OPTIONS FOR ESTABLISHING SHORE POWER FOR CRUISE SHIPS IN

PORT OF COPENAHGEN NORDHAVN

COPENHAGEN MALMÖ PORT

KØBENHAVNS KOMMUNE

BY&HAVN

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1. INTRODUCTION

For a number of years, Copenhagen has positioned itself as one of the major cruise ports in Northern Europe. This is particularly because Copenhagen is an attractive city for cruise tourists, but also because it offers good facilities for cruise ships, because Copenhagen Airport has many direct flights and because ships from Copenhagen can go both into the Baltic and up the Norwegian coast. The City of Copenhagen is working to be carbon-neutral in 2025, and for the air to be clean enough not to damage local people's health. It is in this light that the question of providing shore power to cruise ships has been raised.

Shore power can help to reduce the environmental impact of cruise ships. Shore power comprises an installation on shore and an installation aboard a ship, enabling the ship to be connected to the grid while it is in port. It is relatively costly to establish an on-shore facility, and not all ships can receive shore power.

The City of Copenhagen, City & Port Development and Copenhagen Malmö Port (CMP) have together drawn up this analysis of the need and options for establishing shore power for cruise ships in Nordhavn. The study was occasioned by the City of Copenhagen's Clean Air plan, implemented by a decision of the municipal Finance Committee in September 2014. The study is also part of a cooperative project with other major cruise ports in the Baltic to examine the possibility of establishing shore power for cruise ships.

If a shore power facility is established, Copenhagen will be among the first cities to offer shore power to cruise ships. A good deal of know-how will then be gathered in Copenhagen and a certain employment effect may be expected beyond establishment and operation.

The possibility of shore power for cruise ships in Copenhagen has been examined on several occasions. Both City & Port Development together with CMP and Dansk Energi together with the City of Copenhagen have produced notes on the establishment costs of shore power in the last 3-4 years.

The reason why the parties have chosen to draw up yet another study is the desire of the City of Copenhagen Finance Committee to produce a proposal for a decision on shore power for cruise ships.

The analysis describes the options for establishing shore power at the cruise terminal on Ocean Quay in Nordhavn, including the practical and financial implications. Compared to the earlier assessments, this study aims to go deeper into the opportunities and risks associated with a shore power facility and to analyse how shore power can actually be established and used for cruise ships in Copenhagen – also including an assessment of the financing options and organisation.

We hope you find the report interesting.

Report produced by the City of Copenhagen, City & Port Development and Copenhagen Malmö Port. Unless stated otherwise, the images are from Colourbox, the City of Copenhagen or City & Port Development.

2. EXECUTIVE SUMMARY

Three scenarios have been drawn up for passenger growth over 30 years to 2045 – Baseline, Low and High. Indicative price estimates have also been obtained for shore power equipment, cabling, maintenance, oil and electricity prices etc. These have been used to draw up an analysis to show the environmental effects, business case, socio-economic balance and a suggested organisational and financing model for the establishment of shore power for cruise ships at Ocean Quay in Nordhavn in Copenhagen.

Passenger growth in ships that are expected to take shore power depends on how many ships that can take shore power will visit Copenhagen. In the period 2010-2015, around 19% of the relevant cruise visits were made with ships taking shore power today, or where shore power will be installed during the course of 2015 or 2016. This figure of 19% is used in the Baseline scenario. The expected passenger growth in ships that can take shore power is shown in Table 1.

Table 1: Expected number of berths on ships that can accept shore power – projection to 2045

1,000 berths	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
2016	59	92	57
2026	96	173	80
2036	120	251	86
2045	131	314	82

The environmental effects of establishing shore power are not insignificant, but nor are they striking compared to emissions from other sources. In the Baseline scenario, the reduction in emissions of CO_2, NOx and particles is equivalent to approx. 0.1% of the total emissions of each of these substances in the City of Copenhagen. The overall environmental effects of a shore power facility are shown in Table 2

Table 2: Overall environmental effects of a shore power facility, three scenarios, 2016-2045

Reduction in emissions (tonnes)	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
CO_2	59,048	117,174	45,562
NO_X	1,182	2,346	912
Particles	19	38	15
SO_2	12	24	9

The table shows the total cumulative environmental effects over 30 years from 2016-2045

The costs of establishing shore power, operation and maintenance, purchase of electricity, national taxes and income from sales of electricity have been estimated for the three scenarios. In all three scenarios, there is added revenue to the State from national taxes on electricity. Only the High scenario produces a positive business case, and then only if the added income to the State from electricity taxes is used to finance the facility.

Table 3: Operational business case calculations for the three scenarios, without borrowing

2015 prices MDKK	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
Establishment costs	-74.8	-74.8	-74.8
Later extension of the facility*	0.0	-7.9	0.0
Operation and maintenance	-19.3	-28.2	-17.3
Purchase of electricity excl. national taxes **	-49.4	-99.5	-37.5
National taxes	-18.7	-37.3	-14.3
Sales of electricity	110.5	227.9	88.9
Total	-51.7	-19.8	-54.9
Total excl. national taxes	**-33.0**	**17.5**	**-40.7**

**) Later extension of the facility amortised over 30 years, subject to an expected future demand at the time of expansion. So only the portion of the costs actually written off in 2046 is included.*

***) The national taxes for electricity represent additional revenue to the Treasury, as the oil the ships would otherwise use is not taxed.*

There is a financing need amounting to DKK 74.8 million in public development grants in all three scenarios. On the other hand, the facility will produce a return for its owners after establishment of DKK 34.1-92.3 million if the State covers an amount equal to its revenue from electricity taxes. Alternatively, the establishment costs can be financed by loans. The costs in 2015 prices will then be around DKK 6 million lower based on P/E projections and low interest rates (cf. table 14). There is a need for a public development grant of DKK 45-50 million, as the income cannot cover the interest costs. As there are great uncertainties surrounding future income, loan financing is not recommended.

The study shows that none of the scenarios produces a positive socio-economic return with an internal interest rate over 4%. The Baseline and Low scenarios produce negative socio-economic returns.

Table 4: Socio-economic analysis of the three scenarios, 2016-2045

Present value, 2015 prices	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
Establishment costs	-71.9	-84.2	-71.9
Operation and maintenance	-10.5	-14.8	-9.6
Purchase of electricity	-25.9	-50.2	-20.5
Sales of electricity	57.4	113.6	48.2
Value of the facility after 30 years	1.2	5.9	-
Environmental aspects	27.2	53.0	21.4
Net tax factor	-26.0	-29.3	-26.2
Tax distortion loss	-10.0	-5.9	-10.7
Total (MDKK)	-58.5	-11.9	-69.3
Internal interest	**<0%**	**3.3%**	**<0%**

If the State and the City of Copenhagen wish to establish a shore power facility in Nordhavn, this could be done by a public company, with the State and the City of Copenhagen injecting the necessary capital to develop the facility. A possible organisational and financing model could be as follows:

1) A publicly owned company establishes and finances a shore power facility producing 20 MW to serve one terminal. The company can either obtain all the capital from the State and the municipality, or it can borrow a portion of it.

2) The shore power facility is made available to an operator, such as CMP.
3) The operator or operating company collects a competitive shore power charge from the ships based on their consumption of electricity. The costs to the operator and the operating company are covered by the profits from sales of electricity minus operating costs to run the plant.

3. TECHNICAL BACKGROUND

Every year, cruise ships bring some 600,000 tourists to Copenhagen, benefiting the city's businesses to the tune of DKK 1.5 billion p.a.[1] A cruise ship docking in Copenhagen typically carries between 2,000 and 3,000 passengers plus 800-1,500 crew members. In recent years there has been a big increase in the size of these ships and this trend is expected to continue. Cruise ships carrying 4,000 passengers and more are now being built.

The ships typically have an energy consumption of 7-11 MW while they are in port in Copenhagen. This is equal to the average electricity consumption of 27,000-42,000 Copenhagen households in the same period[2]. Every year, over 300 cruise ships visit Copenhagen with a total energy consumption of the order of 17 GWh. This is equivalent to the annual consumption of around 7,500 average Copenhagen households.

The energy consumption of cruise ships is currently covered by on-board diesel engines. This form of electricity production – together with production from coal – is among the most polluting. There is therefore an environmental benefit to be obtained if the ships can use a less polluting energy source while they are at the quay.

3.1. Global development

Shore power for cruise ships consists of an installation plant both on the quay and on the ship, to enable cables to be taken on board that can deliver power to the ship while it is in port. The ships typically use 7-11 MW today, so a very large connection is needed to make this possible. By way of comparison, ferries use around 1-2 MW. The cruise ships typically use the 'North American standard'. This means that the alternating current on board runs at 60 Hz, as opposed to the European standard of 50 Hz. The European current therefore has to be converted, which is costly.

The only shore power for cruise ships in Europe is in Hamburg, where the first installation is due to open in the summer of 2015. In the USA/Canada it exists on the East Coast at a terminal in New York, and on the West Coast in San Diego, Los Angeles, San Francisco, Seattle, Vancouver and Juneau (Alaska). All of these ports received financial support from the public purse, and the financing costs and electricity prices are somewhat lower than in Europe. There is thus a greater financial incentive in the USA and Canada for ships to use shore power while they are in port. At the global level there are some 400 ships, and as far as we know only around 40 of these can accept shore power; about 10% of the total fleet[3]. The vast majority of these ships sail the West Coast of the USA and Canada. Some of the remaining ships are prepared for shore power, but the final installations are not in place. It will require investments of DKK 2–20 million per ship to prepare these vessels to take shore power.

There is now an ISO standard for shore power, which describes the technical aspects. Practical elements, such as the placement of the plug connector on the ship, are not part of the standard, which means that connection facilities on shore have to be mobile, as one

[1] Figures from the Cruise Copenhagen network.
[2] According to the City of Copenhagen's CO_2 accounts for 2013, each inhabitant of Copenhagen consumes 1,152 kWh of electricity per year, excluding electric heating, equivalent to 0.13 kWh per hour. The average household in the City of Copenhagen comprises 1.99 persons.
[3] The figures are uncertain, as some shipping lines do not provide precise details.

cannot count on a fixed connection point on the ship. Mobile facilities have higher operating and construction costs. This is one reason why shore power for ferries is cheaper to establish and operate, as it is always the same ship(s) using the ferry dock.

3.2. Environmental measures at the international level

Many environmental measures for ships are in progress at the international level. Severe restrictions on the amount of sulphur that can be emitted from ships in the Baltic and the North Sea have already been introduced. Restrictions on nitrogen (NOx) emissions are on the way in the USA and probably in Europe too. The EU has decided that all the major ports (including Copenhagen) should be able to provide liquid natural gas (LNG) from 2025 as a possible substitute for oil. These are positive measures, which will reduce air pollution in the cities and have an effect while the ships are at sea. However, they will not reduce CO_2 emissions.

In October 2014, the EU decided that the major ports should be able to provide shore power from 31 December 2025, if there is a demand and if "*the costs are in reasonable proportion to the benefits, including the environmental benefits*". It is not clear whether this only applies to cargo ships or also to passenger ships, including cruise ships.

It can be seen that the shipping companies are reacting to the international environmental measures. Since 1 January 2015 there have been restrictions on the amount of sulphur ships can discharge in the Baltic and the North Sea and along the coasts of Canada and the USA.

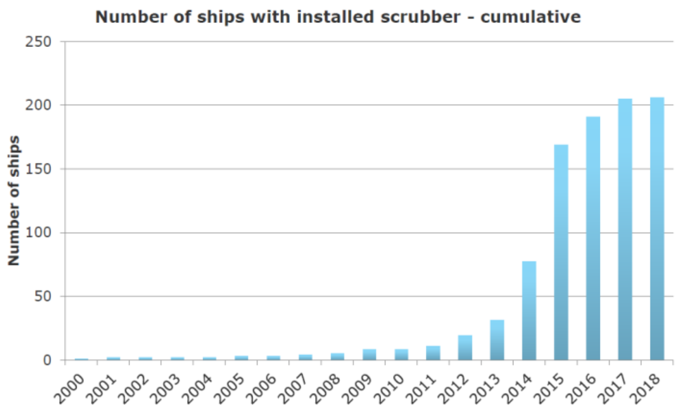

Figure 1: Number of ships with scrubbers around the world, incl. conversions ordered (all ship types)

The shipping lines have therefore been obliged to use low-sulphur fuel or to install fuel gas scrubbers on the ships. As a result, companies have started to invest in scrubbers for their ships, as this is presumed to be the cheapest option. Around the world, the number of ships that have installed a scrubber has risen from around 20 in 2013 to some 170 in 2015[4]. At least a quarter of these are ferries operating in the Baltic or the North Sea. Although there are still very few vessels, it can be clearly seen from figure 1 that many scrubbers have been installed around 2014-2015.

As scrubbers only reduce emissions of sulphur (SO_2) and particles, they do not solve the problems of NOx and CO_2 emissions in particular. City & Port Development and CMP expect requirements for NOx emissions to be laid down from 2022 or later, and possibly also CO_2 reduction targets from 2025 or later. The requirements for NOx emissions can be addressed with post-treatment equipment. Reduced CO_2 emissions demand improved energy efficiency, different fuels and/or supplying part of the ship's energy consumption from a shore power facility when the ship is in port.

[4] SECA is real now, Baltic Ports Organisation, April 2015.

Liquid natural gas or liquid biogas can reduce emissions of sulphur, NOx and CO_2, so they may be a technology for the future. However, the benefits may turn out not to outweigh the disadvantages, as liquid gas takes up a lot of space on the ships and carries a certain risk. For example, the fire authorities in some ports will not permit ships to fill up with liquid gas while there are passengers on board, which makes it very unsuitable for cruise ships.

Figure 2: Costa Luminosa at Ocean Quay in Nordhavn.

Interviews with cruise ship operators show that, whereas a few years ago shore power was seen as a technology of the future that they wanted to use in port, they are now starting to install scrubbers in newer existing ships (retrofitting) and to order new builds with scrubber systems installed. This may also mean that fewer shipping companies will want to install shore power systems on their ships in the coming years. On the other hand, the study carried out among the operators in connection with this analysis shows that several of them are also installing shore power on existing ships (retrofitting) in 2016, while others see the two technologies as alternatives. It is therefore hard to assess which way the trend will go, and it will depend on the facilities offered in the ports.

3.3. Possibility of shore power

The balance between greater environmental demands and the desire for more cruise passengers makes it difficult to place stricter requirements on the cruise ships. It is therefore felt that there needs to be a real incentive for the shipping companies before shore power facilities are installed on cruise ships on a large scale. As things stand today, cruise ships can only connect to shore power in one port in Europe. If there is to be a real incentive for cruise ships, they must be able to connect to shore power in several ports in the course of a season. The total energy consumption of the ships in ports in the Baltic is approx. 15% of their overall energy consumption, and they typically visit 4-5 ports on a voyage and many ports in a season. Thus, only one port can offer shore power; the incentive to carry out the installation on board is limited.

In connection with this analysis, we examined whether it might be possible to obtain EU funding for a shore power facility. Given the current allocation criteria, it is considered relatively unlikely that the EU will grant funding to establish a shore power facility for cruise ships.

In connection with this analysis, we contacted Oslo and Stockholm, but they currently see no basis for cooperation to establish shore power for cruise ships. Instead, the major cruise ports in the Baltic are investing in the provision of shore power to ferries. This brings a greater overall environmental benefit to these cities with relatively modest establishment and operating costs. Examples of this are the ports of Stockholm, Oslo and Helsinki, where shore power is being installed for the extensive ferry operations.

Copenhagen has only one ferry route (to Oslo), so the environmental gains from shore power to ferries are relatively small compared to other ports in Scandinavia.

4. CALCULATION PARAMETERS

CMP expects a growth in the number of cruise passengers in the future, but based on ships getting larger and carrying more passengers while the number of port visits stagnates or increases more slowly. This also arises from greater competition from Asia in particular and the fact that the Mediterranean is not subject to SECA rules[5].

4.1. Types of visit and passenger growth

We distinguish between two types of cruise ship visit – transit stops and turnaround stops.

- Transit stops are ships that dock in Copenhagen in the morning and sail in the evening without taking on any new passengers. These ships are typically berthed at Langelinie, as the passengers want to be close to the centre and no space is needed for baggage handling. Approx. 55% of the cruise ship arrivals are transit stops. In the period 2010-2015, an average of 5% of the transit stops in Copenhagen (ranging from 0 to 3 ships) involved ships able to accept shore power. Langelinie is too narrow to be able to handle shore power at the same time as providing the other services. It is therefore not possible in practice to establish shore power at Langelinie.

- Turnaround stops are the stops where passengers are replaced with new passengers. These passengers typically spend one or more nights in hotels in Copenhagen. The ships also take on more supplies. Turnaround arrivals are generally berthed at the new cruise terminals on Ocean Quay in Nordhavn, mainly because of the space needed for baggage handling. Approx. 45% of the cruise ship visits are turnaround stops, and 80% of these arrive at the weekend. In the period 2010-2015[6], an average of 13% of the turnaround stops in Copenhagen involved ships able to accept shore power. Some of these ships will have shore power installed (retrofitted) in 2015 and 2016. If these ships had had shore power facilities at the time of earlier visits, the average would have been 19%. This analysis is based on the 19%.[7]

For space reasons, it is necessary to prioritise turnaround ships at Ocean Quay. The other ships (transit stops) will only be berthed alongside Ocean Quay in exceptional circumstances.[8]

The calculations of the potential for shore power assume that only turnaround ships will be offered shore power. In 2014, Copenhagen had a turnaround capacity of 284,000 passenger berths. As the trend is moving towards larger ships, and as Copenhagen is expected to attract more turnaround stops in the future, CMP expects an average growth in passenger numbers of 5%. This would mean approx. 313,000 berths in 2016. In 2020, the figure will rise to some 380,000 berths on turnaround ships. By 2030, the capacity in Nordhavn will be fully utilised and it will only be able to increase marginally thanks to bigger ships.

[5] SECA rules govern the amount of SO_2 that ships are allowed to emit in some areas. See page 21 for more detailed notes.
[6] Including ships registered in 2015
[7] A list of the actual ships is given in Annex 5
[8] See Annex 5

Whether shore power is a good idea economically depends especially on how many ships come to Copenhagen in the future and how many of these will be able to take shore power. To get a picture of this, three scenarios for passenger growth on these ships have been developed. It should be noted that there is some uncertainty in the underlying data, mainly regarding the number of expected arrivals able to take shore power, as there is a relatively large change in cruise ships visiting Copenhagen from year to year. In developing the scenarios, we contacted the major shipping lines to gather their expectations of the market, and used statistics from the last six years' arrivals in Copenhagen[9].

We have worked with three scenarios for passenger growth in ships that can take shore power. They are all based on a 5% annual increase in the number of turnaround passengers up to 2030 and an annual increase of 1% thereafter. This should be viewed in light of the fact that the ships are generally getting bigger, that the season may be prolonged more than today, and that a new cruise terminal may be constructed to the north of the three existing terminals on Ocean Quay.

- Scenario 1 (Baseline), in which the number of ships docking that can take shore power remains unchanged at 19%. Here, the shipping companies are focusing mainly on installing scrubbers to clean the exhaust of sulphur and some particles. This is costly and will therefore limit the appetite for investment in other emission-reducing equipment. Besides, scrubbers also reduce emissions when the ship is not in port. It is assumed that scrubbers will be installed on 3% of the ships each year.

- Scenario 2 (High), in which the trend from 2013-2015 is expected to continue, when 28% of the arrivals could take shore power. The number of ships able to take shore power increases by 1.5% per year, to 31% in 2020 and 36% in 2030. This is especially a possibility if more cruise ports in the Baltic region and Scandinavia install shore power equipment. It will then be easier to attract ships that can take shore power to the Baltic region. It is assumed that scrubbers will be installed on 2% of the ships each year.

- Scenario 3 (Low), in which the number of ships able to take shore power in the whole 30-year period decreases by 1.5% per year. With an increased focus on scrubbers, fewer operators may opt to install shore power. It is expected that scrubbers will be installed on 6% of the ships each year.

Scenario 1 (Baseline) is the most likely scenario, while scenario 2 and scenario 3 are considered to be two equally likely scenarios. This info is no longer used.

Table 5: Expected number of berths on ships that can accept shore power – projection to 2045

1,000 berths	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
2016	59	92	57
2026	96	173	80
2036	120	251	86
2045	131	314	82

[9] See Annex 5

In the scenario with the most arrivals that can take shore power, we assume 314,000 berths in 2045, equivalent to 80-110 visits, or a more than threefold increase from 2014. As the cruise season lasts around 150 days from 1 May to 1 October, this implies that there will be 4-5 cruise ship arrivals per week in 2045 that can take shore power. These will probably be scheduled with two on Saturday, two on Sunday and one on a weekday, but on some days three ships may dock at the same time.

4.2. Power consumption

Earlier estimates of the potential for shore power assumed that each turnaround ship would spend an average of 10.5 hours in port. Of these, it is expected that they could receive shore power for 9.5 hours. This study assumes that each passenger berth is expected to have an average energy consumption of 3 kW per hour[10]. The section on 'Sensitivity' contains a calculation using an average energy consumption of 2.5 kW per hour (see page 35)

4.3. Electricity prices for purchases from the grid

The Danish parliament (Folketing) has altered the basis for taxation of shore power. Under the new rules, users only pay for distribution (9.9 øre/kWh), the public service obligation, or PSO levy (21.1 øre/kWh) and an EU-defined minimum electricity tax (0.4 øre/kWh). They also have to pay for the electricity consumed (27.6 øre/kWh in 2014). Electricity costs then total 59 øre/kWh (at 2014 prices). Of this, 21.5 øre/kWh goes to the State as extra income compared to the present solution where electricity is produced on the ship. Projected electricity prices from Energinet.dk were used for the calculations. Taxes and distribution prices are assumed unchanged at fixed prices. The estimated prices are shown in table 6.

Table 6: Estimated electricity prices

Øre/kWh, fixed 2015 prices	**PSO levy**	**Electricity tax**	**Transport**	**Electricity**	**total**
2016	21.1	0.4	9.9	25.3	**56.7**
2026	21.1	0.4	9.9	46.0	**77.4**
2036	21.1	0.4	9.9	47.3	**78.7**
2045	21.1	0.4	9.9	47.3	**78.7**

4.4. Oil prices

The oil prices are based on a projection produced by EIA in the USA[11]. The price of low-sulphur marine gas oil is estimated based on the difference between heavy fuel oil (HFO) and marine gas oil (MGO) in Rotterdam on 14 February 2015.

In winter 2014/2015 there was a sharp fall in the price of oil, which is not included in the estimates. According to the Danish Energy Agency, we will see fluctuations in energy and oil prices. However, these fluctuations will not affect the trend, so the projections stand.

[10] By & Havn and CMP: Report on shore power for cruise ships, 2012
[11] U.S. Energy Information Administration

4.5. Electricity prices for sales to cruise ships

The price of electricity produced by the ships' auxiliary engines with max. 0.1% sulphur is assumed to be DKK 1.24/kWh in 2014[12]. As the ships need to have an incentive to switch to shore power, and bear the cost of installing equipment on board, it is assumed that they will need a cost reduction in the order of 10% to accept shore power. It is thus expected to be possible to sell shore power to the ships at a price of around DKK 1.12/kWh.

If we assume that the ships take shore power at DKK 1.12/kWh at 2014 prices, the proceeds from sales of electricity will be 53 øre/kWh plus 21.5 øre/kWh in national taxes, particularly the PSO levy[13]. The sale price of electricity is projected in the calculations on the basis of expected oil prices and the rate at which scrubbers are expected to be phased in on cruise ships. The price of electricity for cruise ships is thus set at 90% of what it would cost them to produce electricity themselves[14]. As the rate at which scrubbers are phased in varies in the three scenarios, the costs to the cruise ships for producing electricity will differ in the three scenarios. Similarly, the income per kilowatt-hour from electricity sales will also vary.

[12] By & Havn and CMP: Report on shore power for cruise ships, 2012

[13] Although electricity from shore power is exempt from the normal electricity tax, a minimum tax (0.4 øre/kWh) and the PSO levy (21.1 øre/kWh) will still be payable. The PSO (public service obligation) levy is paid to reduce Denmark's CO_2 emissions.

[14] This is based on an average assessment. In practice, the ships that have installed dry scrubbers will have a slightly lower electricity production price while those without dry scrubbers will have a higher electricity production price. This could be addressed e.g. by introducing a shore power charge for ships that do not have a dry scrubber installed, and setting the electricity prices according to the level at which ships with a dry scrubber can produce electricity. This then needs to be examined in more detail.

5. CONSTRUCTION COSTS

The establishment costs break down into the costs of investment in the shore power facility itself, of a building to house the installation, of connection equipment on the quay and of connection to the grid.

We have used three pricing examples based on systems of different sizes. The smaller the installation, the lower the establishment and maintenance costs. On the other hand, the costs of future expansion will be increased. We also use a fourth pricing example in which shore power is established for a future Terminal 4 to the north of the existing terminals.

To allow for future expansion, we assume the same building in all four scenarios. This is a building with a ground area of 500 m2 on 1½ storeys. It is expected that the building can be maintained for approx. DKK 25,000 per year.

To bring electricity from the grid to a shore power facility, a cable has to be laid from a transformer station at the Svanemølleværket plant to the shore power facility itself. There are basically two ways of providing the cable. Either DONG can own the cable and take responsibility for supply, maintenance etc., or a public company or other investor can own the cable and take responsibility for supply and maintenance.

If it is to own the cable (B-customer), DONG will lay two cables on different routes. This is in order to guarantee supply even if one cable should be damaged (redundancy). DONG has estimated the price of this at approx. DKK 40 million in one-off costs, for 30 MW.

If a publicly owned company or other investor should own the cable (A-customer), they will only lay one cable, as the ships themselves have an engine that can produce electricity. This increases the risk of a power failure; in this event, it is therefore assumed that the ship will be able to use its own engines to produce electricity. The costs for 30 MW will be around DKK 11 million in investment plus DKK 100,000 in annual maintenance costs. This is equivalent to a present value of approx. DKK 13 million at 4% internal interest. This alternative is the most suitable as it will reduce the scale of investment in both the short and the long term.

Maintenance costs for the shore power facility itself are expected to amount to 0.8% of the construction costs per year.

All prices are based on the best objective estimates, and the actual prices will be determined by a tendering process. They may then turn out to be higher or lower, but some of the suppliers who have offered price estimates have stated that they expect lower prices in a competitive situation in connection with a tendering procedure.

5.1. Price example 1: Full scale – 40 MW

In the full-scale example, a future-proof facility for three ships is established from the outset. The plant produces 40 MW, and it is possible to supply up to three ships with a total demand up to 40 MW. The output can be split between the three ships according to their needs, but no more than 20 MW can be delivered to one ship. In other words, there could be one ship using 20 MW, a second using 13 MW and a third using 7 MW – 40 MW in total[15].

Table 7: Establishment costs, 40 MW

Converters, equipment etc.	DKK 62.5 m
Building, foundations etc.	DKK 15.0 m
Cable facility (3 ships)	DKK 18.0 m
Connection charge (40 MW)	DKK 14.0 m
Contingency (15%)	DKK 16.4 m
Total establishment costs	**DKK 125.9 m**

The annual maintenance costs are estimated at DKK 635,000.

5.2. Price example 2: Medium scale – 30 MW

In this example, a facility is established for three ships, but with lower output. It is then still possible to deliver up to 20 MW to each of the three ships, but only up to 30 MW in total (e.g. 15+7+8 MW). There are thus some restrictions on the number of very large ships that can be supplied with electricity from on shore. The largest ships today use up to 14 MW, so 30 MW is considered to be sufficient for the foreseeable future. The system can be expanded later to 40 MW for approx. DKK 33 million (2014 prices).

Table 8: Establishment costs, 30 MW

Converters, equipment etc.	DKK 44.5 m
Building, foundations etc.	DKK 15.0 m
Cable facility (3 ships)	DKK 18.0 m
Connection charge (30 MW)	DKK 11.0 m
Contingency (15%)	DKK 13.3 m
Total establishment costs	**DKK 101.8 m**

The annual maintenance costs are estimated at DKK 481,000.

5.3. Price example 3: Small scale – 20 MW

In this example, a facility is established for just one ship. However, the plant is designed for possible expansion to supply more ships. It is thus assumed that only one ship at a time will receive shore power. The remaining ships will have to use their own engines to generate electricity. The plant can be upgraded later to price example 2 (Medium scale – 30 MW) for approx. DKK 30 million. Similarly, it can be upgraded to connect to an extra ship for DKK 6 million.

[15] The ISO standard calls for capacity to supply 16 MW per ship and recommends 20 MW per ship. However, current ships will need less, so it is assumed at this time that acceptable operation can be achieved with the figures given here. This is true for all four pricing examples.

Table 9: Establishment costs, 20 MW

Converters, equipment etc.	DKK 33.0 m
Building, foundations etc.	DKK 15.0 m
Cable facility (1 ship)	DKK 6.0 m
Connection charge (30 MW)	DKK 11.0 m
Contingency (15%)	DKK 9.8 m
Total establishment costs	**DKK 74.8 m**

The annual maintenance costs are estimated at DKK 389,000.

5.4. Price example 4: Small scale in new terminal 4 – 20 MW

In this example, the same plant is established as in scenario 3. It is placed close to a fourth terminal to be constructed to the north of the three existing cruise terminals. Such construction has not been decided, but it could be established within the foreseeable future, probably around 2020-22 depending on the occupation of the area.

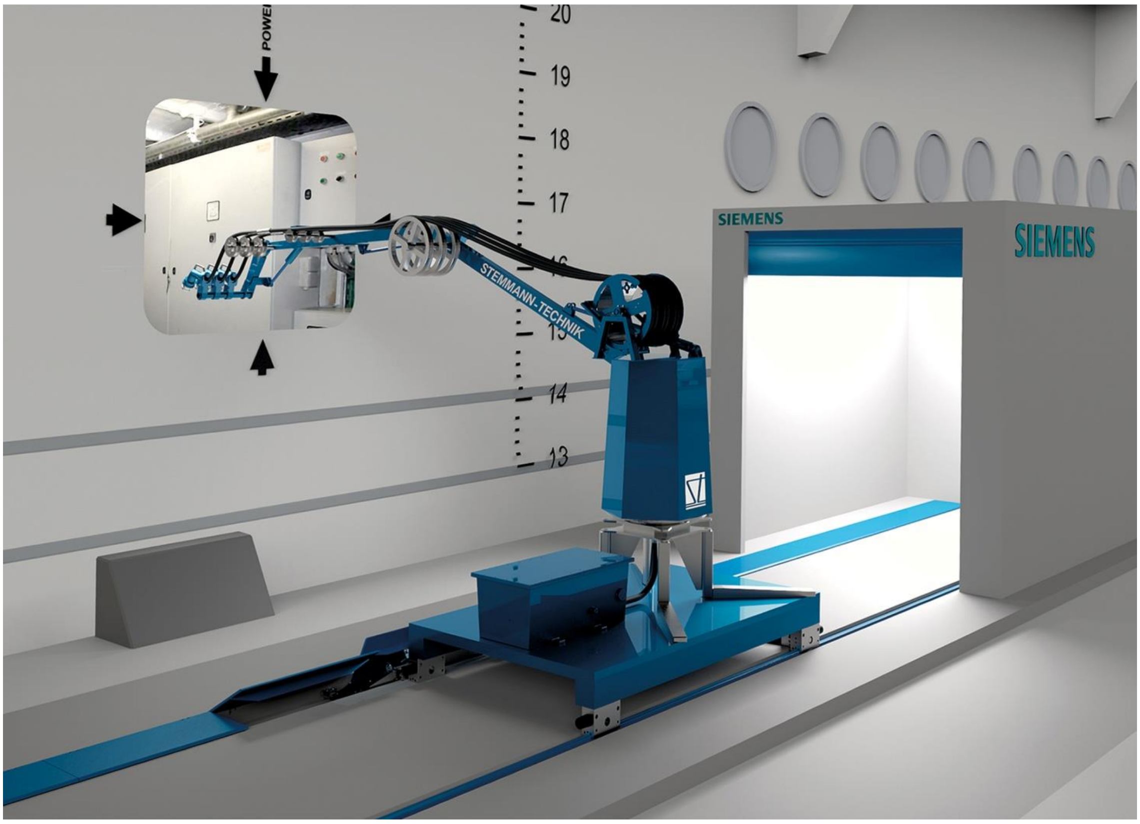

Figure 3: Illustration of cable facility in Hamburg. Source: Siemens

Combining the establishment of shore power with a new terminal will make it possible to provide a connection to the ships with lower operating costs. Terminals 1-3 are already prepared for the installation of shore power, with cable channels laid under the quay. The investment costs for a system using a technology with lower operating costs at a new terminal will be higher than for the equivalent installation at Terminal 1, 2 or 3.

Table 10: Establishment costs, 20 MW, Terminal 4

Converters, equipment etc.	DKK 33.0 m
Building, foundations etc.	DKK 15.0 m
Cable facility (1 ship)	DKK 10.0 m
Connection charge (30 MW)	DKK 12.0 m
Contingency (15%)	DKK 10.5 m
Total establishment costs	**DKK 80.5 m**

The annual maintenance costs are estimated at DKK 389,000.

6. OPERATIONAL SETUP

If a shore power facility is established in Nordhavn, an operational setup will have to be determined. It is not expected that the City of Copenhagen and the State will be actively involved in the operation of shore power. It is therefore considered most appropriate for a publicly owned company to take care of the investment, establishment and purchase/sale of electricity, and for the State and the municipality to contribute a development grant and/or a deficit guarantee during the amortisation period of the facility. CMP or another operator can undertake live operation.

6.1. Handling of shore power equipment

For cruise ships, 4 11 kV cables will typically be used, plus one communication cable per ship. The thickness and weight of these cables require handling with a crane and a purpose-built cable drum. If a mobile crane is used, 3-4 persons will be needed to handle the cable. CMP estimates that 15 working hours per visit will be spent connecting and disconnecting the electricity supply (DKK 2.70 per passenger berth). As this will involve high voltage, one employee will probably be required to have a high-voltage certificate. Before the ship docks, the team will move the equipment to the place on the quay where the cable is to be attached to the ship. When the ship has docked and been made fast, the electricity cables will be fed through a hatch and attached by the ship’s crew. The power will then be switched on and synchronised. The reverse procedure will be used before departure.

In pricing example 4 above, some of the work will be simplified. This will reduce the expected handling price to DKK 1.35 per passenger per berth.

6.2. Interest in a shore power plant

The City of Copenhagen and the State may have a common interest in being able to supply shore power to cruise ships, as this will lead to reduced CO_2 emissions, clean air and reduced NOx pollution. The municipal council (Borgerrepræsentationen) and the Folketing could therefore decide to allocate funding to a shore power facility in the form of a development grant or a deficit guarantee.

CMP wants to be able to provide shore power to its customers on the condition that the company does not run a financial risk with the investment. CMP therefore does not want to own a plant but would be able to undertake the practical operation of the connection to the ships.

City & Port Development will be able to provide a site or a building free of charge.

If a shore power facility is established under the current rules, the State will receive a relatively large amount of extra income from electricity taxes. This is because fuel oil for ships is not taxed, but there is a minimum electricity tax plus a PSO levy for electricity.

7. ENVIRONMENTAL EFFECTS

Cruise ships use a lot of energy. As the energy is typically produced from MGO (marine gas oil), there are emissions of CO_2 and various harmful substances from the ships.

Around 15% of the energy consumption of cruise ships is used in port, while the remaining 85% is used while the ship is at sea. Therefore, the greatest potential improvements will come from solutions that also work while the ships are sailing – particularly when it comes to CO_2, which has the same impact whether it is emitted on the water or in a port. Also concerning NOx, particles and SO_2, it is worthwhile to focus on emissions regardless of the ship being in port or at sea, but in this context high concentration, and hence health problems, are more of an urban issue. As approx. 85% of the ships' emissions are discharged at sea, emission-restricting solutions on-board the ship will, other things being equal, have a greater environmental impact than solutions in port.

From 1 January 2015, an environmental zone was introduced in the Baltic and North Sea area, in which sulphur emissions have to be reduced by 90% compared to the previous rules. There are plans for a similar zone for NOx pollution, but these are not expected to take effect until 2022 at the earliest. The effects of such a zone are therefore only included in a sensitivity analysis (see page 36).

In 2005, the Danish Environmental Protection Agency commissioned an analysis of the spread of NOx emissions from cruise ships and their effect on air pollution in Copenhagen. This showed that NOx pollution, based on the weather and the actual dockings at Langelinie in 2003, spread particularly towards the north-east to Sweden, but also that increased NO2 concentrations in the order of 0.5µg/m^3 may be expected in the whole radius of approx. 800 metres in all directions from the cruise ships. No calculations were carried out for a wider radius, as the effects at greater distances are not known. If we base the same calculation on the weather in 1999, the spread can be seen especially to the north and west.[16] It should be noted that the analysis concludes that the cruise ships are not contributing significantly to NOx pollution in Copenhagen, and that concentrations of NO2 at the measuring station in Copenhagen were well below the limits. Since then, however, the limit at the measuring station on H.C. Andersens Boulevard has been exceeded, and the concentration is now at a level where 0.5µg/m^3 has a real bearing on whether the limit for Copenhagen can be maintained.

Statistically, the prevailing wind in the summer time is from the west, which substantially reduces the impact on people living in Copenhagen. Ocean Quay is also a long way from urban areas and hence from the measuring station on H. C. Andersens Boulevard, so the effect of cruise ships at Ocean Quay on breaches of the limit is considered small.

7.1. Emissions

CO_2 emissions from cruise ships are not subject to quotas. If part of the energy consumption is switched to shore power, it will therefore become included in the quota-based energy

[16] Danish Environmental Protection Agency Assessment of the cruise ships' contribution to air pollution, 2005

production. The extra electricity production brought about by shore power will therefore be included in the quota schemes and so will not create more CO_2 in itself.

Emissions of NOx, particles, SO_2 etc. are not subject to quotas, so emissions from power stations corresponding to the Nordic mix are expected to continue[17].

Table 11: Emission coefficients from the production of electricity

Production/emission	CO_2 (g/kWh)	NO_X (g/kWh)	Particles (mg/kWh)	SO_2 (g/kWh)
Auxiliary engine, MGO (0.1% sulphur)	645	13.20	207.00	0.20
Electricity, Nordic mix	0 (subject to quota)	0.32	0.02	0.07

Each passenger uses around 3 kWh every time a ship is in port. The environmental effects of implementing shore power can be calculated as the difference between the emissions from the auxiliary engine and those produced from the Nordic mix:

Table 12: Reduced emissions from a shore power facility, three scenarios, 2016-2045.

Tonnes	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
CO_2	59,048	117,174	45,562
NO_X	1,182	2,346	912
Particles	19	38	15
SO_2	12	24	9

The table shows the total cumulative environmental effects over 30 years from 2016-2045

The environmental effects of establishing shore power are not insignificant, but nor are they striking compared to emissions from other sources. In the Baseline scenario, the reduction in emissions of CO_2, NOx and particles is equivalent to approx. 0.1% of the total emissions of each of these substances in the City of Copenhagen.

Calculated emissions from cruise ships over the next 30 years in Copenhagen are based on the assumption that no shore power facility is established, and then compared with the Baseline scenario. The emissions are shown in table 13 below. It can be seen that CO_2 emissions in the 30-year period will fall by 19% from 314,000 to 255,000 tonnes. The annual CO_2 effects of a shore power facility are roughly equivalent to 685 Copenhagen residents' average annual CO_2 emissions at current levels[18]. In the High scenario, the CO_2 reduction will average 37%, while the Low scenario produces an average CO_2 reduction of 15%.

On past evidence, in the course of a cruise season, up to 6 ships may be docked in the port of Copenhagen at the same time. With one ship connected to shore power, most ships will still emit CO_2 and harmful substances.

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[17] The Nordic mix is a term for the production of electricity in the Nordic countries with a mix of different producers. For example, it includes nuclear power from Sweden, wind power from Denmark, hydro-electric power from Norway, fossil power from various coal-fired plants, and much more. The Nordic mix is declared each year based on the actual average emissions per kWh.

[18] City of Copenhagen CO_2 accounts for 2013

Table 13: Total emissions 2016-2045 from cruise ships in turnaround

Tonnes	Emissions, 2016-2045 without shore power	Effect 2016-2045 (Baseline)	Emissions, 2016-2045 with shore power (Baseline)
CO_2	313,853	59,048	254,805
NO_X	6,283	1,182	5,101
Particles (PM2,5)	101	19	82
SO_2	63	12	51

The reduced emissions in scenario 1 (Baseline) will reduce early mortality by a total of 60 years of life in the 30-year calculation period. The reduced emissions will also lead to around 9,000 fewer sick days in the same period. On average, this equates to a saving of 2 years of reduced life and 300 sick days per a year. By way of comparison, the City of Copenhagen's project to install particle filters on at least 200 city buses will save around 3 years of reduced life and 200 sick days per year[19]. The establishment costs for this are around DKK 10 million.

7.2. Ship technology

The SECA (sulphur emission control area) rules have been introduced in the North Sea and the Baltic and in the USA and Canada with effect from January 2015. The SECA rules mean that ships can no longer emit SO_2 equivalent to a sulphur content of more than 0.1% in marine fuel within the SECA areas. The previous limit was 1.5% up to 2010 and 1.0% from 2010-2015 in the SECA areas. Outside the SECA areas, the limit is 3.5% sulphur (previously 4.5%). These limits have been set by the IMO, which is the maritime arm of the UN.

Since 1 January 2015, as a result of the SECA rules, ships have either had to use a more expensive SECA fuel (marine gas oil, or MGO) or take the option of installing fuel gas cleaning, or 'scrubber' technology.

Scrubbers remove 90% of the SO_2 and around 50% of the particles from heavy fuel oil with 1% sulphur. By way of comparison, SECA fuel (marine gas oil) also removes 90% SO_2, but approx. 60% of the particles[20]. It is therefore possible to go using a cheaper and more sulphur-rich fuel oil in SECA areas while achieving the same positive environmental effect as with the use of 0.1% fuel. However, scrubbers increase fuel consumption by approx. 2% and do not reduce NOx and CO_2 emissions.

Some scrubbers use large quantities of seawater to clean the exhaust gas, while others use caustic soda. The model that uses seawater discharges SO_2 and soot particles directly into the seawater, so it cannot be used in port. The model that uses caustic soda to remove SO_2

[19] The difference in the ratio of sick days to years of life arises because the bus project focuses only on particles, while the focus with shore power is on particles, NOx and SO_2.
[20] DNV: Greener Shipping in the Baltic Sea

produces a waste material that must be sent for treatment/landfill. This model can be used anywhere. It is possible to combine the two models, so caustic soda is only used in port. An international investigation is currently ongoing with regard to the rules for the use of scrubbers.

Although the SO_2 emissions are significantly reduced under the SECA rules, there is still a positive environmental effect to be obtained by using shore power in ports. This assumes that the electricity used is produced in a more environmentally friendly way than the electricity the ship itself can produce.

The USA and Canada are introducing so-called NECA areas (NOx emission control areas) from 1 January 2016 for new ships. In these areas, ships registered after 1 January 2016, will have to comply with tighter rules for NOx emissions. Technically, this will be done with SCR catalysts, which are expensive to run. That is why the NECA rules in North America are not expected to have any impact on emissions in the North Sea and Baltic areas before similar rules are passed in these areas. There are plans to establish a similar NECA area in the Baltic, but it has not been possible to keep to the current timetable for an interim decision. The Helsinki Commission (HELCOM) is addressing the matter, and the rules are not expected to be phased in before 2022.

8. OPERATING COSTS, SOCIO-ECONOMIC ASPECTS AND FINANCING

The section on calculation parameters outlines three scenarios for the growth in the number of ships that can take shore power, and which visit Copenhagen:

- Scenario 1 is a Baseline scenario. This assumes that the same number of arrivals as seen in the period 2010-2015, will be able to take shore power in the future.
- Scenario 2 is a High scenario. This assumes that the trend from 2013-2015 will continue and that an increasing proportion of ships visiting will be able to take shore power in the future. This scenario is more likely if other ports in the Baltic area also choose to offer shore power at a price which is competitive with the ships' own production of electricity.
- Scenario 3 is a Low scenario, where the proportion of ships visiting that can take shore power in Copenhagen is assumed to fall. This scenario is more likely if more ships invest in scrubber systems instead of shore power facilities.

All three scenarios assume that the smallest shore power facility is established to start with. In scenarios 1 and 3, this plant is sufficient for the whole of the 30-year calculation period. In scenario 2, the plant is expanded to be able to handle two ships after eight years. After 25 years it is expanded to be able to take three ships at a time and also upgraded from 20 MW to 30 MW.

If it is decided to establish shore power in a possible new Terminal 4 (pricing example 4) the establishment costs increase in all three scenarios. At the same time, the operating costs go down. The reduced operating costs do not however offset the increased construction costs, so no calculations have been carried out for pricing example 4.

The operation of a shore power facility can be financed by a public company taking a loan to cover the establishment costs, after which income from sales of electricity wholly or partially finances interest and repayments. Alternatively, the company could receive a public development grant to cover all the costs of establishing a shore power facility, with subsequent operation returning a profit.

8.1. Operating costs with borrowing

The net operating costs comprise expenditure for establishment, operation and maintenance, purchases and sales of electricity and national taxes. Of the three scenarios, only the High scenario produces a positive return. There is thus a need for public co-financing if shore power for cruise ships is to be established.

The calculations assume that establishment costs are financed through a 30-year annuity with an interest rate of 1.5% p.a. All figures are in fixed 2015 prices, so do not include any other return on investment for the owner of the shore power facility beyond the usual price projection. For the price projection of costs in actual annual prices (interest and loan repayments), we have used the price/earnings (P/E) estimates from Local Government Denmark as of 24 February 2015, which extend to 2019. For subsequent years, prices are projected to rise by 2%. As interest rates are lower than the P/E projection, the costs of interest and repayments in 2015 prices will be lower than the actual establishment costs.

Table 14: Operational business case calculations for the three scenarios

2015 prices	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
Interest and loan repayments	-69.4	-76.4	-69.4
Operation and maintenance	-19.3	-28.2	-17.3
Purchase of electricity excl. national taxes	-49.4	-99.5	-37.5
National taxes	-18.7	-37.3	-14.3
Sales of electricity	110.5	227.9	88.9
Total	-46.3	-13.5	-49.6
Total excl. national taxes	**-27.7**	**23.8**	**-35.3**

Scenario 1, which has been chosen as the Baseline scenario, will require net public investment of DKK 27.7 million, with the State financing a sum equivalent to the electricity taxes – DKK 46.3 million in all. The investment need is greater in the Low scenario (total DKK 49.6 million). The High scenario has a smaller operational shortfall (DKK 13.5 million) and can produce a profit if national taxes for electricity do not have to be paid.

In the Baseline scenario, 3.2 million passengers are expected to arrive on ships that can take shore power over a 30-year period. As stated, the net costs of this scenario are approx. DKK 27.7 million. To achieve operational break-even, approx. 4.8 million passengers need to come to Copenhagen in ships that can take shore power in the 30-year period. This represents an increase of around 50% compared to the Baseline.

The worst case is where the facility simply is not used. In that case, the entire investment in construction in the first year (DKK 74.8 million) will be lost[21]. However, it is considered realistic to assume that the facility will be used in the space between the Low and the High scenarios.

A cash flow analysis can be used to assess whether there is sufficient cash to pay the ongoing costs. For example, there may be a business case for DKK -13.5 million in scenario 2 over 30 years, but as there is a shortfall for the first 15 years and a surplus for the last 15, the plant will run out of cash before it starts to make a profit.

Cash flow analyses of the three scenarios show that a shore power facility will need a further DKK 13.7 million in scenario 2, as the project will make an operating loss in the first few years totalling more than the DKK 13.5 million shortfall shown in the business case. The extra cash requirement will be offset in the second half of the 30-year calculation period. In scenarios 1 and 3, a capital injection in year 1 of DKK 46.3 and 49.6 million respectively will cover the financing of interest, repayments and operating costs in all years.

Table 15: Cash flow analysis for the three scenarios, 2016-2045

2015 prices	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
Business case	-46.3	-13.5	-49.6
Extra liquidity requirement	0.0	-13.7	0.0
Minimum development grant	**-46.3**	**-27.2**	**-49.6**

Based on the above, we may conclude that shore power can be established in Copenhagen if the State and the municipality together finance up to DKK 45-50 million (P/E 2015) as a

[21] As interest and repayments in Table 14 are discounted at the P/E rate, the interest and repayments differ from the total investment need of DKK 74.8 million.

development grant for shore power in Nordhavn. There is also the possibility of spreading the development grant over the first 10-15 years as a rolling operating subsidy or as a deficit guarantee. The breakdown of the costs between the State and the municipality may be decided by negotiation. The final costs can be estimated more accurately after a possible tendering procedure, but only actual operation can show the actual income from the cruise ships.

The costs of project planning, tendering etc. are not included in the calculation.

8.2. Operating costs without borrowing

The alternative to the above is not to take a loan but for the establishment costs to be financed directly. The advantage of this is that any risks are already covered at the time of establishment.

The establishment costs all fall in the first year, so no benefit can be gained from the fact that interest rates are currently lower than the expected P/E projection. On the other hand, no interest will be payable. In all three scenarios, the total costs rise by around DKK 6 million in the 30-year calculation period; cf. table 16.

Table 16: Operational business case calculations for the three scenarios, without borrowing

2015 prices	Scenario 1 (Baseline)	Scenario 2 (High)	Scenario 3 (Low)
Establishment costs	-74.8	-74.8	-74.8
Later extension of the facility*	0.0	-7.9	0.0
Operation and maintenance	-19.3	-28.2	-17.3
Purchase of electricity excl. national taxes	-49.4	-99.5	-37.5
National taxes	-18.7	-37.3	-14.3
Sales of electricity	110.5	227.9	88.9
Total	-51.7	-19.8	-54.9
Total excl. national taxes	**-33.0**	**17.5**	**-40.7**

**) Later extension of the facility amortised over 30 years, subject to an expected future demand at the time of expansion. So only the portion of the costs actually written off in 2046 is included.*

The liquidity need will be DKK 74.8 million in all three scenarios. After establishment, a plant is expected to produce a profit, as there will basically be only operational costs. Income of DKK 41.8 million may then be expected over the 30-year calculation period in the Baseline scenario if the State finances an amount equal to the income from electricity taxes. Similarly, there will be income of DKK 31.1 million in the Low scenario and DKK 92.3 million in the High scenario.

The breakdown of the costs between the State and the municipality may be decided by negotiation. The final costs can be estimated more accurately after a possible tendering procedure, but only actual operation can show the actual income from the cruise ships.

The costs of project planning, tendering etc. are not included in the calculation.

8.3. Socio-economic aspects

The socio-economic analysis is based on the guidelines from the Ministry of Finance and the Danish Energy Agency's unit prices for emissions. No account has been taken of additional costs to the energy companies of producing more green electricity, as there are no unit prices for this. For the initial investments to be seen as socio-economically viable, the internal interest according to the Ministry of Finance must be at least 4%. We have therefore calculated a present value for the investments based on an internal interest rate of 4%.

None of the scenarios produces a positive socio-economic return with an internal interest rate over 4%. The Baseline and Low scenarios show negative interest rates.

Table 17: Socio-economic analysis of the three scenarios, 2016-2045

Present value, 2015 prices	Scenario 1	Scenario 2	Scenario 3
Establishment costs	-71.9	-84.2	-71.9
Operation and maintenance	-10.5	-14.8	-9.6
Purchase of electricity	-25.9	-50.2	-20.5
Sales of electricity	57.4	113.6	48.2
Value of the facility after 30 years	1.2	5.9	-
Environmental aspects	27.2	53.0	21.4
Net tax factor	-26.0	-29.3	-26.2
Tax distortion loss	-10.0	-5.9	-10.7
Total	-58.5	-11.9	-69.3
Internal interest	**<0%**	**3.3%**	**<0%**

8.4. Financing model

A shore power facility can be financed for DKK 74.8 million and is expected to return DKK 31.1-92.3 million in income over a 30-year period. Alternatively, the plant can be financed by loans over 30 years, but this carries the risk of insolvency if the income from sales of electricity is not as expected.

If the plant is financed by loans over 30 years, there will be a need for liquidity in both scenario 1 and scenario 3 in the order of DKK 45-50 million to establish and operate a shore power facility in Copenhagen, while scenario 2 creates a liquidity need of around DKK 27 million[22]. If scenario 2 is achieved, some this money will be earned back after 30 years, whereas it will be lost in the other scenarios. All three scenarios produce a profit after 30 years, assuming there is still a demand for shore power.

If the State and the City of Copenhagen wish to establish a shore power facility in Nordhavn, this could be done by a public company, with the State and the City of Copenhagen injecting the necessary capital to develop the facility. This could be supplemented by the company taking out a loan. Because of the great uncertainty as to the number of ships that will use the facility in the future, it is not certain that the company will be able to deliver a return on the capital invested.

The State will receive increased income from the PSO levy and the minimum electricity tax amounting to DKK 14-37 million in the 30-year calculation period (P/E 2015). The willingness of the State to finance shore power has not been investigated in the present analysis.

[22] All three scenarios assume that the establishment costs of DKK 74.8 million will be financed by loans at 1.5% p.a. If a better interest rate can be obtained, the need for liquidity will be reduced.

City & Port Development will be able to provide a site or a building free of charge.

A possible organisational and financing model could be as follows:

1) A publicly owned operating company establishes and finances a shore power facility producing 20 MW to serve one terminal. Either the company can obtain all the capital from the State and the municipality, or it can borrow a portion of it.
2) The shore power facility will be made available to an operator, such as CMP.
3) The operator or operating company collects a shore power charge from the ships based on their consumption of electricity. The costs to the operator and the operating company are covered by the profits from sales of electricity minus operating costs to run the plant.

9. SENSITIVITY ANALYSIS

A number of estimates have been used in this study, which may not hold up in the future. These include passenger growth, energy consumption per passenger and changes to environmental law. This section assesses the sensitivity of the business case and of the environmental effects. It only considers the Baseline scenario (scenario 1) with loan financing.

9.1. Lower passenger growth and lack of capacity in the plant

The years 2000 to 2012 saw a total increase in passengers averaging 14.5% per year, with a slight fall in the number of passengers from 2012 to 2014. The analysis is based on an assumption of annual growth in passengers of 5% to 2030 and 1% thereafter because of a lack of capacity from 2030 onwards. This is an estimate from CMP, but it may turn out that this growth flattens out, goes faster or goes slower.

Nor do the scenarios allow for the fact that more ships may dock on the same day than there is shore power capacity for. In this case, the operator will have to refuse shore power to one ship if two ships that can take shore power dock on the same day. This will be a problem particularly if there is a demand for shore power from the shipping companies.

To illustrate the sensitivity of passenger growth and capacity in the plant, we have assumed passenger growth of 2.5% per year. In this case, the maximum capacity on Ocean Quay will not be reached, so the projection has been used for the whole 30 years. The sensitivity analysis shows that the costs decrease but the income decreases even more. The total costs are then DKK 6.9 million higher. The calculation also shows that the State gets a smaller return from national taxes of the order of DKK 3.8 million. The costs without national taxes then rise by a total of DKK 10.7 million in the 30-year calculation period.

The effects on the business case are shown in the table below.

Table 18: Sensitivity calculation, passenger growth of 2.5%, 2016-2045

2015 prices	Scenario 1 (Baseline)	2.5% passenger growth	Difference
Interest and loan repayments	-69.4	-69.4	0.0
Operation and maintenance	-19.3	-17.5	1.7
Purchase of electricity excl. national taxes	-49.4	-39.1	10.3
National taxes	-18.7	-14.8	3.8
Sales of electricity	110.5	87.7	-22.8
Total	-46.3	-53.2	-6.9
Total excl. national taxes	**-27.7**	**-38.4**	**-10.7**

Fewer passengers also mean less environmental effect. The environmental effects are thus expected to be reduced by around 20%, equivalent to a present value of approx. DKK 5.6 million in the socio-economic calculations. The effects on the environment are shown in the table below.

Table 19: Sensitivity calculation: Reduced environmental effect with passenger growth of 2.5%.

	Scenario 1 (Baseline)	2.5% passenger growth	Difference
CO_2 (tonnes)	58,519	47,294	-11,225
NOx (kg)	1,172	947	-225
Particles (kg)	19	15	-4
SO_2 (kg)	12	10	-2

The table shows the total cumulative environmental effects over 30 years from 2016-2045

9.2. Lower energy consumption per passenger

The calculation assumes that each cruise passenger consumes 3 kW in the time the ship is in port (3 kWh per passenger-hour). This is the same basis for calculation as the earlier notes from City & Port Development and CMP in 2012 and Dansk Energi and the City of Copenhagen in 2013. In a study from 2009, the Danish Environmental Protection Agency referred to a calculation model from 2005, in which average energy consumption was typically put at 3.4-3.8 kW per passenger[23]. On the other hand, events show that cruise ships are carrying out energy renovations with double-glazing, LED lighting etc., which pull in the other direction. It is therefore likely that energy consumption per passenger will be reduced in the coming years. If the ships become more energy-efficient and so use less than 3 kW per passenger berth, this will lead to lower electricity sales and less income.

To illustrate the sensitivity of energy consumption, the business case has been recalculated with an average energy consumption of 2.5 kWh per passenger-hour while cruise ships are in port. The sensitivity analysis shows that the costs decrease but the income decreases even more. The total costs are then DKK 7.1 million higher. The calculation also shows that the State gets a smaller return from national taxes of the order of DKK 3.1 million. The costs without national taxes then rise by a total of DKK 10.2 million in the 30-year calculation period. The effects on the business case are shown in table 20 below.

Table 20: Sensitivity calculation, energy consumption of 2.5 kWh per passenger-hour in port, 2016-2045

2015 prices	Scenario 1 (Baseline)	2.5 kWh/passenger-hour	Difference
Interest and loan repayments	-69.4	-69.4	0.0
Operation and maintenance	-19.3	-19.3	0.0
Purchase of electricity excl. national taxes	-49.4	-41.2	8.2
National taxes	-18.7	-15.5	3.1
Sales of electricity	110.5	92.1	-18.4
Total	-46.3	-53.4	-7.1
Total excl. national taxes	**-27.7**	**-37.8**	**-10.2**

Lower energy consumption also means less environmental effect. The environmental effects are expected to be reduced by approx. 16%, equivalent to a present value of around DKK 4.5 million in the socio-economic calculations. The effects on the environment are shown in table 21 below.

[23] Danish Environmental Protection Agency Ship emissions and air pollution in Denmark, 2009

Table 21: Sensitivity calculation: Reduced environmental effect with energy consumption of 2.5 kWh per passenger-hour in port

	Scenario 1 (Baseline)	2.5 kWh/passenger-hour	Difference
CO_2 (tonnes)	58,519	49,207	-9,312
NOx (kg)	1,172	985	-187
Particles (kg)	19	16	-3
SO_2 (kg)	12	10	-2

The table shows the total cumulative environmental effects over 30 years from 2016-2045

9.3. Scrubbers

The Baseline scenario for the analysis assumes that scrubbers are installed on 3% of the ships each year. These ships produce their own electricity based on heavy fuel oil. If more ships opt to install scrubbers, the price at which a shore power facility can sell electricity will be reduced.

We have calculated the sensitivity where scrubbers are installed on 10% of the ships each year. This reduces the income from sales of electricity by DKK 8 million.

Table 22: Sensitivity calculation, scrubbers phased in at 10% per year

2015 prices	Scenario 1 (Baseline)	10% scrubbers/year	Difference
Interest and loan repayments	-69.4	-69.4	0.0
Operation and maintenance	-19.3	-19.3	0.0
Purchase of electricity excl. national taxes	-49.4	-49.4	0.0
National taxes	-18.7	-18.7	0.0
Sales of electricity	110.5	102.5	-8.0
Total	-46.3	-54.3	-8.0
Total excl. national taxes	**-27.7**	**-35.7**	**-8.0**

Greater use of scrubbers does not change the calculated environmental effect, as the alternative is to use more expensive and cleaner fuel with broadly the same environmental properties.

9.4. NECA zone from 2022

From 1 January 2016, zones are being introduced along the coasts of North America where NOx emissions from new ships have to be reduced by around 75% compared to today's levels (NECA zones). A similar zone has been proposed for the Baltic, but has been repeatedly shelved. It is not expected to take effect before 2022. As it has not been decided upon, the zone is not included in the calculations.

A NOx zone will have a net positive effect on the environment, but for new ships that use shore power, this will reduce the environmental effect of the shore power facility viewed in isolation. This is because the new ships produce lower NOx emissions, decreasing the potential savings from shore power.

We have calculated the sensitivity of the environmental effect of a NOx zone in the Baltic. It is assumed that all new ships will reduce their NOx emissions in port by 75% from 2022. It is expected that 2.5% more new ships will appear each year.

The overall environmental effect of a shore power facility will be reduced by 207 tonnes of NOx over the 30-year period. This is equivalent to approx. 20%. In socio-economic unit prices, this represents a present value of DKK 3.0 million.

Table 23: Sensitivity calculation: Reduced environmental effect with a NOx (NECA) zone in the Baltic from 2022.

	Scenario 1 (Baseline)	With NECA	Effect
NOx (tonnes)	1,182	975	-207

The table shows the total cumulative environmental effects over 30 years from 2016-2045

The technology to remove NOx (SCR catalysts) causes the ship to use extra fuel and a quantity of urea[24]. The increased CO_2 emissions and the costs of fuel and urea have not been included.

9.5. Other uncertainties

Number of ships and arrivals using shore power

In scenario 1 (Baseline) it is assumed that 19% of turnaround ships can use shore power, and that the number of turnaround stops using shore power will increase over the years as more cruise ships stop in Copenhagen. This 19% figure is based on few ships making several stops in Copenhagen in the course of a season. In 2015, for example, there will be 3 turnaround ships that can take shore power. They make a total of 41 visits to Nordhavn. If one of these ships stayed away or did not make a turnaround but only a transit stop, there would be only 25-29 arrivals able to take shore power in 2015, which would have a major bearing on the business case. Conversely, one more ship could produce a further 10-16 visits. With so few ships able to take shore power, there is a great risk of large fluctuations in the number of arrivals each year.

The electricity purchase system

The Scandinavian electricity purchase system is structured so that a large consumer of electricity has to declare in advance how much it wishes to purchase and when. If it takes more than the quantity it has ordered, a penalty charge is imposed. This is to safeguard the total electricity supply to an area, and to ensure that the system does not collapse. A ship that changes its route, or skips a port, possibly because of the weather or an increased risk of terrorism, will incur a penalty charge. This could reduce the possible surplus which is meant to pay for the investment. In connection with the analysis, DONG has judged that there is a very small risk of penalty charges.

Other forms of energy

There have been experiments in recent years with other forms of energy that could replace fuel oil. These are LNG (liquid natural gas), LBG (liquid biogas), hydrogen, combined battery and fuel, methanol and ethanol. LNG and methanol in particular are a possibility in the short and medium term, while hydrogen may be an option in the longer term. This raises an uncertainty as to the period over which investment in shore power can be amortised.

[24] Urea is often used to reduce emissions of nitrogen oxides (NOx). However, this substance is less effective than ammonia, because urea has to be converted to ammonia before the NOx reduction process can take place.

10. CONCLUSION

The study is based around three scenarios for the number of cruise ships docking in Copenhagen that can take shore power – a Baseline scenario and a Low and a High scenario. The study shows that it is only possible to establish a shore power facility for cruise ships in Copenhagen with substantial public funding.

10.1. Environmental effects

The facility will have a certain environmental effect, and it is calculated that CO_2 emissions will be reduced by 46,000-117,000 tonnes and NOx emissions by 912-2,346 tonnes in the 30-year calculation period. Depending on the scenario used, this means that society gains DKK 21-53 million in socio-economic environmental and health benefits spread over a 30-year calculation period (present value, 2015). According to the socio-economic analysis, however, this does not measure up to the investments.

The environmental effects of establishing shore power are not insignificant, but nor are they striking compared to emissions from other sources. In the Baseline scenario, the emissions of CO_2, NOx and particles are equivalent to approx. 0.1% of the total emissions of each of these substances in the City of Copenhagen.

On average, the reduced emissions in scenario 1 (Baseline) will reduce early mortality by 2 years of life and the number of sick days by 300 days a year. By way of comparison, the City of Copenhagen's project to install particle filters on at least 200 city buses will save around 3 years of reduced life and 200 sick days per year. The establishment costs for particle filters on buses are around DKK 10 million.

10.2. Financial conditions

The number of visits by ships that can take shore power varies in the three scenarios. In all calculations, it emerges that in the initial years there is only a need for a shore power facility for one ship, but that some of the scenarios will require the facility to be expanded later. It is recommended that a shore power facility should be built, and that the connection to the grid and the building should be designed for a larger plant, but that a facility to deliver 20 MW to one ship should be established in the first instance. This will make it possible to divide the establishment of a shore power facility into stages. If demand proves to be great, it will be profitable to expand the plant after 8 years. According to estimates in the analysis, the establishment costs for a small plant incl. connection to grid cables, building, shore-to-ship connections etc. run to DKK 74.8 million. The final price will be determined by a tendering procedure, and may differ from the estimate.

Compared to earlier examinations of shore power, this study shows that it is possible to reduce the cost of establishment significantly. This is partly because it is possible to build the facility in stages, but also because prices have fallen. However, the study also shows that we cannot expect as many arrivals of ships that can take shore power as shown in the earlier studies, and that there are substantial operating and maintenance costs associated with running a shore power facility. On the other hand, the State will receive additional revenue in electricity taxes in the order of DKK 14-37 million in the 30-year calculation period.

The business cases for the three scenarios based on loan financing show that only the High scenario produces a positive operating balance. However, this assumes that the State pays back the electricity taxes that it collects. If the added revenue to the State from electricity taxes is paid back to the owner of the shore power facility, the outcome of the business case calculations ranges from DKK -35.3 million in the Low scenario to DKK +23.8 million in the High scenario. The Baseline scenario produces a business case of DKK -27.7 million. If the business case calculations are not based on borrowing, they will be around DKK 6 million worse, as it will not be possible to exploit the current low interest rates. On the other hand, the risk of insolvency will be reduced.

The study shows that none of the scenarios produces a positive socio-economic return with an internal interest rate over 4%. The Baseline and Low scenarios show negative interest rates.

A shore power facility can be organised with a public company as owner and with CMP or another operator to run it. The ships will pay a price for electricity, which will finance the purchase of electricity, maintenance and interest costs, and pay back part of the investment in the shore power facility. The electricity price must be low enough to constitute a proper incentive for ships to choose not to use their own engines to produce electricity, but also high enough to finance the costs of the system. A price of DKK 1.12/kWh is considered to be a reasonable starting price.

10.3. Uncertainties

There are a number of uncertainties in the estimates. The following uncertainties are considered in the analysis:

- Lower passenger growth than estimated and/or lack of capacity in the plant
- Lower energy consumption per passenger
- Rate at which scrubbers are introduced in this sector
- A possible NECA zone in the Baltic from 2022 or later
- The actual ships docking in Copenhagen
- Fines from the supply company where too much or too little electricity is drawn off compared to expected consumption
- Phasing-in of alternative fuels in the cruise ship sector

As there are many uncertainties concerning the income from a shore power facility, it is considered most sensible not to base the establishment of a shore power facility on loan financing, but to finance it through a public development grant. The company through borrowing can finance a possible later expansion of the facility.

11. ANNEXES

Annex 1: Establishment costs for the electrical plant

The establishment costs break down into the costs of the shore power facility itself, and of a building to house the installation.

We have used three scenarios based on systems of different sizes. The smaller the installation, the lower the establishment costs. On the other hand, the costs of future expansion will be increased.

To allow for future expansion, we assume the same building in all four scenarios.

Scenario 1: Full scale – 40 MW

In the full-scale scenario, a future-proof facility is established from the outset. The plant produces 40 MW, and it is possible to supply up to 20 MW to three ships, up to a maximum of 40 MW altogether.

Establishment costs, 40 MW

Converters, equipment etc.	DKK 62.5 m
Building, foundations etc.	DKK 15 m
Total establishment costs	**DKK 77.5 m**

Scenario 2: Medium scale – 30 MW

In this scenario, a facility is established for three ships, but with lower output. It is then still possible to deliver 20 MW to each of the three ships, but only up to 30 MW in total. There are thus some restrictions on the number of very large ships that can dock at the same time. The largest ships today use up to 14 MW, so 30 MW is considered to be sufficient for the foreseeable future.

Establishment costs, 30 MW

Converters, equipment etc.	DKK 44.5 m
Building, foundations etc. prepared for 40 MW	DKK 15 m
Total establishment costs	**DKK 59.5 m**

The costs of upgrading to 40 MW will be approx. DKK 18 million

Scenario 2: Small scale – 20 MW

In this scenario, a facility is established for just two ships, but designed to be expanded to three ships. It is then still possible to deliver 20 MW to each of the two ships, but only up to 20 MW in total. There are thus some major restrictions on the number of very large ships that can dock at the same time. The largest ships today use up to 14 MW, so 20 MW will still give us some flexibility. 20 MW is the smallest possible shore power facility that meets the international standard.

Establishment costs, 20 MW

Converters, equipment etc.	DKK 33 m
Building, foundations etc. prepared for 40 MW	DKK 15 m
Total establishment costs	**DKK 48 m**

The costs of upgrading to 30 MW will be approx. DKK 14 million.

The costs of upgrading to 40 MW will be approx. DKK 32 million.

Other establishment costs

Apart from the establishment costs, there will also be costs for quay facilities, connection to the grid, and operation and maintenance.

Annex 2: Electricity connection

Connection to the public supply network
There are 10 kV, 30 kV and 132 kV networks in the area. The connection charges and ongoing network tariffs differ. The ongoing network tariff generally decreases as the voltage increases, as the grid company has to establish and run less infrastructure to serve the customer; on the other hand, the actual grid connection is most expensive at higher voltage levels because of the higher cost of components.

With a total output of the order of 30-40 MVA, connection to a 10 kV network is not realistic. The facility should therefore be connected to 30 kV or 132 kV. It will help if the facility can be supplied specifically from the 30 kV network without further transformation, as this will save a transformer.

It is theoretically possible to connect the facility to 10 kV, 30 kV or 132 kV. Prices, advantages and disadvantages of connecting to the different voltage levels are discussed below.

We have used the following assumptions:

Network tariff, 2014 figures
To connect to 10 kV and 30 kV the following bands apply:

Price band 1

Working days, all year: 21:00-06:00
Weekends and public holidays, and 1 May, 5 June, 24 and 31 December: all day

Price band 2

April-September: Monday-Friday 06:00-08:00 and 12:00-21:00
October-March: Monday-Friday 06:00-08:00, 12:00-17:00 and 19:00-21:00

Price band 3

April-September: Monday-Friday 08:00-12:00
October-March: Monday-Friday 08:00-12:00 and 17:00-19:00

The network tariff for 132 kV is the same all day/all year.

Price in øre/kWh excl. VAT and charges	Band 1	Band 2	Band 3
10 kV A-customer	32	34	36.4
30 kV A-customer	31.7	33.7	36.1
132 kV	29.9	29.9	29.9

Figures taken from

http://www.dongenergydistribution.dk/da/erhverv/Eldistribution/Priser%20og%20gebyrer/Pages/Prisergebyrer2012_ny.aspx

Connection to 10 kV

With a total output of the order of 30-40 MVA, connection to a 10 kV network is not realistic, either output-wise or financially.

Connection to 30 kV

In the case of connection to 30 kV, City & Port Development will bear the actual costs of connection. A 30 kV connection enables a direct output connection and so eliminates the costs of further network transformers and switches and related transformer losses.

The estimated costs of a connection to 30 kV at SMV are shown in the table below (see Appendix 3) and include estimates of expenditure on cables etc.

The price of cables has been quoted by DONG Energy for a B-customer.

For an A-customer, the cabling work is estimated on the basis of discussions with Aarsleff and an assessment by CMP:

Excavation work:	3,500,000
Cables:	3,200,000
Removal of (contaminated) soil:	200,000
Miscellaneous:	600,000
Total:	7,500,000

DKK millions	Network connection	Cable+ excavation work	Total
30 MVA			
A-customer	3.5	7.5	11.0
B-customer	3.5	36.0	39.5
40 MVA			
A-customer	4.0	10.0	14.0
B-customer	4.0	49.0	53.0

For a 40 MVA A-customer an additional price for cabling work of 31% (from past figures) has been estimated, compared to 30 MVA.

In the case of connection as A-customer, City & Port Development itself will bear the costs of establishing the facility up to the supply point on the quay. The above prices include the costs of this if DONG Energy is to do the work for a charge. City & Port Development will then be responsible for the operation and maintenance of the facility.

In the case of connection as B-customer, DONG Energy will bear all the costs of establishing the facility up to the supply point on the quay and the subsequent operation and maintenance.

An advantage of connecting to 30 kV is that it saves a step-down transformer from 132/(30/10 kV), as the facility can be connected directly to 30 kV.

Connection 132 kV

The price for a network connection to 132 kV (Appendix 4) is quoted for three different solutions:

A 132 kV connection calls for a 132 kV/30 kV transformer and protective circuit-breaker.

New 132/30 kV station on the quay, approx. DKK 60 million.

New 132 kV station with cable, then 132 kV cable to quay and 132/30 kV station on quay, DKK 55.5 m

New 132 kV station with cable, then 30 kV cable to quay, DKK 47 m

The cheapest solution is sufficient and allows up to 50-80 MVA.

If it is decided to connect to the 132 kV network, it is recommended to transform down to 30 kV, as all 12 transformers in the converter facility will then be the same = saving on purchase.

Assessment of network connection options

In a different context, the consultancy produced the following calculation for City & Port Development to assess whether a 30kV or 132 kV connection is most suitable for shore power.

Estimated prices were obtained from Energinet.dk and DONG Energy for the network connection. In order to assess the total costs, they estimated a lifetime of 25 years for the facility and used network tariffs from Energinet.dk and DONG Energy.

The following assumptions were made:

- Period is 1 April to 15 September
- Consumption per ship is 7 MW
- The ship docks at 08:00 and leaves at 18:00 (i.e. 6 hours at price band 2 and 4 hours at price band 3)
- This gives 42 MWh per ship at price band 2, and 28 MWh at price band 3
- Amortisation rate is 3%
- Network connection for 30 MVA

The total expenditure is the sum of:

- The estimated prices of the network connection
- The quoted annual network tariff discounted back to the year of construction at 3% over a 25-year period

	Network tariff projected	Total expenditure in 25 years
Assumption: 40 visits in each of 25 years		
Total grid connection 30 kV A-customer	DKK 16,899,112	DKK 40,749,112
Total grid connection 30 kV B-customer	DKK 16,899,112	DKK 56,399,112
Total grid connection 132 kV	DKK 14,578,287	DKK 61,578,287

Assumption: 40 visits in 10 years, then 200 visits in 15 years		
Total grid connection 30 kV A-customer	DKK 51,204,193	DKK 75,054,193
Total grid connection 30 kV B-customer	DKK 51,204,193	DKK 90,704,193
Total grid connection 132 kV	DKK 44,325,493	DKK 91,325,493

What the table above attempts to show is whether there is a number of visits at which the total expenditure tips over so it becomes cheaper to connect to 132 kV. It is therefore not relevant to assume an even increase in the number of visits over the years.

As can be seen from the above, the total price over 25 years is lowest for a network connection as an A-customer to 30 kV for all scenarios. It is therefore recommended to connect to 30 kV. The internal costs of operating and maintaining the cable must however be assessed and included in a final assessment of the network connection.

Redundancy requirements

Supply networks and important installations are normally designed with redundancy to provide high security of supply to users. Connection as a B-customer also includes redundancy in the cables that DONG will establish. Redundancy involves duplicating the central components and so significantly increases the costs of the facility.

Redundancy, network connection

A fault in the network connection will interrupt the supply to the whole facility. There are basically three potential sources of faults: 132/30 kV transformer failure at SMV (the Svanemølleværket plant), fault in the 30 or 132 kV connection at SMV or in the 30 kV cable to the shore power facility.

The first type of fault may be prolonged; in the worst case, up to a year. But as the system at SMV is designed with redundancy, the downtime will be measured in hours.

The last two faults have a moderate rectification time; the worst is a cable fault, and rectification could take a week.

It is considered that the cost of a redundant network connection is not justified by the benefits of redundancy; partly because of the relatively limited downtime and partly because the consequence of an interruption is merely that the ships have to use their auxiliary engines until the fault has been fixed.

It is therefore not planned to provide redundancy in the network connection.

Redundancy, shore power plant

There are basically three potential sources of faults in a shore power facility as outlined here: The transformers before and after the frequency converters, the 11 kV and 30 kV connections and the control system.

A fault in a transformer, frequency converter or 11 kV connection will interrupt the supply to one quay location for a long time. A fault in the 30 kV connection and the control system will interrupt the supply to all quay locations for a long time.

Based on the same arguments as for the network connection, it is felt that there is no need for redundancy.

However, the shore power facility should be designed to deal with faults that could affect the whole facility for a long time, particularly:

- Risk of fire or consequential damage spreading from one converter to another
- Risk of fire or damage to the control system
- Risk of flooding

Annex 3: Shore-to-ship connection

Cable system on the quay to handle 4 large power plugs and a smaller communication plug.

There are three types of cable system:

1. A fixed cable crane with a working radius of approx. 10 m along the quay. Photo from Seattle Price approx. DKK 1.5 million per crane.

   Solution 1 cannot be used at the cruise terminal in Nordhavn, as many different ships dock at the same quay and cruise ships do not have the shore power facility in the same place. A fixed crane will require different cranes to be placed along the ship, at great inconvenience to shore/ship operations. Exists in Seattle, where each berth is dedicated to a single shipping company.

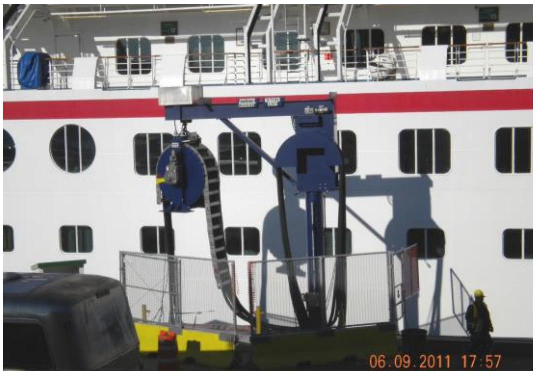

Figure 4: Cable crane in Seattle

2. A cable truck with a working radius of approx. 50 m along the quay. To cover different locations of the shore power facility on the ship, it will be necessary to provide a cable truck and 3 connection points along the quay for each terminal. Price approx. DKK 6 million for the cable truck incl. 3 connection points.

   Solution 2. Can be used at the cruise terminal in Nordhavn. The cable truck will impede shore/ship operations as the cable lies on the apron area, but only on part of the length of the ship.

Figure 5: Cable truck in Hamburg

3. An underground cable system combined with a cable truck. Price approx. DKK 10 million per terminal. The cable is laid in a channel under the apron. The cable truck is connected to the cable and runs along the channel, with shutters opening and closing in front of and behind the crane truck. Under construction in Hamburg-Altona.

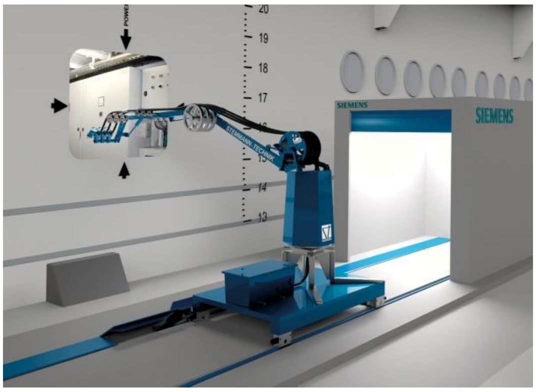

Figure 6: Illustration of cable system in Hamburg

Solution 3. Cannot be used at the 3 existing terminals, as it requires underground cable channels along the quay, which will clash with the anchor channels in the quay walls and with water and waste pipes laid at right angles to the wall. If a fourth terminal is constructed to the north of the 3 existing terminals, it will be possible to implement this solution at the same time as the terminal is built.

Annex 4: Operating costs

It is assumed that the supplier will provide operation and service for the first five years after delivery.

The annual maintenance costs are estimated at 0.8% of the total construction cost incl. connection to the side of the ship. Then there is maintenance of the building. We may also expect a lot of maintenance of the cable, as it will be laid through an urban development area.

Annual maintenance costs

	40 MVA	30 MVA	20 MVA
System	500,000	356,000	264,000
Building	25,000	25,000	25,000
Cable	110,000	100,000	100,000
Total per year	**635,000**	**481,000**	**389,000**

Annex 5: Expectations regarding shore power

Cruise ships in Copenhagen equipped to take electricity from on shore.

This note sets out the expectations regarding cruise ships that can take shore power in Copenhagen – including the expected number of ships, visits, passengers etc. It also describes the way shore power can be handled in practice.

This note only deals with ships that will dock at the new cruise terminal at Ocean Quay in Nordhavn, as it is really here that shore power for cruise ships can be established. Langelinie is too narrow to be able to handle shore power at the same time as providing the other services. For space reasons, it is necessary to prioritise so-called turnaround ships at Ocean Quay. The other ships (transit stops) will only be placed on Ocean Quay in exceptional circumstances.

Shore power today

In January 2015, as part of the work to examine the possibility of establishing shore power for cruise ships in Copenhagen, CMP circulated a questionnaire to shipping companies with ships using the port of Copenhagen in 2013 and 2014 or expected to do so in 2015 and 2016. The responses represent 65 ships. Many of the ships represented in this study do not operate in Europe, or not all the time.

CMP received replies from the following cruise operators:

- Princess Cruises
- MSC
- Norwegian Cruise Line
- Aida Cruises
- Holland America Line
- TUI Cruises
- Costa Cruises
- Carnival Group

An internet search was also run on the operators for which there were no details of the use of shore power, including Royal Caribbean and Celebrity and Cunard/P&O Cruises and Disney Cruises. This looked at the companies' websites and in articles in electronic media.

The list of ships that can accept shore power has been aligned with the list of cruise ships that have visited or are scheduled to visit Copenhagen in 2010-2016, so there are figures for seven years in all. More cruise ships have still to be scheduled to visit Copenhagen in 2016, so 2016 is equated with 2015 in the calculations.

The basis for supplying cruise ships with shore power in Copenhagen today is around 30-35 arrivals per season, rising to around 40 in 2016. The 35 arrivals represent an average of 10% of all cruise ship visits to Copenhagen in the relevant years and 17% of ships will dock at Ocean Quay in Nordhavn (turnaround stops).

Altogether, 65-75 different ships (spread over approx. 300 visits) typically visit Copenhagen in the course of a cruise season.

Table 1. Number of turnaround stops in Copenhagen in 2010-2015 that can take shore power

Shipping line	**Ship's name**	**Comments**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Average 2010-2015**
Princess Cruises	Caribbean Princess	(compl. 2015)			(1)				(0)
Princess Cruises	Regal Princess	(compl. 2015)						13	2
Princess Cruises	Emerald Princess	(compl. 2016)		(12)	(12)	(12)	(1)		(6)
Princess Cruises	Royal Princess	(compl. 2016)		(1)			(12)	(1)	(2)
Norwegian Cruise Line	Norwegian Star					17	16	16	8
Holland America Line	Eurodam		6	6	6	7	10	12	8
Total able to take shore power			6	19	19	36	39	42	27
Total turnaround			135	153	167	164	126	131	146
Shore power (%)			**4%**	**12%**	**11%**	**22%**	**31%**	**32%**	**19%**

Ship technology

The SECA (sulphur emission control area) rules have been introduced in the North Sea and the Baltic and in the USA and Canada with effect from January 2015. The SECA rules mean that ships can no longer emit SO_2 equivalent to a sulphur content of more than 0.1% in marine fuel within the SECA areas. The previous limit was 1.5% up to 2010 and 1.0% from 2010-2015 in the SECA areas; outside the SECA areas, the limit is 3.5% sulphur (previously 4.5%). These limits have been set by the IMO, which is the maritime arm of the UN.

Since 1 January 2015, as a result of the SECA rules, ships have either had to use the expensive SECA fuel (marine gas oil, or MGO) or take the option of installing flue gas cleaning, or 'scrubber' technology.

Scrubbers remove 99.9% of the SO_2 and also 50-80% of the particles. It is therefore possible to go on using a cheaper and more sulphur-rich fuel oil in SECA areas. However, scrubbers increase fuel consumption by approx. 2% and do not reduce NOx and CO_2 emissions.

Some scrubbers use large quantities of sea water to clean the air, while others use caustic soda. The model that uses sea water discharges SO_2 and soot particles directly into the sea water, so cannot be used in port. The model that uses caustic soda to remove SO_2 produces a waste material that has to be sent for treatment/landfill, e.g. with Kommunekemi. This model can be used anywhere. It is possible to combine the two models, so caustic soda is only used in port.

Most cruise operators have indicated that they do not intend to install equipment to accept shore power, as many of them have opted instead to install scrubber technology, which (unlike shore power) also significantly reduces emissions of SO_2 and particles while the ships are at sea. These include Royal Caribbean, which is installing scrubbers on 19 ships, and Carnival Group (Carnival, P&O and Cunard). Discussions between CMP's cruise manager and the American shipping companies at customer meetings in January 2015 indicate that the companies are choosing scrubber technology so they can go on using the cheaper, typically 1.0% fuel.

The tendency is for more operators to choose scrubber technology on their new ships but some are still allowing space for some of their new ships to have equipment for shore power fitted, but – with a few exceptions – without completing the installations. A single operator is actively pursuing the shore power solution. This shipping line (Princess Cruises) operates largely on the West Coast of the USA/Canada up to Alaska, and has relatively few ships in Europe. It has its own terminals with shore power in Seattle and Vancouver. A number of operators have one or a few ships with shore power or the ability to take shore power.

There is no conflict between shore power and scrubbers, but as both technologies are costly to install, there will in practice be a tendency to opt for just one of the technologies on each ship.

Future development

Feedback from the shipping companies indicates that they are focusing on scrubbers, but some new ships are being prepared to have shore power installed at a later date. It is therefore assumed that the proportion of turnaround stops that can take shore power will remain unchanged. In recent years, around 45% of all cruise ship arrivals have been turnaround stops, and with the tighter competition and the limited number of terminals with turnaround facilities, there is no prospect of this situation changing significantly.

There is a general positive trend in passenger numbers and a tendency towards larger and larger ships in the turnaround segment. We may therefore expect an increase in passengers from 2014 of around 5% on average among the turnaround stops. In 2014 there some 284,000 turnaround passengers measured by the number of berths. This would mean approx. 50,000 berths on ships that can take shore power in 2014. In 2020 the figure will rise to approx. 67,000 berths, and in 2030 there are expected to be around 108,000 berths in turnaround visits by ships that can take shore power. This is an uncertain forecast, as there will be both positive and negative trends.

The establishment of a shore power facility in the port of Copenhagen could lead to the port seeing more visits by ships that can take shore power, provided that the costs of receiving electricity from on shore are attractively low. Particularly if the other major ports in the Baltic region incl. Oslo also install shore power, the proportion of ships that can take shore power can be expected to rise, as the incentive to the operators will be increased by this. Before any final positive decision to invest in shore power, the shipping companies should be contacted to test their willingness to use shore power in Copenhagen.

CMP, City & Port Development and the City of Copenhagen have discussed with the port and municipality of Oslo and the port of Stockholm the possibility of establishing shore power for cruise ships in all three ports. Oslo and Stockholm have not shown any interest in this, as they concentrate on shore power for their many ferries. It is felt, however, that the establishment of shore power for cruise ships in Copenhagen could have a *first mover* effect, which could attract other ports in the Baltic region in the longer term, and hence also more visits. However, this is very uncertain.

The study shows that the latest equipment to accept shore power can be installed in relatively many cruise ships, because they are basically prepared for it, but many ships, especially newbuilds, are being fitted instead with scrubber technology, which also works at sea and complies with the IMO’s emission standards for SECA areas both in Europe and in the USA/Canada.

It is not possible now to say with any certainty whether future cruise ships will be fitted with scrubber systems or shore power or both. RO-RO ships operating within the SECA area are noticeably more likely to install scrubber technology in order to go on using the cheaper and more sulphur-rich fuel. In the long term, liquid natural gas (LNG) or liquid biogas (LBG) may be used to some extent instead of fitting scrubbers. The European Commission is working to establish a network of LNG supply stations in Europe by 2030.

Handling of shore power equipment

For cruise ships, 4 11 kV cables per ship will typically be used. The thickness and weight of these cables require handling with a crane and a purpose-built cable drum. If a mobile crane is used, 3-4 persons will be needed to handle the cable, typically for ½-1 hour on two occasions when the ship arrives and leaves. If dock workers are used for this operation, it will be necessary to spend a further 15 working hours per visit to Copenhagen on the electrical connection, compared to the number spent today (total DKK 6,750 per visit, or approx. DKK 2.70 per passenger). As this will involve high voltage, one employee will probably have to have a high-voltage certificate. Before the ship docks, the team will move the equipment to the place on the quay where the cable is to be attached to the ship. When the ship has docked and been made fast, the electricity cables will be hoisted to a hatch and attached by the crew. The power will then be switched on and synchronised. The reverse procedure will be used before departure.

Feedback from the cruise industry

Feedback from the shipping companies below:

- Royal Caribbean
  Installing scrubbers on 19 ships

- Carnival Group (Carnival, P&O and Cunard)
  Focusing on scrubbers

- MSC
  MSC has no ships equipped for shore power, but does have two ships on which it can be installed, and they state that space will also be allowed on future newbuilds.

- Princess Cruises
  Princess has installed equipment for shore power on 11 ships and will install it on a further 5 ships in 2015 and 2016; four of these ships have visited CMP in the last two years. In 2013, Princess had a ship that visited Copenhagen and could take

shore power. After retrofitting of existing ships, the company states that it will have another 5 ships in 2016 that can take shore power.

- Holland America Line
  Holland America Line has two ships in Europe that can take shore power, while the rest of its ships equipped for shore power operate on the West Coast of the USA/Canada. The new ships from this company will be prepared for but not fitted with shore power technology. Holland America Line has one ship with shore power equipment, which also visits Copenhagen on several occasions.

- Norwegian Cruise Line
  Norwegian Cruise Line has one ship with shore power equipment, which also visits Copenhagen on several occasions, but the rest of its fleet cannot take shore power.

There is a trend among many of the operators for space to be set aside on newbuilds for the ship-based equipment for shore power to be installed if this becomes opportune. But the trend towards scrubber technology makes it likely that fewer companies will in future make space for shore power equipment on their new ships.

There is some uncertainty in the response, but in this note we have chosen to interpret the slightly imprecise details given by the shipping companies in a positive light with regard to shore power installation. The overall position for shore power is shown below.

Ships that can take shore power, or are prepared for it

Operator	Ship's name	Plug-in possible today	Prepared but lack latest installations
Aida Cruises	AidaPrima	yes	compl. 2016
Aida Cruises	Aidasol	yes	
Costa	Costa Deliziosa	no	yes
Costa	Costa Diadema	no	yes
Costa	Costa Luminosa	no	yes
Holland America Line	Amsterdam	yes	
Holland America Line	Eurodam	yes	
Holland America Line	Koningsdam		not complete
Holland America Line	Oosterdam	yes	
Holland America Line	Oosterdam	yes	
Holland America Line	Statendam	yes	
Holland America Line	Veendam	yes	
Holland America Line	Westerdam	yes	
Holland America Line	Westerdam	yes	
Holland America Line	Zuiderdam	yes	
MSC	MSC Divina	no	yes
MSC	MSC Fantasia	no	yes
MSC	MSC Magnifica	no	yes
MSC	MSC Musica	no	yes
MSC	MSC Orchestra	no	yes
MSC	MSC Poesia	no	yes
MSC	MSC Preziosa	no	yes
MSC	MSC Seatrade Project 1	yes	(not yet built)
MSC	MSC Seatrade Project 2	yes	(not yet built)
MSC	MSC Seatrade Project 3	yes	(not yet built)
MSC	MSC Splendia	no	yes
MSC	MSC Vista Project 1	yes	(not yet built)
MSC	MSC Vista Project 2	yes	(not yet built)
MSC	MSC Vista Project 3	yes	(not yet built)
MSC	MSC Vista Project 4	yes	(not yet built)
Norwegian Cruise Line	Norwegian Breakaway	no	yes
Norwegian Cruise Line	Norwegian Epic	no	yes
Norwegian Cruise Line	Norwegian Escape	no	yes
Norwegian Cruise Line	Norwegian Getaway	no	yes
Norwegian Cruise Line	Norwegian Jewel	yes	(STB side)
Norwegian Cruise Line	Norwegian Star	yes	(STB side)
Princess Cruises	Caribbean Princess	yes	(compl. 2015)
Princess Cruises	Coral Princess	yes	
Princess Cruises	Crown Princess	yes	(compl. 2015)
Princess Cruises	Dawn Princess	yes	
Princess Cruises	Diamond Princess	yes	
Princess Cruises	Emerald Princess	yes	(compl. 2016)
Princess Cruises	Golden Princess	yes	
Princess Cruises	Grand Princess	yes	
Princess Cruises	Island Princess	yes	
Princess Cruises	Regal Princess	yes	(compl. 2015)
Princess Cruises	Royal Princess	yes	(compl. 2016)
Princess Cruises	Ruby Princess	yes	
Princess Cruises	Sapphire Princess	yes	
Princess Cruises	Sea Princess	yes	
Princess Cruises	Star Princess	yes	
Princess Cruises	Sun Princess	yes	
TUI Cruises	Mein Schiff 3	no	yes
TUI Cruises	Mein Schiff 4	no	yes
TUI Cruises	Mein Schiff 5	no	yes

Annex 6: Socio-economic costs of environmental aspects

The following unit prices have been used to calculate the environmental effects of shore power

	NO_X DKK/kg	CO_2 DKK/tonne	SO_2 DKK/kg	PM2,5 DKK/kg
2015	34	55	27	37
2016	34	61	27	37
2017	34	66	27	37
2018	34	70	27	37
2019	34	75	27	37
2020	34	79	27	37
2021	34	84	27	37
2022	34	89	27	37
2023	34	93	27	37
2024	34	97	27	37
2025	34	101	27	37
2026	34	116	27	37
2027	34	132	27	37
2028	34	160	27	37
2029	34	187	27	37
2030	34	213	27	37
2031	34	235	27	37
2032	34	256	27	37
2033	34	276	27	37
2034	34	296	27	37
2035	34	314	27	37
2036	34	314	27	37
2037	34	314	27	37
2038	34	314	27	37
2039	34	314	27	37
2040	34	314	27	37
2041	34	314	27	37
2042	34	314	27	37
2043	34	314	27	37
2044	34	314	27	37
2045	34	314	27	37

Source: Danish Energy Agency

Annex 7: Price projections, electricity and oil

Figure 7: Production prices for electricity produced on cruise ships

	HFO US$/tonne	MGO US$/tonne	Ship-produced electricity (DKK/kWh) 1% scrubbers/year	1.5% scrubbers/year	3% scrubbers/year
2015	$ 719	$ 941	DKK 1.24	DKK 1.24	DKK 1.24
2016	$ 692	$ 914	DKK 1.20	DKK 1.20	DKK 1.20
2017	$ 680	$ 902	DKK 1.18	DKK 1.18	DKK 1.17
2018	$ 685	$ 907	DKK 1.19	DKK 1.18	DKK 1.17
2019	$ 699	$ 921	DKK 1.20	DKK 1.20	DKK 1.18
2020	$ 715	$ 937	DKK 1.22	DKK 1.21	DKK 1.20
2021	$ 733	$ 955	DKK 1.24	DKK 1.23	DKK 1.21
2022	$ 752	$ 974	DKK 1.26	DKK 1.26	DKK 1.23
2023	$ 772	$ 994	DKK 1.29	DKK 1.28	DKK 1.25
2024	$ 790	$ 1,012	DKK 1.31	DKK 1.30	DKK 1.27
2025	$ 807	$ 1,029	DKK 1.33	DKK 1.32	DKK 1.28
2026	$ 821	$ 1,043	DKK 1.35	DKK 1.33	DKK 1.30
2027	$ 839	$ 1,061	DKK 1.37	DKK 1.35	DKK 1.32
2028	$ 854	$ 1,076	DKK 1.38	DKK 1.37	DKK 1.33
2029	$ 869	$ 1,091	DKK 1.40	DKK 1.39	DKK 1.34
2030	$ 881	$ 1,103	DKK 1.42	DKK 1.40	DKK 1.35
2031	$ 896	$ 1,118	DKK 1.43	DKK 1.42	DKK 1.37
2032	$ 914	$ 1,136	DKK 1.45	DKK 1.44	DKK 1.39
2033	$ 930	$ 1,152	DKK 1.47	DKK 1.45	DKK 1.40
2034	$ 945	$ 1,167	DKK 1.49	DKK 1.47	DKK 1.42
2035	$ 961	$ 1,183	DKK 1.51	DKK 1.49	DKK 1.44
2036	$ 974	$ 1,196	DKK 1.53	DKK 1.50	DKK 1.45
2037	$ 990	$ 1,212	DKK 1.54	DKK 1.52	DKK 1.47
2038	$ 1,005	$ 1,227	DKK 1.56	DKK 1.54	DKK 1.48
2039	$ 1,025	$ 1,247	DKK 1.59	DKK 1.56	DKK 1.51
2040	$ 1,047	$ 1,269	DKK 1.61	DKK 1.59	DKK 1.53
2041	$ 1,047	$ 1,269	DKK 1.61	DKK 1.59	DKK 1.53
2042	$ 1,047	$ 1,269	DKK 1.61	DKK 1.58	DKK 1.52
2043	$ 1,047	$ 1,269	DKK 1.61	DKK 1.58	DKK 1.52
2044	$ 1,047	$ 1,269	DKK 1.61	DKK 1.58	DKK 1.52
2045	$ 1,047	$ 1,269	DKK 1.60	DKK 1.58	DKK 1.51

HFO is the purchase price for heavy fuel oil. MGO is the purchase price for low-sulphur marine gas oil. All prices are in fixed 2014 prices

Figure 8: Purchase prices for electricity (DKK/kWh)

	Raw electricity price	Distributions	Electricity tax	PSO levy	Total electricity price
2015	DKK 0.259	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.573**
2016	DKK 0.253	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.567**
2017	DKK 0.301	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.615**
2018	DKK 0.350	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.664**
2019	DKK 0.398	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.712**
2020	DKK 0.447	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.761**
2021	DKK 0.449	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.763**
2022	DKK 0.451	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.765**
2023	DKK 0.454	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.768**
2024	DKK 0.456	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.770**
2025	DKK 0.458	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.772**
2026	DKK 0.460	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.774**
2027	DKK 0.462	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.776**
2028	DKK 0.464	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.778**
2029	DKK 0.466	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.780**
2030	DKK 0.468	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.782**
2031	DKK 0.469	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.783**
2032	DKK 0.470	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.784**
2033	DKK 0.471	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.785**
2034	DKK 0.472	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.786**
2035	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2036	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2037	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2038	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2039	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2040	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2041	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2042	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2043	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2044	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**
2045	DKK 0.473	DKK 0.099	DKK 0.004	DKK 0.211	**DKK 0.787**

All prices are in fixed 2014 prices

Annex 8: City of Copenhagen Finance Committee approval for a study of shore power

11. Shore power in the Copenhagen harbours (2014-0166135)

The Socialist People's Party tabled a proposal in the municipal council on shore power in the Copenhagen harbours. The municipal council decided at its meeting on 21 August 2014, agenda item 38, to refer the proposal to the Finance Committee, cf. "Summary of political discussion".

MOTION AND DECISION

The Finance Department proposes to the Finance Committee:

1. that the proposal on shore power in the Copenhagen harbours should form part of the wider study already in progress in the Finance Department, but with the amendment that only shore power for cruise ships in outer Nordhavn and for the Oslo ferry in inner Nordhavn should be examined;

2. that the Finance Department should be instructed to brief the Finance Committee on the progress of the study into shore power in Nordhavn by the end of December 2014 and to report the final conclusions to the municipal council by June 2015.

THE PROBLEM

At the meeting of the municipal council on 21 August 2014, the Socialist People's Party tabled a proposal:

1. *that the municipal council should pass a resolution to the effect that the City of Copenhagen intends to establish shore power in the Copenhagen harbours;*
2. *that the municipal council should instruct the Finance Department, with the assistance of relevant parties including City & Port Development, to draw up one or more solution model(s) for ways of establishing and using shore power in the Copenhagen harbours;*
3. *that the municipal council should instruct the Finance Department to present the solution models to the Finance Committee by the end of 2014.*

The City of Copenhagen clean air plan ("Clean air for Copenhageners") already expresses an ambition to establish shore power for cruise ships.

The 2014 budget already includes a resolution to look into cleaner shipping, e.g. through shore power (without financing). On this basis, a study has already been launched involving the City of Copenhagen and City & Port Development regarding shore power for cruise ships in Nordhavn. The study is expected to report in June 2015.

About shore power

Ships typically use oil to produce electricity when they are in port. This is partly because there is no means of taking large quantities of electricity from the ports, but particularly because the oil is tax-free and hence very cheap. In June 2014, the Folketing voted to make electricity for large ships tax-free, and the price of electricity will be reduced accordingly. This tax exemption is currently awaiting approval from the EU.

Tax exemption for electricity is a precondition for establishing shore power. Establishing shore power will reduce the environmental impact of ships that use it. The type of shore power to be established will vary according to the type of ship.

Many ports have already established shore power for ferries. This can be seen, for example in Gothenburg, Stockholm and Oslo, which have ferry departures to many destinations. Copenhagen has only the DFDS ferry to Oslo. City & Port Development is in discussions with DFDS on the establishment of shore power. Establishment costs

Cruise ships use around five times as much electricity as ferries, and the environmental impact is correspondingly greater. There are new, large cruise ships that can be equipped for shore power, and these ships are most likely to visit the new cruise terminal in Nordhavn. This is one reason why City & Port Development, in collaboration with the Finance Department, has chosen to focus the work on shore power around the cruise terminal in Nordhavn. According to the existing analyses, the construction costs for a shore power facility are of the order of DKK 215 million.

The number of cruise ships equipped for shore power is expected to increase as more ports in the Baltic area offer shore power. Hamburg is the first port in Europe to establish a small shore power facility for cruise ships, which will be commissioned in 2015. According to information given to the Finance Department, no ports in the Baltic area have concrete plans to establish shore power for cruise ships.

Moreover, as the container terminal is to be moved to outer Nordhavn around 2025, the Finance Department has not looked more closely at shore power for container ships.

THE SOLUTION

The ongoing study of shore power for cruise ships in Nordhavn will be continued and extended to include an outline of the cooperation between DFDS and City & Port Development regarding shore power for the Oslo ferry. No further studies will be launched until these reports back in June 2015.

WAY FORWARD

The Finance Committee will receive a status report on the work on shore power for cruise ships in Nordhavn by the end of December 2014, and a final report in June 2015. The final report will also set out any conclusions on shore power for the Oslo ferry. If the establishment of shore power is considered feasible, a proposal to this effect can be included in the budget negotiations for 2016.

SUMMARY OF POLITICAL DISCUSSION

It is proposed:

1. that the municipal council should pass a resolution to the effect that the City of Copenhagen intends to establish shore power in the Copenhagen harbours;
2. that the municipal council should instruct the Finance Department, with the assistance of relevant parties including City & Port Development, to draw up one or more solution model(s) for ways of establishing and using shore power in the Copenhagen harbours;
3. that the municipal council should instruct the Finance Department to present the solution models to the Finance Committee by the end of 2014.

(Tabled by the Socialist People's Party)

Resolution of the municipal council at its meeting on 21 August 2014

A motion from the Social Democrats, the Red-Green Alliance, the Social Liberals, the Liberal Party, the Socialist People's Party, the Danish People's Party, the Conservative People's Party and the Liberal Alliance to refer the proposal to the Finance Committee was adopted without a vote.

RESOLUTION

<u>Agenda item 11: Shore power in Copenhagen harbours</u>

Resolution of the Finance Committee, 23 September 2014

It is proposed that point 2 of the motion be amended from:

"2. that the Finance Department should be instructed to brief the Finance Committee on the progress of the study into shore power in Nordhavn by the end of December 2014 and to report the final conclusions to the municipal council by June 2015."

to:

"2. that the Finance Department should be instructed to brief the Finance Committee on the progress of the study into shore power in Nordhavn by the end of December 2014 and to report the final conclusions, including financing proposals, to the municipal council by June 2015, so these can be included in the negotiations on the budget for 2016."

The proposed amendment was adopted without a vote.

The amended motion was then approved without a vote.

ANNEXES

- 2014-01661 35-2 - Annex 1: Proposal from the Socialist People's Party on shore power in Copenhagen harbours
- 2012-166293-9 - Annex 2: Note to the Technology and Environment Committee on the status of shore power