with technology;
• What should happen is that the harbour should invest more in knowledge … make it visible … really invest in a kind of infrastructure … make a new kind of landscape that can attract activities;
• Rotterdam is at the moment, different then the new buildings show you, quite a weak region. The Chemical industry is too important for Rotterdam; that is dangerous. At the moment there is no good alternative for these industries;
• On the other hand he expects that the energy transition and the transformation of the harbour can go much faster … the progress of windmills and battery life is improving faster than expected. These development can mean a sudden transformation of the harbour, or if large protests on climate change … etc. China is for instance proceeding much faster, but on the other hand if Trump holds power 8 years things can slow down much.

Meeting 3
Specialist: Marcel Koeleman | DCMR | specialist soil pollution
Date: 10-03-2017
Summarized transcript:
• A central question is; who is responsible for the pollution, this is probably hard to determine, because old;
• Pollution probably metals plus oil related;
• A question is wheter you have to clean the soil completely. To the multifunctional levels; not always necessary. If the pollution is old you could consider it part of the soil + with some types of use it is not a problem;
• Two stakes: goal (economic) and law (juridical)
• Dig it all away is also possible, but really expensive
• Usually you isolate the pollution
• Seepage water is an issue, it spreads the pollution to the adjacent areas;
• You can make the harbour into a polder to stop the seepage (pumping up);
• To determine who is responsible for the pollution is really important in order to claim the costs of the cleaning of the soil;
• There is a change that companies keep the soil unused, because the costs of cleaning are higher than
to just rent it for ‘eternity’.

### Meeting 4
**Specialist:** Matthijs Kok | Tu Delft | professor water safety  
**Date:** 20-03-2017  
**Summarized transcript:**
- In general professor Kok was really relaxed about water problematique related to sea level rise. In his opinion sea level rise is not too big of an issue. Even if the sea level rises with five metres the Netherlands can handle this rise with dikes. The costs will be considerable but in comparison with the costs is of for instance healthcare the costs are limited;
- A dam in the Nieuwe Waterweg would be very helpful to increase water safety and to help solve issues with fresh water supply;
- If you make a dam you don’t have to raise the dikes until Dordrecht;
- The biggest problem of a dam is the ecological loss … it will kill curtain brackish/tide ecosystems.

### Meeting 5
**Specialist:** Tiedo Vellinga | Tu Delft | professor Ports and Water  
**Date:** 12-04-2017  
**Summarized transcript:**
- Don’t close the dam permanently, keep it partly open for ecological reasons;
- Take also in account the new Blankenburg tunnel and the Oranje tunnel, near Hoek van Holland;
- There are a lot of seagull colonies in and around the harbour;
- The Beer is an old natural area;
- Recycling will be a big thing and renting pipelines too.

### Meeting 6
**Specialist:** Timo Heimovara | Tu Delft | professor soil mechanics  
**Date:** 01-09-2017  
**Summarized transcript:**
- Everything in the soil below 2 meters and everything that happened to the soil before 1990 is considered ‘soil own’ for the law;
- Almost everywhere in the harbour the complete soil is polluted It even in parts that are marked as ‘clean’;
- Source, path, object; it is important to cut the path.
- It is possible to clean soil pollution with natural processes, but it take a lot of time to clean the soil completely;
- It is almost best to keep the polluted areas free of building, make it nature, live next to it, on the water.

### Meeting 7
**Specialist:** Four specialists | DCMR | specialists on soil pollution in the harbour  
**Date:** 11-09-2017  
**Summarized transcript:**
- The area is not so polluted. Because the area is so high it is easy to deal with. The only thing I have to do is to bring up a ‘life layer’ of about 2 metres, after this most uses are possible;
- Seepage water is a problem, but I can’t deal with it;
- Putting mildly polluted soil in the harbour is not a good idea. But is can be done.