Port of Rotterdam

Seizing opportunities from the energy transition

A study of the Port of Rotterdam

A.W.J. Kerpel

Technische Universiteit Delft

TU Delft Delft University of Technology

Challenge the future

SEIZING OPPORTUNITIES FROM THE ENERGY TRANSITION

A STUDY OF THE PORT OF ROTTERDAM

by

A.W.J. Kerpel

in partial fulfillment of the requirements for the degree of

Master of Science

in Hydraulic Engineering

at the Delft University of Technology,

Student number:	4150783	
Supervisor:	prof. ir. T. Vellinga	TU Delft
Thesis committee:	prof. dr. P. Osseweijer	TU Delft
	dr. ir. P. Taneja	TU Delft
	ir. P. Vervoorn	Port of Rotterdam

TU Delft Delft University of Technology

Port of Rotterdam

PREFACE

This thesis represents the graduation project to fulfil my Master degree in Hydraulic Engineering at the Delft University of Technology. The research focuses on how the Port of Rotterdam can seize the opportunities that arise from the energy transition and is carried out at the Port of Rotterdam authority. Being able to complete this thesis, I want to thank everyone that has been involved in the process, but some people in particular..

Before getting into contact with the Port of Rotterdam authority, Cornelis van Dorsser, Poonam Taneja and Tiedo Vellinga showed me the opportunities in the section of Ports and Waterways at the TU Delft. Together, they helped me to formulate the first research proposal. I am very grateful for this since it enabled me to perform a research that embodies the bridge between technical expertise and practical application.

Additionally, I would like to thank Cees Pons and Wilco van der Lans for giving me the opportunity to perform my research at the Port of Rotterdam authority. Even though my first proposal was way too ambitious, they were able to look through it and enabled me to develop a more realistic research goal.

Next, I would like to show my gratitude to the Port Planning department. You made me feel at home from the very first moment, showed me the way throughout the organisation and were always open for a critical discussion on my research topic. Not to mention the great atmosphere, introduction to the Fenix Food Factory and laughing at me for drinking my coffee with sugar (which I quit by now).

Of course, I could not have completed the research without the support of my parents and brother. I am very thankful for encouraging me not only during the graduation work but throughout the entire duration of the study. Especially the everlasting empathy for my grumpiness when the stress increased, even though I rarely talked about it.

Furthermore, I would like to show my appreciation to my closest friends for discussing the research topic and the graduation process as a whole. Especially the provision of distraction and listening whenever I needed to express my frustration and putting these back in perspective (as most of the times it was not so bad at all) helped me a lot.

To conclude this preface, I would like to give a special thanks to the members of the MSc Graduation Committee. Without the guidance, I would not have been able to complete the research.

Tiedo Vellinga for guiding me through the project from the start to the very end and for introducing me to the Port of Rotterdam authority. The critical discussions and sharing of your experience really helped me in the realisation of the graduation research.

Patricia Ossewijer for introducing me into the world of biotechnology and providing me with the needed information and contacts to create the needed knowledge in your field of expertise. Although the research slightly moved away from the initial subject, I really appreciate the enthusiasm and input during the course of the research.

Poonam Taneja for always being there for the unplanned discussions and critically help me to structure the research. Especially the latter really helped me to bring down the scope of the research and gain the confidence of being able to accomplish the set targets.

And last, but definitely not least, Peter Vervoorn for supporting me all the way through and sharing your contagious enthusiasm. I am grateful for how you showed me the way in the organisation and your continuous effort to involve me in the interesting events. Not to mention all the discussions and brainstorm sessions which were always accompanied by a good cup of coffee.

Thank you all!

A.W.J. Kerpel
Delft, October 2018

CONTENTS

List of Figures

List of Tables

GLOSSARY

% cal Percentage Energy Content. 109

€/kW Invested amount of euro per Kilowatt. 25

AACAES Advanced Adiabatic Compressed Air Energy Storage. 25

ARRRA Antwerp-Rotterdam-Ruhr-Rhine Area. 23

BAT Best Available Technology. 29

BAU Business as Usual. 29–31

BIO Biomass and CCS. 29, 31

C5 Sugar molcules with 5 carbon atoms. 79, 89, 92, 133, 134

C6 Sugar molcules with 6 carbon atoms. 79, 89, 92, 133

CAES Compressed Air Energy Storage. 25

CAN Climate Action Network. 9

CAPEX Capital Expenditures. 60

CCGT Combined Cycle Gas Turbines. 25

CCS Carbon Capture and Storage. xiii, 25, 29, 31

CHP Combined Heat and Power generation. 23, 25

CO_2 Carbon Dioxide. ix, 19, 23–26, 28, 30, 31, 51, 53

CSR Corporate Social Responsibility. 58, 61

CYC Closed Carbon Cycle. 30, 31

CYC-ECE Closed Carbon Cycle including early closure of coal-fired power generation. 30

dB Decibel. 52

DBS Digital Business Solutions. 57

DCMR Milieudienst Rijnmond. 83

DDGS Dried Distillers' Grains and Solubles. 110

ETS Emissions Trading Scheme. 9, 29

EU ETS European Union Emission Trading Scheme. 9

GHG Greenhouse gas. xi, 1, 8, 27, 29–32, 110

H_2 Hydrogen. 80

HCl Hydrochloric acid. 80

HIC Harbour Industrial Complex. ix, xvi, 1, 2, 4, 10, 11, 28–30, 32–34, 37, 38, 43, 44, 46–48, 50–54, 57–61, 63–68, 70, 71, 73, 75–78, 81, 83–87, 90–93, 98, 99, 115, 117, 119, 132, 137, 138

IGCC Integrated Gasification Combined Cycle. 25

km Kilometres. 12, 45

kton Kilotonne. 138

LPG Liquefied Petroleum Gas. 110

MER Milieu Effect Rapportage. 52, 53

Mt Megatonne. 20

Mt/yr Metric Tonne per Year. 110

Mtoe Million tonnes of oil equivalent. ix, 17

$NaBH_2$ Sodium borohydride. 80, 81

NL the Netherlands. 27

NO_2 Nitrogen Dioxide. 51, 53

NV Naamloze Vennootschap. 12

OPEX Operational Expenditures. 60

PD Port Development. 14

PM Particular Matter. 51, 53

PoR Port of Rotterdam. ix–xi, xv–xvii, 1–5, 7, 9, 11–16, 27, 28, 30–39, 43–57, 59, 60, 63–66, 68, 75–78, 81, 84–87, 89–101, 109, 110, 115, 131–133, 138, 140, 141

PP Port Planning. 14

PtG Power to Gas. 25

R&D Research and Development. 23

RED Renewable Energy Directive. 67

RES Renewable Energy Supply. ix, 24

SDE Stimulering Duurzame Energieproductie. 134

SWOT Strengths, Weaknesses, Opportunities and Threats. 34

TeCoP Technical, Economical, Commercial, Operational and Political aspects in a project. 43

ToR Terms of Requirements. 47

TP Technological Progress. 29, 31

TWh Terawatt hour. 24

UNFCC United Nations Framework Convention on Climate Change. 7

UPW Ultra Pure Water. 80

SUMMARY

To continue the success of the PoR in the future, a transition to a sustainable industry is essential. Though this is easier said than done. The energy transition involves a variety of initiatives which are at the same time highly dependent on each other. Whilst the increasing scarcity of available area and resources result in the situation that a decision will have to be made. As long as this decision is not made, this leads to high uncertainty on which activities are going to take place in the PoR and at which point in time they are expected.

To support the decision making on which activities to focus on, there is an urgent need for a decision tool at the PoR authority.

CONCLUSIONS

The main conclusion, however, is that it is impossible to develop a decision tool which is able to make a choice among different activities. This decision is impossible because every activity has its own demands and requirements and differs in the contribution it has to the strategic goals. Besides this, it is not possible to express set requirements in a single unit, leading to the situation that a comparison cannot be judged.

Following from the above, it is being discouraged to develop a decision tool. The allocation process and the involved requirements are too versatile to be simplified in a single tool. If such a simplification is made, this will result in missing essential opportunities and potential bottlenecks in the sequential project phases.

Based on the above conclusions, it is investigated whether it is possible to provide the PoR authority with guidelines that support the comparison of different activities. To do so, first of all, the involved requirements are substantiated and to which degree these are influenced. This is represented schematically in figure 1.

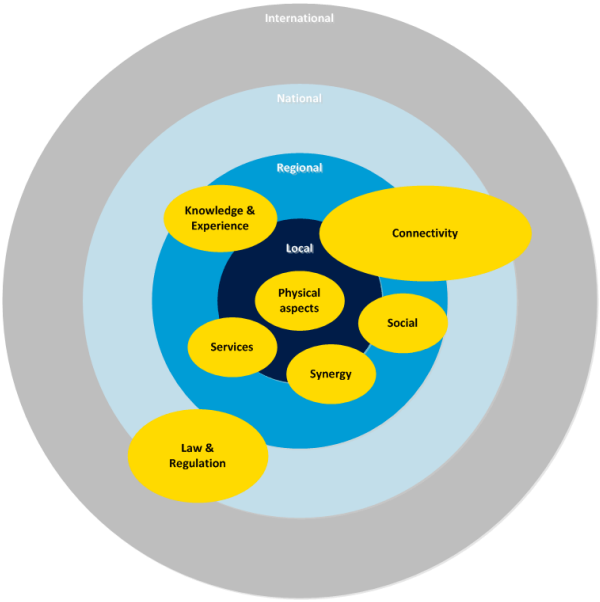


Figure 1: Schematic overview of the substantiated requirements and to which degree they are influenced

These requirements are involved in the allocation process of every activity, but it is dependent on the considered activity to which degree they can be determined and what their priority is in the decision making.

To prioritise the requirements, two case studies have been used. Due to the large dependency on the considered activity, this resulted in the identification of the aspects that enable the importance of the requirements. The most significant aspects in this are:

- Relevance Compliance of the activity to the current activities in the HIC
- Scarcity The degree of limitation that the PoR's resources impose relative to the activity
- Stakeholders The alignment between the different stakeholders of the process
- Uncertainty The degree of uncertainty inherent to the considered activity

The aspects above form the foundation on which the guidelines are founded.

COMMERCIAL STRATEGY OF THE POR AUTHORITY

In addition to the requirements, it is important for the PoR authority to incorporate its communicated strategy into the daily activities. To do so, the commercial strategy has been developed. At first sight, the integration of the commercial strategy is not acknowledged to be a requirement in the allocation process. Though, as the research proceeded, it turned out that the commercial strategy has a more important role in the decision making than anticipated. Resulting in the situation that if the PoR authority is really looking to fulfil its climate targets, the commercial strategy should function as a self-contained requirement in the allocation process.

To incorporate the requirements, supplemented with the commercial strategy, in the daily activities, it is essential to bring together the involved experts and share the knowledge that is present throughout the organisation. The latter forms the main hurdle in this respect. The needed knowledge is well present but scattered throughout the organisation in both physical means (different departments) as well as time wise (experts that are involved in different project phases).

ADVICE

From the conclusions, the advice for the PoR authority is to develop a central team that involves the experts of the relevant requirements to judge the potential activities. This team will have the primary task to evaluate and judge the potential activities prior to entering the project phases. The judgement of the potential activities will be founded on four main themes for evaluation: demand, supply, priority and contribution to the commercial strategy. These themes are schematically presented in figure 2. For a more detailed substantiation, reference is made to chapter 7.

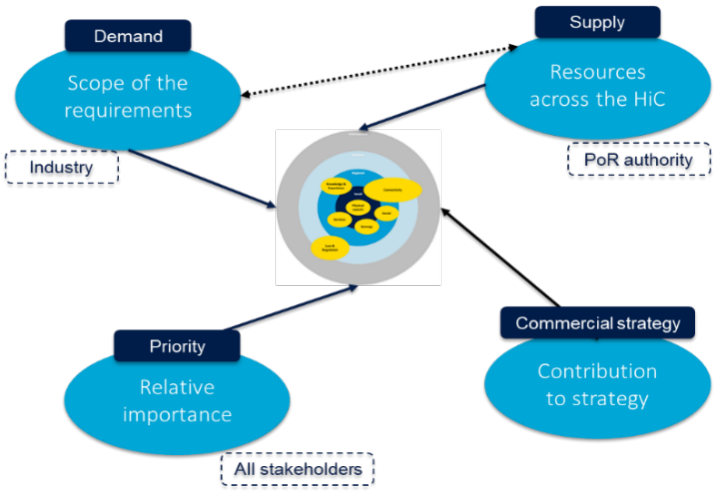


Figure 2: Schematic overview of the themes for evaluation

Though, this advice is not aimed at making the decision itself. The main focus is to supply the evaluations on the potential activities to the decision makers. The decision itself will be based on the supplied evaluations through which a decision can be made on which activities should be allocated in the PoR.

The evaluations of the themes make it possible to identify the optimal alignment between the industry and the PoR's resources, enabling to assign the best terrain for allocation. At the same time, the key opportunities, potential bottlenecks and the contribution of the activity to the energy transition are acknowledged. Despite that the level of detail will differ from activity to activity, the research has proven that by compiling the present knowledge, a substantiated first judgement can be made.

The implementation of the judgement in the initial phases of the allocation process enables comparison between existing and potential industries no matter sector or time span. The results of the evaluations are meant to realise a consistent judgement of activities. As the evaluations are based on set themes, this leads to a structured judgement. Because of this, a substantiated consideration can be made in the final decision making.

1

INTRODUCTION

1.1. BACKGROUND

These days one does not have to explain that there is an ongoing energy transition and that this is becoming more of a necessity than a desire. This means that not only changes at the consumer level have to be made, but maybe more important, the industrial sector will have to undergo a transition away from fossils. The Paris Agreement can be seen as the main initiator of the energy transition by stating the target to limit the global temperature rise below 2 °C (United Nations, 2015). As the Rotterdam Port area is a significant contributor to the national GHG emissions (approximately 15-20 %), the Port of Rotterdam Authority (PoR authority) has defined the energy transition (together with digitization and innovation) as one of their main themes in its commercial strategy (Port of Rotterdam Authority, 2018c).

PROSPECTS OF CURRENT AND FUTURE INDUSTRIES

For the Port of Rotterdam (PoR), this will mean that major changes are on the horizon, as it is host to a world-leading Harbour Industrial Cluster (HIC). New industries will arise and contemporary industries will decline, having a great impact on the existing cluster culture in the HIC. For the sake of optimal usage of the utilities, and resulting synergy, it is vital for PoR to identify how future business will look like and what is needed to accommodate this while maintaining its world-leading position.

CORE BUSINESS FOR POR AS A COMPANY

Although the transition is taking place on many fronts, this does not change the core business of the PoR authority: creating revenues by means of obtained port dues and lease contracts of terrains. Proper profitable business cases on the client side and optimal usage of utilities form the foundation of this business modal. In order to obtain an optimum result, maintaining the leading position of the HIC and at the same time getting the needed support from the government and local communities, sustainable development is required. Sustainable development is the basis for the license to grow and the future licence to operate.

FROM GREENFIELD TO BROWNFIELD

With the realisation of Maasvlakte 2, a long period of continuous expansion has most likely come to an end. Due to the expansions of the HIC, that took place over the years, planning and development of new activities mainly took place in a so-called greenfield environment. This, however, is changing rapidly as the port is reaching its limits in terms of physical area and at the same time, the need for a transition has never been higher. Meaning that in order to facilitate the energy transition, development in a so-called brownfield environment is necessary. As PoR is the facilitator of both the land as well as the surrounding infrastructure, it is seeking for a way of dealing with the uncertainties and translate them into opportunities to create an optimal utilisation in future.

PATHWAYS TO BE SET ON UNCERTAINTIES

Though a great variety of different transition pathways are possible, they involve a high quantity of uncertainty. While creating strategic plans for any organisation, these uncertainties are undesired. By creating strategic documents, PoR authority wants to communicate a clear and robust pathway which reflects its vision and is used as a guideline. In this, one wants to be as specific as possible while maintaining the flexibility to profit from opportunities as they arise.

General statement of problem:
For the allocation of future industries, there is an urgent need for a generic decision-making process to identify which activities should be allocated in the PoR.

1.2. PROBLEM DESCRIPTION AND RESEARCH PROPOSAL

The energy transition will cause not only a transition to other/new activities in the port area, but may also lead to a completely different way of planning for the PoR authority. To accommodate this transition in the PoR, an unambiguous strategy must be implemented which acts supportive to reach the goals as being set out in their future vision.

The apparent contradiction between the necessary overall strategy to guide an organisation towards their targets and the priority to develop individual projects and technologies to take a leap onto the learning curve may prove to be a challenging undertaking for PoR. For the PoR authority it is essential to evaluate different pathways in the energy transition and identify the developments which fit best into the overall strategy and future vision. This will form the foundation of the active role the PoR authority intends to take upon itself in guiding projects into a direction complying with the strategic goals.

MANY PROMISING TECHNOLOGIES

Many different opportunities are exploited and technologies developed to contribute to the energy transition. Although this is, in general, a positive development, it also results into a very unclear situation when an overview is desired. Essential is that the relevance of the technologies is evaluated. Especially when the goal of remaining a world-leading HIC, the PoR authority is pursuing the understanding of the relevant opportunities. The problem for PoR authority is not that the knowledge is not there, but the fact that the knowledge is scattered throughout different departments, this is undesirable when a unified approach is being aspired.

CONTEMPORARY PLANNING METHOD

For over 85 years, the PoR authority has been busy with the planning and development of the port area. During this period, many lessons have been learned and the HIC expanded continuously. Although the dimensions (of the port itself as well as the cargo volumes) have changed vastly over time, the game that is played by the PoR authority, remained essentially the same. This game is changing, however, as the port is reaching its physical limits and at the same time, it is aspiring to move away from fossil feedstock. This has significant effects on the planning procedure and demands the development of new knowledge within the PoR authority. To guide the energy transition into the desired pathway and seize new opportunities, the PoR authority is looking for a way to evaluate upcoming developments and become pioneers before they are actually exploited on large scale.

MISMATCH BETWEEN CURRENT AND DESIRED ACTIVITY

Over the years, PoR authority has been actively involved with clustering activities where possible. This means that most of the time the infrastructure and utilities are specifically designed for the activities in the cluster to accommodate the desired synergy. However, often, there are other activities located in the direct neighbourhood or even within the cluster itself. The infrastructure and utilities are one of the strengths the PoR is known for all over the world and is dedicated to optimising the usage of these. To maximise the utilisation, the PoR authority is looking for an approach which is able to allocate the right future activities to the right terrain, preventing a mismatch between the desired- and the actual activity.

A SYSTEMATIC DECISION-MAKING PROCESS FOR SPATIAL ALLOCATION OF FUTURE INDUSTRIES

In order to create a systematic approach to identify which future activities should be allocated, the PoR authority requires a tool that is able to evaluate the opportunities of the energy transition and incorporate these into a spatial planning strategy which maximises the utilisation of its strong infrastructural network.

To obtain this solution, the tool will have to comply with the following:

- Identifying bottlenecks and key opportunities
- Evaluating individual activities
- Creating a well-defined set of requirements
- Obtaining results that enable to compare
- Identification of the involved uncertainties
- Determination of the contribution to the strategic goals
- Enabling the PoR authority to pursue optimal utilisation

This research will focus on development of such a tool and formulate a recommendation on how to use the results in the practice of spatial planning.

1.3. RESEARCH QUESTIONS

On basis of the problem described above, the main research question for this research is stated below.

MAIN QUESTION

How can opportunities from the energy transition be seized by the Port of Rotterdam?

In order to answer the state main question, the following subquestion will be answered during the course of the research.

SUBQUESTIONS

1. What are the prospects related to the energy transition which could be relevant for the Port of Rotterdam?
2. Which requirement themes are relevant for allocation of activities in the port area?
3. What are the resources available in the Harbour Industrial Cluster?
4. What is the relative importance of the allocation requirements?

1.4. APPROACH AND METHODOLOGY

This paragraph describes the approach and methodology that is used to carry out the research and answer the research questions. In table 1.1, the approach of the research is zoomed in on and an overview is presented of the research process and desired results. This table is followed by an overview that presents in what way the research aims to fill the research gap between the main question and proposed solution.

	Approach	**Result**
Evaluating the energy transition with respect to the PoR	• Literature research • Study on the Wuppertal report • Interviews PoR	Producing an insightful overview of the **opportunities and threats** offered by the energy transition for new industries
Identifying impact Wuppertal pathways	• Review of associated industries • Identifying the impact of new industries on spatial planning • Comparing the treated pathways	A clear **insight** into the potential new industries and their **impact on future spatial allocation**
Determining the strategic value of PoR	• Literature research • Study on determinants for strategic value • Study on relevance for identification of generic requirements	A well defined reasoning resulting in **generic requirements** for spatial allocation forming the **foundation for further research**
Evaluation on the character of the allocation requirements	• Study of current commodities (infrastructure, utilities etc.) • Research on law and regulations e.g. emissions, noise and safety • Study masterplan PoR • Interview involved departments	Overview of **requirements** that are **relevant in the process** and their characteristics
Mapping the representation of resources throughout the HIC	• Desk research • Study on current and planned projects at PoR • Questionnaire for the representative Port planning area managers	A clear **indication** on which resources are **available across the PoR** and the **limits** they impose based on the identified allocation requirements
Determination of relative importance of the allocation requirements in the process	• Developing case studies • Study of key figures • Interview with experts of case study • Workshop with experts that represent the stakeholders	The **relative importance** of **allocation requirements** with respect to to the cases and the main determinants to the priority
		Drawing up the **conclusions & recommendation** for the Port of Rotterdam Authority

Table 1.1: Research approach

The first part of the research will consist of the literature review to present a thorough foundation for the sequential parts. From the literature review, it will become evident what the intention is of the energy transition, how this affects the PoR and finally a substantiation of the involved requirements into their main themes.

Between the main research question and the goal of seizing the opportunities of the energy transition, is the research gap. To fill the gap, a decision tool is proposed to be able to make a substantiated decision on which activities to pursue.

The literature review will be followed by a systematic evaluation of the involvement of requirement themes in the allocation process. By means of this evaluation, the aim is to constructively come to the aspects on which a decision tool should be based. To do so, the evaluation will concern the determined requirement themes from various points of view:

- Demand
- Supply
- Priority

To give a clear substantiation of the requirement themes, the research approach will be according to the various points of view. In fact, this can be interpreted as a triangular approach of the requirements. To clarify this, a schematic overview of this triangular approach is presented in figure 1.1 including reference to the relevant chapters.

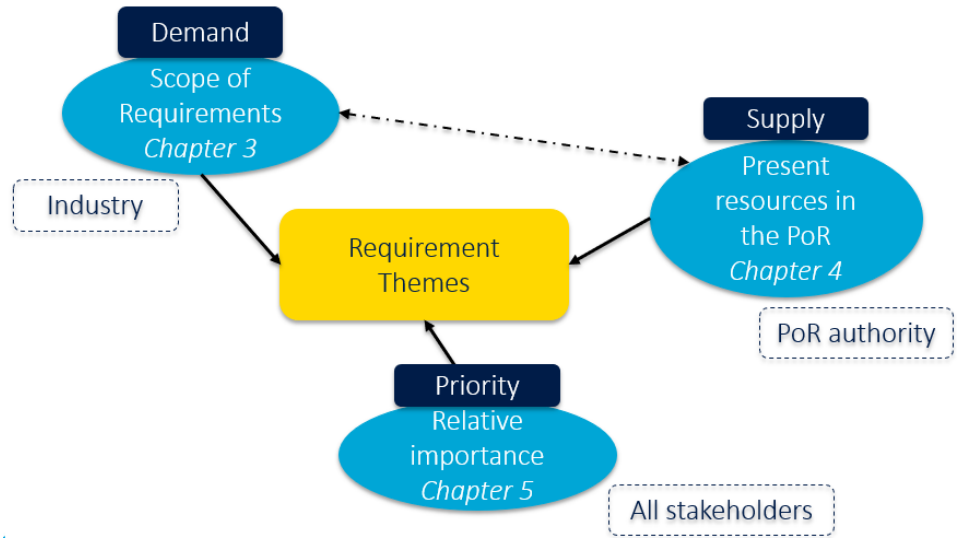


Figure 1.1: Triangular approach

2

LITERATURE REVIEW

2.1. INTRODUCTION

The literature review will concern the following subjects related to the research:

- Paris agreement and its implications
- Current situation in the Port of Rotterdam and its organisational structure
- Trends in energy transition
- Wuppertal report and its relevance for PoR
- Establishing requirements for spatial allocation

The goal of the review is to create a comprehensive overview of the situation an prospects concerning the energy transition in relation to the PoR. This includes the current situation as well as future trends and prospects. The underlying thought of the section is to elaborate upon the (theoretical) background that will form the foundation for the further research.

2.2. PARIS AGREEMENT AND ITS IMPLICATIONS

The Paris Agreement was signed in December 2015 during the United Nations Framework Convention on Climate Change (UNFCC) and entered into force November 4th, 2016. By signing this agreement, the participating parties dedicated themselves to achieve the goal of "keeping the global temperature rise below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (United Nations, 2015). In this section, the agreement is further described and the implications for its participants are assessed. The main focus of this process is the implications for the Netherlands since these will be most relevant for Port of Rotterdam (PoR).

2.2.1. FOCUS OF THE AGREEMENT

The Agreement as it is, functions as a pathway for the participating parties. In this pathway, it is stressed that every party has a different climate (financially, technologically, politically etc.) and therefore unified measures and technologies are not appropriate for the agreement as a whole. The main goal is to restrict the global temperature rise, as described in article 2, Paris Agreement, 2015, together.

The main focus of the UNFCC is to create a mechanism "to contribute to the mitigation of greenhouse gas emissions and support sustainable development" (United Nations, 2015). In this mechanism, equal division of responsibilities among parties and the fostering of sustainable development plays a central role.

The UNFCC acknowledges that not every participating party has the same opportunities in reducing measures, based on the local wealth situation the of the respective parties. To stress this, a distinction is made on three levels; Developed Parties, Less-Developed Parties and Developing Parties. in these three levels, a top-to-bottom approach is applied in the amount of effort a party is (obliged) to put into the mitigation and adaptation of climate change.

To make sure every party is able to perform its duties and has equal access to the needed sources, different mechanisms are created and described in the Agreement; the Warsaw Mechanism for Loss and Damage associated with Climate Change, the Financial Mechanism and the Technology Mechanism (United Nations, 2015). Throughout these mechanisms, the UNFCC strives for a unified approach by the different parties by means of equalising opportunities and creating a transparent platform which can be assessed by expert committees.

As for the global inequality in wealth, the top-to-bottom approach with respect to the individual participating parties is applied in the same manner. Each governmental body is confronted with the main goal that is to be achieved by the participating parties as a whole, and how this is implemented is left to the governmental body. For the implementation of the strategy, it is the task of the governmental body of the party to allocate responsibilities to 'lower' entities, moving from national government towards regional law enforcement and private parties. The task of the national government is actually the same as the UNFCC did; to create a clear pathway and strategy together with smaller scale entities finally leading towards specific mitigation- and adaptation actions.

2.2.2. INTENDED NATIONALLY DETERMINED CONTRIBUTION (INDC) OF THE EU

As part of the Paris Agreement, every participating party is asked to draw up its Intended Nationally Determined Contributions to extrapolate their contributions in to realise the low carbon transition. The Netherlands is represented as a member state in the INDC of the European Union, which was submitted by the Latvian Presidency of the Council of the European Union on the 6th of March, 2015 (Latvian Presidency of the Council of the European Union, 2015).

The main goal of the EU's INDC is to reduce the domestic greenhouse gas (GHG) emissions with at least 40% by 2030. In fact, this mid-term target (2030) has been grounded on the EU long-term climate target which was agreed on by the European commissioners back in 2009; 'an 80-95% reduction of domestic greenhouse gas emissions by 2050' (Dröge and Spencer, 2015) (Höhne *et al.*, 2013). These percentages are relative to the domestic GHG emissions of the base year 1990.

Policy-wise, the EU has proposed a qualitative elaboration in its INDC. "In contrast to Copenhagen, the EU is entering the Paris negotiations without an adopted legal framework to implement its 2030 Framework; this will be legislated progressively over the course of the coming years." (Dröge and Spencer, 2015). This approach makes it possible for the member states to substantiate their own views and contributions to achieve the goals and create a clear policy over the coming years based on the INDC. To create an overview of the key policies that have to be the driving forces of the EU towards its targets, they are presented in table 2.1 together with their underpinning initiatives.

It must be noted that the targets and policies presented in table 2.1 are drawn up for the EU as a whole. Since the EU has the same approach to the allocation of responsibilities among its member states as the UNFCC adopted, one should keep in mind that a country like the Netherlands will be on the higher end of the targets, as it belongs to the upper segment of member states based on prosperity and technological knowledge.

It is argued, however, whether the EU takes its fair share by adopting its INDC. First of all, it is important to bear in mind that it is hard to define what is fair, but attempts have been made over several studies (Hof *et al.*, 2012) (Höhne *et al.*, 2013) (Höhne *et al.*, 2014). Their results vary in a range between 45-50% reduction of domestic GHG emissions by 2030 for the EU's INDC to represent its fair share. In order to be in line with the 2 °C global temperature rise target, the Dutch Environmental Assessment Agency argues that "developed countries would have to adopt targets of 25% to 40% below 1990 in 2020 and 80% to 95% in 2050". From the results derived in the above studies, it should be concluded that it can be assumed likely that the upcoming EU policies on climate are to be more strictly rather than a softened approach.

Key policy target/initiative	**Implementing measures (estimated date of legislative proposal by the European Commission)**
At least 27% share of renewable energy in final energy consumption by 2030	Renewable Energy Package/new Renewable Energy Directive (2016-2017)
At least 27% improvement of energy efficiency (relative to 2005) by 2030	Reviews of Directives on Energy Efficiency(2016), Energy Performance of Buildings (2016), Energy Labelling and Ecodesign (2015), and Regulations on CO2 and cars/vans (2016-17)
43% GHG emission reduction in ETS (ETS) sectors by 2030 (from 2005), including increased linear reduction of 2.2% per year	Revision of the EU ETS (EU ETS Directive (2015)
30% GHG emission reduction in non ETS sectors (from 2005)	Legislative proposals on the Effort-Sharing Decision to allocate binding non-ETS targets to each Member State (2016)

Table 2.1: Key policy targets and initiatives underpinning the EU's INDC (Dröge and Spencer, 2015)

2.2.3. IMPLICATIONS FOR THE PORT OF ROTTERDAM

As being said in the previous section, a country like the Netherlands will have to create a policy which is to achieve the higher end of the EU targets based on the country's prosperity. Since the Port of Rotterdam is accountable for a 15-20% share of the yearly domestic GHG emissions of the Netherlands (Mebius, 2017), it will play an important role in the energy transition of the Netherlands.

For the PoR authority it will be of great importance that both a clear legislation, from higher governmental bodies, and an attractive innovation climate is created in order to be able to reach the reduction targets. As the port region has a variety of energy intensive-businesses and activities, it seems that this cannot be covered by a single innovative technology. This is substantiated by Lisa Jacobson, president of the Business Council for Sustainable Energy: "An essential building-block of this energy transformation is the utilisation of a diverse portfolio of existing clean energy technologies and resources." (Voegele, 2016).

POLICY

The creation of a clear policy by the higher governmental bodies (EU parliament and Dutch Government) will be the basis for PoR authority on which a healthy port strategy should be founded on. Without clear global targets and their associated incentives, it will be hard to achieve the low carbon transition while maintaining its internationally strong competitive position.

Although it is stated that the Paris Agreement aims at; "Making financial flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development" (United Nations, 2015), a clear quantitative description of how the policy is going to look like is lacking. This is clarified by the Climate Action Network (CAN) which addresses the creation of a clear strategy on both the ending of subsidies on fossil fuels and the encouragement to use renewable sources, as one of the major steps to be taken in order to achieve the targets (Mclynn *et al.*, 2016).

Besides the subsidiary side, the debate on the Emission Trading System (ETS) is a hot topic in the policy debate. Although progress is made, no real ETS is globally available and therefore current emission prices are too low to function as an incentive for individual companies to really focus on a transition to low carbon sources. Organisations involved have not yet agreed upon such a global ETS, which makes it hard for parties to make a clear policy which includes such a vital system. The EU government is committed to implementing such a system as a policy tool, but due to internal conflicts on behalf of energy solidarity in the organisation, the progress is hampered (Dröge and Spencer, 2015).

These quantified policies have to be created on short-term, in order for organisations PoR authority to develop an effective internal policy which provides enough certainty for mid- and long-term planning.

2.3. CURRENT SITUATION IN THE PORT OF ROTTERDAM

Before being able to look into the future trends and scenarios, it is of great importance to create an overview of the Port of Rotterdam as it is now. In this section, the facts and figures will be presented and their relevance with respect to the energy transition. It mainly concerns the HIC together with closely related activities like the im- and export of feedstock and the transhipment of bulk. From the general facts and figures, the modal split among the different available energy carriers will be zoomed in on, both from the side of production as well as consumption in the PoR region. For a further elaboration that is specified on biobased production, reference is made to appendix C.

2.3.1. OVERVIEW FACTS AND FIGURES

THE PORT'S YEARLY THROUGHPUT

The transhipment activities performed in the Port of Rotterdam can be assigned to four main sectors: dry bulk, wet bulk, containers and break bulk. Those four sectors account for the major part of the added value of the port region and together result in the total throughput of the port. Currently, all these sectors are heavily dependent on fossil resources, both in production process and consumption, as only a relatively small fraction can be assigned to renewable sources.

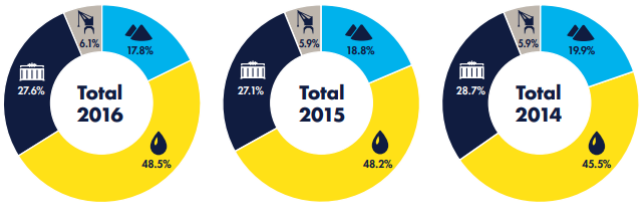


Figure 2.1: Total throughput PoR by sector in 2016 (Port of Rotterdam Authority, 2016a)

Figure 2.1 depicts the relative share of total throughput from each sector from 2014 until 2016. For this research, which mainly focuses on the industrial cluster, basically only the wet- and dry bulk are relevant and the container and break bulk are not taken into consideration because the industrial (chemical industry, electricity production, refineries etc.) mainly use liquid bulk (eg. crude oil) and dry bulk (eg. coal for the power plants) as feedstock for the production process. From the figure, it can be seen that the two considered sectors together, make up over 60 % of the total throughput of the port region. As the sectors are currently heavily reliant on fossil resources, a lot of improvement in the industrial cluster has made to comply with the targets set in the Paris Agreement.

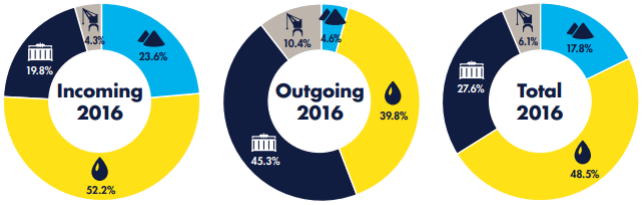


Figure 2.2: In- and outgoing products PoR by sector in 2016 (Port of Rotterdam Authority, 2016a)

As an addition to the total throughput, figure 2.2 represents the share of import and export of the port region and how this adds up. From the differences between incoming and outgoing product flows it can be concluded that the region has a net import of dry- and wet bulk. Since more is imported than exported, the industrial complex uses more, either by means of feedstock or consuming for the sake of production, than is produced into higher value products or transported out of the region. This emphasises the importance of the industrial cluster when the value chain of the port as a whole is considered.

The Port of Rotterdam is the number one port in Europe and leading in every discussed sector across the Le Havre - Hamburg range. As presented in figure 2.3, Rotterdam has a high relative market share based on throughput in all of the different sectors. As the goal of PoR is to maintain this share where necessary and expand it where possible, it will need to keep innovating in new technologies and more efficient processes.

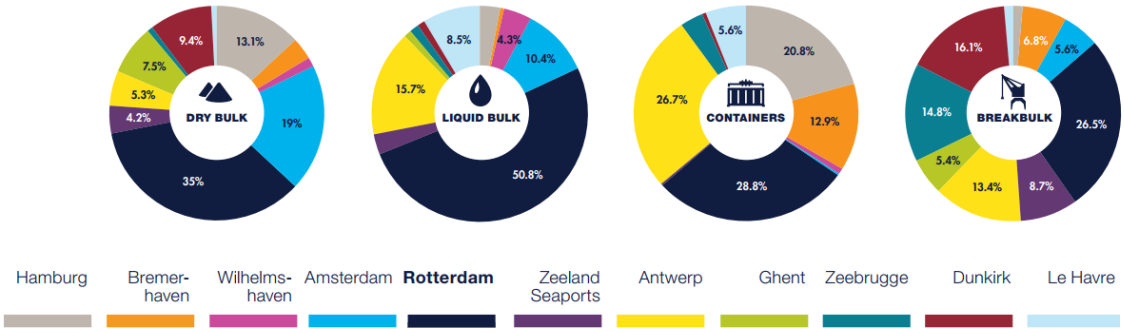


Figure 2.3: Total throughput by commodity across the Le Havre - Hamburg range in 2016 (Port of Rotterdam Authority, 2016a)

As dry- and liquid bulk play a major role in both the throughput of PoR as well as the market share across the Le Havre - Hamburg range, the PoR has to seek for opportunities to comply with the set emission targets as well as maintaining the leading international position. The discussed sectors will need to undergo substantial changes and the port's core business might even shift towards 'new' sectors as technologies emerge in future.

PoR'S INDUSTRIAL CLUSTER

The contemporary industrial cluster's most important businesses are the production of fuel, energy and chemicals. The cluster mainly produces higher value products from feedstock (either liquid or dry) that can be used further into the chain both locally as well as in more remote industries. Especially the production of fuels and chemicals are exported in large scale to the hinterland and play a vital role in for instance the inland chemical clusters. The production of energy, however, is more locally orientated to supply the industry and the residential areas in the region with a sufficient and reliable power supply. Since the production of energy has a different approach, it is out of the scope of this research and treated as a separate sector. Though the energy production might be considered when the integration of the supply chain is treated. for a schematic overview on the main value chains in the HIC, reference is made to appendix B, where the most important feedstocks, processes, products and links among different processes are distinguished.

The PoR is already active in the accommodation of new industries, but in general this is still very dependent on the maternity of the concerned technology. An example of this is the current biobased fuel production which is further elaborated in appendix B.

2.4. PORT OF ROTTERDAM AS AN ORGANISATION

The aim of this section is to create an insight of the Port of Rotterdam as an organisation, how it is structured and which role it fulfils in daily practice. Since the research also involves the decision-making process concerning the allocation of new industries, an elaboration will be presented which clarifies the role of the different departments in this process. To conclude this section, the strategic documents and their role will be treated.

2.4.1. COMPANY OVERVIEW

Port of Rotterdam is a non-listed limited liability (NV) company with two shareholders: the Municipality of Rotterdam (70.83 %) and the Dutch State (29.17 %). Although both shareholders are governmental bodies, Port of Rotterdam is operated as a commercial entity. Through its role of administrator, operator and developer, Port of Rotterdam is pursuing to live up to its mission: 'Creating economic and societal value by cooperating with clients and stakeholders in realising sustainable growth in a world-class port' (Port of Rotterdam Authority, 2018a).

Over the years, the Port of Rotterdam has expanded from a port in the city of Rotterdam, all the way into the North Sea covering over 40 km. With this expansion, the area for which the PoR authority is responsible also increased to a significant amount as shown in figure 2.4.
A more extensive review of the company and the current facts, figures and ongoing developments can be found in the 2017 'Jaarverslag' (Port of Rotterdam Authority, 2018a).

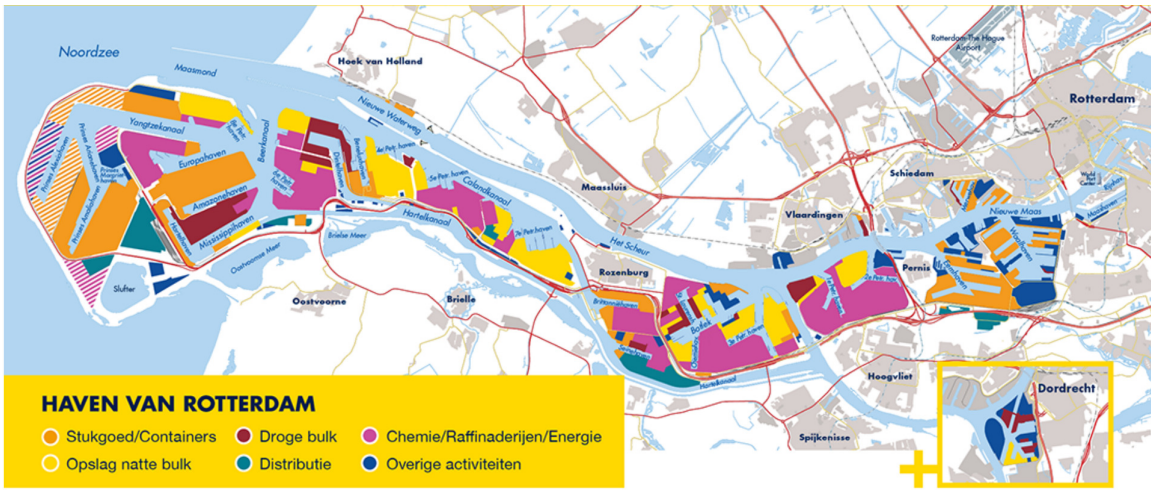


Figure 2.4: Overview area of responsibility for Port of Rotterdam (Port of Rotterdam Authority, 2018a)

2.4.2. CORE BUSINESS

By living up to the mission and by actively pursuing a sustainable future, the PoR is creating the foundation for its license to grow and license to operate currently and in the future. For its role as administrator, operator and developer, investments into flexible and robust developments are a priority. This holds for both physical infrastructures as well as in terms of the organisational side of being the world-leading port in logistics. The core activities, as described by the Port of Rotterdam, are focused on endorsing this (Port of Rotterdam Authority, 2016c):

- Developing, constructing, administrating and operating of the port- and industrial area in Rotterdam
- Fostering an effective, safe and efficient shipping settlement in the Port of Rotterdam and the offshore run-up area

As stated in the previous paragraph, the Port of Rotterdam functions as a commercial entity, meaning that revenues have to be made in order to facilitate investments into developments. By means of its role as administrator and operator, PoR creates revenues in the form of port dues and land lease contracts with clients in

the port area in order to be able to fulfil its role of developer. The activities of PoR authority can be subdivided into physical products (preparation of terrains for lease and port infrastructure) and services (guidance for shipping, inspections and digital services). A full overview of the creation of value by the Port of Rotterdam is presented in figure 2.5.

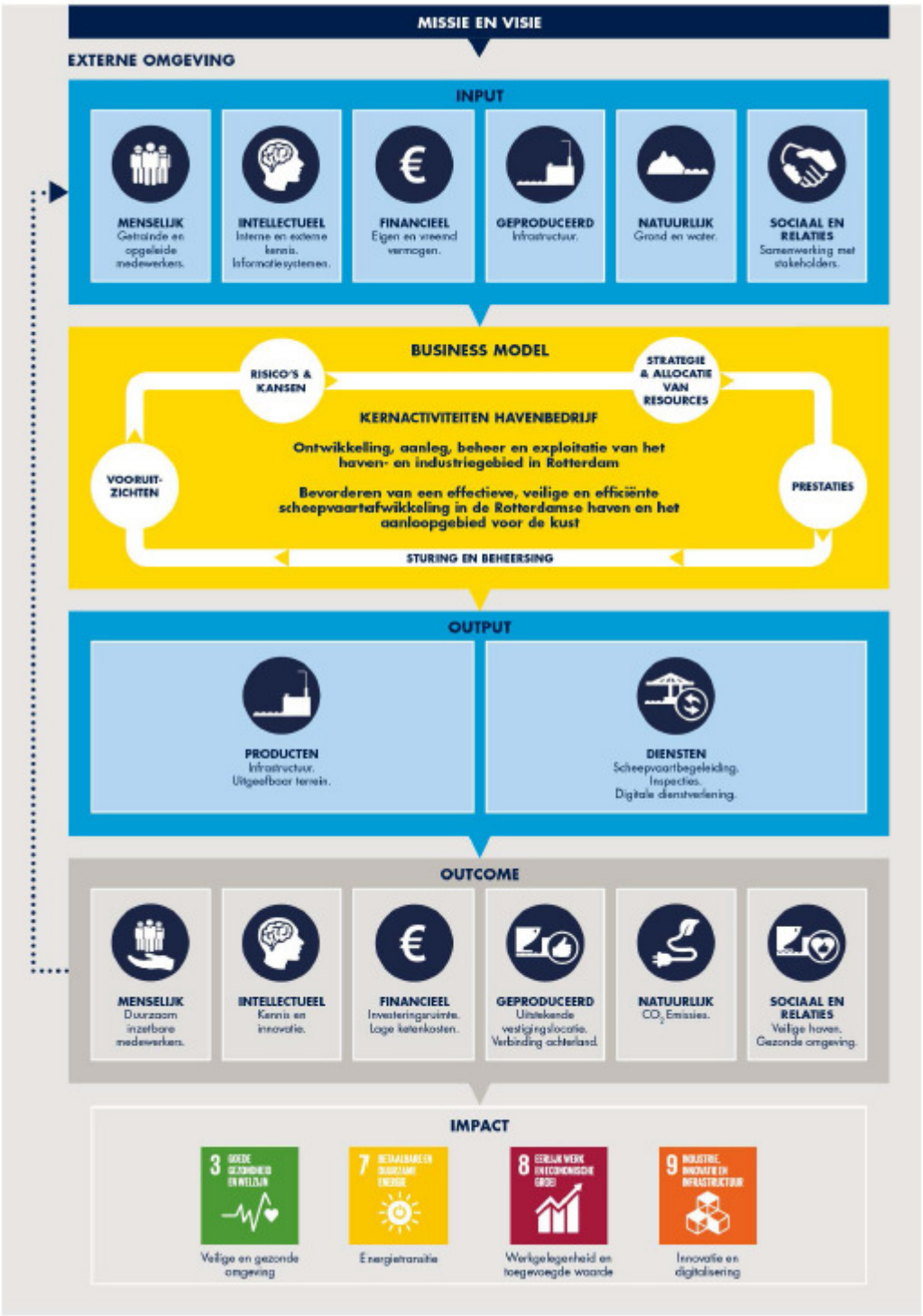


Figure 2.5: Creation of value by Port of Rotterdam (Port of Rotterdam Authority, 2018a)

2.4.3. ORGANISATIONAL STRUCTURE

As depicted in figure 2.6, the organisation is divided into several main- and sub-departments with their own speciality. As a whole, it can be stated that the commercial departments have finding and binding of (new) customers as their main focus, whereas the Harbour master's division concerns public law activities (like traffic management, inspection and acting in case of incidents). In conclusion, the staff-departments are focused on the supportive task that enables the company to perform its core activities.

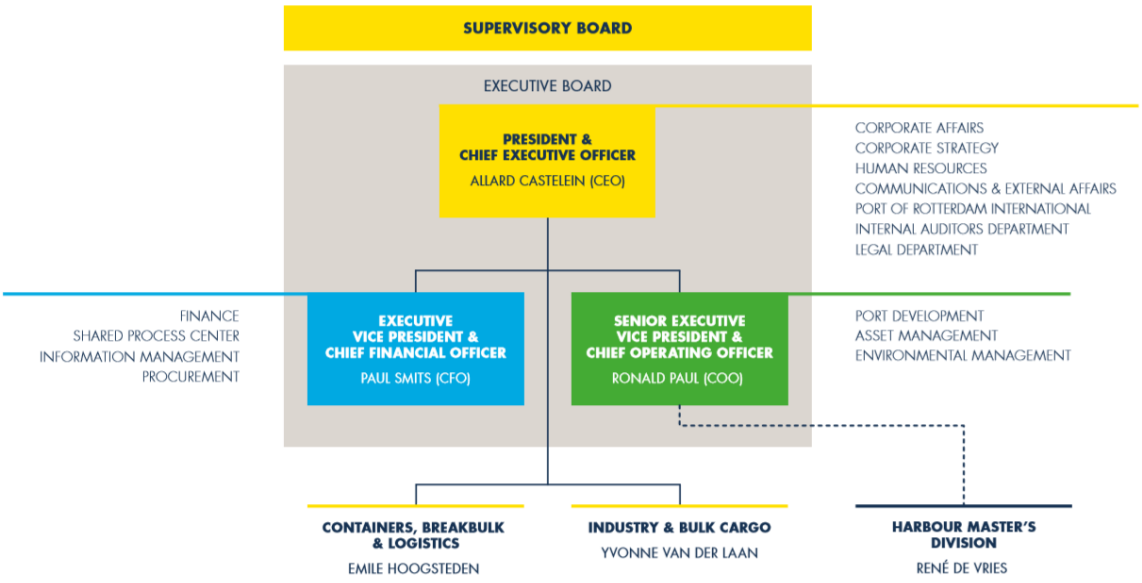


Figure 2.6: Organisational structure Port of Rotterdam (Port of Rotterdam Authority, 2018a)

As this research is mainly focused on the (future) port development (PD), the role of the similarly named division is important in particular as it is responsible for the allocation, development, repossession, redevelopment, land lease and purchase of commercial terrains in the port area.

As the main topic concerned is the allocation of possible future industries, the most relevant department in PD is the Port Planning (PP) which consist of the Port planning area managers and spatial development analysts. This department is looking into the possible future businesses combined with the current and is aiming at an optimal usage of terrains terms of availability as well as complying with the set targets and strategies of the port.

Although all departments are presented as separate, a project (almost) always finds its way through various different departments and accountable employees before a well-founded decision can be made. Interconnectivity among the different departments is therefore of vital importance when a smooth and correct decision is desired.

The process of decision-making for future port developments at the PoR authority is presented in figure 2.7. The figure clearly depicts the complexity and variety of departments that are involved in the decision-making process.

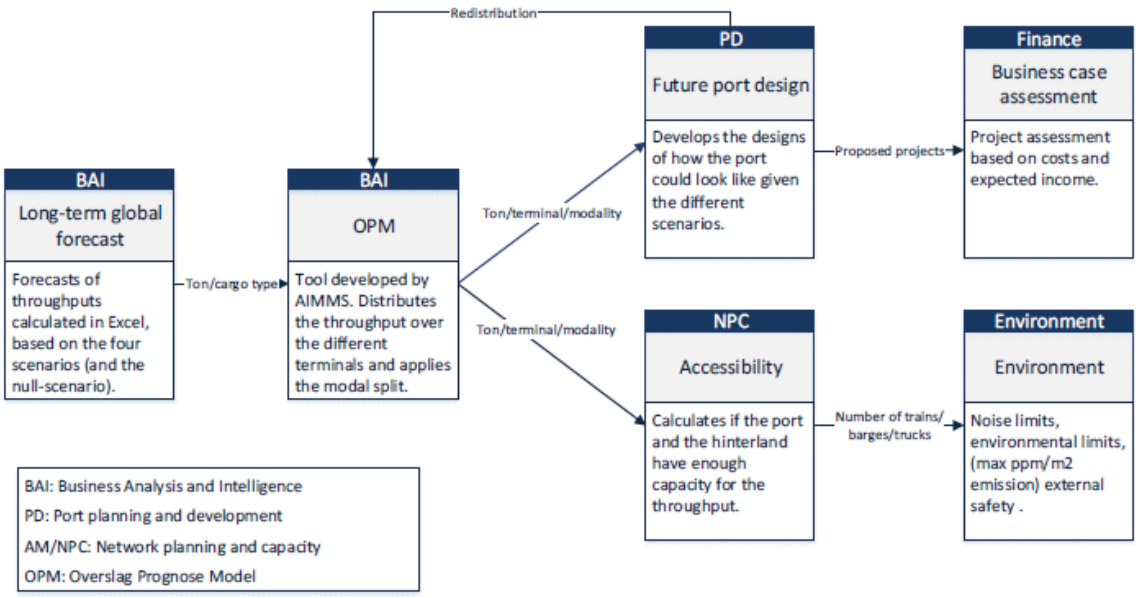


Figure 2.7: Overview of the decision-making process for future port developments at PoR according to (van Oel, 2017)

2.4.4. STRATEGIC VISIONS AND DOCUMENTS

For the communication and realisation of the future trends and goals, PoR uses two main documents:

- Port Vision 2030 (Port of Rotterdam Authority, 2011)
- Commercial strategy (Port of Rotterdam Authority, 2016c)

Both these documents are aimed to translate the goals defined by trend analysis and targets involved in the energy transition, to a tangible strategy in relation to the Port of Rotterdam. The main difference between the two documents is the covered time span, which also influences the level of detail. A graphical representation of the two documents is given in figure 2.8.

Figure 2.8: Comparison between the Port Vision 2030 and the Commercial strategy of PoR (Port of Rotterdam Authority, 2016b)

For internal use and the realisation of tangible actions and projects, the strategic documents are put into practice in the form of the Masterplans. The goal of this instrument is to give directions for the spatial- and desired developments in the port area for the time period until 2040 (Port of Rotterdam Authority, 2018b).

The different time frames that are being evaluated in the various documents means that much attention needs to be paid to the complementary aspects among them. This holds that an iterative process is vital and regular updates necessary to ensure these aspects. Not only the documents are involved in this respect, but also the long-term trends (based on the themes fossil forward, green unlimited, conservative carbon and lean & green (Port of Rotterdam Authority, 2011)) and on the other hand the short term planning form important input for the generation of the documents and have to be aligned with each other.

In general, it can be said that PoR is giving direction to the future ambitions by identifying a set of general themes and goals. The main strategic statement is that PoR focuses on the so-called "and-and strategy". Meaning that not only effort is put into new (and uncertain) developments and industries, but at the same time, it is striving to facilitate the contemporary clients maximal in order to retain the position of best establishment location in Europe (Port of Rotterdam Authority, 2016c).

The general themes also act as the connection among the different documents and are mainly directed to future developments.The three main themes are identified as:

- Energy Transition
- Digitisation
- Innovation

To realise this and make sure that the strategy of maintaining the best establishment position is also being pursued, the following eight goals have been identified by PoR:

- Competitive in mature markets
- Market leader in growing markets
- Front-runner in the development of new markets
- Excellent establishment location
- Leading in the sustainability of chains and clusters
- The most efficient and safe handling through all modalities
- Creation of value by means of international port development
- Sufficient long-term investment capital

Although the various documents address the subjects in a different manner and have different goals in the communication, they cannot be seen separately. Altogether they are aimed to provide a systematic approach to the future uncertainties and be a clear directive on different levels of the organisation as well as public communication.

Figure 2.9: Influence of short term trends and long term trends on spatial planning (Port of Rotterdam Authority, 2018b)

2.5. TRENDS IN ENERGY TRANSITION

The main question that is treated in this research is; 'How can opportunities from the energy transition be seized by the Port of Rotterdam?'. Prior to answering this question, the problem should first be evaluated extensively to be able to identify the necessity and opportunities in tackling the problem.

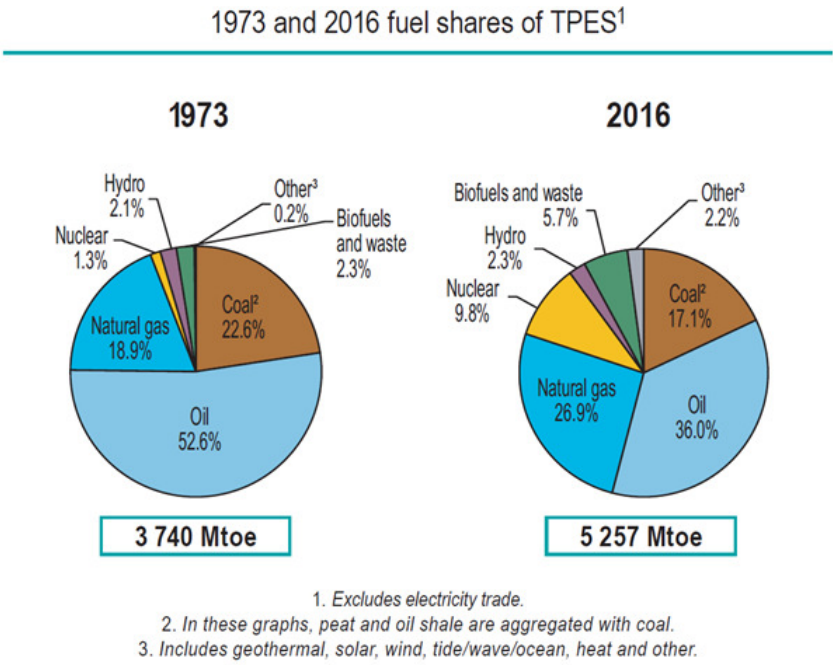


Figure 2.10: Global fuel shares of Total Primary Energy Supply in Mtoe (International Energy Agency, 2017)

As extrapolated in the section on the Paris Agreement (2.2), a transition towards a non-fossil orientated economy is necessary in order to limit global warming and the consequences. In this section, it has been made clear that the way the economy is working right now, will harm the environment both locally as well as globally to such extent that it may threaten coming generations. This section focuses on the current situation and the transition that has been laid down until now. Initially, the current fossil-economy is described and identifying its strengths, which will form the benchmark for the transition process. Next, the subject of energy transition is described by presenting visions from different sectors and how they think the process will be embodied, their targets, challenges and opportunities.

2.5.1. IMPORTANCE OF FOSSIL FEEDSTOCK

The fact that fossil feedstock were so extensively used, is enough evidence showing the strength of the feedstock. However, the counter side is its (very) long carbon cycle, which is largely released into the atmosphere in a relatively short period of time affecting the carbon balance, as well as other particular matter that is emitted when combusted (like nitrogen, phosphors, sulphides etc.).

Although fossil feedstock comes in a wide variety of forms and types, its main function is that it contains a high energy density which can be converted into the needed form (heat, fuel, electricity etc.), are very efficient when combusted and stored with relative ease, not to mention the great variety of products that are developed based on fossils over time. Due to this, many industries evolved, leading to large employment and prosperity, and a vast increase in the use of fossil feedstock has led to the point that the world realises that this needs to change to guarantee the quality of life for future generations. But before being able to seek for solutions, the strengths of the contemporary feedstock must be recognised as it sets the benchmark for renewable sources and production processes.

MULTI-PURPOSE

The main reason that fossil feedstock forms the basis for a great variety of industries, is the fact that is has a very multi-purpose nature. Due to the fact that the feedstock can be converted and stored in many different products, there will (nearly) always be a market available to which the product can be sold to, resulting in a high certainty for the producing companies (like refineries).

When different fossil feedstocks are considered, the three main resources are petroleum, natural gas and coal since they account for the majority of global usage (figure 2.10). Where petroleum and natural gas are mainly used to produce chemicals and fuels, coal is mainly used as feedstock in the production of energy and heat. Although one type of feedstock is not able to fulfil all functions, the great variety of production processes allow for many purposes among the different feedstocks, leading to a high flexibility and certainty when energy security is considered.

For reasons of convenience, fossil fuels offer a great benefit when compared to renewable sources of feedstock. The processes of collecting, transforming and storing have been performed by nature over the cause of thousands of years. When renewable feedstocks are explored, one first needs to develop an efficient and cost-effective way of doing this, before it can be converted to any form of energy carrier. Together with the fact that most of the fossils are relatively easy to retrieve and convert, it is a huge challenge to exploit renewable production processes that are able to compete with the contemporary fossils (Cheek, 2016).

COMPLEMENTARY PRODUCTS AND INFRASTRUCTURE

Like the majority of energy sources, fossils are also dependent on a well-organised infrastructure, in which energy can be transported and stored in order to achieve an effective distribution and be able to fulfil the demand at any given time. Due to the widely adopted use of these fossil resources, in particular when fuels are considered, this infrastructure is in place already and gives the product a huge advantage over new technologies. This must be seen in combination with the complementary technologies (like the combustion engine) which are based on the availability of the fossil energy sources. If the transition is to be made, for instance to electrified drive-trains, one has to build such an infrastructure either from scratch or adapt the storage and transportation in such a way that the contemporary infrastructure can be used, but both come at significant cost.

A good example is illustrated by Sjors Gereadts from GoodFuels from the marine sector. It is expected that in the long run, vessels will be largely electrified (especially on shorter distance routes) by either using battery systems or fuel cell technology. On a shorter time frame, no major changes are expected in the technologies used in the drivetrain of the vessels. As the vessels produced these days, are designed to have a lifetime of at least 30 years and (complete) conversion to electrification of a ship already in use does not seem viable, the only short-term option is to supply fuels with the lowest possible GHG emission and at the same time are compatible (or by means of minor changes) with the installed combustion engine. GoodFuels is bringing such fuels to the market originating from biobased feedstocks, facilitating a transition towards a biobased economy in the marine sector (Gereadts, 2017).

EMBEDDED IN SOCIETY

The way society currently makes its choices (where to live, work, recreate etc.) has changed significantly over the past decades due to the widely available sources of energy and associated mobility. Although nowadays most people understand that many products are made from fossil feedstock and with this forms a threat to the environment, the relative cheap supply and ease of use makes that it is completely embedded in the way society functions. In fact, society is relying on the availability of resources (Rinkesh, 2015).

2.5.2. PROSPECTS OF ENERGY TRANSITION

In the long run, the targets as being set during the Paris Agreement (United Nations, 2015), a great reduction of GHG emissions is acknowledged to be necessary. In fact, the use of fossil feedstock must be replaced by other means of feedstock based on renewable sources. The use of a select group of feedstock that is able to create a large number of different products, as this can be said about fossil feedstock, does not seem a viable option. This can be accounted to both the availability of the renewable feedstock as well as the fact that working with renewable sources holds (in most cases) that working with nature is a central process and therefore geographical location is of great importance for the opportunities a region has exploiting certain resources. Another determinant is that every sector needs different forms of energy (carriers) or feedstock and have their own specific requirements.

Therefore the sectors will be treated separately and a general overview is created in which it should become clear what the goals, trends and opportunities are for each sector on the long run and acknowledge the results of the pathways (Bruggink *et al.*, 2014). The different sectors that are taken into consideration are transport, production of chemicals and energy production, as they currently are heavily dependent on fossil feedstock, have a high energy intensity and are very relevant for the processes in the Port of Rotterdam, as depicted in figure 2.11. A significant part of the refining of crude oil can be accounted to the production of fuels for the transport sector. For this reason, and since liquid transport fuels are one of the big customers of the oil refineries, in this section the fuel production is approached from the demand side.

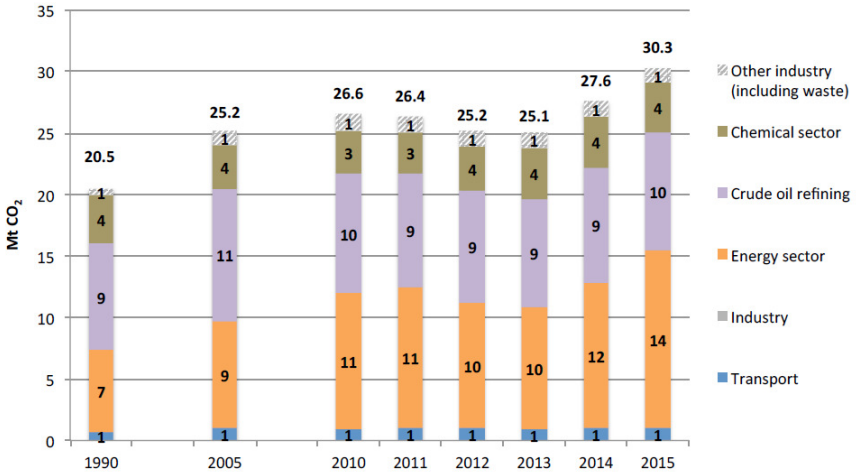
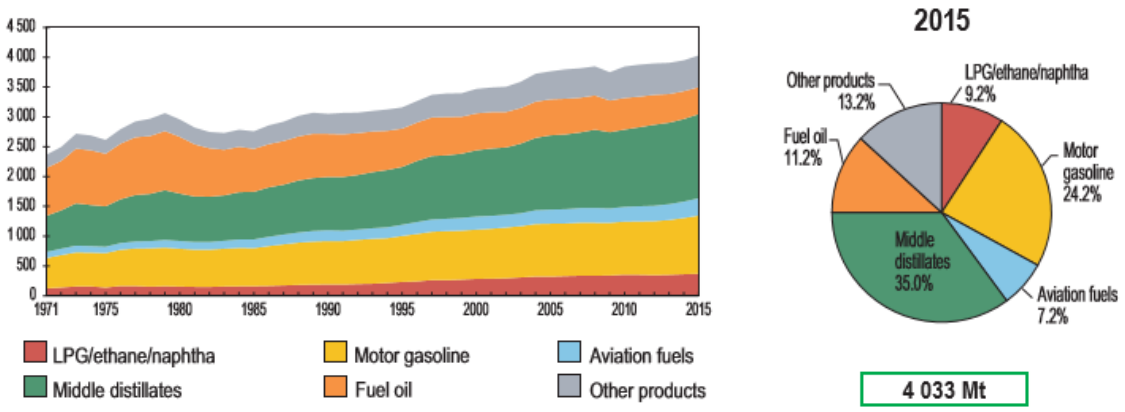


Figure 2.11: Annual CO_2 emissions for the PoR area from 1990 to 2015 per sector (Samedi *et al.*, 2016)

LIQUID FUELS

As explained above, the transport sector is currently heavily dependent on fossil fuels that are used to power the contemporary combustion engines in the majority of the sector (only rail transport can be seen as an exception to this). To tackle the associated GHG emitted by the use of these technologies, significant improvement and transitions should be made, as the transport intensity is not likely to reduce. In figure 2.12 it can be seen that large parts of the refined products refer to the use as fuels for the transport sector. Although there is a difference in the use of fuel for each mode of transport (aviation, seaborne-, road- and rail transport), they are all mainly refined from the same fossil feedstock: crude oil.



(a) World refinery output from 1970 to 2015 by product (Mt)

(b) World refinery output share per product 2015 (Mt)

Figure 2.12: World refinery output over the years and per product (International Energy Agency, 2017)

When trends are being observed, the main final target is to electrify all modes of transport where possible. This, however, comes with a big challenge; not every mode of transport is compatible with electric forms of drivetrains as the technologies are right now. Especially the aviation industry has great difficulties in forming a transition to renewable forms of energy due to the long range and low weight that is needed, and it looks like (advanced) bio- and clean synthetic fuels combined with the improvement of efficiency is the only viable option both on short- as well as long-term. For the other mentioned modes of transport, the general remark is that the lower distance that is travelled without refuelling (range), the greater the opportunities are to electrify the mode of transport (Mobiliteitstafel, 2014). This also affects the time frame in which electrification of a certain mode of transport can be exploited, again the shorter distance modes are likely to be first (e.g. package distribution in a city) and long-distance last (e.g. container freight between Europe and Asia).

This will all lead to the gradual phasing in of the transition to electrified drivetrains in the transport modes. The pace in which this can be achieved, and therefore also the share of electrified drive trains in a sector, will be largely determined by the time interval in which technological breakthrough can be accomplished together with a well-executed governmental vision and action plan to roll out new technologies and make them competitive with current alternatives. Successes from one sector may be able to give other sectors a push by means of developed technology and showing that opportunities can be exploited which result in a viable business. Expected is that forensic road transport combined with smaller derivatives of seaborne transport (e.g. pleasure boats) will be the initiators of the transition towards electrification (Cuelenaere *et al.*, 2014). From this enrollment, it is expected that the first steps on the learning curves can be set and opportunities are to be created for the up-scaling of the technologies.

It must be noted, however, that the phasing in of new technologies does not directly mean that the whole transport mode is electrified, especially when a vehicle is designed to have a long lifetime. Although the target announced is that all newly sold cars in the Netherlands have to be fully electric by 2035 (Mobiliteitstafel, 2014), does not automatically mean that by 2050 the road transport only consists of electrified vehicles. To make the transition turn into a success story, special attention is needed for the creation of a reliable and robust infrastructure and incentives to convince the consumers to choose an electric vehicle over the combustion engine.

When looking forward to 2050 it is expected that it will be clearly noticeable, especially in daily activities, that the transition is in full progress and a significant share of the road-, train- and smaller waterborne transport has been electrified. Together with the fact that electric transport modes are not only reliant on charged batteries, but hydrogen (and associated infrastructure) will have made a strong progress in being a compatible energy carrier for electric drivetrains in the transport sector. The aviation- and seaborne sectors are expected to have made significant improvements in efficiency and the use of more sustainable biobased fuels gained an important share in its fuel mix. The division among resources and resulting energy carriers for all transport modes are depicted in figure 2.13. Especially the right side of the figure is of importance when the long term is concerned (except for aviation and long distance waterborne transport).

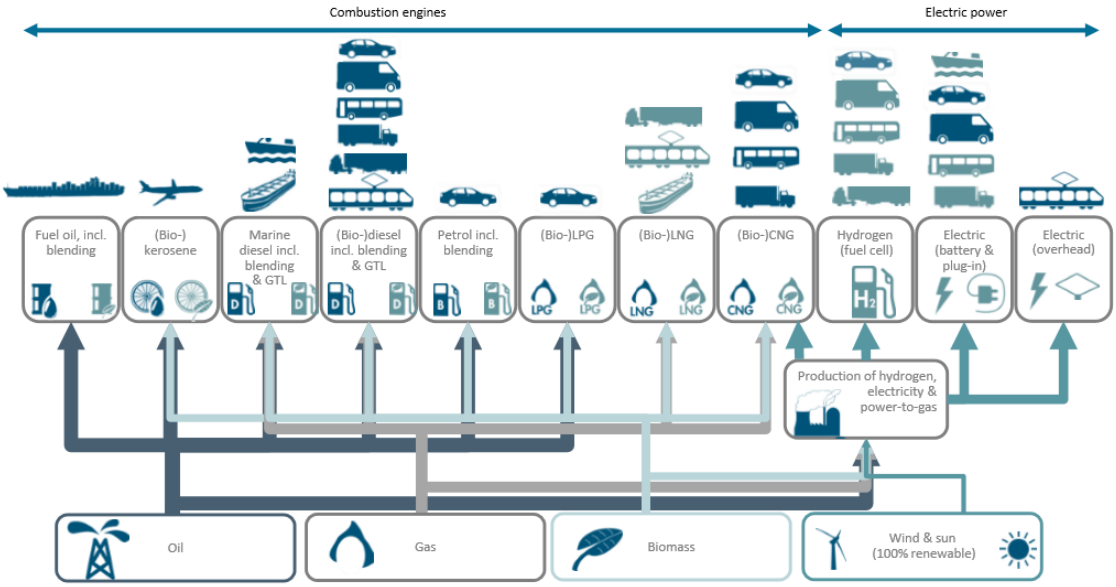


Figure 2.13: Energy carriers transport sector specified for each mode of transport (Mobiliteitstafel, 2014)

CHEMICALS

As with the other sectors, the production of chemicals plays a significant role in the emission of GHG, represented by 'industry' in figure 2.11. Besides the energy-intensive production processes (in which mainly heat and electrical energy are used), the chemical sector also deals with the origin of their feedstock from the input side and the extent to which it can be recycled and biodegradability at the end-of-use phase. The chemical sector might look more complex in this respect, but in the end, it adds up to the following main requirements for sustainability:

- Restrict the use of resources (material and energy)
- Maximise the share of renewable resources as input
- Minimise the generation of pollutants and waste during production
- Produce recyclable or biodegradable products

When performed well, the development of technologies can enable the decoupling of economic growth and environmental impact (Jenck *et al.*, 2004).

When production of chemicals is being discussed, one should keep in mind that the chemical industry contains a great variety of different production processes and resulting products. General remarks may therefore account for the majority, but certainly not for the entire industry. Besides this, the chemical industry, although treated as a separate industry, cannot be seen apart from the other sectors being discussed in this section as overlapping factors are evident:

- Most refineries are also producing chemicals or building blocks for chemicals processes
- A foremost energy source for chemical production is electricity, making the industry (and its sustainable performance) dependent on the production of energy
- Usage of same resources, e.g. coal for the production of the needed steam (conflict with energy production) and (products based on) crude oil for the input of the production process (conflicting with the liquid fuel production)

When the energy- and heat supply of the chemical sector are considered, it is heavily dependent on other sectors supplying these, so there is little influence (besides the efficiency of the process) the sector has on this part of the GHG emissions. Due to this, the main focus of the sector has to be on both the input as well as the output side of the production process. For the chemical industry, the implementation of biotechnology is seen as the main answer to comply with the transition towards a sustainable economy. By using biobased resources instead of fossils most GHG emission reduction is achieved by the reduction of the process energy needed for production (Ministerie van Economische Zaken, 2015). Reuse of residual energy and heat flows may result in even higher emission benefits on behalf of efficiency improvement.

Biobased products themselves do not necessarily result in lower GHG directly. The main difference between the use of biomass compared to fossil resources (besides the energy and heat needed for production) is the fact that the time it takes to complete the carbon cycle is significantly shorter for biobased- ($\approx$ 1-4 years) than it is for fossil resources ($\approx$ thousands of years). Another advantage of the biobased production of chemicals, as compared with fossil-based, is on the waste side of the spectrum of the process, where products from biobased resources have promising opportunities for the process to produce biodegradable or highly recyclable products. Altogether, the transition towards a biobased economy can result in a significant GHG emissions reduction of the chemical sector when the whole life-cycle is considered (cradle to cradle approach) (Hatti-Kaul *et al.*, 2007).

Biomass resource	**Uses**
Corn	Solvents, pharmaceuticals, adhesives, starch, resins, binders, polymers
Vegetable oils	Surfactants in soaps and detergents, pharmaceuticals (inactive ingredients), inks, paints, resins, cosmetics, fatty acids, lubricants, biodiesel
Wood	Paper, building materials, cellulose for fibers and polymers, resins, binders, adhesives, coatings, paints, inks, fatty acids, road and roofing pitch

Table 2.2: Common products from biomass (Gavrilescu and Chisti, 2005)

As presented in table 2.2, just three different resources of biomass can result in a variety of uses and it shows that some similar products can be produced from different resources of biomass. The uses can also vary on the type of product, in fact from any source of biomass resource, chemical as well as fuels can be produced and this is when the production of food is left out of the picture. After all, depending on the same resources, may cause problems (high prices for food, exploitation of foreign agricultural production sites etc.) and tends to make it difficult when competition with products from fossils are considered (United Nations, 2015).

The production from food crops is referred to as 1st generation biobased products, whereas 2nd generation biobased products make use of waste streams (from either crops or from e.g. wastewater treatment) and therefore do not interfere with the production of food and the possible consequences. This is an important point of interest when biotechnology will develop further and scale-ups are to be made.

The chemical industry is strongly influenced by its image towards society, from which it has suffered problems in the (recent) past. The problems mainly arise from the output side, by the dumping of toxic waste in the public domain, the 'plastic soup' of waste plastics that has evolved etc.. These image problems are likely the reason that the sector is already performing the extensive R&D.

Future trends and expected amounts of GHG emission reductions for the chemical industry have been described by governmental bodies and firms in order to be able to create a clear and robust vision (Ministerie van Economische Zaken, 2015). In this vision, an important role has been assigned for the cascading of material and feedstock in the production processes (Rabbinge, 2015). Also, it is emphasised that on behalf of value creation by the biotechnology, one should focus on high-quality products (e.g. chemicals and pharmaceuticals). At first glance, this might look contradictory to the drop-in legislation (in transport fuels) and co-burning of biomass for the sake of energy production. However, by applying this strategy, the technological development is able to take a significant step on the learning curve and at the same time have a viable business case for the near future.

Until 2030, a 6.5 % yearly growth of biobased products in the chemical sector to be achieved until 2030 (Ministerie van Economische Zaken, 2015). To comply with the increasing demand for biobased products, the 'Commissie Corbey' states that both the scaling-up as well as the optimal allocation of biomass are of vital importance (Kamp and Dijksma, 2016).

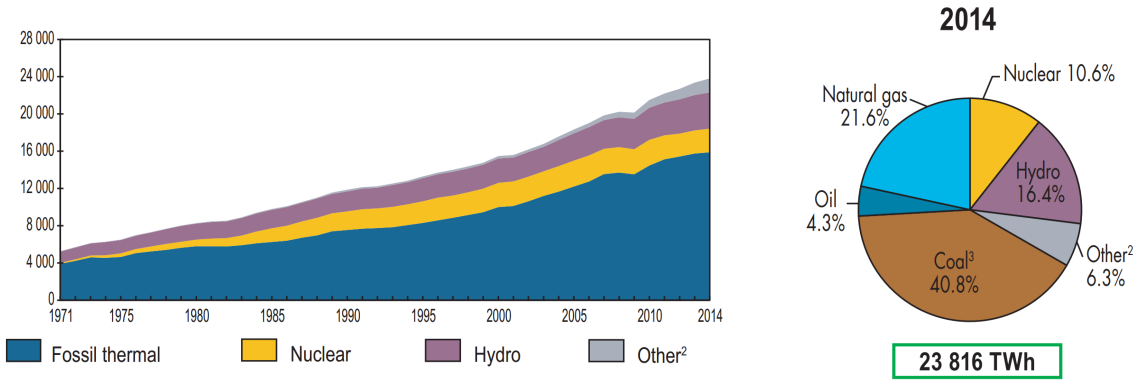
The development of the Antwerp-Rotterdam-Ruhr-Rhine Area (ARRRA) network, enables its chemical cluster to make big steps in terms of efficiency as well as maintaining its world-leading position. The aim as resulted from the Paris Agreement is to reduce the GHG emissions by the chemical industry by 50 % in 2030 over the entire production cycle in the sector (Krebbekx *et al.*, 2012). Although biotechnology seems to be the future of chemical production, hydrocarbons are still expected to form the dominant feedstock (15-20 %), next to shale gas, from 2030 onward. From 2030 to 2050 different scenarios for the use of biomass are acknowledged, varying from 0 - 15 % of biomass use as a percentage of the total use of feedstock (Vaessen and Oomes, 2012).

ENERGY PRODUCTION

As can be seen in figure 2.11, the generation of energy accounts for the largest share of the total output of emissions when the different industries are compared. The energy sector mainly consists of two forms; dedicated power plants and co-generation of energy while producing heat for industrial purposes (CHP). Both forms of power generation account for approximately half of the total power generation (Frontier Economics, 2015) in the Netherlands and can be found in the Port of Rotterdam region. The generation of energy in the dedicated plants still is highly dependent on the use of fossil feedstock (predominantly natural gas and coal as can be seen in figure 2.14) and even newly installed power plants are using this as a feedstock. Those power plants, in general, can be regarded as the largest single emitters of CO_2 of an industrial area.

The energy generation sector is seeking a variety of different solutions in order to become more sustainable as a whole. This process involves several new technologies of energy generation as well as mitigation of emissions, taking place on both large- and smaller scale initiatives. The main challenge for the sector is managing the different stages of maturity of evolving technologies and integrating them in such a way that they all contribute to the sustainability goals. The other side of the spectrum involves the adjusting and phasing out the contemporary polluting technologies, which are known for their long lifespan, to reduce their negative effects (Samedi *et al.*, 2016).

Besides the change to other means of energy production, an important trend is that the Netherlands is changing from an energy importer to an exporting country. This should all happen around 2023 and is mainly because of the phase-out program of the German nuclear power plants (Schoots *et al.*, 2017).



(a) World electricity generation from 1971 to 2014 by fuel (TWh)

(b) World electricity generation by fuel 2014 (TWh)

Figure 2.14: Electricity generation by fuel (International Energy Agency, 2017)

Renewable energy generation

As depicted in figure 2.14a, electricity production has grown significantly over the years and this has been supplied mainly by fossils. In the last few years, the renewable forms of energy have gained terrain and they will have to continue in doing so to be able to reach the sustainability targets as being set. The main focus of this part of the energy transition is on the generation of wind- (both on- and offshore), solar- and other means of energy (like biomass). Although the technologies are relatively immature, they prove to be working and are exploited on the market already (private as well as public). The approach of these technologies is vastly different from what the conventional supply of energy used to be and partnerships among provincial/national- and municipal governments prove to be of crucial importance, since the usage of land, has a much more significant impact on local circumstances (Schoots *et al.*, 2017).

Both (Schoots *et al.*, 2017) and (Frontier Economics, 2015) project that by 2035 around 50 % of the electricity supply in the Netherlands will be from renewable sources (mainly wind and solar) and contrary to the increasing energy usage from the past decades, consumption of energy will be dropped by 8 %. As depicted in figure 2.15, a large increase in the supply of renewable energy is expected the coming five years, caused mainly by a sharp increase of wind and solar. After 2020 onward, a steady growth of all three renewable sectors is expected (other RES are excluded here) leading to the 65-70 % share of renewables in 2035 and a decrease in CO_2 emissions of 30 % for the energy generation sector as a whole (Frontier Economics, 2015).

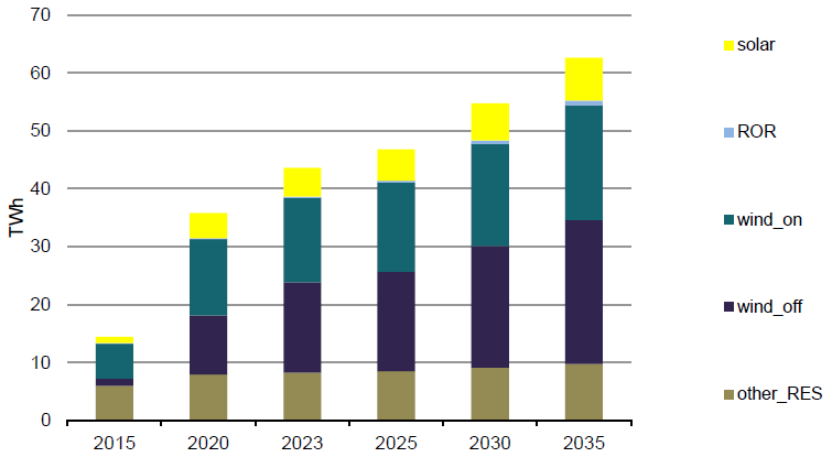


Figure 2.15: Development of renewable electricity supply (RES) in the Netherlands (Frontier Economics, 2015)

Storage facilities

Due to the fluctuations in the demand for energy and the dependency of most renewable technologies on environmental circumstances, the need for storage will gain more and more importance. On a consumer level one will likely be able to fulfil this need by using battery technology, but when a buffer for industrial practices is considered, batteries are very unlikely to be sufficient. To guarantee energy security and optimal use of the produced renewable energy in the long term, it is necessary to either develop a reliable and effective storage system or develop technologies that are able to use the storage capacity of infrastructural networks that are already in place.

To tackle the storage capacity issues, several technologies are being developed including: CAES (Chen *et al.*, 2013), AACAES (Pickard *et al.*, 2009), PtG (Jentsch *et al.*, 2014) and Power to liquid. Since electrification by means of sustainable sources of energy and the inherent fluctuations, the development and implementation of large scale and efficient storage is seen as a crucial step.

Table 2.3 presents the timescale of exploitation in the Netherlands and investment cost for each of the three previous technologies.

Technology / Fuel	**Available in (year)**	**Investment cost (€/kW)**
CAES	2023	806
Hard coal (IGCC) with CCS	2025	2750
Natural gas (CCGT) with CCS	2025	1200
AACAES	2030	1300
Power-to-Gas (to-Power)(PtG)	2030	1650

Table 2.3: Possible mitigation and complementary technologies including availability date and investment cost (Frontier Economics, 2015)

Mitigation technologies

As the contemporary power plants will be in use for at least the coming decades, a large part of the energy generation sector will still be dependent on fossil fuels. To make sure the effects of these power plants will be minimal as well as the security of energy is maintained, the emissions have to be minimised (European Commission, 2014). The different mitigation technologies together with their availability in time and investment cost are presented in table 2.3.

A promising technology to accomplish this is carbon capture and storage (CCS). The idea of this technology is that the CO_2 of the power plant (but also other industrial companies) is captured and transported to a place where it can be stored, for instance, an empty gas field (Samedi *et al.*, 2016). Developments and pilot projects are already being initiated, but these have so far not led to real leaps forward due to problems with funding and the political debate around it. The technology has proven to be promising and challenging at the same time. Especially when exploitation is considered, large investments are needed to provide the pipeline infrastructure and the availability of storage is crucial. Due to this, the expected exploitation of the CCS technology is not expected before 2025 (Frontier Economics, 2015), but it can play a crucial role reaching the long-term sustainability goals.

Co-firing of biomass in the power plants, as well as the CHP plants, could provide another mitigation option to tackle the emission problems of the sector. Although this still involves a comparable amount of CO_2 emissions, the balance in the atmosphere is not disturbed as with fossil fuels (due to the short cycled nature of biomass). It is expected that this will not take place in a short period of time, as the development of energy production based on biomass is still ongoing and contemporary forms are in competition with food. If the co-firing of biomass and the CCS technology are combined, theoretically it must be possible to achieve even a net negative emission (Samedi *et al.*, 2016).

Besides the mitigation technologies that are to be deployed in future, table 2.3 also presents complementary technologies that are common practice nowadays: Combined Cycle Gas Turbines (CCGT) and Integrated Gasification Combined Cycle (IGCC). These technologies are mainly focused on increasing the efficiency of the coal- (IGCC) and gas (CCGT) power plants.

POLICY FOR TRANSITION

To achieve any of the targeted long-term goals, a well-defined policy describing the path is of vital importance. Developed policies will have to function as a guide for the energy transition. The Dutch government described these paths by means of defining six main themes and their associated goals. Table 2.4 presents these themes, goals and proposed paths as an overview. The paper (Kemp *et al.*, 2007) in which this table is presented, also addresses the policy by elaborating on six crucial stages which need to be handled correctly in order to make the policy successful. These six crucial stages will be treated in this section.

Ambivalence about goals

Different people and sectors have different perceptions of the problems and solutions for the environmental problems. What one thinks is sustainable, another might completely disagree. Although not everything might be agreed on (yet), a clearly defined problem together with the definition of key parameters, provide the foundation for a reliable, affordable and low in CO_2 future energy system. Parameters that are more subject to debate, can be added and adjusted in a later phase by a continuous and iterative process.

Uncertainty about goals

The knowledge of ecological causal relationships is often quite limited, especially in the development phases, but more often also during more evolved processes. This causes difficulties in making accurate future projections and deciding on the right paths to follow. Another risk is the uncertainty about intervention and long-term socio-technical changes (including the changes in preferences and needs of society over time) (Collingridge, 1982). These uncertainties will over time cause future orientated policies to become more robust, diversified and adaptive.

Distributed control

The government these days, are divided into many subdivisions (both horizontally as well as vertically) and are not well equipped for long-term changes. Most governmental divisions focus rather on the short-term. To tackle this and create a unified approach, a portfolio of visions is needed which can be assessed continuously and actions can be based on (Walker *et al.*, 2001). By assessing and combining of visions form the basis for guidance, unity and socio-technical adaption.

Political Myopia

Socio-technical transitions have a lifespan covering multiple of political cycles (Geels, 2005). In order for the transition program to survive each of these cycles, awareness must be created continuously and on a regular basis. There is no other clear solution other than keeping everyone realising the importance of the problem at hand.

Determination of short-term steps for long-term goals

Although at first hand looking like the most obvious, the translation from long- to short-term actions that are in line with the goals have proven to be difficult. A thorough and regular strategy is necessary including farseeing and backcasting based on integrated system analysis. Vital in this will be the wide scope (including visions, trends, goals etc.) to keep track of all actors involved and perform regular strategic experiments to create awareness (Loorbach, 2007).

Danger of lock-in

The danger of getting stuck with a solution which proves to be a good short-term action, but might turn out to be ineffective when long-term goals are considered. To prevent this from happening, the transition strategy must contain a portfolio of solutions in the form of a transition agenda (Weber, 2006). This enables diversity and a competitive market as well as guidance towards the same long-term goals. In time, this portfolio should be used as a dynamic steering tool and adapted according to developments.

On the policy side of the spectrum, the main challenge turns out to be the translation from long-term to short- and mid-term. This requires incorporating into daily practice while keeping the unified and clear long-term in sight. At the same time, a balance must be found among control, stimulating measures and maximising market opportunities (by limiting restrictions). This section treats the themes from a governmental perspective, though it is well applicable for PoR when translating its visions into a strategy with tangible actions and intermediate goals.

Theme	**Goal**	**Transition path**
New gas	To become the most sustainable gas country in Europe	Decentralised electricity generation Energy efficient greenhouses Green gas hydrogen Clean fossil fuels
Sustainable mobility	Factor 2 reduction of GHG emissions for new vehicles in 2015 and factor 3 reduction for all vehicles in 2030	Hybrid propulsion Biofuels Hydrogen vehicles Intelligent transport systems
Green resources	Substitution of 30% of resources for energy by green resources by 2030	Biomass production in NL Chains for biomass import WISE Biomass co-production Synthetic Natural Gas Sustainable Chemistry
Chain efficiency	20-30% extra improvement of product chains by 2030	Optimizing the waste chain Precision farming Process intensification Multimodal transport Clearing house for bulk products Symbiosis (closing material loops) Micro co-generation Energy efficient paper production
Sustainable electricity supply	To make electricity supply more sustainable	Renewable energy sources Decarbonisation and co-generation Electric infrastructure Electricity use
Built environment	To accelerate energy improvement programmes and stimulate innovations	Energy improvements in built environment Development and implementation of innovations Removal of institutional barriers

Table 2.4: The energy transition themes, goals and paths identified by various platforms (Kemp *et al.*, 2007)

2.6. WUPPERTAL REPORT AND ITS RELEVANCE FOR PoR

By setting the goals, already in 2007, of a 50 % reduction in CO_2 emissions by 2025 increasing to 60 % by 2030 for its HIC, the PoR authority (as part of the Rotterdam Climate Initiative) set an ambitious goal in becoming a sustainable port area (Port of Rotterdam Authority, 2011). With the signing of the Paris Agreement (United Nations, 2015), these goals became more of a necessity than a desirability. As the current HIC in Rotterdam is highly intensive with respect carbon fossils, the PoR commissioned the Wuppertal institute to conduct a study on the 'Decarbonization Pathways for the Industrial Cluster of the Port of Rotterdam' (Samedi *et al.*, 2016).

In the conducted study, four scenarios have been developed on how the HIC could look like in 2050. The first scenario treats the future as if the "Business as usual" is continued and the other three are based on a decarbonization pathway varying in levels of ambition and technological strategies. The author acknowledges that future developments are most likely to be quite different for the projected pathways. The goal of the study, however, is not to define an exact future projection, but to broaden the way of thinking on what is needed to develop the HIC in such a way that it is still compatible on a decarbonizing world.

For this research, it is relevant to evaluate the various industries that have been treated in the report and address the aspects that will have an effect on the future spatial planning. In this section, the different scenarios will be treated briefly and an evaluation of relevant factors, and involved industries, on future spatial allocation will be conducted.

2.6.1. BRIEF DESCRIPTION OF DECARBONISATION PATHWAYS

The purpose of this section is to give a general overview of the different scenarios and the main industries that are involved. The background information on which the various industries are based is also taken into consideration as these might well be good indicators for the overall system the PoR is approaching in the respective pathway. For the full study, reference is made to (Samedi *et al.*, 2016).

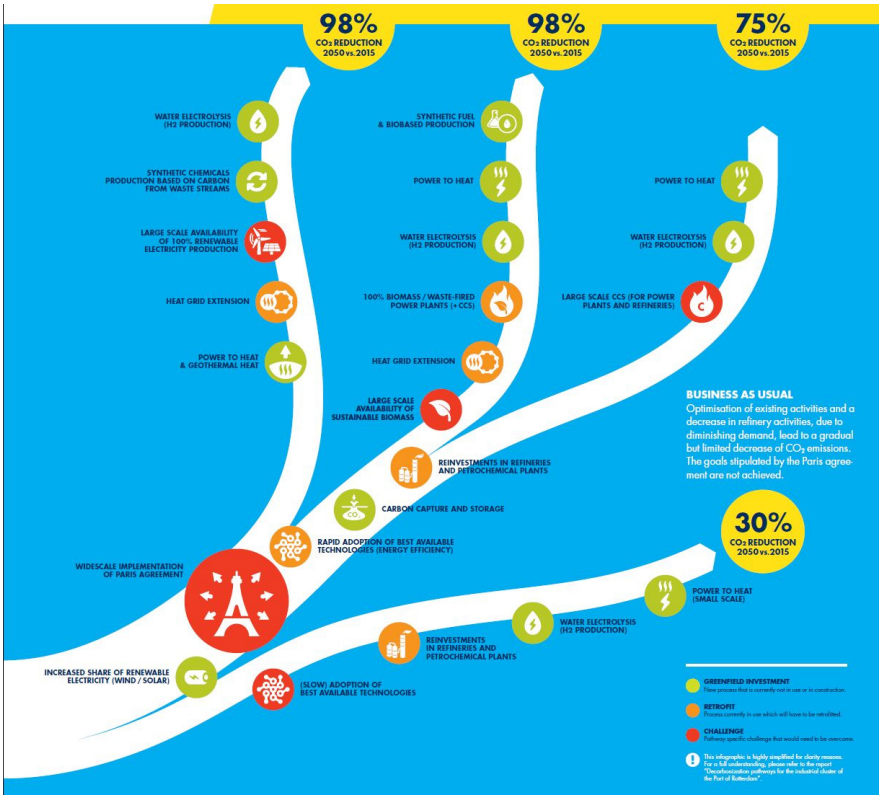


Figure 2.16: Overview of the pathways towards decarbonisation (Samedi *et al.*, 2016)

In the study, the relevant sectors of the HIC are defined as: Refinery industry, Chemical industry and Power and Heat production. Generally, it proves to be difficult to treat these sectors separately as they are very interrelated concerning the complete production processes. For the sake of creating an overview, however, it provides the opportunity to evaluate the scenarios in a systematic way. The following paragraphs provide a brief overview of the different scenarios (Samedi *et al.*, 2016).

A graphical overview of the pathways and a general display of the phasing in technologies is depicted in figure 2.16. In conclusion to this section, the resulting GHG emissions of the different pathways is presented in figure 2.17.

BUSINESS AS USUAL (BAU)

Essence of the scenario: No significant cuts will be made to drive down GHG emissions after 2020. Until this period, planned closures and projects have effect on the GHG emissions followed by a gradual decline due to technological improvements and declining of the refinery production. This scenario is mainly meant to be the benchmark to which the three decarbonization scenarios can be compared.

Vital technologies:
Not applicable

TECHNOLOGICAL PROGRESS (TP)

Essence of the scenario: Strong technological progress with only moderate changes in energy and transport systems to reach a 80 % GHG emission reduction by 2050 (compared to 1990).

Vital technologies:

- CCS and infrastructure (e.g. storage and carbon grid)
- Implementation of the Best Available Technology (BAT)
- Expansion renewable electricity generation
- Improve energy efficiency in all sectors
- Renewables for the production of heat and hydrogen
- Tightening of the ETS scheme

BIOMASS AND CCS (BIO)

Essence of the scenario: Biomass as feedstock for all three sectors combined with the implementation of CCS to reach a 90 - 95 % GHG emission reduction by 2050 (compared to 1990).

Vital technologies:

- CCS and infrastructure (e.g. storage and carbon grid)
- Renewable electricity generation (reaching almost 100 % market share by 2050)
- Firing of biomass and waste
- Power-to-Heat
- Electrolysis
- Electrification of transport system
- Large supply of sustainable biomass

CLOSED CARBON CYCLE (CYC)

Essence of the scenario: Almost completely based a circular economy combined with renewable electricity which will supply heat, hydrogen (for generation of feedstock for chemicals) and the remaining small remainder of fuels in transport to reach a 90 - 95 % GHG emission reduction by 2050 (compared to 1990).

Vital technologies:

- Fossil feedstock is kept in a circular system
- Substitution of steam crackers with methanol-based feedstock
- Feedstock (like methanol) derived from waste streams and renewables
- Substitution of crude oil with the import of Fischer-Tropsch wax

Note: the study also developed a variant in which early closure (2019/2025) of the two coal-fired power generation plans is assumed (CYC-ECE).

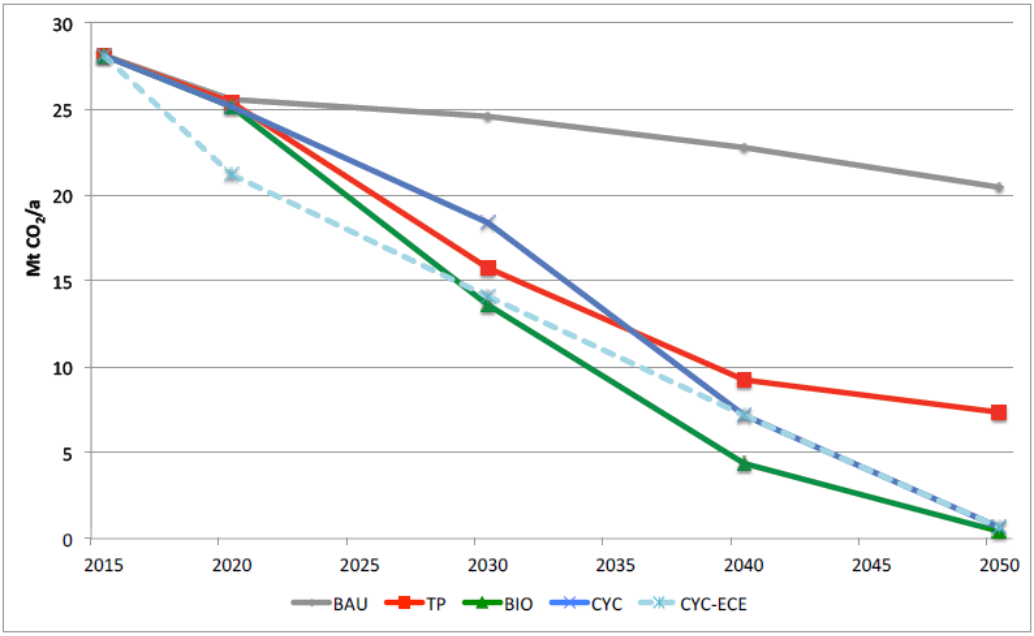


Figure 2.17: Comparison of the CO_2 emissions in the HIC in the different pathways (Samedi *et al.*, 2016)

2.6.2. IMPACT OF VARIOUS INDUSTRIES ON SPATIAL ALLOCATION

Evolving new industries can change the port system. Not only the allocation of new industries themselves, but also the likeliness of contemporary industries depleting (as incorporated in the pathways in section 2.6.1). Of course, the extent to which the port system changes is heavily reliant on the type of industry that is considered. The following paragraphs provide an evaluation of the impact the different pathways will have on the future spatial allocation in the PoR.

BUSINESS AS USUAL (BAU)

The term "Business as usual" already implies that no real changes to the port system will be expected. This does not mean that no new clients will be allocated, but the industries do fit into the current HIC in terms of activities and processes. Nevertheless, this pathway will face the difficulty of the port reaching its physical occupancy limits. Combined with the fact that significant decrease in current industries is not expected in this pathway, it will become increasingly difficult to allocate new clients. Basically, it can be concluded that this pathway has the least impact on the port system, but due to the increasing scarcity of available area, it provides to the most difficult case for the future allocation process.

TECHNOLOGICAL PROGRESS (TP)

From the three decarbonisation pathways, the TP pathway has the least impact on the port system as a whole since the focus of this pathway is mainly on complementary technologies and increasing efficiency for the current industries (e.g. CCS) to accomplish a significant reduction in GHG emissions. This, however, does mean that infrastructure and utilities need to be developed/retrofitted to accommodate the CO_2 drain and to facilitate renewable forms of energy, but the activities of the industry remain essentially the same. In terms of the future allocation process, this pathway faces the same difficulties with respect to the availability of physical area as in the BAU pathway. Additionally, the TP pathway aims at a more ambitious (80%) reduction of GHG emissions, it is presumable that stricter requirements in terrain specific environmental budgets will be applied when new activities will be allocated in the future. In conclusion, the TP pathway faces the same kind of hurdles as being concluded on in the BAU pathway, but at a higher level of complexity due to the additional measures to achieve the climate goals.

BIOMASS AND CCS (BIO)

Contrary to the two previous pathways, BIO has the substitution from the feedstock fossils by biomass as a foundation. Since this is relevant in all three sectors, significant changes in the port system are necessary to make this possible. This is meant in the broadest sense, as another feedstock does not only change processes in the industries itself, but also the handling and transhipment of bulk (and might even imply a shift from liquid- to dry bulk). For this aspect it must be kept in mind that it is reliant on which part of the supply chain is going to take place in PoR (only refinery versus preparing feedstock and production) and the availability of sustainable biomass. Next, the BIO pathway also includes the challenge of implementing the CCS technology to achieve, in combination with the firing of biomass, a net 'negative' emission. On the energy side of the spectrum, renewable energy is the way to go (as being extrapolated for the TP pathway) caused by the energy-intensive processes to prepare biomass for production. For the sake of spatial allocation, the substitution of fossils will imply a reduction of the fossil-related industries causing availability of terrains for the 'new' bio-industry. The challenge here is more on the optimal allocation of these terrains since the new industries require a different set of specifications for a terrain than the contemporary fossil industry. As a final remark, it can be said that the BIO pathway affects both the port system as well as the allocation process to a large extent (with the exception that the scarcity problem is less significant in this case).

CLOSED CARBON CYCLE (CYC)

CYC can be considered as the pathway having the most far-reaching impact on both the port system as well as the future spatial allocation process. The basis for this pathway is founded on a circular economy combined with renewable energy for electricity, the production of heat, hydrogen (for the chemical industry) and the small remainder of fuels. To realise this, an extensive network for renewable energy is to be developed together with the infrastructure and utilities that make it possible to facilitate a circular approach. Due to this approach, it means that there is still some room left for the use of fossils in the processes as long as it is recycled at the end of life phase in such a way that it causes no pollution. To achieve the ambitious targets, the fossil-based industry will be declining (and crude oil replaced by Fischer-Tropsch wax) creating the available area for new industries. For these available terrains, it is of vital importance that the clients that are allocated, fit into the existing cluster in an optimal manner and can make use of the utilities that are in place enabling the circular economy. Altogether, the CYC pathway changes the way the port functions, makes industries more interdependent and changes the importance of infrastructure and utilities in the allocation of new industries.

2.6.3. COMPARISON OF THE INDUSTRIES INVOLVED IN THE PATHWAYS

Of course, the presented overview of potential new industries in table 2.5 is not complete, but the goal is to evaluate what the potential impact of an evolving industry can be on the PoR. Although not all of them can be directly related to the current industries in the HIC, they can play a crucial role in facilitating and/or complementing certain industrial activities. This section makes such an evaluation of the activities that are taken into consideration in the pathways of the Wuppertal report (Samedi *et al.*, 2016) to create a sense for the potential impact of different new industries.

The purpose is to illustrate, by means of the examples, the variety and different challenges involved for PoR when allocation of potential new industries is involved. This will underline the complexity to tackle the problem adequately. The process is not simply about replacing an oil refinery for a sustainable industry, but a lot of factors are involved in matching the strengths of PoR to the requirements of these industries.

Potential new activity	Expected implementation
Offshore wind	2017-2019
biobased chemistry	2018-2022
Demand-side-management and energy storage	2018-2022
Use of waste	2030-2035
Synthetic fuels	2040
Carbon-neutral primary steel production	2045

Table 2.5: Expected implementation of new activities to reduce the GHG emissions according to the Wuppertal report (Samedi *et al.*, 2016)

OFFSHORE WIND ENERGY & DEMAND-SIDE-MANAGEMENT AND ENERGY STORAGE

The production of offshore wind energy has at first hand no direct connection to the industries in the HIC (except for the consumer purposes). Though, for the PoR it becomes interesting when significant improvements are being made and production capacities increase. This development is taking place as we speak with the initiation of the energy island on the 'Doggersbank' (Ingenieur, 2016). At this island, offshore wind farm will be connected and from here transportation to the mainland will take place. Besides the facilitation of renewable energy for the industry, these developments provide the opportunity for the HIC to accommodate the arrival at the mainland prior to the distribution to the hinterland. Assuming development reaches a sufficient level, over capacities need to be stored (e.g. batteries, potential energy or liquid energy carriers) and a complementary industry arises. Especially by storing in the form of liquid energy carriers, the PoR offers unique opportunities due to its expertise and knowledge developed in the liquid bulk (and petro-chemical) sector.

As explained in the pathways, many of the possible new industries are heavily reliant on the generation of energy from renewable sources. This makes it of vital importance for an industrial cluster which facilitating/complementary role it can play to create a sufficient and secure supply for itself and its hinterland.

BIOBASED CHEMISTRY AND USE OF WASTE

Although described separately, biobased chemistry and the use of waste for industrial purposes are very closely related. In fact, they both retrieve the useful substances, from their own specific feedstock, to function as a building block in the resulting production processes. Table 2.5 describes that the industry becomes relevant from 2030, (pilot) projects are already being developed like the Waste-to-Chemicals consortium (Messenger, 2018) in the PoR.

A shift to the described sources of feedstock directly impacts the essential refinery and chemical industries that form the foundation of the contemporary HIC. These industries need to adapt radically or be replaced by new clients. The impact goes deeper than only the industries themselves, as the import of feedstock means that also the handling and transhipment of dry- and liquid bulk is subject to a shift. Though this might look like a threat, the developed network and experience in the region might well be the supercharger that provides the PoR with the status of the location of choice for these industries (de Moel, 2018).

SYNTHETIC FUELS

Synthetic fuels are chemically the same as their fossil equivalents, but they are produced by means of a reaction between carbon monoxide and hydrogen. To make the production sustainable, relatively high quantities of energy are needed and therefore is not yet viable due to its reliance on the up-scaling of renewable energy. The productions technologies are there and a wide range, large in possibilities, can be produced already when the sustainability hurdle could be taken.

Although most of the trends project a (full) electrification replacing fuels, there will be some sectors that are not compatible with this transition (e.g. long-distance shipping and aviation). For these industries synthetic fuels can provide an adequate solution which is able to comply with current engine technologies (Terwel and Kerkhoven, 2018). The relevance for PoR is that these markets are already supplied from the HIC currently and an extensive transport network has been build to facilitate these markets. Making the PoR a possible attractive location for the synthetic fuel industries to allocate.

CARBON-NEUTRAL STEEL PRODUCTION

The production of carbon-neutral steel is considered a very ambitious one since the melting of ores require high quantities of energy (heat). A change to carbon-neutral will imply a change in feedstock and production process. This will affect the PoR both in a direct and indirect manner. Directly in the sense of the transhipment of coal for the (mainly German) steel industry will diminish over time and indirectly because of the complete new production processes. A radical change in the process may well lead to the situation of moving the industry to a more favourable location providing an opportunity for the PoR. If this situation arises, the capturing of carbon monoxide from the steel ovens comes into play. This can be very advantageous for the production of synthetic fuels, as carbon monoxide requires much less effort to turn into syngas than carbon dioxide.

2.6.4. REVIEW AND CONCLUSIONS

Opportunities for PoR, while varying in magnitude, arise in all of the treated pathways. Required criteria and match with the HIC are different for individual industries, but in most cases, the strengths of the port can contribute positively to the allocation of potential industries.

The importance of externalities and the inter-dependency of developments becomes very clear from the treated examples. Especially the development and scale-up in the availability of renewable energy plays a crucial role in the viability and the extent of sustainability of new industries.

Even though the match with the strengths of the PoR might be quite obvious, one should keep in mind that besides the treated developments, there are many technologies evolving. This emphasises that the best match between the port and new technologies must be pursued to create a 'new' cluster that is able to exploit the strengths of the location as well as facilitating a more circular economy.

From the performed evaluation, the hypothesis arises that the experience and network resulting from years of world-class fossil-based activities combined with the development of an extensive network creating an abundant and stable supply of renewable energy will have to form the foundation to attract new industries to the HIC.

2.7. ESTABLISHING REQUIREMENTS FOR SPATIAL ALLOCATION

Requirements form the basis for any important consideration a company has to make. When an allocation is concerned, a client will always set its own requirements which a terrain, region and/or business climate has to fulfil in order to compare different options to each other and be able to choose the option fulfilling their requirements in an optimal manner.

As most industries that are allocated in the HIC have a broader vision than the Rotterdam region, and sometimes even Europe, the first question in the allocation process is: 'Which port will the industry be located in?'. In fact, this is the most important decision for the involved port authorities and is mainly based on the strategic position/value of the respective ports. This, however, does not mean that there are no local influences. This section considers the build-up of the different layers (from local to (inter)national) to support to the overall strategic value of the port region that has to result into a client's choice for the PoR.

Such a strategic position may be very different for various industries (and even among companies). However, this positioning is (almost) always a summation of different individual characteristics of the region, terrain and business climate has to offer. This section's goal is to create an overview of the involved factors that determine the strategic value of the PoR and on which requirements can be based on. In conclusion, a determination of the different main themes a (new) industry will be founding its requirements on will be presented.

2.7.1. ESTIMATION OF STRATEGIC VALUE

As mentioned in the introductory part of this section, the strategic value of an (industrial) region is dependent on many factors varying from local to (inter)national and internal to external. To identify the main characteristics and what influence each of them has on the HIC, a clear division needs to be made. The report of (Van den Bosch *et al.*, 2011) has made such an elaboration by identifying the quantitative part and 3 separate qualitative parts of the strategic value of the PoR for the Netherlands. Reference to this report is made for the sake of the identification process of these characteristics and their importance. The following paragraphs will create a depper insight into these characteristics and the underlying thoughts.

For every (new) industry, the strategic location might be different, but the essence of a strategic location remains the same: *"A location strategy is a plan for obtaining the optimal location for a company by identifying company needs and objectives and searching for locations with offerings that are compatible with these needs and objectives. Generally, this means the firm will attempt to maximise opportunity while minimising costs and risks"* (Heil, 2012).

It must be noted that the strategic value and competitiveness of a certain region are very closely related and therefore used both in literature.

As described in the report of (Van den Bosch *et al.*, 2011), every evaluation of the strategic value of the location has a quantitative- and a qualitative part. The quantitative can be used as a first generic indication of the region and is made up out of economic figures that are known for the majority of industrial regions. For the latter, it becomes more difficult. Although several methods are developed and used in literature (like SWOT analysis, data envelopment analysis, market share analysis etc.) they all struggle to capture the quantitative part in an unambiguous manner (Scaramelli, 2010).

QUANTITATIVE VALUE

The strategic value of a region is a good first indicator in the decision-making for allocation from the client's point of view, but when properly assessed very complex as well. The characteristics concerning the quantitative part of the strategic value have mainly a generic character. The involved factors (direct- & indirect added value, direct- & indirect employment and expected amount of investments) can be drawn up for nearly all industrial regions. These values indicate the competitive position of the region, but in the research of (Van den Bosch *et al.*, 2011) are not specified for a specific industry. The results of the quantitative value of the HIC as a whole can be found in figure 2.20.

Such economic figures are drawn up by the World Economic Forum in their yearly update of the Global Competitiveness Report (Schwab and Sala-i Martin, 2017). In these reports, a rating is given for all relevant factors of the evaluated countries to give an overview of their relative competitive position and how the individual factors compare to other countries. As the Netherlands is quite a small country, the majority of the treated key indicators have high relevance on the strategic value of the PoR. Such reports provide a good first indication for a possible client to evaluate the business climate, opportunities and developments in a for a region of interest and can lead to a first selection.

QUALITATIVE VALUE

During the interviews with several employees at PoR, allocation of different industries that have taken place in the (recent) past have been discussed (for the complete interview see appendix F). From these conversations, it became clear that every industry wants to settle itself in a strong and prospective economic environment. On the other hand, it is really client dependent what type of characteristics form the deciding factor to allocate themselves in the PoR. This includes the valuation of the characteristics which are not easily (at least not in a unified way) quantified and is rather dependent on the clients perspective. Although the difficulties, fair attempts have been made to create insight into the main aspects of the strategic value.

An early, but the still widely used Diamond Framework by (Porter, 1990), is making such an evaluation of relevant indicators that determine the national competitive position. In this framework, four different key indicators are being identified as essential building blocks for a strong strategic value (Van den Bosch *et al.*, 2011):

- Factor Conditions
  - Production factors; natural resources, size & quality of the available workforce, capital resources
  - Physical infrastructure; water-, road-, pipeline- and railway capacity
  - Other infrastructure; e.g. administrative-, information- and scientific infrastructure
- Context for firm strategy, structure & rivalry
  - How companies create their strategy and deal with external stakeholders
  - The intensity of internal competition in the PoR
- Demand conditions
  - Lead users that are in the position to stimulate and/or pressurise complementary industries to innovate and adjust productivity in order to meet their demands
- Related & supporting industries
  - The contribution of (mainly) suppliers to the competitiveness, the higher this is and the more they are connected to the leading firms, the higher the contribution will be

From the description of the four main indicators in the diamond framework, it can be concluded that the nature of these is locally orientated. It also emphasises the importance of the local characteristics for the bigger picture of the allocation decision for (new) industries (which port offers the most favourable conditions for allocation). A graphical overview of the diamond framework and the inter-connectivity of the different indicators are depicted in figure 2.18. The resulting findings of the (Van den Bosch *et al.*, 2011) report with respect to the Diamond Framework are presented in figure 2.20

Although presented as separate indicators, they are highly interconnected, meaning that, for instance, strong demand conditions cannot be set if the related and supporting industry is relatively small. All four indicators can be seen as highly important in the decision-making of allocation by possible clients and are dependent on the activities of the concerned industry, to which extent emphasis is being put onto the individual indicators.

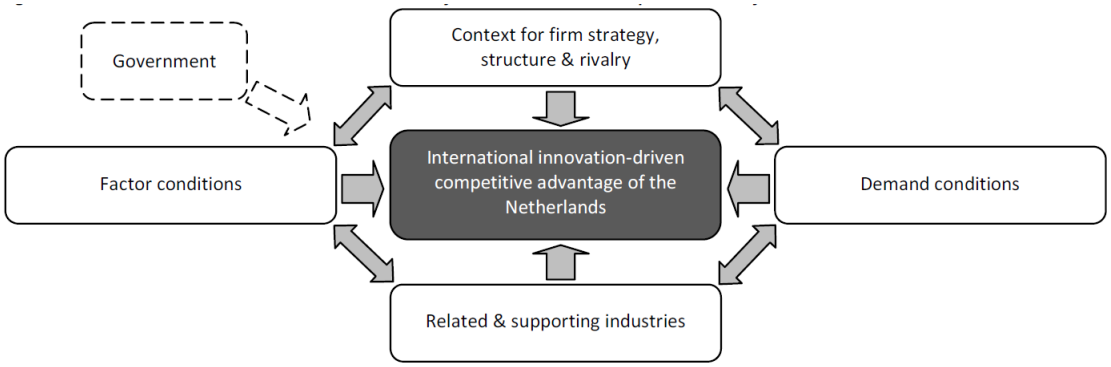


Figure 2.18: Porter's Diamond Framework: the determinants of the international competitiveness of the industry in the Netherlands (Van den Bosch *et al.*, 2011)

Although highly important, the downside of the Diamond Framework is the fact that the contributions to the strategic value of a region are not exclusively dependent on local indicators. Especially when an international port is considered, the involved industries are globally orientated and freight is transported from and to port from all over the world.

With globalisation gaining importance during the past decades, the connectivity with national and international (port) clusters has evolved to a key indicator for the strategic value of the port region. To include this in the determination of the strategic value, the research of (Van den Bosch *et al.*, 2011) developed the Triple Strategic Value Framework that is depicted in figure 2.19. This framework still places the Diamond Framework as the focal point but extends it by introducing two key indicators for strategic connectivity (the first on national and the second on an international level).

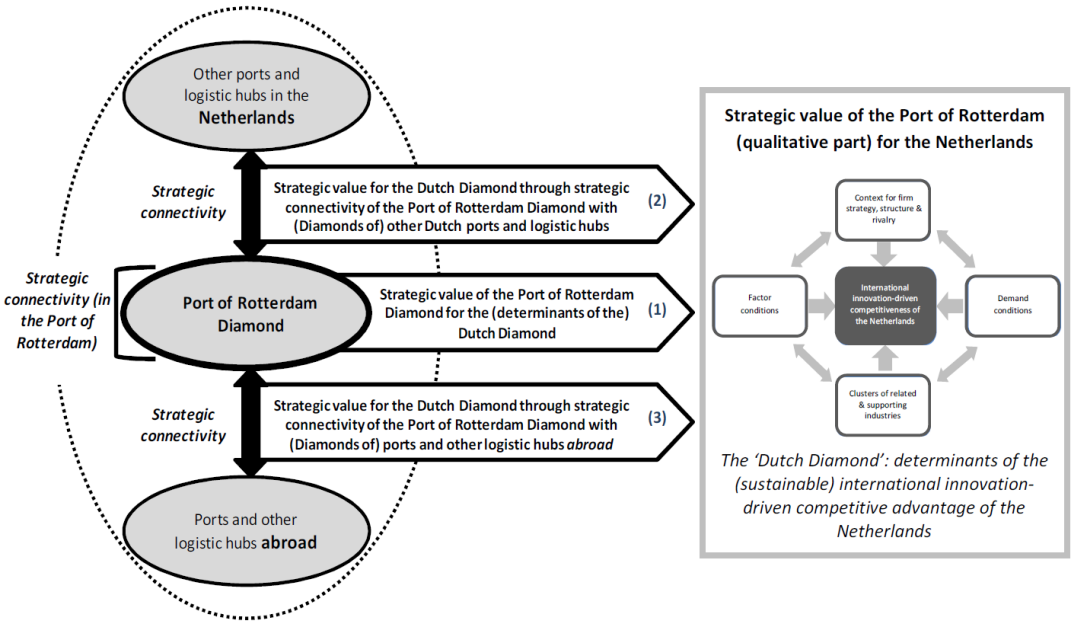


Figure 2.19: Triple strategic value framework (Van den Bosch *et al.*, 2011)

The upper part of the framework is focused on the national strategic connectivity with other ports and logistical hubs. In fact, in this case, the whole hinterland of the port is to be assessed as it performs a key function in the chain to and from these industries. For customers and suppliers located in the port's hinterland, the connectivity with a major port (like PoR) is of crucial importance to maximise their own added value. Good corporation with these industries results in an increase of specialisation, innovation and renewal in the supply chain. These developments are parallel to the development and improvement of the physical connections and are of vital importance for the strategic value of the PoR.

The lower part of the framework considers the international strategic connectivity with ports and logistical hub located abroad. As terminal operators in all major sectors are increasingly globally orientated, and with this development, an increasing influence is realised, corporation with foreign ports is gaining priority to ensure future cargo flows. An example of this is the terminal operators in the container sector, who are due to their allocation in several major ports, have created the situation that they are able to decide to a large extent which ports are being called at. Another benefit for the strategic value is the fact that companies that are located in multiple ports, benefit from several local diamonds. This stimulates innovation and the sharing of knowledge among the different locations in the regarded company.

All the aspects, together with the quantitative value of the strategic value, are described in figure 2.20. The results that are presented in the right column of this figure are evaluated in further detail in the coming section.

REVIEW OF THE RESULTING STRATEGIC VALUE OF POR

The overview of the strategic position of the PoR gives a good indication of the strengths and weaknesses of its HIC. Although the report conducted the research with respect to the contribution of the PoR to the strategic value of the Netherlands, the main indicators and methodology do not change when the strategic value of the port itself is to be evaluated.

For the qualitative value of the results, it can be concluded that the figures indicate a very strong and healthy business environment. This is even more striking when these figures are being put into perspective with the figures of the Netherlands as a whole. It indicates the fact of the PoR being a crucial link in the Dutch market and the opportunities it has in reaching customers and suppliers located in its hinterland.

Quantitative part of strategic value	
The economic importance of the Port of Rotterdam for the Netherlands	
- Direct value added created:	15,5 billion euro
- Indirect value added created:	6,7 billion euro
- Direct port related employment:	90.000 persons
- Indirect employment:	55.000 persons
- Expected volume of investments:	approx. 10 billion euro
Qualitative part of strategic value	
First contribution to the Dutch Diamond: the influence of the determinants of competitiveness of the Port of Rotterdam on the international innovation-driven competitiveness of the Netherlands.	
- Factor conditions:	Unique contribution to the Dutch multimodal physical, transport, knowledge and energy infrastructure.
- Demand conditions:	Large multinational firms in the Port of Rotterdam challenge innovations in infrastructure, clusters of industries and knowledge in the Netherlands.
- Related and supporting industries:	The Port of Rotterdam provides the Netherlands with unique clusters of industries containing world players.
- Context for firm strategy, structure and rivalry:	Unique contribution to the Dutch context for stimulating business sophistication and innovation, corporate headquarter locations, strategic connectivity and competition.
Second contribution to the Dutch Diamond: the influence of strategic connectivity of the Port of Rotterdam with other *Dutch* ports and logistic hubs on the international innovation-driven competitiveness of the Netherlands.	
- Impact of *national* strategic connectivity on the Dutch Diamond:	Difficult to substitute, i.e. unique, growing and already strongly positive impact on the Dutch Diamond, in particular regarding improvement of specialization and integration of knowledge and logistics chains in the Netherlands and of domestic competition and innovation.
Third contribution to the Dutch Diamond: the influence of strategic connectivity of the Port of Rotterdam with *foreign* ports and other logistic hubs abroad on the international innovation-driven competitiveness of the Netherlands.	
- Impact of *international* strategic connectivity on the Dutch Diamond:	Difficult to substitute, i.e. unique, growing and already positive impact on the Dutch Diamond, in particular regarding the improvement of international knowledge and chain integration, specialization and innovation.
Indication of the effect of the qualitative part of strategic value.	
- Effect of the qualitative part of strategic value for the Netherlands:	The contribution of the Port of Rotterdam to the international innovation-driven competitive advantage of the Netherlands is estimated to be at least 6 billion euro of added value for firms located elsewhere in the Netherlands .

Figure 2.20: Overall fact sheet of the strategic value of the Port of Rotterdam (Van den Bosch *et al.*, 2011)

For the evaluation of different qualitative indicators can best be interpreted from the presented spider diagram in figure 2.21. From this figure, it can be concluded that the strengths of the port, are mainly in the local aspects of the strategic value. Its strong economic importance together with the factor conditions of the Diamond Framework are the key components for the resulting strong position of the Port. The main weakness of the PoR on the strategic level, is the international connectivity with other ports. Where Chinese ports started such corporation projects already in the early 90s, the PoR only initiated such projects in 2002, resulting in an inferior amount of corporation projects with respect to comparable ports elsewhere in the world. The other local aspects (demand conditions, supporting industries, firm strategy and connectivity on a national level) are evaluated to be at an average level. Although this may sound negative, the indicators are evaluated with respect to the other world-leading ports. when the comparison is made in Europe, PoR still offers unique facilities in this respect.

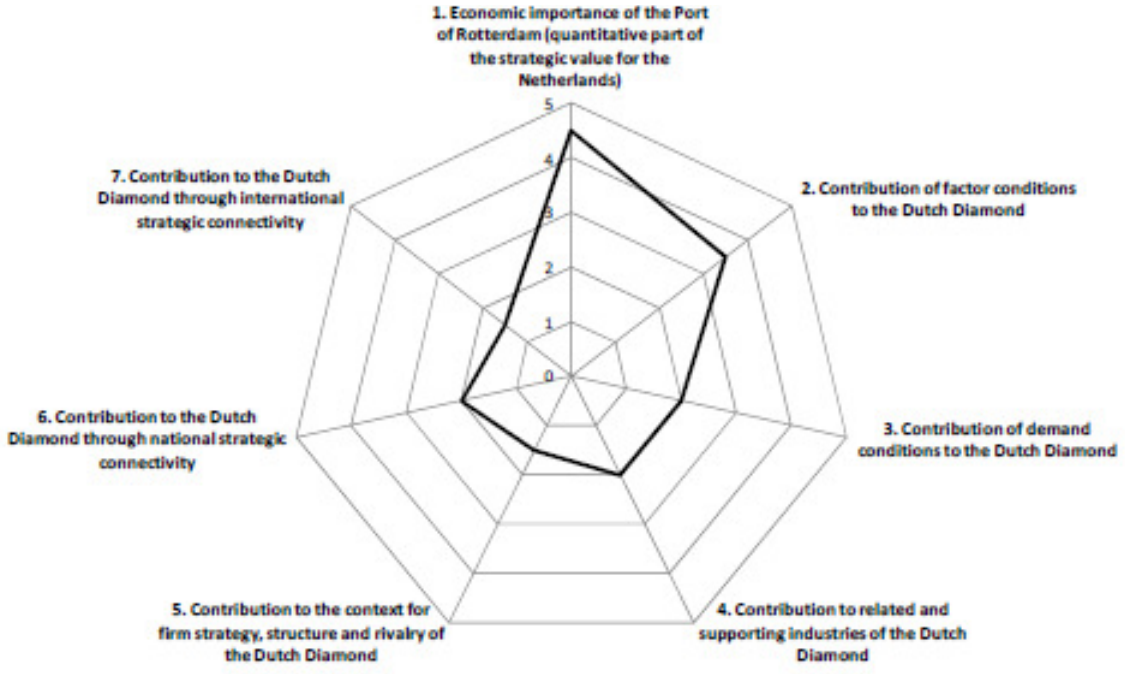


Figure 2.21: Spider diagram for the strategic value of PoR (Van den Bosch *et al.*, 2011)

In the evaluation of the World Economic Forum (Schwab and Sala-i Martin, 2017), the Netherlands is identified as one of the stronger economies in the world. As characteristic for an economy in this range, an innovation-driven economy is expected. For the past decades, however, the PoR has mainly been performing innovation to increase the efficiency of the different industries (which is in general a characteristic of a middle-income country). The conclusion that can be drawn, is the fact that although the basic ingredients for the fierce competition are present in the HIC, it is not leading to a high degree of innovation. The efficiency-driven character emphasises the high priority of identifying the opportunities of the energy transition and create the circumstances which are favourable to accommodate innovation-driven industries.

2.7.2. THE STRATEGIC BALANCE METHOD

The strategic balance method is being developed in the research of (Van den Bosch *et al.*, 2011) to compare two alternatives with respect to a certain location in the PoR on basis of their contribution to the strategic value of the HIC. In essence, the same indicators are treated as described in the Triple Strategic Value Contribution Framework (figure 2.19) and scores from 1 to 5 are assigned to each of the indicators (as done in the spider diagram of figure 2.21). By adding up the final scores, the PoR authority should be able to decide which of the activities fits best in their vision and strategic documents.

The strategic balance method is a convenient tool to make a strategic comparison among:

- Two or more new customers competing for the same location in the port
- A new and an existing customer
- Two existing customers
- Two different market segments
- Alternative destinations of new and existing locations

An illustrative example of the strategic balance between two different alternatives (A and B) is presented in figure 2.22.

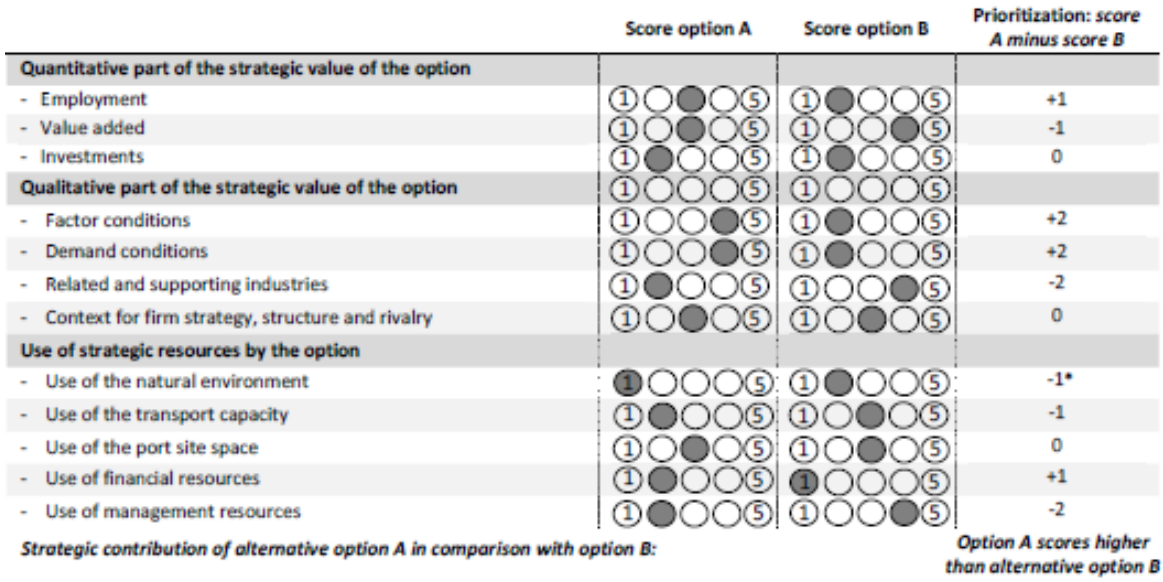


Figure 2.22: Illustrative example: trade-off of the strategic contribution of alternative options A and B by means of the strategic balance (Van den Bosch *et al.*, 2011)

The strategic balance method is developed for the PoR authority to evaluate different alternatives, but might just as well be turned around to the client's point of view. In this case, the scope of the indicators remains the same, only this time it is to evaluate how alternative ports contribute to the strategic position of the client. The indicators must this time be read as being the characteristics of the port region and what it is able to offer in terms of strategic value to the specific client.

Quantitative part of the strategic value	Score port A	Score port B	Prioritization (score A minus B)
Employment	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Value added	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Investments	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Quantitative part of the strategic value			
Factor conditions	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Demand conditions	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Related and supporting industries	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Context for firm strategy, structure and rivalry	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Availability of resources by the port			
Natural environment	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Transport capacity	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Port site space	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Financial resources	① ② ③ ④ ⑤	① ② ③ ④ ⑤	
Management resources	① ② ③ ④ ⑤	① ② ③ ④ ⑤	

Figure 2.23: An illustrative example of the flipped Strategic Balance method

The indicators as they are provided in the research (Van den Bosch *et al.*, 2011), do give a good indication for a client on the structure of the port. This can be very useful in preliminary stages of the decision-making process, but as the short-list is getting shorter, the level of detail is not sufficient for a client to make a well-substantiated choice. To achieve this, the strategic values must be substantiated for the specific sector to prevent a mismatch of information. For instance, the connectivity to the German steel industry is very interesting for the overall strategic value of the port, but completely irrelevant when a new container terminal is taken into consideration.

2.7.3. MAIN REQUIREMENT THEMES

By turning the strategic balance around towards a client's point of view, the indicators evolve to the character of requirements. Before going into detail on the identification of requirements for new industries, this section will substantiate the main themes on which further elaboration of specific requirements will take place.

As the first question of a client is to gain insight to which location it should be allocated to enhance its strategic position in the best possible way. Together with the fact, as described in the diamond framework (Porter, 1990), that local indicators strongly contribute to the strategic value, it proves that the strategic positioning forms a good starting point for the identification of different themes of requirements. These requirements should be seen as necessities a particular client has in order to be able to exploit its activities in an optimal manner. An overview of the requirement themes is presented in figure 2.24.

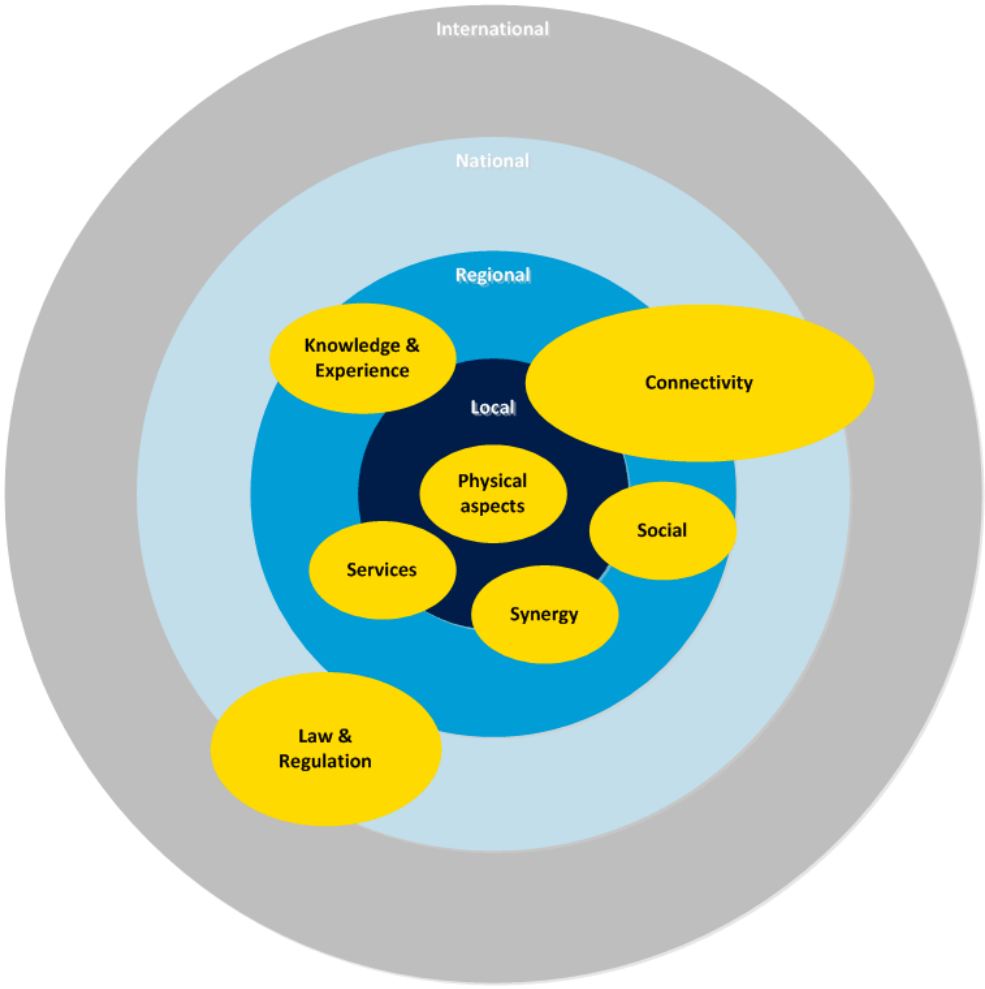


Figure 2.24: Requirements themes and area of influence

A strong overlap among the identified themes and the indicators from the strategic value framework can be observed. To give a better insight into the different themes, a brief description of each of them is given in the following.

- Physical aspects
  The requirements a terrain has to satisfy in terms of acres, availability of quay wall etc.
- Synergy
  Opportunities for synergy with respect to integration of supply chains, specifically needed products and possible co-siting
- Connectivity
  Connectivity to the hinterland (for all modes of transport) and exchange of products through utilities in the port area
- Services
  Complementary industries that have developed to support the main industries and provide the opportunity to outsource specialised activities
- Law & Regulation
  Applicable law and regulation for the available terrains in terms of emissions-, noise- and safety budgets
- Knowledge & experience
  Availability and the degree of knowledge and experience of the workforce, industry and institutions
- Sociopolitical aspects
  Increasing importance of the public opinion, image quality, interaction with the city and employment

This categorisation will be the basis for the further detailing on the different themes. The next chapter is aimed at providing the detailed evaluation on the requirement themes from different perspectives. As a foundation the themes will be used to gain a fair and relevant comparison among the different perspectives, their relevance, impact and influence.

3

SPECIFICATION OF REQUIREMENTS

This chapter is an elaboration of the different themes of requirements as treated in section 2.7.3. The main focus of this chapter is to create a clear insight into the different requirements that are involved in the decision-making process for allocation. By means of the identification of the key aspects involved in each theme, the background and the (potential) effect on the decision is being treated. Main themes of the elaboration are importance, impact and influence (by PoR) on the requirements.
One should keep in mind that the research is seeking for the generic characteristics of requirements to be used. Many requirements can be used in this way, but the exact application will still be dependent on the specifications of the clients and its specific activities.

The interaction between a port region and a potential future industry is to be seen as a supply and demand situation. In this process, the possible client will demand a set of requirements which it has identified to be necessary to perform its activities in an optimal manner. On the other side of the spectrum, the port is offering its resources. In this process, an optimal match is pursued in which the port is able to satisfy the requirements of the client and at the same time is able to make optimal use of the available resources. Traditionally seen, a client will be allocating in a port which fulfils its needs best gaining the opportunity to create a competitive advantage.

3.1. ZOOMING IN ON THE REQUIREMENT THEMES

Over the years, an increasing amount of aspects have gained importance in all projects in or around the public domain. This also holds for the allocation of clients in the PoR. Historically, the main focus has been on the physical aspects (such as needed area, berth length etc.) and the aspects having a direct impact on the production process. Of course, these aspects are still implemented in the requirements of new clients, but since the initiation of (Port of Rotterdam Authority, 2011) and realisation of the Maasvlakte 2, a broader view on social, political, technical and environmental aspects have been incorporated in the process and their importance has reached significant levels to strive for a more sustainable industry. To tackle this in a systematic way, the PoR authority has adopted the so-called TeCoP (Technical, Economical, Commercial, Operational and Political aspects involved in a project), which makes sure that every possible aspect is analysed accordingly and no possible aspects are missed in the allocation process. In the continuation of this section, all relevant aspects, as described in section 2.7.3, for the generation of requirements will be treated in further detail and an assessment on the relevance in the decision-making process of allocation is made as well as its importance for the PoR authority that activities are being allocated at in such a way that the are able to enhance the strengths of the HIC.

Since the identification of requirements in 2.7.3 is done based on the general themes, this section will acknowledge the sub-aspects that are involved in the requirements. The final substantiation, which is also treated in this order, is as follows:

1. Connectivity	i.	Intra-Port connectivity
	ii.	Inter-Port Connectivity
2. Knowledge & Experience	i.	Relevant institutions
	ii.	Experience of the industry
	iii.	Subsidies
3. Law & Regulation	i.	Safety & security
	ii.	Emissions
	iii.	Subsidies
4. Physical aspects	i.	Needed hectares
	ii.	Access to waterside
5. Services	i.	Physical services
	ii.	Administrative services
	iii.	Digital services
6. Sociopolitical	i.	Public opinion
	ii.	Political arrangement
	iii.	Interaction with residential areas
7. Synergy	i.	Supply chain of the cluster
	ii.	Strategic cooperations

The main goal of this section is to identify the degree of differentiation in the HIC based on the substantiated requirement themes. For a requirement being generic for the whole HIC does not mean that is shouldn't be treated, but it can be concluded that it won't be a decisive element in the consideration among different terrains in the HIC. In general, a generic character also means that the influence of the stakeholders in the allocation process is relatively small.

3.1.1. CONNECTIVITY

Any form of traded products, from physical to digital, is reliant on a goal-orientated connectivity. Without such connectivity, a client is unable to trade any of its products in a cost-effective manner. The existence of an extensive and reliable connectivity network in a port has great benefits for the competitive position of any client.

Before an elaboration on the forms of connectivity of a port is carried out, a subdivision into inter-port - and intra-port connectivity is made. Pointing out on the connectivity of firms in the port with their customers in the hinterland and the connectivity of firms in the ports system among themselves respectively. Both the forms of connectivity make it possible for clients that are allocated in the HIC to trade products and feedstock and at the same time contribute to the character of the gateway to Europe of the PoR.

Although it might look quite obvious that a good connectivity is set as a requirement from the client's point of view, there are significant distinctions to be made among possible location options. This section will elaborate upon the relevance and background of different aspects in the sense of connectivity, complemented by the identification of impact on the decision-making process of allocation.

INTER-PORT CONNECTIVITY - THE MODAL SPLIT

The modal split concerns both the incoming as well as the outgoing cargo volumes of the port system. Where incoming products are mainly seen as the cargo arriving at the PoR by vessel from all over the world (at least the majority is transported in this way), the outgoing volumes are mainly assigned to reaching the next link in the supply chain by the so-called 'hinterland transport'. A schematic overview of the situation, with the PoR as the process box, is presented in figure 3.1.

The modal split, as presented in the scheme, is addressed as inter-port connectivity and therefore only flows entering- or going out of the port system of PoR are being addressed. When inter-connectivity is concerned, accessibility of the port system and the successive links in the supply chain is the key for an effective connectivity.

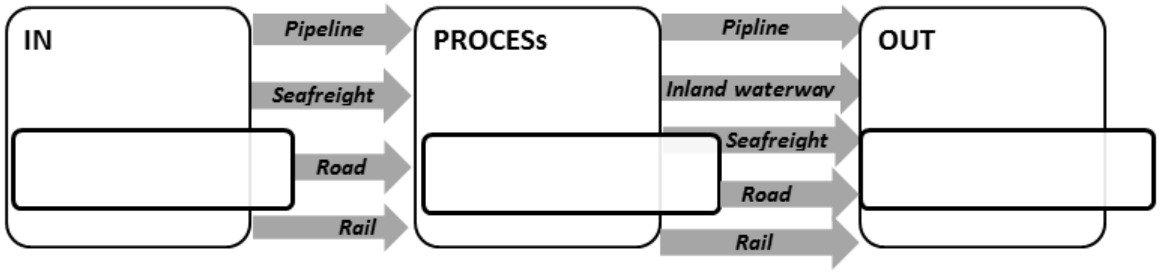
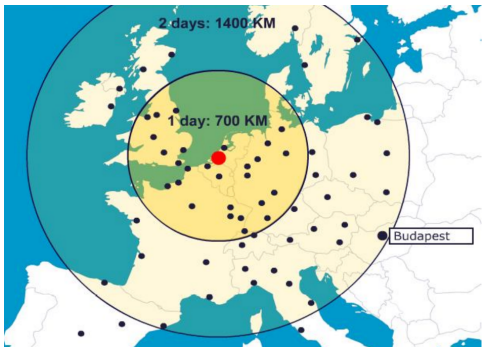


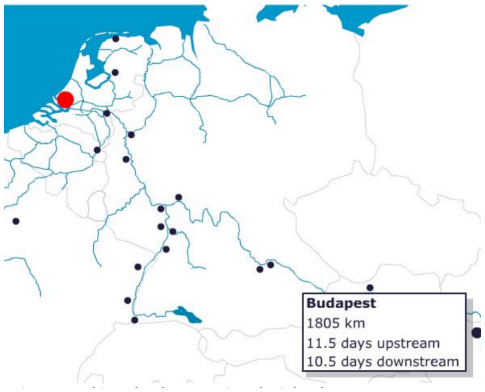
Figure 3.1: Overview of the modes that account for the modal split for incoming- and outgoing products

For the PoR it is of great importance that the connectivity is being developed and extended to be able to compete with (inter) national ports. The main strength of the port is that is able to host all available sizes of vessel on the incoming side (which is rather unique in Europe) and at the same time it has developed an extensive connectivity towards the hinterland being able to reach 350 million consumers (as depicted in figure 3.2) by the different modes of transport.

(a) Pipelines from PoR



(b) Reachable hinterland by road transport



(c) Reachable hinterland by inland waterway

(d) Reachable hinterland by railway

Figure 3.2: Overview of the different modalities and their reach (Port of Rotterdam, 2018a)

The vast difference in volumes of cargo per freight, as well as the distances travelled (an average of 7233 km for incoming and an average of 233 km for the hinterland transport), result in a completely different modal split for the incoming and outgoing cargo flows. The main characteristics are that the majority of incoming cargo is transported by international sea-freight due to the large scales involved. After processes have taken place within the port system, the hinterland transport takes place by the different modes as presented in the modal split scheme of figure 3.1. For this hinterland transport, the volumes per freight are generally (significantly) smaller than the incoming flows and the efficiency of transport, location of the successive link in the chain and nature of the product are the main determinants of the decision on which transport mode is used.

As the Netherlands has a rather high population density, keeping the transport system efficient is a highly complex problem. To comply with the needs of private and commercial transport movements, it has developed a highly effective transport system which is ranked as world's best (Schwab and Sala-i Martin, 2017). With ever increasing pressure on the system, together with the challenge opposed by the energy transition, the PoR is heavily pursuing to retain the accessibility of the port system. By posing objectives for shifts in the modal split (from road towards rail, waterway and pipeline) and rewarding participating tenders stimulating this, it endeavours to guide the shift.

Impact of inter-port connectivity on the spatial allocation:
Retaining an excellent accessibility and intra-connectivity of the port system, future clients can be convinced by the opportunity of gaining a competitive advantage in this respect. Although the efficiency of transport (and associated modes) is rather dependent on the nature and volume per freight of the product, a good connectivity of incoming as well as outgoing freight is of vital importance for clients to increase the overall efficiency in their supply chain. Especially when relatively 'new' technologies are considered, most of the time, the cost competitiveness with contemporary comparable products is difficult to achieve. By being able to reduce costs in the transportation, the chance of being able to compete increases significantly (specifically for high volume, low priced products). Although it might seem generic, due to the limitation in access to the different modes of transport (like draught), it has a specific side when different terrains are compared across the port area.

INTRA-PORT CONNECTIVITY

The intra-port connectivity refers to the connectivity of industries, companies and activities by means of trading or transporting (semi) finished products within the port system. Basically meaning that the supply of a product can be directly delivered from within the HIC. Due to the large scale that products are produced on in the HIC, over the years, the situation aroused that it has proven to be beneficial to separate the supply chain and specialise each link. To be able to supply the produced products to the sequential link of the chain, effective connectivity plays a crucial role.

As being addressed earlier, the PoR (as the majority of industrial ports) has a high degree of clustering activities. The clustering can be characterised by the following definition: *"Clusters are geographic concentrations of interconnected companies and institutions in a particular field"* (Porter, 1998). As the definition already points out, the connection is vital for the industry to act as a cluster. Since an important role is assigned to the clustering of activities, the HIC is heavily reliant on the connectivity among different companies that are creating the opportunity for the involved parties to exchange and trade products among themselves.

The connectivity among the companies in the HIC should be seen in the broadest sense as it is not only about the trading of physical products, but also nearby complementary industries (e.g. storage and distribution facilities) and sharing of knowledge & experience. The clustering and connecting of industrial activities have proven to be able to push an increase in productivity and innovation, strengthening cluster as a whole.

The majority of connections in the HIC is subject to an agreement of some sort. These agreements can be among two individual companies all the way up to central line systems connecting multiple industrial activities. Such an agreement can include both physical- (e.g. pipelines, railway, co-siting etc.) as well as administrative connections (e.g. dedicated cooperation, alliances, supplier contracts, lease contracts on infrastructure etc.) or a combination of both.

Examples of projects in the HIC that emphasise the importance of connectivity:

- Container Exchange Route (CER) - a dedicated system that is able to exchange containers among the terminals on the Maasvlakte (Port of Rotterdam, 2018c)
- Multi-core pipelines - a joint venture of Vopak and PoR enabling clients to lease and transport chemical products efficiently between Pernis and Europoort (Port of Rotterdam, 2018d)
- 'Warmte Rotonde' - exchange of industrial heat to other industry and residential areas (Zuid-Holland, 2018)
- Specialised suppliers of industrial gasses - supplying the chemical- and refinery industry with the needed building blocks to perform their activities.

If a more circular approach is to be applied in the HIC, connections among activities and to central systems are the basis for exchanging any kind of product. Without an efficient infrastructure, connecting the industries will be too costly and the possible advantageous of a circular approach could be largely reduced. On the other hand though, the initiation of connection to a centralised system based on waste streams, is posing a threat for the current (specialised) suppliers of these products. These dedicated suppliers form an essential link in the contemporary cluster structure thus will be determant to keep their position intact. Not to mention the significant alterations in this structure that have to be made in order to make the such a circular approach viable.

Impact of intra-port connectivity on the spatial allocation:
As is apparent from the previous paragraphs, intra-port connectivity is of vital importance in the creation of an excellent performing cluster and an efficient supply chain. It is therefore not a big surprise that new clients stress on the availability of connective infrastructure to be able to take advantage of the developed industry that is present in the HIC when formulating their Terms of Requirements (ToR). By having access to the applicable connective networks, clients are able to buy feedstock, building blocks and fuels locally and at the same time, the variety of suppliers provides the security of supply, reducing both costs as well as risk. For a particular activity, it might well be that it is essential to have a supplier that is able to deliver a specific product(s) continuously in order to create a viable business case at all.

For the HIC the connectivity is almost always possible, either directly to an existing network or by means of an investment into a new pipeline. Though the availability is in place, clients tend to prefer an individual connection, which involves an additional investment, and it should be carefully assessed whether this is profitable. The applicable investments for the connection, vary throughout the HIC and therefore the conclusion can be drawn that this requirement is quite specific, though the majority of terrains will be able to offer the needed connective requirements, the variation is mainly in the associated investment costs to realise the connection.

3.1.2. KNOWLEDGE & EXPERIENCE

Over the years it might be obvious that the HIC has developed a substantial portfolio of knowledge and experience. In an ever-changing environment, it is of vital importance that it is kept up to date and contribute to the developments of today and the future.

For a new industry arriving in the PoR, it is highly important that the knowledge applicable to the concerned sector is available and the skill level up to standards. Without the availability of the labour force, applicable to the concerned industry, the establishment climate will be negatively influenced.

RELEVANT INSTITUTIONS

In the Global Competitiveness report (Schwab and Sala-i Martin, 2017), institutions and education in the Netherlands are identified as two of the most important pillars contributing to its 4th place ranking. For the PoR it is of great importance to create and maintain a good relationship with educational- as well as research institutions, especially in a transition in which innovation will take a central role. This can be looked at from different perspectives; the supply of labour with the necessary set of skills and the research that is needed to exploit new technologies.

The transfer of knowledge and experience is of great importance in order to maintain and improve the leading position of the PoR. This starts with providing a high-level educational system that is able to address and teach the relevant topics in order to create a smooth and efficient transition to the labour market. To accomplish this, the PoR authority has active support for a variety of institutions and educational entities. These can be differentiated into two main categories: the guarantee of a stable and reliable supply of skilled labour to the market (e.g. STC, Techniek College Rotterdam, Albeda and Zadkine) and secondly institutions contributing in the form of research (e.g. Deltalinqs, TNO, Erasmus University and TU Delft). Though it must be noted that the universities also perform the role of the provision of skilled labour.

Impact of relevant institutions on the spatial allocation:
For a new industry, it is an important condition that the knowledge is present and available in the region of allocation in order to perform its activities. The role of institutions is quite clear in this respect, but with the new industries which are increasingly involved in an innovative sector, platforms stimulating innovation are crucial. For the PoR this means that it is meaningful to have close relations with existing incubators and be able to stimulate the innovations that positively affect the port system. The PoR has besides these cooperation also taken the lead by turning the two of the former city harbours into the so-called Makersdistrict (consisting of the Merwe Vierhavens and the RDM Campus). These areas give the opportunity to start-ups in the relevant sectors to exploit their technologies and get themselves ready for a scale up. On the supportive side, the PoR also developed the PortXL that serves as accompanist for the innovative companies and bringing industry and innovation together.

In the end, it is the innovative culture and the presence of knowledge, now as well as in the future, that can be a crucial aspect for a potential client. This knowledge of the labour force, however, comes at a price. In a prospective country like the Netherlands, labour is expensive. This means that for a client, the excess knowledge must be compensating the extra cost of hiring, emphasising the importance of a high level of knowledge. The applicability of the relevant institutions is not very different across the HIC and can therefore be assigned of having a highly generic character.

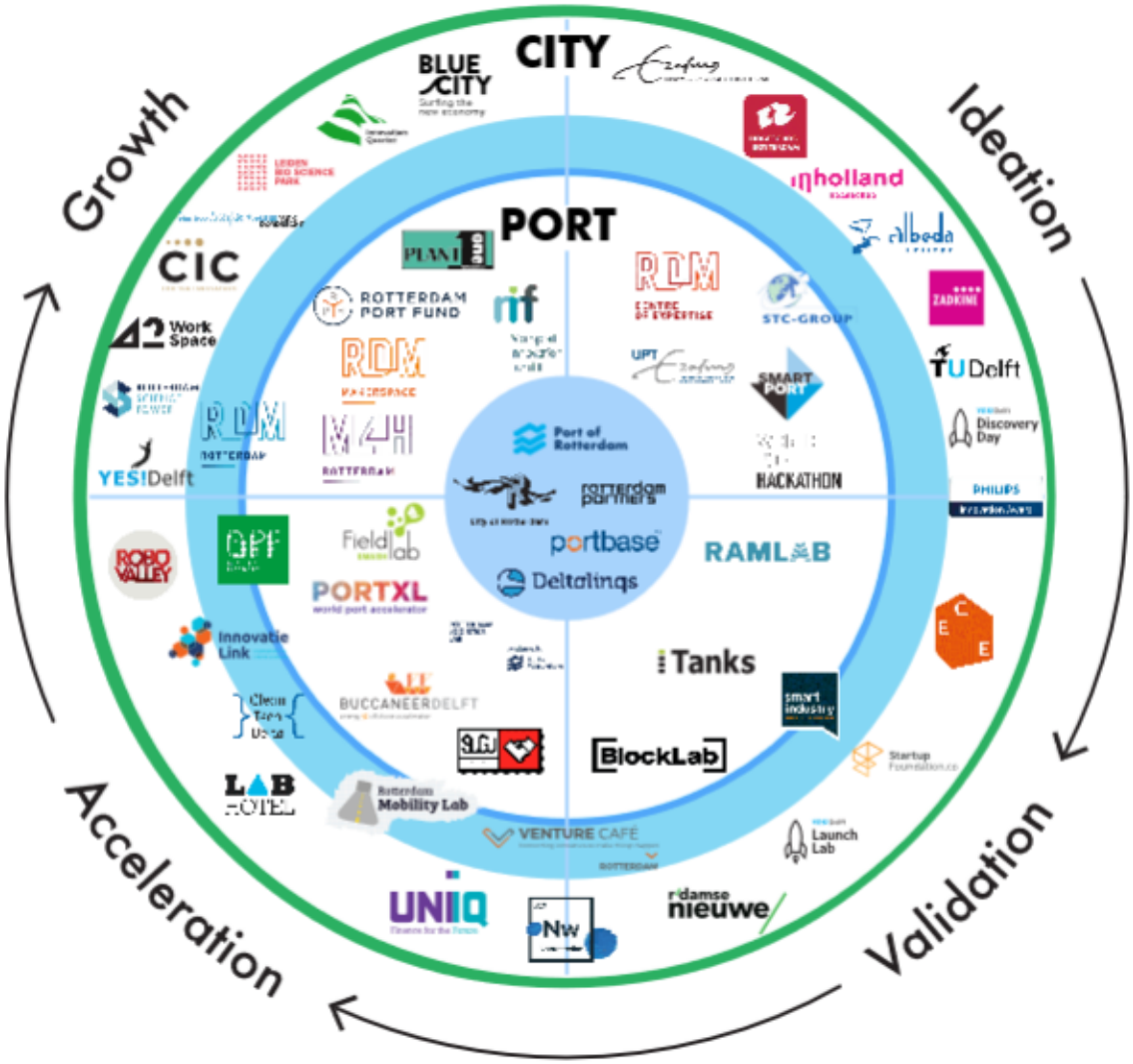


Figure 3.3: Innovation climate and the involvement of the PoR authority in the different stages (Port of Rotterdam, 2015)

DEVELOPED EXPERIENCE BY INDUSTRIES

The PoR has developed into a world-leading industrial cluster that is able to distinguish itself by the production and optimisation of chemicals and oil-based products. This development has evolved parallel with the generation of the high-quality transhipment and services which altogether contribute to the current status of the PoR.

In the described evolution, a lot of experience and knowledge has been gathered by the industry. Though the focus has been on optimisation and improvement of efficiency (related to the scaling effects), the transition towards a more sustainable HiC requires a 'new type' of knowledge that is more innovation-, rather than efficiency-driven. The efficiency-driven knowledge, however, does provide a very fertile basis since a deep understanding of processes is developed by the efficiency improvements.

Over the years, the companies that are in the HiC also improved significantly both in numbers as well as scale. Some of these companies even became world-leading in their specific sector. Most of these leading companies have multiple locations and industrial sites all over the world. Meaning that experience is not only gained within the PoR but also elsewhere in the world, complementing to the overall knowledge capacity of the concerned company.

For the industrial knowledge to be the foundation for innovation, the gap between industries and start-ups must be closed on short terms (Bloom, 2015). By sharing the knowledge from both sides of the spectrum, as well as the investment opportunities that are vastly bigger in the current industrial sector, an optimal innovation climate can be created which has the opportunities to evolve into a mature future industry.

Although new industries might require a new approach to (parts of) the process, it does not mean that a completely new production process is developed. In the majority of the processes, a high degree of overlap can be recognised with the current practice. Especially for the overlapping aspects, the already developed knowledge can play a crucial role in the development and (cost effective) exploitation of new industries.

Next, to the processes, the current industry has developed an extensive network of infrastructural facilities to be able to trade their products in the most efficient and cost-effective way. These are aspects that are not likely to change during the transition to a sustainable industry. All the developed experience in the transportation and logistics sector, together with the complementary services that have been developed over the years, give new industries the opportunity to gain an advantage over the exploitation in a less experienced region.

Impact of developed experience by industries on the spatial allocation:
For the allocation of a new industry, the presence of knowledge and experience in the industry can be of vital importance. The existence of the already developed skillset in the region gives the opportunity of stepping onto the learning curve at a higher level. The developed knowledge and experience are more related to the kind of industry rather than the location and therefore is assigned having a generic character. The differentiation that can be made is the fact that industries are being clustered in the port and therefore the available experience is merged in a particular area.

SKILL LEVEL

Of course, the skill level in the port region is not an isolated subject, but can be considered a result of the climate and culture that has evolved parallel to the education, knowledge and experience developments. The reigning availability of skilled labour and research is an important factor for new industries in the decision-making process for allocation. Without a relevant skill level that is able to contribute to the client's activities, allocation of the industry is very unlikely to happen. From the viewpoint of society, it is also relevant that companies use the resources that a region has to offer with respect to enhancing employment and prosperity of the region as a whole.

Due to decades of build-up in experience and knowledge in the sectors for which the PoR is known for, a high level of skill has developed in its labour force. In this respect, not only the directly related industry must be taken into account, but also the complimentary industries and services are highly important (e.g. trade, transport & logistics, financial, legal and insurance). To supply the skill set that is required to perform these activities, a development also took place on the education side of the spectrum to fulfil this demand. In fact, the evolving industries had a direct, though slightly lagging, impact on the structure and climate on the development of knowledge and specialisations.

Although an evolving industry is able to push the skills to a higher level, finding an industry that requires a comparable skill set as the current industries in the HiC, has the highest added value for the considered industry itself as well as the region on the short term (International Labour Office, 2011).

As described above, the skillset associated with a certain industry has a very multi-modal nature. The skill level that is present in the labour force, is to be assessed as being a resource of a certain region. Although the skill level and specialisations are able to develop by the hand of a new industry, it is important that new industries, in the transition, are able to exploit the resources. This holds both for the region as well as the fact that a developed skill can give the activity a competitive advantage for the client. For the PoR authority, it is aspired to enter into the transition with industries that are able to exploit the developed resources in an optimal manner in order to maintain and expand the leading position.

Over the past decades, the required skills have changed significantly. By means of developments, digitalisation and increasing atomisation, the focus of skills has been shifting towards the organisational side of the performed activities. As labour is known to be relatively expensive in prosperous countries (like the NL), high levels of progressive orientated skills will have to add value to justify these high costs. The development and transition are not likely to stop and will exercise an increasing pressure on the skill level to keep developing.

The transition to a sustainable HiC will result in a more innovative climate. This will hold that a shift in the approach and demanded skill set will be needed in order to accommodate the transition and realise the goals as they have been set. On the technical side, the skill level is very well present in the region, the main attention will need to be paid to the realisation of the innovative climate.

Impact of the skill level on the spatial allocation:
In the end, the skill level of the region is a decisive factor in the allocation decision of possible new clients. If the demanded skill level (from client's side) and the skills present within the region differ too much, the time consumed to bridge the gap and exploit the activity to full extent might prove that another region is more favourable, but within the HIC the requirement with respect to skill level is identified as generic. No matter what, the transition towards a sustainable HiC, includes new industries which all have their own requirements on the level of skill. For the PoR region, it is therefore of vital importance to enhance the development of skills to accompany the industries that have the most added value for a HiC in transition.

3.1.3. LAW & REGULATION

Law and regulation are two important themes when activities are being performed in or affecting the public domain. Next to that, it is the responsibility of the PoR authority to make sure that the rules are being applied in the contracts with their clients and safety is being warranted. Therefore, when clients are being allocated, extensive research is being performed in order to guarantee that rules and regulations are being applied in a correct manner. The following sections will provide a deeper understanding on the laws en regulations that are applicable for the allocation of clients.

SAFETY & SECURITY

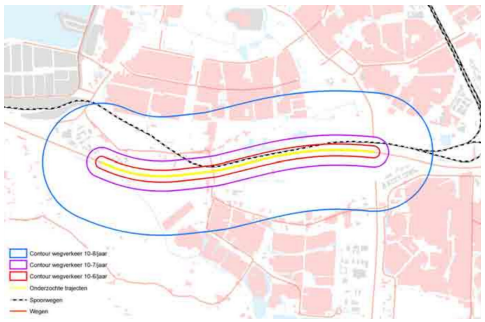
The security of the region is on behalf of the protection of the stakeholders against possible threats like cybercrime, terrorism etc.. Although highly important in today's society, these measures are not considered to be related to a specific terrain, but rather to a region or even a country and therefore have no significant role in the allocation decision and are considered to have a generic character when treated in the HIC. For this reason, the security aspects are not treated in further detail.

Safety is considered to be very important from the PoR perspective. Of course, an accident causing harm and/or damage to stakeholders is undesired, such an event also damages the image of both the company where it took place, as well as the HiC as a whole.

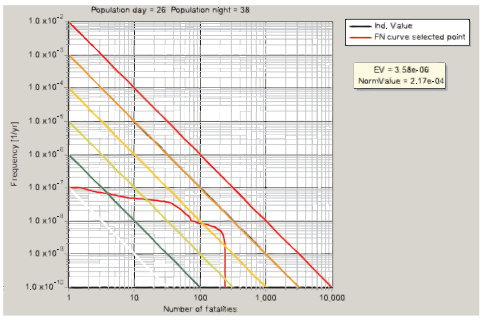
The safety measures and industries that have to be taken into account are described in the 'Wet Ruimtelijke Ordening' (Overheid, 2016). This law states that external safety concerning groups as well as location bound risks must be assessed by means of an extensive Quantitative Risk Assessment (QRA). Both the group- and location-bound risk are described in detail in the 'Handleiding Risicoberekeningen Bevi versie 3.3' (Rijksinstituut voor Volksgezondheid en Milieu, 2015).

To determine the location-bound risks, the so-called “Schillenmodel” is used (of which an example is depicted in figure 3.4a). This model basically determines the distance away from the activity that is subject to a certain risk (= probability * consequence). These distances are the risk contours drawn up for several levels (e.g. 10-4, 10-5 and 10-6) defining the probabilistic occurrence of a lethal accident in person/year. By drawing these contours on a map, a comprehensive overview can be given of the degree of risk and analysis can be made whether any vulnerable groups of people could be facing consequences if disaster strikes.

Secondly, the manual prescribes that the group risks must be determined for institutions which are to be protected (e.g. schools, hospitals etc.) and to determine the possibility of an event resulting into an excess of 10 casualties (e.g. nearby infrastructural work). The manual prescribes a determination of the risk by means of the F-N-Curve method, presented in figure 3.4b, in which an orientation value forms the benchmark which cannot be exceeded. Every specific situation/institution has been prescribed by the Government with its own specific orientation value. To evaluate this, the group risks in the surrounding are plotted into the F-N-curve and it can be (visually) determined whether the orientation value is not exceeded.



(a) The ’Schillenmodel’ for the determination of the local-bound risk contours



(b) A FN-curve for the determination of the group risks

Figure 3.4: The used methodologies for the risk assessment (Kuppen and Engelhard, 2007) and (Gooijer *et al.*, 2007)

Partially based on the possible allowances in risks, the so-called ‘bestemmingsplannen’ (destination plans) are being assigned to each specific area. In these documents, a destination is being assigned to the location itself in such a way that it does not interfere with the destination of surrounding areas. The goal is to provide the needed space for risky activities and at the same time protect people working and living in neighbouring areas. These plans are also developed for the HiC.

For a new industry, the safety contours applicable to the terrain are important in the decision-making. Too strict safety measures (on for instance the use of chemicals), relative to the intended process, may restrict the company from performing its activities. If the risk contours are not sufficient for the (desired) activities of a client, the likeliness of choosing for the PoR is almost zero.

Impact of safety and security on the spatial allocation:
For allocation the purposes, the involved client must assess these safety requirements that are relevant to their production processes (of which the majority is being described in the (Rijksinstituut voor Volksgezondheid en Milieu, 2015)). For the operational phase (which is most important for the client), it must be very clear that no resistance arises which will shut down or damage the activities. Most of the time, the closer an activity is situated to a residential and/or protected area, the stricter the applied safety regime will be and therefore this requirement is highly specific.

EMISSIONS

For the general public, the main focus concerning emissions is on behalf of the CO_2 that is emitted into the air. Although this is justified and is seen as a real threat, this problem is of global reach and therefore is not decisive for allocation within a region. For the noise-, nitrogen dioxide (NO_2) and particular matter (PM), the opposite is true. To be in line with its strategy, the PoR will most likely prefer the allocation of activities with low CO_2 emissions, but as no clear guidelines have been set, the emission of CO_2 is treated as generic for the whole HIC.

To protect people living in the Netherlands, the government have decided to make the drawing up of a so-called 'bestemmingsplan' (destination plan) compulsory for every region in the country. These plans describe what destination is being set for the particular stretch of land (e.g. living, offices, chemical industry, recreation etc.) and the associated limit values that have to be met in order to fulfil this function. For the PoR such plans have also been drawn up and the activities in the port have to meet the standards in order to make sure no nuisance is being perceived by the people in the surrounding areas. The following section will describe into more detail how the regulations have been set and what the consequences are for the port area and possible future allocations.

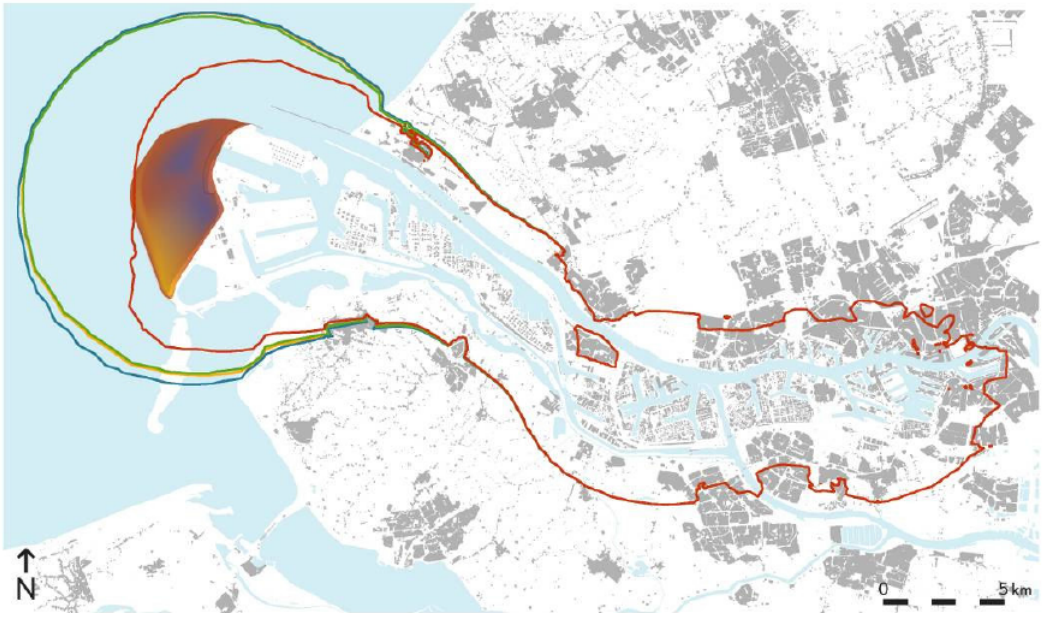


Figure 3.5: A graphical representation of the limiting value for noise emissions of 50 Db (red line) (Rotterdam, 2008)

In the 'bestemmingsplannen' a noise level for a residential area of 50 dB is being identified. This means that for an industry that is situated in the HIC the noise levels must be either low enough or the distance to the residential area large enough to stay within the set limits. For clients (arriving) in the HIC, the impact of the noise levels is being assessed beforehand and checked while in operation.

Before a client is allocated, the noise level is being described as part of the so-called 'Milieu Effecten Rapportage' (MER). From extensive research, characteristic values of produced noise levels have been determined for the different forms of industries that are present in the HIC. These characteristic values are used to determine whether the considered activity fits within the given limitations. By means of drawing the different contour lines of specific dB values, it can be determined graphically whether any nuisance will be experienced by the surrounding areas.

To evaluate whether future activities fit in the HIC based on noise levels, maximal noise budgets have been set by the PoR authority. Together with the outer contour which is the maximal reach the 50 dB contour (as is depicted in figure 3.5) is allowed to have, this gives a good overview of the allowances and possibilities in the port region with respect to noise levels.

Basically, the same approach is applied for the determination of air pollutants that can be emitted into the air. In this respect, the main focus is also on the contribution of the considered activity on the surrounding area. As an upper bound, specific maximal values for the different forms of pollutants which are substantiated for several destinations that can be performed on a particular location (residential, recreational, offices etc.). As the maximum values for noise emission, the upper bounds for air pollutants are also part of the 'bestemmingsplan' and MER.

(a) NO_2 emission (b) PM emission

Figure 3.6: An example of a berth facility and its associated emission contours (Niemendal and Bouman, 2014)

Graphically seen, the outer bound which is depicted in figure 3.5 does not really differ from the contour which is used for emissions (only slight differences can be found in the detailing). Also, the approach when evaluating possible future scenarios, by using emission budgets and characteristic values for each industry is, in essence, the same as being described for noise emission. The main difference in the methodology of determination is the fact that distinction is being made for different types of emitters (e.g. a chimney) and this can have a significant effect on the contribution of an industrial activity to the emission levels that are being measured at a certain location.

For practical application, the contours for different concentration values can be drawn in for air pollution as well. A clear example for both the NO_2 as well as the PM can is presented in figure 3.6.

Impact of emissions on the spatial allocation:
For the sake of possible future allocation, it is of high importance that the activity and its associated emissions stay within the set limits. Additionally, the MER is the basis for the permit that is obtained if regulations are that will remain the same during the whole period of operations and therefore not be exceeded. With the transition to a more sustainable industry, these regulations are likely to get stricter as time passes to reach the set targets. Also, the developments around carbon taxation might give a completely new approach to the dealing of industrial companies with the emitted substances. In the end, although variations are applicable across the PoR, it can be a showstopper if the activity is not able to stay within the set limits by either having to pay for the surplus in emissions or get a no for an answer directly. Within the HIC, the emissions (with the exception to CO_2) have a rather site specific character since the location of a terrain with respect to public activities determines to large extent what limits are applicable for the considered terrain.

SUBSIDIES

'Subsidies make it possible to make projects fanciable and thereby accelerate the realisation. Subsidies can also serve as a means to bring stakeholders together and/or create more support for a project or development in an area' (Port of Rotterdam, 2018e).

Subsidies related to sustainable initiatives are developed at several levels: International (mainly EU), National and Regional. The availability of subsidies in a certain area can be of vital importance for a new industry when the allocation decision is to be made. Besides the levels in the degree of internationality, also distinction is made in the degree of maternity and nature of the company/institution/governmental body. As the innovation and development of new technologies stimulating the energy transition involve all these stages and at the same time the PoR is stimulating innovation at different levels of maternity, the relevance of the distinction is obvious.

One might think at first hand that only subsidies involving large scale industries are relevant for the PoR, however, the collaboration among the different layers has been identified to be of vital importance. To stimulate this, there are subsidies available for collaborations among different types and scales of industries/companies with institutions and governmental bodies.

A comprehensive overview of subsidies is proving to be difficult to make, but at the RVO website, an insight in opportunities can be found in which a distinction has been made among the so-called 'Topsectors'. These Topsectors are identified by the RVO as being important industries in which the Netherlands, historically seen, is able to excel. Many of these topsectors, especially with the energy transition, are highly relevant for innovative projects in the PoR. The overall energy transition is guided by the European Union (and its Parliament). The subsidies on the European level are very interesting for new industries (and thus possible PoR clients), but differentiation is lacking. Meaning that the availability of these subsidies are the same for every seaport in the European Union and therefore no real effect on the strategic decision (why allocating in the PoR?) of a client is present.

To comply with the international (EU) targets, the Dutch government developed the so-called SDE(+) ('Stimulering Duurzame Energie') funding programme. In this programme, a substantial yearly budget is available for companies and (non-profit) institutions for the realisation of renewable energy production. In essence, the SDE+ bridges the gap between the market value of the produced energy and the production costs in six different categories: biomass, geothermal, water, wind and solar energy. The funding programme is at a national level (for NL) stimulating industries to exploit new technologies (at full scale) while they cannot be viable by itself (yet). The funding has proven to be able to be an essential aspect in the project decision, but differentiation from an allocation point of view is irrelevant on a national level.

Impact of subsidies on the spatial allocation:
Experiences with the available subsidies within the PoR authority are that objectively seen, local subsidies perform well with respect to guiding which direction to go, but are not vital when industrial investments are to be made due to their relatively low impact with respect to the total investment. Thus not having a substantial impact on the allocation decision of new industries. For the national funding programmes, this is different but is still really dependent on the industry that is being considered combined with the alternatives locations and the available funding programmes. These forms of subsidies are specific on the type of activity rather than based on the different locations in the HIC for which they can be assigned as being generic.

3.1.4. PHYSICAL ASPECTS

The physical aspects to the terrain have always, and most likely will in future, be the basis for any allocation decision. Due to their quantitative nature, they are in majority of times quite straightforward and can be clearly communicated and processed. The currently increasing scarcity of available land, does not make life easier for the PoR authority and makes the need for optimal allocation more important than ever. The following section is aimed to provide a better insight in the physical aspects, their importance and the spatial puzzle involved.

NEEDED HECTARES

The first question concerning the physical aspects to ask is the number of hectares that are necessary for a client to perform their activities and all complementary facilities. One should think about the area needed for the production facility itself, but also the associated offices, parking spaces, storage and even the needed zoning around specific activities in terms of safety separating the different facilities.

Besides the quantitative aspects, the activities that are to be performed will also result in qualitative requirements for the terrain. The nature of the production process can make a significant difference in the extent to which a terrain must be prepared. This preparation includes the strength of the soil layers (for instance when heavy lifting is to be performed at the site) as well as safety for the performed activities (pipelines for transport to storage) and even potential ground pollution must be properly assessed and handled.

Together the quantitative and qualitative aspects form the degree of preparation that is necessary to allocate the specific client on a terrain. As this involves significant costs, these aspects do contribute to the total value per square meter and the resulting price. One should keep in mind that these requirements do have to be fulfilled no matter what the specific location is going to be. On the other hand, this must be seen as an iterative process, as the investments for preparation can be considerable, it is well worth the effort to evaluate whether it is worth to upgrade a specific terrain or it is a better option to allocate another industry which needs less preparation. On the other hand, if the terrain has been prepared to a high quality in the past, it is the goal of the PoR authority to utilise these specifications as good as possible.

Impact of the needed hectares on the spatial allocation:
This puzzle is proven to be a difficult undertaking for the involved parties, but a constructive approach is vital for the correct allocation. As a client has developed its requirements, based on its own expertise, it is worthwhile to go over them once more. By assessing, it might well be true, that outsourcing or synergy opportunities are missed by the client and by exploiting these opportunities an investment reduction as well as a reduction in needed hectares/quality. The needed hectares in first instance have a generic character where the intended production process will lead to the needed hectares based on the process units. The availability of terrains themselves and possibility to outsources certain links in the process might lead to a very different amount of needed hectares and contribute to the specific character of the requirement.

ACCESS TO THE WATERSIDE

Besides the land-orientated requirements, the physical aspects also address the required access to the waterside. By answering this question, a large number of terrains can be put out of scope and a more comprehensive selection is left over. The access to the waterside involves both the incoming- as well as the outgoing transport. As the PoR authority invests in the so-called nautical infrastructure, it is of great importance to specify the needs in detail.

Next, to the question whether access to the waterside is necessary, the nature of the product (containerised, break-, dry- or wet bulk) is also decisive with respect to the possible locations. These various natures in products require a different approach to the berthing location as well as the equipment that is needed to accommodate the transhipment. Different nature of a product, generally, also involves a certain type of ship that is used with its typical dimensions (draught, length, width etc.) affecting the location of choice due to the fact that not every location is able to host all sizes of vessels.

Since one of the main forms of income for the PoR authority are the payments made for each unit of product that is being handled at the berth, the goal of the PoR is to allocate clients at the waterside which maximise these revenues. For clients having relatively low volumes of transhipment, this might mean that, although being dependent on waterborne transport, it will be proposed to either outsource the transhipment or share berth(s) with another client which is also not able to utilise its berth capacity.

Besides the direct physical aspects that are involved in the accessibility to the waterside, it also involves both the nautical safety- and water safety regulations. Where the first is meant to give the rules and regulation of ships that are sailing and berthing in the PoR. The nautical safety is highly addressed by the involved authorities and is decisive in the determination to which ships are allowed to berth (and in what manner) at a specific location. Secondly, the water safety deals with the protection against water hazard by means of events like flooding. As the quay walls have the double function of both facilitating the berthing of vessels, as well as, retaining the water from entering the terrain, it can have a significant influence on the design (and thus investment costs).

Impact of access to the waterside on the spatial allocation:
For a new client, allocating in the PoR, it will be evident that it has specific physical requirements to the terrain and the location in the port. The most crucial part for the client is the availability of the needed terrain which is providing the opportunity to perform the activity in an optimal manner. These physical requirements are highly dependent on the activity that is to be performed. As described in the previous, these physical aspects are influenced by the opportunities and availability of cositing, synergy and regulations. Therefore the physical aspects are altered continuously as the other requirements are assessed in more detail. In fact, the decisive part on the physical requirements is the availability of terrain and waterside access, the remaining physical aspects are to be part of the iterative puzzle for which a solution is being pursued by treating all other requirements.

3.1.5. SERVICES

As an industrial area develops, complementary services are generally following the same trend. When industries grow, specialisation will increase and the need for outsourcing of certain services becomes an important subject to reduce the operational costs and the associated risks. The presence of the needed services is vital for an industry as it provides the opportunity to plug into the current port system and at the same time create the security of both the process itself as well as the prior and sequential connectivity. Services are provided in various types and scales and can be seen as the enablers of all other requirements as a company does not have all knowledge and facilities in-house. In this section, the main aspects of relevant port services will be treated including the role of the PoR authority and the possible impact on the allocation process.

PHYSICAL SERVICES

For the supply chain of the port-related businesses, the physical services perform vital links in enabling the chain to be handled in an efficient manner. This already starts at the moment a vessel is arriving in at the port where pilots and tugboats make sure that the terminal can be supplied. From there on, the production process takes place. The necessary industrial maintenance and equipment facilitators make sure the company is able to fulfil its core business. When the process is completed, logistics and warehousing will form the backbone for any sequential link to be reached and, in fact, are the facilitators of the hinterland connectivity.

One might argue whether the facilitating of industrial gasses and other semi finished products should be accounted as physical services, but since a direct trade (mostly contract based) is performed in this process, it is treated as a part of connectivity which is treated in section 3.1.1.

An important aspect to realise is the inter-dependency between the main industry and the complementary services. The main industry is dependent on its service providers to keep the process up and running and to get the products (incoming as well as outgoing) to its destination in the desired manner. At the same time, the service providers are dependent on the main industry to keep on producing products to be able to facilitate the cargo-flows and production processes. In general, the two treated businesses provide each others security of supply.

The majority of the physical services is being performed in the private domain. There are only a few exceptions to this when the safety of the PoR is involved, a guiding role is being taken by the PoR authority. Due to the competition and large-scale operations, the service providers have developed a lot of experience and are able to deliver high-quality services at competitive price levels.

Impact of physical services on the spatial allocation:
The provision of services can really be seen as an industry on its own and it is desired to be situated within the port region. Although terrains for these service providers are preferably not the locations which could be used for the main industries (e.g. located at the waterside), complete distribution parks have been developed in the direct neighbourhood of the main industries and are therefore assigned with an average degree of location specifics. The presence of the physical services can be seen as the enabler of connectivity and synergy by providing their clients with its knowledge and experience that has been build up over the years.

ADMINISTRATIVE SERVICES

As in any type of business, companies that are active in the port region need the support of administrative services. These services can be linked to the everyday activities like the financial, legal and insurances that are necessary to keep the company going. On the other hand, port-related industries have developed to such a scale, that it has been worthwhile for service providers to develop specialised port-related services.

Since as seaport, like the PoR, involves a lot of international cargo-flows, many service providers have developed expertise in the handling and support of the additional administration that is involved with the cross-border business approach. Additionally, the industries that are performed in the port region, generally involve a higher level of risk due to the use of vast equipment and hazardous substances that the provided services, need to include these risks into their supportive products (like goal orientated insurances).

Impact of administrative services on the spatial allocation:
Although a lot of business activities of an administrative service provider can take place in the port region. The necessity of being allocated in the port itself is not that high. The office buildings that are used by these companies have no significance with the resources that are provided by the terrains in the port area and are therefore generic when allocation of industries is concerned. Therefore these service providers are generally located near the border between port and city. Still close enough to maintain close contact with their clients, but at the same a location that is not offering a surplus of resources.

DIGITALISED SERVICES

As can be observed in the industry as a whole, automation and digitisation play an important role in the development. Services are no exception to this and it can even be concluded that the provision of digital services has turned into a new, fast growing, market. As acknowledged by the PoR authority, by making it one out of their three main themes in its commercial strategy (Port of Rotterdam Authority, 2016c), it is pursuing to exploit the opportunity of being a facilitator of digital business solutions (DBS which is also a new department within the PoR authority) in the port area (Port of Rotterdam, 2018f).

By the implementation of tools and applications, the PoR is pursuing the opportunities the technical developments are offering in creating a more efficient and safer working environment in the port area. These tools and applications are a new type of business and the PoR is mainly involved as a facilitator and active partner for the technology developers. The (to be) implemented digital services are aimed to increase the efficiency of the supply chain, the (monitoring of) safety in the port area, handling of goods and bulk and creating platforms that are able to bring data and knowledge together. This can be done for very practical applications (e.g. reservation of buoys and dolphins) as well as the automation of processes (e.g. scanning and registration of the containers in and out of the terminals).

Impact of digitalised services on the spatial allocation:
The presence and availability of service in the port area are of high value for clients, but at the same time most digital services are aimed at a multiple use (in terms of clients as well as geographically seen) and are not dependent on location. It provides the client with the opportunity to focus on its core business while other aspects can be sourced out in the form of services to specialised companies at a competitive price level. At the same time, digitalisation is leading to more effective and less error sensitive environment in terms of the supply chain and processes concerning the handling of goods. Especially for clients that are active in a comparable/existing sector which is already present in the HIC, one can be relatively certain that the applicable services are present in the port area and therefore the operational costs can be reduced. Though, on the other hand, new sectors might have more difficulties finding all of the needed services as not every service is applicable for all industries and the services that are in place have developed alongside the current types of industries. One should not forget, however, that it is not uncommon that clients have their own (worldwide) service contracts which enable them to have the freedom to allocate wherever the other requirements suite the activity best. Although the PoR has the ambition to be a front runner in this sector, enhancing its innovation climate, the availability of digital services in the time span for which an average client is allocated, the requirement can be assigned to be generic.

3.1.6. SOCIOPOLITICAL

As the industrial activities in and around the PoR have an impact on the public domain, the managing of the societal values and political support is important for companies. Without a clear and adequate policy with respect to the direct environment and the society as a whole, undesired events can lead to significant resistance, affecting the business directly. The public opinion is gaining importance as the emerging industries over the past decades is accounted justly for a large contribution to the environmental challenge society faces. This section will zoom in on the relevance and impact the sociopolitical aspects have on the allocation process and how this is present in the requirements.

PUBLIC OPINION

Over the years, the public opinion has gained importance and parallel did the so-called Corporate Social Responsibility (CSR): '*The awareness a company has for the interests of society, demonstrated by active acknowledgement of the effects the activities of a company have on consumers, employees, shareholders, the municipality and the environment*' (SanderP, 2012). If industries will not live up to their CSR, a transition towards a sustainable HIC is not plausible.

Social support to the industry is not to be underestimated, though there are several factors that influence the degree in which society will interfere with the process, if society turns against a certain company, it has proven to be very tough to gain back the trust. In this respect, industries that involve direct consumer products or have a direct impact on the neighbouring environment, generally face higher social resistance than industries supplying building blocks for sequential links or specialised products for a particular industry.

Evidently, this also holds for a positive societal development. It is becoming more and more common to integrate the added social value into the business cases by means of quantification. By doing so, it is stimulated to enhance the social benefits and the actual returns on investment are reduced. One should not forget that the role of the media and its strategic use can play an influential role in this respect for both sides of the spectrum and the influence of the public opinion is subject to large differences in a global respect.

POLITICAL ARRANGEMENT

The political arrangement around the allocation of a new project is, in fact, the active support of the (local) governmental bodies on the initiative. Technologies that involve a high degree of innovation and at the same time act in the public domain (by for instance direct supply of energy) are very keen on the political support. This support is not only in the form of financial means (e.g. subsidies), but also the involved image of the project with the acknowledgement by the governmental bodies. By participating in a project, the political institutions generally give their approval for the development.

Basically, with the right arrangement of political entities, a project can be able to limit the social risks as it is shared with the involved parties. This risk sharing will affect the business case in a positive manner and together with the integration of societal value into the financial evaluation, the chances of a positive business case increase.

INTERACTION WITH RESIDENTIAL AREAS

Although the port area is mostly seen as a nuisance for the surrounding residential areas, the interaction between port and city is of vital importance for the availability of workers from the region. As it is a good development that the industry has expanded over the years, the workforce that has been undergoing a parallel upward motion also needs a place nearby in which they can live. Without the sufficient residential and recreational opportunities in the direct neighbourhood, travel times will turn into a hurdle for the employees to subscribe for a job in the port region.

When the city and port area are not developed parallel to each other, it can cause vast problems for future industries. Either the employees are not able to live in the area, because of the port developing faster than the surrounding region, and labour becomes a scarce and expensive factor. Or the other way around, if the city developing at a faster pace than the industry is, creating an overcapacity of labour that will result in high unemployment rates. For the creation of a sustainable future port, both need to be in balance and a close link is to be made to the knowledge that needs to be included in this respect.

Impact of sociopolitical aspects on the spatial allocation:
With respect to the allocation of a new client, the support of both political- and local entities are of significant importance. Although from a financial point of view, the benefits to be reached are marginal, the downsides can lead to great difficulties. Without a positive culture being present in the area, both employees, as well as resistance from the public domain, may result in restrictions on the performed activities of the client. On the other hand, new industries that are aimed at contributing to the energy transition, generally experience a more positive attitude from both public as well as politics. This is a situation that is clearly present and counts as an opportunity for new industries to allocate in the PoR. The main contribution to the degree of generic character of the allocation has to do with the interaction with the residential areas. The higher this aspect is, more pressure of the public opinion and politics is expected, adding up to an average location specifics of the requirements.

3.1.7. SYNERGY

As described in literature, synergy are the links among business units that result in additional value creation (Economist, 2009). By the implementation of synergy, it seemingly creates extra value without consuming resources. The availability of synergy options on a certain location must be seen as an opportunity for the possible client and at the same time an added value for the provider of the terrain. When an industry is allocated in a cluster with which it has no synergy options, this opportunity is missed and results in a mismatch between the desired- and actual activity. To create the highest value for a terrain, the industries that are allocated should be able to maximise this opportunity.

One should realise that synergy can be obtained in more aspects than only the trading of physical products. Availability and cooperation on the basis of waste streams, knowledge and experience may well be a decisive element that a particular company needs in order to excel in the performed activities. This section will give an overview of the different aspects that are applicable to the creation of synergy and what the added value is for a possible new client.

SUPPLY CHAIN OF THE CLUSTER

It is sometimes conceived that synergy is all about the integration of different (sequential) links in the supply chain. Although it is true that this is a form of synergy, there are various more aspects that are able to create added value by means of synergy effects. Before evaluating these opportunities, it is important to realise which part of the supply chain is taking place in the region of concern.

As addressed earlier, the HIC in Rotterdam functions as the gateway to Europe with its main industries in the chemical, petrochemical and energy production sectors. The feedstock for these processes is mainly obtained from abroad and brought into the port by ship. This is where the role of the PoR takes off. The core businesses are mainly related to the storage, production and redistribution into the hinterland of (mainly) fuels and building blocks for sequential links in the supply chain. This means that, seen from a schematic point of view, only a small part of the complete chain is taking place in the PoR (as depicted in figure 3.7 for the example of crude oil). In this respect, synergy is obtained by other means than a solely vertical integration of the chain and more focused on the complementary products that are needed in the process.

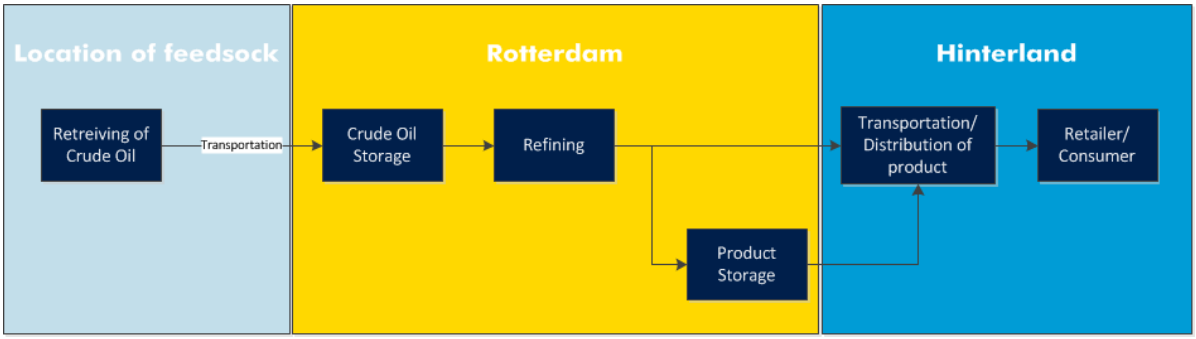


Figure 3.7: A broad overview of the supply chain of crude oil including the role of PoR

Although the relative part of the supply chain, schematically seen, is not that extensive, this does not mean that there is no significant synergy in the PoR. Over the years, a substantial industry has evolved, being able to process vast quantities of product. To accommodate this in an efficient manner, a high level of synergy is obtained with the complimentary industries. Since needed products, like industrial gasses, are needed for the processes in such large extent, specialized companies have developed and are allocated in the port region, securing a supply of complementary (but essential) products to their clients. For possible new clients, this holds that the opportunity of synergy is present. By exploiting the opportunities for synergy, the client is able to keep its focus on its core business, whereas the needed products can be obtained from within the cluster. The main advantage of the business case is that the CAPEX is largely reduced, since the trades in products supplied are assigned to the OPEX. This reduction is especially important when the comparison to Greenfield developments is made.

STRATEGIC COOPERATION

The synergy that is based on the trading of products within the cluster, has a high correlation with connectivity. Besides the trading of products, the integration of services into the direct environment has proven to be an effective measure to reduce costs and risks for the operations. The ultimate form of synergy in the port region the co-siting of different companies by, in fact, sharing the physical area of terrain(s) to optimise the processes and have a direct cooperation to enhance the process efficiency. By these intensive cooperation, the involved companies create the environment in which not only physical products are traded, but an increase of knowledge and experience through the specialisation is obtained. A good example of this co-siting is presented in figure 3.8, in which it can be clearly seen how Huntsman is co-siting with several different suppliers as well as the cooperation with their suppliers (just) outside the direct plot.

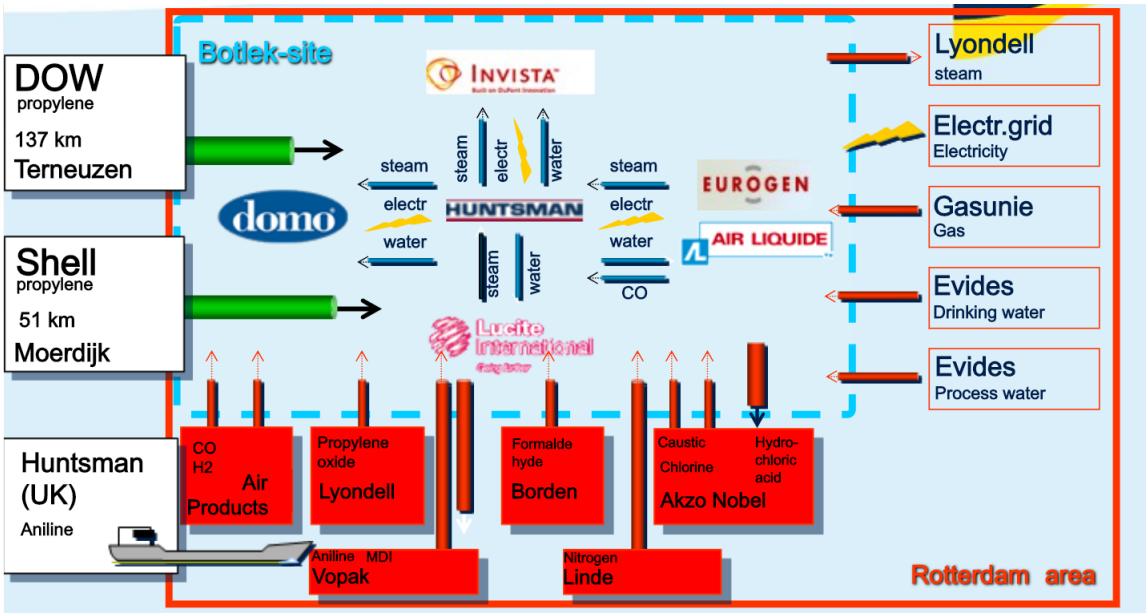


Figure 3.8: An illustrative example of the co-siting at Huntsman and the involved synergy (Baas, 2016)

It is common practice that such a local cluster with co-siting, is developed around one leading firm such as Huntsman (but the Shell cluster is also a good example). From figure 3.8, it can be clearly seen that the cooperation have a wider orientation than the cluster itself. It should not be underestimated, that leader firms are located all over the world and therefore do have their strategic cooperation with clients supplying the complementary products (and services) on an international level. This might be enhancing the synergy opportunities for the considered leader firm itself, it is also providing a hurdle for the synergy utilisation for the PoR as a whole. This is mainly from a competitive point of view among the different leader firms (e.g. Shell and BP) and the possible reluctance to corporate with competitive firms due to set cooperation contracts. Such cooperation might locally result into the transportation of product over large distances, whereas another firm could supply it from within the HIC, but for the overall worldwide synergy utilisation, it can still be advantageous for the considered company.

Strategic cooperation are expanding beyond national borders, but at the same time, the integration can be outside the supply chain or core business of a certain company. For instance, the acquisition of sustainable developments in energy carriers by the refinery industry can be explained from several perspectives. First of all, it is strategically desired to be ready for the future and maintain the competitive position for the decades to come. On the other side, it is also advantageous for the sector to be able to market the fact that they are involved with the transition to a sustainable future, whereas their main profit is still made on production of fossil products. By doing this the leader firms from the fossil era, are trying to enhance their Corporate Social Responsibility (CSR), creating a future-proof business case and at the same time gain some control in the development of possible competitive products.

Impact of synergy on the spatial allocation:
For a potential new client, it is highly important to be able to obtain synergy effects in the port of allocation. As business cases, especially for initiators of innovative technologies, are highly sensitive in order to make a price competitive product, reduction of investment costs by synergy are able to provide a decisive topic in the decision-making process for allocation. The degree to which synergy, in the sense of physical products, is decisive, is dependent on the degree of resource dependency of the considered production process. Although many suppliers might be present in the HIC, it is not always simply 'plug & play' as existing contracts between supplier and user must be lived up to and a part of these suppliers will have a dedicated supply to a particular company. For a potential new client, it is important to perform preliminary research and negotiations with present industries to explore the opportunities and degree of synergy effects that could be obtained at a specific location. For innovative 'new' industries it is therefore of great value, to be able to set up a close cooperation, and possibly even co-siting, with an existing industry to be able to reduce initial investment as well as profit from the developed knowledge, scale advantage and security of supply and demand.

3.1.8. REVIEW AND CONCLUSIONS

By means of the elaboration of the (sub) requirements that have been performed in this section, an indication is made on whether the requirement has a generic or specific character when different locations in the HIC are considered.

One should keep in mind that the overview that is presented in 3.9 is assigned as a first indication since specific sector-related industries might have a completely different perception of the requirements relative to their performed activities. For instance, an industrial activity that has (very) low emissions will account the requirements on emissions as generic as it does not exceed any of the determined emissions budgets that have been set across the HIC. For an activity with significant emissions, however, these requirements will be (highly) specific as it can only allocate in specific parts of the HIC if it is to stay within the limits.

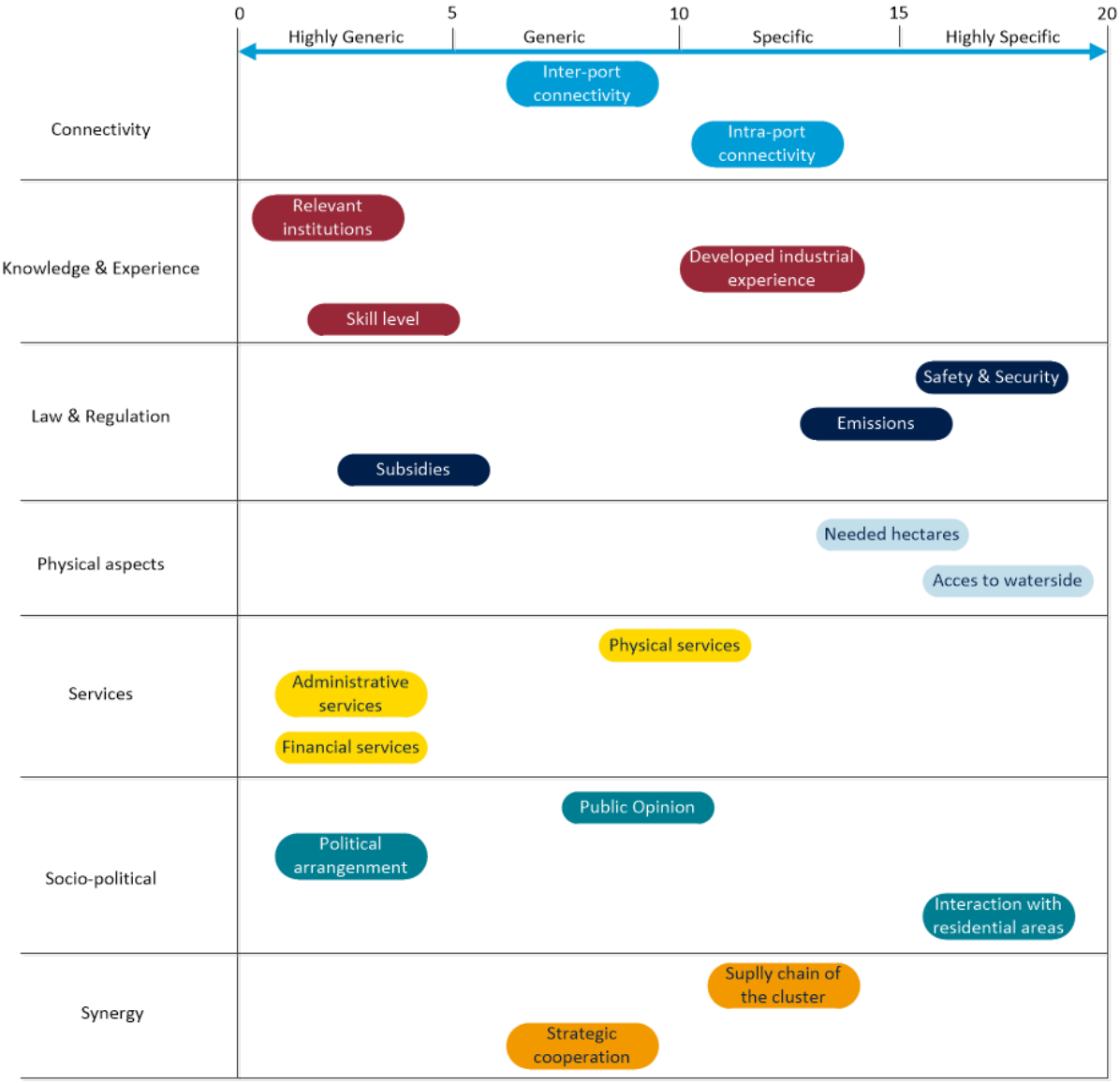


Figure 3.9: A preliminary indication on the requirement characteristics for each sub-aspects

4

CHARACTERISTICS OF THE DIFFERENT AREAS IN THE PORT

Where the previous section treated the various requirements from the client's point of view, this section will zoom in on the perspective of the PoR authority. As pointed out in the introductory part of this chapter, in every market there is a supply and demand side involved and the allocation of an industry is no exception. In this respect, the resources that are offered by the PoR, are to be seen as the supply.

The role of the supplier by the PoR authority tends to become more extensive when future allocation is considered. Since for new and innovative industries, it is highly important to have an active participating partnership with the port authority as well as being provided with a lease contract for the land and associated infrastructure. This, however, does not mean that the PoR is no longer a supplier of resources which it pursues to be allocated in such a way that the potential of the location as well as the financial resources are being utilised in an optimal manner. In fact, this holds that the strengths of a certain location are to be utilised. Before the optimisation can take place, the strengths and weaknesses of the different areas will need to be identified.

To gain a fair and objective relation with the previous section, the strengths and weaknesses will be identified for each of the described requirements. When one looks at an overview of the PoR, it is easy to conclude that every area in the port has its own specific industries. This is for a large part due to the clusterisation of activities, but also very likely due to the practical issues and opportunities the different areas contain.

By means of expert interviews with the Port planning area manager from the PoR authority, a scorecard will be filled out to represent to what degree the expert thinks the particular area has a strong position on the considered requirement. By combining the results from this survey and the identified degree of specifics in figure 3.9, it should be possible to draw up a preliminary conclusion on the opportunities and threats for the different areas and requirements.

In the end, the identification of the characteristics of the various areas is aimed to clarify the differentiation among them within the HIC. It is also meant to be the foundation for a hypothesis on the prioritisation of the requirements which will be treated in section 5. This section will start with a brief overview of the different areas that will be considered, followed by the methodology of the interviews. Finally, the results of the interviews will be presented and the conclusions will be drawn up.

4.1. OVERVIEW OF THE TREATED AREAS

To gain a better understanding of the HIC and how it is being divided for the Port Planning department, this paragraph is aimed to give an introduction to the different areas, where they are situated and what its generic characteristics and main businesses are. This should give an overview before going into depth with the expert interviews in section 4.4.

All of these areas together make up the cluster that is being labelled as the HIC and is being depicted in figure 4.1. In general, it can be said, that by moving through the port from west to east the draught becomes shallower, scales get smaller, shifting from modern to contemporary and influences from the city increase. By means of a short description of the different areas, it will become evident what role the areas have in the HIC.

Although the majority of the terrains are occupied in the current situation, this does not mean that there are no future opportunities. Due to this, it is important to know the resources the areas have to offer as if there is an available terrain to be able to exploit such opportunities when they arise.

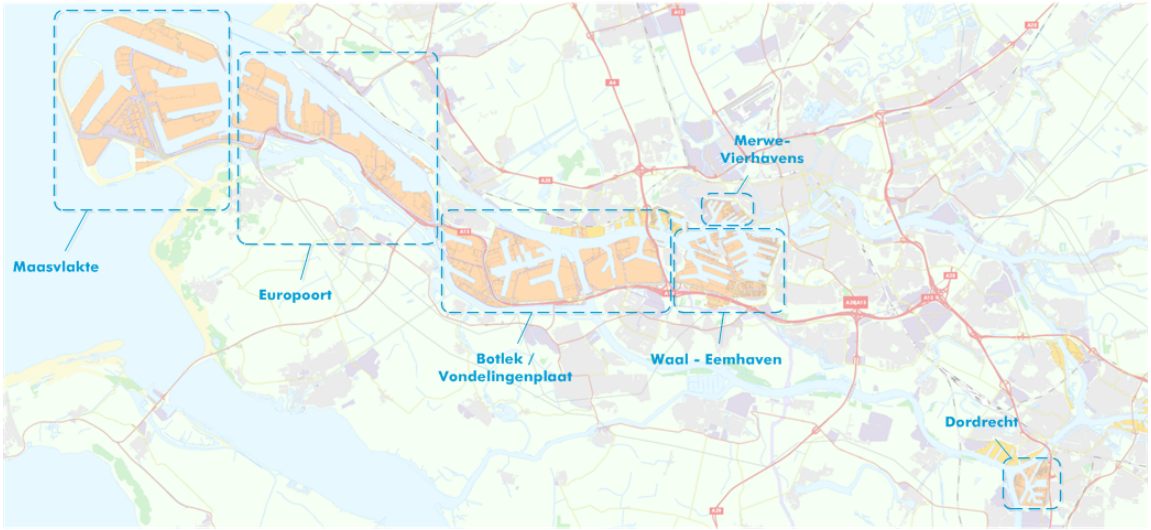


Figure 4.1: An overview of the different areas in the PoR as they area divided among the Port planning area managers (Port of Rotterdam, 2018b)

4.1.1. MAASVLAKTE

The Maasvlakte is the most recently developed, and in fact still partly under development, area of the PoR. The land was acquired in an area which used to be sea and now hosts several port related activities, as is depicted in figure 4.2. The main characteristics of the Maasvlakte are the Greenfield development and the fact that the area is able to host the largest ships available providing the PoR with a unique position in its region. Next to the scale, it also hosts to the, in general, most modern industries and activities in the HIC. As we speak, the main industry that is allocated at the Maasvlakte is the transhipment of containers and the related distribution. Together with the chemical companies and the storage of dry- and wet bulk, the area is aiming to host a variety of activities that are able to benefit from its unique resources.

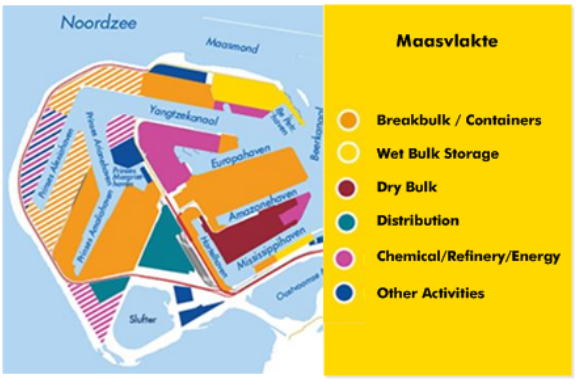


Figure 4.2: Maasvlakte (Port of Rotterdam Authority, 2018a)

4.1.2. EUROPOORT

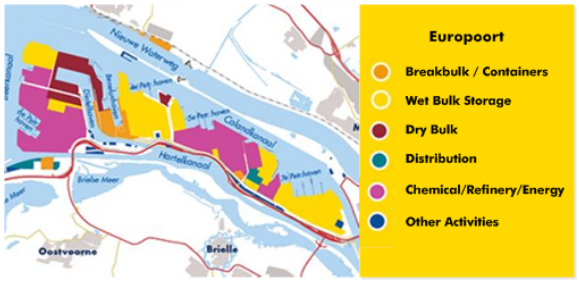


Figure 4.3: Europoort (Port of Rotterdam Authority, 2018a)

As for the Maasvlakte, the Europoort is in the western part of the HIC and has a high accessibility from the seaside as well as being able to host the largest type of ships based on draught. The Europoort area is host to a significant part of the petrochemical cluster for which the PoR is known. The main activities that are performed in this area, relate to the storage and production concerning (petro)chemical products and the transhipment of the needed feedstock.

4.1.3. BOTLEK - VONDELINGENPLAAT

Figure 4.4: Botlek - Vondelingenplaat (Port of Rotterdam Authority, 2018a)

Together with the Europoort, the Botlek Vondelingenplaat area is the foundation of the petrochemical cluster in the HIC. In this cluster leader firms have been allocated and a highly efficient supply chain has been realised. The availability of terrains is scarce and co-siting is the main form of allocation. The main differences are that the available draught is less than in the western areas (approximately 15 m) and the degree of storage that is higher in the Europoort, whereas the Botlek Vondelingenplaat is mainly hosting production sites and wet bulk storage.

4.1.4. WAAL - EEMHAVEN

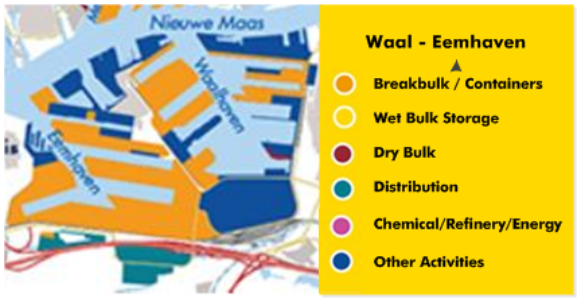


Figure 4.5: WaalEemhaven (Port of Rotterdam Authority, 2018a)

The Waal - Eemhaven area is relatively close to the city centre and therefore has to deal with the interaction to residential areas. The activities that are taking place in this area, are mainly related to transhipment of containerised goods, break bulk and other activities. The available draught (approximately 13.5 m) and the port-city interaction result in the situation that this area is (no longer) suited for allocation of heavy industries. A unique aspect of this area is the fact that it is host to the RDM campus which is providing the opportunity for start-ups to perform its business and grow when the time is there.

4.1.5. MERWE - VIERHAVENS

The Merwe - Vierhavens area is one of the oldest in the PoR and is still has its port-related functions. Due to its relatively small draught (approximately 10.5 m), the scales at which activities (mainly breakbulk, containerised and remaining activities) are taking place are not to be compared with the western areas of the HIC. As we speak, the Merwe - Vierhavens is facing a complete makeover which is aimed to integrate the city and the port area together with the development of innovative industrial start-ups. The latter will be in collaboration with the RDM campus.

Figure 4.6: MerweVierhavens (Port of Rotterdam Authority, 2018a)

4.1.6. DORDRECHT

The port area in Dordrecht is special in the sense that it is originally not part of the PoR, but since the collaboration has been signed, the PoR authority is closely involved in the development of the Dordrecht seaports. Although situated far inland, the port is still considered being a seaport as it is situated at a unique junction of several modes of transport.

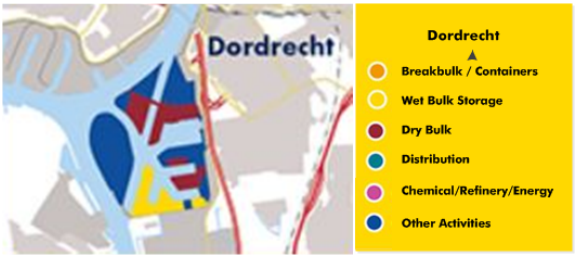


Figure 4.7: Dordrecht (Port of Rotterdam Authority, 2018a)

4.2. MAPPING THE CHARACTERISTIC

In the previous section, the different areas in the HIC have been briefly described to give an overview of the main characteristics. Although mainly from the industries that are currently being performed, it can be roughly extrapolated what the likely strengths and weaknesses of the particular area are, the exact characteristics are still not evident. To clarify these exact characteristics, this section will provide an insight of the methodology that will be used to create a comprehensive overview. This overview is aimed to result, combined with the previous and sequential sections, into an evaluation on the differentiation in the characteristics across the HIC.

Since this research focuses on the allocation of possible future industries, it is not particularly relevant to look at the currently located industries, but the picture has to be broadened in such a way that the requirements can be evaluated for the area as a whole. This means that the contemporary availability of a terrain is not taken into consideration and the requirements are to be seen as the resources a particular area has to offer. The main reasoning behind this choice is the fact that the future occupancy rate of the different areas is still too uncertain to work with and therefore it is more relevant to look at the essentials of the area itself instead of the availability of terrains.

To clarify the specific characteristics of the different areas, expert interviews are arranged with the involved Port planning area managers of the PoR authority. This will be done by means of a survey in which the requirements are treated according to the defined themes and underlying requirements as described in section 3.1. By approaching the various requirements as being a resource the area is supplying to the industry, in fact, the strengths and weaknesses of the particular area are identified.

By filling out a questionnaire, the different requirements will be scored on a scale of 0 - 20 to represent the quality of the resources in the area. The scoring of the requirements will result in an overview of the stronger and weaker aspects the area is able to offer in the allocation process and provides the opportunity to compare the different areas based on a specific requirement to one another. By comparing the resources of the areas, it should be possible to draw up conclusions on the differentiation of the characteristics that are applicable across the HIC. The scoring represents the following interpretation:

Value	Interpretation
0	Not available, has to be performed/developed on site
5	Insufficiently available in quantity and quality
10	Available, though significant investments have to be made
15	Available at reasonable levels of investment
20	Directly available in quantity and quality

Table 4.1: Interpretation scores resulting from the survey

The reason that such a broad scale has been chosen, is that the valuation of a requirement is not a yes or no question. To illustrate this based on intra-port connectivity, the Lyondell case provides a good example from the interview with Joris Hurenkamp (Hurenkamp, 2018). For the allocation of Lyondell at the Maasvlakte, it was essential to have a continuous supply of ethylene. Although this pipeline does exist and thus availability is present, an additional investment was necessary to extend the existing pipeline to the site. To indicate this with a score, somewhere between 10 and 15 would be representative. If a direct connection at the site would have been possible, it would be scored 20 due to the fact that there was no need for an additional investment.

The goal of this section is to define the characteristics of the different areas in the HIC with respect to the requirements in the allocation and at the same time form a solid foundation, together with section 3.1, to construct a hypothesis for the prioritisation that is described in section 5. On the other hand, the degree of differentiation per requirement across the HIC is to be identified. This will be done by comparing the scores across the HIC relating to the same requirement. The higher the variation among the scores happens to be, the more specific the requirement is (and thus a high degree of differentiation) and vice versa. In fact, this part will be the substantiation for the conclusions that have been drawn in section 3.1.8.

The methodology for the survey is founded on (Lietz, 2010).

4.3. DEFINING THE SYSTEM BOUNDARY

In essence, this research is aimed at the identification of requirements that are applicable to various industries. The experience developed throughout the research, however, has proven that it is quite difficult to obtain the intended information unless a clear system boundary is presented. Especially with interviews or brainstorming sessions, presenting the boundary acts as a good guide for the conversation. For the current and previous section, the goal is closely related to the identification of the differentiation in the requirements across the HIC. On the other hand, differentiation is also applicable when the requirements of different industries are compared to each other. By assuming the latter differentiation as a constant factor, by means of the system boundary, a deeper understanding can be gained on the differentiation across the HIC.

For the performed survey with the Port planning area managers to map the requirements, and the following sections, the system boundary is used as presented in figure 4.8. For communication purposes, it has been schematically presented and used in a short presentation prior to discussing the questionnaire to give the participating Port planning area managers a taste of the research and a clarification on how the interview is to contribute to the research as a whole.

The choice for a production site for biofuels has been made based on several factors. The most important is the fact that there are production facilities in place within the HIC and the technology is ready to be exploited on an industrial scale (Port of Rotterdam Authority, 2016a). Together with the RED legislation on the compulsory blending percentages of biofuels in the transport sector (Lieberz and Scott, 2017), a risk reduction on the take-off side is in place and the stimulation towards more sustainable forms of biofuels (which are not in competition with the production of food) is initiated.

Taking the previous into account, it should be possible to produce a viable business case. While currently still dependent of the mandates and subsidisation, the significance of the off-take market should provide the opportunity to increase the efficiency, thus becoming more price competitive, and ultimately develop the technology to produce 3^{rd} generation biofuels and chemicals that use biomass as feedstock.

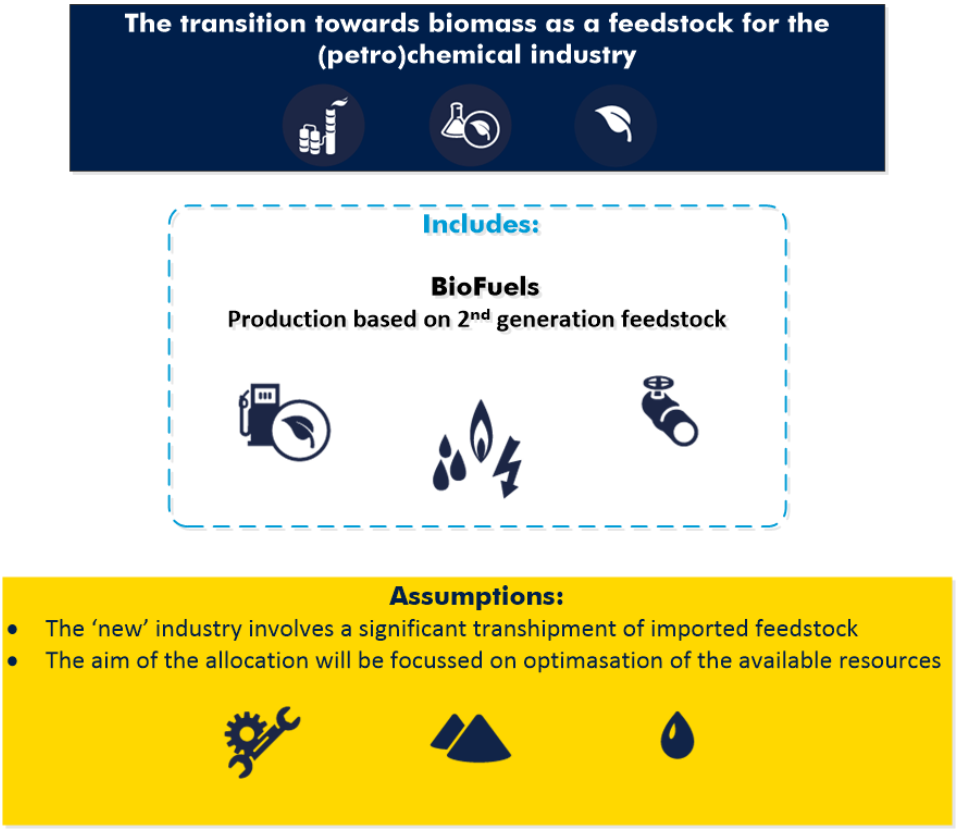


Figure 4.8: A graphical representation of the defined system boundary

Another beneficial aspect is the fact that the current processes to produce biofuels show significant similarities in the refining steps compared to the fossil fuel refinery process. The main differences in the complete process, are the nature/retrieval of the feedstock and the needed preparation of feedstock in the case of biofuel production. For the sequential steps in the process highly similar processes take place and thus large opportunities arise for clusterisation and synergy with the current strong petrochemical sector in the HIC on product basis as well as knowledge and experience.

When a biobased cluster is considered, one mainly aims at the integration with energy- and chemical production. In this cluster, the respective order of time and product value is energy - fuel - chemicals (BiobasedDelta, 2018). The main reason to cluster these activities is to obtain a beneficial situation in which transhipment of feedstock can be performed at a central terminal which is able to supply all three activities. The timeline approach of such a cluster is that in the early phases the majority of feedstock is used in energy production and gradually shifts towards fuel production. At the same time, as technologies develop parallel, the implementation of biobased chemicals will be initiated and scaled up, leading to the long-term shift towards biochemicals.

Maybe even more important, is that a transition (or at least blending mandates) towards biofuel into the current fossil fuel system is in compliance with the transition towards a more sustainable industry. This is of course only the case when the feedstock for the industry is based on a sustainable production. On the other hand, the reigning general opinion is that, although being a transition fuel towards electrification, the long-distance shipping and the aviation sector provide a secure market for the coming decades. This is mostly due to the difficulties that are expected in these sectors with a transition to full electrification and the design lifetime of the currently produced new assets (hindering a quick implementation of a completely new technology) (Gereadts, 2017).

For a better insight into the current production of biofuels in the PoR, reference is made to section C.1 in appendix D.

4.4. RESULTS ON AREA CHARACTERISTICS

This section treats the results of the characteristics that were obtained during the survey. The first part will be a short review of the scores that were assigned to the respective themes and presents conclusions based on these results. Next, the unexpected and striking aspects will be discussed in further detail and finally the comparison and validation of the generic character, as is treated in section 3.1, will be reviewed. For the complete elaboration of all four questionnaires reference is made to sections D.1 until D.4 in the appendix.

One might notice that in section 4.1 more areas were introduced than that are treated in the questionnaire. The reasoning behind the choice to only evaluated the Maasvlakte-, Europoort-, Botlek/ Vondelingenplaat- and Waal/Eemhaven area is the fact that these are the areas in which heavy industry is possible. The other areas either have a high interaction with city development or are subject to too strict measures on basis of safety en environment. Although all four considered areas have the capacity to host a biofuel production plant, significant differences were expected before starting the survey due to the different nature and developed character of the areas.

The scores that have been assigned by the Port planning area managers in the questionnaire are presented in figure 4.9. Due to the limited number of considered areas, and thus interviewees, a central discussion is being held after the survey in the team meeting of the Port Planning department. This discussion not only helped to validate the results by means of obtaining different views, it was also aimed to reduce the subjectivity that aroused on certain topics during the survey. After the central discussion, several minor adjustments have been carried out on the scores with the responsible Port planning area manager when the interpretation proved to be not aligned with the others. The presented scores in figure 4.9 include these alterations.

	Requirement	Maasvlakte Score [1-20]	Europoort Score [1-20]	Botlek/ Vondelingenplaat Score [1-20]	Waal Eemhaven Score [1-20]
Connectivity	Intra-port Connectivity	10	13	20	2
	Inter-port Connectivity	8	20	20	15
Knowledge & Experience	Relevant Institutions	15	17	15	12
	Experience of the Industry	20	17	20	0
	Skill Level	15	15	15	15
Law & Regulation	Safety & security	20	20	15	5
	Emissions	18	20	15	5
	Subsidies	15	10	10	10
Physical aspects	Needed acres	17	15	15	12
	Access to waterside	20	20	15	15
Services	Physical services	18	18	20	8
	Administrative services	20	15	15	15
	Digital services	20	18	15	15
Sociopolitical	Public opinion	7	17	10	0
	Political arrangement	10	15	10	5
	Interaction with residential areas	20	15	10	5
Synergy	Supply chain of the cluster	12	20	20	5
	Strategic corporations	15	18	20	0

Figure 4.9: Resulting scores from the filled out questionnaire with the responsible Port planning area managers

At first sight, it seems that the areas which are currently host to the (petro)chemical cluster, provide the best opportunities for allocation of a biofuel production site. Especially based on the hard requirements (connectivity, synergy, services and physical aspects) the scores are rather high for the Europoort- and Botlek/ Vondelingenplaat area. It is not that the other areas are not able to host the new industry, but the main reasoning is that the investment for a biofuel production site is at the lower end of the spectrum and connections and/or development of physical requirements are subject to relatively high investments compared to the complete business case.

4.4.1. UNEXPECTED OBSERVATIONS

When the evaluation of the questionnaire results is performed, it has proven that the additional remarks that were asked to substantiate on what the scores are founded are at least as useful for comparison as the scores themselves. By means of the additional remarks (which are included in sections D.1 until D.4 in the appendix) it also becomes possible to check whether the interpretation of the asked question is in line with the other performed survey. Especially these remarks clarified a set of unexpected observations which are described in the following.

The first unexpected observation is on behalf of the public opinion and the relation to interaction with residential areas. The reigning expectation was that the further west the considered area in the HIC is situated, the lower the experienced interference of the surrounding public will be due to the increasing distance between industry and residential areas. Although this is true in general, the distance between the activity and residential areas is not the only aspect determining the degree of interference. In this respect, the perception of the people living in the area of influence turns out to be of great importance. In practical terms, this results in the situation that the areas currently hosting the (petro)chemical cluster experience fewer difficulties when new activities are allocated. Though the distances to residential areas in the Europoort- and Botlek/ Vondelingenplaat area are relatively low, the people living in the direct neighbourhood are used to the heavy industries for decades and therefore do not experience a new industry as a great nuisance (especially when the overall nuisance is not increasing). This results in the opposite being true when the Maasvlakte is considered. Though theoretically, the physical distances to vulnerable groups are the largest in the HIC, the greenfield development means that the situation is changing from 'nothing' to (heavy) industry. This is generally experienced by the public as being a big drawback and therefore results in resistance.

The next observation maybe less unexpected and might sound quite logical, though it is worth realising. The approach of the survey was to take a step back from the currently allocated industries. Meaning that, where possible, it is the purpose to zoom in on the characteristics the area possesses intrinsic rather than looking at the functional aspects the current industries include. The survey revealed, however, that the development of the currently allocated industries cannot be seen separate from the fundamental characteristics of the area. This holds not so much for the more generic themes, but when for instance synergy, connectivity, knowledge & experience and even sociopolitical aspects (as described in the previous paragraph) are being considered, the development of the current industries resulted (over time) into the characteristics the area has to offer in this respect.

4.4.2. INTERACTION AMONG THE VARIOUS REQUIREMENTS

In the previous sections, the various requirements are addressed individually. This does not mean that all requirements are to be seen separately and show no signs of interaction. Left aside the generic requirements, every requirement shows correlation with at least one of the other requirements. For the sake of convenience, the following will address the correlated requirements as two groups; hard requirements and soft requirements.

The interaction on behalf of the hard requirements is in line with the reasoning that the development of an industry results in the characteristics of a certain area. For the interaction of these requirements, all complementary aspects that enhance the performance of a cluster develop accordingly over the years. The clusters as they are today, are able to create synergy effects due to the vast production scales and different specialities that are present within the HIC. This synergy is only possible when an extensive connective network is present within the port system. Parallel to the scale-up developments over the years, complementary services (mainly physical) have allocated in the direct neighbourhood of the main industries and are able to supply a purposely build services to their clients. Additionally, the development of industries is not possible without the buildup of high-quality labour and thus knowledge and experience (which can also be seen as a soft requirement). From the previous it is concluded that to form a well-performing cluster, it is vital to develop the hard requirements hand-in-hand and therefore it is quite trivial that when one hard requirement is addressed as a strong characteristic, the others are most likely strong as well and vice versa. The only real condition to fulfil is the relevance of the current cluster to the industry that is considered for allocation.

On the other side of the spectrum, a clear pattern can be observed in the soft requirements. As evident in daily life, the interaction between the group of influence and an activity determines the public opinion towards the activity. The interaction between the industries and its neighbouring residential areas in the port region forms no exception to this.

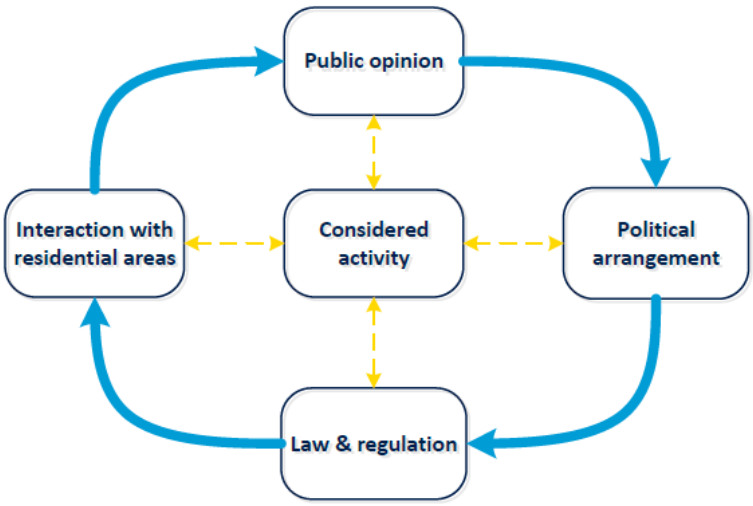


Figure 4.10: Circular process soft requirements

Sequentially, the public opinion influences the political arrangement, since political support is most likely for initiatives that enhance societal well-being. Left alone that the local governments represent its inhabitants from which support is needed to maintain position in the democratic system. The second to last step is the translation from the political arrangement to law & regulation as it is part of the regulatory power in the system. The set laws & regulations then translate back to the public opinion. In fact, laws & regulations provide society with a hard-line benchmark of what is allowed and the public opinion will be altered accordingly. The described process can be seen as a circular process (depicted in figure 4.10) that will repeat itself over and over again in a time span of several years. The main message of the previous inter-dependency is not to what extent the impact reaches, but mainly to illustrate that the different considered soft requirements are inter-dependent and that it is logical that the scores of the different themes show a correlation in the questionnaire results.

4.4.3. VALIDATION OF THE GENERIC CHARACTER

In section 3.1.8 a conclusion has been drawn up on the degree of generic character each of the requirements has based on reasoning and literature. This approach is valuable for gaining a deeper understanding on the different requirement themes involved in the allocation process, though a quantified substantiation will enhance the objectivity of the obtained results.

During the survey, the four participating Port planning area managers all gave a score of their area of responsibility with respect to the various requirement themes. By means of comparing the four obtained scores for a particular requirement, a conclusion can be drawn on the degree of generic character. This evaluation is performed by means of determining the standard deviation. These values are used as an indicator for the degree of generics; a low standard deviation indicates a highly generic character and a high value for the standard deviation a highly specific character. By assigning four classes of standard deviation (as presented in table 4.2) a conclusion has been drawn divided into four categories (as in figure 3.9) enabling comparison between the two sections and being able to assign the scoring with the function of validating the reasoning.

Standard deviation	Conclusion
$0 < x < 2$	Highly Generic
$2 < x < 4$	Generic
$4 < x < 6$	Specific
$6 < x$	Highly Specific

Table 4.2: Values Standard Deviation

These quantified results are followed by the comparison to the conclusions that have been drawn in section 3.1.8. The comparison can be seen in the far right column of figure 4.11 and are marked with colours to indicate to which extent the two results correspond to each other. Since the significant differences are the ones which are most interesting, these will be discussed in more detail in the following paragraph.

In general, the resulting standard deviation and thus the degree of generic character is in line with the expectations. The majority of the considered themes show no significant differences to the conclusions drawn in section 3.1.8. Though five themes do show an unexpected difference between the two conclusions (shown in red in figure 4.11):

- Intra-port connectivity
- Access to waterside
- Public opinion
- Political arrangement
- Strategic cooperation

	Requirement	Standard Deviation [-]	Conclusion	Conclusion as in section 3.1
Connectivity	Intra-port Connectivity	7,46	Highly Specific	Generic
	Inter-port Connectivity	5,68	Specific	Specific
Knowledge & Experience	Relevant Institutions	2,06	Generic	Highly Generic
	Experience of the Industry	9,60	Highly Specific	Specific
	Skill Level	0,00	Highly Generic	Highly Generic
Law & Regulation	Safety & security	7,07	Highly Specific	Highly Specific
	Emissions	6,66	Highly Specific	Specific
	Subsidies	2,50	Generic	Highly Generic
Physical aspects	Needed acres	2,06	Generic	Specific
	Access to waterside	2,89	Generic	Highly Specific
Services	Physical services	5,42	Specific	Generic
	Administrative services	2,50	Generic	Highly Generic
	Digital services	2,45	Generic	Highly Generic
Sociopolitical	Public opinion	7,05	Highly Specific	Generic
	Political arrangement	4,08	Specific	Highly Generic
	Interaction with residential areas	6,45	Highly Specific	Highly Specific
Synergy	Supply chain of the cluster	7,23	Highly Specific	Specific
	Strategic corporations	9,07	Highly Specific	Generic

Completely different
Slightly different
Equal

Figure 4.11: Standard deviations for each of the themes and the resulting conclusion

The main factor that caused the differences in conclusions is the introduction of the system boundary prior to the survey whereas in section 3.1 the specific industry was treated as an undefined variable. This is especially evident when the intra-port connectivity and strategic cooperation are considered. It does not mean that the other areas have bad connective networks or little opportunities for strategic cooperation, but since their current activities are not relevant for the considered system boundary, it will not be assigned with a high score in this respect. Practically, this results in high scores for the areas which currently host the relevant industries and low scores for the areas that show little overlap with the treated activity. This inevitably results into a larger standard deviation among the scores given to the respective areas and thus a highly specific character.

With respect to the access to the waterside, the opposite is true when the effect of the system boundary is taken into account. Of course, the different areas will slightly differ in functional aspects related to the water side. The conclusion of the requirement being highly specific (as is drawn up in 3.1.8) is mainly based on the difference in qualitative aspects across the HIC (e.g. type of quay wall, draught etc.). Though for the applicability of the system boundary, currently the 'Handymax' class of vessels (Marine Connector, 2018) is used to transport the dry biomass and these vessels feature a self (un)loading system. This means that these vessels have no practical restrictions throughout the considered areas and thus the conclusion of a generic character is logical from the survey with respect to the system boundary.

For the softer requirements (the public opinion and political arrangement) the interaction with residential areas and the perception of stakeholders plays a bigger role than expected prior to the survey. From the results of the survey, a clear interdependency between the soft requirements can be observed (as addressed earlier in figure 4.10. By means of this dependency on the interaction with residential areas and their perception, it is quite trivial that the results for the public opinion and political arrangement are assigned with a (highly) specific character as well.

5

PRIORITISATION OF THE REQUIREMENTS

As discussed in the previous chapters, there is are a variety of different requirements that can be acknowledged and each of them plays its own role in the decision-making process. Although it is important that all aspects are incorporated in the decision-making, not every aspect is being treated with equal effort or assigned with equal importance. Of course, this is a very natural trend as priorities of both clients as well as the PoR authority shift from project to project.

This does not mean that the identification of the key requirements in a proactive way is not worthwhile. Complete assessment of the various aspects creates awareness of the complex environment in which the decision-making process is taking place. If one is able to gain a thorough understanding of all the different aspects involved during the allocation, the probability of addressing all requirements with the necessary effort increases.

By proactive identification, opportunities may arise which could have otherwise been overlooked when the pressure cooker with the client is entered right away. It enables the PoR authority to evaluate which industries are contributing most for the port itself as well as the region. This is gaining importance due to the scarcity of physical available area there is left and at the same time the ambitious goals that have been set in with respect to the transition to a sustainable HIC. Additionally, it creates the circumstances to identify the opportunities to increase the value of the new industry for the activity itself and the surrounding industries.

Requirements can be closely related to the different stakeholders. Each of the stakeholders has its own interests, influence and priorities which are not always in line with each other (Mendizabal, 2012). For the PoR authority, it is one of the tasks to guide the process among the different stakeholders in the right direction. When this is achieved, the allocation of a client in the HIC provides a fertile foundation for a long-term collaboration which is aligned with the interests of its surrounding.

The interpretation and importance of requirements can differ among the various stakeholders. All involved parties will have their 'must haves', 'nice to haves' and aspects that are considered irrelevant. By combining these aspects, the priorities can be substantiated for the complete set of stakeholder and focus can be appointed for the project.

The main difficulty with respect to the prioritisation of the requirements is on behalf of the large differences that are involved among industries. During the earlier performed interviews and conversations with experts at the PoR authority, it revealed that the priority of requirements is largely different with respect to the considered industry. Due to the lacking genericity and the increasing importance of soft requirements, a proactive approach to the requirements should be identified for a specific industry or even activity.

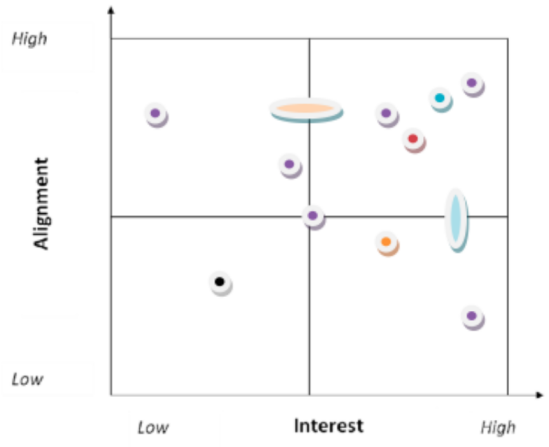


Figure 5.1: An example in which different stakeholder are mapped according to their interest and alignment (Mendizabal, 2012)

5.1. APPROACH

Although difficult, prioritising the requirements in a proactive manner will enhance the overall strategy towards a sustainable HIC. This is not only beneficial for the PoR authority itself, but also a well-founded decision will enhance the creativity of solutions for all stakeholders.

Since the variety of requirements has been gaining in numbers as well as importance, in the PoR authority departments have evolved accordingly. This means that when difficulties are faced with the common subjects involved in the projects, experts are present within the organisation. These experts are able to translate and act accordingly to serve the interest of the stakeholders in such a way the PoR authority is able to strive for the best overall result.

For the sake of this research, the expertise that is present throughout the organisation is highly valuable when prioritisation is concerned. As it is a highly complex task, and with sometimes even contrary results, to prioritise requirements from literature, a workshop is organised to bring together the experts. The participating experts are presented in table 5.1 together with their expertise and the relation to the described requirements.

Name	Expertise	Department	Related requirement
Alan Dirks	Program manager	EM/P&P	Law & regulation
Jelle Peddemors	Analyst spatial development	PD/PP	Physical aspects
Marlies Langbroek	Advisor	CEA/EA	Socio-political
Peter Vervoorn	Port planning area manager	PD/PP	Physical aspects
Poonam Taneja	Researcher	TU Delft/CiTG	Knowledge & experience
Sjaak Verburg	Advisor	AM/NPC	Connectivity
Wilco van der Lans	Business manager	PIM/EP	Synergy

Table 5.1: Participants of the workshop and their roles in the organisation

During this workshop, prioritisation will be the tool to identify the role of the requirements and will be treated by means of two case studies. To present a clear system boundary for the discussion in the format of a case study, a factsheet has been presented to the participants during the workshop. The factsheet includes a brief explanation on the context of the activity, the incoming and outgoing product flows, an indicative quantification on the product flows and a table presenting in which phase the products are considered (import, storage and/or export) with their associated quantities and mode of transportation/storage. A full elaboration of the factsheets can be found in Appendix E, section E.3. The introduction of the two considered cases gave a constant character to the system boundary and therefore enabled to constructively prioritise the requirements relative to the cases.

As the research focusses on the energy transition and its (possible) future industries, the two following cases have been elaborated for the workshop:

- A biorefinery producing building blocks for fuels, chemicals and bituminous products (asphalt industry)
- The production of an energy carrier (hydrogen) for the use as a transport fuel

The two cases that are presented are vastly different, though overlap is present in the fact that both initiatives are supplying the transport market with a (more) sustainable option for fuel and are therefore to be substantiated from a competitive perspective. Most of the remaining aspects are different, demonstrating the fact that many different technologies are able to contribute to a more sustainable HIC, even when their final use is comparable.

The main difference between the two case studies is the level of abstraction. Where the production based on biomass is already ongoing in the PoR and the presented case is a step forward in the technology, the second case involves a highly new technology that is still in its early phases of development. Additionally is the fact that refining of biobased origin, shows a large overlap with the comparable fossil based processes and therefore it does not require too much imagination to be fitted into the current cluster. On the other hand, the production of the synthetic energy carrier requires a completely different approach than the ones on which contemporary port-related activities are based. Its transport volumes are of a much lower scale and the question whether such a activity should take place in the HIC can be justly asked. Contrary, the PoR does provide a good foundation and experience with the involvement of hazardous substances and the needed safety precautions enabling allocation of the industry. In the end, it are these differences that are interesting to evaluate the involved requirements to identify the best match between considered activity and available terrains for future allocation.

As with the previous sections of this chapter, the themes that are being substantiated among the requirements will be the same. By doing this, coherency and the ability to compare and complement the results from the different sections is pursued. In the approach of the workshop, this can be seen in two different ways. Firstly the themes that are to be prioritised follow the outline as treated in the previous and on the other hand the participants are invited based on their expertise on one (or several) themes.

For the sake of overview, only the main themes and an explanation of the associated sub-requirements are used during the workshop. This is contrary to the two previous sections of this chapter where all sub requirements are treated. Besides convenience, the more open approach to the themes also enables for slight variations of interpretation which might lead to interesting differences to the understanding of the participating experts on the other involved requirements.

The goal of the differentiation in expertise is to start up a discussion in which all the different stakeholders are being represented by an expert. In this way, it should be possible to constructively come to a conclusion on the relative importance of the themes for the considered industry. As a result of the discussion, the aim is to draw up the order to which the requirements are assigned to their relative importance. Simplified, this means that the requirements are evaluated to be a ‘must have’, a ‘nice to have’ or ’irrelevant’ to the considered industry.

After an introduction on the considered respective cases, the participants are asked to fill out the priority of each of the involved requirements by ranking them, in which 1 is the requirement with the highest priority and 7 the lowest, together with identification of the requirement’s character (must have, nice to have or irrelevant) and a substantiation of the filled out results. The format in which this has been executed is presented in figure 5.2. Subsequently to the individual assessment, a central discussion will be held in which the participants extrapolate their motivation of the assigned priorities. In this way, the aim is to get a comprehensive overview on the motivations on the importance of the respective requirements. For the results and the drawing up of the conclusions, the interviews with the Port planning area managers have proven that the substantiation, during the workshop both from the individual assessment as well as the central discussion, can be of great use to generate the background to the decisions that are being made.

Requirement	Explanation	Priority [1 - 7]	Must Have	Nice to Have	Irrelevant	Additional remarks
Connectivity	Connectivity of in- and outgoing products of the cluster. Also the products within the supply chain and utilities are within the scope.		✓ / ×	✓ / ×	✓ / ×	
Knowledge & Experience	The quantity, quality and availability of knowledge and experience in the port region. E.g. corporations with institutions, relevant industrial experience and the skill level of the labour market.		✓ / ×	✓ / ×	✓ / ×	
Law & Regualtion	The aspects concerning the safety of the excecuted activity. One should think of external safety, emissions and the opportunities to obtain grants.		✓ / ×	✓ / ×	✓ / ×	
Physical aspects	The necesarry physical area needed for allocation of the activity concerning both land use, water and the interaction between the two.		✓ / ×	✓ / ×	✓ / ×	
Services	The availability and quality of relevant services supporting the core business. One should think of physical- (like maintainance), administrative- and finincial services.		✓ / ×	✓ / ×	✓ / ×	
Sociopolitical	The interaction of the industrial cluster with the social stakeholders. Both the surrounding residential areas as well as the political support form the foundation for the formation of the public opnion.		✓ / ×	✓ / ×	✓ / ×	
Synergy	Opportunities for creation of synergy effects on behalf of chain integration and/or strategic corporation with other activities in the cluster (e.g. cositing).		✓ / ×	✓ / ×	✓ / ×	

Figure 5.2: The form that is to be filled out during the workshop by the participants

5.2. GOAL OF THE WORKSHOP

The main goal of the workshop is to create a discussion with the represented stakeholders (experts) about the role that the various requirements have in the allocation process. By means of prioritisation the objective is to gain a better insight of the reasoning why a certain requirement is important. Since the cases that are to be used differ significantly, it should be possible to identify the determinants that affect the role and importance of the requirements in the process. Although the scoring can give the first indication in this respect, the lack of a large number of cases and the limited number of participants will result in the additional remarks and central discussion having a more decisive role in this respect.

In the end, the goal is to link the different sections and create a comprehensive overview of how the match can be made between what is required to allocate an industry and the characteristics the different areas have to offer. By means of prioritisation, one is able to identify the importance, which is closely linked to the value a terrain has for the client. A proactive determination of importance gives an overview on which requirements need further attention allocate a certain desired industry. At the same time, it enables the PoR authority to identify which industries fit best to the strengths of the port, as a high priority of a requirement can generally be linked to the either the largest opportunities or decisive bottlenecks the industry will be facing.

The results from the prioritisation should give the PoR authority a deeper understanding and realisation of the importance that the different requirements have in the allocation process. At the same time, the complexity of the requirements for the various industries underline the difficulty of being future-proof but do give a well-founded indication of what is already known and what still needs to be investigated in order allocate the industry successfully.

In the end, the workshop with the experts should be a more practical approach of the strategy that has been laid down towards a more sustainable HIC. The cases should touch on the difficulties that are faced in practical terms which are experienced when one looks further ahead in the future.

5.3. INTRODUCTION TO THE CASES

For the workshop, two different cases have been described. The main function of these cases is to present a clear system boundary to the participants. As the goal of the workshop is to discuss the requirements and time is limited, a discussion on the content of the cases is undesired. To avoid this from happening, the two fictional cases need to present a clear and realistic process.

For the elaboration of the cases two initiatives are taken as a foundation:

- REDEFINERY for the biorefenery case
- H2Fuel for the synthetic energy carrier case

To achieve the realistic values and gain a solid understanding of the process, a thorough research is performed in both literature as well as from interviews. When all relevant information is obtained, a comprehensive overview is being drawn up for the workshop. The main reason that these simplification have been carried out are the goal of being easy to understand together with the confidentiality of the exact quantification and process information.

Before the two cases will be introduced in more detail, table 5.2 presents an overview including the origin from which the information is obtained.

H2Fuel		
Subject	**Source**	**Used for**
Interview Joris Hurenkamp	(Hurenkamp, 2018)	Introduction to initiative
External report	(H2Fuel-Systems, 2016)	Elaboration on process and technology
Company visit PlantOne	(Appendix F.1)	Explenation to technology and testing methods
REDEFINERY		
Subject	**Source**	**Used for**
Invitation for consultation	(BiobasedDelta, 2015)	Introduction to initiative
Interview Alder vd Kooij	(Appendix F.2)	Explenation and deeper insight in processes
Data recieved from Aldert vd Kooij	(Cordfunke, 2018)	Specification and quantification of the process

Table 5.2: References and relevant to formulate the case studies

5.3.1. BIOREFINERY - REDEFINERY

THE ESSENCE OF THE PROCESS

The initiative is a blueprint that is aiming at producing building blocks for sequential production processes (chemicals, fuels and additives for asphalt production). It should not be confused with a biofuel/chemical production site itself, but the processes that take place involve the preparation of the feedstock by converting and separating the useful components of the biomass into base products for further production. The refinery process is founded on the use of woody biomass as feedstock (in chunks, chips of pelletized form) to produce lignin, C5- and C6 sugars. These products will then be transported to the next production step to produce the end products (Cordfunke, 2018).

The initial focus of the process is the production of the C5/C6 sugars as a building block for fuels and chemicals respectively. The lignin is providing REDEFINERY with an opportunity if a cost-effective steam supply is possible at the site. When this is indeed the case, the lignin can be isolated and used in the asphalt industry as bitumen. This application has a higher value than using the lignin to produce steam (that is used in the process again) and thus is beneficial for the overall business case.

TARGET MARKET

Confidential

PRODUCTS AND QUANTIFICATION

Confidential

SAFETY & EMISSIONS

Confidential

5.3.2. SYNTHETIC ENERGY CARRIER - H2FUEL

THE ESSENCE OF THE PROCESS

H2Fuel is an initiative concerning the production of an energy carrier ($NaBH_2$) that is able to store hydrogen (H_2) in atmospheric conditions. The sodium boron is able to produce hydrogen when brought into reaction with ultra-pure water (UPW) and an activator in the form of diluted hydrochloric acid (HCl) and/or a catalyst. The produced hydrogen can be used as an energy carrier for several transport modes and production activities comparable to the hydrogen that is produced by other means (e.g. electrolysis). The advantage of the sodium boron as an energy carrier is in the atmospheric storage instead of the high pressures or extremely low temperatures that are needed for gaseous hydrogen (H2Fuel-Systems, 2016).

TARGET MARKET

The sodium boron offers a variety of opportunities when different offtake markets are considered:

- Production of electric energy by means of a fuel cell
- Production of heat by means of a catalyst
- Large-scale storage of electrical energy
- Storage of surpluses of sustainable energy

Due to the variety of possible offtake markets, the initiative has viable opportunities for near- as well as long-term future. Additionally is its compatibility with the electrification and the positive contribution to the energy transition.

In practical terms, H2fuel should be compared with other energy carriers (in the form of hydrogen) and hydrogen in its gaseous form. In the Netherlands, several institutes are exploring the possibilities of using formic acid and ammonia for storing hydrogen at atmospheric conditions. When the radius is concerned for usage in cars, these technologies are able to cover between 300 and 350 km on a single 60 l tank. These numbers also hold for storage of gaseous hydrogen at 700 bar in a 60 l tank. For the same tank capacity, the H2Fuel is able to achieve a radius of 600 to 700 km.

PRODUCTS AND QUANTIFICATION

The main objective of the production plant itself is to provide the offtake market with the desired hydrogen that is stored in the $NaBH_2$. To make the price levels of the end product viable compared to fossil alternatives, the process is aimed at recycling the spent fuel that is returned after use. This holds that the import of new feedstock, which is also $NaBH_2$ in the considered case, is being held at a minimum. For the import of the feedstock, $NaBH_2$, 20-foot containers are used that are transported from China and have a capacity of approximately 21 tons of feedstock. The remaining products that are needed for the production are energy, hydrochloric acid and sodium hydroxide. For quantification and specifics, reference is made to the process scheme in figure 2.

The processes that take place at the plant can be substantiated in three main groups; internal synthesis, external synthesis and the reaction of sodium boron into hydrogen. In which the reaction is designed to produce the needed hydrogen for the internal- and external synthesis. Next, the internal synthesis is aimed at producing $NaBH_2$ for use in the facility itself whereas the external synthesis produces the $NaBH_2$ for sales to the market.

Parallel to the main process that is described in the previous paragraph, the activator is also produced at the site. Specifics are, however, not mentioned in the descriptive documents of H2Fuel. The only thing that is mentioned is that the activator used in a mobile form is diluted hydrochloric acid and in a static configuration a catalyst will provide the desired effect. Additionally, a small percentage of sodium hydroxide is added to the end product to guarantee stability.

The activator and the produced $NaBH_2$ (solid) will be the products that are supplied to the gas station. At the station, a local clarification step will provide the UPW that is needed to create a pumpable slurry which can be supplied to the vehicle. In the process, oxygen is the side product that is generated through the reaction. This means that the opportunity must be pursued to supply this to the market.

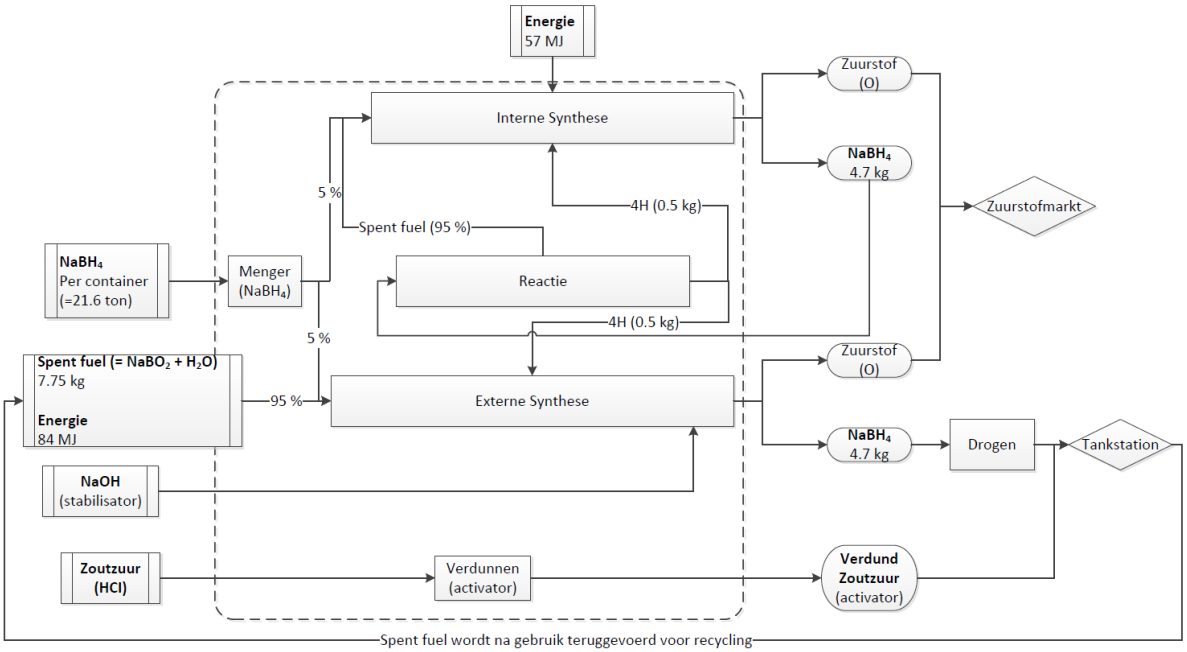


Figure 5.3: The process scheme of the H2Fuel production plant

SAFETY

Due to the different nature at which the product is stored compared to its fossil counterparts or even pressurised hydrogen, different safety regimes are applicable. The main safety hazards that are related to the $NaBH_2$, are concerning possible contact with water and the resulting flammable gasses that are produced in this reaction. When this requirement is met, the product is rather stable and is easier to handle when safety is concerned.

With respect to the industrial activities that currently take place in the HIC, the production of H2Fuel has no significant risks concerning safety. As long as the storage and treatment are handled in a correct manner, the activity will fit into the current destination plans in the PoR.

On the user side of the spectrum, the safety of using $NaBH_2$ scores significantly better than other forms that need either pressurisation or extreme cooling. This is the main risk that has been identified, and in fact raising resistance by the public opinion, when the gaseous variant of hydrogen is considered.

EMISSIONS

The two main reactions that take place during the production process only have oxygen as a side product which is preferably transported to another customer. On the other hand, energy is needed to make sure the reactions are taking place. In the report that is made public by H2Fuel, they claim that for the sake of emissions as well as financial, the assumptions is made that the energy supply will result from an internal produced sustainable form of energy (e.g. wind and solar) and if needed will be connected to another circuit which produces energy from the synthesis reaction.

On the user side, the reaction that is taking place is highly similar to the reaction on the production side. As the output of this reaction, the emissions are mainly oxygen and water and H2Fuel concluded that no toxic emissions or residues are involved. This is mainly due to the recycling step that is included in the system which uses the spent fuel and enables an upgrade to be used as H2Fuel again.

5.4. RESULTS & REVIEW

As described in the previous section, the goal of the workshop is to gain a deeper understanding of the relative importance of the various requirements have in the decision-making process of allocation. By means of two cases followed by an individual assessment and central discussion, the participating experts were able to substantiate the importance and provide new insights to the implementation of their specialisation.

The individual assessment provided a clarification on both the priority of requirements for the considered cases as well as the identification of the requirement character by assigning it as a 'must have', 'nice to have' or 'irrelevant'. Of course, it is interesting to evaluate these individual rankings and assigned character, of which an averaged result per case is presented in figure 5.4a and 5.4b, for the sake of creating a general overview, however, it is of higher importance to look at the substantiation which resulted in the given scores.

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant
Wet & Regelgeving	1	✓		
Connectiviteit	2	✓		
Fysieke aspecten	2	✓		
Synergie	4		✓	
Sociopolitiek	5		✓	
Dienstverlening	6		✓	
Kennis & ervaring	7		✓	

(a) Averaged results case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant
Wet & Regelgeving	1	✓		
Sociopolitiek	2	✓		
Connectiviteit	3	✓		
Fysieke aspecten	4		✓	
Synergie	5		✓	
Kennis & ervaring	6		✓	
Dienstverlening	7		✓	

(b) Averaged results case 2

In the discussion, during the workshop, interesting statements are being made by the participants. One of the most general conclusions was related to the decisive character of the requirements in which it was concluded that 'irrelevant' is of non-existence in the allocation process. In general, the input of the experts is experienced to be very useful. This means that every requirement has its relative importance in the allocation process.

Although very interesting, this section will not focus on the individual results nor the scores of the respective cases. The aim of this section will be to identify the foundation on which priorities are being assigned. This means that the additional remarks and central discussion will be the main source for the evaluation of the results. Additionally, by the identification of the key aspects leading to the priority, it is possible to reflect the results in other cases.

For a full elaboration of the participants, cases and individual assessments, reference is made to Appendix E.

During the evaluation of the results, it became evident that the priority of the requirements is based on three key aspects:

- Perspective of the stakeholder
- Complexity of the considered case
- Degree of uncertainty in the considered case

These key findings will be treated in the following paragraphs of this section to substantiate the reasoning behind the priority of the different requirements.

5.4.1. IMPORTANCE OF THE DIFFERENT ALLOCATION REQUIREMENTS

During the workshop the experts, identified each of the requirements with a priority relative to the treated case study. This section will give an overview of the main findings accompanied by a general conclusion and from which stakeholder perspective the requirement is of importance. This will be done by treating each of the identified themes respectively.

CONNECTIVITY

Connectivity is identified by the participants as being of crucial importance. The connectivity is seen as one of the main aspects a port has to offer and production cannot take place without connectivity to supply- and off-take markets. The availability of connective networks has a high correlation with the viability of the business case, where distance and quantity are the main determinants for the modality of choice. Connectivity and accessibility have their importance for both the region as a whole as well as the activities taking place in the HIC. At the same time, a clear substantiation is made between the port system and the remaining hinterland. Where the HIC has been developed (e.g. infrastructures but also laws and regulation) to facilitate optimal connectivity, in the hinterland, it might prove to be a bottleneck. In practical terms, the connectivity in the port system is interpreted as being the enabler of synergy among activities.

Conclusion: Connectivity is of vital importance as a basic requirement. When more dedicated forms of connectivity are considered, the tendency is that the requirement has a 'nice to have' character to create advantages for the business case. Although the main priority is on behalf of the clients, from a regional perspective society will be dedicated to keeping the negative effects of connections to the hinterland to a minimal.

KNOWLEDGE & EXPERIENCE

There is no question that knowledge and experience are essential in order to develop a certain industry. The priority, however, turned out to be on the lower end of the spectrum. The main reasoning behind this is the fact that knowledge is being acknowledged to be "footloose", especially when taking globalisation into account. The main priority is on behalf of the overall industrial knowledge and experience that must be present, whereas specialised knowledge can be obtained from elsewhere. This is of course under the assumption that the knowledge is developed somewhere in the world. From experience of the participants, the cooperation with specialised institutes (for instance DCMR) have proven of great value in the later phases of allocation process.

Conclusion: It is evident that the availability of knowledge and experience is vital for the business exploitation. In this respect, knowledge is seen as being independent on location or region whereas developed experience and institutions are dependent on the region of consideration. In the end, the importance is on behalf of the client but at the same time society will benefit from a good balance between available- and required skill.

LAW & REGULATION

Meeting the standards are identified as the most crucial requirement during the workshop. Exceeding the set limitations means that an industry will not be able to execute its activity. When an industrial activity is considered, primarily the attention is drawn by the use and transport of hazardous substances. Although the safety and emission contours in the HIC are developed with a dedication to the heavy industry, the main hurdles arise when transport is stretching outside the industrial perimeter. If society is affected, the importance and influence of this stakeholder increase significantly. From the societal perspective, the industrially related nuisance that is experienced by smell should not be underestimated. On the other hand, when looking to the future, it is being acknowledged that the development of new industries will be accompanied by the development of according laws and regulation. Though, due to the strict character of the set limits, laws and regulation are difficult to assess properly if the exact quantification and process details are lacking.

Conclusion: Law and regulation are identified as a crucial requirement as there is no mediation; it is either possible or not. At the same time, it affects all stakeholders in one way or another. This leads to the situation that a high attention to detail is pursued with respect to the laws and regulation resulting in difficulties when future activities are being evaluated with a high degree of uncertainty.

SERVICES

With respect to services, the financial and administrative services are considered to be less dependent on the activity that is performed and is widely present in a region that has an extensive business climate. It is therefore that the priority that has been assigned is quite low. On the other hand, the physical services (such as maintenance) are dependent on the activity, but since the service companies are acting in an open market, the expectation is that if specialised services are required, the market will seize the opportunities that arise.

Conclusion: Services are well arranged and widely available in a region such as the PoR. Crucial services are expected to be developed accordingly as they are required by the industries. In this respect, differentiation is especially among separate regions and therefore the priority of the requirement is mainly on behalf of the client.

PHYSICAL ASPECTS

The physical aspects form the foundation of allocation where no terrain means no allocation. The physical aspects are in close relation to law, regulations and sociopolitical requirements as the physical location of an industry determine to a large extent the degree of the nuisance that can be experienced by its surrounding. The physical aspects cannot be seen as a requirement on its own since the other requirements will act as a filter to which the best match between terrain and activity is to be made. In this respect, it can be seen as a resultant. Depending on the scale of the industry and the dependency on connective networks, cositing can provide the client with an advantageous situation to utilise the available resources to an optimum.

Conclusion: The physical aspects are the backbone of the allocation process and show high interaction with the other requirements. Due to the scarcity of available terrains, the physical aspects are a complex undertaking which results in the relatively high priority that has been assigned. Additionally, the location and properties affect all of the stakeholders in one way or another, underlining the importance of the requirement.

SOCIOPOLITICAL

The sociopolitical effects have been identified by the experts as the license to operate. In this respect it is a 'must have' requirement. Though the sociopolitical requirements have a subjective character. To manage the societal effects properly, it is of crucial importance that the public message is communicated in a correct manner and the process is clearly defined and well structured. The perception of stakeholders and the current relation with the society of the area should not be underestimated during the process, especially due to the increasing importance and influence of the requirement. To enhance a smooth process, staying within the set limits and obeying the set regulations provide a decent foundation for the creation of acceptance.

Conclusion: Without the needed support, sociopolitical effects have the capacity to be a showstopper and therefore affect all stakeholders. However, due to the experience with managing the surrounding, these effects can, in general, be managed correctly and will at most be able to set alterations in the process. To maintain a good relationship with the societal stakeholders, it is well worthwhile to evaluate an initiative before entering the concrete stages of the process, to prevent unnecessary fierce discussions. Though increasing in importance, the ability to manage the societal requirements result in a relatively moderate importance.

SYNERGY

The importance of synergy is mainly seen from the perspective of the client. In the overall process it is assigned as a 'nice to have' which results in potential positive effects for the client on its business case and, due to the increased efficiency, positively contributes to the transition to a sustainable HIC. Synergy is seen as a resultant of connectivity and development of clusters. Therefore a high correlation with the connective- and physical requirements can be observed. Synergy has the capacity to be an enabler of opportunities and by means of strategic cooperation provide a risk reduction for the client.

Conclusion: The highest importance is at the client's side, but at the same time synergy is able to enhance the strategic goals of the PoR authority and increase the efficiency of the cluster as a whole. With respect to optimisation of the available terrains and possible activities, the degree of synergy opportunities provides a good indication to which extent an industry is in line with the current activities. The overall importance of synergy is assigned to be moderate as it is seen as a 'nice to have' rather than being a decisive element in the decision process.

5.4.2. PERSPECTIVE ON PRIORITY

As can be observed in the previous paragraphs, the perspective from which the requirements are assigned with importance varies among the different requirements. As there will always be a variety of stakeholders, which all have there own interest, it is unavoidable that differentiation will be present in alignment and priority.

During the workshop, the participants stressed that the perspective from which the assessment is being made can lead to completely different results. This also underlined the importance that all the involved experts were present at the workshop to represent the various stakeholders. In this way, the relative importance of the different stakeholders could be translated to the priority in the overall process.

The different perspectives give a good indication of the alignment among the various stakeholders. In general, the priority increases when either the interests are well aligned and a common goal is being pursued (opportunity) or when stakeholders have completely opposing interest (potential showstopper). Due to the increasing importance of the societal stakeholders, alignment of the interests and managing the expectations are becoming a decisive element for successful allocation.

5.4.3. ROLE OF THE PoR AUTHORITY

For the PoR authority, the difference in perspective is well illustrated by the role the organisation takes upon itself in the process. Although it is the goal of the PoR authority to strive for the best overall result, it cannot be denied that the port authority has its own direct interests and is a stakeholder in the process.

The direct interest mainly concerns the requirements that affect the (contemporary) core business of the organisation; as described in section 2.4.2. In this respect, the PoR authority has an active participating role and requirements concerning connectivity and physical aspects have a high priority.

When an indirect interest is applicable, the PoR authority takes an advisory role in the process. This is mainly because the organisation acknowledges the fact that requirements concerning law, regulation, synergy and sociopolitical do contribute to the HIC as a whole and its competitive positioning, but the PoR authority has no direct influence on the outcome and effects of these aspects. At the same time, specialised departments are present in the organisation which are enhancing the overall result and guiding towards the strategic goals by means of an advisory role.

As observed in during the workshop, requirements concerning services, knowledge and experience, are on behalf of the respective markets. As an organisation, the PoR authority has little direct influence on the development in these markets and therefore has a guiding role in this respect. Although this role has a more passive nature, by means of collaboration with institutes, initiation of strategic partnerships and dedicated communication of strategic goals, it strives to provide the market with guidelines towards a perspective that enhances the HIC and its stakeholders.

5.4.4. ENABLING- VERSUS ESSENTIAL ALLOCATION REQUIREMENTS

In the previous section, it has been identified that the stakeholder perspective is an important aspect which affects the importance of the different requirements. Next to this distinction, a more subjective division of requirements can be made between enabling- and essential requirements. As evident from the elaboration of importance for each of the requirements, some are more factual than others. Meaning that the factual requirements have to be met anyways and mediation is limited, whereas the other requirements have an enabling approach to create added value.

Essentials:	**Enablers:**
Synergy	Connectivity
Knowledge & experience	Law & regulation
Sociopolitics	Physical aspects
Services	

As stated earlier, this distinction is indefinite due to the fact that an enabling character may change in time due to changes in priority or differences in considered industries. During the workshop, however, it did become evident that the approach to the different characterised requirements by the experts is significantly different.

ESSENTIAL ALLOCATION REQUIREMENTS

The essential requirements have a 'must have' character where it is either possible or not. There is generally no real mediation. Although nuances can be made in different alternatives of the requirements, the basics have to be met anyways. In general, this results in a relatively high importance. The main differentiation among these requirements is the difficulty to obtain the desired result. If this is expected to be highly complex, the priority of the requirement will be higher. On the other hand, it is industry specific to which degree the requirement is relevant. As illustrated by the example of minimum needed draught needed for incoming biomass, this is a requirement that has to be met in order to allocate the industry. However, when the PoR is considered, the typical draught for biomass transhipment is not a limiting factor and thus results in a low priority.

In general, the essential requirements are based on guidelines, laws and regulation and therefore not open to a large degree of creative interpretation. For elaboration, the majority of the involved aspects are quantified and directly compared with the reigning limitations. In this way, a clear answer can be formulated whether the requirement can be met. When the requirement can be fulfilled by just a select number of terrains in the area, complexity of the requirements increases and so will its importance.

ENABLING ALLOCATION REQUIREMENTS

Enabling requirements are the foundation of the added value that allocation in the PoR has over other regions which are also able to meet the essential requirements. In fact, this is the main motivation for the pursued optimisation between what the terrains have to offer and what is required by the industries to exploit their business. The increasing scarcity of available terrains enables the PoR authority to look beyond the essential requirements seek for the best possible match between terrain and activity to maximise the utilisation of terrain characteristics based on added value.

Contrary to the essentials, enabling requirements can be approached with more creativity as they are open to interpretation. The leading motivation to realise the enabling requirements are the goals that are being set by the different stakeholders. The higher the level of ambition these goals incorporate, the higher the importance of the enabling requirements will be (potentially becoming essential). For industries that are developed to contribute to the energy transition, technologies are often immature and business cases tight. For these industries, the added value of the enabling requirements can be the decisive element to allocate in a particular region.

CONCLUSIONS

Although it is difficult to compare requirements that have a different character, the distinction clarifies the reasoning on which they are being prioritised. The key findings in this respect are the degree of relevance of the requirement and the complexity of the implementation with respect of to the industry. The relevance of a requirement is in fact the degree of limitation the requirement faces across the HIC. The relevance has high correlation with the character of the requirements based on the degree of generics. If a requirement is highly specific across the HIC, the requirement is most likely assigned to be of great importance.

In accordance with the relevance of the requirements, the degree of complexity also gives a good indication on the priority. The workshop has proven that the experts assess the requirements with a high priority when the challenge ahead is identified as complex. In fact, it are the requirements facing a complex procedure that are assigned to be potential shows stoppers. It is therefore evident that these are the requirements with a high priority.

5.4.5. RELATION BETWEEN SOFT- AND HARD ALLOCATION REQUIREMENTS

Besides looking at the enabling- and essential character of the requirements, it is also well worthwhile looking into the distinction between soft- and hard requirements. As being described in the review of the area characteristics in section 4.4, the soft- and hard requirements show high internal correlation. As with the previous subdivision, comparing the two groups to each other is difficult if objectivity is pursued.

Soft requirements:	**Hard requirements:**
Knowledge & experience	Connectivity
Sociopolitics	Law & regulation
	Physical aspects
	Services
	Synergy

The hard requirements are all about functions, tasks or activities that have a clearly defined in- and output, usually by means of quantification. The soft requirements follow a more qualitative nature in this respect. For the latter, the requirements are harder to formulate objectively and the degree of fulfilment is difficult to measure (Glen, 2014).

Though during the last decade, several methodologies have evolved that are aiming at quantifying (for instance by monetising) the qualitative aspects to be compared and even incorporated into the business case, this field of expertise is still rather subjective. The subjectivity is emphasised by the great variety of different methodologies that are used to quantify and compare the soft aspects of a project (Johanisova *et al.*, 2013).

During the workshop, it was interesting to the see the different approaches to the two forms of requirements that are identified. As departments in the PoR authority are specialised in the different themes, the experts feel participants feel comfortable with the ability to fulfil the soft requirements, as long as the familiarity and experience have been developed for the considered industry. When this is indeed the case, the tendency is that the focus (and thus the assigned priority) is shifting towards the hard requirements, in quantified targets must be met in order to be fulfilled.

The opposite is also true. When the considered case is relatively unfamiliar to the represented stakeholders, one generally primarily wants to generate the intangible requirements before setting any quantified requirements. The familiarity with the considered case finds its origin at the level of abstraction and the degree to which an activity is currently being present in the HIC. In fact, from the discussions during the workshop, it can be concluded that the level of abstraction and the resulting uncertainty of the considered case strongly influences the relative importance of the soft- and hard requirements.

The cases that were evaluated in the workshop illustrated this tendency. Where the first case (biorefinery) provided an activity from which comparable industries are already allocated in the HIC, the participants rated relatively high importance for the hard requirements. The opposite was experienced in the discussion about the second case (synthetic energy carrier) in which the case was considered having a high degree of uncertainty and difficult to compare with current activities in the PoR. By evaluating this case, it is observed that the relative overall importance increased for the soft requirements as tangible quantification of hard requirements were hard to formulate.

By assessing the relation between soft- and hard requirements, it became clear that the level of uncertainty is one of the indicators for the relative importance of the two identified forms of requirements. In practical terms, this means that when the importance of requirements is being evaluated for long-term future developments and/or radical new initiatives, the hard requirements will be complex to formulate and thus the resulting higher importance of the soft requirements accompanied by a more subjective discussion.

6

CASE STUDY

To validate the process and conclusions that have been drawn up in the previous chapters of the research, the REDEFINERY initiative is treated as a case study. Since the initiative has already been used during the workshop and an elaboration can be found in section 5.3.1 and appendix F.2, the introduction in this chapter will mainly consist of a wrap-up of the most relevant information. It should be noted that due to the confidentiality of the obtained parameters, the presented quantification during the workshop focused on the general aspects and are not the exact parameters. Additionally, the name REDEFINERY has been replaced by biorefinery in the presented factsheets.

The initiative is a blueprint that is aiming at producing building blocks for sequential production processes (chemicals, fuels and additives for asphalt production). It should not be confused with a biofuel/chemical production site itself, but the processes that take place involve the preparation of the feedstock by converting and separating the useful components of the biomass into base products for further production. The refinery process is founded on the use of woody biomass as feedstock (in chunks, chips of pelletised form) to produce lignin, C5- and C6 sugars. These products will then be transported to the next production steps to produce the final products (Cordfunke, 2018).

The initial focus of the process is the production of the C5/C6 sugars as a building block for fuels and chemicals respectively. The lignin is providing REDEFINERY with an opportunity if a cost-effective steam supply is possible to the site. When this is indeed the case, the lignin can be isolated and used in the asphalt industry as bitumen instead of using it for the sake of steam production.

In the sequential sections, the aim of the case study is to act as a showcase to evaluate the triangular approach that is based on chapters 3, 4 and 5. By means of these evaluations, a substantiation will be made on the identified aspects that result into the demand, supply and priority of the involved requirements. It is on behalf of these evaluations, that conclusions are to be drawn whether the match between the REDEFINERY initiative and the resources the PoR has to offer is contributing to the set strategic goals.

As the foundation for the performed evaluation, the information and conclusions will be based on the interview with its project manager (appendix F.2), discussion with experts during the workshop (appendix E) and the obtained information relative to the initiative (BiobasedDelta, 2015).

6.1. TRIANGULAR APPROACH

The triangular approach aims to give an evaluation prior to entering the project phases where the client is involved. By identifying the main aspects, the approach is able to present a preliminary substantiation on the match between the PoR's resources and the demanded requirements to exploit the technology. Additionally, the expected most crucial bottlenecks and opportunities will be identified in section 6.3 to determine the necessary expertise during the project phases. By making such an evaluation for REDEFINERY, the initiative can be compared to other potential industries and tested based on its contribution to the overall strategy.

6.1.1. STAKEHOLDER EVALUATION

By evaluation of the stakeholders, a deeper insight is created on the perspective and alignment of the involved stakeholders. Especially the reasoning behind the position towards the industry provides a clear foundation for where hurdles can be expected and solutions need to be pursued.

PERSPECTIVE AND ALIGNMENT

When the use of biomass as feedstock is considered, one of the main aspects is the public discussion on the sustainability of the process. Especially the food versus fuel and the land use that is related to the production of biomass is a hot topic in this respect. For the REDEFINERY case, the food for fuel debate is not relevant since woody residues are being used. On the other hand, with the land use aspect and the shipping of feedstock across the globe, resistance in the form of public opinion and a critical approach by politics is in the line of expectation.

Additionally, it has been proven from experience that biobased production processes involve nuisance in the form of smell. If the terrain allocation leads to the hindrance of smell to the surrounding areas, mitigation measures will need to be made in order to gain the necessary support.

Besides nuisance, the allocation of REDEFINERY will also positively attribute to the employment of the region as a whole. The fact that the needed expertise is very much in line with the developed industrial experience, a good match between the skill level and the required knowledge of the labour market is expected.

When looking into the alignment of goals between the PoR authority and the REDEFINERY initiative, the goals are quite different. Whereas the port authority is looking at the contribution of the initiative as a whole and optimal utilisation of the available resources, the client will tend to focus on its own core business and the directly related industries in its supply chain. As the REDEFINERY initiative is aiming for Public Private Partnership, involving both organisational entities as well as partnerships between the links in the supply chain, the initiative is reliant on the clusterisation and synergy aspects. For the PoR authority these aspects are important factors that are being identified to enhance the HIC as a whole. At first sight, it can, therefore, be concluded that the alignment of goals between the initiative and the port authority are well aligned.

INFLUENCE

Inherent to the participatory partnership approach (as depicted in figure 6.1), is the increasing influence of all the involved partners. Whereas the core process is mainly on behalf of the client, several areas of interaction with participating stakeholders can be identified. By using this approach, the necessary support and corporation agreements with clients are being created in an early stage of the allocation process. This means that expectations can be managed and aligned prior to the exploitation reducing the risks and at the same time emphasises the crucial importance to the creation of the partnership.

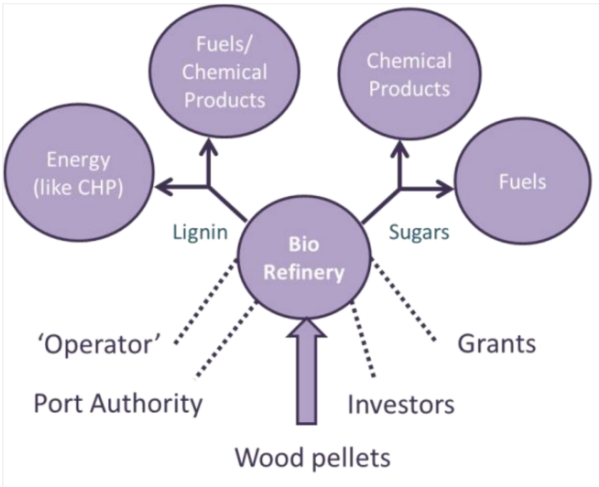


Figure 6.1: Structure of the REDEFINERY consortium

One of the most important stakeholders with respect to the influence in the process are the complementary industries that are on the offtake side. As industries are still limited in the use of biobased building blocks, a high reliance on just several potential customers will be expected. These customers will play a decisive role in the success of the REDEFINERY initiative and therefore its influence should not be underestimated.

On the other hand, by realising the participation, the influence of the various involved stakeholders can be used for the benefit of the consortium instead of opposing the project. By seizing common goals and benefit from each others experience, the influence, especially the influence that has a negative impact, can be managed properly.

FAMILIARITY WITH THE ACTIVITY

For the involved stakeholders, the familiarity with the considered industry has a significant impact on the interpretation and management of the various stakeholders. With respect to REDEFINERY, production processes based on biomass already take place in the HIC. Although not completely comparable, the initiative can be seen as a technological step forward compared to current production. The involved processes, based on emissions, safety, nuisance, product flows etc., is comparable to the currently allocated processes.

The familiarity with the process means that the involved stakeholders have a clear picture of how the process looks like. In general, this will enhance the ability to communicate, but it also involves that both the positive as well as the negative aspects of the initiative are known. Especially for the general opinion on the true sustainability of biomass (land use and shipping distances), the familiarity with the industry results in an already formed opinion which has to be substantiated constructively and therefore will require an intense management process.

Although the feedstock and product characteristics differ from other industries, familiarity with the industry can also be looked at from a higher level. In essence, a biorefinery is highly comparable with contemporary chemical- and refining industries. This means that the overall familiarity of the region with respect to industrial knowledge will be beneficial for the exploitation of the REDEFINERY initiative.

6.1.2. EVALUATION OF THE ACTIVITY

Prior to being able to evaluate the match between the resources that the PoR has to offer, the industry itself should be evaluated. Especially relevant is the ability of the initiative to contribute to the port system as a whole. By means of such an evaluation, industries can be compared to one another even though the scope of the industry differs.

COMPLEXITY OF THE CASE

Although the opportunities that an initiative is able to offer are very important, the difficulty that is involved to realise the opportunities are a good indication for the potential bottlenecks. In the REDEFINERY case, the technological side of the process is not significantly more complex than contemporary industries. Additionally, the products that are being produced and imported are either known to the HIC or have high relevance to current products.

For the REDEFINERY case, the main complexity is in the ability to scale up to industrial scale and organise the pursued organisational structure. These are the being identified as the main hurdles to take in the near future and will be of crucial importance if an allocation is pursued. In this respect, the complexity of the case is prior to the allocation process itself. Experts acknowledged that if this part of the process can be successfully completed, they feel confident that the allocation procedure will not incorporate too much complexity.

COHERENCE WITH CURRENT INDUSTRIES

For an optimal implementation in the port system as well as a first indication on the connection to the strengths of the system, the coherence with the current industries forms a good first indication. The opportunities in this respect are the enablers of connectivity and synergy. For the REDEFINERY initiative, connective networks are essential in the formation of the business case and can be subdivided into three main categories; import of biomass, supply of products to clients and supply of remaining products.

At the import side, the transhipment of biomass (woody residues) has a high coherence with the transhipment and handling of dry bulk. In this respect, experience has been build and efficient systems can be created in the HIC. With the presence of specialised dry bulk terminals, the opportunity arises to outsource the transhipment related activities. On the other hand though, the handling and storage of biomass do have the risks that are related to the (flammable) dust and the need to be kept in a dry environment during all stages of the process.

At the offtake side, the supply of the produced building blocks to its clients is an essential link in the connective network. As the building blocks are being produced for three different industries, each of them is reliant on a dedicated connection. For the C5 and C6 sugars this means that a connection to the related client has to be made which is present in the HIC. At the same time this forms the main difficulty, though coherent industries are currently present, there are only a limited amount of potential customers resulting in a high reliance. For the produced lignin, this is exactly opposite, the asphalt industry is scattered throughout the country and are therefore outside the port system, but it does have a great variety of potential customers.

In order to facilitate the process, it is necessary for REDEFINERY that the remaining incoming products are well arranged. This is especially important for the supply of steam. In this respect, there are potential suppliers in the current HIC, but the realisation of the connection still requires close attention to determine the viability of the supply and the reliance after the connection has been realised. Besides steam, the refinery is in need of enzymes, ammonia and sulphuric acid. Quantities are relatively small and production is in place within the port system (with exeption of the enzymes for which this is still unknown). In this respect, the connectivity itself should be no major problem, but the safety during transport and storage will need a more detailed study.

In general, the necessary products and related industries are present in the current HIC, but the crucial character of the connective networks together with the limited alternatives of some results in the fact that close attention is crucial.

ADDED VALUE OF THE ACTIVITY

The added value of the activity is related to the value that the allocation of the initiative has in contribution to the region and the set strategic goals. The foundation of this is the economic determinants such as financial flows, employment and related product volumes, but maybe more interesting are the intangible aspects in contribution to the surrounding and the energy transition.

The REDEFINERY initiative is aiming to enhance the transition moving away from fossil feedstock and at the same time enhances reaching the targets that are being set in the biofuel blending mandates concerning the use of 2nd generation biomass. When addressing the fuel market, the prospects in the near future provide a fertile basis, but with respect to the electrification goals, the use of biomass seems a temporary market when the time line is extended. On behalf of the production of biochemicals, the long-term future provides a better opportunity, as biomass is seen as the feedstock of choice for future chemical industries. For the use of lignin in the asphalt industry, the products are really a breakthrough as there are no real alternatives available that are not reliant on fossil feedstock.

With respect to the regional goal of creating a world leading innovative climate, the initiative is a good example of new technologies that are developed at a small scale and exploited in an industrial context. In essence, the initiative is well in line with the set goals and transition towards a more sustainable industry which is beneficial for the region as a whole. But on the other hand, it can be justly asked whether the initiative has the flexibility of the building blocks when future changes to markets arise (and potentially to the value of the product) and the electrification takes shape.

6.1.3. EVALUATION OF THE ALLOCATION REQUIREMENTS

The requirements that have played a central role in the earlier stages of the research, will have to be matched and managed accordingly. All the stakeholders will have their influence on the formulation and implementation, whereas in the final stages of the allocation procedure is mainly between the PoR authority and the client. The following paragraphs are aimed to identify the key aspects of this part of the process and the match between the resources and requirements.

DEGREE OF LIMITATION OF RESOURCES IN THE POR

The requirements are being set in order to allocate the industry in a certain area, it does not mean that this should be of any limitation when the HIC is considered. In relation to the REDEFINERY initiative, the draught that is needed to ship the necessary feedstock (approximately 14 m), is available in all relevant areas of the PoR. The same is inherent for the contours related to emissions and safety. Since the initiative is no exception in terms of these aspects and the PoR has been developed to be able to host heavy industries, no problems are expected. Although these requirements will have to be met anyway, by allocating in the HIC no limitations are present regarding these requirements.

On the other hand, there are also requirements for which the PoR may present limitations that result in bottlenecks. The availability of terrains is such a requirement. With the limited number of available terrains, it might be possible that before assigning a terrain, several activities will be in the race to be allocated. Furthermore, though the safety- and emission contours are relatively large, there are several residential areas nearby the industrial area. Especially based on the interaction with the public and potential nuisance of smell, difficulties are expected when allocated in the neighbourhood of such an area. For the sake of transportation, these contours are also relevant. As not the whole supply chain is present in the HIC, transport movements will stretch beyond the PoR borders and potentially provide limitations.

IDENTIFICATION OF UNCERTAINTIES

Of course, the REDEFINERY initiative is aiming to reduce and distribute the risks by means of a participatory approach, it does not mean that there are no uncertainties. Especially since the consortium is yet to take shape, uncertainties are present with the security of supply to the customers and the supply of steam to the site. As both of the product flows will be reliant on a limited amount of potential clients, the risk of not being able to reach for alternatives when problems arise is significant. Also, the exact locations and quantities of hazardous products transported will determine the extent of the risk that is related to the safety of transport.

Looking more to the viability of the business side of the project, the relatively low quantities in product flows oppose high uncertainty on whether direct connectivity and the investment in a dedicated transhipment facility can be viable. The reliance on cost-effectiveness and maybe even outsourcing provides high uncertainty in the current phase of the project. Combined with the fluctuations in the sugar pricing and the uncertainty on how the market on biobased products will be evolving in the future, one should be aware of the potential difficulties.

ACQUAINTANCE WITH INDUSTRY

Besides the familiarity of the stakeholders with the industry, the acquaintance of the involved regulatory and organisational stakeholders in the allocation process can be of crucial importance. When a thorough understanding of the industry is developed among the different stakeholders, the process will be much more efficient and indications can be made more precise.

In relation to the REDEFINERY case, experience has already been gained with the involved products and subprocesses. Meaning that the responsible experts will know what it takes to be able to facilitate the industry in terms of laws and regulation. The already build up experience will also result in a more efficient procedure and exchange of knowledge. Additionally, it enables the relevant experts to be assigned to the project teams based on the expected hurdles and opportunities.

6.2. FUNCTIONAL CONSIDERATIONS

Based on the above evaluations and the information that is gathered with respect to the activity, an attempt has been made to determine the functional considerations for allocation. Because this is outside the scope of this research, reference is made to appendix G for the elaboration. Additionally, an overview of potential clients on both the supplier- as well as the customer side of the activity is presented in appendix G.

6.3. CONCLUSIONS AND REVIEW

As it is still unclear how the partnership will be formed and which participants will be involved, a functional design is based on a high level of abstraction. In the phase that the initiative is currently situated, it is more relevant to identify the various options. The exact quantification and completion of the design aspects will take shape when decisions are made in the partnership.

6.3.1. KEY OPPORTUNITIES

- Enabling biobased production for multiple products
- Potential cluster formation
- Filling the gap if coal transhipment reduces
- Complementary industries present in the region
- Enabler for further innovation

6.3.2. POTENTIAL BOTTLENECKS

- Fluctuations in sugar price
- Transport of hazardous products
- Steam supply
- Nuisance from smell
- Reliant on limited amount of suppliers and costumers
- Public opinion on biomass
- Reliance on creation of the partnership
- Scaling up yet to be proven

6.3.3. STRATEGIC CONTRIBUTION

- Enhancer to the energy transition
- Stimulates for innovation
- Ability to circular use of products (e.g. use of 'waste' steam)

6.3.4. CONCLUSIONS

The case study is an illustrative example for which exact specification is still lacking. For such a case, it is very well possible to perform an extensive evaluation. The expert opinions from the workshop have proven to be of crucial importance in this respect. Without the import from the various experts, possible bottlenecks and potential opportunities would definitely have been overlooked.

On the other hand, the functional considerations substantiated that a lot of factors are still too abstract to be the foundation for a representative functional design. Although it is valuable to illustrate which options are still open and in particular to identify the potential hurdles to take before realisation takes place.

For the PoR authority the initial focus is to answer the question on which activities to seize in order to seize the opportunities from the energy transition. The evaluation by means of the triangular approach provides a clear insight for the decision makers to base their decision on. By using this approach, an expert judgement is provided prior to the decision itself to provide the decision makers with a complete evaluation of the particular activity and enabling them to compare the initiative to other potential activities.

7

CONCLUSIONS AND RECOMMENDATIONS

Since both the Port of Rotterdam as well as the energy transition have a such a broad field of interest, the main challenge was to narrow the scope of the research to such extent that clear answer could be formulated for the set research questions. The formulation of the questions itself is therefore aimed at guiding the research in a clear pathway to the final conclusions. All the individual subquestions contribute to answering the main question. A visualisation of the structure of the research question, subquestions and the corresponding sections in this report are presented in figure 7.1.

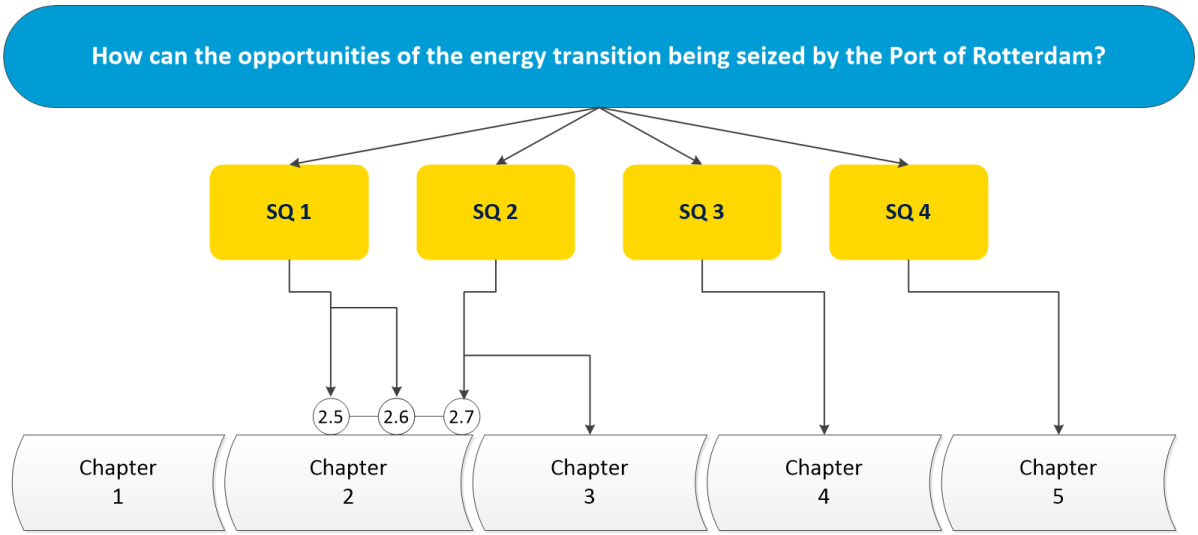


Figure 7.1: Relation among the set subquestions (SQ) and the sections in which they are treated

7.1. CONCLUSIONS

To continue the success of the PoR in the future, a transition to a sustainable industry is essential. Though this is easier said than done. The energy transition involves a variety of initiatives which are at the same time highly dependent on each other. Whilst the increasing scarcity of available area and resources result in the situation that a decision will have to be made. As long as this decision is not made, this leads to high uncertainty on which activities are going to take place in the PoR and at which point in time they are expected.

To support the decision making on which activities to focus on, there is an urgent need for a decision tool at the PoR authority.

In order to develop the decision tool, the research questions have been formulated. Since the conclusions of the research arise from the results of the subsequent subquestions, this structure is also maintained to present the final conclusions. By describing the process and the associated conclusions of the subquestions briefly, it will be clear how the conclusions to the main question are being built up. These descriptions will be followed by the most significant conclusions for the considered subquestion in the form of:

- most significant conclusions for the considered subquestion

For an in-depth substantiation of the results, reference is made to the concluding sections of the respective parts as indicated in figure 7.1.

7.1.1. SUBQUESTION 1

What are the prospects related to the energy transition which could be relevant for the Port of Rotterdam?

The description of the transition as a whole is performed by means of treating the relevant industries for the PoR (production of energy carriers, chemicals and energy) and identifying the challenges ahead. By evaluation of the different sectors, it is evident that in order to successfully achieve a transition, all sectors must be developed accordingly as they are highly interdependent. This emphasises the complexity of the challenge ahead.

To structure and quantify the set targets, the PoR authority commissioned the Wuppertal Institute. In (Samedi *et al.*, 2016), the pathways and extrapolated results are presented for the HiC. The report emphasises the importance of using the current strengths as a foundation for future activities. Nonetheless, many different developments are potentially involved and uncertainties are high. In the end, opportunities arise in all of the presented pathways and the main hurdle is the interdependency among the different technologies. Due to the variety of technologies, the future for spatial use and allocation are exposed to the significant differences and therefore difficult to anticipate.

MAIN CONCLUSION SUBQUESTION 1

- Proper identification of the uncertainties involved in the allocation of a particular activity is key to make a substantiated decision.

To determine the involved aspects of the decision making, the requirements are identified first. Sequential, these requirements are evaluated to identify the main aspects that determine the decision making. This is based on the three different involved points of view in the allocation process: the demand side (activity), the supply side (PoR authority) and the priority of the requirements. As the identification of the requirements and the three points of view form the backbone of the research, a schematic overview of this structure is presented in figure 7.2.

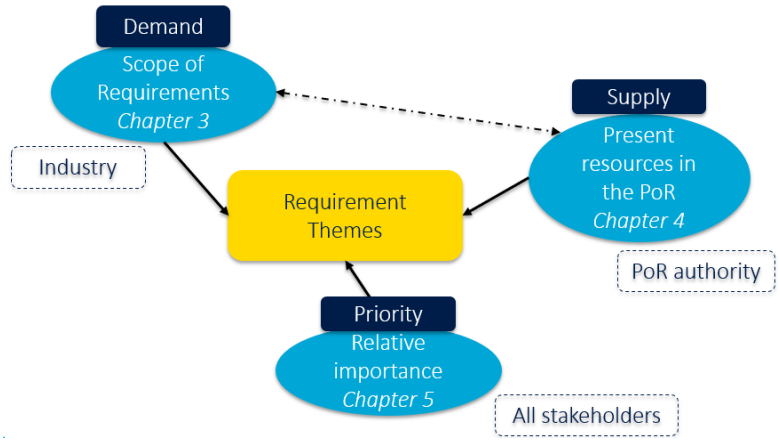


Figure 7.2: Triangular approach to evaluate the requirements based on the demand, supply and priority

7.1.2. SUBQUESTION 2

Which requirement themes are relevant for allocation of activities in the port area?

Although highly important for the port as a whole, the valuation of the PoR is treated as being a result of the various characteristics the area has to offer (Van den Bosch *et al.*, 2011). To evaluate the characteristics, this section elaborates on the strategic value of the PoR. For the determination of this value, the relevant aspects are being approached from either a qualitative or a quantitative perspective.

The determinants of the strategic value can, in fact, be seen as the requirements that are identified by a client to base its decision on when allocation is concerned. Additionally, they form the aspects to which the PoR can be compared to other (port) areas by means of the strategic balance method (Van den Bosch *et al.*, 2011). From the evaluation of the strategic value and its involved determinants, a translation to spatial allocation is made resulting in the main allocation requirements and their respective area of influence (presented in figure 7.3). The seven identified main requirements will form the foundation for the evaluations in latter parts of the research.

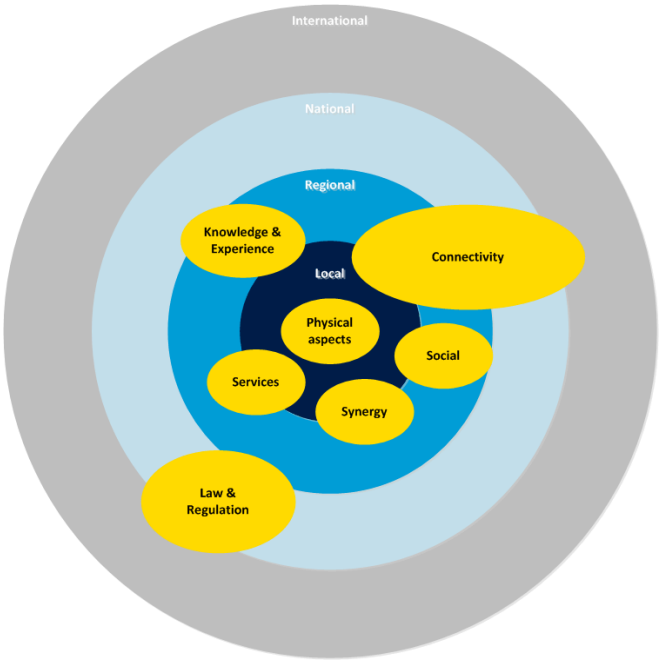


Figure 7.3: Requirements themes and area of influence

MAIN CONCLUSIONS SUBQUESTION 2

- Every activity has its own demands and requirements
- Expression of the requirements in a single unit is impossible

Based on the above conclusions, it is being discouraged to develop a decision tool. The allocation process and the involved requirements are too versatile to be simplified in a single tool. If such a simplification is made, this will result in missing essential opportunities and potential bottlenecks in the sequential project phases.

Instead of pursuing the decision tool, it is investigated whether it is possible to provide the PoR authority with guidelines that support the comparison of different activities. By answering subquestions 3 and 4, the main aspects that must be included in the guidelines are identified.

7.1.3. SUBQUESTION 3

What are the resources available in the Harbour Industrial cluster?

Where the previous mainly considered the demand side of the process and allocation of activities is about balancing the demand and supply, this part is based on the latter. At first, the identified allocation requirements have been evaluated based on their degree of generic character across the different area in the HIC and potential impact on spatial allocation. These characteristics raised a first indication and hypothesis, but are definitely not sufficient as exact characteristics, especially when qualitative aspects are considered.

As a result from the conclusion that the requirements for allocation are highly dependent on the considered industry, a clear system boundary is introduced to identify the character of the allocation requirements relative to the activity.The system boundary involves the production of biofuels. Based on the set system boundary and the substantiated allocation requirements, surveys have been carried out with the responsible Port planning area managers to gain insight into the strengths and weaknesses of the respective areas.

Especially the discussion and additional remarks that were made during the process, have proven to be very interesting and mainly based on this, the survey resulted in the following main findings:

- The perception of the stakeholders plays a very dominant role when the influence and effect of social requirements are considered
- The characteristics evolve parallel to the development of a cluster. This means that taking a bird's eye view, which is looking into the fundamentals of the area, is rather impossible
- A high degree of interaction is being observed in the soft- and hard allocation requirements reciprocally

In accordance with the findings for the previous subquestions, the surveys revealed that the determination of a strength (or weakness) of the resources of a port area is very much dependent on the considered activity. The relative strength of an area can therefore vary from activity to activity.

MAIN ASPECTS FOR THE GUIDELINES RESULTING FROM SUBQUESTION 3

- Coherence of the considered activity with the current activities in the PoR
- Familiarity of the stakeholders with the considered activity
- Degree of limitation imposed by the PoR's resources to the considered activity

7.1.4. SUBQUESTION 4

What is the relative importance of the allocation requirements?

Of course, every identified allocation requirement has its role in the decision-making process, but at the same time, every project has its own crucial aspects. By means of a workshop, the relative importance of the various allocation requirements has been identified through the assessment of two fictional cases. During the workshop, experts whose expertise is in line with one of the requirements were present to give an expert opinion on their subject of concern in the process.

As already acknowledged in earlier sections, the dependency on the system boundary is of too great importance to be able to identify genericity of importance over a set of cases. By using two significantly different cases, the objective of the workshop is to identify the determinants that are causing the allocation requirements to be assigned with a particular importance.

As with the surveys that are performed to map the allocation requirements across the HiC, the central discussion and the additional remarks have proven to be of great use as an addition to the filled out scoring. The following will describe on the determinants that have been identified by the outcome of the workshop.

Due to the variety of stakeholders involved in the process, there will be different perspectives to approach the case at hand. This is embodied by a variety of interests among the stakeholders. Especially the alignment of the interests with respect to the treated requirement has proven to be a crucial determinant when the importance of the different requirements is considered. If either alignment is lacking (potential showstopper) or the interests are in line (opportunity) the tendency is that the requirements gain relative importance.

Since the PoR authority is a stakeholder in the process itself, it became evident during the workshop that the degree of interest and the role the organisation takes upon itself are closely related. The role of a stakeholder in the various parts of the process is closely related to the influence it has on the decision making. Such a differentiation can be made for all involved stakeholders. For the PoR authority, this resulted in the following division of roles that it will play in the process:

Direct interest:	Active participating role
Indirect interest:	Advisory role
Little influence:	Passive or guiding role

As the main objective is to identify the main determinants that are the enablers of the resulting priority, two subdivisions have been made to determine the involved aspects.

Firstly the differentiation is being made into enabling- and essential requirements. This revealed that higher priority is assigned to the essential allocation requirements if either the degree of limitation imposed by PoR's resources is high or the activity shows little relevance to the current activities in the HIC and vice versa.

The second differentiation is based on the distinction between soft- and hard requirements. By means of this distinction, the results from the workshop clearly showed that priority shifts to the soft requirements as the considered activity is more complex. This complexity leads to high uncertainty and leaves the experts to focus more on the qualitative soft requirements.

MAIN ASPECTS FOR THE GUIDELINES RESULTING FROM SUBQUESTION 4

- Perspective and alignment of the stakeholders
- Influence of the respective stakeholders
- Complexity of the considered activity
- Acquaintance of the stakeholders with the new activity

7.1.5. COMMERCIAL STRATEGY OF THE POR AUTHORITY

In addition to the allocation requirements, it is important for the PoR authority to incorporate its communicated strategy into the daily activities. To do so, the commercial strategy has been developed. At first sight, the integration of the commercial strategy is not acknowledged to be a requirement in the allocation process. Though, as the allocation requirements were examined, it turned out that they were not able to cover the important role of the commercial strategy in the decision making. Resulting in the situation that if the PoR authority is really looking to fulfil its climate targets, the commercial strategy should function as a self-contained requirement in the allocation process. The integration of the commercial strategy in the approach results in the extended overview as depicted in figure 7.4

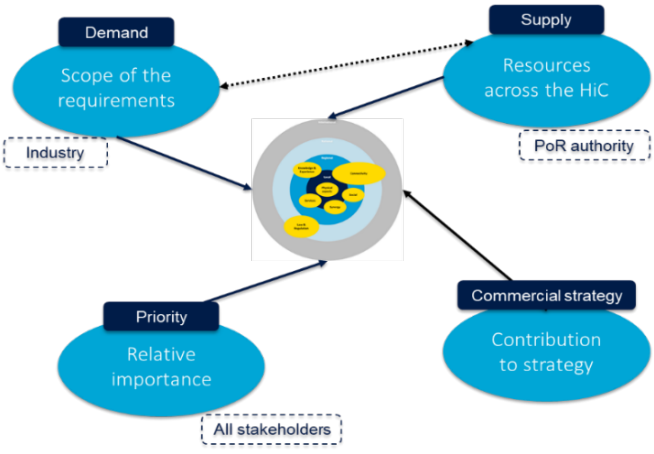


Figure 7.4: Schematic overview of the approach to evaluate the activities

To incorporate the requirements, supplemented with the commercial strategy, in the daily activities, it is essential to bring together the involved experts and share the knowledge that is present throughout the organisation. The latter forms the main hurdle in this respect. The needed knowledge is well present but scattered throughout the organisation in both physical means (different departments) as well as time wise (experts that are involved in different project phases). The workshop has proven that when the knowledge of the relevant experts is compiled, a well-founded judgement of the involved aspects for the allocation of an activity can be made.

MAIN ASPECTS FOR THE GUIDELINES RESULTING FROM INTEGRATING THE COMMERCIAL STRATEGY

- Added value of the activity with respect to the commercial strategy

7.2. RECOMMENDATION

How can the opportunities from the energy transition be seized by the Port of Rotterdam?

To provide an answer to the main question, a recommendation has been formulated for the PoR authority. From the conclusions, the recommendation for the PoR authority is to develop a central team that involves the experts of the respective allocation requirements to judge the potential activities. This team will have the primary task to evaluate and judge the potential activities prior to entering the project phases. The judgement of the potential activities will be founded on four main points of view: demand, supply, priority and contribution to the commercial strategy.

Though, this recommendation is not aimed at making the decision itself. The main focus is to supply the evaluations on the potential activities to the decision makers. The decision itself will be based on the supplied evaluations through which a substantiated consideration can be made on which activities should be allocated in the PoR.

For the evaluations on the activities, the main aspects that must be included have been identified by answering the subquestions. The identified aspects have been assigned to three main themes of evaluation: stakeholder evaluation, evaluation of the activity and evaluation of the allocation requirements. This results in the following overview:

1. Stakeholder evaluation
   - Perspective and alignment of the stakeholders
   - Influence of the respective stakeholders
   - Familiarity of the stakeholders with the considered activity
2. Evaluation of the activity
   - Complexity of the considered activity
   - Coherence of the considered activity with the current activities in the PoR
   - Added value of the activity with respect to the commercial strategy
3. Evaluation of the allocation requirements
   - Degree of limitation imposed by the PoR's resources to the considered activity
   - Identification of uncertainties inherent to the considered activity
   - Acquaintance with the new activity

When the evaluations are made, it is of crucial importance that the focus is being kept to the main determinants as uncertainty ensures that quantification is complex.

The evaluation of the themes makes it possible to identify the optimal alignment between the industry and the PoR's resources, enabling to assign the best terrain for allocation. At the same time, the key opportunities, potential bottlenecks and the contribution of the activity to the energy transition are acknowledged. Despite that the level of detail will differ from activity to activity, the research has proven that by compiling the present knowledge, a representative first judgement can be made.

The implementation of the judgement in the initial phases of the allocation process enables comparison between existing and potential industries no matter sector or time span. The results of the evaluations are meant to realise a consistent judgement of activities. As the evaluations are based on set themes, it leads to a structured judgement. Because of this, a substantiated consideration can be made in the final decision making.

7.3. RECOMMENDATIONS FOR FURTHER RESEARCH

Although this research formulates the guidelines for the judgement of potential activities, the decision on which activities to allocate will still have to be made. For such a decision, the aspects that are part of the judgement will have to be compared and methods need to be developed to be able to do this consistently. To support this decision making, the following topics for further research have been identified:

- Integration of the judgement of potential activities with the current funnel boards.
- Determination of the relative importance between the optimisation of supply and demand compared to the strategic contribution of the activity.
- Developing a methodology that enables to score the strategic contribution of an activity since a simple yes or no is not an answer when the best overall activities are pursued.
- Implementation of best practices and no-go projects in the decision making for allocation of activities as experience with the process will increase over the coming years.
- Identification of added value of an activity for society, as little contact with societal stakeholders will be present in the initial phases of the allocation process, but at the same time, these stakeholders are important in the sequential project phases.

Besides further research in the decision making and underlying methodologies, the examination of the energy transition also revealed research opportunities for the PoR authority. To improve the interpretation throughout the organisation and obtain a unified approach to the energy transition, the following topics require further research:

- Examining the role the PoR is willing to take in the participatory approach that is increasingly used by activities that are part of the energy transition. The shift from the function of the landlord to a participatory stakeholder in partnerships offers opportunities. Though, at the same time, a consistent approach to the role must be developed to manage the expectations of clients towards the role of the PoR authority.
- Developing a comprehensive set of scenario analysis for the main sectors. The initial report of the Wuppertal and their successive report on the transport- and logistics sector provides a good foundation, but the integration of the sector-specific scenarios are of vital importance to create a comprehensive overview of future prospects.

In conclusion, it became clear that not only research with respect to the decision making and the energy transition is needed. The following recommendation for further research focuses on the organisation as a whole and enhances more than only the activities that are relevant for this research:

- Enhancing internal communication, not only during the initial phases of the allocation process but throughout the entire project to seize optimal utilisation of the present knowledge and experience.

A

APPENDIX A - CONTRIBUTORS TO THE RESEARCH

A.1. CONTRIBUTORS FROM THE PoR AUTHORITY

Name	Department	Date
Michel Bresser	Port Planning - Area manager Maasvlakte	9-4 & 16-7-18
Jelle Peddemors	Port Planning - Spatial development analyst	11-4 & 21-8-18
Arjan Hoefnagels	Port Planning - Area manager Waal-Eemhaven	12-7-2018
Peter Vervoorn	Port Planning - Area manager Botlek-Vondelingenplaat	11-7 & 21-8-18
Kees Kleinhout	Port Planning - Area manager Europoort	18-7-2018
Cees Pons	Port Planning - Manager Port Planning	25-7-2018
Stijn Effting	Energy & process industry - Business Manager	5-3-2018
Monique de Moel	Energy & process industry - Business Manager	5-4-2018
Wilco van der Lans	Energy & process industry - Business Manager	21-8-2018
Joris Hurenkamp	Energy & process industry - Business Manager	23-4-2018
Floor Schipper	Containers, Breakbulk & Logistics - Project manager	5-6-2018
Chenny van Est	Port Planning - Designer	14-8-2018
Marlies Langbroek	Strategic Environment Management - Advisor EA	21-8-2018
Alan Dirks	Policiy & Planning - Programme manager	22-8-2018
Sjaak Verburg	Network Planning and Capacity - Advisor	23-8-2018

Table A.1: Overview of the contributors to the research from the PoR authority

A.2. CONTRIBUTORS FROM EXTERNAL COMPANIES

Name	Company	Date
Sjors Gereadts	Goodfuels	7-11-2017
Gabriël Tschin	PlantOne	26-6-2018
Carland Lopez	PlantOne	26-6-2018
Aldert van der Kooij	Biobased Delta	2-8-2018

Table A.2: Overview of the contributors to the research from external companies

B

Appendix B - Overview of production in Harbour Industrial Complex

Figure B.1: Overview Activities PoR

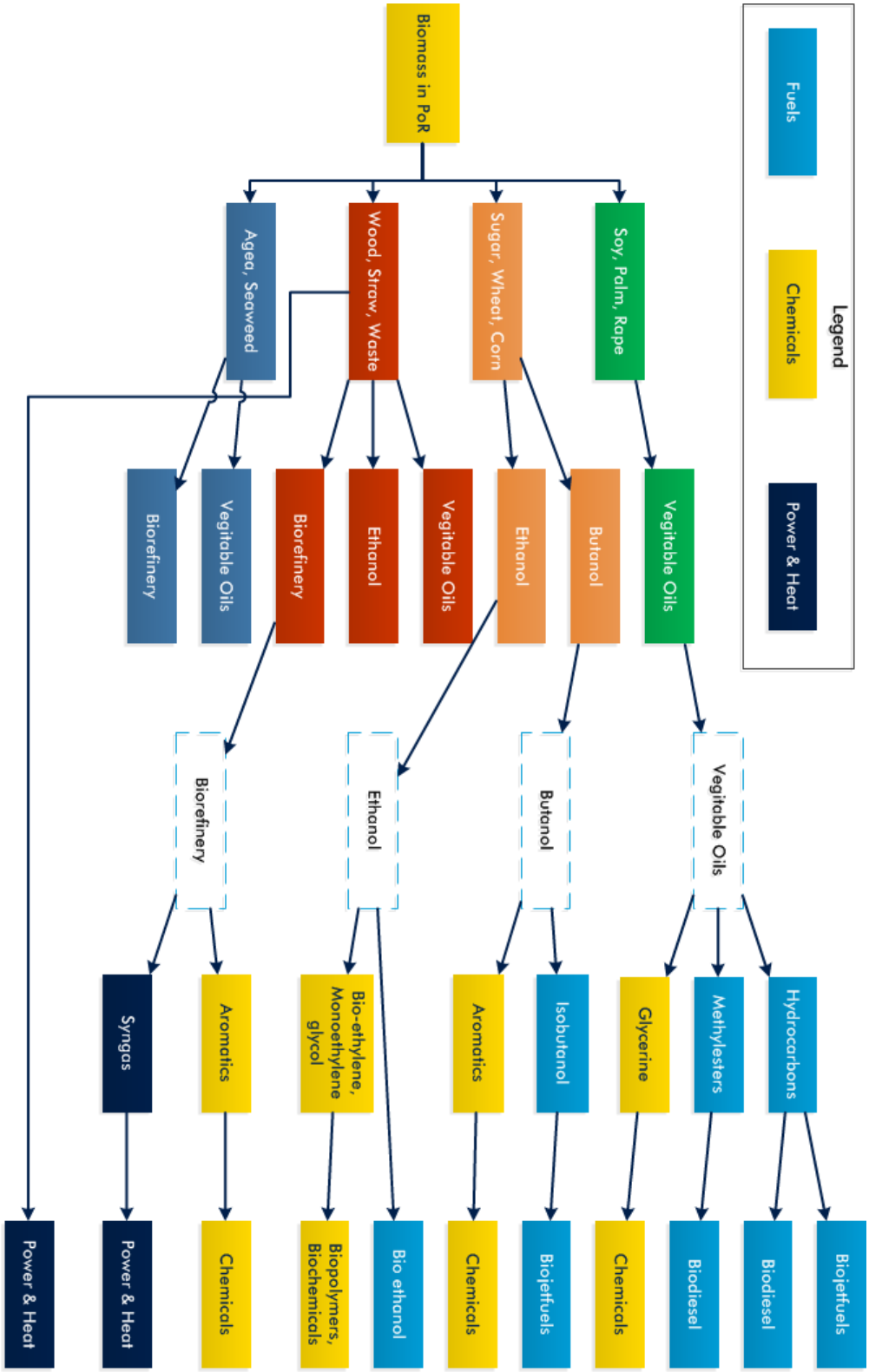


Figure B.2: Value Chain Biobased Industry

C

APPENDIX C - CURRENT BIOBASED FUEL PRODUCTION

C.1. CURRENT BIO-BASED FUEL PRODUCTION

Due to the biofuel mandates, full-scale production facilities for biofuels are already being exploited in the PoR region. Although the relative share of the biofuel production compared to its fossil equivalents is still small (figure 2.10), PoR is currently host to the largest renewable industry cluster in the world (Port of Rotterdam authority, 2017).
The biofuel mandates, as decided on by the Netherlands, differentiates between the blending with 1^{st}- and 2^{nd} generation biofuels. The overall blending percentages in the mandate are presented in table C.1, as part of this overall percentages, in general, it can be said that the share of 1^{st} generation biofuels is decreasing over the years, whereas the share of 2^{nd} generation biofuels is increasing in time. The main reasoning behind this is the debatable sustainability of the 1^{st} generation biofuels (Ghizzardi, 2018), but at the same time, the development of 2^{nd} generation biofuels which is lagging behind. This section will elaborate on the ongoing activities in the PoR region regarding biofuels including pilots and initiatives.

Year	2014	2015	2016	2017	2018	2019	2020
Overall Percentage (% cal)	5.50	6.25	7.00	7.75	8.50	9.25	10.0

Table C.1: Short term bio-fuel mandates the Netherlands (Lieberz and Scott, 2017)

As can be seen in figure C.1, the production from biomass is highly integrated with the production of chemicals and energy. This results in the situation that industries producing biofuel, usually also have other (side) products which can be addressed as chemicals. Classification of the production process (refinery or chemical plant), may therefore deviate from one another in literature.
For PoR the main focus was on the development of a bio-based chemical production site, but due to the lack in policy and incentives, it has proven to be difficult getting the involved companies to lower the risk to such an extent, that it is encountered as bearable and investments can be made. Meaning that the integration presented in figure C.1 is certainly there, but the share between the different presented paths is not equal to each other. The main reason for this it the differences in development between the sectors. For the PoR authority, the main goal in the process is to guide future developments in such a way, that the presented integration can be achieved and to make sure the cluster is able to obtain a leading status in the world of bioindustry (van der Lans, 2016).

Until recently, the upper path in figure C.1 was the main route to take in which vegetable oils form the feedstock for the production of biofuels (1^{st} generation production). Due to the fierce debate on the sustainability of this generation of fuels, stimulation and developments in the exploitation of 2^{nd} generation biofuel plants has picked up the pace and respectable levels of production are reached in the PoR region. The current production of both generations, can be found in table C.2. From this table, it can be seen, that the majority of

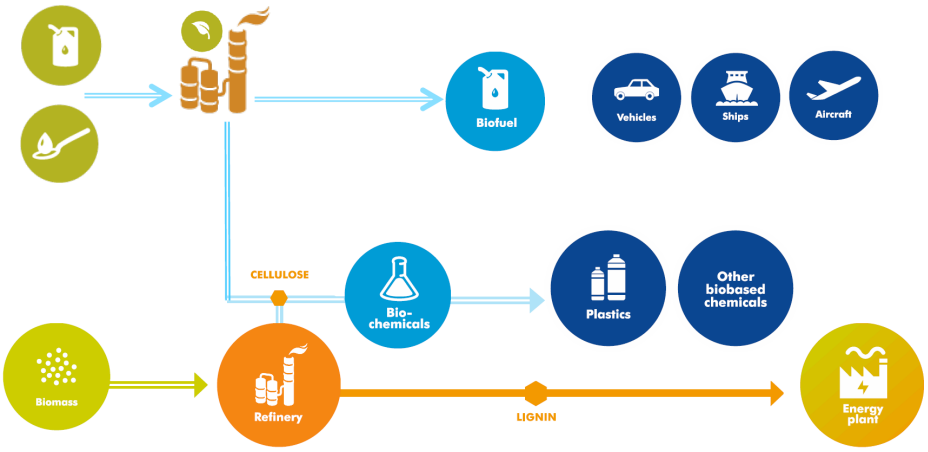


Figure C.1: Overview diagram production opportunities from biomass in PoR (van Klaveren, 2016)

the processes result into multiple products (which can even be assigned to different industrial sectors), but at the same time, a clear dominant business can be distinguished.

Company	**Main Products**	**Capacity [Mt/yr]**	**Generation Biofuel**	**Feedstock**
Biopetrol Rotterdam BV	Biodiesel	400,000	1^{st}	Rapeseed oil
Biopetrol Pernis BV	Biodiesel	250,000	1^{st}	Rapeseed oil
Neste	NEXBTL	1,000,000	2^{nd}	Used vegetable oils/fats
	Bio-LPG	40,000	2^{nd}	Used vegetable oils/fats
Alco Group (Albengoa)	Bio-ethanol	480,000	2^{nd}	Cereals
	DDGS	400,000	-	Cereals
	CO2 (for syngas)	350,000	-	Cereals
Wilmar	Biodiesel	120,000	1^{st}	Palm oil
	Edible Oils	750,000	-	Palm oil

Table C.2: Overview of production capacity of biofuels in PoR, 2016 (Port of Rotterdam Authority, 2016a)

The resources that are used as feedstock for biofuel production, differ a lot between the two generation considered. Besides the fact that 1^{st} generation feedstocks are in competition with food crops, the tendency is that these feedstocks also originate from remote locations (like Brazil and Indonesia) and therefore have to be transported over long distances, affecting the sustainability of the process. Due to the fact that the 2^{nd} generation feedstocks are in general produced more locally (like waste streams or woody biomass), together with the fact that there is little competition with food crops, this is the preferred way of producing biofuels (which also is made clear in the existing policies).

Besides the currently in use biofuel production plants, which are mainly aimed at the road transport, there are also several initiatives and projects ongoing in the PoR concerning biofuels. Two examples of such projects are the Green Corridor and Bioport Holland.

Bioport Holland is an initiative by PoR, KLM, Neste Oil, SkyNRG, Schiphol Group and several governmental departments. The scope of the project is to reduce the GHG emissions in the aviation sector through the use of advanced biofuels. By teaming up, the involved parties are aiming to prove that biofuels offer a sustainable solution for the aviation industry to comply with the reduction targets (Lunter, 2015). The actors collaborated to make optimum use of both knowledge and existing infrastructure to drive the project into a success.

Additional to the aviation sector, the opportunities of biofuels in waterborne transport are exploited simultaneously. The Green Corridor is a collaboration between Heineken, PoR, Goodfuels, Nedcargo and the relating province and municipalities to make the transportation between the Heineken brewery in Zoeterwoude and the PoR more sustainable. To realize this, a 30 % drop-in of advanced biofuels into the contemporary combustion fuel system has to result in a 25 % reduction of GHG emissions. (Heineken, 2017)

D

APPENDIX D - RESULTS SURVEY MAPPING THE CHARACTERISTICS

D.1. INTERVIEW – ARJAN HOEFNAGELS POR

INFORMATION

Date:	12-7-2018
Name:	Arjan Hoefnagels
Company:	Port of Rotterdam
Department:	Port Development - PP
Role:	Gebiedsmanager Waal/Eemhaven area

This interview has been performed for the sake of mapping the characteristics for the Waal/Eemhaven area. These characteristics are evaluated based on the substantiation of themes that has been performed in chapter 2. During the interview, the aim was to fill out the scorecard to identify the relative strength of the evaluated themes.

SCORING OF THE REQUIREMENTS

The scoring is based on the following principle:

Score	Contribution
0	Not available, has to be performed at the site
5	Insufficiently available in quantity and quality
10	Available, though significant investments have to be made
15	Available at reasonable levels of investment
20	Directly available in quantity and quality

Table D.1: Definition of the scores

It must be noted that the scores can be interpreted slightly different when the different themes are treated, but the above table has the purpose to give an indication on how the quantification should be performed.

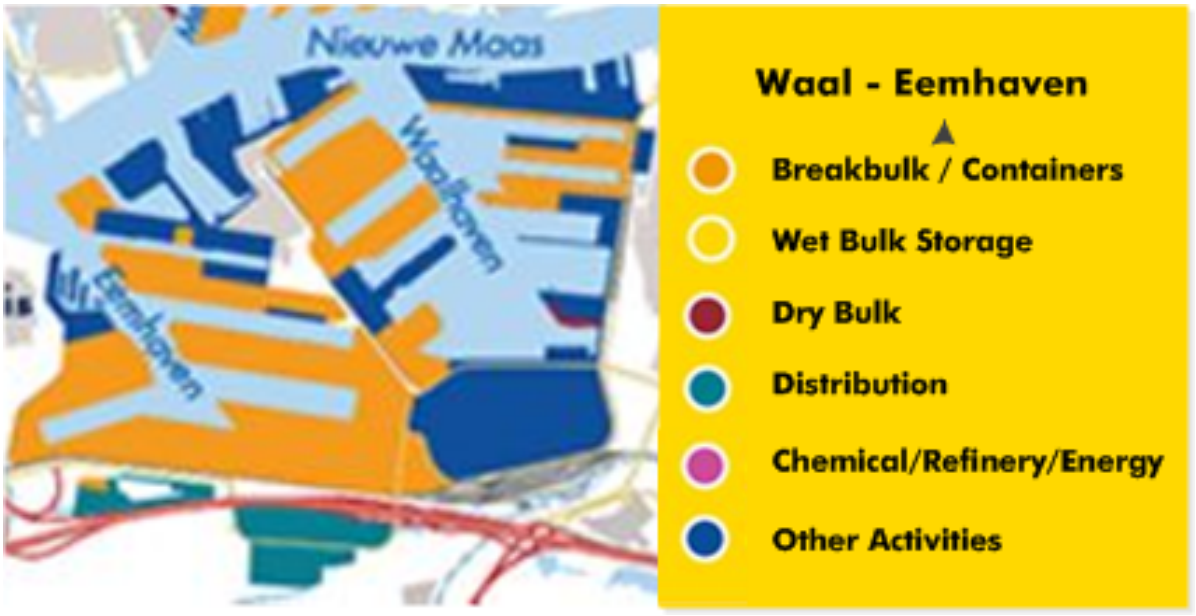


Figure D.1: Overview of the Waal/Eemhaven area (Port of Rotterdam Authority, 2018a)

RESULTS AND CONCLUSIONS

	Requirement	Waal/Eemhaven Score [1-20]	Additional Remarks
Connectivity	Intra-port Connectivity	2,0	Geen leidingen, connectiviteit niet relevant voor biobrandstoffen
	Inter-port Connectivity	15,0	Goede bereikbaarheid multilmodaal, inkomend diepgang beperking
Knowledge & Experience	Relevant Institutions	12,0	Gemiddeld, klein voordeel door aanwezigheid van RDM campus
	Experience of the Industry	0,0	Veel ervaring maar niet voor de relevante industrie
	Skill Level	15,0	Dichtbij werknemers, level is generiek
Law & Regulation	Safety & security	5,0	Veiligheidscontouren niet op zware industrie ingericht
	Emissions	5,0	Emissiecontouren niet op zware industrie ingericht
	Subsidies	10,0	Geen onderscheid HiC
Physical aspects	Needed acres	12,0	Kwaliteit erg goed, weinig vervuiling grond, plots relatief klein (tov kades)
	Access to waterside	15,0	Relatief veel water & kade, kwaliteit kademuren verouderd voor zware activiteit
Services	Physical services	8,0	Veel maritime dienstverlening, geen industriele services
	Administrative services	15,0	Gebied kent veel kantoren die deze activiteiten huisvesten, nabij stad
	Digital services	10,0	Geen onderscheid HiC
Sociopolitical	Public opinion	0,0	Bewoners "no way" richting intensivering van de industrie
	Political arrangement	5,0	Relatief veel weerstand door omliggende bewoonde gebieden
	Interaction with residential areas	5,0	Heel goed verhaal benodigd om initiatief voor elkaar te krijgen
Synergy	Supply chain of the cluster	5,0	Indien anders verbonden dan pijpleiding zijn er mogelijkheden
	Strategic corporations	0,0	Niet aanwezig

Figure D.2: Overview of resulting scores Waal/Eemhaven

The results that are presented in table 2 give an overview of the resources that the Waal/Eemhaven area is able to offer with respect to hosting a biofuel production site. In general, it can be said that the area has developed in such a way that activities that take place in the region, are of a smaller scale and are more transhipment and handling related. To make the shift to heavy industry, as the production of biofuels, the main hurdle will be the situation with respect to the residential areas.

This is posed in two ways. Firstly, the situation with respect to the residences will result into the strict use of law & regulation and at the same time reluctance of stakeholders to shift from current practices towards a heavier industry (and thus difficulties in the political arrangement). On the other hand, the situation with respect to the city of Rotterdam poses the opportunity of a large workforce and together with development at the RDM Campus can provide benefits for an(y) new kind of industry.

In the approach of mapping the characteristics, it is opted not to focus on the industry that is there already but broaden the perspective by looking at the resources essentially has and not the ones that are used by the current practices. In the Waal/Eemhaven area, however, it can be clearly seen that the current activities are

there for a reason. Although the area does not involve high-tech and large-scale industry, the activities that do take place are able to use the resources available and at the same time, stay within the limitations that are posed by the situation of the area.

At first sight, it seems unlikely that the Waal/Eemhaven area is the area of choice when production of biofuels is considered. Besides the hurdles in relation to the situation of the area, also the connectivity and synergy opportunities with (related) businesses in the port area are lacking to provide any competitive advantages for the allocation of a biofuel production site.

D.2. INTERVIEW – PETER VERVOORN POR

INFORMATION

Date:	11-7-2018
Name:	Peter Vervoorn
Company:	Port of Rotterdam
Department:	Port Development - PP
Role:	Gebiedsmanager Botlek/Vondelingenplaat area

This interview has been performed for the sake of mapping the characteristics for the Botlek/ Vondelingenplaat area. These characteristics are evaluated based on the substantiation of themes that has been performed in chapter 2. During the interview, the aim was to fill out the scorecard to identify the relative strength of the evaluated themes.

SCORING OF THE REQUIREMENTS

The scoring is based on the following principle:

Score	Contribution
0	Not available, has to be performed at the site
5	Insufficiently available in quantity and quality
10	Available, though significant investments have to be made
15	Available at reasonable levels of investment
20	Directly available in quantity and quality

Table D.2: Definition of the scores

It must be noted that the scores can be interpreted slightly different when the different themes are treated, but the above table has the purpose to give an indication on how the quantification should be performed.

Figure D.3: Overview of the Waal/Eemhaven area (Port of Rotterdam Authority, 2018a)

RESULTS AND CONCLUSIONS

	Requirement	Botlek/Vondelingenplaat Score [1-20]	Additional Remarks
Connectivity	Intra-port Connectivity	20,0	
	Inter-port Connectivity	20,0	
Knowledge & Experience	Relevant Institutions	15,0	Generic over HiC
	Experience of the Industry	20,0	
	Skill Level	15,0	Aandachtspunt voor de toekomst voldoende nieuwe aanwas
Law & Regulation	Safety & security	15,0	
	Emissions	15,0	
	Subsidies	10,0	Generic over HiC
Physical aspects	Needed acres	5,0	Andere partijen nodig ... van/ is de grond te krijgen / sanering / NGE
	Access to waterside	5,0	Geen ruimte meer
Services	Physical services	20,0	Relatie conneciviteit
	Administrative services	15,0	Generic over HiC
	Digital services	15,0	Generic over HiC
Sociopolitical	Public opinion	10,0	Nabijheid Rozenburg/Pernis en zuidelijke gemeenten -> perceptie (bijv. geur)
	Political arrangement	10,0	Generic over HiC
	Interaction with residential areas	10,0	Acceptatie is er al, men weet niet beter
Synergy	Supply chain of the cluster	20,0	
	Strategic corporations	20,0	

Figure D.4: Overview of resulting scores Botlek/Vondelingenplaat

The results that are presented in table 2 give an overview of the resources that the Botlek/ Vondelingenplaat area is able to offer with respect to hosting a biofuel production site. In essence, it can be concluded that the area is host to highly related industries (especially refinery and chemical production sites) and therefore has a high score based on the opportunities for synergy and connectivity. The drawback that can be identified is related to the situation of the area with respect to the villages of Rozenburg and Pernis that poses its limitations on behalf of the safety and emission contours at the adjacent terrains.

As with the majority of areas in the PoR, the development of a certain/selection of industries that resulted into the formation of the current cluster, go hand in hand with the development of the connective networks and necessary facilities. This also means, especially for the production of biofuels, that the related industry is in place and high opportunities for synergy arise. Besides the physical requirements, the developed industry also incorporates a high level of developed experience and knowledge.

During the interview, Peter identified several themes that are to be generic across the HIC. Especially the availability to regional and national funding in the form of subsidies and the availability of services which are limited in their influence in their situation with respect to the main industry. Of course, these aspects might well vary when allocation is compared to areas outside the port system, within the port system it is unlikely to find much differentiation in this respect.

As a preliminary indication, the Botlek/ Vondelingenplaat area has a high potential for allocating a biofuel production facility. The availability of connectivity, synergy opportunities and knowledge should provide a fertile basis to set up a biofuel site. In the current situation, however, the Botlek/ Vondelingenplaat area is highly occupied and merely has the ability to allocate based on cositing.

D.3. INTERVIEW – MICHEL BRESSER POR

INFORMATION

Date:	16-7-2018
Name:	Michel Bresser
Company:	Port of Rotterdam
Department:	Port Development - PP
Role:	Gebiedsmanager Maasvlakte area

This interview has been performed for the sake of mapping the characteristics for the Maasvlakte area. These characteristics are evaluated based on the substantiation of themes that has been performed in chapter 2. During the interview, the aim was to fill out the scorecard to identify the relative strength of the evaluated themes.

SCORING OF THE REQUIREMENTS

The scoring is based on the following principle:

Score	Contribution
0	Not available, has to be performed at the site
5	Insufficiently available in quantity and quality
10	Available, though significant investments have to be made
15	Available at reasonable levels of investment
20	Directly available in quantity and quality

Table D.3: Definition of the scores

It must be noted that the scores can be interpreted slightly different when the different themes are treated, but the above table has the purpose to give an indication on how the quantification should be performed.

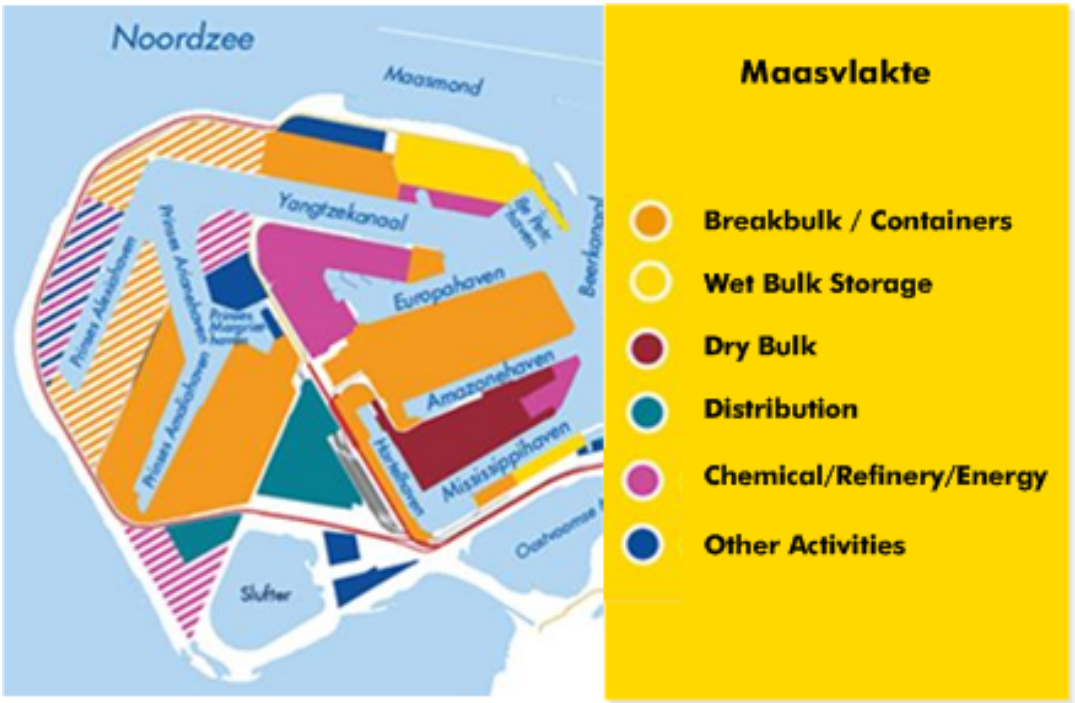


Figure D.5: Overview of the Maasvlakte area (Port of Rotterdam Authority, 2018a)

RESULTS AND CONCLUSIONS

	Requirement	Maasvlakte Score [1-20]	Additional Remarks
Connectivity	Intra-port Connectivity	10,0	Basis goed aanwezig (stoom/stroom/water), specifics vergen investering
	Inter-port Connectivity	8,0	Pijplijn niet aanw, Import via externe terminal, evt oplossing cositing bij EMO
Knowledge & Experience	Relevant Institutions	15,0	Instituten en relevantie goed aanw, industrie werk goed samen met instituten
	Experience of the Industry	20,0	Biobrandstoffen worden reeds geproduceerd, afstand tot andere relevante indu
	Skill Level	15,0	Qualiteit is aanwezig, Quantiteit is lastiger
Law & Regulation	Safety & security	20,0	Meeste fysieke ruimte tot kwetsbare activiteiten
	Emissions	18,0	Budgetten zijn ruim, PM en Nox regio overstijgend
	Subsidies	15,0	Subsidie niet specifiek aan gebied (EU->REDII) herstructurering biedt hier me
Physical aspects	Needed acres	17,0	Veel mogelijkheden en flexibiliteit, opspuiten van terrein wel erg kostbaar
	Access to waterside	20,0	Goede mogelijkheden en specificaties, ontwikkeling naar wensen klant
Services	Physical services	18,0	Goed realiseerbaar, afstanden overbrugbaar (nog niet direct on site aanw.)
	Administrative services	20,0	Minder locatie afhankelijk, uitstekend aanwezig in de regio
	Digital services	20,0	Minder locatie afhankelijk, uitstekend aanwezig in de regio
Sociopolitical	Public opinion	7,0	Westvoorne erg actief, nieuwbouw zorgt voor extra activiteit, mensen nog niet
	Political arrangement	10,0	Locaal toenemend kritisch tov. Bio -> food/fuel en elektrificering
	Interaction with residential areas	20,0	Wel kritiek, afstand tot bewoning maakt goed managable
Synergy	Supply chain of the cluster	12,0	Bio raffinage aanw, aan- en afvoer product via derden (de helft is aanw.)
	Strategic corporations	15,0	Biedt mogelijkheden bijv. EMO bij consolidatie van doorvoer kolen

Figure D.6: Overview of resulting scores Maasvlakte

The results that are presented in table 2 give an overview of the resources that the Maasvlakte area is able to offer with respect to hosting a biofuel production site. In general, it can be concluded that it is very well possible to allocate a biofuel production site at the Maasvlakte. The main drawback for this area is the fact that the terrains are still to be produced and the majority of connections (excluding the basics; water, steam, electricity) are not in place.

On the other hand, the Greenfield character of the Maasvlakte offers opportunities. Especially the flexibility of the desired terrain that the area is able to offer is unique in the port area. Additionally, it is the relatively remote location to residential areas and vulnerable activities, that provide the situation of a significant tolerance when noise, emissions and safety are concerned. The, at first sight, surprising conclusion is the relatively low score for the Public opinion (where one might expect that the remote location will be positively influencing this score). The main reason for this is the fact that realising something at a site at which no activity took place before, has in perspective always a negative perception from the public, whereas substitution of an industry by industry is less experienced as a nuisance.

From the perspective of synergy and connection to the surrounding industry, the Maasvlakte offers opportunities as well as hurdles. When greenfield development will be executed for the realisation of the biofuel production site, the incoming feedstock will most likely be handled at the EMO terminal and transported to the biofuel plant. On the outgoing side, also an extra step is necessary to get the produced fuel into the current fuel system (as these pipelines are not present at the Maasvlakte). The opportunity side of the story lies at the, most likely decreasing amounts of transhipped coal at the EMO terminal, providing an opportunity for cositing at the terminal to secure the volumes of dry bulk transhipment and improve efficiency at the incoming side of the supply chain.

At first sight, the Maasvlakte area is definitely able to host a biofuel production site, but it is not able to offer the opportunities based on synergy and connectivity that is present in other parts of the HIC. Also, the specifications of the Maasvlakte are not really necessary for hosting a biofuel plant and the terrains are, in fact, over-designed for the considered activity.

D.4. INTERVIEW – KEES KLEINHOUT POR

INFORMATION

Date:	18-7-2018
Name:	Kees Kleinhout
Company:	Port of Rotterdam
Department:	Port Development - PP
Role:	Gebiedsmanager Europoort area

This interview has been performed for the sake of mapping the characteristics for the Europoort area. These characteristics are evaluated based on the substantiation of themes that has been performed in chapter 2. During the interview, the aim was to fill out the scorecard to identify the relative strength of the evaluated themes.

SCORING OF THE REQUIREMENTS

The scoring is based on the following principle:

Score	Contribution
0	Not available, has to be performed at the site
5	Insufficiently available in quantity and quality
10	Available, though significant investments have to be made
15	Available at reasonable levels of investment
20	Directly available in quantity and quality

Table D.4: Definition of the scores

It must be noted that the scores can be interpreted slightly different when the different themes are treated, but the above table has the purpose to give an indication on how the quantification should be performed.

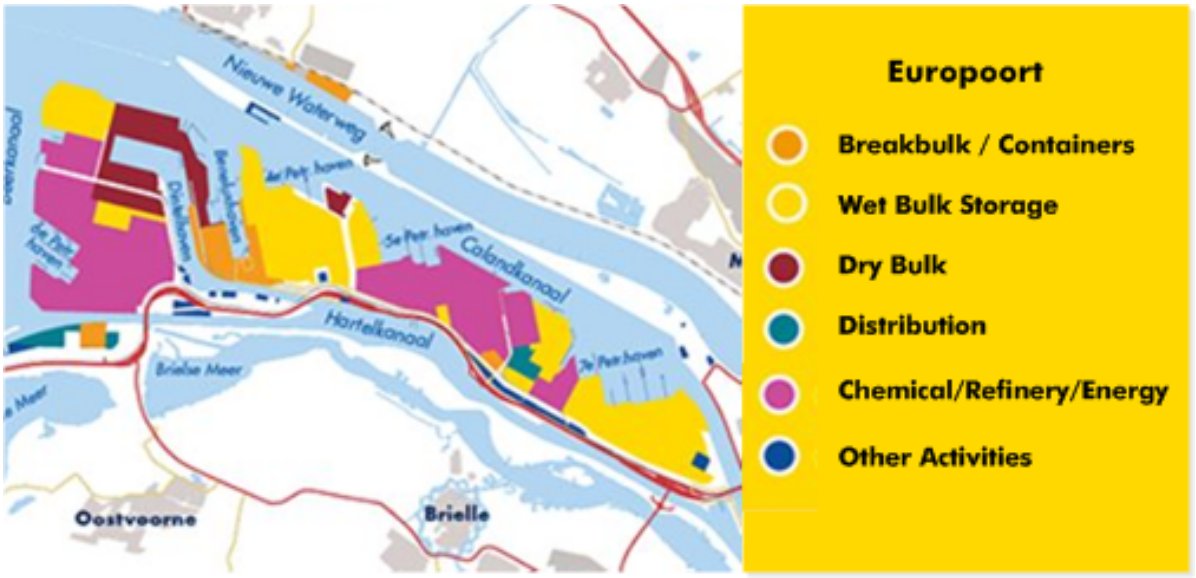


Figure D.7: Overview of the Europoort area (Port of Rotterdam Authority, 2018a)

RESULTS AND CONCLUSIONS

	Requirement	Europoort Score [1-20]	Additional Remarks
Connectivity	Intra-port Connectivity	13,0	Lang gerekt -> grote afstanden, vooral georienteerd op ruwe olie
	Inter-port Connectivity	20,0	Alles aanwezig, zowel modaliteiten als bereikbaarheid invoer uitstekend
Knowledge & Experience	Relevant Institutions	17,0	Goed aanwezig, systeem grens strekt zich wel buiten HiC (landelijk?)
	Experience of the Industry	17,0	Goed aanwezig, strekking is regionaal georiënteerd
	Skill Level	15,0	afstanden relatief groot tot woonkernen, level goed maar omscholing benodigd
Law & Regulation	Safety & security	20,0	veel ervaring en toepassingen van risicovolle industrie -> veiligheidscontouren
	Emissions	20,0	maximale bovengrens wat betreft toepassingen binnen het havengebied
	Subsidies	10,0	industrie afhankelijk niet gebieds-, hooguit voor aanleg infra op nationaal/EU le
Physical aspects	Needed acres	15,0	Kavels ruim toereikend, verontreiniging van grond, uit optimalisatie oogpunt nie
	Access to waterside	20,0	Veel water met uitmuntende karakteristieken, schaal grootte overstijgt het ber
Services	Physical services	18,0	Veel ervaring met type industrie, gebied is er als geheel goed op ingericht
	Administrative services	15,0	Goed maar niet gebiedsafhankelijk
	Digital services	18,0	Efficiëntie gericht, draagvlak belangrijk, PoR koploper, generiek
Sociopolitical	Public opinion	17,0	Mensen weten niet beter, calamiteiten veroorzaken wel realisatie
	Political arrangement	15,0	Indien significante bijdrage hinder/geur/uitstoot valt er veel te winnen
	Interaction with residential areas	15,0	In geval van vooruitgang tov vorige activiteit weinig hinder
Synergy	Supply chain of the cluster	20,0	Veel raffinage en mogelijkheden tot bijmenging in brandstofsysteem
	Strategic corporations	18,0	Veel mogelijkheden, hierin een goede 2e tov botlek

Figure D.8: Overview of resulting scores Europoort

The results that are presented in table 2 give an overview of the resources that the Europoort area is able to offer with respect to hosting a biofuel production site. In general, the area is perfectly suited to host an industry such as biofuels due to its extensive development around the petrochemical industry and all complementary assets. On the other hand, it should be argued whether the Europoort area is the best option from an optimisation point of view. At first sight, it is expected that the area is over-dimensioned for hosting a relatively small plant.

As it was intended, the Europoort area is really developed to be an area that is able to host vast scale activities that are related to the petrochemical industry. With its main orientation on the handling and refining of crude oil products, its facilities and connections in this respect have excellent quality. For the other utilities, the longitudinal layout of the Europoort has proven to require significant investments when connectivity within the port system is to be realised.

Due to its dedicated purpose, the regulatory side together with the interaction and the interference from the public opinion has developed accordingly. This means that the people living in the surrounding areas are known with the risks and have a different perception of new (heavy) industrial activities than people who are not used to this. Additionally, the budgets concerning emissions, noise, safety etc. are in the maximally allowed bandwidth that is to be found across the HIC.

From a synergy perspective, the Europoort is host to highly related industries, as long as the assumption is made that in the near future the produced biofuels will be part of the contemporary fossil fuel systems. This means that the area offers good opportunities when corporations and the connection between different links in the supply chain are to be considered.

From the above, it can be justly concluded that the Europoort area is a very good option to host a biofuel side and does not have major downsides at first glance. The hurdles arise when the match between the desired destination and the production of biofuels is to be elaborated. The strength of the area is based on scales and large volumes. To optimise these resources, the allocation of a biofuel plant, with its belonging factors of scale, seems not the right candidate to utilise them.

E

APPENDIX E - RESULTS WORKSHOP PRIORITISATION REQUIREMENTS

E.1. OVERALL RESULTS WORKSHOP

Case 1: Bio raffinage

	Score	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant
Wet & Regelgeving	12	1	✓		
Connectiviteit	18	2	✓		
Fysieke aspecten	18	2	✓		
Synergie	22	4		✓	
Sociopolitiek	26	5		✓	
Dienstverlening	36	6			✓
Kennis & ervaring	36	7			✓

Case 2: Synthetische energiedrager

	Score	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant
Wet & Regelgeving	5	1	✓		
Sociopolitiek	14	2	✓		
Connectiviteit	19	3	✓		
Fysieke aspecten	21	4		✓	
Synergie	24	5		✓	
Kennis & ervaring	26	6		✓	
Dienstverlening	31	7			✓

Figure E.1: Overall results from the workshop

E.2. SCHEDULE AND OVERVIEW OF PARTICIPANTS

Time	Activity
14.00 - 14.15	Introduction to research and objective of the workshop
14.15 - 14.30	Case 1 - Biorefinery: Individual assessment
14.30 - 14.45	Case 1 - Biorefinery: Central discussion
14.45 - 14.55	Short break
14.55 - 15.10	Case 2 - Synthetic energy carrier: Individual assessment
15.10 - 15.25	Case 2 - Synthetic energy carrier: Central discussion
15.25 - 15.30	Wrap up

Table E.1: The schedule of the workshop held on the 21st of august

Name	Expertise	Department	Related requirement
Alan Dirks	Program manager	EM/P&P	Law & regulation
Jelle Peddemors	Analyst spatial development	PD/PP	Physical aspects
Marlies Langbroek	Advisor	CEA/EA	Socio-political
Peter Vervoorn	Area manager - Botlek	PD/PP	Physical aspects
Poonam Taneja	Researcher	TU Delft/CiTG	Knowledge & experience
Sjaak Verburg	Advisor	AM/NPC	Connectivity
Wilco van der Lans	Business manager	PIM/EP	Synergy

Table E.2: Participants of the workshop and their role in the organisation

E.3. FACTSHEETS CASES

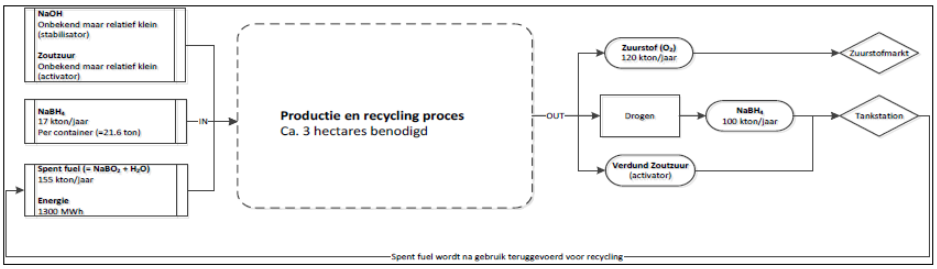
E.3.1. FACTSHEET SYNTHETIC ENERGY CARRIER

Introductie industrie

Synthetische energiedrager

Het process licht ten grondslag voor de productie en recycling van Natriumboorhydride als energiedrager van waterstof onder atmosferische omstandigheden. De energiedragen kan worden gebruikt als transportbrandstof in combinatie met een fuel cell en wordt als vaste stof naar het tankstation getransporteerd. Na gebruik blijft er de zogehete 'spent fuel' over, deze zal weer worden teruggevoerd naar de productie locatie. Vanuit de reststoffen vindt er recycling plaats waardoor de energiedrager opnieuw te gebruiken is. Door het recycleproces, wordt de aanvoer van grondstoffen beperkt. Naast de productie van de energiedrager worden ook zuurstof (voor de zuurstofmarkt) en verdund zoutzuur (activator die tijdens gebruik wordt toegevoegd om de reactie plaats te laten vinden) ge. Wat betreft veiligheid en emissies biedt het initiatief de mogelijkheden om zonder gebruik van hoge druk waterstof op te slaan en in de emissies bestaan uitsluitend uit zuurstof en water.

Proces schema



Specificatie & quantificatie

Product	Tansport in Quantiteit [kton/jaar]	Mode	Opslag Quantiteit [kton]	Vorm	Transport uit Quantiteit [kton/jaar]	Mode
Natriumboorhydride $NaBH_4$	17 [1]	20 ft container	2	Vast	100	Vrachtwagen
Spent fuel	155	Tankvrachtwagen	20	Slurry	n.v.t.	
Warmte		Hernieuwbare bron	n.v.t.		n.v.t.	
Elektriciteit		Hernieuwbare bron/ directe aansluiting		$NaBH_4$ [3]	n.v.t.	
Zuurstof (O_2)	n.v.t.		n.v.t.		120	Directe aansluiting
Water	8 [2]	Wegtransport/directe pijpleiding	n.v.t.		90 [4]	Directe pijpleiding
Natriumhydroxide (NaOH)		Wegtransport		Vloeibaar		Wegtransport [5]
Verdund Zoutzuur (HCl)		Wegtransport		Vloeibaar		Wegtransport

[1] Uitgaande van een continue process, zonder de benodigde hoeveelheid om op te starten
[2] Een deel als retourcomponent via de weg, overige als aanvoer vanuit de pijpleiding
[3] Wanneer er een overcapaciteit aan energie wordt opgewekt kan deze worden opgeslagen in de vorm van watersof in het $NaBH_4$
[4] Mogelijkheid tot hergebruik in proces
[5] Onderdeel van de geproduceerde $NaBH_4$

Figure E.2: Introductory factsheet H2Fuel case

E.3.2. FACTSHEET BIOREFINERY

Confidential

E.4. INDIVIDUAL RESULTS

E.4.1. RESULTS WILCO VAN DER LANS

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	1	✓			Korte ketens/afstanden van lastige producten kunnen doorslaggevend zijn. Bijv. Lignine en Stoom
Kennis & ervaring	6		✓		Dit is in Rotterdam een gegeven, speelt meer in vergelijking met andere gebieden
Wet & Regelgeving	2	✓			Voldoen aan wet & regelgeving is ook een gegeven. Activiteiten van een bioraffinage passen goed in PoR
Fysieke aspecten	3	✓			Is een randvoorwaarde. Bij ruimte allocatie zou het intressant zijn te kijken naar toegevoegde waarde ipv alleen naar €/m^2
Dienstverlening	5		✓		Dit is in Rotterdam een gegeven, speelt meer in vergelijking met andere gebieden
Sociopolitiek	4	✓			Activiteit is niet vreemd/nieuw in PoR. Gebruik van biomassa an sich wordt wel kritisch gevolgd door NGO's
Synergie	7		✓		Lignine en stoom synergie kunnen specifieke voordelen bieden, scundair voordeel

Algemene opmerkingen

- Voorstel splitsen in harde en softe randvoorwaarden (die vervolgens dus ook te rangschikken zijn op een relatieve schaal)
- M.b.t. Kennis en ervaring: Bijvoorbeeld het realiseren van een bioraffinaderij dicht bij gebieden waar biomassa wordt geproduceerd, zonder industriele kennis en ervaring is een groot risico
- M.b.t. Connectiviteit: Belangrijk voor biomassa is connectiviteit met grondstofproductie gebieden flexibiliteit t.a.v. connectie met biomassa produceerde gebieden biedt een compatitief voordeel. (voowaarde is dat biomassa zich gaat onwikkelen tot commodity, geeft keuzevrijheid)
- M.b.t. Wet & regelgeving: Let op geuraspect bij biochemische processen

Figure E.3: Results Wilco van der Lans on Case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	3	✓			Aansluiting op E-net is cruciaal
Kennis & ervaring	6		✓		Veel innovatie en verandering nodig
Wet & Regelgeving	1	✓			Veligheidsaspect van de keten en daarbij behorende wet en regelgeving moet worden ontwikkeld voor verdere uitrol
Fysieke aspecten	4	✓			Randvoorwaardelijk
Dienstverlening	5		✓		Technologie heeft veel impact op hele keten (brandstofketen)
Sociopolitiek	2	✓			Inpassing van deze technologie vergt veel verandering t.a.v. maatschappelijke inpassing
Synergie	7		✓		Keten aanpak noodzakelijk, maar dit geldt vooral buiten het HiC

Algemene opmerkingen

Is het nodig om 1 centrale opwekkingsfabriek te hebben of zijn er meerdere fabriekjes in het binnenland

Figure E.4: Results Wilco van der Lans on Case 2

E.4.2. RESULTS MARLIES LANGBROEK

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	1	✓			Essentieel + denk ook belangrijk voor de business case van het initiatief
Kennis & ervaring	4	✓			Kennis + ervaring met instituten als DCMR + VRR blijkt essentieel te zijn voor het realiseren van projecten
Wet & Regelgeving	3	✓			Projecten moeten aan wet + regelgeving voldoen, maar nieuwe regelgeving is nodig voor nieuwe business
Fysieke aspecten	7	✓			Ruimte is noodzakelijk, zie ik als uitgangspunt, anders valt een project niet te realiseren
Dienstverlening	6	✓	✓		Belangrijk element in het totaal maar ik denk dat de markt hierop inspeelt, kansen pakt.
Sociopolitiek	5	✓	✓		Hangt heel erg af hoe de boodschap wordt geformuleerd en het proces wordt ingericht. Welke hinder wordt er ervaren?
Synergie	2	✓			Kan belangrijke invloed hebben op business case en daarmee haalbaarheid van het initiatief

Algemene opmerkingen
Aangeven waar de 5 ha in het factsheet mee te vergelijken is krijg je meer gevoel bij de omvang

Figure E.5: Results Marlies Langbroek on Case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit		✓ / x	✓ / x	✓ / x	
Kennis & ervaring		✓ / x	✓ / x	✓ / x	
Wet & Regelgeving		✓ / x	✓ / x	✓ / x	
Fysieke aspecten		✓ / x	✓ / x	✓ / x	
Dienstverlening		✓ / x	✓ / x	✓ / x	
Sociopolitiek		✓ / x	✓ / x	✓ / x	
Synergie		✓ / x	✓ / x	✓ / x	

Algemene opmerkingen
Vanuit omgegevingsmanagement gezien: zie redenering case 1
Vraagt nog wel veel uitzoek werk, nog veel inhoudelijke vragen m.b.t. de case wat weer van invloed is of kan zijn op onderstaande aspecten
Moet dit in de haven?

Figure E.6: Results Marlies Langbroek on Case 2

E.4.3. RESULTS ALAN DIRKS

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	6	✓			Voldoende beschikbaar
Kennis & ervaring	5		✓		Voldoende beschikbaar
Wet & Regelgeving	1	✓			Voorwaarden m.b.t. gevaarlijke stoffen (ammoniak, zwavelzuur), voor locatie en transport. Stank?
Fysieke aspecten	3	✓			Voldoende beschikbaar
Dienstverlening	7	✓			?
Sociopolitiek	4	✓			Noodzaak voor license to operate
Synergie	2		✓		Gunstig voor efficiency, kan positief zijn voor energie transitie

Algemene opmerkingen

Figure E.7: Results Alan Dirks on Case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	4	✓			Veel distributie nodig over heel NL. Lokaal vormt dit geen probleem
Kennis & ervaring	2	✓			Nog onzeker proces!
Wet & Regelgeving	1	✓			Te veel onzekerheden, eerst nader onderzoeken
Fysieke aspecten	6	✓			Oplosbaar
Dienstverlening	5	✓			Oplosbaar
Sociopolitiek	3	✓			Acceptatie van .. Onzeker brandstof
Synergie	7		✓		?

Algemene opmerkingen

$NaBH_4$ is een gevaarlijke stof en dus niet geschikt voor gebruik in tankstations

Figure E.8: Results Alan Dirks on Case 2

E.4.4. RESULTS PETER VERVOORN

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	2	✓			Zonder logistiek geen business case. Aanvoer biomassa per schip
Kennis & ervaring	7		✓		Kan ook van ver ingevlogen worden
Wet & Regelgeving	4	✓			Subsidie relevant om te kunnen starten vergunning is nodig, proces lijkt vrij onschuldig
Fysieke aspecten	1	✓			Zonder geschikte ruimte geen productie. Opslag nodig voor continuiteit, mogelijk co-siting
Dienstverlening	6		✓		Kan ook op afstand, onderhoud wel organiseren on-site (turnarounds) Rol HbR
Sociopolitiek	5		✓		Draagvalk - uitputting bossen - bio ethanol - icm fossiel brandstof Feedstock
Synergie	3	✓			Afzet zekerheid Bouwstenen op korte afstand kunnen gebruiken i.v.m. prijsvoordeel

Algemene opmerkingen

Figure E.9: Results Peter Vervoorn on Case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	4	✓			Grote transportstroom spentfuel. Effect op bereikbaarheid/veiligheid
Kennis & ervaring	6		✓		Kan van buiten ingebracht worden, opschaalbaar, werkbaar
Wet & Regelgeving	1	✓			Toxiteit, onduidelijkheid, systeem transport akkoord wetgeving?
Fysieke aspecten	5	✓			Veel wegtransport, kan overal vestigen, veiligheidscontour wel erg relevant
Dienstverlening	7		✓		laatste zorg - specialistisch proces eigen sourcing wel belangrijk
Sociopolitiek	2	✓			Draagvlak, risico volksgezondheid
Synergie	3	✓			Zou dit proces ook elder plaats kunnen vinden? Dichtbij de energiebron?

Algemene opmerkingen

Batterij op industriele schaal oplossing (seizoensbuffer)

Figure E.10: Results Peter Vervoorn on Case 2

E.4.5. RESULTS JELLE PEDDEMORS

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	5	✓			Gezien de kleine volumes kan veel per as worden aan-/afgevoerd
Kennis & ervaring	7		✓		Is net als bij dienstverlening ook van verder weg te halen / te kopen
Wet & Regelgeving	1	✓			gevaarlijke stoffen als ammoniak hebben een grote externe veiligheids contour
Fysieke aspecten	2	✓			Terrein van 5 ha met wateraansluiting en benodigde connectiviteit zijn schaars, optie is co-siting bij andere klant
Dienstverlening	6		✓		Is deels 'foot-loose' en kan ook van verder weg worden gehaald
Sociopolitiek	3	✓			Publiek opinie/politiek worden steeds belangrijker en doorslaggevend
Synergie	4	✓			Gezien de kleine schaal van de plant en de onderbenutting als ze eigen pijpleiding/kade hebben is clustering/gezamenlijk gebruik van infra. wenselijk

Algemene opmerkingen

Figure E.11: Results Jelle Peddemors on Case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	5	✓			Energie aanvoer is groot, retourstromen ook
Kennis & ervaring	6	✓			Veel relevanter dan case 1
Wet & Regelgeving	1	✓			Onbekendheid/onduidelijkheid geen regelgeving
Fysieke aspecten	4	✓			Moet dit wel in de haven?
Dienstverlening	7		✓		Foot loose
Sociopolitiek	2	✓			Onbekendheid maakt onbemint, maatschappij heeft mening
Synergie	3	✓			M.b.t. energie aanvoer

Algemene opmerkingen
- Waarom moet dit in de haven en niet nabij tankstation
- Centrale re-distributie via binnenlandse terminals

Figure E.12: Results Jelle Peddemors on Case 2

E.4.6. RESULTS SJAAK VERBURG

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	3	✓			Zie algemeen
Kennis & ervaring	7		✓	✓	Hoeft niet 'om de hoek'
Wet & Regelgeving	1	✓			Lijkt binnen het HiC geen probleem
Fysieke aspecten	2	✓			Het moet wel passen
Dienstverlening	6		✓	✓	Hoeft niet 'om de hoek'
Sociopolitiek	5		✓		Bio-raffinage in het huidig HiC-complex lijkt niet op bezwaar te stuiten
Synergie	4	✓			Zie algemeen

Algemene opmerkingen
Connectiviteit heeft sterke relatie met synergie.
Voor leidingen geldt: hoe langer de leiding; hoe hoger de kosten (investering per meter) en hoe hoger de benodigde hoeveelheid om economisch haalbaar te zijn. (Lange leidinge: hoge kosten)
Veel synergy: Gedeelde kosten; dus lager
Grondstof of afzet dichtbij, minder transport, leidingen eerder economisch haalbaar

Figure E.13: Results Sjaak Verburg on Case 1

	Prioriteit [1 - 7]	Must Have	Nice to Have	Irrelevant	Opmerkingen
Connectiviteit	3	✓ / ×	✓ / ×	✓ / ×	
Kennis & ervaring	6	✓ / ×	✓ / ×	✓ / ×	
Wet & Regelgeving	1	✓ / ×	✓ / ×	✓ / ×	Veel impact buiten HiC (tankstations)
Fysieke aspecten	2			✓	Past bijna overal
Dienstverlening	7	✓ / ×	✓ / ×	✓ / ×	
Sociopolitiek	5	✓ / ×	✓ / ×	✓ / ×	
Synergie	4	✓ / ×	✓ / ×	✓ / ×	

Algemene opmerkingen
Zie opmerkingen case 1 : connectiviteit/synergie
Voor stroomaansluiting (bij Tennetpunt?)
Voor warmte (bij warmtenet of gethermische bron)
"foute case"? -> Technologie (vooralsnog) geschikt als (seizoens) batterij op grote schaal
-> Als lokale batterij op 'Energy-Island' wordt de case heel anders (geen transport, synerie inherent, etc.)

Figure E.14: Results Sjaak Verburg on Case 2

F

APPENDIX F - EXTERNAL INTERVIEWS

F.1. COMPANY VISIT – PLANTONE

INFORMATION

Date:	26-6-2018
Name:	Gabriël Tschin & Carland Lopez
Company:	PlantOne
Role:	General Manager & Chemical- and Research Engineer (respectively)

As part of a tour through the Botlek area in the PoR, organised by Peter Vervoorn, PlantOne has been visited. In essence, PlantOne is a facilitator which enables (chemical) start-ups and innovation to test their technology before being able to scale-up.

HISTORY

The initiative of PlantOne started in 2010 which was at the time funded by subsidies and the consortium containing the PoR authority, Deltalinqs, Green Tech Delta etc. The collaboration ran until 2015 and was moderately successful. In 2015 the consortium amortised its funding and PlantOne continued as a private company.

From 2015, Gabriel pursued his approach that initiatives and start-ups should be able to be facilitated with the needed resources at a competitive price instead of running on subsidies. From that moment on various projects have been undertaken successfully and Gabriel claims to have a high occupancy rate for the years to come.

COMPANY DESCRIPTION

At PlantOne innovative chemical technologies can be tested before scale-up to a production facility is to be made. Gabriël stresses that PlantOne is more than just a facilitator of physical space to perform these tests. Within the company a lot of knowledge is present on how to translate an initiative into an actual facility. In practice, this means that the employees of PlanOne are actively involved in the design and realisation of the test plant.

In general, Gabriël claims that most entrepreneurs have the ideas, but the input of knowledge and engineering is vital to come to a smooth realisation. He also stresses that due to an overarching license of the PlantOne plot, the initiatives are able to put their ideas to the test within a unique time frame.

When looking into the future, interest has been increasingly showed from other regions in the Netherlands and even from abroad. Due to this demand, PlanOne is expanding in two ways. Firstly, by renting an extra 20 acres next to their current terrain to enhance its current location. And secondly, by starting a new establishment in the Moerdijk area. Although safety budgets are slightly stricter in the Moerdijk area, Gabriël sees significant opportunities to exploit business in the region.

Whereas currently many initiatives are reliant one subsidies, PlantOne is convinced that testing of a innovation shouldn't be. The projects that are launched at the facility, should be founded on a solid business case and prove viability by itself. According to Gabriël, many subsidised projects are seeking to find 'the egg of Columbus' instead of creating technological progress in steps. By moving step by step, PlantOne is convinced that exploitation should be possible.

RELATION BETWEEN PLANTONE AND ALLOCATION & REVIEW

Of course PlantOne is one of the many clients that are leasing on of the terrains in the HIC and since their chemical related activities do fit in the surrounding area, its allocation seem to be using the resources quite well. The interesting fact, however, is that PlantOne is the 'supplier' of physical space to its clients that are looking for a test location and therefore the allocation process is pretty comparable with that of the PoR authority (keeping in mind the difference in scale of course).

As with the allocation of industries in the PoR, the requirements needed to facilitate the activity must be matched at PlantOne. During the conversation, Gabriël stressed that their overarching permit related to the activities that are allowed to take place at the site, enable clients to directly move to the practical side of the testing instead of spending a lot of time into gaining permission. With this statement, Gabriël underlines the fact that safety and security provide a high valued resource for PlantOne.

At the same time, as testing might be part of an extensive project, strategic corporation and interests of stake- and shareholders can have significant impact on the allocation when scaling up towards production takes place. Of course, the aim of such a company in the port is to enhance innovation and try to make sure that when scale-up takes place, this happens in the HIC. But when shareholders are involved that are allocated elsewhere themselves, it will be very likely that such an activity will leave the Rotterdam Port area after testing have been successfully completed.

REVIEW & CONCLUSIONS

The main conclusion of the company visit contains the association that PlantOne is more than a facilitator of physical area to exploit innovation of chemical technologies. By means of its in-house knowledge and gained experience, it is able to actively participate in the process of development and exploitation of the test plant. The combination of this knowledge and experience together with the facility itself and its unique connectivity and availability of permits, PlantOne is able to offer start-ups a unique opportunity to put its technology to the test.

In fact, PlantOne can be seen as a good example in which experience that is obtained in the fossil era, is used to generate and facilitate new technologies that are aimed to enhance the transition towards a more sustainable industry. The focus is on technologies that are aimed at continuously improving the approach of individual components that are performed in the chemical industries together with initiatives inventing technologies to be used in new fields of expertise (such as recycling of plastics) that are, in general, derived from technologies that are being applied in other processes. In this way, PlantOne is able to contribute with its expertise in the development of a viable test facility and all the processes involved.

One aspect that became evident from the visit is that the facilitation of different initiatives at PlantOne, demonstrates significant similarities of the allocation process within the HIC. Though a vastly different scale is applicable and PlantOne is focused on their main sector (chemical innovations), the majority of requirement themes that are identified in section 2.7.3, are applicable to the allocation of the test facilities. Additionally, Gabriël also acknowledged that these requirements differ in the degree of decisiveness and that the unique element at PlantOne is mainly concerned on the overarching permit and connectivity to the surrounding industry due to its allocation at the Huntsman site.

F.2. INTERVIEW – ALDERT VAN DER KOOIJ BIOBASED DELTA

INFORMATION

Date:	2-8-2018
Name:	Aldert van der Kooij
Company:	Biobased Delta
Department:	REDEFINERY
Role:	Projectmanager

WHAT IS REDEFINERY?

The initiative is a blueprint that is aiming at producing building block for sequential production processes (chemicals, fuels and additives for asphalt production). It should not be confused with a production site itself, but the processes that take place involve the preparation of the feedstock by converting and separating the useful components of the biomass into base products for further production. The refinery process is founded on the use of woody biomass as feedstock (in chunks, chips of pelletized form) to produce lignin, C5- and C6 sugars. These products will then be transported to the next production step to produce the end products.

The initial focus of the process is the production of the C5/C6 sugars as a building block for fuels and chemicals respectively. The lignin is providing REDEFINERY with an opportunity if a cost-effective steam supply is possible at the site. When this is indeed the case, the lignin can be isolated and used in the asphalt section as bitumen. This application has a higher value than using the lignin to produce steam (that is used in the process again) and thus is beneficial for the overall business case.

REFINING AT THE ORIGIN OF THE FEEDSTOCK

At first sight, it seems that refining nearby the origin of the feedstock is a more viable option to create a highly valued business case, both from a financial point of view as well as the transportation and belonging emissions. It seems that transport of the needed building block (and thus a high density of the needed component) is more effective than transporting the raw materials and let the refining take place in Western Europe.

Although this might sound the most logical. It has proven that the experience and connective networks in areas like the PoR have evolved to such levels of sophistication, that the cost and even the related emissions for the complete life cycle have are beneficial when the refining step takes place in Western Europe. Besides the experience of the industry, the supply of steam has proven to be an essential step in closing the business case (since lignin can then be supplied for higher value purposes instead of steam production). If the refining step would take place in, for instance, Brazil, which is one of the areas where the feedstock can be imported from, it would need the lignin to produce steam.

Additionally, it would use the C5 sugars to produce ethanol as a local transportation fuel since its value (and energy density) is too low to be transported around the world. Resulting in the situation that only the C6 sugars are left for the European market.

STATE OF THE TECHNOLOGY

As the situation is now, all the individual processes (indicated as the blocks of the scheme) are proven at small scale and ready to be scaled up. The main risk is found in the area of interaction between the different blocks. The challenge is to make sure that the performance of the various steps is equivalent when they are part of the complete process, as they were individual. The technologies that are part of the designed process, have been developed with the literature as a foundation and extensively tested and improved by the knowledge institutions that are contributing to the partnership.

THE PUBLIC-PRIVATE PARTNERSHIP (PPP)

As the title suggests, the consortium is build up from partners from both the public – as well as the private sector. The biorefinery will play the central role in this respect and additionally, operators, the port authority, investors and grants are necessary (as depicted in figure F.1) to create the environment that has a well-founded business case and a fair distribution of risks. In this respect, an active form of participation is desired from the involved partners. For the consortium, it is also of vital importance that contracts are being set with partners at the supply – as well as the take-off side.

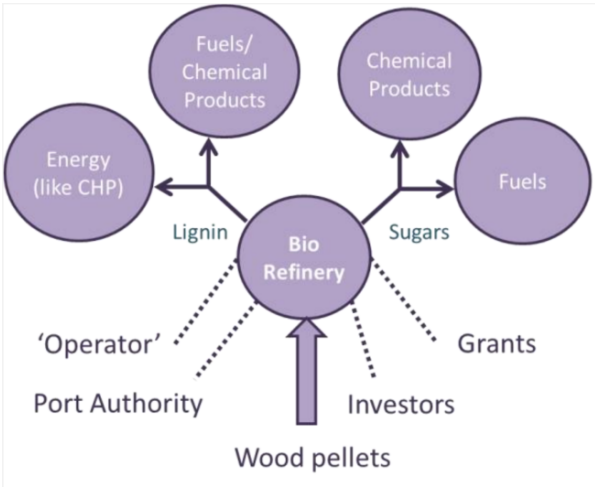


Figure F.1: Structure of the REDEFINERY consortium (BiobasedDelta, 2015)

GRANTS / SUBSIDIES

In the operational phase, the grants are not vital anymore for making the business case viable. Besides the lack of necessity, the current Dutch national subsidies programmes are mainly aimed at the production of sustainable energy (SDE+) and not so much on fuels and chemicals. The vitality of the grants is mainly in the development phase. Without these grants, the research and knowledge institutional partners are not able to develop the technologies. Aldert does acknowledge that if opportunities arise to raise grants in the operational phase, this will be seen as an additional benefit in the business case.

SYNERGY AND CONNECTIVITY

As described in the invitation for consultation (BiobasedDelta, 2015) the preferred location is a seaport. The main reason for this is the transhipment of the feedstock and the direct availability of steam supply. Additionally, the clusters in the seaport areas that are considered also provide the opportunity to be able to realise a direct supply of the products (C5/6 sugars and lignin) over relatively short distances to the next link in the supply chain. These connective advantages may well result in a cost reduction in the logistical process and at the same time limit the belonging emissions.

Besides the transhipment of the main feedstock (woody biomass), the seaport clusters also provide the opportunities to create a direct connectivity to utilities (water, electricity, etc.) and synergy opportunities arise when the secondary products that are necessary for the process (e.g. sulphuric acid, ammonia and enzymes). Especially when these secondary products take shape into serious scales, direct supply from a dedicated producer is part of the opportunity framework.

SUGAR PRICE

Confidential

STORAGE

Confidential

COMPARISON WITH THE FOSSIL REFINERY PROCESS

Confidential

REQUIREMENTS: MUST HAVES & NICE TO HAVES

Confidential

GENERAL REMARKS

Confidential

G

APPENDIX G - FUNCTIONAL CONSIDERATIONS CASE STUDY

G.1. FUNCTIONAL CONSIDERATIONS

By making the assumption that allocation of the REDEFINERY initiative will proceed, this section aims at identification of the main considerations that are inherent in the process. These considerations will be treated by means of the earlier identified requirement themes 2.7.3.

Since not all processes can yet be described in detail, the majority of the considerations will have a qualitative nature. In the following, the order in which the requirement themes are treated is coherent with the identified priority (form high to low) as is identified during the workshop.

G.1.1. LAW AND REGULATION

TRANSHIPMENT AND STORAGE OF HAZARDOUS GOODS

For the transport movements of the involved hazardous products (mainly ammonia and sulphuric acid) close attention must be paid to the safety of the process. For the sake of transportation, movements within the HIC will be not so much of a problem as long as the safety precautions are borne in mind. This is different when the transportation involve routes that stretch beyond the borders of the port region. It is therefore evident that the location of the site with respect to its suppliers and the mode of transport is of crucial importance for the safety of transhipment of the hazardous products.

The onsite storage will mean that safety precautions must be in place. One should think about dry storage (in silo's or tanks) and possibly pressurisation depending on the stability of the product. Additionally, a safety buffer will be necessary that when leakages occur, the product is contained in the buffer. These do have consequences for the spatial requirements of the storage.

TRANSHIPMENT AND STORAGE OF BIOMASS

The handling of incoming biomass and the storage of the woody product seem not that complex at first sight. Though there are some aspects of crucial importance. For a safe handling and protection of the product quality, dry handling and storage are preferred. This is mainly due to the (flammable) dust that is involved. As a consequence, the conveyor belt systems, as well as storage, must be covered and ventilation during storage must be present. Covering the system and protection against weather condition also enhances the possible nuisance of smell and forms a protection against pests.

SAFETY CONTOURS AND NUISANCE OF SMELL

Of course one must bear in mind that the safety contours form the outer limitation based on hindrance and emissions to surrounding areas. In this respect, the emissions and noise are expected to stay well within limits, but nuisance of smell is a hot topic when distances to residential areas get smaller. In the end, these limitations are dependent on the exact location allocation will take place relative to the vulnerable groups to assess the external safety properly.

G.1.2. CONNECTIVITY

STEAM

Business case wise, the realisation of a steam connection that is able to use the produced steam from for instance a power plant is essential. Such a connection is only possible in the form of a pipeline. In the PoR there are areas which provide a connection with relative ease, such as the steam network in the Botlek area, but in most cases, a dedicated connection will have to be developed. With such a connection the main hurdles are that the limiting length over which steam can be transported and costs rise in a rather linear manner with respect to length.

BIOMASS

Since the source of biomass most likely finds its origin in either South- or North America. Therefore import will be by means of vessels. As woody biomass is comparable to the current transhipment of dry bulk, no major hazards are expected. The currently used vessels for transport of biomass are of the so-called 'handymax class' (approximately: loa = 190 m, draught = 14 m, width = 30 m, DWT = 50 – 60 kton). With the considered import quantity of 1000 kton/year, this means that approximately 20 vessels a year will call at the port to supply the Redefinery plant. Resulting in a relatively costly situation when an own berthing location is considered. If possible, partnering with another client for the transhipment seems viable.

SUGAR PRODUCTS AND LIGNIN

As these are the main produced products, connection to the off take market is vital. As for the sugar products, potential customers are still limited but at the same time volumes are substantial, a dedicated connection is preferred. For such a pipeline connection a comparable consideration holds as is elaborated for steam. Since sugar has limiting pumping capacity (maximal 10 km) the location of will determine the transport mode of choice. For the lignin, on the other hand, it is first and foremost dependent on the availability of steam supply. Only if this is realised, the lignin can be used in the production of bituminous products for the asphalt industry. As it is still unclear to which customer the lignin will be supplied and the asphalt production sites are scattered across the county, it is very likely that transport will be in the form of road, rail or inland vessels.

WATER

For both incoming and outgoing flows, the infrastructure for water is very well present throughout the HIC. This is for both industrial water quality as well as fresh water from Evides and the treatment facility of AVR. Depending on the degree and nature of contaminants that are present in the outflow, onsite pre-treatment might be necessary. Although having a spatial impact, little can be quantified in this respect as the regulations are being set by the owner of the infrastructure.

ELECTRICITY

The supply of electricity seems no limiting factor as an extensive network is present across the port area that is dedicated to industrial purposes.

AMMONIA, SULPHURIC ACID AND ENZYMES

As these products are rather specialised and product volumes are relatively low transport will most likely be by road. The origin of the product may cause that inland shipping becomes a viable option, but this is highly dependent on location and how the storage is preferred. The main bottleneck in this respect will be on behalf of the laws and regulations concerned with transportation.

G.1.3. PHYSICAL ASPECTS

LAND AND NAUTICAL AREA

In this respect, the necessary hectares needed to allocate the Redefinery plant is dependent on several aspects. As it has been indicated that the core refining process will need approximately 5 hectares this has been assumed. Furthermore, storage is the main contributor to the space use at the site. The storage volumes will be mainly determined by the frequency, dependency and flexibility of delivery. As shutting down of the production process is very costly, security is the driving force. This is most evident for storage of biomass, where the frequency is relatively low and flexibility is minimal due to the shipping distances. This means that at least 2 deliveries must be stored. Such an elaboration can be made for all products that are delivered in batches. It must be noted that safety distances between particular activities of the process can lead to increasing space use. To quantify, however, the specifics of the process are to be clarified and compared with the guidelines.

On the other hand, the nautical area is most likely not so much of a problem. The vessels that are used as the benchmark (handymax class) can be very well handled in the majority of the port areas. Additionally, it is common that these ships have onboard crane facilities leading to a less complex berthing facility and quay wall design.

ARRIVAL OF CONNECTIVE NETWORKS

The arrival of connective networks is mainly dependent on the transported product and nature it is transported in. For this sake, the products that are being transported in the form of a pipeline have a relatively low intensity in space use. The main space use will be in the form of safety distances and the puzzle where the pipelines are best implemented on the site. For the physical modes of transport (trucks, rail, inland vessels) impact is more on behalf of physical space use. For these modes, it is usual that dedicated facilities are present at the site. In essence, the arrival of connective networks in case of the Redefinery plant does not have a substantial space use, but their main complexity is in the puzzle of how they are situated relative to each other.

FUNCTIONALITIES; OFFICES, PARKING ETC.

Of course, there are always the basic requirements based on facilities for employees and working spaces. Although volumes are not significant, they do have an impact and easy access is preferred. Though parking may be increasingly important if the modal split turns out to involve a high degree of trucks. When this is the case, truck parking and loading facilities can lead to significant space use. As the modal split is still too dependent on the developed partners, quantification is not yet possible.

G.1.4. SYNERGY

OFFTAKE MARKET AND STEAM SUPPLY

As indicated by the public-private partnership approach and limiting number of offtake possibilities, synergy is essential in creating a viable business case as well as security. The creation of such a partnership forms an essential milestone in the creation of the essential synergy. The spatial impact of these product lines is not significant when it is assumed to be incorporated in the partnership.

TRANSHIPMENT AND STORAGE

Besides the essential synergy requirements, there are also several opportunities to create a positive impact on the spatial use. By relocating the transhipment and possibly even storage of the incoming products by vessel (in this case mainly biomass), a significant reduction in space use can be realised. The main advantage of such a relocation is that the berthing location can be shared (leading to lower costs) and the bulk can be handled by a dedicated terminal (scale advantages). The bottleneck may arise in the transportation from the transhipment terminal to the production site. On the other hand, provide the prospects of declining coal transhipment an opportunity to fill this gap with transhipment of biomass.

G.1.5. SOCIO-POLITICS

PUBLIC OPINION ON BIOMASS

As the process is a development in the already present biobased sector, familiarity with the project exists and a public opinion has developed. The fierce discussion based on the true sustainability of the biomass that is used (land use, food/fuel debate etc.) will also be expected in the case of Redefinery. The experts from the PoR authority assign this hurdle as well manageable. It must be carefully assessed and communication must be clear and convincing. The hurdle is therefore seen as being manageable and definitely not a showstopper.

NUISANCE OF SMELL

The possible nuisance of smell is more of a definite problem. Experience in the region has shown that people experience the nuisance with the currently exploited biomass plant. To tackle this, it must be carefully assessed where to locate the emitters of smell relative to the vulnerable groups and possibly mitigative measures should be proposed to convince the public.

G.1.6. SERVICES

SPECIALISED SERVICES

The experts during the workshop that the necessary services are rather trivial for a production plant like Redefinery. Meaning that dedicated companies are present in the region that are able to perform the necessary general services. Specialised services, if not present, are evaluated as being 'footloose' and in case necessary can be obtained from elsewhere or developed in-house.

INDUSTRIAL KNOW-HOW

Through the industrial know how that is present in the area for decades together with the already in place biobased production sides. It is expected that the majority of services can be outsourced to companies in the direct neighbourhood. Therefore the onsite spatial impact of services is expected to be minimal.

G.1.7. KNOWLEDGE AND EXPERIENCE

INDUSTRIAL KNOWLEDGE AND EXPERIENCE

The knowledge and experience are, in general, in accordance with the storyline of the services. Although experience in relatively small on the sector specifics, the overall industrial experience will be beneficial when exploiting at industrial scale. This is also the case with knowledge, as the allocation of industries has been performed several times, the know-how of the processes involved is very well present.

SPECIALISED KNOWLEDGE AND EXPERIENCE

The specialised part is mainly in the phasing of the project. As the initiative is still preparing on moving to industrial scale, specialised knowledge must be obtained to enable this process. The allocation, however, is aimed at the sequential phases. Therefore the degree of specialised knowledge needs to be developed or gained from elsewhere if not present.

G.2. POTENTIAL PARTNERS

To illustrate the context of the Redefinery initiative, an overview is presented of the potential suppliers and customers. As became evident in the previous sections, the distance between the production site and the customer/supplier is of crucial importance for some of the product, this is the reason why the respective locations have been added. As can be seen from the tables, the list is not complete. In the overviews of the PoR authority only the main products are presented. More specialised products are not presented and are therefore left blank.

G.2.1. POTENTIAL CUSTOMERS

Confidential

G.2.2. POTENTIAL SUPPLIERS

Confidential

H

APPENDIX H - CONFIDENTIAL DOCUMENTS

BIBLIOGRAPHY

P. Port of Rotterdam Authority, *Facts and Figures. A wealth of information*, Report (Port of Rotterdam, 2016).

P. Port of Rotterdam Authority, *Jaarverslag 2017*, Report (Port of Rotterdam Authority, 2018).

A. P. A. van Oel, *Multi-scale-multi-models: from forecasts to strategy and operations in the Port of Rotterdam*, Report (TU Delft, 2017).

p. Port of Rotterdam Authority, *Jaarverslag 2016,* (2016b).

p. Port of Rotterdam Authority, *Masterplan hic 2018,* (2018b).

I. International Energy Agency, *Key World Energy Statistics 2017*, Report (International Energy Agency, 2017).

S. Samedi, S. Lechtenböhmer, C. Schneider, A. Karin, M. Fischedick, D. Schüwer, and A. Pastowski, *Decarbonization Pathways for the Industrial Cluster of the Port of Rotterdam*, Report (Wuppertal Institute, 2016).

Mobiliteitstafel, *Een duurzame brandstofvisie met LEF*, Report (SER, 2014).

F. Frontier Economics, *Scenarios for the Dutch electricity supply system*, Report (Frontier Economics Ltd, London, 2015).

P. d. F. A. Van den Bosch, M. R. Hollen, P. d. H. W. Velberda, and D. M. G. Baaij, *The strategic value of the Port of Rotterdam for the international competitiveness of the Netherlands*, Report ISBN: 978-90-817220-2-5 (Erasmus University Rotterdam, 2011).

a. Port of Rotterdam, *Intermodal transportation,* (2018a).

a. Port of Rotterdam, *Ondernemersstrategie 2016-2020,* (2015).

i. I. Kuppen and i. W. Engelhard, *Milieueffectrapport Aanleg en Bestemming Maasvlakte 2 Bijlage Externe veiligheid*, Report (Havenbedrijf Rotterdam N.V, 2007).

L. Gooijer, A. van Vliet, T. Wiersma, and H. Boot, *Groepsrisico op de kaart gezet*, Report (VROM, 2007).

G. Rotterdam, *Ontwerp - Partiële herziening Bestemmingsplan Maasvlakte*, Report (Gemeente Rotterdam, 2008).

E. Niemendal and D. Bouman, *Luchtkwaliteitsonderzoek Scheurkade*, Report (Antea Group Nederland BV, 2014).

L. Baas, *Industrial ecology as regional corporate sustainability system,* (2016).

a. Port of Rotterdam, *Portmaps,* (2018b).

E. Mendizabal, *The allignment, interest and influence matrix (aiim) guidance note - toolkits,* RAPID , 6 (2012).

N. van Klaveren, *Biobased built on assets,* (2016).

. BiobasedDelta, *Redefinery*, Biobased Delta , 14 (2015).

S. Dröge and T. Spencer, *The EU's INDC and its contribution to a successful deal in Paris 2015*, Report (SWP research - devision global issues, 2015).

M. Gavrilescu and Y. Chisti, *Biotechnology—a sustainable alternative for chemical industry,* Biotechnology advances **23**, 471 (2005).

R. Kemp, J. Rotmans, and D. Loorbach, *Assessing the dutch energy transition policy: how does it deal with dilemmas of managing transitions?* Journal of Environmental Policy and Planning **9**, 315 (2007).

S. Lieberz and E. Scott, *Biofuel mandates in the eu by member state in 2017,* USDA Foreign Agricultural Service , 13 (2017).

U. United Nations, *Paris Agreement*, Report (United Nations Framework Convention on Climate Change, 2015).

p. Port of Rotterdam Authority, *Mission, vision and strategy,* (2018c).

L. Latvian Presidency of the Council of the European Union, *Submission by Latvia and the European Commission on behalf of the European Union and its member states*, Report (UNFCCC, 2015).

N. Höhne, A. Gilbert, M. Hagemann, H. Fekete, L. Lam, and R. de Vos, *The next step in Europe's climate action: setting targets for 2030*, Report (Ecofys, 2013).

A. Hof, C. Brink, A. Mendoza Beltran, and M. den Elzen, *Greenhouse gas emission reduction targets for 2030*, Report (PBL Netherlands Environmental Assesment Agency, 2012).

N. Höhne, M. Den Elzen, and D. Escalante, *Regional ghg reduction targets based on effort sharing: a comparison of studies,* Climate Policy **14**, 122 (2014).

D. Mebius, *Haven rotterdam wil co2-uitstoot opbergen in lege olie- en gasvelden onder noordzee,* De Volkskrant (2017).

E. Voegele, *Paris agreement on climate change enters legal force,* Biomass magazine (2016).

M. Mclynn, L. van der Burg, and S. Whitley, *Briefing: Pathways in the Paris Agreement for ending fossil fuel subsidies*, Report (Climate action network, 2016).

p. Port of Rotterdam Authority, *Ondernemerstrategie,* (2016c).

p. Port of Rotterdam Authority, *Havenvisie 2030*, Report (Deltalinqs, 2011).

L. Cheek, *3 reasons we are still using fossil fuels,* University of Arkansas sustainability blog (2016).

S. Gereadts, *Interview sjors gereadts - goodfuels,* (2017).

Rinkesh, *Pros and cons of fossil fuels,* Conserve Energy Future (2015).

A. Bruggink, D. van der Hoeven, and P. Reinshagen, *Groene Groei*, Report (Biobased Press, 2014).

R. Cuelenaere, G. Koornneef, R. Smokers, H. van Essen, A. van Grinsven, M. 't Hoen, M. Londo, C. van Zuijlen, H. de Wilde, and O. Usmani, *Scenarios for energy carries in the transport sector*, Report ECN-E–13-067 (ECN CE Delft TNO, 2014).

J. F. Jenck, F. Agterberg, and M. J. Droescher, *Products and processes for a sustainable chemical industry: a review of achievements and prospects,* Green Chemistry **6**, 544 (2004).

M. Ministerie van Economische Zaken, *Biomassa 2030 - strategische visie voor de inzet van biomassa op weg naar 2030,* Directie Groene Groei and BioBased Economy , 36 (2015).

R. Hatti-Kaul, U. Törnvall, L. Gustafsson, and P. Börjesson, *Industrial biotechnology for the production of bio-based chemicals–a cradle-to-grave perspective,* Trends in biotechnology **25**, 119 (2007).

R. Rabbinge, *Reactie visiedocument: duurzame bio-economie 2030,* - (2015).

H. Kamp and S. Dijksma, *Brief aan de kamer,* (2016).

J. Krebbekx, W. de Wolf, B. Postma, G. Duivenvoorde, J. Lenselink, and D. Meuzelaar, *De sleutelrol waarmaken, routekaart chemie 2012-2030,* Energie en klimaat (2012).

W. Vaessen and V. Oomes, *The Chemical Industry in the Netherlands: World leading today and in 2030-2050*, Report (VNCI Deloitte, 2012).

K. Schoots, M. Hekkenberg, and P. Hammingh, *National Energy Outlook 2017*, Report 3164 (ECN, 2017).

H. Chen, X. Zhang, J. Liu, and C. Tan, *Compressed air energy storage,* in *Energy Storage-Technologies and Applications* (InTech, 2013) Book section 2 Principles, pp. –.

W. F. Pickard, N. J. Hansing, and A. Q. Shen, *Can large-scale advanced-adiabatic compressed air energy storage be justified economically in an age of sustainable energy?* Journal of Renewable and Sustainable Energy **1**, 033102 (2009).

M. Jentsch, T. Trost, and M. Sterner, *Optimal use of power-to-gas energy storage systems in an 85% renewable energy scenario,* Energy Procedia **46**, 254 (2014).

E. European Commission, *Een beleidskader voor klimaat en energie in de periode 2020-2030,* Report (European Commission, 2014).

D. Collingridge, *The social control of technology,* - (1982).

W. E. Walker, S. A. Rahman, and J. Cave, *Adaptive policies, policy analysis, and policy-making,* European journal of operational Research **128**, 282 (2001).

F. W. Geels, *Technological transitions and system innovations: a co-evolutionary and socio-technical analysis* (Edward Elgar Publishing, 2005).

D. Loorbach, *Transition management: new mode of governance for sustainable development* (-, 2007).

K. M. Weber, *Foresight and adaptive planning as complementary elements in anticipatory policymaking: A conceptual and methodological approach,* Reflexive governance for sustainable development , 189 (2006).

D. Ingenieur, *Gigantisch stopcontact op eiland doggersbank,* De Ingenieur , 1 (2016).

B. Messenger, *Enerkem to lead consortium to develop waste to chemical project in rotterdam,* Waste Management World (2018).

M. de Moel, *Bioport holland,* (2018).

M. R. Terwel and D. I. J. Kerkhoven, *Carbon neutral aviation with current engine technology*, Report (Sanegeest, 2018).

K. Heil, *Location strategy,* (2012).

S. Scaramelli, *The Determinants of Port Competitiveness: The case of Valencia*, Report (Erasmus University Rotterdam, 2010).

P. K. Schwab and P. X. Sala-i Martin, *The Global Compeditiveness Report 2017 - 2018*, Report ISBN-13: 978-1-944835-11-8 (World Economic Forum, 2017).

M. E. Porter, *The competitive advantage of nations,* Competitive Intelligence Review **1**, 14 (1990).

M. E. Porter, *Clusters and the new economics of competition,* (1998).

a. Port of Rotterdam, *Container exchange route,* (2018c).

a. Port of Rotterdam, *Pipeline network,* (2018d).

W. K. Zuid-Holland, *Warmte rotonde - cluster west,* (2018).

K. Bloom, *The innovation gap,* Korn Ferry Institute , 12 (2015).

I. International Labour Office, *A skilled workforce for strong, sustainable and balanced growth: A g20 training strategy,* International Labour Organization , 48 (2011).

Overheid, *Wet ruimtelijke ordening, wro,* (2016).

R. Rijksinstituut voor Volksgezondheid en Milieu, *Handleiding risicoberekeningen Bevi*, Report (RIVM, 2015).

s. Port of Rotterdam, *Subsidies,* (2018e).

A. Port of Rotterdam, *Digitalisation,* (2018f).

SanderP, *Corporate social responsibility (csr),* Infonu , 1 (2012).

T. Economist, *Synergy,* The Economist , 1 (2009).

J. Hurenkamp, *Allocation of (bio) chemical clienst,* (2018).

P. Lietz, *Research into questionnaire design: A summary of the literature,* International Journal of Market Research **52**, 249 (2010).

. BiobasedDelta, *Redefinery,* (2018).

w. Marine Connector, *Handymax,* (2018).

b. H2Fuel-Systems, *H2fuel: dragen van waterstof energie,* H2Fuel-Systems , 45 (2016).

P. Cordfunke, *Data for functional design sander kerpel, por/tud,* (2018).

J. Glen, *Qualitative vs. quantitative,* Business Dictionary , 1 (2014).

N. Johanisova, T. Crabtree, and E. Fraňková, *Social enterprises and non-market capitals: a path to degrowth?* Journal of Cleaner Production **38**, 7 (2013).

P. Port of Rotterdam authority, *Bio industry, rotterdam, the world largest bio industry cluster,* Department of Energy and Processindustry (2017).

S. Ghizzardi, *Green gold,* (2018).

W. van der Lans, *Bio synergy in the port,* Port of Rotterdam, department Energy and Processindustry , 18 (2016).

M. Lunter, *Presentation - bioport holland,* (2015).

N. Heineken, *Organisaties tekenen intentieverklaring groene corridor,* (2017).