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Darel CONSULTANCY

Economic Market Models for Shore Power in Maritime Shipping

23th of April 2025,
Prepared by DAREL on behalf of North Sea Port

Structure of the report

For North Sea Port different economic models for shore power were explored.

An overall introduction into shore power is given where the different technical aspects are discussed; current regulation and regulation that will be imposed in the future and finally an introduction of North Sea Port.

Different type of economic models are subsequently explained, a division is made between the building, design and finance phase and the operation and maintenance phase. For these phases the best practices, advantages and disadvantages are described. To compare the price of a kWh for MGO and shore power a price breakdown of both sources is given. Finally different ways to mitigate risks are described.

To see what kind of economic models are used in different ports around the world, interviews were held. In total twelve ports in Europe and North America were interviewed about the background and experience regarding shore power. Secondly their operational model was discussed and finally the questions focused on the economic model that was applied. With the help of these interviews theoretical models could be compared to real life models.

To involve the stakeholders of the implementation of shore power in North Sea Port four workshops were held. The first three focused on the terminals, shipping companies, network companies and service companies for each sub-area of the port (i.e. Gent, Terneuzen and Vlissingen). During these workshops the different aspects of shore power were discussed. A fourth workshop with governmental bodies was held.

To find out what the optimal economic market model is for North Sea Port a multicriteria analysis was performed – this was done with the help of different criteria and a TECOP model. Per segment typical TECOP risk and opportunities archetypes were defined. Which subsequently could be used to describe what role parties should take in North Sea Port. And this gave way to highlight what role North Sea Port could take.

With the help of the interviews, workshops and multicriteria analysis the challenges and currently used business models were elaborated.

In the final chapter conclusions and recommendations have been summarised.

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1. Introduction and approach

In 2019 the European Green Deal was presented, a new growth strategy towards a climate-neutral and circular society. The fit for 55 package was the first set of legislative proposals to meet the targets of the European Green Deal. A part of the fit for 55 package was the future obligation of certain ships to use shore power – and thereby cutting the emission of CO_2, NO_x, particular matter and noise. The FuelEU Maritime regulation oblige vessels (i.e., Cruise, RoPax and Container vessels) to use shore power for all electricity needs while moored at the quayside in major EU ports as of 2030. It will also apply to the rest of EU ports by 2035. The AFIR (*Alternative Fuel Infrastructure Regulation)* requires that 90% of the port calls of certain ship types must be facilitated with shore power, in line with FuelEU Maritime. Furthermore, AFIR obliges inland ports should at least have one shore power point.

North Sea Port has asked Darel to examine what economic models are being used to enable shore power and what model is best suited for the quays situated at North Sea Port.
The objectives of this study are:
1. Identify the economical and legal success factors and legal pitfalls
2. Provide insight in economical market models and the corresponding gains and costs
3. Clarify how to mitigate risks
4. How to make use of stimulus policies available for shore power?

In the following paragraphs shore power at North Sea Port is further introduced.

1.1. Shore power

The idea behind shore power is straightforward: while a vessel is at berth a connection is made to the onshore grid. By connecting to the onshore grid, the vessel's own power generation i.e., the engines of the vessel can be turned off. This results in a reduction in CO_2, NO_x, particular matter and noise which have both global and local benefits.

In Figure 1 a schematic representation is shown from grid to vessel. It starts at the high voltage grid (1) which is transformed to medium voltage (2) to distribute it to places where it is needed. The standard frequency on international vessels is 60 Hz and the frequency of the grid is 50 Hz and therefore should be converted (4). As safety measure a galvanic separation is set up between the shore and the vessel (5). To connect the vessel to the grid a cable management system – a system that is moveable, can make use of different connection sockets and is safe to use and therefore can be used on a variety of vessels (6). These parts together make a shore power installation.

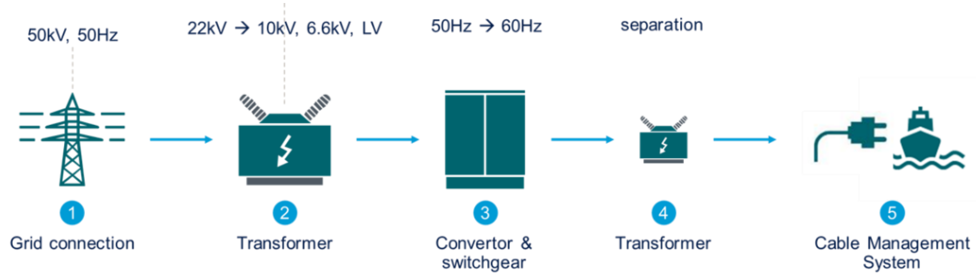


Figure 1: From grid to vessel

1.2. Regulation

Shore power deployment is – at least in the European Union – for a large part driven by European legislation. The fit for 55 package was the first set of legislative proposals to meet the targets of the European Green Deal. In total there are thirteen proposals which provide legislation in a wide range concerning sustainability.[1] Three proposals are of most concern for the introduction of shore power in Europe: 1) Revision of the Alternative Fuels Infrastructure Regulation (AFIR), 2) FuelEU Maritime, and 3) Revision to the EU Emission Trading Scheme (Revision EU ETS).

1) AFIR

The AFIR (*Alternative Fuel Infrastructure Regulation)* requires 90% of the port calls, of certain ship types, must be facilitated with shore power at seaports, in line with Fuel EU Maritime by 2030. AFIR also obliges those inland ports should at least have one shore power point by 2030.[2]

2) FuelEU Maritime

The Fuel EU Maritime oblige vessels (i.e., Cruise, , RoPax and Container vessels) to use shore power for all electricity needs while at berth in major EU ports as of 2030. It will also apply to the rest of EU ports by 2035.[3]

3) Revision EU ETS

The Revision to the EU Emission Trading Scheme extends the current EU's Emission Trading System (ETS) to cover CO_2 emissions from all large vessels (>5000 gross tonnage) that enter EU ports. The system covers: 50% emissions on voyages into or out of the EU; 100% of emissions that occur between two EU ports and when vessels are within EU ports. The ETS covers CO_2 and from 2026 also CH_4 and N_2O.[4] The new ETS system will be mandatory for cargo/passenger vessel (5000 GT) from 2024 and for offshore vessels (5000 GT) from 2027.[5]

[1] Ealing Activity 1 – Milestone 6 report: https://ealingproject.eu/wp-content/uploads/2022/11/EALING_Milestone-6_DEF-24112022.pdff

[2] Directive 2014/94/EU: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0094

[3] Directive 2009/16/EC: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0562

[4] Reducing emissions from the shipping sector: https://climate.ec.europa.eu/eu-action/transport-emissions/reducing-emissions-shipping-sector_en#:~:text=Inclusion%20of%20maritime%20emissions%20in,of%20the%20flag%20they%20fly

[5] FAQ – Maritime transport in EU ETS: https://climate.ec.europa.eu/eu-action/transport-emissions/reducing-emissions-shipping-sector/faq-maritime-transport-eu-emissions-trading-system-ets_en

1.3. Introduction North Sea Port

North Sea Port is a port that covers two countries and extends over 60 kilometres. Figure 2 shows the location of North Sea Port. It is a multimodal port that distributes goods from all over the world and distributes it across Europe and beyond. It is the 10th biggest port in Europe and in total there are 550 companies active in the port. The port handles a wide range of goods and articles – from dry and wet bulk to containers and food. Because of this variety the vessels that moor at the quays of the port also vary a lot. It influences the kind of vessels, the time at berth and the energy used while at berth.

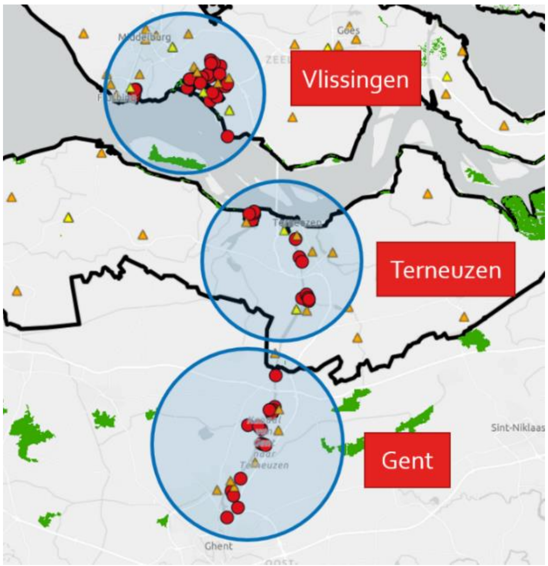


Figure 2: Map of Nort Sea Port

In Appendix 1 an estimate is provided on the reduction potential of environmental impact from shore power at North Sea Port.

When building a shore power installation, it must be clear what type of vessels will use it, how long they will stay at the at the quay and what the energy use of the vessel is. The type of vessels can be categorised in following types: container, RoRo, liquid bulk, break bulk, dry bulk, utility vessels and tugboats.

2. Economic models for shore power

Shore power supply is not yet mandatory, and the use of a vessel's own energy supply is usually cheaper than the use of shore power. This makes the implementation of shore power financially unattractive, and subsidies are needed to cover the difference between using electricity for the vessel's own generator and the use of shore power. In this chapter the different economic models that are used for shore power in the build, design and finance phase and the operation and maintenance phase will be described.

2.1. Build, design and finance phase

There must be an incentive to build shore power installations. Different parties can take the lead in the realisation of shore power. In Table 1 the various possibilities are described with an example of a best practices and both the advantages and disadvantages. It thus depends on the type of vessels, the quay itself (e.g., cruise terminal, container terminal) and how the different actors in a port interact.

Table 1: Design, build and finance options

Design & Build (Finance)	Best practices	Advantages	Disadvantages
EPC[6] by Port	Many cruise terminals	Port can possibly influence port fees and discounts	Usually applied when port participates in terminal (e.g. cruise)
EPC by Terminal	Off Shore	Shore power installation can be integrated in existing infrastructure	Currently it is difficult to make a financial sound business case. Level playing field needs to be created
ServiceCo	Rotterdam Shore Power	Effort outsourced	Future demand needs to be known for ServiceCo to set adequate fees

In general, it is hard to make a sound business case. It helps when port, terminal, key ship operators and ServiceCo (when applicable) are aligned on future expectations of the use of the intended shore power installation.

[6] EPC = Engineering, Procurement and Construction

2.2. Operation and maintenance phase

When the installation is built and ready for use a next set of choices must be made concerning the operation and maintenance phase. A shore power installation can only be handled by skilled workers therefore the operation and handling of vessels that make use of the shore power installation must be appointed to a certain part. Next to the day-to-day operation regular maintenance is also needed.

In Table 2 the various types of Operation and Maintenance (O&M) options are shown.

Table 2: Operation and maintenance shore power installation options

Operate and maintenance	Best practices	Advantages	Disadvantages
ServiceCo	Rotterdam	Effort outsourced	Future demand needs to be known for ServiceCo to set adequate fees
O&M contractor of port	Many cruise terminals	How to involve O&M partner in design & build?	
O&M contractor of terminal	Gothenburg	How to involve O&M partner in design & build?	
Concession	Sandefjord	Effort outsourced	Complex tendering

2.3. Price breakdown

To compare the price that is paid per kWh for the marine gasoil (MGO) situation – where a vessel uses its own engines for energy – and the shore power situation all direct and indirect costs must be considered. In Figure 3 the breakdown for the future MGO situation is explained. It consists of fuel usage; maintenance on the engine and a CO_2 price that will be imposed in the future.

The shore power situation is made up of three components: firstly, the desired shore power rate (SP rate) – which will be discussed later; secondly the depreciation of the onboard shore power installation and thirdly the operational costs of connecting the vessel to the shore power installation.

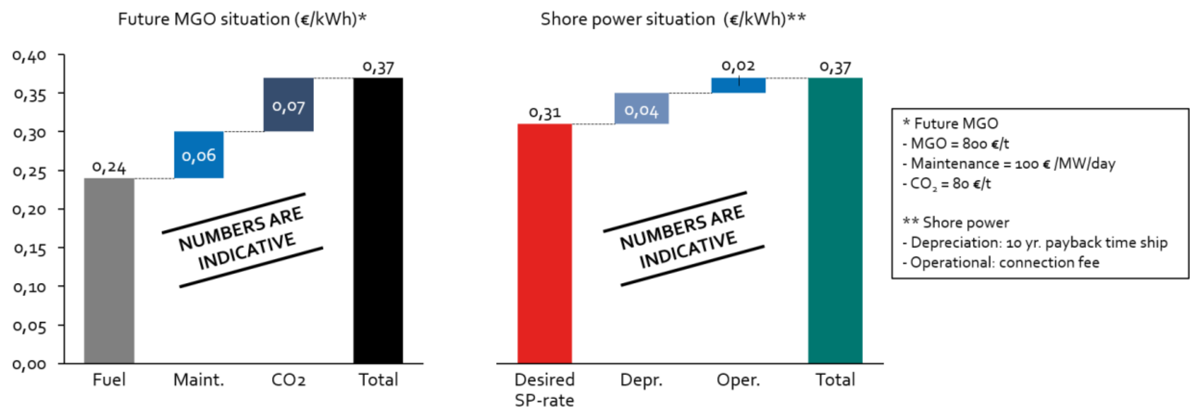


Figure 3: Price comparison future MGO and shore power

For the shipowner it is important that the Total Cost of Ownership (TCO) for shore power is comparable to the current Total Cost of Ownership (from MGO), including all indirect costs. For the operator/owner of the shore power installation the shore power-rate should cover all costs regarding with the installation these include:

1. *Electricity price:* this is the wholesale price of electricity including taxes;
2. *Grid-costs:* all the costs that come with having an electrical connection: the transport of electricity, capacity of the connection; connection fee; etc.;
3. *Depreciation:* the depreciation of all the shore side installations: cable managements systems; frequency converters, transformers, etc.;
4. *Maintenance:* periodically maintenance that has to be performed in order to keep the installations running;
5. *Service:* The operation of the shore power installations: connection the socket to the vessel, billing and administration, etc.

To compete with the MGO-case the difference between the desired shore power-price and actual shore power-price should be overcome by subsidies. In this way the price per kWh is lowered to the kWh price that a vessel pays in the MGO-case. There are however potential risks for the stability of this price due to volatile electricity prices, utilisation rates, potential subsidies and costs of finance and operator.

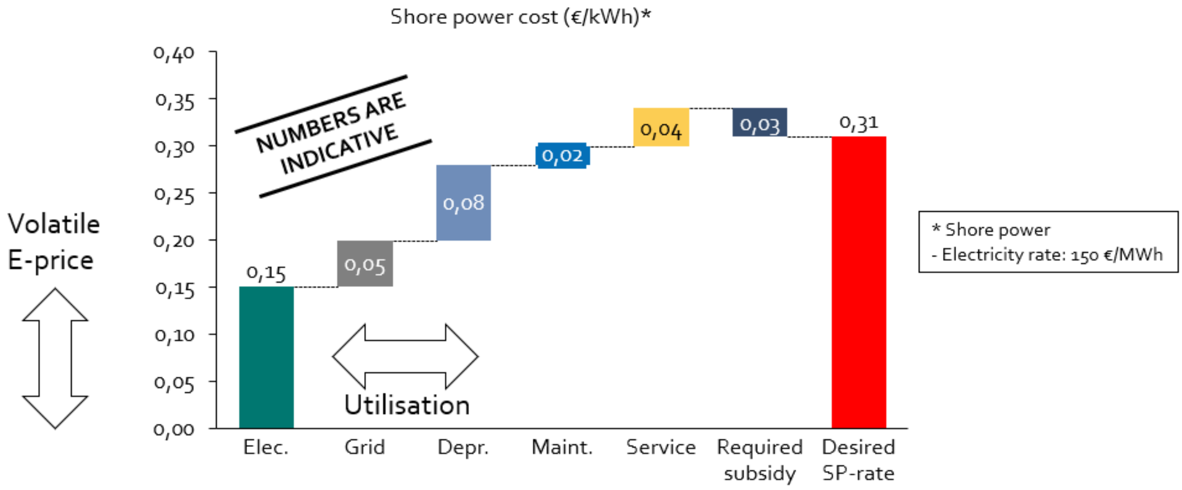


Figure 4: Breakdown of shore power costs (€/kWh)

2.4 Risks in economic models

To mitigate risks involved with building and operating a shore power installation Table 3 gives an overview of commercial constructions that can be implemented to overcome some of these risks.

Table 3: Option table for commercial constructions and risks

Guarantee demand	Mitigation low demand at start	Price mechanism	Upside sharing	Downside sharing
Loi from ship operators	None	Fixed price (set at certain level)	None	None
Government guarantee	Gradually increasing (10% -> 100% in 2030)	Variable price (wholesale) plus margin	Capped IRR	Fixed OPEX per year
North Sea Port facilitates	Needed as long as there is no AFIR legislation	Hedged to MGO	Open book	In function of demand
None (= risk provider)	Generator ban	Fixed price (set in competition)	Other	Other

2.5 Conclusions

Looking at the economic models for the design, building and finance phase; the operation and maintenance phase; the price breakdown and the commercial constructs and risks two key conclusions can be made:

- Government guarantees and/or subsidies are required to make a viable business case for shore power.
- Letter of Intents (LoIs) that the key ship operators will use the shore power installations are also required to make a suitable business-case.

3. Interviews and workshops

To see what kind of different economic models that are used for shore power, interviews were conducted with twelve different ports around the world. Simultaneously three area specific workshops with the particular stakeholders and one workshop with governmental bodies was organised.

3.1 Interviews

An interview setup was used to structure and standardize the interviews. Firstly, a set of questions asked about the background and experience of the port regarding shore power. Secondly, the operational model was discussed with the interviewee and finally the questions focused on the economic model that was applied.

3.1.1 Segments and responsibilities

In the following figures, the most important findings from the interviews regarding what segments have shore power and how the responsibilities are divided are shown.

	Segment					
Port	Cruise	Container	Ferry	RoRo	Bulk	Offshore
Port 1	Investment decision for implementation taken	Investment decision for implementation taken				
Port 2		Investment decision for implementation taken		Implemented		
Port 3	Implemented	Implemented				
Port 4	Implemented		Implemented			
Port 5	Implemented		Implemented			Implemented
Port 6					Implemented	
Port 7	Investment decision for implementation taken	Investment decision for implementation taken		Investment decision for implementation taken		Implemented
Port 8	Implemented					
Port 9	Implemented	Implemented		Investment decision for implementation taken		
Port 10	Implemented	Implemented	Implemented			
Port 11	Implemented	Implemented				
Port 12	Implemented					

Implemented   Investment decision for implementation taken

Figure 5: Summary of realised terminals with shore power

In many ports the cruise segment is the front runner in the fulfilment of shore power installations. From the interviews it was made clear that this was the case because of environmental concerns (cruise terminals are often close to build environment) and the willingness of the cruise segment to be sustainable (and pay a premium to make use of shore power). Other segments that are obliged by AFIR to use shore power by 2030 – RoPax and Container vessels – see also an uptake in investments in shore power installations.

As discussed in chapter 2 there are different phases in the development of shore power:

		Responsible parties for shore power					
Port	**Segment***	Owner	Design and build**	Operate**	Maintenance**	Billing**	Role Port
Port 1	Container	Terminal	Tbc	Tbc	Tbc	Tbc	◔
Port 2	RoRo	Port authority	Port authority	Terminal	Terminal	Terminal	◑
Port 3	Container	Port authority/terminal	Port authority	Port authority	Port authority	Port authority	●
Port 4	Ferry	Port authority	Port authority	Ferry	Port authority	Port authority	◕
Port 5	Ferry	Port authority/Ferry	Port authority/Ferry	Ferry	Ferry	Ferry	◔
Port 6	Bulk	Terminal	Utility	Utility	Utility	Utility	◔
Port 7	Offshore	Service Co	Service Co	Service Co	Service Co	Service Co	◔
Port 8	Cruise	Ship operator	Utility	Utility	Utility	Utility	◔
Port 9	Container	Terminal	Port authority	Terminal	Port authority	Port authority	◕
Port 10	Container	Port authority	Ready	Tbc	Tbc	Tbc	◑
Port 11	Container	Port authority	Port authority	Port authority	Terminal	Utility	◔
Port 12	Cruise	Port authority	Port authority	Port authority	Port authority	Port authority	◑

** Dominant shore power segment (if existent) after cruise*
*** Responsible party has economic risks and usually has SLAs with suppliers*

Ports mostly took first initiatives, but aim to move to facilitating role where market parties enter

Figure 6: Overview of responsibilities for shore power at different ports

In Figure 6 the responsibility for every phase of shore power per port has been shown. Because of the dominance of the cruise segment in the development of shore power at the interviewed ports and since this is not the case at North Sea Port – it was chosen to focus on the segment other than cruise if present. The port authorities mostly took first initiatives for shore power but aim to move to facilitating role when market parties enter.

The building and operation of a shore power installation is capital-intensive and cannot entirely be paid back by the fees that vessels pay to make use of shore power during the start-up phase when shore power is not mandatory. So, in almost all cases subsidies are mandatory to overcome this finance hurdle. From the interviews we learned that the subsidies were usually paid by regional and national governments. In some cases, the capital needed came from funds from the port. In that case the ports sometimes decided not to require the return on investment they typically seek for.

3.1.2 Price build-up and incentives

Next to the installation on shore the vessels must also be made ready for the use of shore power. Adjustments to a vessel is needed to make it shore power ready. For example, the electrical infrastructure including the right socket must be available and reachable to make contact with a shore side cable management system. These costs are carried out by the vessel-owners themselves.

	Electricity price build-up				
	Base price			Extra's	
Port	Open market	Fixed	MGO hedged	Add-on	Connection fee
Port 1	To be decided		☐	To be decided	
Port 2	Up to terminal (as operator)		☐	Up to terminal (as operator)	
Port 3	✓	☐	☐	✓	✓
Port 4	✓	☐	☐	☐	✓
Port 5	✓	☐	☐	✓	✓
Port 6	Up to terminal (as operator)		☐	Up to terminal (as operator)	
Port 7	✓	☐	☐	✓	✓
Port 8	✓	☐	☐	☐	☐
Port 9	☐	✓	☐	☐	☐
Port 10	☐	✓	☐	☐	✓
Port 11	☐	✓	☐	☐	☐
Port 12	✓	☐	☐	✓	✓
	Electricity prices are set at level that are considered 'reasonable' given the regulation				

Figure 7: Overview economic models used in interviewed ports

Different price models are applied:

1. *Open market* the price for the electricity is set in an open market mechanism (usually a wholesale market);
2. *Regulated* a certain price is set by the regulator of the electricity market in that country;
3. *Add-on* this is usually combined with the open market price the user pays a fixed fee per MWh on top of the open market price;
4. *Connection fee* on top of the amount of electricity that you use.

The above pricing methods should cover the operational costs of operating and maintaining the shore power installation. Fluctuations in electricity price from the grid are passed on to the customers.

The ports or responsible governmental organisations have different methods to increase the use of shore power. The first one is subsidies. Subsidies in a shore power installation could consist of a percentage of the capex investment of the shore side of the installation – without the operational costs and incomes from the sale of electricity. These subsidies cover the unprofitable top while the use of shore power is not widespread yet and thus results in a lower price for the users of the installation.

Secondly, ports can give a discount on the port fees if a vessel uses shore power instead of its own engines. In this way the possible extra costs of the use of shore power are decreased.

The third way is to install shore power at more suitable quays. Quays that for example are closer to the city or closer to infrastructure that is needed at berth. How these instruments are used at the ports that have been interviewed can be seen in Figure 8.

	Incentive shore power		
Port	Subsidies	Lower port fees	Premium quay location
Port 1	To be finalised	☐	☐
Port 2	40 %	☐	☐
Port 3	70-100 %	☑	☐
Port 4	30%	☐	☐
Port 5	75 %-> 0%	☐	☐
Port 6	0 %	☐	☐
Port 7	30-100%	☐	☐
Port 8	0 %	☐	☑
Port 9	30-50%	☑	☑
Port 10	55 %	☐	☐
Port 11	30-70 %	☐	☐
Port 12	0%	☑	☐

Figure 8: Incentives to increase the use of shore power

3.1.3 Tenders

During the interviews the tendering phase was not discussed in much detail. Clustered tenders were not mentioned and appeared not to be common due to the pilot scale of shore power installations. Terminals that collectively issue a call for tenders are not common either, this is probably due to the lack of information of the individual costs for each terminal. The business cases for different types of terminals varies a lot – therefore it might commercially difficult to cluster tenders.

Because most ports we interviewed are public companies most of the shore power projects were publicly tendered. Although public tendering is transparant, it is a complex given for public companies due to high requirements and standards that are demanded, also it limits flexibility.

3.2 Workshops

To include North Sea Port stakeholders, four workshops were organised. Three area specific workshops(i.e., Ghent area, Terneuzen and Vlissingen area), where the following parties were invited: North Sea Port, terminals, shipping companies, public grid companies and service companies. Finally, a fourth workshop was held with related governmental organisations.

3.2.1 Area specific workshops

The participants of the workshops can be found in Figure 9.The workshops were organised to discuss shore power with relevant stakeholders. Firstly, the context of shore power was given with most important points below:

- Shore power is a promising and sustainable investment
- High investments needed, with a lot of uncertainty concerning volume and price
- Collaboration with different parties is essential
- Run-in period: at this moment no obligation

Segment	Parties present	Roles	Location		
			Gent	Terneuzen	Vlissingen
Break bulk / dry bulk	8	Terminal	☐	☑	☑
Liquid bulk	5	Terminal	☑	☑	☑
RoRo	5	Terminal	☑	☑	☑
Offshore	3	Terminal / shipowner / yard	☐	☐	☑
ServiceCo	3	Supplier	☑	☑	☑
Network company	2	Network company	☑	☑	☐
Reefer	2	Terminal	☑	☐	☑
Container	2	Terminal	☑	☐	☑
Shipping	1	Shipping	☐	☑	☐

Figure 9: Parties present during workshops with terminals

3.2.2 Workshops with terminals and government bodies

Government bodies often take a strong role in regional planning (e.g. master planning for electricity grid) and stimulating the reduction of environmental impact from shipping. Implementation of shore power is often included in the climate change ambitions of the local government body for example when there is a need for improvement of air quality. The dialogue on a joint ambition for shore power from North Sea Port together with its relevant government bodies is at an early stage. The potential for shore power and relevant schemes are regularly exchanged between North Sea Port and its government bodies. A step-up in joint ambitions could be pursued. However a push towards shore power from the local/regional governments is not so much felt in North Sea Port.

3.3 Conclusions

- The cruise segment was in almost all cases the segment that made most progress in the development of shore power.
- Drivers behind this lead of the cruise segment are environmental concerns – the location of the cruise terminals in a port which is usually near the city – and the willingness of cruise operators to pay a premium.
- Subsidies are usually granted for the capex of the shore side of the shore power installation, not for the opex costs and neither for the vessel adjustments.
- The subsidies often come from regional and national governments.
- To mitigate risks in the fluctuation of electricity prices and utility costs interviewed ports have a straightforward approach for price setting:
    - Operational costs are incorporated in electricity/supply costs.
    - The risk of volatile electricity prices is transferred to the end users, the ship operators.
- Incentives for ship operators to make use of shore power is on one hand discounts on port-fees and on the other hand the use of shore power at premium locations.
- More and more ship operators are asked by their clients to green the supply chain and reduce the environmental CO_2-footprint by using shore power.
- In most cases the ports took the first initiative in implementing shore power. After building the installation port authorities aimed to introduce market parties to operate and maintain the facility.
- Terminals have limited influence on the demand for shore power of shipping companies
- A level playing field should be created so a ship will favour a terminal in North Sea Port over a terminal outside of North Sea Port. North Sea Port and terminal operators should therefore work together.
- In the end the shipping companies and end customers will decide if a vessel will use shore power.
- The service companies that were present at the workshops are willing to help with the fulfilment of shore power in North Sea Port, by offering Engineering and Construction services and offering shore power as a service (ServiceCo model).
- For some of the terminals it was still unclear what is needed for a shore power installation: there is a need for more information.

4. Multicriteria analysis

In this section, various roles and responsibilities are compared with each other for the specific situation of North Sea Port. We do this based on several criteria, the so-called multi-criteria evaluation. The methodology of the multicriteria analysis can be found in

Appendix 2: Methodology Multicriteria analysis From this, conclusions can be drawn about the most optimal economic market models for shore power for North Sea Port. The roles and responsibilities can possibly be further adjusted, so that a truly customized solution is created.

4.1 Terminal archetypes

The multi-criteria analysis has been applied to the terminals in North Sea Port. Together with the interviews of international ports several archetypes can be defined. The archetypes are explained in more detail in chapter 5. Findings per segment.

- Dry bulk and breakbulk (hub terminal)
- Dry bulk and breakbulk (end terminal)
- Reefer
- Liquid bulk
- Offshore vessels
- RoRo terminal
- Frequently used container terminal

4.2 The roles that parties should take

To mitigate the risks and use the opportunities that arise from the TECOP analysis multiple parties need to work together. Figure 10 below shows how multiple parties could work together in the example of a shore power project lead by a ServiceCo.

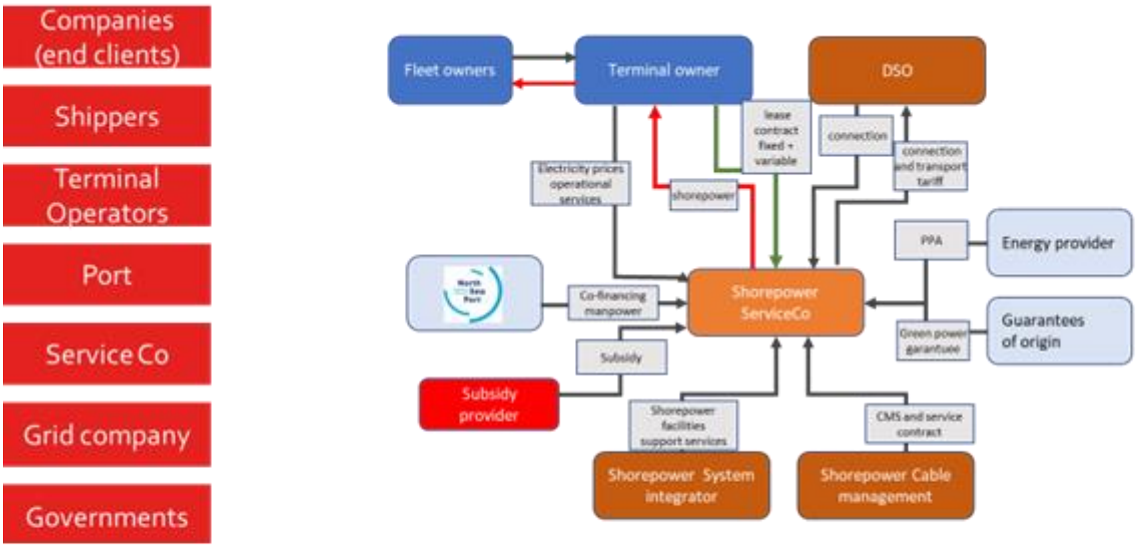


Figure 10: Cooperation model for shore power ServiceCo

From the interviews with international ports, it was concluded that shore power projects often were initiated by the Port Authority (out of necessity), and that it was the aim to move responsibility for implementation to market parties. To identify what responsibilities market parties could pick up, the key TECOP activities in have been mapped in Figure 11.

Figure 11: Model for mitigation of shore power TECOP risks

Looking for the parties that could best mitigate the TECOP risks and opportunities, and applying it to the archetypes we defined earlier, the following preferred parties taking the lead could be defined for the archetypes (Figure 12).

<u>Initiation phase</u>

Prevailing risk or opportunity	Initiator for shore power project
Technical	Terminal / ServiceCo
Environmental	Port authority / Subsidies (local government)
Commercial	Terminal / Subsidies (local government)
Operational	Terminal / Port authority
Political	Port authority / Subsidies (local government)

Figure 12: Party to lead first phase for shore power projects for North Sea Port archetypes

In the TECOP analysis for risks and opportunities for each category (Technical, Environmental, Commercial, Operational and Political) the preferred first mover to initiate was determined. If the prevailing risk was pure technical in nature the initiator could be terminal together with a ServiceCo due to the expertise in solving the technical problems.

In the case of environmental risks the port authority with help of subsidies from the municipalities could initiate shore power. Due to the environmental benefits on the surroundings/build environment of the terminal.

If the highest risk is commercial in other words installing and using shore power is too expensive the local government could help the terminal to cover this unprofitable top by granting subsidies.

If there are operational risks the terminal together with the port authority should seek how to make the terminal more favourable for ships to make a call and make use of the shore power installation.

Political risks mean the terminal is no AFIR segment and there are no legal obligations to implement shore power. To stimulate these terminals there are subsidies needed – till regulation comes into place - from the local government and a clear vision from the port authority to enable shore power.

E(ngineering) P(rocurement) C(onstruction) and O&M phase

After the initiation phase mixed models are also possible. For example, a port and a utility company have a joint ownership in a ServiceCo that is specialised in installing shore power. Another possibility is a joint venture between a port and a terminal (special purpose vehicle) for the fulfilment of shore power. It is also possible for a terminal and an EPC-partner to share the risks when installing shore power. But there is also cooperation possible between ports and municipalities to apply for subsidies. Finally in the operating of the system – who is responsible for the connection – it should be clear what responsibilities each partner has.

All these examples of preferred parties taking the lead are not set in stone but can shift over time due to new legislation or other factors. Therefore, it is recommended to include evaluation clauses in the commercial contracts, anticipating shifts in roles.

4.4 Conclusions

In this section a categorisation of terminals based on the TECOP-framework was explained. This categorisation and framework are helpful to discuss the risks and opportunities for shore power projects. It also gives some guidance on which parties are best positioned to mitigate the risks. Several terminal 'archetypes' were defined.

The optimal economic model for the individual terminals will vary from the archetypes for the whole segment. For some terminals, clients might have different needs or wishes than for the broader client category. It is therefore recommended to discuss the TECOP analysis with the individual terminals, and check whether they see risks and opportunities the same as in the analysis.

Also, feasibility studies will help to develop a common view on risks and opportunities. It is therefore recommended that feasibility studies must be carried out with a broader perspective (technical, commercial, environmental, organisational and political). With that in mind it can be agreed upon which party can and will lead in what stage of the individual shore power project.

5. Findings per segment

The multi-criteria analysis has been applied to the terminals in North Sea Port. Together with the interviews of international ports several archetypes can be defined. The tables below describe the typical TECOP risks and opportunities for these archetypes.

5.1 Liquid bulk

About 26% of transhipments of goods by sea-going vessels in the North Sea Port can be found in the liquid bulk segment. Although there is no AFIR obligation for liquid bulk vessels there has been activity on the standardisation of shore power for the liquid bulk segment. There are some difficulties with the liquid bulk segment: e.g., the energy demand of these ships vary a lot and can be very large. Furthermore, the liquids that are shipped can be dangerous (ATEX[7]), so there is a need for safe and reliable procedures. Since shore power for liquid bulk is not yet extensively being used the economic models are currently in development.

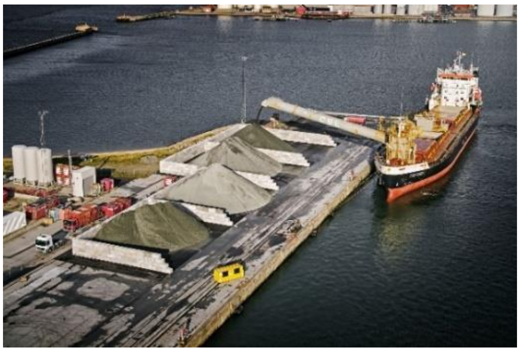
Table 4: Liquid bulk

Technical	Medium standards
Environmental	Good benefits / €
Commercial	Medium business case
Organizational	Good coordination needed
Political	No AFIR

Initiate	EPC	O&M
Terminal	*Tbd*	*Tbd*
Port	*Tbd*	*Tbd*

[7] ATmosphere EXplosible (ATEX)

5.2 Break bulk / Dry bulk



Break bulk and dry bulk accounts respectively for 15% and 51% of the transhipment of goods by seas-going vessels in North Sea Port. Break bulk and dry bulk are not AFIR obliged, and shore power standardisation is not at a very mature stage. A difficulty with break and dry bulk is that the number of calls per terminal vary a lot due to the use of a spot market. Due to the immature state of shore power readiness for these vessels there are a lot of unknowns when it comes to making the vessels shore power ready. It is not yet clear what the best economic model is for this segment and is therefore still in development. A distinction was made between a hub terminal and an end terminal.

Table 5: Break bulk / Dry bulk (hub terminal)

Technical	Poor standardisation
Environmental	Medium benefits / €
Commercial	Unprofitable top
Organizational	Multi customer
Political	No AFIR

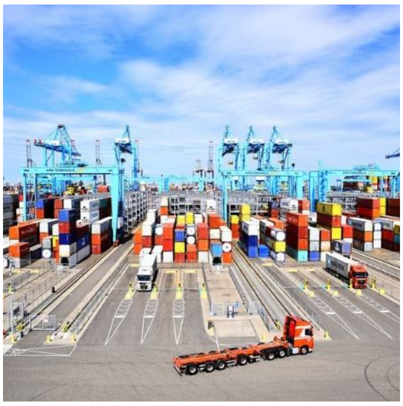
Initiate	EPC	O&M
Port	*Tbd*	*Tbd*
Terminal	*Tbd*	*Tbd*

Table 6: Dry bulk and breakbulk (end terminal)

Technical	Poor standardisation
Environmental	Medium benefits / €
Commercial	Unprofitable top
Organizational	More regular customers
Political	No AFIR

Initiate	EPC	O&M
Port	*Tbd*	*Tbd*
Terminal	*Tbd*	*Tbd*

5.3 Container / Reefer



Container that includes reefer (refrigerated container) are both AFIR in 2030. Because of this deadline already there has been made a lot of progress. Standardisation is in an advanced state. However, there is still uncertainty about pricing. Therefore, coordination between different ports is needed to create a 'level playing field' until shore power is obligated, to prevent that vessels go to the 'next' terminal in another port where the use of shore power is not obliged by the port. The reefer segment has logistic challenges with multi-customers and keeping the containers cooled. The initiative to install shore power until now was taken mostly by the port authorities but a shift towards terminals is pursued.

Table 7: Frequently used container terminal

Technical	Good standards
Environmental	Good benefits / €
Commercial	Medium business case
Organizational	Multi-customers
Political	AFIR

Initiate	EPC	O&M
Port	ServiceCo	ServiceCo
Terminal	EPC Terminal	O&M Terminal

Table 8: Reefer

Technical	Logistic challenges
Environmental	Good benefits / €
Commercial	Medium business case
Organizational	Multi-customers
Political	AFIR

Initiate	EPC	O&M
Port	ServiceCo	ServiceCo
Terminal	EPC Terminal	O&M Terminal

5.4 RoRo

RoRo vessels are currently not obliged under AFIR to make use of shore power. However there have been made some progress and standardisation (e.g in Gothenburg en Rotterdam). The RoRo segment has the advantage that the terminal and vessels are sometimes part of the same company. In this case there is no split incentive between the terminal and the shipowner, which makes it easier to install shore power.

Table 9: RoRo terminal

Technical	Standard standards
Environmental	Good benefits / €
Commercial	Unprofitable top
Organizational	Limited # customers
Political	No AFIR

Initiate	EPC	O&M
Terminal	EPC Terminal	O&M Terminal
Port	ServiceCo	ServiceCo

5.5 Offshore

Offshore vessels are also present at terminals in North Sea Port, there is no AFIR obligation for this type of vessels. The main problems for implementation of shore power in this segment is the difficulty to predict the demand and the relatively low utilisation grade. Offshore vessels have a strong relation with the terminal where they berth and the knowledge to install shore power is often in-house. At berth the electricity use is usually a relatively small part of the service costs, so the electricity price will have a relatively smaller effect on the costs at berth than with vessels from other segments. For most companies in the offshore segment sustainability is of importance in the value chain, which makes it more beneficial to install shore power. The common economic models that are used are a) to do the investment by themselves with an independent company that does the operation or b) use a ServiceCo that installs shore power with subsidies.

Table 10: Offshore vessels

Technical	Complex technically
Environmental	Medium benefits / €
Commercial	Unprofitable top
Organizational	Clients demand shore power
Political	No AFIR

Initiate	EPC	O&M
Terminal	EPC Terminal	O&M Terminal
Port	ServiceCo	ServiceCo

6. Conclusion and Recommendations

From the interviews, workshop, multi criteria analysis and research into economic models the following conclusions can be drawn.

1. Government guarantees and/or subsidies are often still required to make a viable business case for shore power.
2. Letter of Intents (LOIs) from key ship-operators are also required to meet a minimum offtake.
3. If there is no obligation to use shore power the port authority - when there is an environmental related push - often took the first initiative.
4. A level playing field should be created. If a terminal installs shore power this should not have a negative effect upon the amount of calls the terminal receives.
5. The service companies that were present at workshops are willing to help with the realisation of shore power in North Sea Port by offering EPC-services or offering shore power as a service.
6. For some of the terminals it was still unclear what is needed to realize a shore power installation, there is a need for more information.

With the help of the TECOP-framework risks and opportunities were identified for various types of terminals (bulk, reefer, RoRo, offshore container, cruise). This gives guidance on which parties are best positioned to mitigate the risks, and what party could take best what role.

It is recommended to discuss the TECOP analysis with the individual terminals, and check whether they see risks and opportunities the same as in the analysis. Also, feasibility studies will help to develop a common view on risks and opportunities. The feasibility studies will not only look at technical feasibility, but at broader financial, organisational, and regulatory risks. With that it can be agreed upon which party can and will lead in what stage of the individual shore power projects.

Appendix 1: Reduction potential of North Sea Port

The total reduction potential for North Sea Port for the top 60 locations is 200.000 tonne CO_2/year and 2.200 tonne NO_x/year. The reduction potential in percentages is 50% for the Vlissingen cluster and both 25% for Terneuzen and Gent. The top 60 locations are based upon the number of ships, berthing duration and the different types of ships that berth. In Figure 13 the reduction potential for the top 60 locations of the three different clusters is described in more detail. (Source: North Sea Port)

The grid capacity in Figure 13 is a first estimate of the maximum capacity that is needed to connect all vessels that moor at the quays with a shore power installation. The Capex that is needed to develop all the shore power installations is also a first estimation.

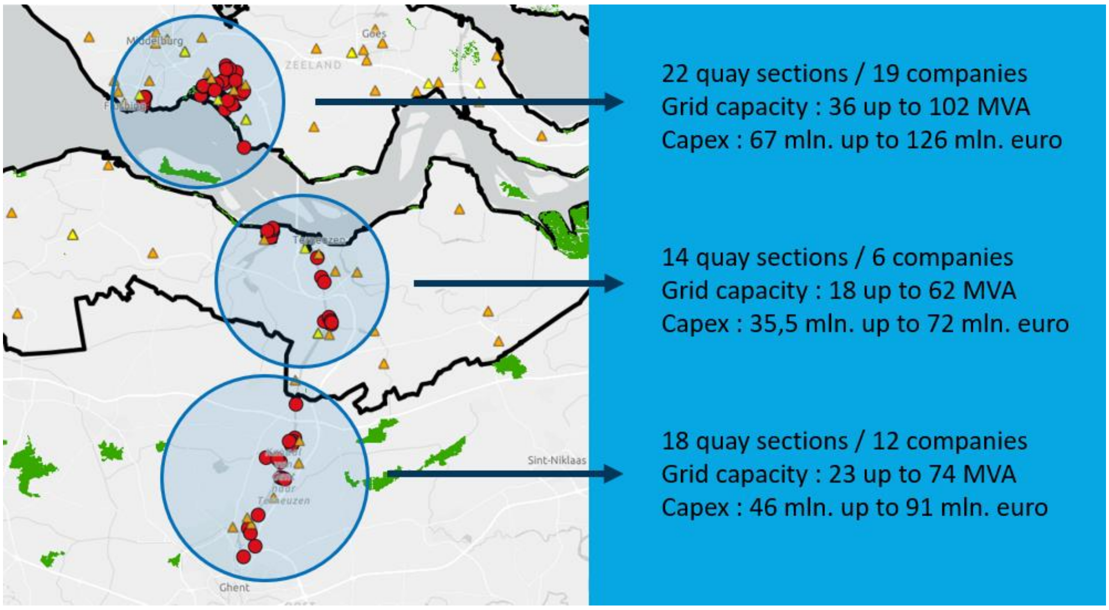


Figure 13: Reduction potential North Sea Port

Appendix 2: Methodology Multicriteria analysis

To determine the optimal economic market model the TECOP model is applied. TECOP is a risk analysis framework used to assess and manage risks in projects or businesses. The bottom-line of the TECOP model is that it describes risks for a project. These risks could be technical, financial, organisational, and external (regulation & subsidies). For this study the generic TECOP model is modified, to also include the benefits and opportunities from shore power and to highlight where shore power is most attractive. An earlier multi-criteria analysis on terminals was conducted at North Sea Port. The purpose for that study was to 'rank' the terminals with their societal costs and benefits from shore power but paid less attention to pitfalls and barriers.

The objective of the multicriteria analysis is to provide insights on what party is best suited to manage certain risks. For example, operational risks usually can be best managed by the terminal; commercial risks can be best managed by an energy supplier or ServiceCo, etc. This is summarised below.

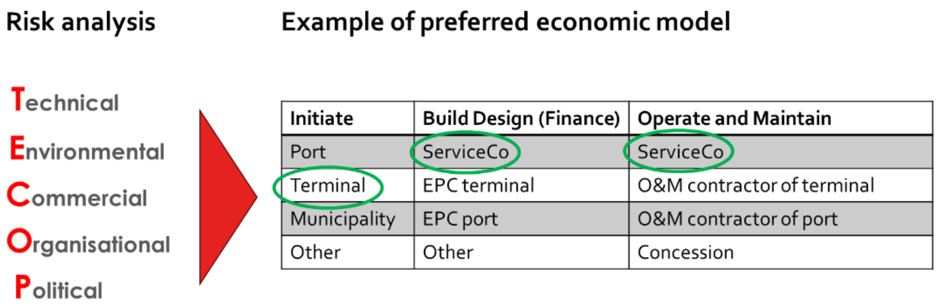


Figure 14: TECOP approach to preferred economic model

As a first step the criteria have been defined for the TECOP risk groups and the scales of the criteria have been determined (e.g. MWh, €, ratio, ordinal, yes/no, nominal) and the scores per criterion for all alternatives have described in an effect table. The scales of the criteria that were used are shown in Figure 15.

	Scope	0	1	2	3	4	Remarks
Technical	Electrical utilisation (MWh / MW)	> 4000	> 2000	> 1000	> 500	< 500	Installation with good utilisation is easier to connect
	Connection (min.)	> 4h	> 2h	> 1h	< 30m	< 10m	The longer the time to connect the easier
	Segment	Container	RoRo	Liquid bulk	Break / Dry bulk	Offshore	Rate of standardisation per segment
Environmental	Capacity (GWh)	40	30	20	10	0	Higher benefits for larger installation
	NOx (t / yr)	40	30	20	10	0	The higher the NOx reduction the better
	Distance buildings (m)	Noise complaints	< 600	> 600			Shore power is beneficial near build environment
Commercial	Price electricity	4 x MGO	3 x MGO	2 x MGO	1,5 x MGO	1 x MGO	Price shipowners are prepared to pay
	Unprofitable top (%)	0%	25%	50%	75%	100%	As percentage of CAPEX
Operational	Operator ship / quays		Same owner		Different owners		
	Regularity ships		Regular trade lane		Incidental		
	Size terminal		Multinational		SME		
	Status quay		In use		Public		
Political	AFIR	Yes			No		Shore power will be mandatory
	Subsidies		Yes		No		Are addiotianal subsidies possible?

Figure 15: Scales of criteria

Finally, an effect table lists all the opportunities and risks for the terminals at North Sea Port, and sometimes show that there are very dominant hurdles for implementation of shore power. The effect table contains commercial sensitive data and is therefore confidential.