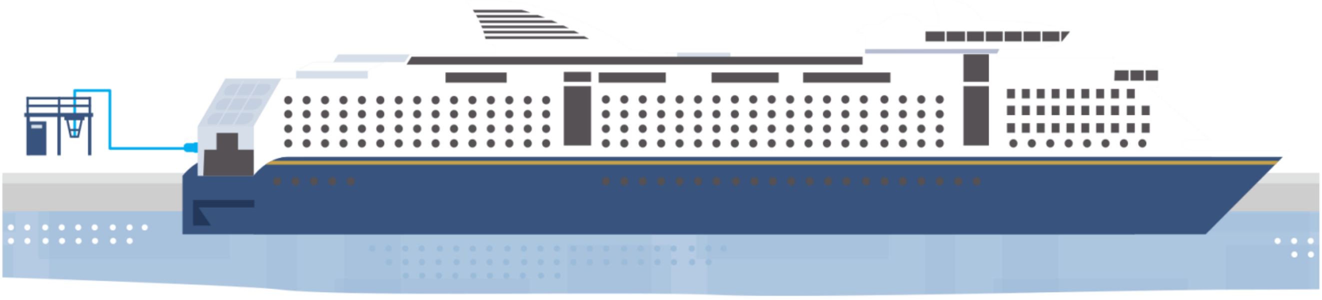
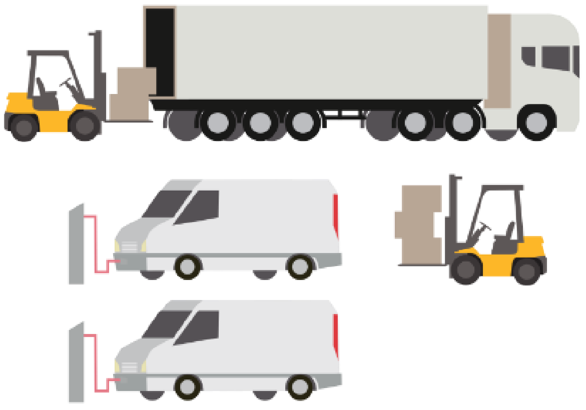
Oslo kommune

PORT OF OSLO
AS A ZERO-EMISSION PORT

Action plan, June 2018

Department of Business Development and Public Ownership





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1 SUMMARY

Background

Shipping contributes considerably to air pollution and greenhouse gas emissions on a local, national and international level. Emissions of SO_X, NO_X and particulates, for example, contribute to injuries to health and environmental harm, while CO_2 emissions are the most significant greenhouse gas from shipping.

The City of Oslo has considerably more ambitious targets for reducing greenhouse gas emissions than the targets defined at a national level. The Norwegian authorities are aiming to reduce emissions by at least 40 per cent by 2030 compared with emissions levels in 1990, while the City of Oslo aims to reduce greenhouse gas emissions in the city by 36 per cent by 2020 and 95 per cent by 2030. In April 2018, the Norwegian Environment Agency published for the first time an emissions report indicating figures for the individual municipalities, and this includes greenhouse gas emissions for the maritime sector. The emissions in this sector will be monitored via future Norwegian Environment Agency publications and followed up in detail by the City of Oslo.

On 28 September 2016, case 260, Oslo City Council adopted a ten-point strategy for the use of electric ferries in the Oslofjord and arrangement of shore power. The first point in the strategy relates to preparation of an action plan, which in the long term will involve all ships calling at the Port of Oslo using zero-emissions technology when docked, and when entering and leaving the port. This decision, together with the City Council’s strong environmental ambitions, forms the basis for this action plan.

The Port of Oslo is the largest public freight and passenger port in Norway and is one of the bigger Norwegian ports in terms of emissions. Reducing emissions at the Port of Oslo will be key to compliance with both municipal and national targets. While efforts are being made to reduce emissions from port-related activities, increasing maritime traffic benefits the environment. Maritime traffic reduces greenhouse gas emissions by more than half compared with road transport, and so reducing emissions for shipping has to be balanced in order to achieve good, consistent climate solutions.

The figures used as a basis for the action plan indicate that CO_2 emissions from shipping and activities from the Port of Oslo in 2017 amounted to 55,300 tonnes of CO_2. A total of 17 measures are assessed in this action plan, and overall these are estimated to bring about a reduction of 46,700 tonnes of CO_2 by 2030. This is equivalent to an 85 per cent reduction compared with emissions levels in 2017. Similar or greater reductions of SO_X, NO_X and particulates will also be achieved. These are highly proactive plans will require major upheavals both behaviour-wise and in respect of technology.

The action plan shows how further development of infrastructure at the port, partnerships and subsidies for commissioning of emissions-free solutions, plus a clear course where the City of Oslo requests and requires zero-emissions technology in all sectors, will help to ensure that shipping and the port meet existing reduction targets and may become emissions-free in the long term. Clear targets are set for 2030, with an 85 per cent reduction in current greenhouse gas emissions, and after that efforts will continue so that the Port of Oslo becomes a zero-emissions port in the long term.

The action plan is structured so that it can be read in its entirety, or it can be used as a reference work for information on specific areas. If a brief introduction is preferred, the summary in section 1 together with the measures in section 9 and the analysis in section 10 may provide a good overview.

When preparing this action plan, one of the aims was to provide politicians and other relevant stakeholders with good and reasonable information on the environmental scope for port operations. A number of measures have been completed or commenced, while others will require close follow-up in the future. The action plan describes this and indicates areas where further action is needed.

One of the aims has been to provide an overview of the extent of shipping and port operations in Oslo, viewed against the emissions represented by the various segments. For some segments, attempts have also been made to compare maritime transport emissions with emissions from alternative forms of transport.

Another objective is to describe the measures that can be implemented given current expertise with regard to technology and the industry, while also highlighting costs and estimated effects on emissions. Various methods have been assessed, and there is a description of the parties responsible for introducing the measures. It is envisaged that the action plan that will be an operational document that is updated at regular intervals as new technology becomes available and sources of emissions change due to implementation of measures or alteration of activities.

Oslo Port Authority

Oslo Port Authority is a municipal enterprise. Its purpose is to ensure efficient, rational port operations, facilitate efficient, eco-friendly maritime transport, supervise traffic in the city’s sea area and manage the port’s properties and facilities in an economically and environmentally sound manner. Oslo Port Authority runs the biggest public freight and passenger port in Norway. In a normal week, 50 to 70 ships carrying freight and passengers call at the port. Around six million tonnes of freight and seven million passengers arrive in Oslo by sea each year. As part of its port plan for the period 2013-2030, the Port of Oslo is aiming to transport 50 per cent more freight and 40 per cent more passengers via the city port by 2030.

The growth in freight transport is expected mainly to involve groupage in larger units. In order to manage the ambitions for growth, efforts are also being made to streamline port operations and increase capacity for receiving groupage and bulk cargo. Work is also in progress on increasing exports in order to achieve more of a directional balance, so that ships calling at Oslo also transport freight out of the port to a greater degree.

The passenger growth target estimates more than nine million passenger trips a year via the Port of Oslo by 2030. Local ferries in Oslo account for most passengers at present.

Emissions

The Port of Oslo is responsible for approx. 55,000 tonnes of CO_2e per year. This accounts for 4 per cent of total emissions in the City of Oslo (Figure 1-1). The greatest sources of emissions at the port are foreign ferry routes, accounting for around 40 per cent of greenhouse gas emissions, followed by shore activities such as cargo handling and transport on the port site (14 per cent) and local ferries that form part of the Ruter public transport offering (12 per cent).

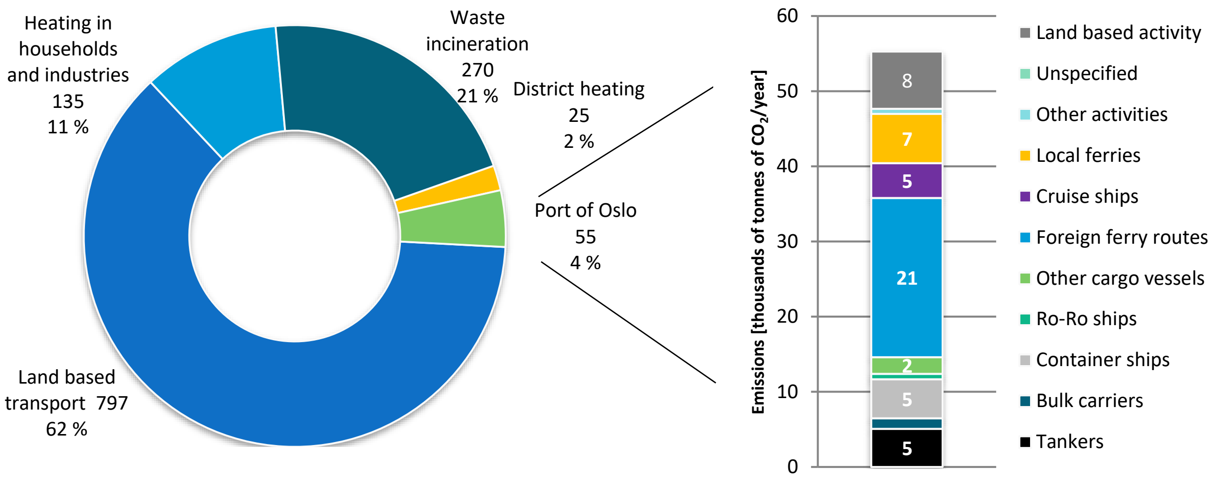


Figure 1-1: Distribution of greenhouse gas emissions in Oslo, per sector [thousands of tonnes of CO_2e/year] and [%], and distribution of greenhouse gas emissions per shipping segment [thousands of tonnes of CO_2e/year] within the Port of Oslo.

Measures

The measures discussed in the action plan are intended to provide an assessment of the potential for reduction of greenhouse gases, and the technical and economic aspects of each individual measure are highlighted at the same time.

The action plan includes 17 measures divided into three main groups:

- **Measures that should be continued (3 measures):** Measures that currently exist and should be continued with equivalent or greater focus over the next few years in order to maintain the effect of the measure in question.
- **Measures that should be reinforced (2 measures):** Measures that currently exist, wholly or in part, but that require greater focus and prioritisation over the next few years in order to trigger the collective potential of the measure.
- **Recommendations for new measures (12 measures):** Measures that do not exist at present but that need to be implemented in order to achieve the ambition of turning the Port of Oslo into a zero-emissions port in the long term.

Table 1-1 shows the recommended measures for the action plan divided into groups of measures, implementation time and estimated greenhouse gas reduction.

Table 1-1: Recommended measures in the action plan, by groups of measures, phase-in time and estimated impact

	ID	Description of measure	Phase-in time	Estimated reduction [tonnes of CO_2/year] and [% red.]
Measures that should be continued	9.1.1	Environmental differentiation of port fees in order to reward low-emissions ships via the Environmental Ship Index (ESI)	2018 - 2020	800 / 1%
	9.1.2	City of Oslo as a member of Grønt Kystfartsprogram [the Green Coastal Shipping Programme]	2018	-
	9.1.3	Update and revise the action plan for the Port of Oslo as a zero-emissions port and incorporate the measures in the climate budget	2019 - 2021	-
Measures that should be	9.2.1	Shore power for foreign ferry routes	2018 - 2020	2,300 / 4%
	9.2.2	Cooperation with other cruise ports with a view to defining collective requirements relating to shore power and other environmental measures, with Oslo taking on a proactive role	2018 - 2025	2,700 / 5%
Recommendations for new measures	9.3.1	Oslo is a driving force for moving more freight from the roads to the sea, and is working to implement equal environmental requirements for maritime transport throughout the Oslofjord in its entirety	2019 - 2030	-
	9.3.2	Emissions-free operation for Nesoddbåtene (route B10)	2018 - 2019	4,200 / 8%
	9.3.3	Emissions-free operation for Ruter express services (routes B11 and B20-B22)	2019 - 2024	2,300 / 4%
	9.3.4	Emissions-free operation for the Øybåtene service	2018 - 2021	-
	9.3.5	Requirement for zero-emissions solutions for foreign ferry routes with effect from 2025 if new routes are established, if existing routes are put out to tender, where contracts are renewed or where permitted by the situation	2018 - 2025	16,600 / 30%
	9.3.6	Environmental differentiation of port fees in order to reward docked low-emissions ships via the Environmental Port Index (EPI)	2018 - 2020	900 / 2%
	9.3.7	Establish communication with national authorities for amendment of the Act relating to ports and fairways so that requirements can be defined for zero-emissions solutions when docked	2018 - 2024	4,800 / 9%
	9.3.8	Infrastructure for piloting autonomous ships	2019 - 2024	-
	9.3.9	Emissions-free activity when handling goods and freight at the Port of Oslo, and other activities on the port site	2018 - 2025	7,500 / 14%
	9.3.10	Emissions-free road transport routes to and from the Port of Oslo	2018 - 2030	-
	9.3.11	Bonus for ships operating at reduced speed and investigation of the effect of speed limits for commercial shipping using fossil propulsion systems	2019 - 2025	1,300 / 2%
	9.3.12	Adaptation in order to meet the steam requirements of relevant ship types at the port when using renewable alternatives	2018 - 2025	3,500 / 6%
Total			**-**	**46,700 / 85%**

All in all, it is estimated that these measures will result in reductions amounting to 46,700 tonnes of CO_2 per year by 2030, representing an 85 per cent reduction compared with the 2017 level. While greenhouse gas emissions are reduced, similar or greater reductions of SO_X, NO_X and particulates will also be achieved in areas occupied by a lot of people and areas characterised by tourism. The majority of reductions in emissions that are recommended must be achieved by means of new measures. Implementation of such measures will require extraordinary effort from the City of Oslo, the Port of Oslo and port stakeholders. It will also put Oslo out in front when it comes to international climate work for city ports.

Important measures towards the objective of achieving a zero-emissions port in the long term

Even if all 17 measures help – either directly or indirectly – to make the port emissions-free in the long term, some measures are particularly crucial in order to approach the potential of an 85 per cent reduction.

Reducing emissions from foreign ferry routes (5 ships) and local ferries (10 ships), while also making operations on the port site emissions-free, will reduce emissions by about two-thirds. Measures in respect of the segments appear to be the three most important in the action plan, and implementation of these in the period up to 2030 is viewed as realistic.

About half of the emissions come from operations when ships dock. A major element of these emissions could be reduced cost-effectively by means of shore power development at the quayside and aboard ships. This should be prioritised for ship types where a relatively small number of ships are responsible for a large proportion of emissions when docked.

Maritime transport and ports are part of an international freight network and can help to halve transport sector greenhouse gas emissions if more freight is transferred from road to sea. Transport by sea has lost out to road transport over the past 50 years. More freight has to be transferred from road to sea in order to reduce global greenhouse gas emissions from the transport sector. Therefore, the action plan also focuses on ensuring that more people are able to request and demand transportation of freight that is as efficient as possible; and in many instances, this will involve public services by sea. Attention is drawn to the fact that this potential may increase local greenhouse gas emissions from shipping in Oslo due to an increase in activity, although it will be a very effective climate measure on a global scale.

A previous target involving a 50 per cent reduction in emissions from sea operations by 2030 was defined previously. The 85 per cent reduction in greenhouse gases as identified in the action plan is highly ambitious for a multipurpose port like Oslo, with more than 300 unique ships arriving each year. Some ships dock just once or twice a year, and these can hardly be approximated using the port’s instruments. It is therefore crucial for the highest-priority measures to focus on the biggest sources of emissions and facilitate the most cost-effective solutions.

2 KEY TERMS

AIS	-	The Automatic Identification System, abbreviated AIS, is an anti-collision aid for shipping. Ships carrying AIS equipment on board transmit and exchange information on their identity, position, speed, course, etc. over VHF frequencies.
Arrival	-	Arrival of a ship at the quay.
Single-point buoy mooring loading system	-	A single-point buoy mooring loading system is a tanker designed primarily to transport oil from the single-point buoy mooring at an oilfield to a receiving port for the oil, as an alternative to transporting the oil to the mainland via a pipeline.
ECA	-	Emission Control Areas (ECA) are sea areas where particular attention to emissions is considered necessary.
HFC gases	-	HFC gases are a group of fluorine compounds used as refrigerants in refrigeration and freezing systems, heat pumps and air conditioning systems for buildings and vehicles. HFC gases have a strong greenhouse effect and remain in the atmosphere for a very long time.
IMO	-	International Maritime Organization. This is the UN’s maritime safety organisation and was created in 1948 in order to ensure safety at sea and prevent pollution of the marine environment.
Approach to Oslo	-	Includes the approach of ships from Steilene, off Nesodden, comparable with an extended area used for investigation of air quality measures for the City of Oslo.
Docking	-	The operation where a ship docks at a quay.
Boiler	-	The boiler aboard a ship produces steam in order to supply the ship with heating and steam. This may include everything from hot water, heating freight and cabins, operating pumps and winches and other energy-intensive consumers. Boilers are generally oil-fired, but electric boilers may also be used. Maritime combustion engines have an efficiency level of around 40 per cent, while boilers have an efficiency level in the region of 70-80 per cent.
kW	-	Kilowatts
kWh	-	Kilowatt hours
LNG	-	Liquefied Natural Gas.
LoLo	-	Lift-on/lift-off. Ships with cranes on board for loading and unloading containers.
Manoeuvring	-	The operation that takes place when a ship makes changes of speed and

		direction before or after docking (speeds of between 0.5 and 3 knots).
MARPOL	-	MARPOL stands for MARine POLlution, and represents the IMO's international marine environmental convention.
MGO	-	Marine gasoil is the most common fuel used in ships that run on diesel in Norwegian waters. MGO meets current SECA requirements for 0.1 per cent sulphur content.
NECA	-	Nitrogen oxide Emission Control Areas (NECA) are sea areas where particular attention to nitrogen oxide emissions is considered necessary.
reCharge	-	A model developed by DNV GL in order to estimate costs for investment in shore power and charging current solutions. This model is based on activity data for the relevant quay/terminal and estimates costs for quayside infrastructure, as well as costs for necessary equipment aboard ships.
RoPax	-	Roll-on/roll-off passenger ship. A ferry that combines the cargo capacity of a RoRo vessel with the passenger capacity of a passenger ferry (e.g. Stena Line, DFDS and Color Line ships at the Port of Oslo).
RoRo	-	Roll-on/roll-off. A RoRo ship is a type of ship with a structure that allows wheeled cargo to be transported from the quay directly onto the ship, and subsequently back off the ship.
SCR	-	Selective Catalytic Reduction. Catalytic converter technology on ships, used to reduce NO_X exhaust emissions by adding urea.
SECA	-	Sulphur Emission Control Areas (SECA) are sea areas where particular attention to sulphur emissions is considered necessary.
Oslo sea area	-	Includes the inner port and sea area within the boundaries of the City of Oslo.
Groupage	-	Groupage is freight transported in units that can be handled by cranes or vehicles.
Terminal	-	A restricted area at a quay where a specific type of freight is loaded and unloaded.
TEU	-	The twenty-foot equivalent unit is based on the volume of a 20-foot container. These containers are 6.1 m long and 2.4 m wide. Their heights are not standardised, varying between 1.3 m and 2.9 m. The most common height is 2.6 m.
Transit	-	The operation that takes place when a ship travels at a relatively constant speed between two destinations (faster than 3 knots).
Dry bulk shipping	-	Ships that transport dry cargoes, such as grain, metals or coal without load carriers in closed cargo spaces.

Unique arrivals	-	The number of times an individual ship calls at the port over a defined period.
Wet bulk shipping	-	Ships that transport oil and other liquid products that are transported without load carriers in closed cargo spaces.

3 BACKGROUND

Shipping contributes considerably to air pollution and greenhouse gas emissions on a national and international level. Emissions of SO_X, NO_X and particulates, for example, contribute to injuries to health and environmental harm, while CO_2 emissions are the most significant greenhouse gas from shipping.

At the same time, maritime transport is the most energy-efficient form of transport for freight and goods over longer distances. The reduction in emissions achieved by moving freight from road to sea increases in line with the distance over which the freight is to be transported (TØI, 2017) and (DNV GL, 2016).

Heavy oil and petroleum distillates have been totally dominant as fuels for ships for a long time. However, alternative energy sources and energy carriers have been launched, tested and further developed over the past few years. The solution involving the use of LNG in ship engines has made a great deal of progress on an international level, but engine suppliers, shipping companies and cargo owners are also working with solutions such as electrification, biofuels, methanol, ethanol and hydrogen, to name but a few examples. Future and existing local and international requirements for reduction of CO_2, NO_X and SO_X emissions are important drivers of this development, along with charging policy and generally greater expectations of eco-friendly, sustainable operations.

On an international level, the most important environmental regulation is linked with the IMO's MARPOL Convention, but regional stakeholders such as the EU are also making demands that are affecting the industry. Shipping is expected to be subject to further international demands for reduction of emissions over the next few years. This is particularly true of greenhouse gas emissions, where there is currently a mismatch between the international regulatory emissions requirements and the adopted political objectives (the 2-degree target).

The Norwegian authorities have devised ambitious objectives for their reduction of greenhouse gas emissions, with a contingent liability to reduce emissions by at least 40 per cent by 2030 compared with emissions levels in 1990. Overall, EU sectors that are not subject to quotas must reduce their emissions by 30 per cent compared with 2005, and Norway can expect to be assigned a target in the region of 40 per cent for these sectors. Transport is the most significant source of emissions in the sector not subject to quotas. Therefore, major reductions have to be made in greenhouse gas emissions in the transport sector, including domestic shipping. The government has made it clear that eco-friendly shipping is a priority focus area. The Port of Oslo is one of the larger ports in Norway in terms of emissions, and reductions in emissions at the Port of Oslo will be key to compliance with the national objectives.

The City of Oslo has considerably more ambitious targets than the targets defined at a national level. The City of Oslo's objective is to reduce its greenhouse gas emissions by 36 per cent by 2020[1] and 95 per cent by 2030, compared with emissions levels in 1990 (Oslo kommune, 2016). The port's target is to reduce emissions by 50 per cent

[1] The original target in the climate strategy for the City of Oslo was to reduce emissions by 50 per cent by 2020. The climate targets for Oslo have been adjusted due to the schedule for the government's work with CO_2 cleaning. The council's climate ambitions are fixed, and the adjusted climate targets are a 36 per cent reduction by 2020, a 50 per cent reduction as soon as possible after that, and a 95 per cent reduction by 2030.

by 2030. These are highly proactive plans will require major upheavals both behaviour-wise and in respect of technology.

As things stand at present, greenhouse gas emissions from maritime activity are not included in Oslo's emissions report. This sector is expected to be incorporated in the next few years, however, so measures in this sector will be of major importance to attainment of the targets in Oslo.

The Oslo climate budget for 2018 includes continuation and a new shore power system for foreign ferry routes with undistributed reduction of emissions. The Climate and Energy Strategy adopted by Oslo City Council in June 2016 has a separate focus area relating to the Port of Oslo: "shore power and other environmental measures shall reduce emissions from port activities in Oslo by at least 50 per cent by 2030" (Oslo kommune, 2016).

In March 2017, the executive board at the Oslo Port Authority adopted the climate strategy that shows how to achieve the objective of halving emissions by 2030 (Oslo havn, 2017).

Furthermore, in September 2016 Oslo City Council adopted a ten-point strategy for the use of electric ferries in the Oslofjord and arrangement of shore power (Oslo, 2016). The first point in this strategy relates to preparation of an action plan, which in the long term will involve all ships calling at the Port of Oslo using zero-emissions technology when docked, and when entering and leaving the port.

This action plan is a direct response to the City Council's order dated 28 September 2016, case 260, resolution 1. When preparing this action plan, one of the aims was to be able to provide politicians and other relevant stakeholders with good and reasonable information on the environmental scope for port operations. A number of environmental initiatives have already been implemented, and information on these is also provided in the action plan.

One aim has been to provide an overview of the scope of activities linked with port operations in Oslo, given the degree of emissions represented by the various segments: this has also been compared with alternatives to maritime transport and the emissions resulting from such alternative forms of transport. The transport industry is adapting to the market to a great degree: if demands are made that result in new costs or delays, it will be possible to transfer transport to other ports or alternative forms of transport.

Another objective is to describe the measures that can be implemented with technological development in 2018, related to costs and calculated effect in the event of reduced emissions. The appropriateness of the various methods has been assessed, along with identification of who is responsible for introducing the measures that ought to be implemented. It is envisaged that the action plan that will be an operational and dynamic document that is updated at regular intervals as new technology becomes available.

Input for the City Council's action plan has been prepared on the basis of a project headed by the Department of Business Development and Public Ownership in close partnership with the Department of Environment and Transport, the Climate Agency and Oslo Port Authority.

The specialist content and textual design has largely been supplied by special consultant Harald Gundersen at the Climate Agency.

Other main contributors are: Anders Berg, Ragnhild Møller-Stray, Aslan Shamsutdin of the Department of Business Development and Public Ownership, Guri Tajet and Solveig Hay Ingebrigtsen of the Department of Environment and Transport, and Heidi Neilson and Carl Johan Hatteland of Oslo Port Authority.

4 METHOD AND CRITERIA

The action plan for the Port of Oslo as a zero-emissions port has been prepared by means of a partnership between the Department of Business Development and Public Ownership, the Department of Environment and Transport, the Port of Oslo and the Climate Agency. Various arenas have also been used for gathering input from external stakeholders; a dialogue conference at Ruter, an input meeting with Port of Oslo clients, meetings with environmental organisations, etc. and other discussions with the industry.

The action plan includes all commercial activity at sea within the "Approach to Oslo" area (this area covers all activity north of 59.8 degrees, at Steilene, off Nesodden), as shown in Figure 4-1. It also includes activities taking place on the land side of the port sites at the Port of Oslo, including moving and loading freight and goods. The area covered by "Approach to Oslo" as been delimited in order to retain compatibility with previous investigations of local emissions from ships and support in the City of Oslo, while also encouraging zero-emissions solutions for activities linked with entering and leaving the Port of Oslo. Your attention is drawn to the fact that choosing "Approach to Oslo" as a system boundary means that greenhouse gas emissions are estimated to be slightly higher (13,000 tonnes of CO_2 equivalents) then if the boundary of the city had been used as a basis for the calculations, as shown in Figure 4-1.

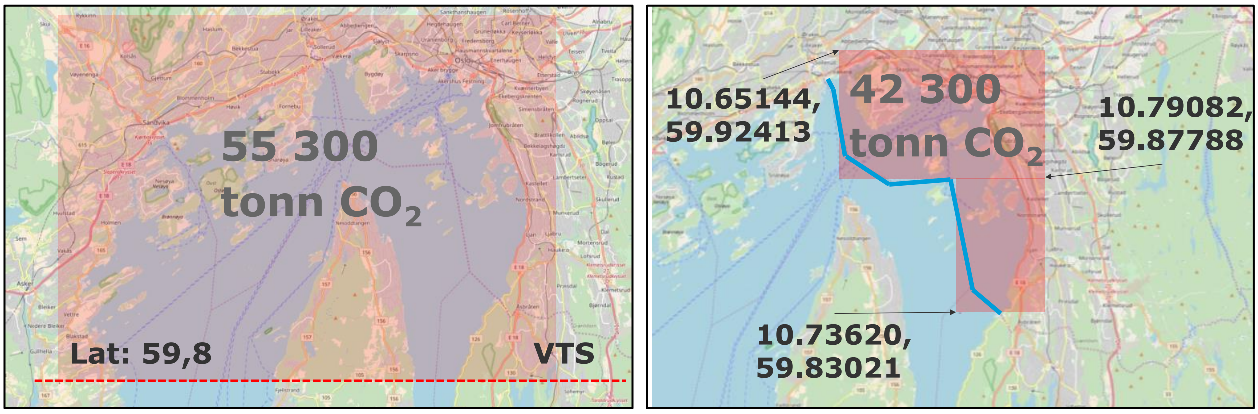


Figure 4-1: The boundary of "Approach to Oslo", south of Steilene at Nesodden (on the left) and the boundary of the City of Oslo (on the right).

The emissions figures from maritime activities at the Port of Oslo are based on a commissioned study supplied by DNV GL in February 2018 (DNV GL, 2018). This study is based on activity data via AIS (Automatic Identification System) data as illustrated in

Figure 4-2, along with relevant emissions factors for each emission type. This has been made possible by extensive implementation of AIS transponders, installed aboard all ships above a defined size. AIS is an international instrument for eliminating collisions at sea and identifying and monitoring ships. Ships with AIS transponders transmit signals at short intervals that indicate the ship's identity and position, as well as a range of other data. These signals are intercepted by other ships, as well as dedicated receivers for collection and structuring of data. This makes it possible to gain an overview of all shipping movements, operating hours and distances sailed and to calculate fuel consumption and emissions within a delimited area in Oslo for 2017.

This approach is relatively accurate for ships in motion, but consumption and emissions are less precise when ships are docked and executing port operations, or are operating at very low speed. Furthermore, this methodology was originally devised with national/regional emissions reports in mind, where data volumes are aggregated for shipping fleets, and uncertainty increases when individual ships are approached. Nevertheless, this approach is considered to be sufficiently accurate for the purposes of this action plan. Comparisons have also been made with reported consumption from individual shipping companies and ships for the purposes of quality assurance of the consumption and emissions estimates. Ruter's reported figures for its shipping routes in 2017 (Ruter, 2017), for example, show a 6 per cent discrepancy in CO_2 emissions compared with the AIS estimates that are used as a basis in the action plan.

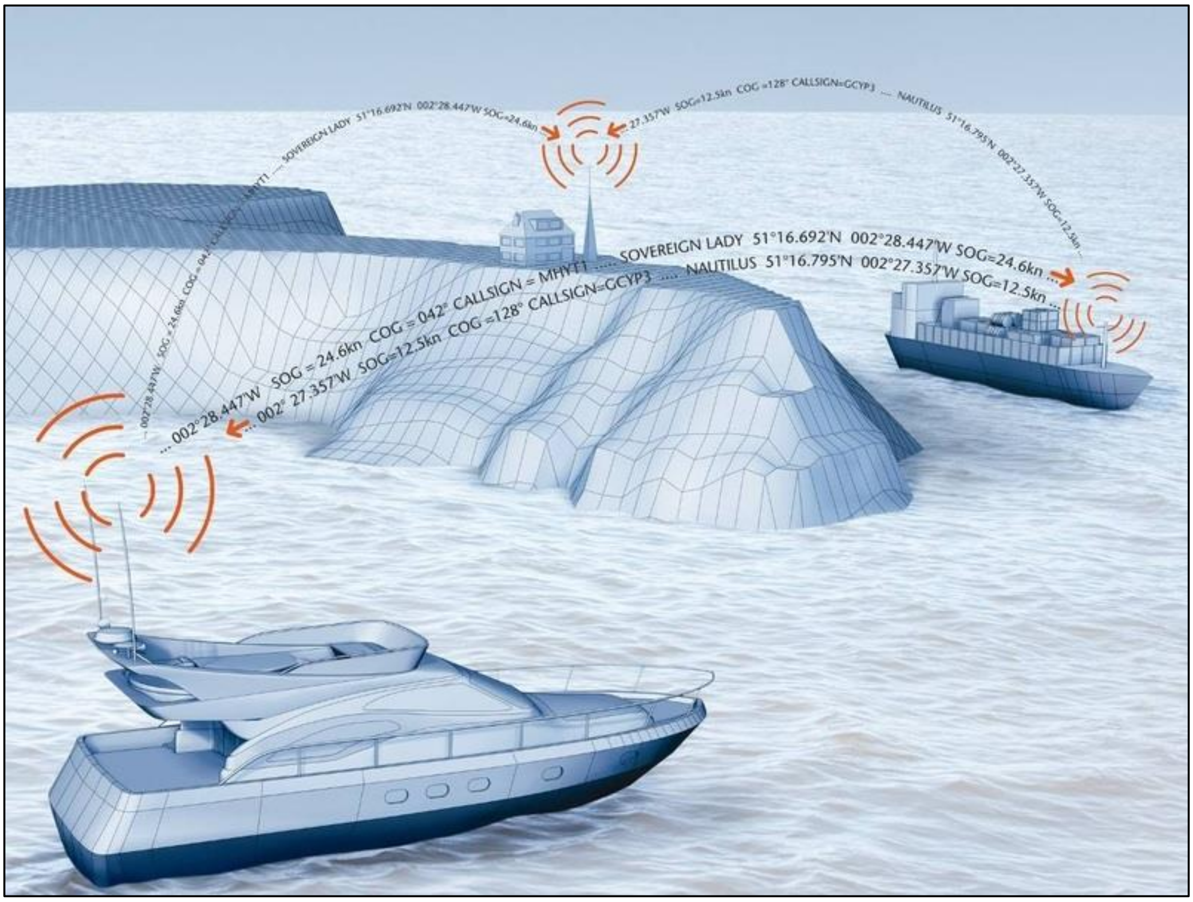


Figure 4-2: Illustration of the AIS concept, with transponders aboard ships and receiving stations on land, and satellites (where used) (Kvaver, 2018).

Manual corrections to consumption and emissions have been made for ships that already have environmental technology installed for emissions to air, in order to reflect the actual emissions. This includes existing shore power facilities for Color Line at Hjortnes, LNG operation on the three ships operating on the Aker Brygge-Nesodden route, use of biodiesel on Øybåtene services and the use of SCR systems on the generators for the two foreign ferry routes belonging to DFDS.

The emissions figures from DNV GL are to be regarded as normative estimates providing a complementary overview of emissions from ships and the port. An overview of this kind is necessary; in order to identify the biggest contributors to emissions, but also in order to implement targeted measures to reduce emissions. The method used as a basis also means that there may be deviating emissions results at individual project level that are based on reported figures and detailed calculations, and at the overall level where AIS data is used as a basis. At the same time, cutting a source of emissions totally will nevertheless bring about a 100 per cent reduction regardless of the calculation method.

In April 2018, the Norwegian Environment Agency – in partnership with KS and Statistics Norway (SSB) – published new greenhouse gas statistics at municipal level for 2016. This showed that the contribution made by shipping within the city boundary is very closely matched with the figures on which the action plan is based. Both sources use AIS data as a basis for their calculations.

The cost estimates for freight infrastructure shown for each shipping segment are based on the ReCharge model developed by ABB, Cavotec, the Oslo Port Authority and DNV GL (DNV GL, 2017).

5 GREENHOUSE GAS AND LOCAL EMISSIONS IN THE CITY OF OSLO

5.1 Greenhouse gas emissions

Norway's total emissions of greenhouse gases amounted to 53.3 million tonnes of CO_2 equivalents per year in 2016 (SSB, 2017). This represents an increase of around 3 per cent compared with emissions in 1990, and a decrease of around 1 per cent on 2015 (Figure 5-1).

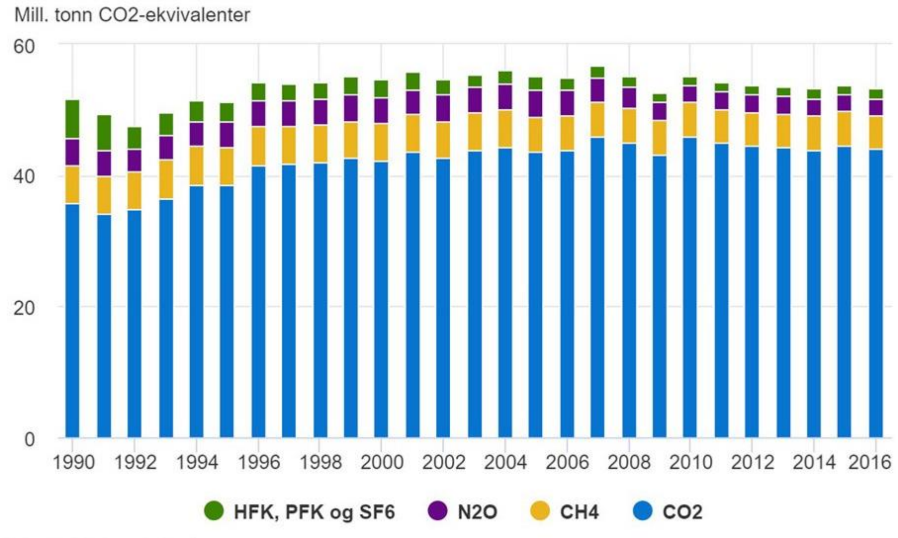


Figure 5-1: Development in Norway's total greenhouse gas emissions [million tonnes of CO_2 equivalents/year] for the period 1990-2016 (SSB, 2017)

The greenhouse gas emissions[2] in the City of Oslo for 2015 amounted to 2015 approx. 1.22 million tonnes of CO_2 equivalents per year (Klimaetaten, 2017), as shown in Figure 5-2. If we include emissions from shipping within the city boundaries, these emissions amount to approx. 1.28 million tonnes of CO_2 equivalents per year. (Oslo Havn, 2017). This is equivalent to 2.2 per cent and 2.4 per cent respectively of Norway's total greenhouse gas emissions. Therefore, the City of Oslo is a significant contributor to national emissions. Identification and implementation of effective reduction measures in Oslo will be crucial in the follow-up of both local and national targets.

[2] As at 2017, shipping and aviation were not included in the climate report for the City of Oslo. However, shipping is included in the climate report for 2018.

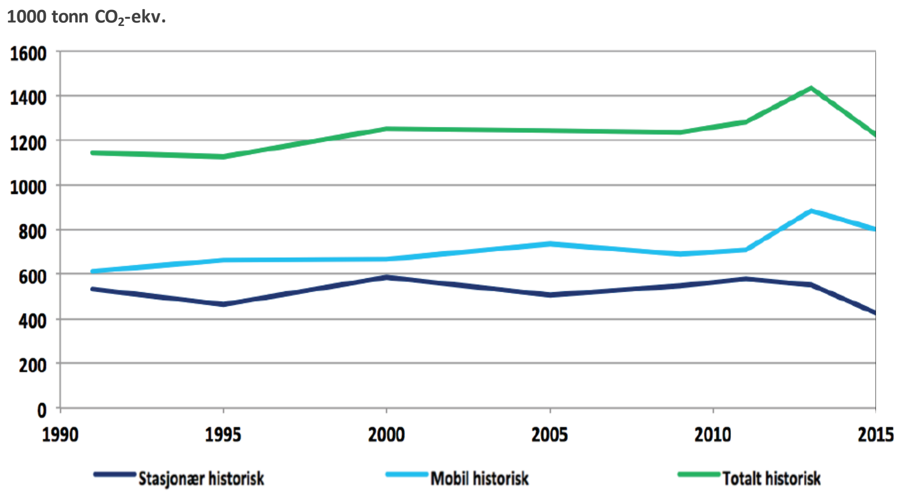


Figure 5-2: Development of stationary and mobile greenhouse gas emissions in Oslo for 1990-2015 **(Klimaetaten, 2017)**

The Port of Oslo is responsible for around 55 thousand tonnes of CO_2 equivalents per year (4 per cent) of total emissions of 1,280 thousand tonnes of CO_2e per year in the City of Oslo.

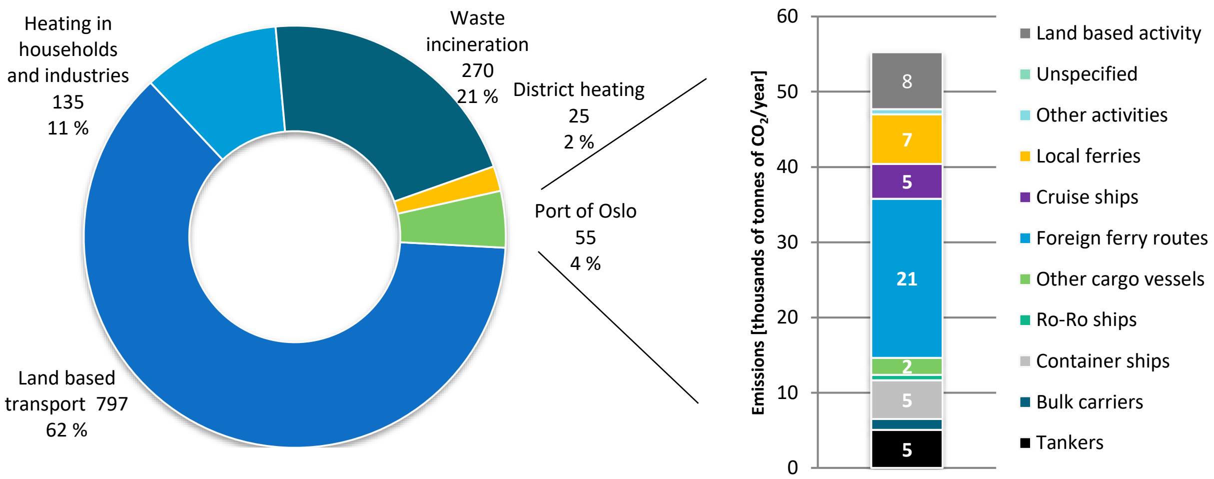


Figure 5-3: Distribution of greenhouse gas emissions in Oslo, per sector [thousands of tonnes of CO_2e/year] and [%], and distribution of greenhouse gas emissions per shipping segment [thousands of tonnes of CO_2e/year] within the Port of Oslo.

5.2 NO_X

In Norway, sources of NO_X emissions are primarily linked with combustion of fossil fuels in oil and gas operations, industry and mobile sources on land and at sea.

As

Figure 5-4 shows, Norway's total emissions of NO_X stood at 153 thousand tonnes of NO_X per year in 2016 (SSB, 2018). This represents a reduction of around 23 per cent compared with emissions in 1990, and a decrease of around 1 per cent on 2015.

Of total NO_X emissions in 2016, coastal traffic and fishing account for a total of 32.6 thousand tonnes of NO_X/year (21 per cent), and hence are the second biggest source of emissions. Oil and gas operations contribute 28 per cent of emissions and road traffic 20 per cent, while industry and mining account for 11 per cent.

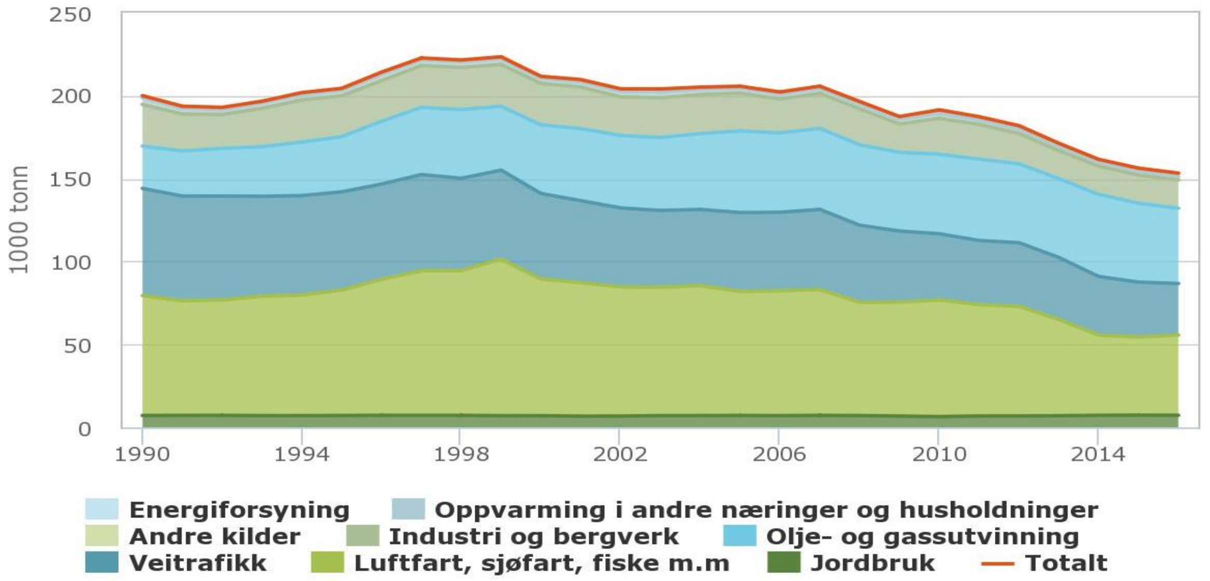


Figure 5-4: Development in Norway's total NO_X emissions [thousand tonnes of NO_X/year] for the period 1990-2016

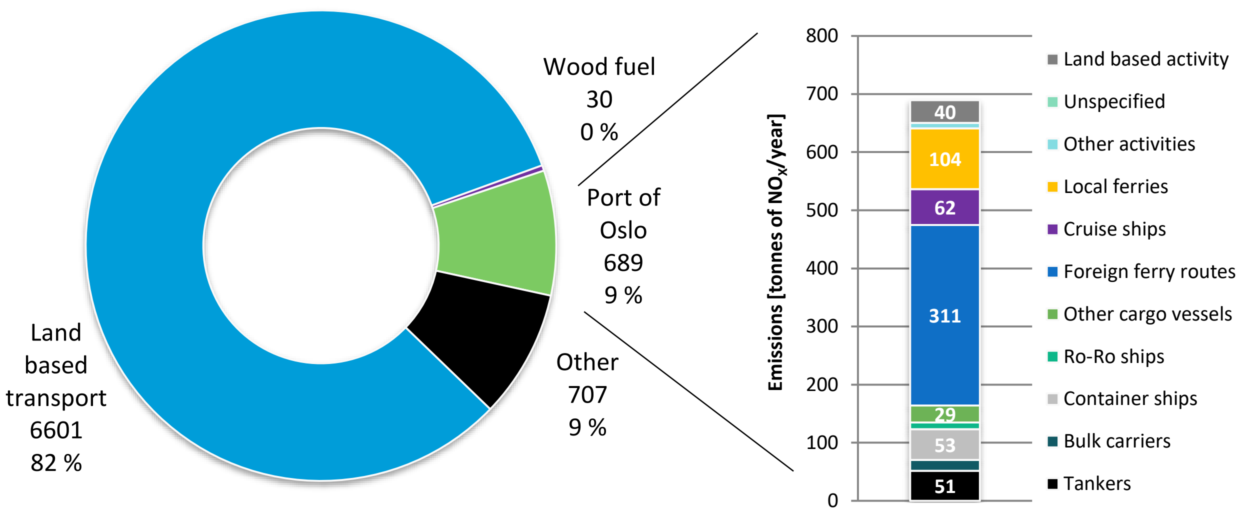


Figure 5-5: Distribution of NOX emissions in Oslo per sector [tonnes of NOX/year] and [%], and distribution of NOX emissions per segment [tonnes of NOX/year] within the Port of Oslo

5.3 SO_X

Sulphur dioxide (SO_2) is a gas that forms when substances containing sulphur – primarily oil and coal – are burnt. In Norway, industry is the primary producer of these emissions. In 2016, Norway's total emissions of SO_X stood at 15.6 thousand tonnes of SO_X per year. This represents a reduction of around 70 per cent compared with emissions in 1990, and a decrease of around 5 per cent on 2015.

Of total SO_X emissions in 2016, domestic shipping and fishing account for a total of 1.1 thousand tonnes of SO_X/year or 7 per cent of total national emissions.

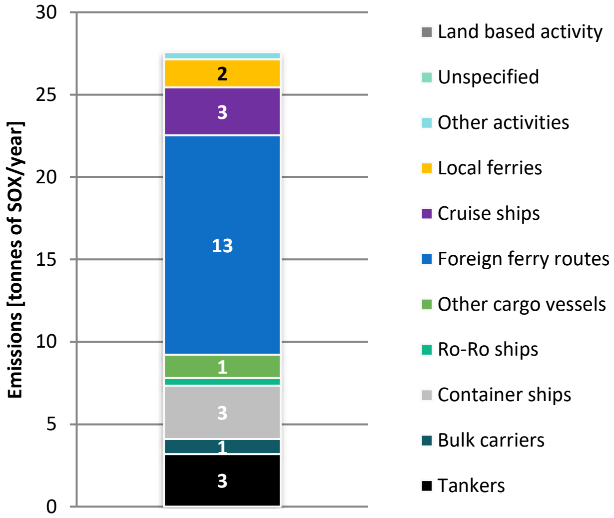


Figure 5-6: Distribution of SO_X emissions in Oslo per segment [tonnes of SO_X/year] within the Port of Oslo, based on traffic in 2017.

5.4 Particulate matter (PM)

Particulate matter is a mixture of various compounds that form particles that remain suspended in the air. In Norwegian law, two particle sizes are regulated: fine particles (PM2.5) and coarse particles (PM10). PM2.5 and PM10 stand for "particulate matter", followed by a designation indicating the diameter of the particle in µm.

The transport sector makes the greatest contribution to high levels of coarse particles. Road wear, partly caused by use of studded tyres, and dust from roads make a significant contribution Levels of fine particles are also associated with impact on health in major Norwegian towns. Levels of fine particles peak in winter when a lot of people burn wood.

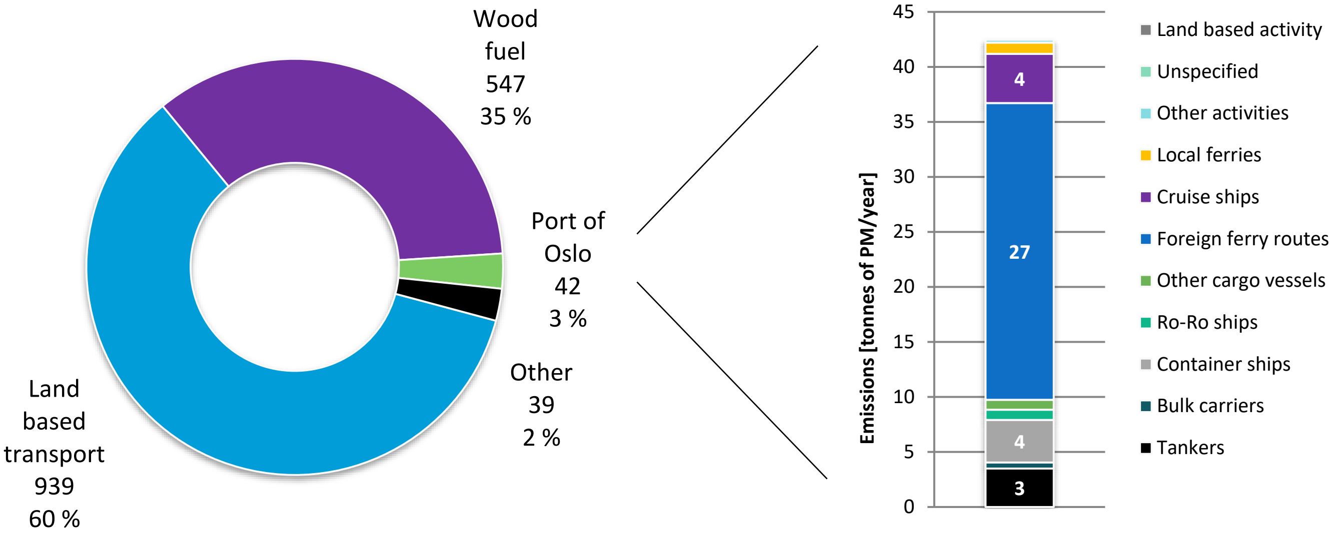


Figure 5-7: Distribution of PM emissions (PM_{10}) in Oslo per sector [tonnes of PM/year] and [%], and distribution of PM emissions per segment, based on traffic in 2017.

6 DESCRIPTION OF TRAFFIC AND EMISSIONS AT THE PORT OF OSLO

The Port of Oslo is the biggest public freight and passenger port in Norway. In a normal week, 50 to 70 ships carrying freight and passengers call at the port. Around six million tonnes of gods and seven million passengers arrive in Oslo by sea each year – on cargo ships, on ferries from Denmark and Germany, on cruise ships and chartered boats, or on local ferries. The quay at Rådhusbrygge is the busiest ferry hub in Norway. Ships travel from here to Nesodden and Slemmestad, carrying almost four million passengers each year. In addition, around one million passengers travel by local ferry services to Bygdøy and the Oslofjord islands. Figure 6-1 shows an overview of the locations of the various terminals at the Port of Oslo and the types of freight handled.

Figure 6-1: Overview of terminals at the Port of Oslo, by use and freight type.

In 2008, the City Council made a decision on Fjordbyen (Figure 12-1). The Oslo Port Authority has transformed the port since then. A large area that used to be home to port terminals is now made up of residences and public attractions (Bjørvika, Tjuvholmen and Sørenga). Together with the establishment of Havnepromenaden in Byhavna and streamlining in Sydhavna, port clients and operators in Oslo have managed to maintain freight volumes – 5-6 million tonnes a year – despite a massive reduction in area and quays.

The Port of Oslo is a multipurpose port with many different types of shipping and freight. The variation in traffic and operations makes it necessary to break down the traffic into subsegments based on ship types and operating patterns. This is necessary; in order to identify the biggest contributors to emissions, but also in order to identify targeted measures to reduce emissions.

Based on the traffic pattern at the Port of Oslo in 2017, ten main segments have been categorised that together represent total emissions at the Port of Oslo. Figure 6-2, Figure 6-3, Figure 6-4, Table 6-1,

Table 6-2, and Table 6-3 show key figures linked with emissions and activity for each of the ten segments based on operations in 2017.

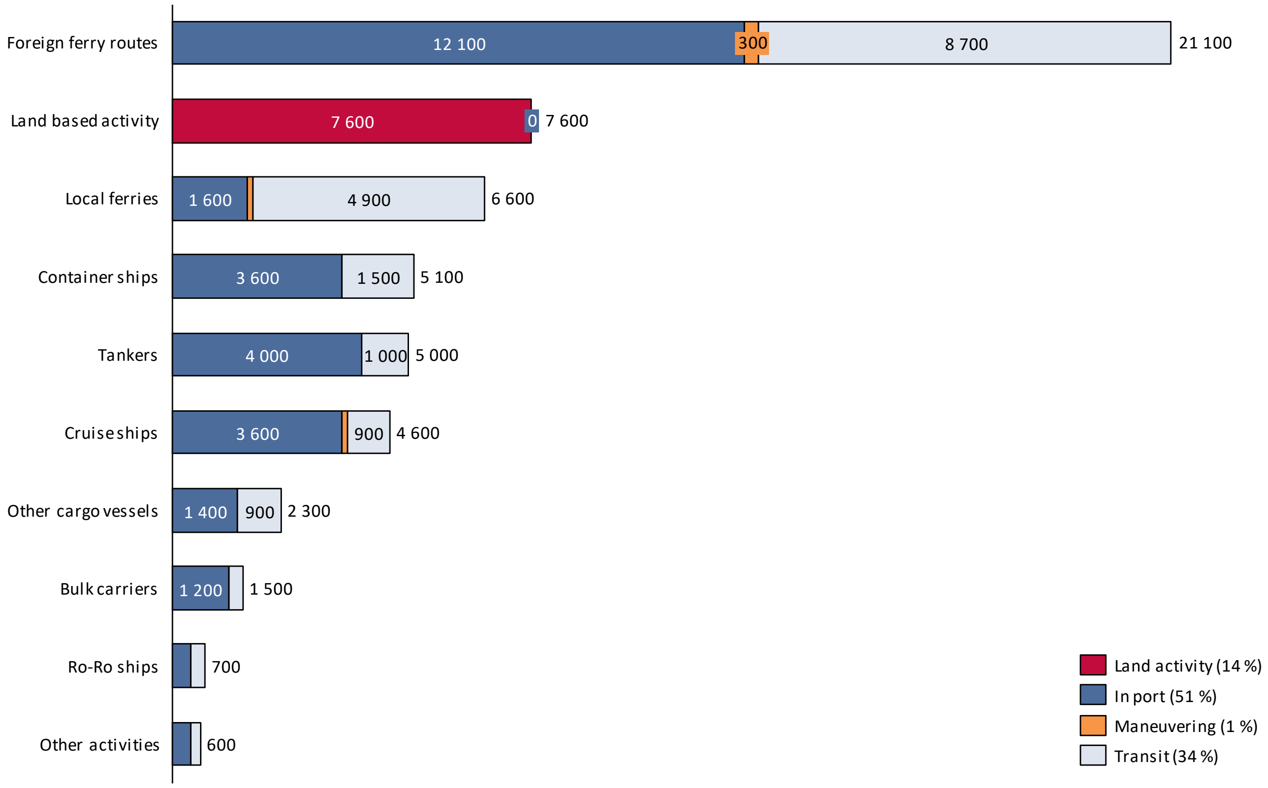


Figure 6-2: Overview of the most important segments at the Port of Oslo and their respective emissions of greenhouse gases per mode of operation, based on operations in 2017.

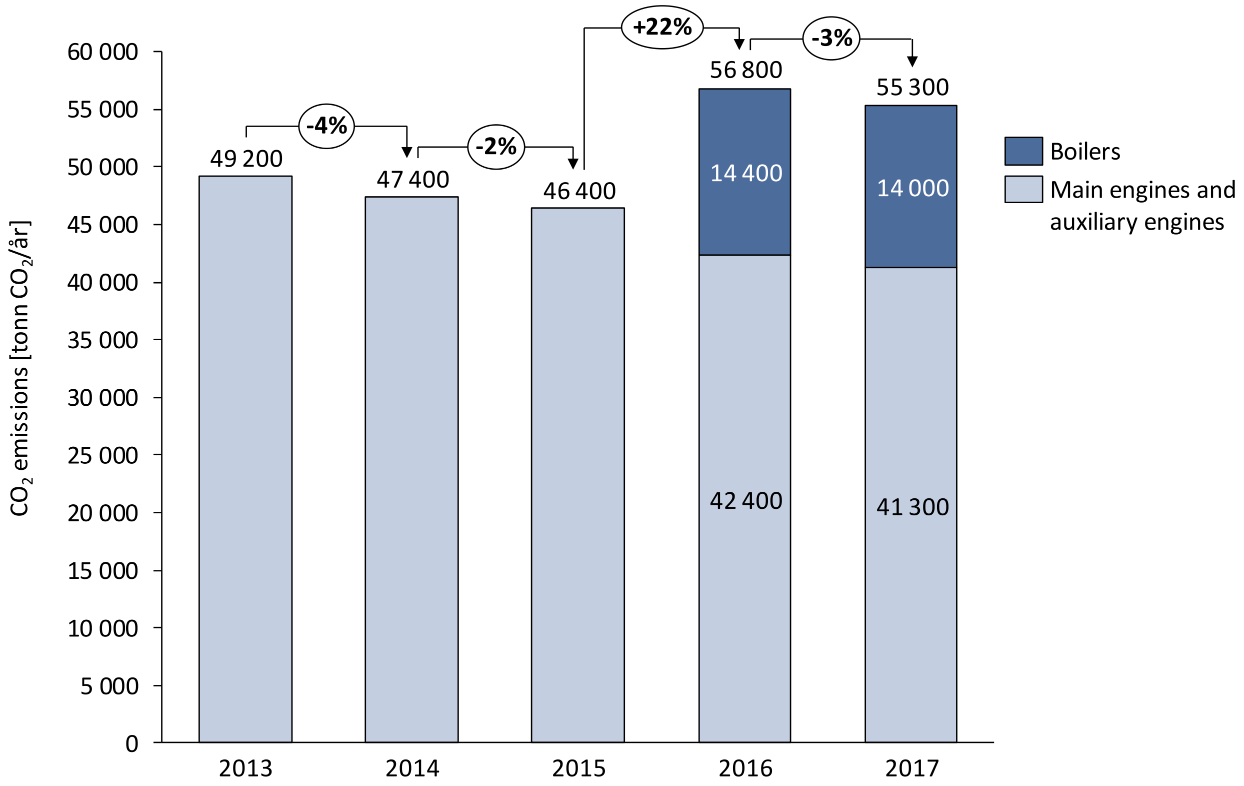


Figure 6-3: Overview of historical greenhouse gas emissions at the Port of Oslo, based on operations for the period 2013-2017. As of 1 January 2016, the consumption and emissions calculations from AIS data also include consumption linked to the operation of boilers aboard ships.

Table 6-1: Overview of the most important segments at the Port of Oslo and key figures for the segment based on operations in 2017.

Segment	Number of ships	Number of arrivals	Arrivals per ship	Average age
Foreign ferry routes	5 (1%)	1,023 (5%)	205	20 years
Local ferries	11 (3%)	14,927 (77%)	1,357	13 years
Cruise ships	43 (12%)	99 (0.5%)	2	22 years
Container ships/LoLo ships	37 (10%)	464 (2%)	13	16 years
Car carriers/RoRo ships	5 (1%)	86 (0.4%)	17	34 years
Tankers	87 (23%)	210 (1%)	2	15 years
Bulk carriers	12 (3%)	102 (0.5%)	9	31 years
Other cargo vessels	140 (38%)	1,066 (5%)	8	26 years
Other activities	31 (8%)	1,447 (7%)	47	43 years
Land based terminal activity	-	-	-	-
Road transport to/from port	-	-	-	-
Total	**371 (100%)**	**19,424 (100%)**	**52**	**28 years**

Table 6-2: Overview of the most important segments at the Port of Oslo and their respective emissions [tonnes/year] of CO_2, NO_X, SO_X and PM based on operations in 2017.

Segment	CO_2	NO_X	SO_X	PM
Foreign ferry routes	21,200 (38%)	311 (45%)	13 (48%)	27 (65%)
Local ferries	6,600 (12%)	104 (15%)	2 (7%)	1 (2%)
Cruise ships	4,600 (8%)	62 (9%)	3 (11%)	4 (10%)
Container ships/LoLo ships	5,200 (9%)	53 (8%)	3 (11%)	4 (10%)
Car carriers/RoRo ships	700 (1%)	12 (2%)	0.5 (2%)	0.9 (2%)
Tankers	5,100 (9%)	51 (7%)	3 (11%)	3 (7%)
Bulk carriers	1,400 (3%)	19 (3%)	0.9 (3%)	0.6 (1%)
Other cargo vessels	2,200 (4%)	29 (4%)	1.4 (5%)	0.9 (2%)
Other activities	700 (1%)	9 (1%)	0.4 (1%)	0.3 (1%)
Land based terminal activity	7,600 (14%)	40 (6%)	*not calculated*	*not calculated*
Road transport to/from port	*not included*	*not included*	*not included*	*not included*
Total	**55,300 (100%)**	**690 (100%)**	**27.2 (100%)**	**41.7 (100%)**

Table 6-3: Overview of the most important segments at the Port of Oslo and their respective emissions of greenhouse gases per mode of operation, based on operations in 2017.

Segment	Port/docking	Manoeuvring	Entry/exiting	Total
Foreign ferry routes	12,138 (34%)	308 (55%)	8,720 (47%)	21,166 (38%)
Local ferries	1,552 (4%)	106 (19%)	4,920 (26%)	6,578 (12%)
Cruise ships	3,630 (10%)	66 (12%)	931 (5%)	4,627 (8%)
Container ships/LoLo ships	3,636 (10%)	30 (5%)	1,495 (8%)	5,161 (9%)
Car carriers/RoRo ships	405 (1%)	5 (1%)	312 (2%)	722 (1%)
Tankers	4,040 (11%)	17 (3%)	996 (5%)	5,053 (9%)
Bulk carriers	1,177 (3%)	8 (1%)	252 (1%)	1,437 (3%)
Other cargo vessels	1,360 (4%)	11 (2%)	875 (5%)	2,246 (4%)
Other activities	436 (1%)	4 (1%)	235 (1%)	675 (1%)
Land based terminal activity	7,600 (21%)	0 (0%)	(0%)	7,600 (14%)
Road transport to/from port	*not included*	*not included*	*not included*	*not included*
Total	**35,974 (100%)**	**555 (100%)**	**18,736 (100%)**	**55,265 (100%)**

Development of emissions: The historical distribution of emissions between primary and auxiliary machinery and boilers shows that emissions have been reduced for every year in the period 2013-2017 (Figure 6-3). As of 1 January 2016, the consumption and emissions calculations from shipping at the Port of Oslo also include consumption linked to the operation of boilers aboard ships. This consumer group was not included in the emissions data previously and it is solely responsible for the 22 per cent increase in emissions between 2015 and 2016.

Major sources of emissions: As the figures show, foreign ferry routes (a total of 5 ships) represent 38 per cent of greenhouse gas emissions, Ruter’s operations (a total of 11 ships) represent 12 per cent, while shore operations on the port site account for 14 per cent of emissions. Therefore, the major greenhouse gas emissions are concentrated around a limited number of vessels, as well as machines that operate over a limited area at the port.

Furthermore, emissions statistics show that about half of the emissions come from operations when ships dock. For some types of ships, a large proportion of quay emissions from the segment in question will be reduced in a cost-effective manner by means of shore power.

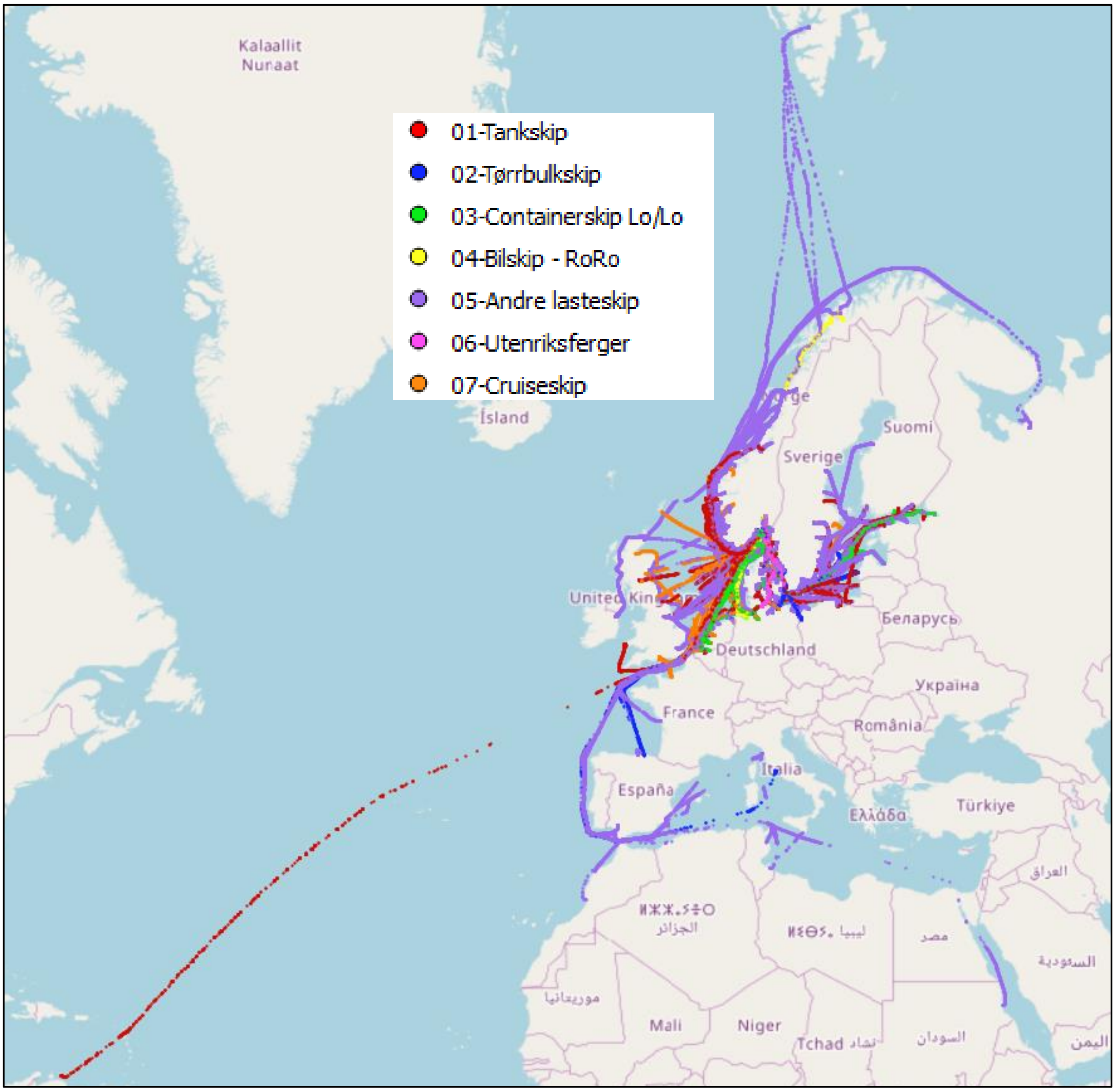


Figure 6-4: Overview of seven of the ten segments at the Port of Oslo and their respective operations and routes, based on operations in 2017.

6.1 Traffic pattern at the Port of Oslo

The next sections describe each of the eleven segments and list key figures, activity, status and scope of operations in 2017, emissions of CO_2, NO_X, SO_X and PM, provide a general overview of current opportunities for zero-emissions solutions, plus costs and CO_2 cost and potential reductions in emissions by means of shore power.

6.1.1 Foreign ferry routes

Key figures for the segment:

Table 6-4: Overview of foreign ferry routes at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
5 (1%)	1,023 (5%)	205	20 years

Activity:

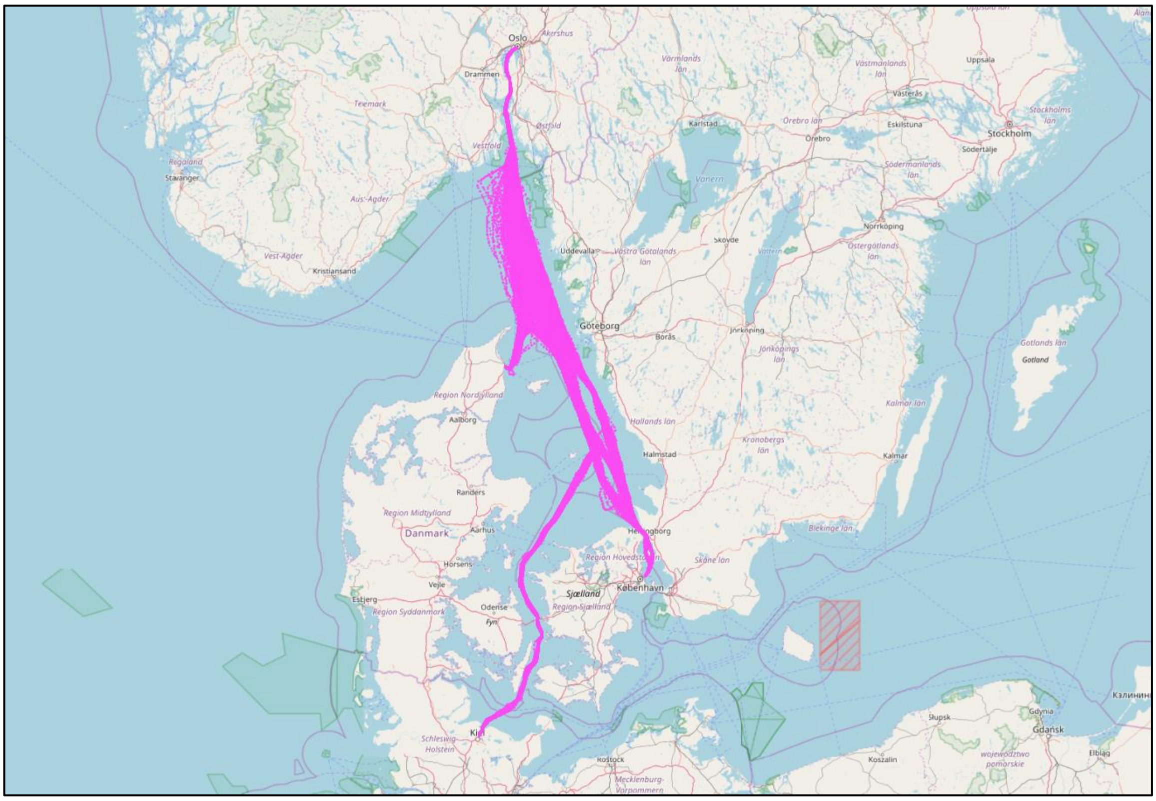


Figure 6-5: Overview of activity from foreign ferry routes to and from the Port of Oslo in 2017

Status in 2017:

The foreign ferry routes calling at the port of Oslo are RoPax ferries; a total of five ferries belonging to three shipping companies.

1. Color Line at Hjortnes operates on the Oslo-Kiel route, with daily departures from Oslo. This service is provided by the following ships:
    - "Color Magic" (2007): Departures from Oslo every two days. Already using shore power at the quay at Hjortnes.
    - "Color Fantasy" (2004): Departures from Oslo every two days. Already using shore power at the quay at Hjortnes.
2. DFDS at Vippetangen operates on the Oslo-Copenhagen route, with departures six days a week from Oslo. This service is provided by the following ships:
    1. "Crown Seaways" (1992): Three departures from Oslo each week. Catalytic converters were installed on the auxiliary engines in 2004 in order to reduce NO_X emissions at the quayside.[3]
    2. "Pearl Seaways" (1988): Three departures from Oslo each week. Catalytic converters were installed on the auxiliary engines in 2004 in order to reduce NO_X emissions at the quayside.
3. Stena Line at Vippetangen operates on the Oslo-Fredrikshavn route, with daily departures from Oslo. This service is provided by the following ship:
    - "Stena Saga" (1980): Daily departures from Oslo. A decision was made in the first quarter of 2018 to install shore power aboard this ship, subject to funding from Enova. This adaptation of the ship was completed in April 2018, so the "Stena Saga" is ready to start using shore power in Oslo.

Figure 6-6: "Color Magic", "Pearl Seaways" and "Stena Saga"

<u>Emissions:</u>

Foreign ferry routes at the Port of Oslo account for 21,200 tonnes of CO_2 per year (equivalent to 38 per cent of overall emissions in the "Approach to Oslo" field), and with that they are by far the biggest segment in terms of emissions. There are also major emissions linked with NO_X and PM on approach and when the ships dock. Although some of the ships use shore power, a large proportion of the emissions will nevertheless persist due to a significant need for heating on board the ships: this

[3] DFDS notified the City Council on 20 June 2018 that they have initiated a process involving installation of shore power connections aboard the two ships operating services to Oslo. The plan is to refit the ships when they come in for planned maintenance at the shipyard in January 2019 (Pearl Seaways) and January 2020 (Crown Seaways).

need is met by boilers producing steam that run on fossil fuels. This need for steam cannot be met by shore power with the existing and new shore power solutions.

Table 6-5: Overview of foreign ferry routes at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
21,200 (38%)	311 (45%)	13 (48%)	27 (65%)

Opportunities for future zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Use of district heating to meet the need for steam when docked
- Battery hybrid solutions on entry to and exit from the port
- Hydrogen operation (in the long term)
- Running on liquid biogas

Costs and potential reductions of emissions with shore power:

Port:	**Pier II for foreign ferry routes**				
Emissions reduction level [% reduction of total port emissions]	**Number of ships** [-]	**CO_2 reduction** [tonnes/year]	**Investment cost at port** [NOK]	**Investment cost aboard ship** [NOK]	**CO_2 cost** [NOK/tonnes of CO2 red.]
44%	1	1,432	4,600,000	4,750,000	244
84%	2	2,733	4,600,000	9,500,000	171
100%	3	3,268	6,700,000	14,250,000	212

6.1.2 Local ships operating on scheduled services

Key figures for the segment:

Table 6-6: Overview of local ships operating scheduled services at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
11 (3%)	14,927 (77%)	1,357	13 years

Activity:

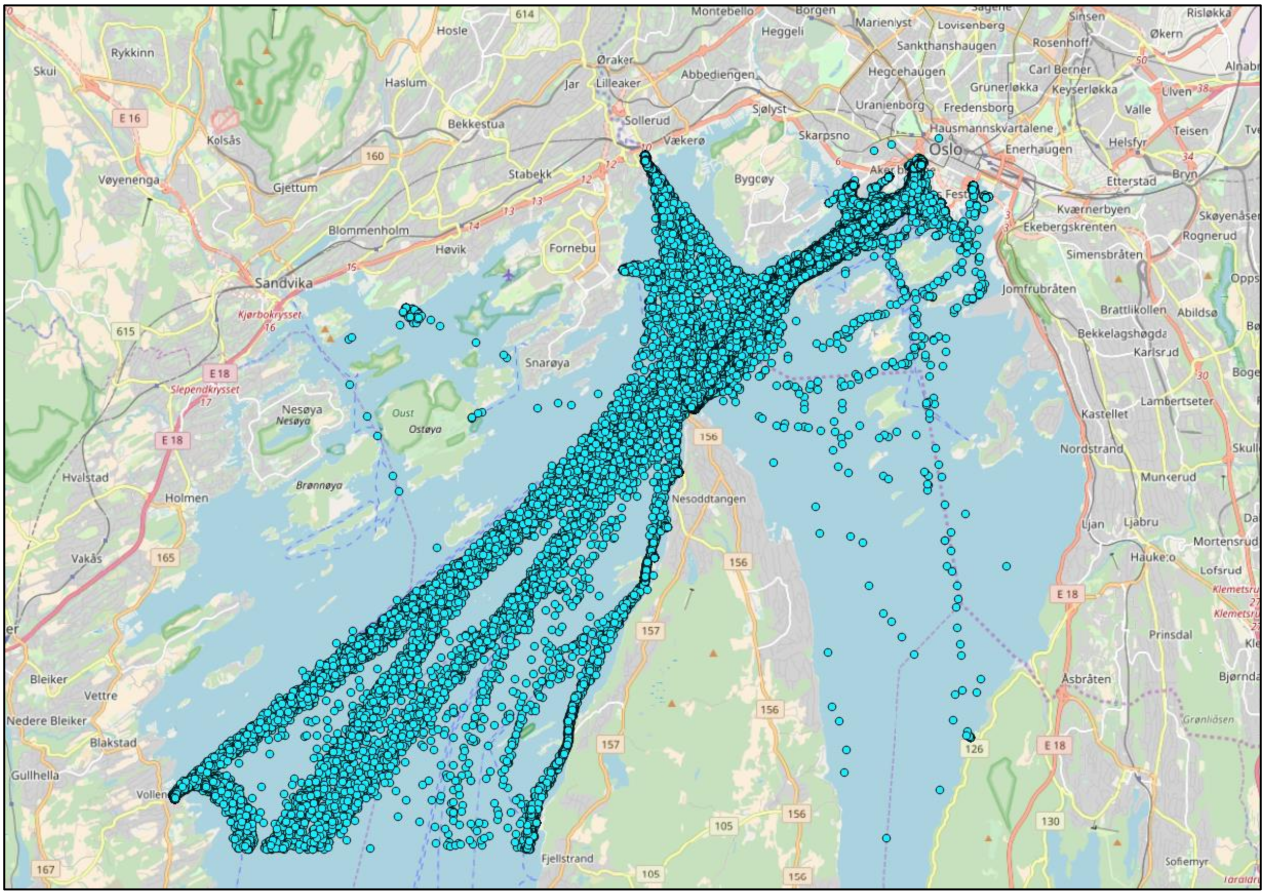


Figure 6-7: Overview of activity from local ships operating scheduled services to and from the Port of Oslo in 2017

Status in 2017:

The local ferries operating in the Oslofjord mainly include local ships operating scheduled services under the auspices of Ruter, and they form part of the public transport offering provided by the City of Oslo and the county of Akershus. There are also individual local ferries run by private companies licensed by the Port of Oslo, such as Bygdøybåten.

Like the Ruter bus services, the various shipping routes are put out to tender and are served by various operators on the basis of tenders. One thing these shipping contracts all have in common is the fact they are of long duration and have extension options of several years.

Ruter currently operates the following shipping routes:

1. Øybåttjenesten (route B1-B4)
2. Nesoddtangen - Aker brygge (route B10)
3. Nesoddtangen - Lysaker (route B11)
4. Aker brygge - Vollen/Slemmestad (route B20)
5. Aker brygge - Drøbak/Son (route B20-B22, summer only)

The present Øybåtene [island boat] service is operated by Oslo-Fergene AS, with three ships and an additional ship that is deployed during the summer season where necessary. These ships run on renewable diesel (HVO). The present contract expires in February 2018, but there is an option to extend it for a further three years. Ruter will be announcing a new tender in 2018. Procurement of shipping services of this type takes a total of four to five years from the time work commences on the preparations until a new contract comes into force, including 1.5-2 years for construction of ships. Ruter has exercised the extension option on the present contract.

Nesoddtangen-Aker brygge (route B10) is operated by Norled and is served by three ships that run on liquefied natural gas (LNG) (2/3) and marine gasoil (MGO) (1/3). These are equipped with gas-electric propulsion systems and are considered appropriate for refitting to battery electric operation. This contract will expire in 2024, but there is an option for a further ten years of operation if the two five-year options are exercised.

Route B20 to Vollen/Slemmestad and routes B21 and B22, which are a summer activity for Drøbak and Son, are also operated by Norled using high-speed ships that run on MGO. Ruter is of the opinion that these ships are not suitable for refitting for zero emissions. This contract will expire in 2019, but there is an option for a further 15 years of operation if the three five-year options are exercised.

Figure 6-8: "Kongen", "Baronessen" and "Oslo VIII"

Emissions:

Table 6-7: Overview of local ships operating scheduled services at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
6,600 (12%)	104 (15%)	2 (7%)	1 (2%)

Opportunities for zero-emissions solutions:

- Battery electric operation
- Running on hydrogen with fuel cell operation (in the long term)
- Running on liquid biogas

6.1.3 Cruise ships

Key figures for the segment:

Table 6-8: Overview of cruise ships at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
43 (12%)	101 (0.5%)	2	22 years

Activity:

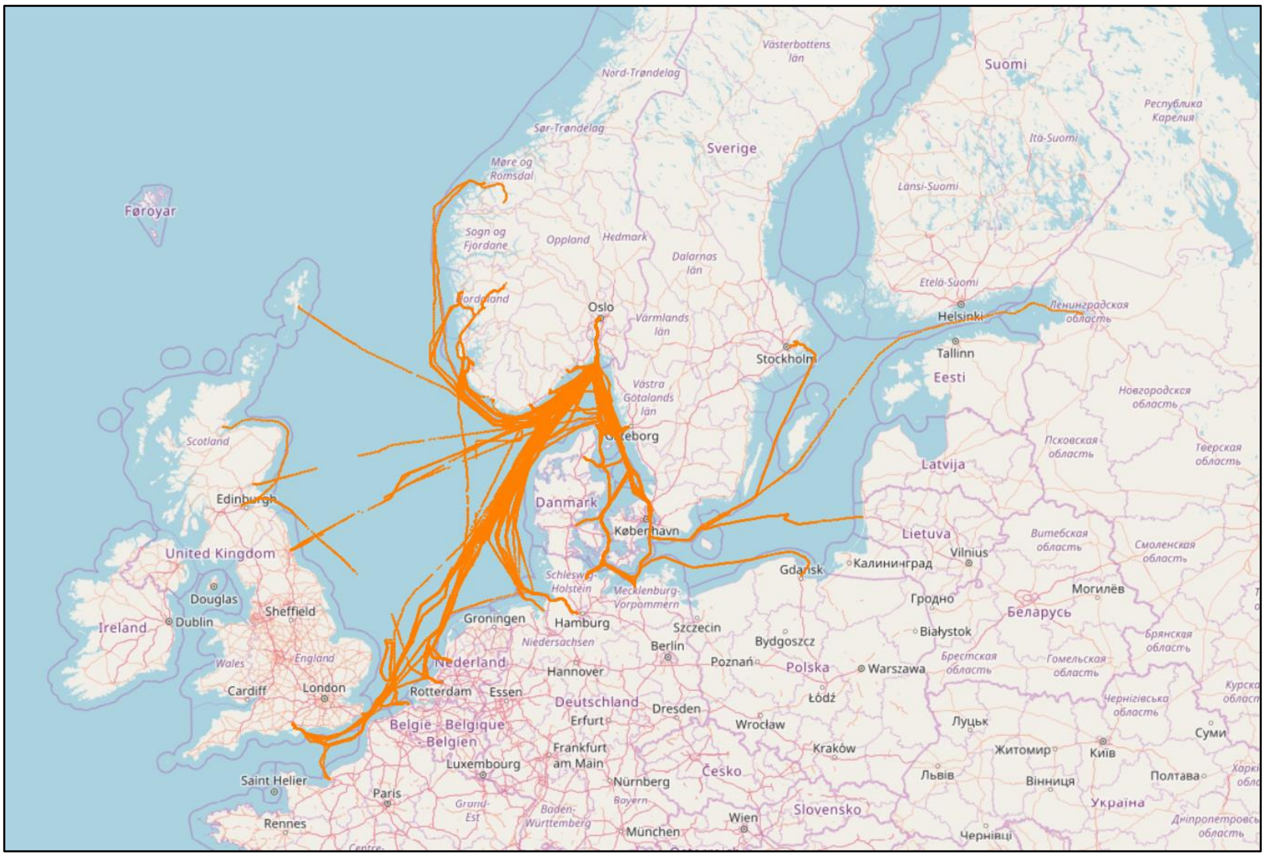


Figure 6-9: Overview of activity from cruise ships to and from the Port of Oslo in 2017

Status in 2017:

Oslo is a popular cruise destination. In 2017, the port welcomed 101 cruise arrivals from 45 different ships accommodating a total of 197,886 guests. Similar demand is expected in 2018, and hence cruise traffic is important for the tourist industry in Oslo.

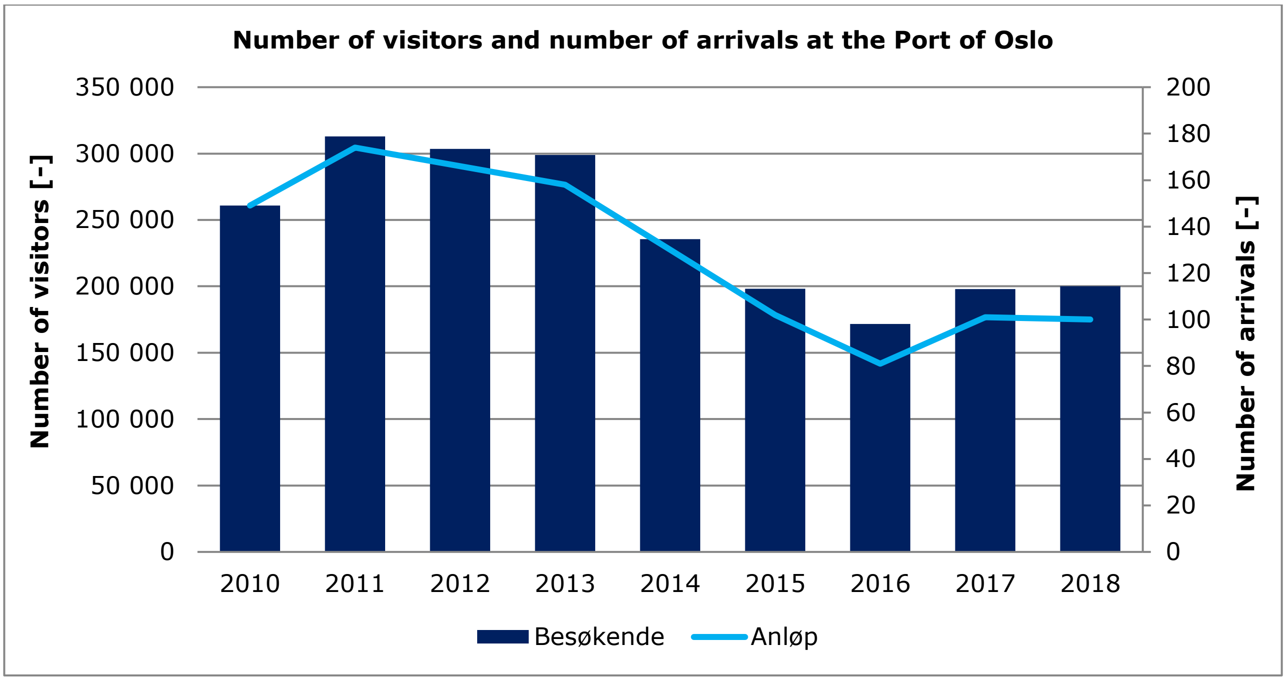


Figure 6-10: Number of visitors (columns) and number of arrivals (line) at the Port of Oslo

Cruise traffic to Oslo is on the increase. In 2016, Norway welcomed 660,000 cruise visitors, equivalent to 2.7 per cent of the global market. 170,000 passengers arrived in Oslo on a total of 82 cruise ships in 2016. In 2017, 101 cruise ships carrying almost 200,000 passengers arrived in Oslo.

Cruise traffic is distributed over four different terminals: Søndre Akershuskai (the main quay for cruise ships), Filipstad, Vippetangkaia og Revierkaia. The Port of Oslo has enough capacity to accommodate five cruise ships simultaneously. Three ships have what are known as “turnaround agreements” in Oslo for 2017. This means that they drop off all their passengers and welcome new ones abroad.

The shipping companies with the most visits in 2018 will be Princess Cruises, AIDA Cruises and TUI Cruises. The largest cruise ship that calls at Oslo is MSC Meraviglia (Figure 6-11), with 5,700 guests and a crew of 1,500. Two of the ships from Norwegian-owned Viking Cruises – Viking Sun and Viking Sky (Figure 6-12) – visit Oslo.

Figure 6-11: MSC Meraviglia, with 5,700 guests and a crew of 1,500.

Figure 6-12: Norwegian cruise ships that dock at the Port of Oslo – Viking Sun and Viking Sky.

Figure 6-13: AIDANova is one of the world's first cruise ships to run on, LNG and will be arriving in Oslo on 17 November 2018.

Emissions:

Table 6-9: Overview of cruise ships at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
4,600 (8%)	62 (9%)	3 (11%)	4 (10%)

Emissions from cruise ships are directly dependent on the number of ships calling at the Port of Oslo. Emissions increase during busy periods, and similarly they decline when there is less activity (Figure 6-14).

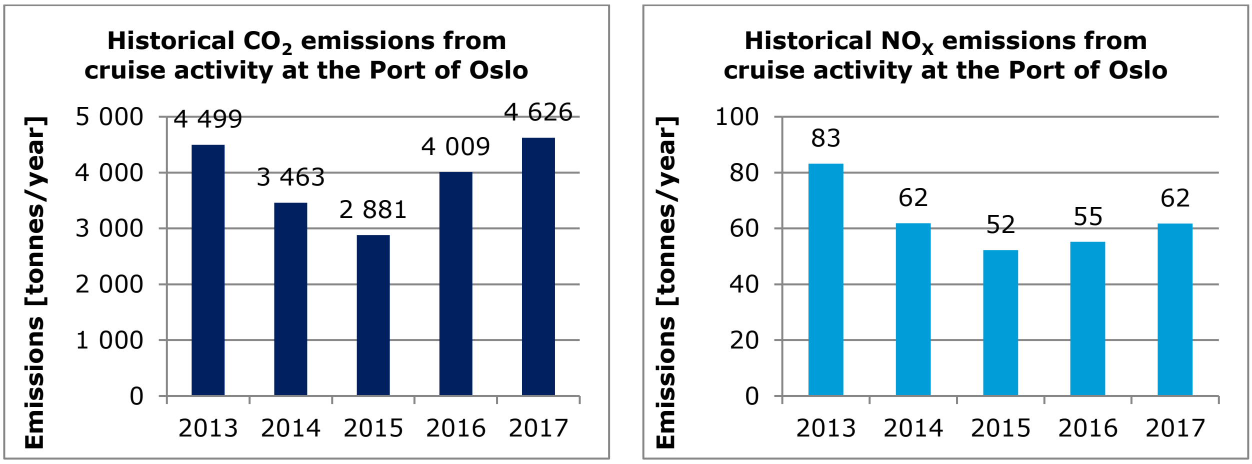


Figure 6-14: Historical CO_2 and NO_X emissions from cruise activity at the Port of Oslo for 2013-2017

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Use of district heating to meet the need for steam when docked
- Battery hybrid solutions on entry to and exit from the port
- Hydrogen operation (in the long term)
- Running on liquid biogas

Costs and potential reductions of emissions with shore power:

Shore power to cruise ships requires frequency converters and large amounts of power. When docked, the electricity needed by a cruise ship is equivalent to the power required to supply approx. 2,000 Norwegian apartments. The ships can use standard charging plugs following the introduction of the joint international standard in 2012, but the connection points on the ships are in different places as they vary greatly in terms of height, width and length. Therefore, the report has to invest in highly flexible cranes in order to connect the varied fleet of cruise ships to power.

The ReCharge model specifies costs linked with developing a shore power solution at the most widely used cruise quay in Oslo. This quay handles approx. 75 per cent of cruise ships arriving each year, and with that it is the longest and most widely used cruise quay in Oslo. Emissions on this quay could be halved if six cruise ships were to be refitted. The overall cost of refitting all ships would be extremely high as a very large number of different cruise ships call at Oslo.

Port:	Søndre Akershuskai – 75% of arrivals use this cruise quay in Oslo				
Emissions reduction level [% reduction of total port emissions]	**Number of ships** [-]	**CO_2 reduction** [tonnes/year]	**Investment cost at port** [NOK]	**Investment cost aboard ship** [NOK]	**CO_2 cost** [NOK/tonnes of CO_2 red.]
51%	6	986	95,600,000	35,160,000	5,740
80%	16	1,546	95,600,000	93,760,000	4,608
100%	38	1,929	95,600,000	222,680,000	5,363

6.1.4 Container ships/LoLo ships

Key figures for the segment:

Table 6-10: Overview of container ships at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
37 (10%)	464 (2%)	13	16 years

Activity:

The map below shows the container ships that called in Oslo in 2017, coming from Rotterdam (227 arrivals), Bremerhaven (61 arrivals), Antwerp (59 arrivals), Fredrikstad (22 arrivals) and Moss (12 arrivals). Internationally, ships from Oslo continued their journeys to Helsingborg (65 departures), Gothenburg (46 departures) and Rotterdam (14 departures). Internally within Norway, ships continued their journeys from Oslo to Larvik (99 departures), Moss (84 departures), Brevik (77 departures), Fredrikstad (61 departures) and Drammen (4 departures).

A new container route between Poland and Oslo will be commencing in 2018. In practice, this will replace 15,000 semitrailers on the roads in Norway and Oslo.

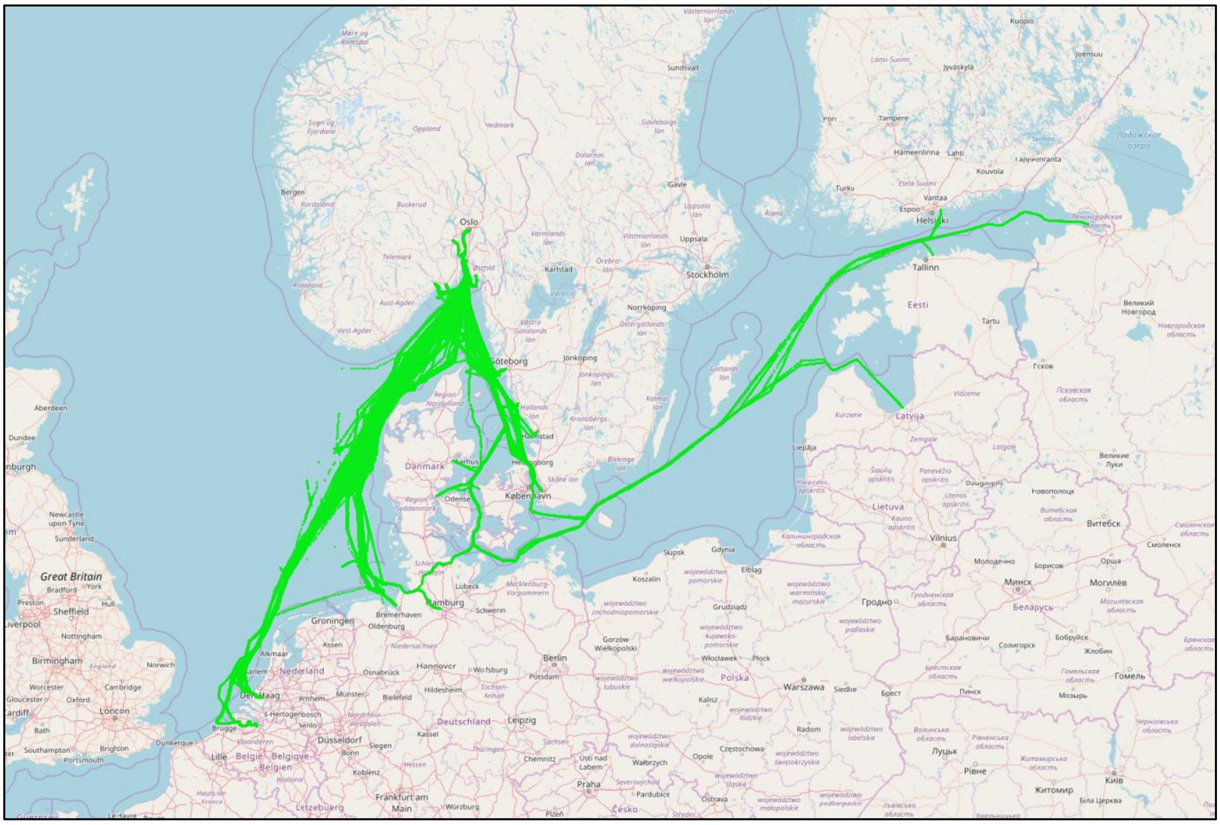


Figure 6-15: Overview of activity from container ships to and from the Port of Oslo in 2017

Status in 2017:

The Port of Oslo's container terminal at Sjursøya is the biggest in Norway, handling around 200,000 TEUs each year. In total, 1.2 million tonnes of cargo are handled via the container terminal with LoLo ships (lift-on/lift-off with container cranes). This terminal is operated by Yilport Oslo, a subsidiary of Yilport Holding Inc., which operates a number of terminals in Scandinavia, Iberia, the Mediterranean, Turkey and South America. Yilport clients are shipping companies that use the terminal. The shipping companies largely bear responsibility for quay-to-quay transportation of full and empty containers. What are known as short sea and feeder shipping companies bring containers by sea to Oslo for the most part, travelling to the Port of Oslo from the major container ports in Europe. Rotterdam and Bremerhaven are the biggest container ports in Europe.

The Port of Oslo's port plan (2013-2030) has defined targets relating to a 50 per cent increase in freight volumes for the period.

Emissions:

Table 6-11: Overview of container ships at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
5,200 (9%)	53 (8%)	3 (11%)	4 (10%)

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Use of district heating to meet the need for steam when docked
- Battery hybrid solutions on entry to and exit from the port
- Running on liquid biogas

Costs and potential reductions of emissions with shore power:

Port:	Sjursøya Container Terminal at the Port of Oslo				
Emissions reduction level [% reduction of total port emissions]	**Number of ships** [-]	**CO_2 reduction** [tonnes/year]	**Investment cost at port** [NOK]	**Investment cost aboard ship** [NOK]	**CO_2 cost** [NOK/tonnes of CO2 red.]
53%	5	834	5,200,000	30,100,000	1,214
80%	11	1,247	5,200,000	66,220,000	1,536
100%	36	1,562	5,700,000	216,720,000	3,652

The results from the ReCharge model show that emissions at the container terminal could be halved if five of the ships calling at the container terminal were to regularly use shore power to the quay. The overall cost of refitting all ships would be extremely high as a very large number of different container ships call at Oslo.

Sjursøya container terminal was completed in 2016. Pipes have been laid in order to bring more power to the edge of the quay, and the transformer is constructed in such a way as to allow a low voltage shore power system to be developed. The Oslo Port Authority is in discussions with users and other Norwegian ports and is getting in touch with relevant European ports in order to identify a joint shore power solution that could be used in future. Low-voltage solutions are currently used at the ports of Bergen and Kristiansand, among others. Hamburg and Antwerp offer power for large container ships, but not to smaller feeder ships that call at Oslo.

6.1.5 Car carriers/RoRo ships

Key figures for the segment:

Table 6-12: Overview of RoRo ships at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
5 (1%)	86 (0.4%)	17	34 years

Activity:

The map below shows that the RoRo ships calling in Oslo in 2017 came from Bremerhaven (72 arrivals), along with a few from Drammen (13 arrivals). Some RoRo ships also travelled from Oslo to Drammen (24 departures).

Figure 6-16: Overview of activity from RoRo ships to and from the Port of Oslo in 2017

Status in 2017:

A large number of RoRo ships calling at the Port of Oslo are car carriers. These call at Sydhavna and supply just under 50,000 vehicles a year. More or less all RoRo cargo ships to the Port of Oslo are 100-150 metres long, with an average capacity of approx. 1,200 vehicles (equivalent to 8,300 – 9,000 gross tonnes).

Shipping company UECC is the primary carrier of these vehicles for importer Harald A Møller AS (importer of Volkswagen, Skoda and Audi to Norway). The entire Harald A Møller operation is linked to the preparation and receiving of cars at the Port of Oslo. UECC's ships call at many ports, and the company has invested in a number of LNG ships.

Some car importers take cars to Oslo on foreign ferry routes. Around 10,000 cars a year are transported in this way, equivalent to 17 per cent of the total number of vehicles transported to Oslo per year.

Most vehicles shipped to Norway are loaded in Bremerhaven (Germany), which is one of the major vehicle shipping hubs in Germany.

Emissions:

Table 6-13: Overview of RoRo ships at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
700 (1%)	12 (2%)	0.5 (2%)	0.9 (2%)

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Battery hybrid solutions on entry to and exit from the port
- Running on liquid biogas

Costs and potential reductions of emissions with shore power:

Port:	Bekkelagskaia				
Emissions reduction level [% reduction of total port emissions]	**Number of ships** [-]	**CO_2 reduction** [tonnes/year]	**Investment cost at port** [NOK]	**Investment cost aboard ship** [NOK]	**CO_2 cost** [NOK/tonnes of CO_2 red.]
89%	1	282	4,900,000	5,540,000	1,360
95%	2	301	4,900,000	11,080,000	1,737
100%	4	318	4,900,000	22,160,000	2,513

The results from the ReCharge model show that emissions at the car carrier terminal could be reduced by almost 90 per cent if just one of the car carriers were to use shore power to the quay on a regular basis. At the same time, the CO_2 cost would be relatively high as emissions are limited.

This is a good example of the fact that a 90 per cent reduction, even with a zero-emissions ambition, may be the relevant target for emissions reduction for this type of ship, as a 100 per cent reduction would involve extremely high costs and small reductions.

As things stand at present, there are no car carriers using shore power in Norway or in Bremerhaven (Germany).

6.1.6 Tankers

Key figures for the segment:

Table 6-14: Overview of tankers at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
87 (23%)	210 (1%)	2	15 years

Activity:

The map below shows that the majority of tankers calling in Oslo in 2017 came from Mongstad (47 arrivals) and Slagentangen (41 arrivals). From Europe, tankers called at Oslo from Gothenburg (18 arrivals), Kalunborg (13 arrivals) in Denmark and Rotterdam (16 arrivals). Most tankers from Oslo go to Slagentangen (38 departures) and Mongstad (36 departures), and Gothenburg (35 departures) and Brofjorden (22 departures) in Sweden.

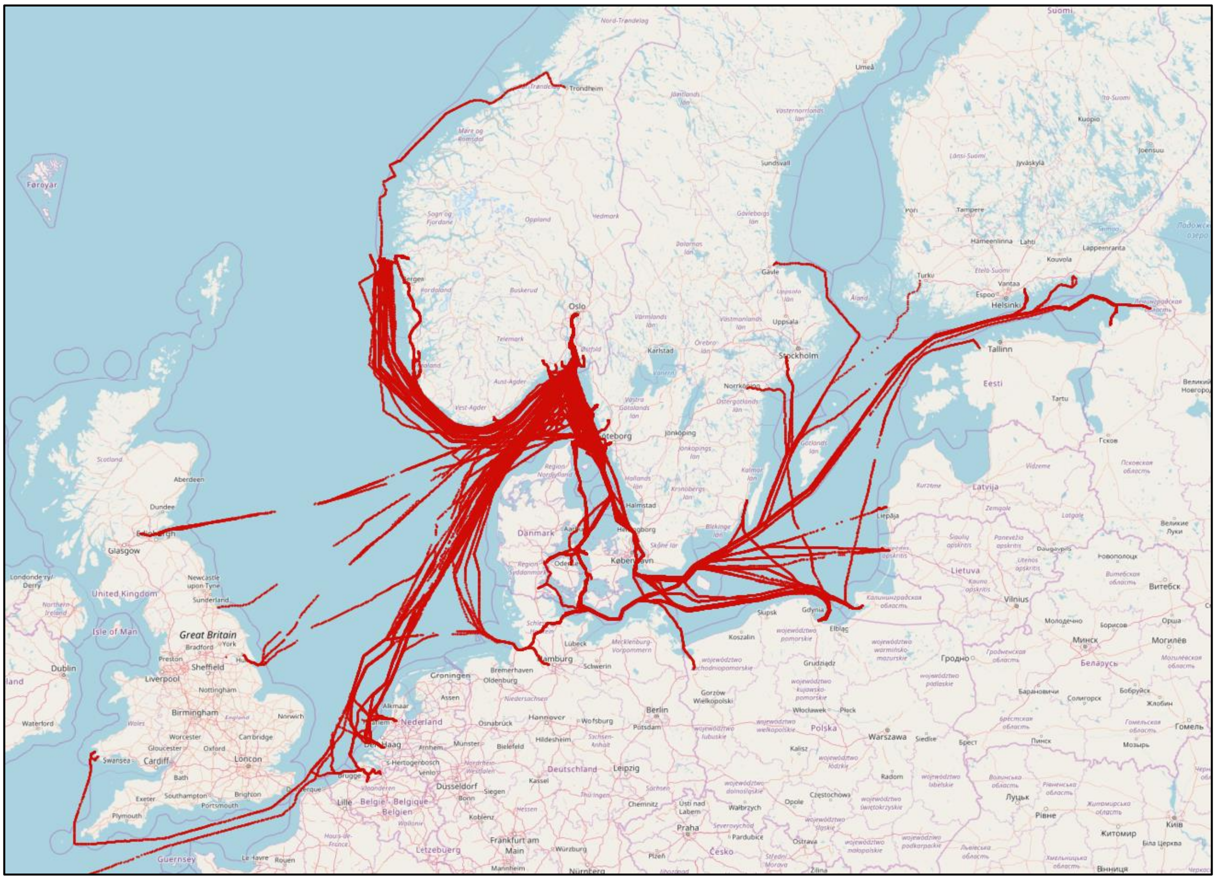


Figure 6-17: Overview of activity from tankers to and from the Port of Oslo in 2017

Status in 2017:

Around 40-45 per cent of the fuel consumed nationally arrives and is handled via the Port of Oslo.

A train 300 metres long transports aviation fuel to Gardermoen, Oslo Airport, twice a day. This transportation is absolutely crucial to flights. Flights out of Oslo airport would grind to a halt if the transportation of aviation fuel via Sjursøya were to stop for more than four days.

The tank is calling at the Port of Oslo primarily supply fuel and fuel additives for use in aviation and land transport.

Tankers transporting fuel to Oslo arrive from a number of international ports, and there is a great deal of variation in terms of size, age and type. This is due to the fact that petroleum products are an international item and sold on the world market.

The European oil and gas infrastructure (location of the refineries and storage terminals) is largely localised around Slagentangen (near Tønsberg), Mongstad (near Bergen), Rotterdam, Gothenburg and a number of refineries in the Baltic Sea. These ports largely represent the tanker routes to and from the Port of Oslo.

After being received at the port, the petroleum products are transported to Ekebergåsen via pipelines for storage in transit. Around 500 thousand tonnes of aviation fuel (Jet A1) are transported annually between Sydhavna/Ekebergåsen and Gardermoen by rail. Other fuel is distributed by tankers to petrol stations and filling stations all over Norway.

The tanker pier at the Port of Oslo can accommodate two ships simultaneously for pumping oil products onto land. At least one tugboat has to be prepared and ready to operate when the ships are docked – this is a legal requirement.

The port site reserved for oil products has more than halved at the Port of Oslo over the last 10-15 years. Such areas, known as the XO zone, have very strict safety procedures in place due to the risk of explosion. Whether arranging shore power and other zero-emissions technology would be complicated due to the safety conditions in the area is unclear.

Figure 6-18: Example of a tanker supplying fuel to the Port of Oslo – Bit Viking

Emissions:

Table 6-15: Overview of tankers at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
5,100 (9%)	51 (7%)	3 (11%)	3 (7%)

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Use of district heating to meet the need for steam when docked
- Battery hybrid solutions on entry to and exit from the port
- Running on liquid biogas

Costs and potential reductions of emissions with shore power:

Port:	**The tanker pier at the Port of Oslo**				
Emissions reduction level [% reduction of total port emissions]	**Number of ships** [-]	**CO_2 reduction** [tonnes/year]	**Investment cost at port** [NOK]	**Investment cost aboard ship** [NOK]	**CO_2 cost** [NOK/tonnes of CO_2 red.]
50%	10	1,160	6,800,000	41,000,000	1,177
80%	29	1,870	6,800,000	118,900,000	1,771
100%	83	2,342	8,900,000	340,300,000	3,822

The results from the ReCharge model show that emissions from docked tankers could be reduced by almost 50 per cent if ten tankers were to use shore power to the quay on a regular basis. At the same time, the CO_2 cost would be relatively high as emissions are limited, and distributed over a very large number of ships.

In this case, if the number of unique ships does not change over time, achieving zero emissions in this segment would be very demanding as a very large number of ships would have to be refitted.

6.1.7 Bulk carriers

Key figures for the segment:

Table 6-16: Overview of bulk carriers at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
12 (3%)	102 (0.5%)	9	31 years

Activity:

The map below shows that the majority of bulk carriers calling in Oslo in 2017 came from Brevik (56 arrivals) and Rostock (14 arrivals).

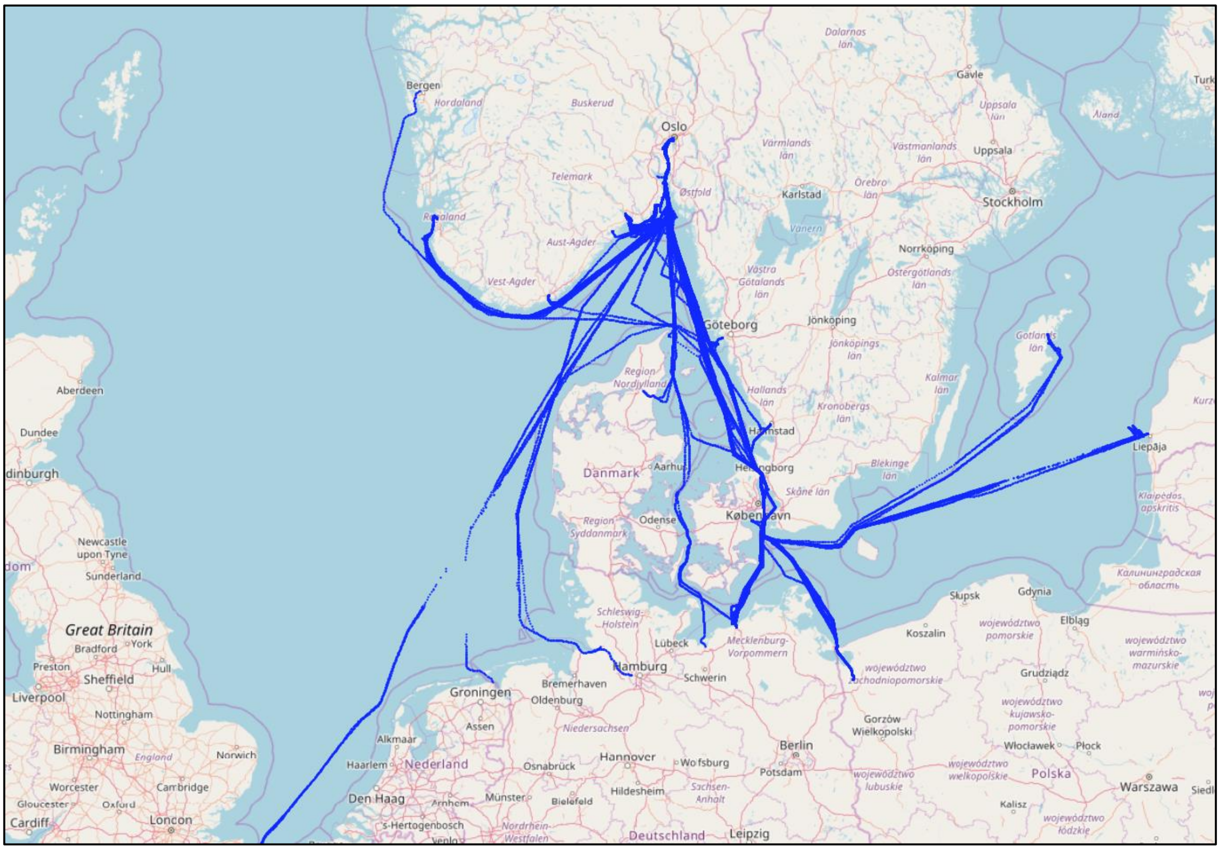


Figure 6-19: Overview of activity from bulk carriers to and from the Port of Oslo in 2017

Status in 2017:

In total, bulk carriers supply approx. 1.8 million tonnes of dry goods to the Port of Oslo each year. Of this, construction raw materials used in the city of Oslo (cement, sand, aggregate, gravel) account for around 70 per cent. The remaining 30 per cent is made up of salt, grain, fertiliser, Leca and suchlike.

The dry bulk shipping fleet is fragmented, and varies from small Norwegian ships to larger ships with international owners. Bulk carriers sailing to Oslo are generally smaller than the tankers, sail shorter distances and sail close to the coast. A typical bulk carrier carrying grain and calling at Oslo has a load capacity of 2-3,000 tonnes, while an average ship carrying petroleum products transports twice that amount. Bulk carriers supply goods from Stavanger, Fredrikstad, Trondheim, Gdansk, towns in Denmark, Klaipeda, Rotterdam, etc.

Some of the key stakeholders in the bulk shipping segment at the Port of Oslo include:

- Norcem and Cemex receive approx. 5-600,000 tonnes of cement each year. This continues its journey by road, involving around 70-100 trucks a day in and out of the port. 50-70 per cent of the cement imported is used locally in or in the direct vicinity of Oslo.
- Norbetong supplies approx. 100,000 m^3/year of ready-mixed concrete to Oslo, delivering it to locations approx. 10 km from the port. This is transported by means of approx. 100-200 trucks a day from the port.
- Strand Unikorn receives food and feed grain by sea that is stored in silos at the Port of Oslo before being processed in Oslo to make flour.

The number of tonnes of dry bulk has increased steadily at the Port of Oslo between 2012 and 2016. There is reason to believe that this is linked with high levels of construction activity in the Oslo region (Oslo havn, 2016).

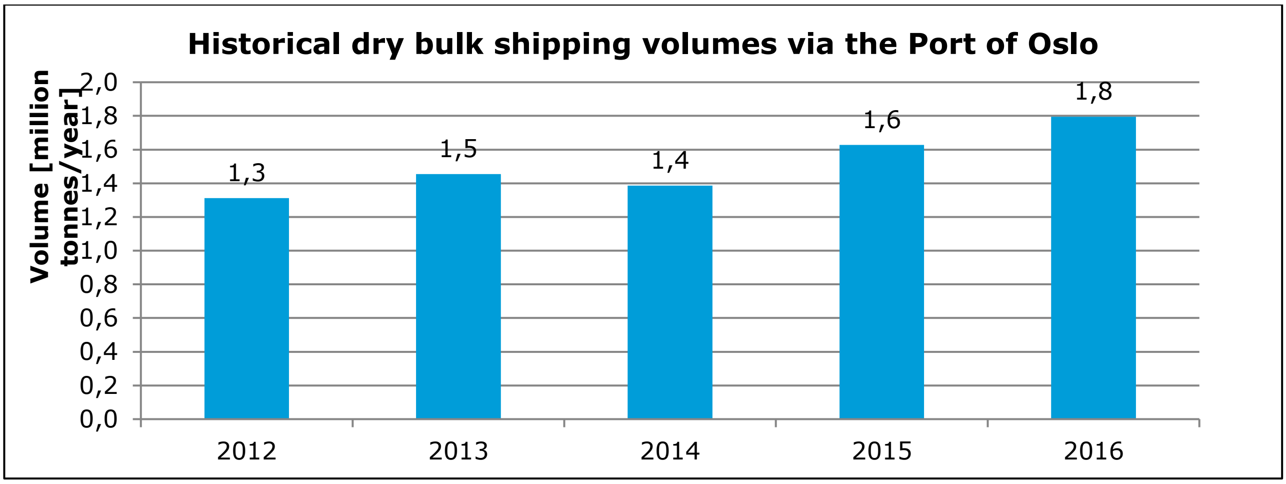


Figure 6-20: “MV Greenland” (left) and “MV Fjordkalk”, both of which carry cement

Figure 6-21: "MV Wilson Dover" transports grain

Emissions:

Table 6-17: Overview of bulk carriers at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
1,400 (3%)	19 (3%)	0.9 (3%)	0.6 (1%)

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Battery hybrid solutions on entry to and exit from the port
- Running on liquid biogas

Costs and potential reductions of emissions with shore power:

Port:	Nordre Sjursøya				
Emissions reduction level [% reduction of total port emissions]	**Number of ships** [-]	**CO_2 reduction** [tonnes/year]	**Investment cost at port** [NOK]	**Investment cost aboard ship** [NOK]	**CO_2 cost** [NOK/tonnes of CO_2 red.]
48%	1	665	6,800,000	4,100,000	665
80%	4	1,103	6,800,000	16,400,000	680
100%	67	1,379	8,900,000	274,700,000	5,304

The results from the ReCharge model show that emissions from docked tankers could be reduced by almost 80 per cent if four tankers were to use shore power to the quay on a regular basis. The CO_2 cost would be relatively low as few ships would need to be refitted.

In this case, if the number of unique ships does not change over time, achieving zero emissions in this segment would be very demanding as a very large number of ships would have to be refitted.

6.1.8 Other cargo ships

Key figures for the segment:

Table 6-18: Overview of other cargo ships at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
140 (38%)	1,066 (5%)	8	26 years

Activity:

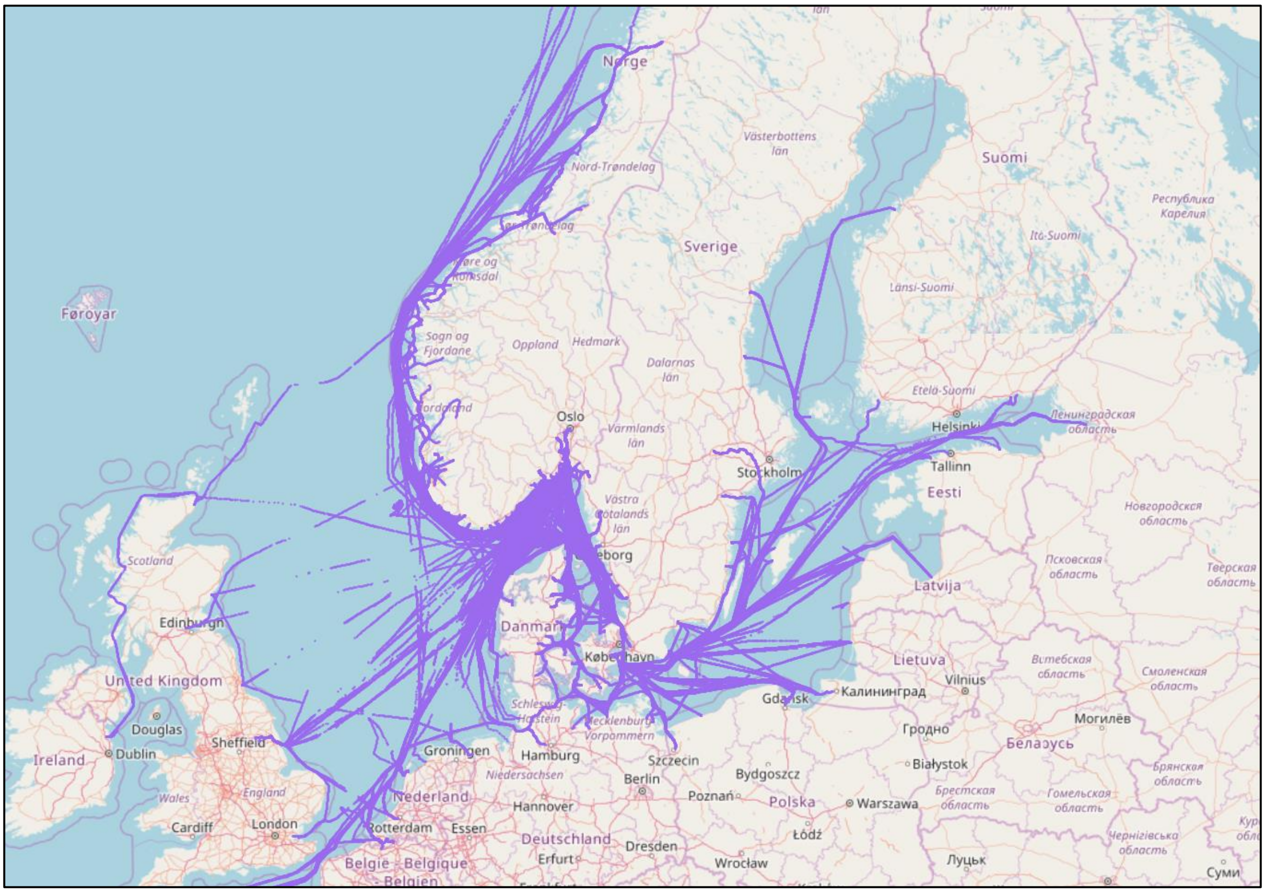


Figure 6-22: Overview of activity from other cargo ships to and from the Port of Oslo in 2017

Status in 2017:

Cargo ships come carrying grain, road salt, various masses and goods. These are smaller ships transporting various kinds of bulk products, and the map above shows (purple dots) that they call at several different quays at the Port of Oslo. Occasionally they have to wait at the port before they can be accommodated at the berths where they will be unloading and loading. This is one of the cargoes undergoing growth at the Port of Oslo in line with major development projects in the city.

Suledrott and Suleviking are both more than 30 years old and frequently sail between Oslo and Holmestrand with spoil from construction sites to be sent to landfill on the island of Langøya. Cargo ship Karmsund calls regularly with waste from the United Kingdom (Immingham) that is incinerated in Oslo and provides district heating to the city.

Figure 6-23: Smaller cargo ships carrying masses, such as Suledrott (left) and Suleviking (top), and smaller cargo vessels such as Karmsund (right) fall under the "other cargo ships" category.

Emissions:

Table 6-19: Overview of other cargo ships at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
2,200 (4%)	29 (4%)	1.4 (5%)	0.9 (2%)

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked
- Battery hybrid solutions on entry to and exit from the port
- Running on liquid biogas

6.1.9 Other ships

Key figures for the segment:

Table 6-20: Overview of other ships at the Port of Oslo and key figures for the segment based on operations in 2017.

Number of ships	Number of arrivals	Arrivals per ship	Average age
31	1,447	47	43 years

Status in 2017:

This category includes all smaller boats not referred to previously. Examples of these are commercial trawlers, leisure boats, working boats, marine vessels, the Bygdøy boats and private yachts. These include:

The sister ship to the sailing ship Christian Radich (Statsraad Lehmkuhl) received funding from Enova in 2017 to develop battery power on board. In future, the tugboats may possibly use some of the hybrid solutions used by offshore at present, combining LNG and power. The company that frequently provides tugboat services at the Port of Oslo is participating in discussions and is positive about future solutions.

Different solutions may also emerge for these ships. The Oslo Port Authority will be continuing to focus on facilitating matters for the chartered boats based at the Port of Oslo and is ensuring the continuous upgrading of the quays at Byhavna. In 2017, Rådhusbrygge 2 was fully renovated in order to provide better capacity for chartered boats so that they can deposit waste and sewage, along with options for more power. The Akershus pier will be upgraded in 2018-2019.

Figure 6-24: A sailing ship, tugboat and marine vessel included in the "other ships" category

Emissions:

Table 6-21: Overview of other ships at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
7,600 (14%)	40 (6%)	-	-

Opportunities for zero-emissions solutions:

- Shore power to meet the need for electricity when docked

- Battery hybrid solutions on entry to and exit from the port
- Battery operation
- Running on liquid biogas

6.1.10 Handling of goods, cargoes and other activities at the Port of Oslo

Status in 2017:

1. **Handling of cargoes:**

   When loading and unloading ships, electric cranes and solutions are mainly used. Cranes owned by the Oslo Port Authority are electric; with the exception of one mobile dockside crane, which will be phased out within a few years. In connection with container operations at Sjursøya, the Oslo Port Authority developed and invested in the world's first electric RTG (Rubber Tyred Gantry) cranes. Since RTG cranes were introduced, two-thirds of all container lifting has taken place using electric machinery and the number of fossil-driven machines handling containers has fallen from 13 to four. One port client has also invested in an electric crane that is used to handle bulk cargo at the port.

2. **Processing and interim storage:**

   Goods are unloaded, loaded, repacked, sorted and processed at all ports of any size, particularly those near to major cities and transport hubs. These are port-related operations.

   A lot of processing and interim storage: takes place on Port of Oslo land. A few examples are provided below:

   Strand Unikorn AS imports grain and concentrated feed to its two silos from all over the world. Concentrated feed (animal feed) is brought to the Sjursøya silo, while food grain is brought to the Vippetangen silo.

   Cars are imported at Sydhavna. More than 40,000 new cars arrive each year. Almost half of these were electric cars in 2017. This is the location of the import facility of car importer Møller Logistikk (Harald Møller AS), Norway's buggest importer of Audi, Volkswagen and Skoda.

   Norsteve AS operates at Filipstadkaia. This company offers terminal services and storage. They have three warehouses totalling 20,000 sq m here, and these are used for groupage. They import apartment modules that are shipped out to construction projects in the Oslo region for Selvaag, Obos et al.

   Up to 2018, Coop Norway and Joh. Johannson have imported more than half of all the coffee consumed in Norway to the quay at Filipstad. The coffee is roasted and packed at the Filipstad premises. The coffee used to come by ship directly from Brazil and Colombia to Filipstadkaia. Now the coffee beans are transported in containers to Sydhavna via major European ports such as Hamburg and Antwerp.

   Celsa Armeringsstål AS operates out of the scrap iron recycling terminal at Grønlia. Iron and metal from all of eastern Norway are collected here, before being sent on by sea to Mo i Rana for resmelting. The scrap iron comes back in the form of various iron products, such as rebar and wire.

HMH CEMENT AS is a leader in the field of masonry products in Oslo and Akershus. They operate out of Filipstad.

BMC AS (Building Material Corporation) is a big name in the distribution of construction materials to the markets in both Norway and Denmark. One of BMC's logistics centres is at the Port of Oslo.

Salt is not mined in Norway, so all salt is imported. A lot of this salt is imported by G.C. Rieber Salt AS at Sjursøya. Salt is used for a number of applications. Most obviously salt is used in food, and also salt is used on the roads in winter. Much of this salt is used in animal feeds and for the metal industry, but it is also used to produce plastic. Mesta has a road salt warehouse in Filipstad.

Unicon, the biggest supplier of ready mixed concrete in Scandinavia, operates out of Sjursøya north. They supply various kinds of ready mixed concrete to the construction industry. Similarly, Norbetong produces concrete for the Oslo market.

Cemex is Norway's first and biggest importer of bulk cement for the ready mixed concrete industry, concrete element manufacturers, municipal product (?) manufacturers, and manufacturers of mortar and paving stones. They operate out of Nordre Kongshavn.

Norcem AS develops, produces, markets and sells all types of cement to the building, construction and oil industries in Norway. Norcem AS is Norway's only producer of cement. They supply bulk cement to their carriers and customers from their silo station at Sjursøya.

Skanska Industrial Solutions AS produces asphalt at Filipstad which is then used in the Oslo region.

3. **Other activities at the port:**

   Salt is unloaded and distributed for consumer use and road maintenance. The same is applicable to cement. Norwegian grain for which Oslo is the nearest port is delivered to Sjursøya, and grain that is to be ground into flour in Oslo passes via Vippetangen. Leca, which is produced in Rælingen, is shipped out via the Port of Oslo to receiving facilities along the coast, and for export. Sorted waste for incineration at Klemetsrud arrives at the port, and ash to be recycled abroad is shipped out.

Emissions:

Port operations on land involving the handling of cargoes and other activities at the port account for 7,600 tonnes/year, equivalent to 14 per cent of total CO_2 emissions at the Port of Oslo.

1. **Handling of cargoes:**

   The equipment for handling cargoes is responsible for most emissions, amounting to approx. 5,500 tonnes/year (approx. 72 per cent of total emissions from land-based operations).

In connection with new and existing terminals, availability and commercial opportunities are being reviewed for zero-emissions technology for loading/unloading, internal transport and terminal management, and for land-side inbound and outbound transport; and the opportunities for the Oslo Port Authority to help by offering incentives for the introduction of such technology have been assessed and facilitated, partly due to the executive board's introduction of an NOK 3 million subsidy scheme in 2018 that will help to reduce emissions in the geographical region of the Port of Oslo.

2. **Processing and interim storage:**

   Processing and interim storage at the port will reduce emissions by reducing traffic on the roads and the total distance over which goods have to be transported by eliminating additional transportation to/from the processing or interim storage location.

3. **Other activities at the port:**

   Traffic on the port site is responsible for the rest of the emissions, approx. 2,100 tonnes/year (approx. 28 per cent of total emissions from land-based operations).

   Heavy vehicles used at the Port of Oslo are replaced at regular intervals, and phasing-in of more eco-friendly technology for heavy transport largely follows best available technology (BAT). The Port of Oslo maintains regular dialogue with stakeholders at the port with regard to what constitutes applicable BAT on the transport side of things, and is stepping up discussions with a view to pilot-testing and accelerating the introduction of zero-emissions transport (electric and hydrogen-electric) which is not yet technologically and/or commercially available. The City of Oslo has assessed potential synergies between the carbon capture facility and vehicle fleets to and from the Port of Oslo to see whether this could help to create a commercial offering and distribution of alternative (zero-emissions) fuels. A pipeline solution is currently being investigated.

Table 6-22: Overview of port operations on land, handling of cargo and other activities at the Port of Oslo and their respective emissions [tonnes/year] and percentage of total emissions [%] of CO_2, NO_X, SO_X and PM, based on operations in 2017.

CO_2	NO_X	SO_X	PM
7,600 tonnes/year	40 tonnes/year	n/a	n/a

Opportunities for zero-emissions solutions:

1. **Handling, processing and interim storage of cargo:**

   In connection with new and existing terminals, the port's customers are reviewing availability and commercial opportunities for use of zero-emissions technology for loading/unloading, internal transport and terminal management, and for land-side inbound and outbound transport. The Oslo Port Authority will plan for, and ideally be at the cutting edge of and develop necessary infrastructure when these solutions materialise and can be commissioned. The Oslo Port Authority is considering continuing the subsidy scheme in the next financial period (2019-2022) in order to demonstrate a commitment to its own customers who wish to phase in new solutions on an ongoing basis.

Environmental requirements are being defined, and it is requested that BAT should be assessed and ideally used as a basis for procurement procedures/rental agreements without becoming tied to a specific type of technology.

2. **Other activities at the port:**

The Port of Oslo is building loading solutions for its own vehicles and guest car parking. Customers and tenants are doing the same thing at the Port of Oslo. The next step will be to identify standardised loading solutions for both heavier vehicles and terminal equipment. It is possible that the technology will turn out to combine electricity with other fuel.

The Oslo Port Authority has participated in a project assessing commercial production and access to hydrogen, and found this to present a challenge. This assessment was performed on the basis of the need to transport liquid CO_2 which has to be shipped out via the CO_2 capture project.

Hydrogen may still be of relevance to other user groups, but as things stand at present it presents a challenge due to a lack of regulations in relation to production, retention, storage and filling.

6.1.11 Road transport to and from the Port of Oslo

Status in 2017:

Goods vehicles in Oslo:

Around 80-90 per cent of containers that are transshipped at the Port of Oslo have collection or delivery addresses in Oslo and Akershus. Approximately 140,000 container transports travel to and from the Port of Oslo in total. Approx. 60,000 of these pass between the Port of Oslo and the Alnabru area. Emissions linked with container transport between the Port of Oslo and the Alnabru area are in the order of 1,600 tonnes of CO_2 per year (Flowchange, 2017).

Oslo is the logistics and railway hub for Norway. Domestic freight transport on the railways in Norway accounts for 9-10 million tonnes per year, of which 6 million tonnes are bulk products such as ore/minerals, oil products (aviation fuel), timber, etc. Furthermore, 4 million tonnes are Alnabru cargo, goods transported by rail in containers, semitrailers and suchlike. Such freight travels by rail, via several channels (groupage, warehouses, directly from the port or manufacturer). Freight that is loaded/unloaded via the Port of Oslo accounts for an estimated 10-15 per cent of all domestic rail transport, approx. 5 per cent of which is aviation fuel from the Port of Oslo to Gardermoen (approx. 8 per cent of the 6 million tonnes of bulk goods on the railways). Of the remaining 4 million tonnes of freight that travel by rail, freight loaded/unloaded via the Port of Oslo represents an estimated 20-30 per cent.

Construction products in Oslo and the Oslo region are generating a great deal of transport. Access to construction raw materials and shipment of contaminated spoil should be transported with as few emissions as possible, and at a cost that is as low as possible. Therefore, the port and maritime transport should be used even more extensively than is currently the case. As the locations where construction raw materials are produced become more and more remote from Oslo, maritime transport will become even more attractive in terms of both costs and reduced emissions along the way.

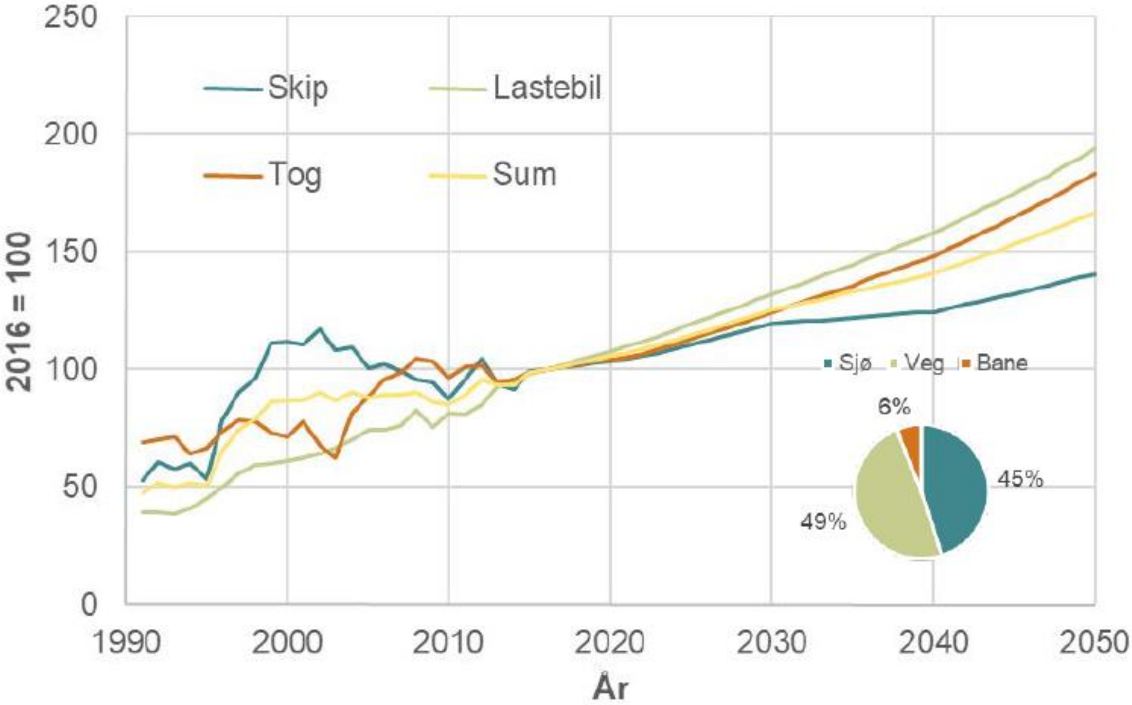


Figure 6-25: Historical development in domestic transport work between 1991 and 2015, market shares in 2015 and estimated development 2016-2050. Excluding crude oil and natural gas (TØI, 2018).

Primary transport routes in Oslo

Industrial and goods warehouses in Groruddalen and Akershus represent relatively large goods volumes in total. The figure below shows that the largest traffic volumes involving heavy goods vehicles in Oslo can be found on the main roads, and that volumes of goods to/from the Port of Oslo and Alnabru are much the same.

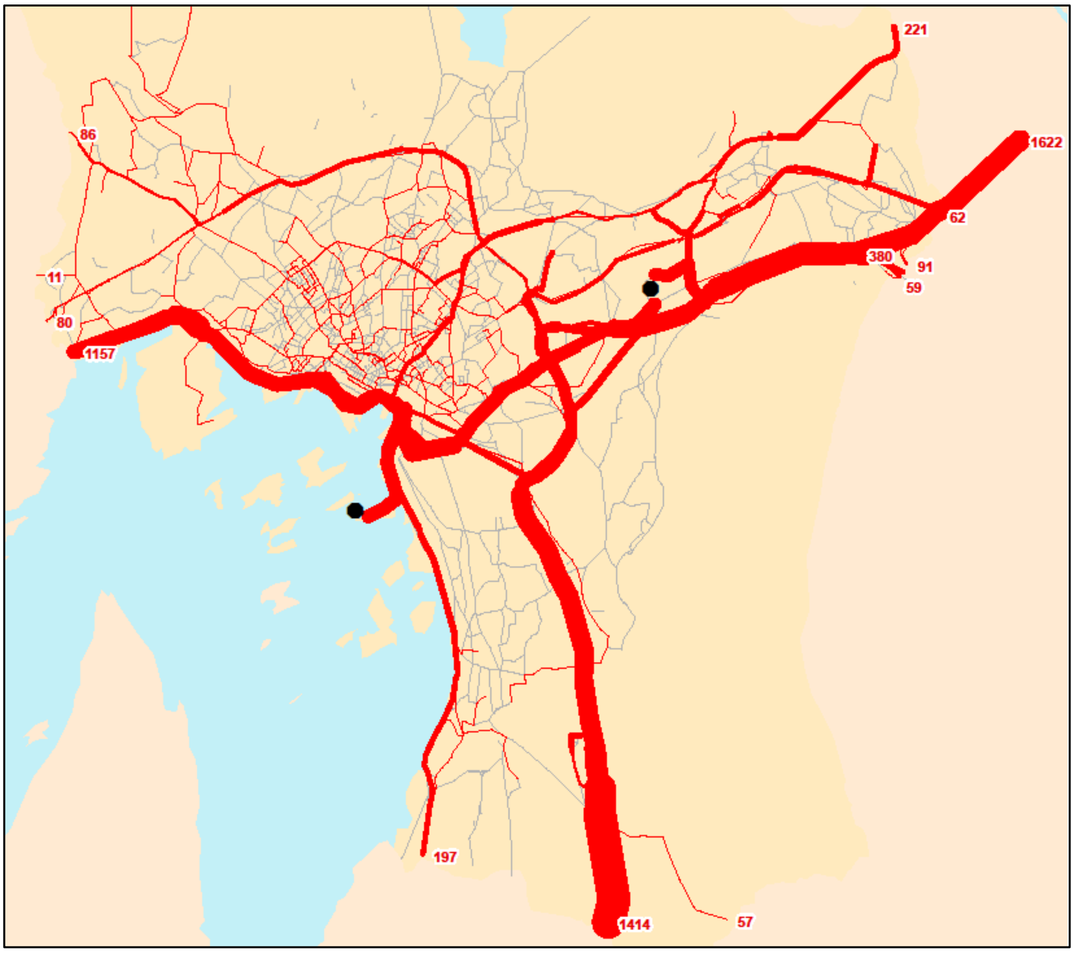


Figure 6-26: Online journey matrix for heavy goods vehicles. The thicknesses of the links illustrate the number of journeys. The number of journeys is displayed in 1000 of journeys per year. Black dot = the Port of Oslo and Alnabru railway terminal (SSB, 2016).

The Alnabru area is defined as groupage, freight forwarding and wholesale businesses are and near the Alnabru terminal. The container volume to this area is estimated at approx. 500,000 tonnes, equivalent to approx. 83,000 TEUs plus freight transport by rail from there. There are an estimated 50,000-70,000 journeys by road, equivalent to 240 road journeys per working day.

Major groupage companies such as Schenker and Bring are included in this volume, but it also includes wholesalers such as Bama, which are located in the same area. Rail company Cargonet is also a major client for such container transport. Containers are transported between the Yilport terminal and the Cargonet arrival point at the

Alnabru terminal. From there, the containers are then loaded directly onto trains and transported onwards using the Norwegian rail network.

Freight transport at the Port of Oslo

The Port of Oslo is an important provider of premises for domestic rail transport in the Norwegian logistics and railway hub.

Bulk transport:

Domestic freight transport on the railways in Norway accounts for 9-10 million tonnes per year, of which 6 million tonnes are bulk products such as ore/minerals, oil products (aviation fuel), timber, etc.

Construction products in the Oslo region are generating a great deal of transport. As the locations where construction raw materials are produced become more and more remote from Oslo, maritime transport will become even more attractive in terms of both costs and reduced emissions.

Container transport:

Approx. 202,000 TEUs (20-foot container units) are equivalent to an estimated 140,000 single journeys involving transportation of containers. The average weight for loaded tonnage amounted to approx. 6 tonnes of freight per TEU. Loaded containers actually weigh more, an estimated 10 tonnes, while a fairly large number of empty containers are transported back to the port or other Oslofjord ports due to the fact that the directional imbalance of import/export cargo stands at approx. 70/30.

In total, 1.2 million tonnes of cargo were handled via the container terminal with LoLo ships (lift-on/lift-off with container cranes). By way of comparison, the Oslofjord ports of Oslo, Moss, Borg, Drammen and Larvik jointly handled approx. 420,000 TEUs with 2.8 million tonnes of cargo in 2016.

Railway track, Port of Oslo – Alnabru

There is a railway track between Sydhavna/Sjursøya and Alnabru. The part of the track located on the port site is private, and the port owns the infrastructure for this part, which is not electrified. The line continues as a public track via the Bane Nor station in Lodalen and up Brynsbakken to Alnabru.

The railway track is currently used for transporting aviation fuel to Gardermoen, with an average of one departure per day. The train is pulled by a diesel locomotive to Lodalen, and then by an electric locomotive on to Gardermoen.

It emerged during a meeting with the Port of Oslo that the options for electrifying the track have been assessed on a number of occasions. Electrification of the track all the way down to the port would be a challenging task. This would possibly require relocating the fuel filling plants, as well as demolishing buildings and relocating the track in order to prevent conflicts between road traffic and the railway line.

If electrifying the track in Oslo is still being considered, it is possible to assess whether responsibility ought to be transferred to Bane Nor, making the state responsible for electrifying and operating the track.

Emissions:

Emissions linked with the transportation of goods/freight to and from the port and elsewhere in Norway have not been included in the emissions data for the port, but the City of Oslo would like to view this in greater detail.

Opportunities for zero-emissions solutions:

The Port of Oslo can contribute towards zero-emissions solutions in a number of ways for freight to be transported onwards by rail, as well as facilitating increased use of the railway as an interim form of transport for freight that can be collected from/delivered to Alnabru instead of the Port of Oslo. However, the commercial framework conditions for use of the railway between the Port of Oslo and Alnabru our very weak, and the Port of Oslo, Bane Nor the Norwegian Railway Directorate are working jointly towards altering these conditions. Transportation of cars from the Port of Oslo is one example: new cars are transported on car transporters from the Port of Oslo to Drammen before then being loaded onto a train.

Maritime transport is quickly disregarded if it requires a number of reloading operations between road, sea and rail transport. There are good reasons as to why the truck industry is referred to as one of the port’s most important partners. For the most part, the products on board a ship have been transported by truck to the port, and all freight arriving at the Port of Oslo are to be transported onwards by road or rail to varying degrees.

If the cargo cannot be processed at the port, the goods have to be reloaded several times. This makes maritime transport less attractive as it results in a number of unnecessary logistics operations that are costly and take time, before the freight reaches the customer.

Processing, interim storage, stripping and stuffing of containers have always been part of port activities. Maritime transport is competitive in terms of price, but multiple routes with faster delivery will be important when it comes to dealing with competition from flexible road transport.

6.2 Future development of operations and emissions

6.2.1 Ambitions for growth

As part of its port plan for the period 2013-2030, the Port of Oslo is aiming to transport 50 per cent more freight and 40 per cent more passengers via the city port.

The 50 per cent growth in freight transport via the port is expected mainly to involve groupage in larger units such as containers or semitrailers. Efforts are being made to streamline port operations and increase capacity for receiving groupage and bulk cargo. Work is also in progress on increasing exports in order to achieve more of a directional balance, so that ships calling at Oslo also transport freight out of the port.

The target of a 40 per cent increase in the number of passengers has calculated that there will be 9.2 million passenger journeys each year via the Port of Oslo in 2030.

The following objectives have been defined for the respective segments for 2030:

- **Foreign ferry routes:** Oslo is the biggest port in Norway for foreign ferry routes, and the aim here is to bring about a 50 per cent increase in passengers for the period 2011-2030, bringing the numbers up to 3.28 million passengers.
- **Local ships operating on scheduled services:** The target for local ships is to achieve a 40 per cent increase for the period, to around 5.3 million passengers per year.
- **Cruise ships:** Cruise activity increases during the summer, and the season has also been extended. It is envisaged that there will be a 50 per cent increase in cruise passenger numbers for the period, to 0.47 million passengers.
- **Container ships/LoLo ships** 63 per cent increase in LoLo operations for the period 2011-2030, to 2.2 million tonnes per year
- **Car carriers/RoRo ships:** 114 per cent increase in RoRo operations for the period 2011-2030, to 1.71 million tonnes of cars per year
- **Wet bulk shipping:** 25 per cent increase in wet bulk shipping for the period 2011-2030, to 2.59 million tonnes per year
- **Dry bulk shipping:** 31 per cent increase in dry bulk shipping for the period 20112030, to 1.75 million tonnes per year
- **Groupage:** 82 per cent increase in groupage for the period 2011-2030, to 0.3 million tonnes per year.

6.2.2 Ongoing initiatives for more eco-friendly port operation

The shore power facility at Vippetangen will be completed in 2018. The Port of Oslo has itself provided approximately the same amount of funding as Enova, as port customer Stena Line wishes to use shore power at two quays[4]. The solution being

[4] DFDS notified the City Council on 20 June 2018 that they have initiated a process involving installation of shore power connections aboard the two ships operating services to Oslo. The plan is to refit the ships when they come in for planned maintenance at the shipyard in January 2019 (Pearl Seaways) and January 2020 (Crown Seaways).

constructed at Vippetangen has been upgraded and will include enough power to allow two ferries to draw power simultaneously, with options for electric heating boilers on board ship and possibly charging batteries when they are docked.

In 2013, the Oslo Port Authority completed an investigation for designing a shore power solution for cruise ships on the basis of approval of a new international standard for high-voltage shore power in 2012. This investigation showed that the solution takes up a lot of space and is very costly. Quality assurance took place in 2014 and showed that the shore power solution would cost more than NOK 100 million. Estimated Enova funding of just 8 million, requirements for space on the site to undergo urban development and a great deal of uncertainty as to whether cruise ships would start using the solution meant that the Oslo Port Authority brought the project to a halt. What was then the city council for environment and transport went to the Storting – Norwegian parliament – to request more state funding if shore power facilities were to be constructed for cruise ships.

In 2016, the Oslo Port Authority was invited to form part of a cooperation with ABB, Cavotec and DNV GL in order to gain an overview of where shore power could have the greatest impact on the environment. A calculator was developed that showed estimated costs for both port infrastructure and refitting of ships. The ReCharge model also uses AIS data so that it is possible to identify which ships need to be refitted, and how many.

The ReCharge model has been used in the work on this action plan in order to estimate what a zero-emissions port would cost and how many ships would be expected to be refitted in order to achieve a 50, 80 and 100 per cent reduction in emissions by means of regular shore power when the ship is docked.

This means that the costs described in this action plan have to be considered to be estimates. It is likely that the cost will go up when the solutions are to be designed; cf. the implementation solution for power for foreign ferry routes at the Revier quay.

In 2017, the Oslo Port Authority implemented a pilot project in order to reveal potential low-emissions solutions that were assessed prior to the procurement of shore power for ships at Vippetangen. The purpose of this pilot project was to reveal potential multipurpose use of the shore power solution at Vippetangen, and potential development of district heating for ships was assessed at the same time.

The pilot project reveals that there is free grid capacity to meet the majority of current and future shore power and charging needs at Vippetangen (25 megavolt amps). The greatest savings will be achieved with shore power for Pier II. A new power supply cable from the Pipervika transformer station to Rådhusbrygge 4, which is rented by Ruter, will have to be established. This would be able to meet needs for electrification of the island ferries and the Nesodden link.

There is enormous potential for the supply of district heating to the foreign terminals. For Vippetangen, it will be necessary to lay a district heating pipeline from the main lines in Myntgata. Existing branch lines in the vicinity do not have the necessary capacity. There is sufficient capacity in the branch to the terminal area at the Hjortnes terminal, but not into the terminal itself.

Using the shore power solution for ships for other purposes is considered inappropriate. The ships require large amounts of power and use high-voltage systems. Local ferries and smaller ships use less power, and hence they use low-voltage systems. Even less power is used for charging buses, vehicles and trailers, and direct current systems are used. Vippetangen has enough of a power supply for all these purposes, but the shore power facility itself will only be built to provide power to ships with high-voltage capabilities. Therefore, a solution will be constructed at Vippetangen that will be used for large passenger ships where the greatest potential for reduction of emissions has been identified.

6.2.3 A collective phase-in plan for the Oslofjord in its entirety

The Oslo Port Authority is working on preparing an overview of how quickly it would be possible to arrange more zero-emissions solutions for ships, terminal handling and transport in and out of the port.

The City of Oslo has a clear political majority in favour of a quick transition to the green shift. Everyone has to work together towards the city's zero-emissions vision, and many are willing to commit themselves, enter into partnerships, invest and build the zero-emissions port of the future in the City of Oslo.

In relation to this, the Oslo Port Authority has begun working on mapping infrastructure needs for the zero-emissions solutions of the future. This work is expected to be completed in 2018.

Communication on a common phase-in plan consistent with the phase-in rate, from a realistic temporal perspective, in line with the construction of infrastructure and giving the shipping companies time to refit their ships, will be a useful way of identifying good partnerships. It will only be possible to achieve reductions in emissions through long-term partnership that provides security so that major investments can be made in the maritime transport of the future.

This will require major investments if it is to be possible to offer zero-emissions solutions throughout the entire port. Costs for developing infrastructure at Sydhavna alone are estimated at around NOK 50 million, and NOK 1 billion if all the freight ships calling at Oslo have to be refitted. The solution for cruise ships alone is estimated to amount to NOK 100 million. Therefore, it is important to operate a targeted approach towards the ships that call frequently and find solutions that reduce individual major point sources of emissions in order to achieve a zero-emissions port in the long term.

New infrastructure at the port will also require infrastructure into the port provided by Hafslund Nett. The current grid has sufficient capacity to meet the power needs of the entire city, but offering power all the way out to the edge of the quay is often highly costly. These costs, the construction contributions, are not included in the ReCharge model and will be in addition to the estimated costs. This could increase costs considerably if Hafslund AS does not take greater responsibility for investment in the future and develop power facilities in order to offer zero-emissions solutions to ships and the port in Oslo.

7 EXISTING TARGETS, MEASURES AND INSTRUMENTS

Shipping has been subject to a fairly strict regime over the past few years, with rules restricting emissions of NO_X, SO_X and CO_2, and the industry is expected to be subjected to further demands to reduce emissions. This section provides a brief overview of existing and future regulations for shipping, regulating emissions of NO_X, SO_X and CO_2.

7.1 Greenhouse gas emissions

Greenhouse gases, mainly CO_2, methane (CH_4), nitrous oxide (N_2O) and F-gases (fluorinated gases), are gases that help to heat up the global climate system, and where the concentration in the atmosphere is affected by human activity, such as deforestation and burning of fossil fuels. Man-made CO_2 emissions are the biggest contributor to this heating, so CO_2 is considered to be the most important greenhouse gas for which emissions must be reduced.

7.1.1 On an international level

IMO

As things stand at present, CO_2 emissions from maritime activity are currently partly regulated on an international level by the IMO via MARPOL Annex VI, which includes the Ship Energy Efficiency Management Plan (SEEMP) and Energy Efficiency Design Index (EEDI). Both the SEEMP and the EEDI came into force on 1 January 2013. The SEEMP specifies no requirements in terms of emissions, while the EEDI requires a minimum energy efficiency level for new buildings.

The EEDI is based on a formula for calculating ship-specific emissions of CO_2. The results for each ship are based on design documentation and engine data, and are expressed in grams of CO_2 per "capacity mile". The EEDI for a specific ship must be less than or equal to the EEDI requirement, which is expressed by means of reference lines developed by the IMO for each ship type. The EEDI reference lines will become stricter over time, and with this the EEDI will encourage development of energy-efficient ships. At the same time, the index permits comparison of the energy efficiency of similar ships of the same size and type. The IMO has also previously discussed market-based mechanisms for regulating CO_2 emissions from shipping, but to no avail. At present this discussion is centred around further technical and operational measures, in particular further efficiency standards.

EU

CO_2 emissions were not regulated at a regional level within the EU until 1 January 2018, when the EU MRV (monitoring, reporting and verification) system came into force. All ships above 5000 GT, regardless of their flag, must report their CO_2 emissions for travel to, from and between EU ports each year. Ships must also report transport work for these journeys. The EU views this as a step towards a global MRV system, along with further requirements for reducing CO_2 for shipping.

The EU's trans-European transport network (TEN-T) provides guidelines on how ports included in the network should approach various alternative fuels as part of the initiative towards more eco-friendly transport.

- Priority must be given to ports that are part of the TEN-T network as regards the establishment of shore power (before 31 December 2025), unless this would be inappropriate in terms of costs.
- Charging points must be compliant with standards and use smart metering systems where appropriate. The prices must be available in the public domain, comparable and non-discriminatory.
- The countries must use the national instrument framework to organise establishment of an appropriate number of filling points for LNG (including mobile installations) at maritime ports and inland ports so that ships running on LNG can circulate in the TEN-T core network before 31 December 2025.
- The countries must use the national instrument framework to organise establishment of an appropriate number of publicly accessible filling points for CNG (Compressed Natural Gas) so that vehicles running on CNG can circulate in urban areas and other densely populated areas, 31 December 2020.
- Inclusion of hydrogen filling points in the national instrument framework is voluntary. If this is selected, an appropriate number of points must be available so that vehicles running on hydrogen can circulate in the network before 31 December 2025.

7.1.2 On a national level

Norwegian authorities

The Norwegian authorities have devised ambitious objectives for their reduction of greenhouse gas emissions, with a contingent liability to reduce emissions by at least 40 per cent by 2030 compared with emissions levels in 1990.

Overall, EU sectors that are not subject to quotas must reduce their emissions by 30 per cent compared with 2005, and Norway can expect to be assigned a target in the region of 40 per cent for these sectors. Transport is the most significant source of emissions in the sector not subject to quotas. Therefore, major reductions have to be made in greenhouse gas emissions in the transport sector, including domestic shipping. The government has made it clear that eco-friendly shipping is a priority focus area. The Port of Oslo is one of the larger ports in Norway in terms of emissions, and reductions in emissions at the Port of Oslo will be key to compliance with the national objectives.

City of Oslo

The City of Oslo has considerably more ambitious targets than the targets defined at a national level. The City of Oslo's objective is to reduce its greenhouse gas emissions by 36 per cent by 2020 and 95 per cent by 2030, compared with emissions levels in 1990. These are highly proactive plans will require major upheavals both behaviour-wise and in respect of technology.

As things stand at present, greenhouse gas emissions from maritime activity are not included in Oslo's emissions report. This sector is expected to be incorporated in the next few years, however, so measures in this sector will be of major importance to attainment of the targets in Oslo.

The Oslo climate budget for 2018 (Klimaetaten, 2017) includes continuation of an existing and a new shore power system for foreign ferry routes with undistributed reduction of emissions. The Climate and Energy Strategy adopted by Oslo City Council in June 2016 has a separate focus area relating to the Port of Oslo: “shore power and other environmental measures shall reduce emissions from port activities in Oslo by at least 50 per cent by 2030” . Furthermore, in September 2016 Oslo City Council adopted a ten-point strategy for the use of electric ferries in the Oslofjord and arrangement of shore power; cf. City Council resolution 260/16. The first point in this strategy relates to preparation of an action plan, which in the long term will involve all ships calling at the Port of Oslo using zero-emissions technology when docked, and when entering and leaving the port. This decision forms the basis for the action plan represented by this report.

7.1.3 Relevant technologies

The following technologies reduce greenhouse gas emissions from operation of ships, with the proviso that power is produced using green methods and production of biofuels is sustainable:

- Shore power
- Electrification and plug-in hybridisation
- Hydrogen
- LBG (liquid biogas)
- Biodiesel

7.2 NO_X

NO_X (a generic term for the nitrogen oxides NO and NO_2) are exhaust emissions that lead to acid precipitation, eutrophication and increased concentration of ground-level ozone. These emissions can have harmful effects on ecosystems and vegetation. Moreover, they affect human health at high levels of contamination in towns and cities. Norway has international obligations to reduce NO_X emissions, defined by the Gothenburg Protocol and the EEA Agreement.

7.2.1 On an international level

IMO

Emissions of nitrogen oxides (NO_X emissions) are regulated on an international level by the UN’s International Maritime Organization (IMO) via MARPOL Annex VI, which defines requirements for emissions levels NO_X Emission Control Areas (ECA). Figure 7-1 below shows an overview of present and future requirements for NO_X emissions (Tier III) within and outside NO_X ECAs.

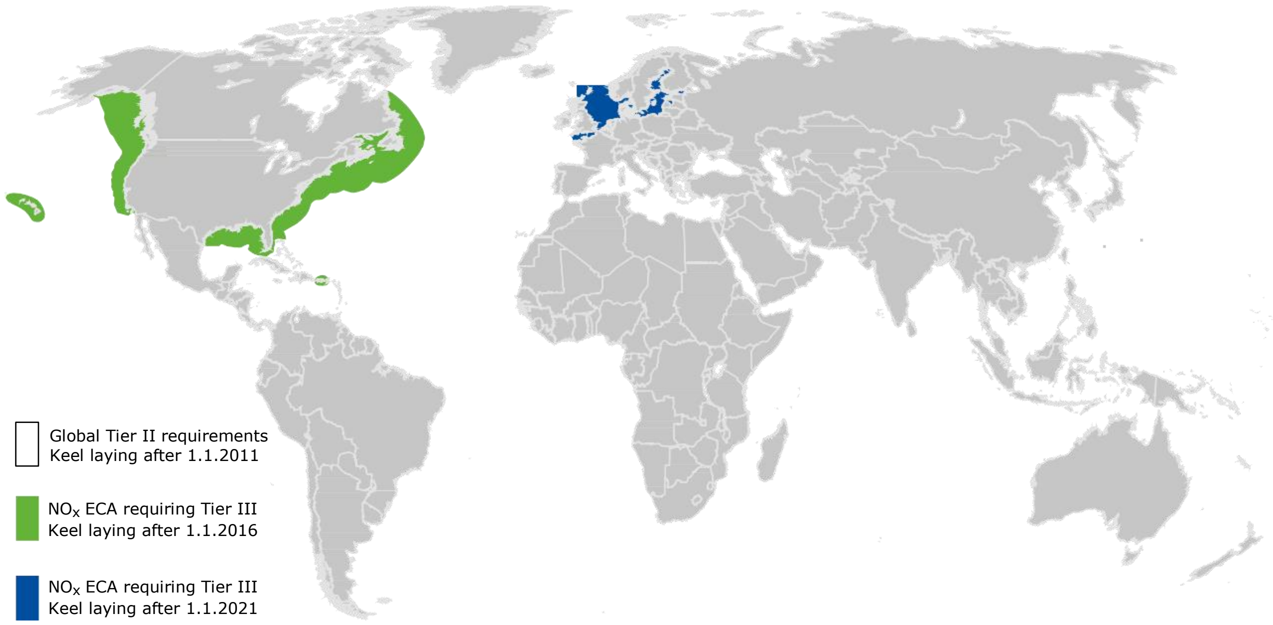


Figure 7-1: Present and future requirements relating to NO_X emissions (Tier III) (DNV GL, 2018).

Tier III requirements will involve an 80 per cent reduction in NO_X compared with current Tier II levels and will present the industry with a major challenge for all new ships that will operate entirely or partly in the US/Caribbean (from 2016) or the North Sea/Baltic Sea (from 2021).

7.2.2 On a national level

The NO_X foundation

In May 2017, the Ministry of Climate and Environment signed a new environmental agreement with 15 trade organisations concerning a reduction in emissions of nitrogen oxides (NO_X) that are harmful to health and the environment. In this agreement, the business community commits – via the NO_X Fund – to reduce annual NO_X emissions by 16,000 tonnes by 2025 (Figure 7-2). Individual enterprises are exempted from payment of charges by joining the environmental agreement. At the same time, they commit to reducing their emissions. Instead of paying an NO_X charge to the state, affiliated enterprises pay a membership fee (greatly reduced on the regular fee) to the business community's NO_X Fund. In turn, the Fund allocates funding for the implementation of measures at enterprises aimed at reducing emissions.

Historical and estimated future emissions of NO_X and emission caps in the NO_X Agreement for the period 2018-2025

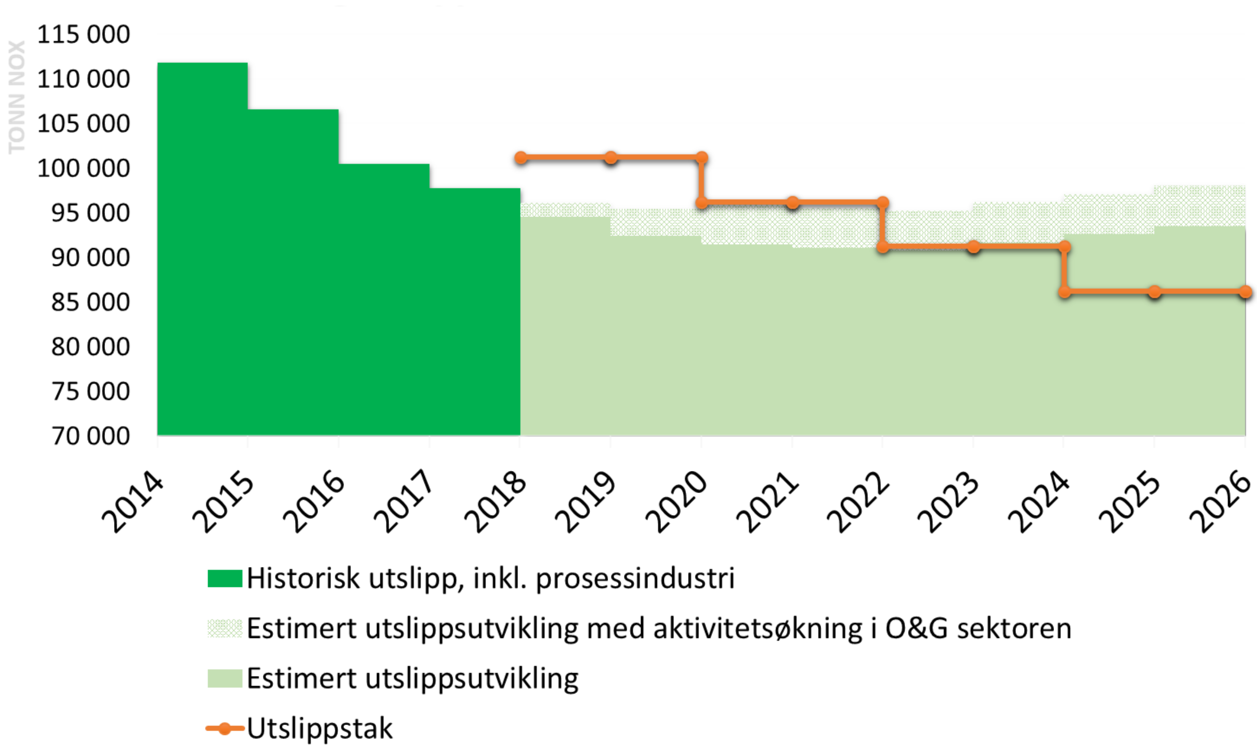


Figure 7-2: Historical and estimated future emissions of NO_X and emission caps in the NO_X Agreement for the period 2018-2025 (NOx-fondet, 2018).

7.2.3 Relevant technologies

The following technologies make ships Tier III-compatible and are currently available on the market, such as:

- Use of catalytic converters on exhaust gas (SCR) with supply of urea (NH_2)
- Recirculation of exhaust gas (EGR)
- Use of alternative fuels
    - LNG (liquefied natural gas), LPG (liquefied petroleum gas), LBG (liquefied biogas)
    - Electricity
    - Hydrogen

7.3 SO_X

Sulphur oxide emissions from ships are due to incineration of fuel containing sulphur. Sulphur dioxide (SO_2) is a colourless, non-flammable gas with a penetrating odour that irritates the eyes and respiratory tract. It reacts on the surface of a number of airborne particles, is soluble in water and can oxidise in airborne drops of water.

Marine fuels (oil and diesel products) normally have a high sulphur content compared with fuels used on land. In Europe, shipping is responsible for around 20 per cent of SO_X emissions. This percentage is expected to increase in years to come, as land-based sources are reducing their emissions of SO_X more extensively than is the case with shipping.

7.3.1 On an international level

IMO

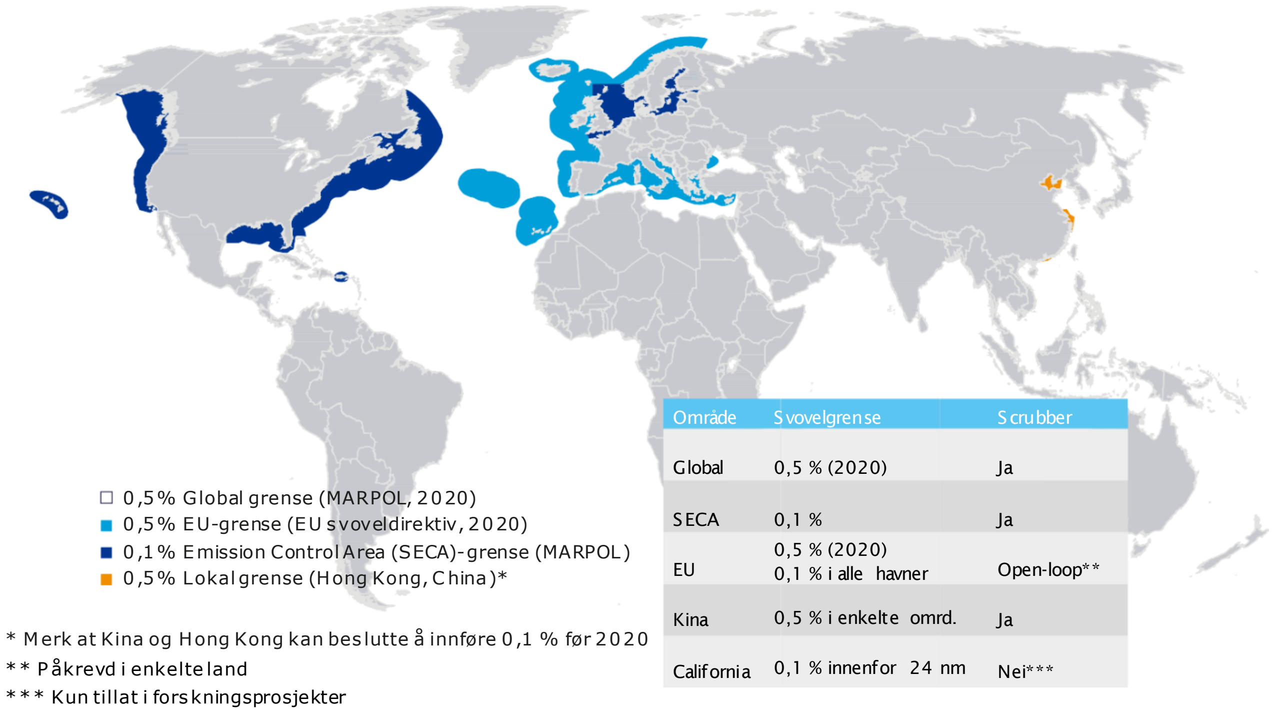
Emissions of sulphur oxides (SO_X emissions) are regulated on an international level by the IMO via MARPOL Annex VI, which defines requirements for emissions levels globally, as well as stricter emissions requirements in SO_X Emission Control Areas (SECAs). At the same time, SO_X emissions are regulated at a regional level in the EU via the EU's Sulphur Directive. Both the IMO and the EU regulate SO_X emissions by defining requirements relating to sulphur levels in marine fuels.

Figure 7-3 shows an overview of present and future emissions limits for SO_X for various geographical regions.

Sulphur Emission Control Areas (SECAs) are already subject to a 0.1 per cent level, the strictest emissions requirement defined in MARPOL Annex VI. Existing SECAs include the North Sea, the Baltic states, North America and the American part of the Caribbean. Norwegian waters south of 62 degrees north are included in the North Sea SECA. The majority of ships operating in Norwegian waters use Marine Gasoil (MGO) with a 0.1 per cent sulphur content, while a small number of them use heavy fuel oil (HFO) with a sulphur content of approx. 2 per cent. The average sulphur content for Norwegian maritime traffic as a whole stands at around 0.2 per cent.

EU

The EU's Sulphur Directive defines similar requirements to MARPOL Annex VI, but they are not entirely identical. This directive covers ships operating within the EU's economic zone. As things stand at present, a 0.1 per cent sulphur level is required in ports and for domestic services for all ships. Passenger ships operating on regular routes have an additional requirement of 1.5 per cent in all non-ECA EU Waters until 2020. As of 2020, a 0.5 per cent sulphur level will be required for all ships in the EU's economic zone, regardless of whether the IMO's 0.5 per cent requirement comes into force in 2020 or 2025.



Område	Svovelgrense	Scrubber
Global	0,5 % (2020)	Ja
SECA	0,1 %	Ja
EU	0,5 % (2020) 0,1 % i alle havner	Open-loop**
Kina	0,5 % i enkelte omrd.	Ja
California	0,1 % innenfor 24 nm	Nei***

Figure 7-3: Present and future requirements relating to SO_X emissions (DNV GL, 2017).

7.3.2 On a national level

Norwegian authorities

The sulphur content in marine fuel is regulated on a national level via the Product Regulations (regulations relating to restrictions on the use of chemicals and other products hazardous to health and the environment). These national requirements harmonise with the EU's requirements in respect of SECA by means of the following wordings:

- *The production, import and sale of marine gasoil containing more than 0.10 per cent by weight of sulphur is prohibited, if this is intended for incineration aboard marine vessels.*
- *Marine diesel oil means any marine fuel defined for DMB quality in Table I in ISO 8217, with the exception of the reference to the sulphur content.*
- *Marine gasoil means any marine fuel defined for DMX, DMA or DMZ quality in Table I in ISO 8217, with the exception of the reference to the sulphur content.*

In practice, this means that it is not possible to use heavy fuel oil or other fuel types containing more than 0.1 per cent sulphur, without exhaust cleaning systems installed.

City of Oslo

The City of Oslo has no regulations regulating the sulphur content in marine fuels beyond the national guidelines.

7.3.3 Relevant technologies

The following technologies make the ship compatible with the strictest sulphur requirements laid down for shipping (0.1 per cent), and they are available on the market today:

- Use of scrubbers (open-loop, closed-loop or a hybrid scrubber solution)
- Use of low-sulphur oil or diesel (marine gasoil or hybrid fuel)
- Use of alternative fuels
    - LNG (liquefied natural gas), LPG (liquefied petroleum gas), LBG (liquefied biogas)
    - Electricity
    - Hydrogen

8 TECHNOLOGIES

The following section provides a general overview of the most relevant environmental technology solutions that will be available to shipping over the next decade. The content in these sections is largely based on DNV GL reports: “Analyse av tiltak for reduksjon av klimagassutslipp fra innenriks skipstrafikk” [Analysis of measures for reducing greenhouse gas emissions from domestic shipping] prepared for the Norwegian Environment Agency (DNV GL, 2018), “Samfunnsøkonomisk vurdering av tilskudd til miljøtiltak i havner” [Socio-economic assessment of subsidies for environmental measures at ports] prepared for the Norwegian Coastal Administration (DNV GL, 2016), and “Reduksjon av klimagassutslipp fra norsk innenriks skipsfart” [Reduction of greenhouse gas emissions from Norwegian domestic shipping] prepared for the Ministry of Climate and Environment (DNV GL, 2016).

Table 8-1 sums up the reductions assumed for each energy carrier and emission component.

Table 8-1: Overview of fuel types and emissions reductions, viewed in relation to MGO

Fuel type	Emissions reduction [% reduction compared with MGO]			
	CO_2	NO_X	SO_X	PM_{10}
Shore power	100%	100%	100%	100%
Electrification*	100%	100%	100%	100%
Hydrogen	100%	100%	100%	100%
Biodiesel**	100%	0%	100%	0%
Biogas	100%	90%	100%	100%
LNG	12% / 20%***	90%	100%	100%

*) For plug-in hybridisation, the effect will be dependent on the degree of hybridisation
**) If biodiesel is admixed, the reduction in emissions is proportional to the admixture percentage
***) CO_2 emissions from LNG are affected by unburnt methane (CH_4) in the exhaust gas

8.1 Shore power

Shore power is electricity from land, replacing power production from the ship’s own machinery (which typically runs on diesel) when docked. The ship’s opportunity to receive shore power is equally as important as the port’s opportunity to deliver power. The vast majority of cargo ships and older ships have only limited capacity when it comes to receiving power from land. The connection has normally been dimensioned for ships in the workshop or laid up, and it largely meets just a very limited percentage of the ship’s energy requirements (lighting, heating, galleys, etc.). Moreover, they frequently do not have the option of supplementing their own power requirement with power from shore coordinated with their own auxiliary machinery. If ships’ electrical systems and ability to use shore power are to be dimensioned to meet the entire demand when docked, most ships in this category will have to be refitted or upgraded. The same is true on the port side of things, where it is necessary to invest in extensive equipment so as to be able to supply sufficient power to allow ships’ own generators to be shut down when docked.

On the land side, this could include the following main components:

- Implementation of a high-voltage network
- Transformers
- Control panels and junction boxes
- Frequency converters (depending on requirements)
- Cable reels (may also be available on board ships) and coupling devices

Aboard the ships, the equipment needed could typically include:

- Transformers
- Distribution systems
- Control panels and junction boxes
- Cable reels (may also be available on the quayside) and coupling devices
- Possibly frequency converters

Although different connection systems are currently operated, a lot of effort has gone into standardising coupling surfaces and interfaces. At present, standards have been developed for high and low-voltage systems as follows:

- IEC/IEEE 80005-1 High Voltage Shore Connection Systems - General requirements
- IEC/IEEE 80005-2 High voltage shore connection (HVSC) systems - Communication interface description
- IEC/IEEE 80005-3 Utility connections in port - Part 3: Low Voltage Shore Connection (LVSC) Systems - General requirements

Enova's funding programme for development of shore power at Norwegian ports assumes that the facilities receiving funding have been constructed in accordance with applicable standards. If facilities are adapted to suit a very specific activity/type of ship, there could be good reason to deviate from the standard for more optimal special solutions. This could typically be the case for ferries, which only call at dedicated quays that would not be used by other ships.

Ships with a limited power requirement that spend a significant amount of time in port, such as fishing vessels, offshore vessels and suchlike, are usually better equipped to receive power from land. These may have dedicated quay systems where shore power is set up and dimensioned in accordance with needs.

If ships are only to use shore power when remaining in port, two modes have to be assessed:

1. The ship is docked and loading/unloading or undertaking technical operations, often with varying and occasionally high power demand. The ship could use significant energy volumes here, occasionally more than when sailing, as port operations require cranes, pumps and other systems to be operating. A battery system on land or aboard the ship may help to handle the power peaks so that

it is possible to get by with less capacity on the land side, and this could result in significantly lower construction costs. This "peak-shaving" method is very widespread in the power grid in many countries. The battery-powered ferry "Ampere" uses batteries on land which are charged when the ferry is not docked so that it has access to enough power with just a short charging time from a grid with limited capacity.

2. The ship is docked, without loading/unloading and with occasionally high power peaks. In this case, the ship's "hotel consumption" has to be covered (lighting, heating, ventilation, galleys, etc.), as well as other systems that it may not be possible to shut down (depending on the type of ship – a great deal of equipment aboard offshore ships or military vessels, for example). However, this requirement is considerable for larger passenger ships.

The consumption requirements for the two modes may be very different to an extent.

8.2 Electrification and hybridisation

As far as ships are concerned, battery and hybrid operation with optimised power control may result in significant reductions in fuel consumption, maintenance and pollution, as well as making the ship more reactive, consistent and safe in critical situations. The battery may also act as a storage platform for energy and energy recovery, as well facilitating the use of renewable energy.

8.2.1 Full electrification

At present, full electric operation with batteries is appropriate only for shorter distances where there are options for frequent charging.

Electricity does not cause direct emissions. Although emissions can be linked with the production of electricity, the City of Oslo ascribes zero CO_2 emissions to electricity. Electric operation will also result in lower energy consumption due to higher efficiency compared with conventional diesel engines.

Using electricity as the only energy carrier for ships requires robust battery solutions and development of infrastructure for onshore charging. Current battery and power transmission solutions already offer good capacity, and further improvements are expected in years to come. The charging process is power-intensive, and the low-voltage supply network at the quay normally has to be developed in order to supply sufficient power for charging ships. It is also possible to use stationary, land-based battery packs that are used as a buffer for charging batteries aboard ships. This reduces the need to upgrade the power grid.

8.2.2 Plug-in hybridisation/partial electrification

Plug-in hybrid ships are ships that run partly on batteries charged on land, in combination with an internal combustion engine. Both fossil fuels and biofuels can be used in the internal combustion engine, and the batteries facilitate more optimal use of the internal combustion engine. This reduces emissions of greenhouse gases, NO_X

and other emissions. The effect on emissions of greenhouse gases and substances harmful to the environment will be dependent on how much the ship runs on electricity, whether the ship uses fossil fuel or biofuel, and whether the engines run on gas or diesel.

Little has been done to date in order to identify the potential for hybridisation of ships travelling longer distances, e.g. operating internationally. Hybrid solutions are generally suitable in applications where there are major fluctuations in power takeoff, where the battery bank can handle the power peaks while the engines constantly operate consistently within the optimum range.

Assessment of the various shipping segments' potential for electrification

All shipping segments could be of relevance for full or partial electrification, but the level of electrification/efficiency effect will vary depending on the form of operation and the energy requirement. Operations where there are major power takeoff variations, or ships with periods of low engine utilisation, stand to gain the most from using batteries. Offshore vessels, tugboats and ferries are typical examples of ships that encounter major variations in power takeoff. Ships that are often left waiting in order to load and unload, fishing boats that are fishing and service vessels in wait mode are examples of ships with periodically low levels of engine use. The proportion of the energy requirement that can be met by means of shore power is dependent on the energy requirement and opportunities for charging. Ferries with relatively short crossings that have frequent opportunities for charging, for example, are very well suited to full electrification.

The various shipping segments will have different criteria for full and partial electrification. The average distance sailed by ships will vary and is important to battery capacity and level of hybridisation.

Table 8-2 Shows how much of the energy requirement per trip[5] can be covered on average by a battery for a given ship size[6], for all ship types and size categories where data is available. The battery size assumed is dependent on the size category.

Table 8-2: Estimated proportion of fuel consumption per trip that could be covered by a battery, for an average ship in each shipping segment operating in Norwegian waters (DNV GL, 2018).

Ship type	Size category						
	1	2	3	4	5	6	7
1. Oil tankers	3%	1%	2%	1%	1%	1%	0%
2. Chemical/product tankers	3%	4%	2%	2%	2%		
3. Gas tankers	3%	2%	2%	2%	1%	0%	0%

[5] Based on AIS data, the average energy consumption per trip and shipping segment has been estimated for the 6,000 or so ships included in the database for domestic shipping in Norway

[6] Category 1: < 1,000 GT; Category 2: 1,000 – 5,000 GT; Category 3: 5,000 – 10,000 GT; Category 4: 10,000 – 25,000 GT; Category 5: 25,000 – 50,000 GT; Category 6: 50,000 – 100,000 GT; Category 7: > 100,000 GT.

4. Bulk carriers	4%	2%	2%	8%	4%	2%	2%
5. General cargo ships	17%	5%	2%	4%	4%		
6. Container ships	17%	5%	5%	8%			
7. RoRo cargo	8%	5%	6%	4%	5%	2%	
8. Reefer/freezer ships	1%	3%	6%				
9. Passenger	133%	36%	19%	5%	1%	1%	1%
10. Offshore supply ships	11%	3%	2%				
11. Other offshore services	16%	5%	1%	1%	1%		
12. Other activities	30%	4%	1%	1%	0%		
13. Fishing vessels	11%	1%	0%				

Investment costs for batteries

Full electrification require significant investments both on board ship and on the land side. For example, purchasing a new battery-operated ferry at present typically costs NOK 10-30 million more. However, if we look at investments in the ferry in isolation, the investment made to pay for itself over time with low electricity prices by 2030.

Electrification of ships requires battery packs with power electronics, as well as other equipment and enhancements/reinforcements in accordance with the classification rules for ships carrying batteries. There is a major difference in cell types depending on the output properties, and this is reflected in the average price. Marinisation of batteries, power electronics and installation costs are additional costs that also have to be taken into account.

In its report for the Norwegian Environment Agency, DNV GL assumed a cell price of just over NOK 6,000/kWh, and a power electronics cost of NOK 1,300/kW. A 50 per cent drop in the price of cells between 2018 and 2030 it is also assumed, along with a reduction in the cost of marinisation as takeup increases and the technology is consolidated in the industry. The installation cost remains constant regardless of the size of the battery packs.

It is uncertain whether there will be an increase in battery energy density towards 2030. Historically, There has been both a major reduction in the price of battery cells and an increase in the energy density of Li-ion batteries, particularly over the last few years. For instance, some environments are reporting a sixfold increase in energy density between 2008 and 2015. It is thought that much of the potential in terms of energy density has been extracted, but that it is reasonable to assume doubling of the capacity up to 2030 compared with current conditions. This means that the level of hybridisation as shown in Table 8-2 will increase linearly to twice its level in 2030.

8.3 Hydrogen

Hydrogen (H_2) is a pure energy carrier that will permit genuine zero-emissions solutions on board ships. Electrical energy can be produced in fuel cells aboard ships that run on hydrogen, usually in a hybrid solution with batteries. Hydrogen is stored in tanks aboard the ship and the fuel cells produce power for electric motors. As storage of hydrogen gives higher energy density (both volume and weight) than in batteries, hydrogen operation may be of relevance for longer, more energy-intensive routes than could be travelled purely using batteries. Tanks and fuel cells are very heavy, so using hydrogen as a fuel aboard ships may result in a weight increase compared with a conventional system, and so more energy will be required to push the hull through the water.

As an energy carrier, hydrogen is of particular interest for storage of renewable energy. Propulsion based on hydrogen used in fuel cells will eliminate CO_2 emissions, NO_X emissions and other emissions (zero emissions for the ship). As for other energy carriers, from a life cycle perspective there will be some emissions linked with the production and any distribution of hydrogen, but this will be dependent on the value chain and on whether production is based on renewable energy or other sources (fossil fuels, nuclear power). Norway produces hydrogen from electrolysis and reformation of natural gas, and as a byproduct of industrial processes. For instance, distributed production of hydrogen based on electrolysis from “trapped power” may be of relevance along the coast. This may form a basis for a hydrogen bunkering infrastructure. Reformation of natural gas requires CO_2 storage if it is to be viewed as a low-emissions alternative.

DNV GL recently performed a review of relevant fuel cell technologies for maritime use for EMSA. PEM (Proton Exchange Membrane) fuel cells, as shown in Figure 8-1, are the type that has been most widely used for transport purposes to date, and this technology is used in fuel cell cars and buses. PEM technology is considered to be relatively mature and accessible. The technology offers good tolerance for load variations and is compact and relatively lightweight, but it requires high-purity hydrogen and a relatively complex water treatment system. A high-temperature version, HT-PEM, is also available. This does not need a complex water treatment system, and utilisation of heat can at the same time provide opportunities for enhanced efficiency.

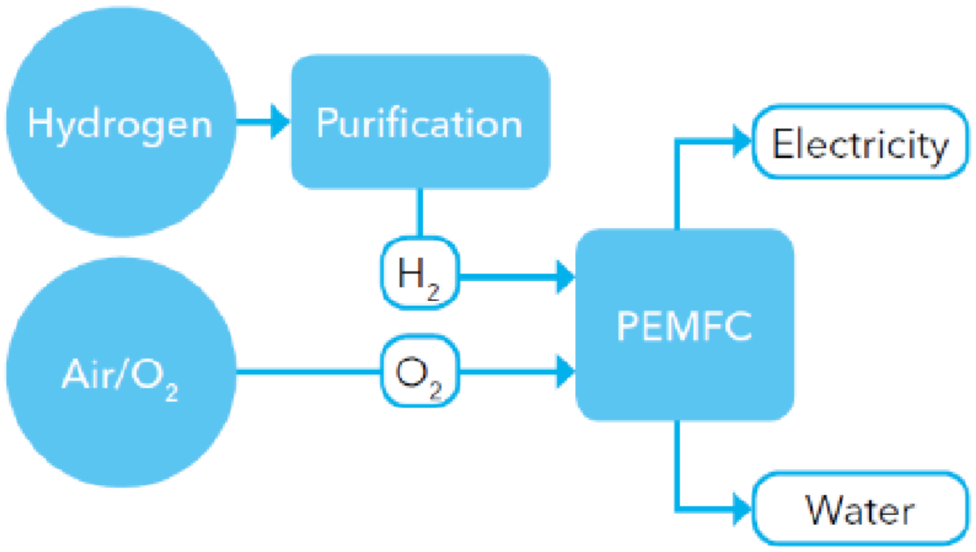


Figure 8-1: Basic diagram showing PEM fuel cells(DNV GL, 2017).

Use of hydrogen is restricted by factors such as space available for storage tanks aboard the ship and access to bunkering facilities. Both pressurised hydrogen and liquid hydrogen require larger tanks than conventional fuels due to the lower energy density of hydrogen (by volume). It is anticipated that liquid hydrogen will be most appropriate for storage of the large quantities of hydrogen needed for use for long-distance shipping. Hydrogen has to be cooled to -253 °C to transform it to the liquid state, and production, storage, transportation and bunkering are all energy-intensive processes. Transforming the hydrogen into liquid results in an energy loss that is in addition to the energy used for producing hydrogen gas. There are also fuel cell projects in which the energy is taken from other media such as LNG, methanol and ammonia.

Use of hydrogen as a fuel for ships is still at the development stage, and this technology is not mature for operation as yet. Deficiencies in current regulations, resulting in a demanding approvals process, is considered to be the most key barrier to hydrogen operation. Safety challenges related to the storage and handling of hydrogen, as well as the low availability of the fuel, high investment costs and uncertainty with regard to operational costs, also present significant barriers to the use of hydrogen for shipping. Hydrogen is deemed to be most suited to new structures due to the need for extensive investments and custom design with regard to the positioning of tank and fuel cell systems. A development process involving qualification and upscaling of solutions for bunkering, marinisation of fuel cells and storage of hydrogen aboard ships is needed so that these can be adapted to suit relevant maritime requirements and conditions.

Investment costs for hydrogen systems

When using hydrogen as a fuel, fuel cells, pressure tanks and associated systems are used to store and process hydrogen aboard the ship, along with batteries for load balancing where the battery supplies power in order to handle the power peaks so that the fuel cells can be dimensioned for lower maximum output. In simplified terms, the investment cost is calculated as the sum of the costs of these components, plus installation costs.

There is a great deal of uncertainty linked with estimated investment costs for ships running on hydrogen, as no implemented projects exist where the entire cost scenario has been outlined. There is also uncertainty linked with the availability and development of hydrogen bunkering infrastructure. The relationship between available bunkering infrastructure and time and potential storage capacity aboard ships will also impact on costs. The Norwegian Public Roads Administration suggests an additional cost of NOK 100 million for a hydrogen ferry in its ongoing development contract, but the estimated relationship between investment costs and operating costs is not specified here.

8.4 Biodiesel

Biodiesel is a liquid biofuel. Biofuel is a renewable energy carrier that is extracted from biogenic material and made from a broad range of organic materials such as edible crops (e.g. rape and corn), non-edible crops (marginal crops that do not compete with food production), sludge, timber and compost, food waste/fat and algae (experimental production).

Biofuels are frequently referred to as first, second and third-generation fuels, depending on the raw material used. There are other categorisations here as well, such as conventional and advanced biofuels, that are used in the national regulations in order to define partial requirements for advanced biofuels. Biofuels can be used as "drop-in fuels" (i.e. to replace marine fuels where there is compatibility with existing infrastructure and engine systems) or by modifying infrastructures and engine systems. There are mainly two types of liquid biofuel that are currently being considered for ships in Norway:

1. **Conventional biodiesel** is a fuel resembling diesel that is produced from vegetable oils or animal fat. The most common form is FAME (Fatty Acid Methyl Ester), ref. EU standard EN 12214, that is usually characterised as first-generation biodiesel. It shares many of its properties with fossil diesel. Fossil diesel with low blending (approx. 20 per cent) of biodiesel can be used with minor or no adaptations of most current diesel engines. High blending or use of pure biodiesel normally requires a number of adjustments and adaptations of the diesel engine.
2. **Synthetic renewable diesel**, can be made from waste products from agriculture, forestry and food. Synthetic biodiesel known as HVO (Hydrogenated Vegetable Oil) is relatively new on the market. This product is in accordance with the CEN TS 15940 specification for paraffin/diesel oil. It is believed that it will be possible to use this product in marine diesel engines with minor or no technical adaptations of machinery and fuel systems.

Greenhouse gas emissions will be reduced considerably as CO_2 from biodiesel is considered to be part of the normal CO_2 cycle. Zero CO_2 emissions are ascribed to the use of biodiesel in the national emissions report (and in this action plan). It is assumed that the biofuel must meet the sustainability criteria.

When using biodiesel, NO_X emissions equivalent to fossil diesel have traditionally been used for calculation purposes. Some people argue that increased NO_X emissions must be expected for combustion of some biodiesel products, but lower NO_X emissions than fossil diesel may be a consequence of some products as well. Analyses are necessary in order to verify the NO_X emissions from more recent products,

It is assumed that an admixture of up to 20 per cent this possible without modifying engines, with associated additional investments.

8.5 Biogas

In terms of its chemical composition, biogas is the same as natural gas (primarily methane) and therefore has the same properties as natural gas. Biogas can be cooled and condensed into liquid (LBG) and used on LNG ships in the same way as LNG. No additional investment costs are associated with the use of LNG with admixed LBG.

As LNG and LBG (liquid biogas) can be used interchangeably on ships and use the same infrastructure, LNG may pave the way for LBG and so trigger further greenhouse gas reductions. LBG can also be mixed with LNG, and so LNG ships can be used to build a market for LBG.

Biogas can be produced by decomposition of a broad range of biogenic material such as food waste, sludge, timber, compost and other waste and byproducts. As for biodiesel, zero CO_2 emissions are ascribed to the use of biogas in the national emissions report. The reduction in NO_X emissions will be equivalent to the use of LNG, i.e. a reduction of up to 90 per cent (depending on engine technology). All forms of biofuel means that emissions of SO_X are all but eliminated.

8.6 LNG

Liquefied natural gas (LNG) is a natural gas that is cooled and condensed to liquid. LNG is mainly produced in order to facilitate the transportation of gas where investment in gas pipes is not appropriate, as well as for storage purposes.

LNG is the most common alternative fuel for ships at present. Overall greenhouse gas emissions for LNG are affected by the fact that there may be emissions of unburnt methane (CH_4), which is a powerful greenhouse gas. Depending on the LNG solution (with current technology), greenhouse gas emissions from use of LNG may be anything from slightly higher to around 25 per cent lower than conventional use of diesel. With anticipated technological development, we are assuming that there will be a 12 per cent reduction in emission of CO_2 equivalents compared with MGO as a reasonable average value for the period until 2030. However, emissions of unburnt methane will be reduced in combination with batteries as this will allow engined to operate more optimally, and this will assume a 20 per cent reduction in emissions of CO_2 equivalents if LNG is used in combination with battery hybridisation (with or without plug-in). Use of LNG results in considerable reduction of NO_X emissions; up to 95 per cent depending on the engine type. However, for some LNG solutions (high-pressure engines) additional technology (EGR) is required in order to bring about a significant reduction in NO_X.

Bunkering infrastructure is in place in Norway to an extent, and it is also being constructed elsewhere in the world. However, it is far from an adequate global infrastructure in line with the infrastructure that is in place for conventional marine fuels. The price of LNG and the additional investments in ships will therefore be the deciding factors in such initiatives. It is also possible to establish onshore/quayside marine bunkering terminals with tank systems supplied by trucks or small LNG tankers from nearby LNG export terminals. Ship-to-ship bunkering from such LNG ships is also of relevance.

Use of LNG as a fuel for ships is expected to increase all over the world, particularly in short sea shipping. Emissions regulations for ships (MARPOL Annex VI, particularly within ECAs, as well as the EU and USA, but also global sulphur requirements from 2020), low gas prices compared with the price of oil and diesel, and positive profiling linked with sustainable and eco-friendly operation, are key drivers for this development. Ships that are able to document Norwegian taxable speed and reduced NO_X emissions from running on LNG can also receive funding of up to 80 per cent of their additional costs from the NO_X Fund. Establishment of LNG infrastructure may also attract investment funding.

As at April 2018, 122 ships running on LNG are operating throughout the world (see Figure 8-2 below). In 2000, the car ferry "Glutra" was the first commercial ship to run solely on LNG. There are also 132 confirmed orders for ships that run on LNG. Most of these are of Norwegian origin, but there has been a massive increase in foreign numbers over the past few years. Furthermore, 111 ships have already been prepared so that they can run on LNG and are "LNG-ready". Although this is a relatively small number of ships compared with the world fleet, LNG can nevertheless be considered a mature technology; but bunkering options still present a challenge in many locations.

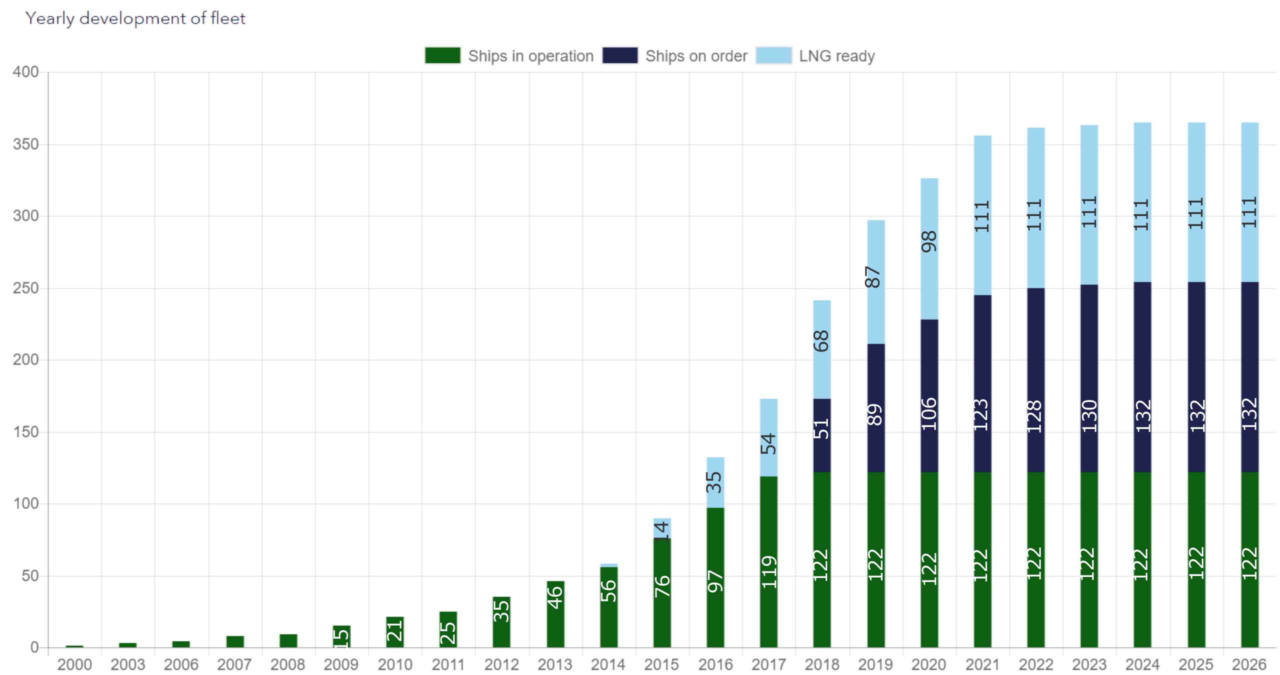


Figure 8-2: LNG ships in operation and on order as at April 2018 **(DNV GL, 2018)**

Investment costs

Installing an LNG engine and associated fuel systems currently represents considerable additional investment compared with a traditional diesel solution. This additional investment in a ship is typically in the order of 20 per cent. Refitting costs for existing ships may be considerably more expensive than the additional cost of an LNG solution when constructing a new ship. In operation, running on LNG could be cheaper than oil-based fuels, depending on the prices of oil and gas.

9 MEASURES OFFERING POTENTIAL FOR GREENHOUSE GAS REDUCTIONS

The action plan is intended to provide an assessment of the potential for reduction of greenhouse gases, and the technical and economic aspects of each measure are highlighted at the same time. The action plan includes 17 measures divided into three main groups:

- **Measures that should be continued (3 measures):** Measures that currently exist and should be continued with equivalent or greater focus over the next few years in order to maintain the effect of the measure in question.
    1. Environmental differentiation of port charges in order to reward low-emissions ships (ESI)
    2. City of Oslo as a member of Grønt Kystfartsprogram [the Green Coastal Shipping Programme]
    3. Update and revise the action plan for the Port of Oslo as a zero-emissions port
- **Measures that should be reinforced (2 measures):** Measures that currently exist, wholly or in part, but that require greater focus and prioritisation over the next few years in order to trigger the collective potential of the measure.
    1. Shore power for foreign ferry routes
    2. Cooperate with other ports for cruise ships with a view to defining collective requirements relating to shore power and other environmental measures, with Oslo taking on a proactive role
- **Recommendations for new measures (12 measures):** Measures that do not exist at present but that need to be implemented in order to achieve the ambition of turning the Port of Oslo into a zero-emissions port in the long term.
    1. Encourage the transfer of freight from road to rail
    2. Emissions-free operation for the Nesoddbåtene service
    3. Emissions-free operation for Ruter express services
    4. Emissions-free operation for the Øybåtene service
    5. Requirement for zero-emissions solutions for foreign ferry routes if new routes are established or put out to tender, where permitted by the situation
    6. Environmental differentiation of port charges in order to reward docked low-emissions ships (EPI)
    7. Establish communication with national authorities for amendment of the Act relating to ports and fairways so that requirements can be defined for shore power
    8. Infrastructure for piloting autonomous ships

9. Emissions-free activity when handling goods and freight at the Port of Oslo, and other activities on the port site
10. Emissions-free road transport routes to and from the Port of Oslo
11. Bonus for ships operating at reduced speed and investigation of the effect of speed limits for commercial shipping using fossil propulsion systems
12. Adaptation in order to meet steam requirements at the port when using renewable alternatives

As well as being described qualitatively, these measures have also been assessed on the basis of seven different criteria amalgamated in a facts box for the outlines for each measure.

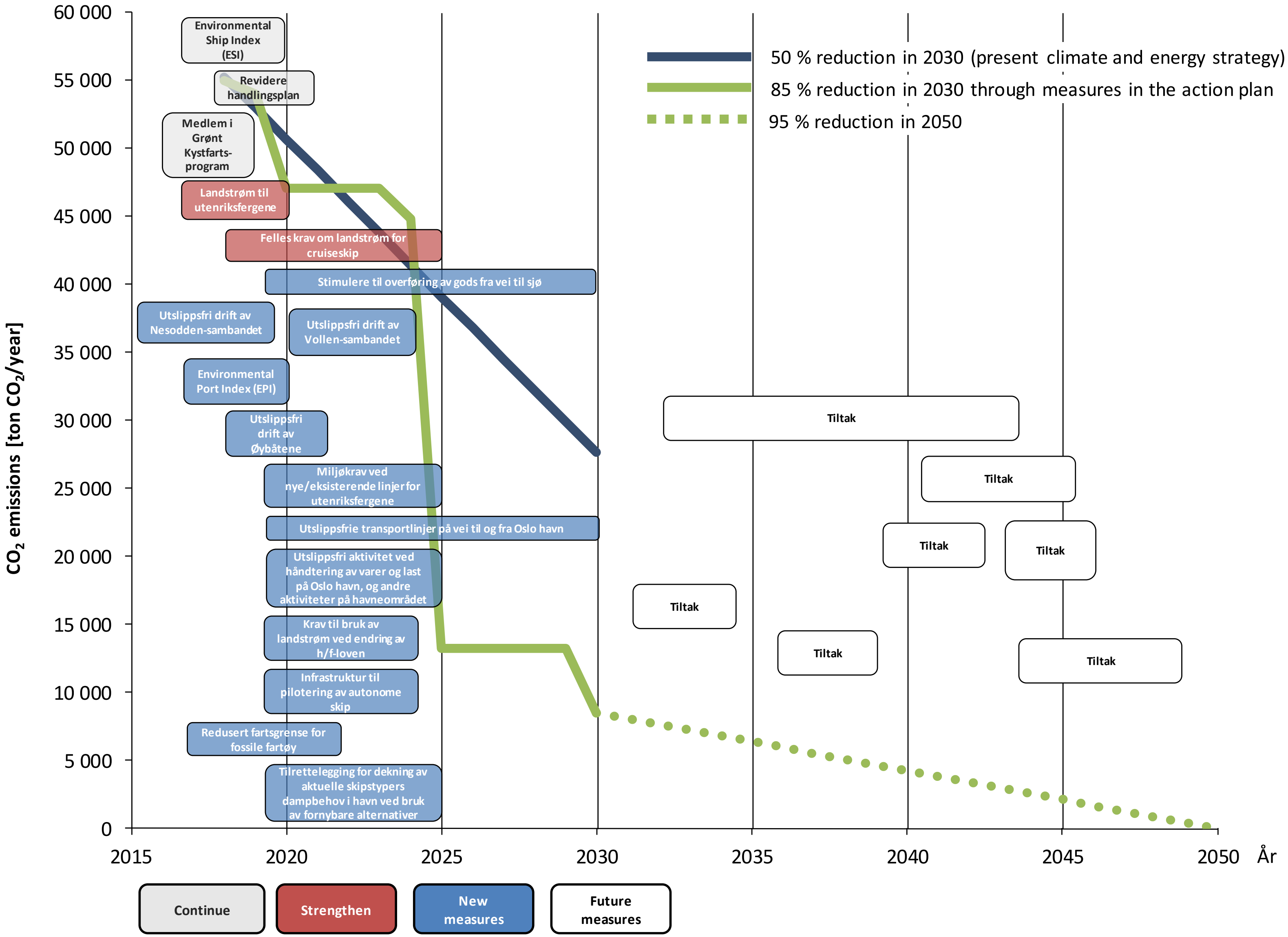
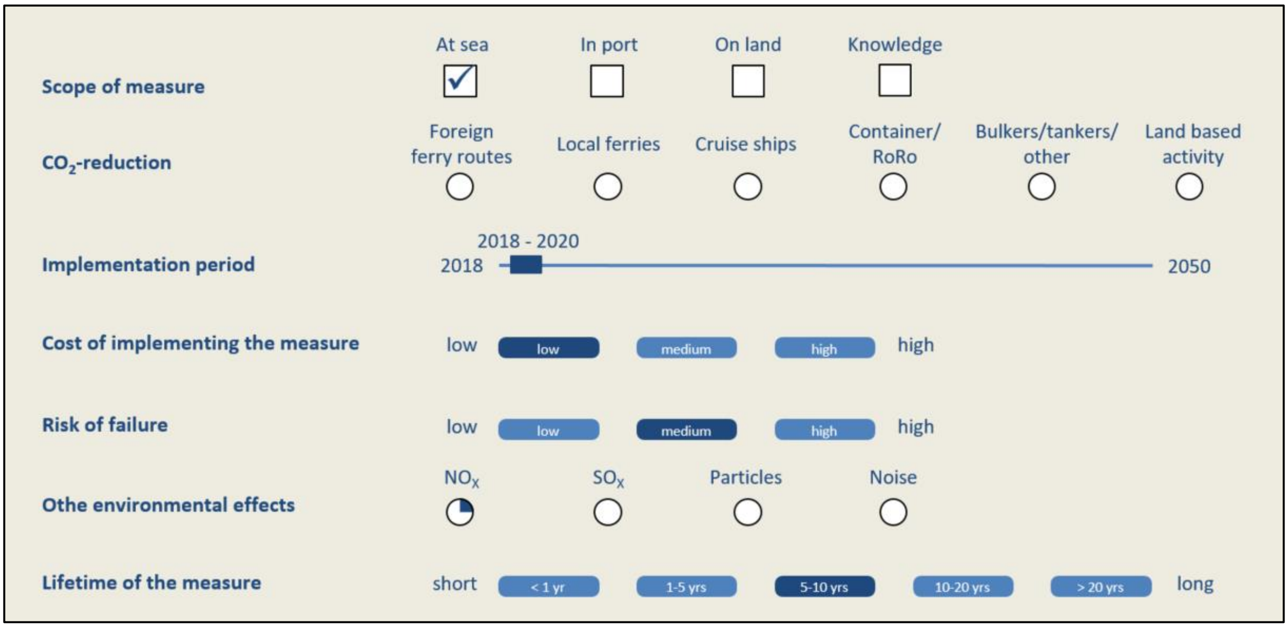


Figure 9-1: Forecasts for the present climate and environmental strategy for Oslo and the results of recommended measures for the action plan, distributed over groups of measures and the time of implementation.

9.1 Measures that should be continued

9.1.1 Environmental differentiation of port charges in order to reward low-emissions ships via the Environmental Ship Index (ESI)



Description: This measure includes introduction of the Environmental Ship Index (ESI). Where the Environmental Port Index (EPI) indicates the ship's emissions level when it is docked, the ESI represents the overall emissions level for all operations, focusing in particular on operation during sailing. Discounts on port charges are given only if measures aboard ships reduce CO_2, NO_X and SO_X beyond requirements laid down in national and international laws and regulations. The size of these discounts is determined by the ports themselves, working on the basis of the total number of points amassed by the ships based on a formula for calculating ESI points:

$$\textbf{ESI points} = \textbf{ESI } NO_X + \textbf{ESI } SO_X + \textbf{ESI } CO_2 + \textbf{Shore power}$$

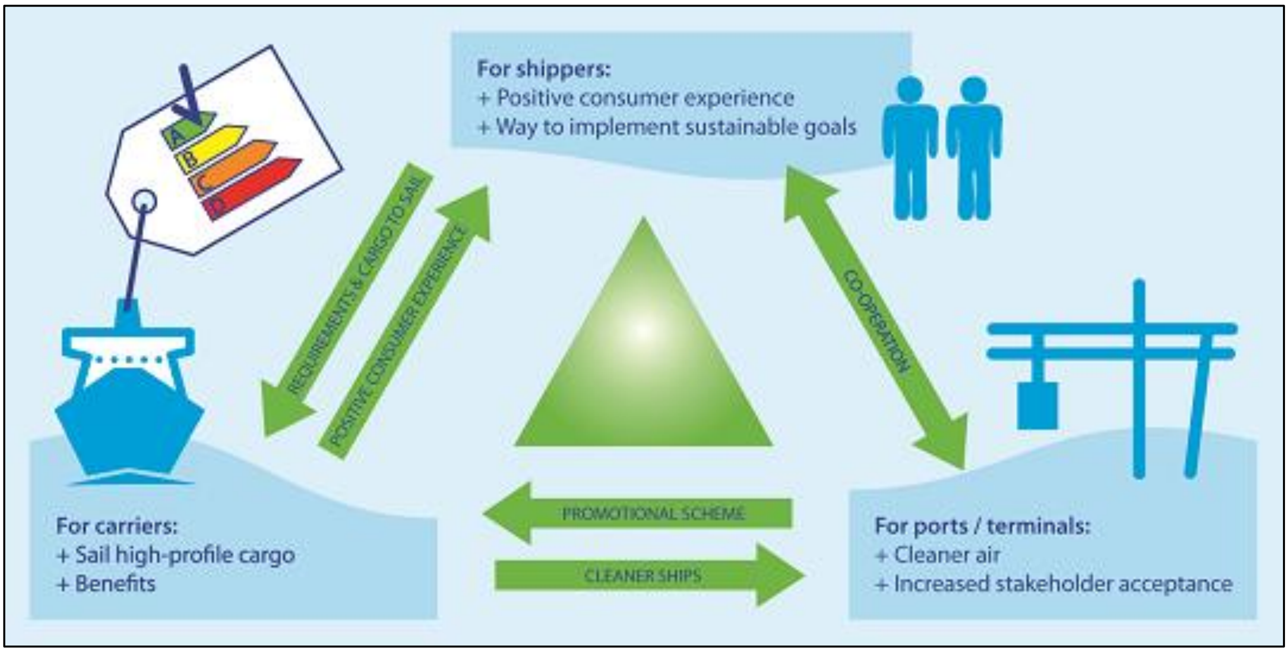


Figure 9-2: "Environmental Ship Index" roles and stakeholders

Scope: The ESI is used internationally by ships of all types. The Port of Oslo was one of the world's first ports to start using it, but this scheme has not been used to any great extent by ships calling at the port and a decline has been evident over the past few years. The Port of Oslo has adapted the scheme so that the threshold for discounts is low, but large discounts can only be achieved if ships reduce their emissions considerably.

Unlike EPI, this scheme does not restrict itself to cruise operations specifically, but aims to include all segments. A total of 371 unique ships called at the Port of Oslo in 2017, most of these ships having made no major efforts to reduce emissions linked with the climate or local environment, beyond those required by law.

For the scheme to succeed, it is crucial to be able to automate reporting and documentation as far as possible, and for reporting and documentation to be implemented without the involvement of the port. The importance of ensuring that the Norwegian Coastal Administration also uses the scheme, as a way of making the scheme more interesting, is also pointed out.

Phase-in plan: This measure should undergo further development in close dialogue with the other ports in Norway. Opportunities to cooperate with international port authorities should also be considered, in order to create a collective demand for environmental solutions based on the scheme. The scheme should be revised in 2018, intensified in 2019 and take full effect in 2020.

Climate effects and other environmental effects: The reduction in CO_2 when introducing environmental measures based on the ESI is uncertain. The scheme must be arranged so that it will be sufficiently beneficial in financial terms – due to reduced port charges – to invest in the environmental technology. Provided that the scheme is arranged appropriately, it is estimated that the sum of climate measures may reduce around 5 per cent of greenhouse gas emissions linked with maritime operations at the port. This is equivalent to around 800 tonnes of CO_2 per year. As well as reducing emissions at the port, this measure will also be set up to trigger measures that could reduce local emissions. For NO_X, it is likely that the reduction could be greater in percentage terms as lots of ships without NO_X cleaning technology call at the port at present. The measure will also remove SO_X, particulates and dust in an area occupied by a lot of people and characterised by tourism.

Duration of the measure: The duration of the measures will be dependent on the extent to which the measures are used by ships, and it is assumed that this will be dependent on the extent to which the scheme is upheld. If the scheme is formulated correctly, the effect of the measure is expected to be permanent, with progressively greater impact on the environment.

Costs: The costs associated with the measure are restricted to the reduction in port charges that the Oslo Port Authority is willing to agree to. Discounts given by the ports also mean lower traffic revenues for the port. This means that as discounts are given to ships with good environmental performance, the price has to be increased for other ships with weaker environmental performance.

There will be an additional cost for implementing the solution and monitoring the updated environmental status of each ship calling at the port if every port has to assess documentation and keep its own logs of ships calling there.

It may also be appropriate to enter into communications with the state in order to look at reducing other port charges administered by the Norwegian Coastal Administration, if it turns out that stronger incentives are needed in order to trigger measures.

Other measures/arrangements/instruments and other conditions: A coordinated initiative with other ports is key to successful implementation of the measure, making conditions for calling at Norwegian ports as consistent as possible. It will also be crucial to ensure that the EPI scheme (section 9.3.6) does not conflict with the ESI and result in unfortunate consequences for phase-in. Furthermore, the predictability of the scheme should be demonstrated to the industry so that investments made aboard ships provide a competitive advantage in the future as well.

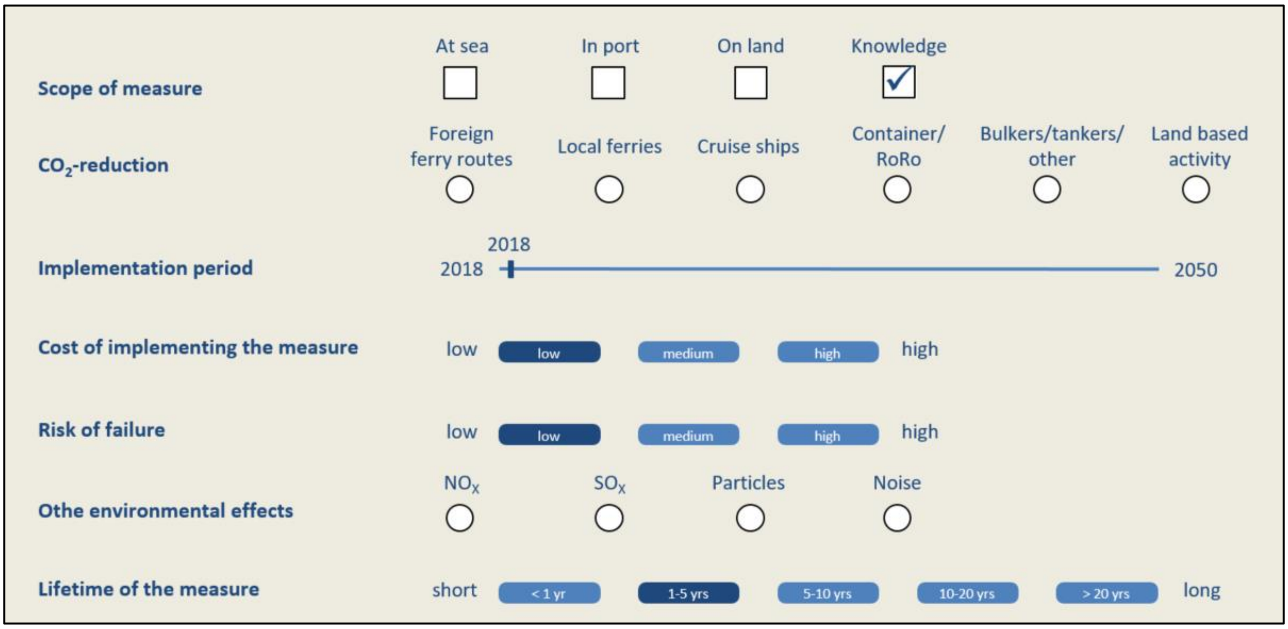
Responsible: The Port of Oslo is responsible for further work on the scheme, in close cooperation with the Department of Business Development and Public Ownership and relevant national authorities and partner ports.

Barriers to implementation:

- Limited funding in the scheme to trigger environmental measures

- Efforts of the various ports not very coordinated
- Emissions requirements for ships are gradually becoming stricter, which makes it more difficult to make major reductions that form a basis for discounts
- Lack of willingness among shipping companies to invest in measures that go beyond statutory requirements
- The scheme requires a smarter, global and digital solution that is administered easily

9.1.2 City of Oslo as a member of Grønt Kystfartsprogram [the Green Coastal Shipping Programme]



Description: This measure includes the continuation of the City of Oslo's partnership with Grønt Kystfartsprogram by means of the collective involvement of the Climate Agency and the Port of Oslo. Grønt Kystfartsprogram is a partnership programme between the private sector and the public sector. This programme should be an effective instrument for implementation of the government's maritime and port strategy. The objective of this programme is for Norway to establish the world's most efficient, eco-friendly coastal traffic that runs entirely or partly on batteries, LNG or other eco-friendly fuels.

Pilot projects have been established by the partnership, all of which are looking at how they can help to make Norwegian domestic shipping greener and more eco-friendly:

- **Battery hybrid single-point buoy mooring loading system:** This project is examining how batteries can improve single-point buoy mooring loading system operations, reduce energy requirements and increase energy storage potential.
- **Hybrid aquaculture vessel:** With their pilot project, ABB and Kystrederienes forening [the Association of Coastal Shipping Companies] wanted to examine which hybrid propulsion system would work best on an aquaculture vessel.
- **Green port:** With its project, the port of Risavika (near Stavanger) wishes to become a green port, with lower energy consumption and extensive use of electricity.
- **Biodiesel ferry:** Grønt Kystfartsprogram wishes to help highlight the use of biofuels in the maritime sector, and help to shine a spotlight on barriers linked with the use of sustainable fuel.

- **High-speed passenger ship running on hydrogen:** Following the initiative implemented by the municipality of Flora, a partnership of local companies going by the name of GKP7H2 has launched a pilot project in the second phase of Grønt Kystfartsprogram. This project is looking at a high-speed passenger ship that runs on hydrogen.
- **Autonomous coastal feeder:** The aim of this pilot project is to develop a sea-based logistics solution, taking freight currently carried by road and transferring it to the sea.
- **Transportation of fish – salmon from road to sea:** The aim is to establish a sea-based transport system for fresh fish from central Norway to Europe. The pilot project will be developing a commercial and technical concept that can be realised, before then finding funding and testing the concept with existing tonnage.
- **Reduction in emissions from fishing boats:** Fiskebåt – havfiskeflåtens organisasjon [Fishing Boat – the Sea Trawler Organisation] is aiming to reduce emissions of greenhouse gases from trawlers by at least 40 per cent between 2005 and 2030. In this pilot, Fiskebåt, will take the measures further and look specifically at opportunities for – and the effects of – transitions to low and zero-emissions fuels aboard fishing vessels.

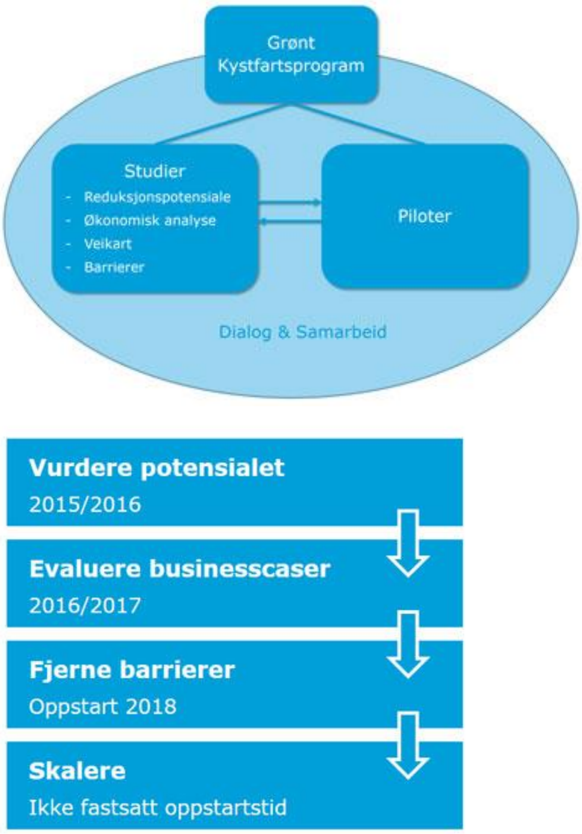


Figure 9-3: Grønt Kystfartsprogram organisation of activities/phases

Scope: The Grønt Kystfartsprogram partnership is focusing on climate and environmental measures in all segments, in particular segments where there are no instruments at present. The City of Oslo should put forward proposals for pilots and concerning implementation of studies focused on segments that make major contributions to environmental emissions and greenhouse gas emissions at the Port of Oslo.

Phase-in plan: The Port of Oslo and the Climate Agency are already involved in the programme, and they should use the partnership to an even greater extent to implement initiatives relevant for Oslo for the period 2018-2025.

Climate effects and other environmental effects: Participation in the partnership will not result in any direct reductions, but implementation of pilots, studies and surveys will help to trigger climate and environmental measures in the long term. Furthermore, experiences from the programme will help to build up important environmental skills in the maritime sector within the City of Oslo, and it will be possible to use these skills on a local level.

Duration of the measure: Implementation of a third phase is planned for 2018, where the aim is to eliminate barriers to green solutions as well as developing detailed implementation plans. The emphasis will be on cargo ships, high-speed ships/ferries, fishing vessels and aquaculture services for the oil companies, as well as transferring freight from road to sea. Commencement of ten new pilots is planned.

A final fourth phase is also planned for the 2020 to 2030 period. The aim here is to ensure that the plans from phase three are implemented and the solution is escalated so that coastal traffic becomes noticeably more eco-friendly and emissions are reduced.

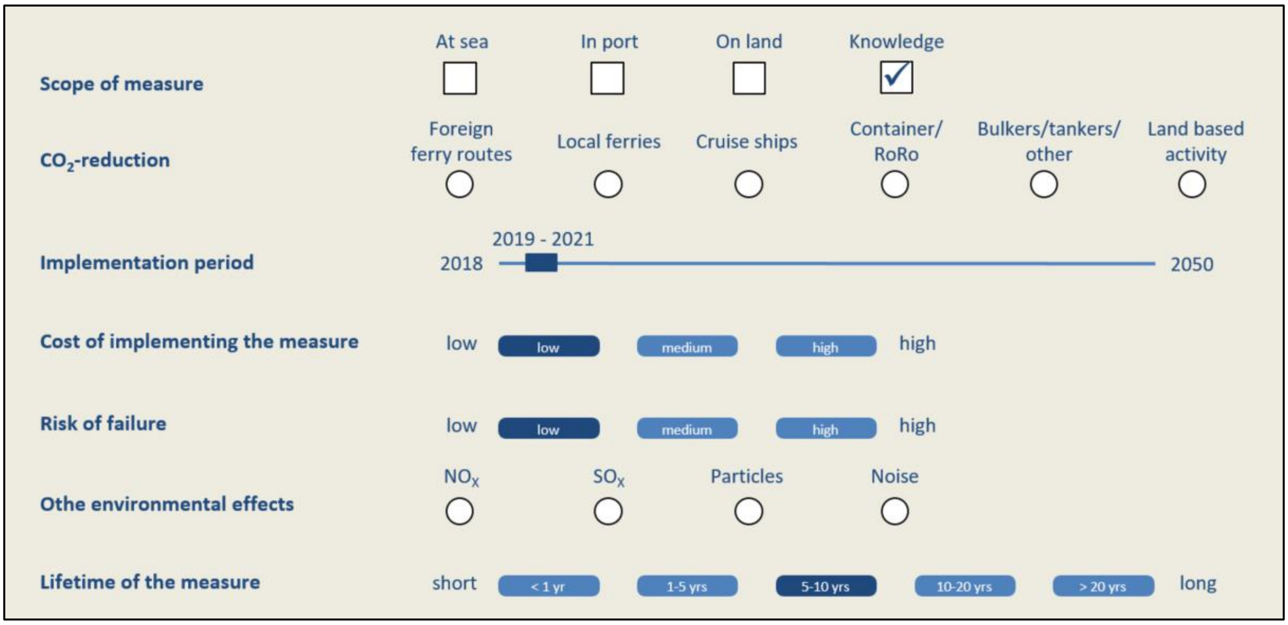
Costs: The costs linked with this measure are restricted to the charge for participants paid by programme partners. This amounts to NOK 100,000 for participation in phase 3 for 2018-2019. Funding relevant pilots implemented at the Port of Oslo may also be of relevance. However, it is difficult to estimate the need for funding for such pilots.

Responsible: The Oslo Port Authority and the Climate Agency are responsible for involvement in the programme.

Barriers to implementation:

- Limited funds for implementing pilots
- Lack of ownership of the partnership

9.1.3 Update and revise the action plan for the Port of Oslo as a zero-emissions port and incorporate the measures in the climate budget



Description: This measure includes updating and revising the action plan for an emissions-free port in order to ensure that development of the industry, the status of the implementation of measures and new measures and opportunities are also included in the action plan. Furthermore, the proposed measures will form part of the City of Oslo's climate budget on the basis of the relevant year for phase-in.

Scope: This work will include revising emissions data, technological opportunities and descriptions of measures.

Phase-in plan: Starting work on revising the action plan is recommended for 2020, with completion in 2021. The status of measures relevant to the climate budget should be established annually.

Climate effects and other environmental effects: There will be no direct climate and environmental effects linked with the measure. However, the action plan will enhance expertise and help to trigger other measures laid down in the action plan with quantified climate and environmental impact.

Duration of the measure: A duration of three to four years is recommended for the action plan prior to it being revised.

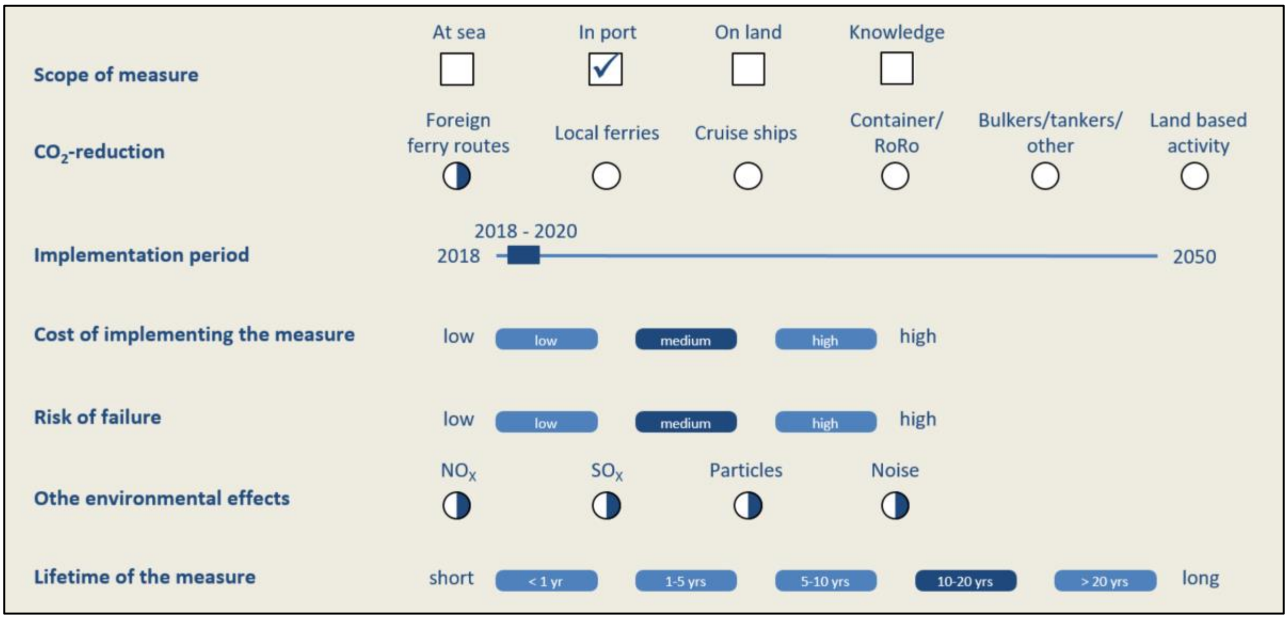
Costs: Marginal costs will be linked with the revision of the action plan.

Other measures/arrangements/instruments and other conditions: Statistics Norway publishes county-level emissions figures on a regular basis. Furthermore, an updated survey of the type that forms a basis for the emissions illustration presented in section 6 could be of relevance. These updates could potentially change the foundation for the formulation and prioritisation of the measures.

Responsible: The Department of Business Development and Public Ownership and the Department of Environment and Transport are responsible for revising the action plan.

9.2 Measures that should be reinforced

9.2.1 Shore power for foreign ferry routes



Description: This measure includes establishment of a shore power solution at Pier II at Vippetangen with Enova funding in 2018, and Revierkaia financed by the Oslo Port Authority. Color Line has been linked with a shore power solution at Hjortnes for a number of years.

Scope: Pier II is used solely by:

- DFDS (two ships, each departing three times a week)
- Stena Line (one ship, departing daily)

The shore power connection could provide power to two foreign ferry routes at the same time. This measure includes the opportunity for zero-emissions solutions for DFDS and Stena Line, but not local ferries at Rådhusplassen, cargo ships and tankers at Sydhavna, or the cruise terminals.

Phase-in plan: This measure has been implemented and will be completed in autumn 2018. Stena Line refitted its ship in April 2018, while as things stand at present DFDS has no equipment on board for connecting to shore power[7]. According to the plan, the DFDS ships will go into dock in January 2019 and 2020.

Climate effects and other environmental effects: The anticipated reduction in CO_2 with shore power is estimated at 300 tonnes of CO_2 per year for "Stena Saga"

[7] DFDS notified the City Council on 20 June 2018 that they have initiated a process involving installation of shore power connections aboard the two ships operating services to Oslo. The plan is to refit the ships when they come in for planned maintenance at the shipyard in January 2019 (Pearl Seaways) and January 2020 (Crown Seaways).

and 2,000 tonnes of CO_2 per year for "Crown Seaways" and "Pearl Seaways", if we assume full use of the facility for the three ships in question. This measure will also help to reduce greenhouse gas emissions by around 50 per cent at the port, and also reduce local emissions to a similar level. The measure will also reduce noise in an area occupied by a lot of people and characterised by tourism.

A 100 per cent reduction will not be achieved at the port due to the fact that there will also be a significant need for heating on board the ships that will be met by fossil-fired oil boilers that produce steam. This need for steam cannot be met by shore power alone. Pilot projects are in progress involving connection to the city's district heating network in order to meet such a need for heating on board the ships. The Oslo Port Authority as assessed and discussed this with the users, but a decision was made to construct a larger shore power facility instead that is able to offer sufficient power if the boilers on board the ships are electrified. This measure will also reduce NO_X emissions by 7 tonnes of NO_X per year for "Stena Saga" and 7-12 tonnes of NO_X per year for "Crown Seaways" and "Pearl Seaways".

Duration of the measure: The measure has an anticipated technical service life of 10-15 years before the facility will need to be replaced or improved. The duration of the measure may also be restricted by contractual conditions between the shipping companies in question and the Port of Oslo, and their collective perspective on the relevant routes operated. As ships of this kind operate according to a set schedule, there is little uncertainty in terms of consumption and the associated potential for reduction.

Costs: Around NOK 14-15 million will be invested in the quay. The Oslo Port Authority has been granted funding amounting to NOK 7.8 million by Enova to develop shore power at Pier II at Vippetangen, while the rest will be funded by the company. A modular solution is planned that can be extended in the long term as different needs are identified (such as electric boilers on board ships for producing hot water, and charging of batteries that can be used when entering and exiting the port). For all three ships to be provided with power, it will be necessary to organise three cranes that can handle the shore power connection (two cranes at Pier II and one crane at Revierkaia).

Other measures/arrangements/instruments and other conditions: Stena Line's "Stena Saga", which operates on the Frederikshavn-Oslo route, went into dock in April 2018 and was refitted there so that it could use the facility. As at May 2018, no decision has been made as to whether "Crown Seaways" and "Pearl Seaways", the two DFDS ferries operating on the Copenhagen-Oslo route, should be refitted[8]. SCR systems were installed to the generators aboard these two ferries in 2004 and are already reducing NO_X emissions from the generators by around 80 per cent by using catalytic converters when docked. Therefore, any shore power effect will have less impact on NO_X emissions. DFDS states that the company will make a decision in spring 2018 on whether it will be investing in shore power systems on board these two ships, as it is known that these ships are relatively old and currently have about

[8] DFDS notified the City Council on 20 June 2018 that they have initiated a process involving installation of shore power connections aboard the two ships operating services to Oslo. The plan is to refit the ships when they come in for planned maintenance at the shipyard in January 2019 (Pearl Seaways) and January 2020 (Crown Seaways).

five years of service left on this route. A lack of interest from DFDS could potentially result in the envisaged CO_2 reduction being curtailed by around 2,000 tonnes of CO_2 per year, even if the shore power facility is established and available from late summer 2018. The Color Line Kiel ferries "Color Magic" and "Color Fantasy" have already been operating on shore power at Hjortneskaia for more than six years, with reductions of around 3,000 tonnes of CO_2 per year since this system was established.

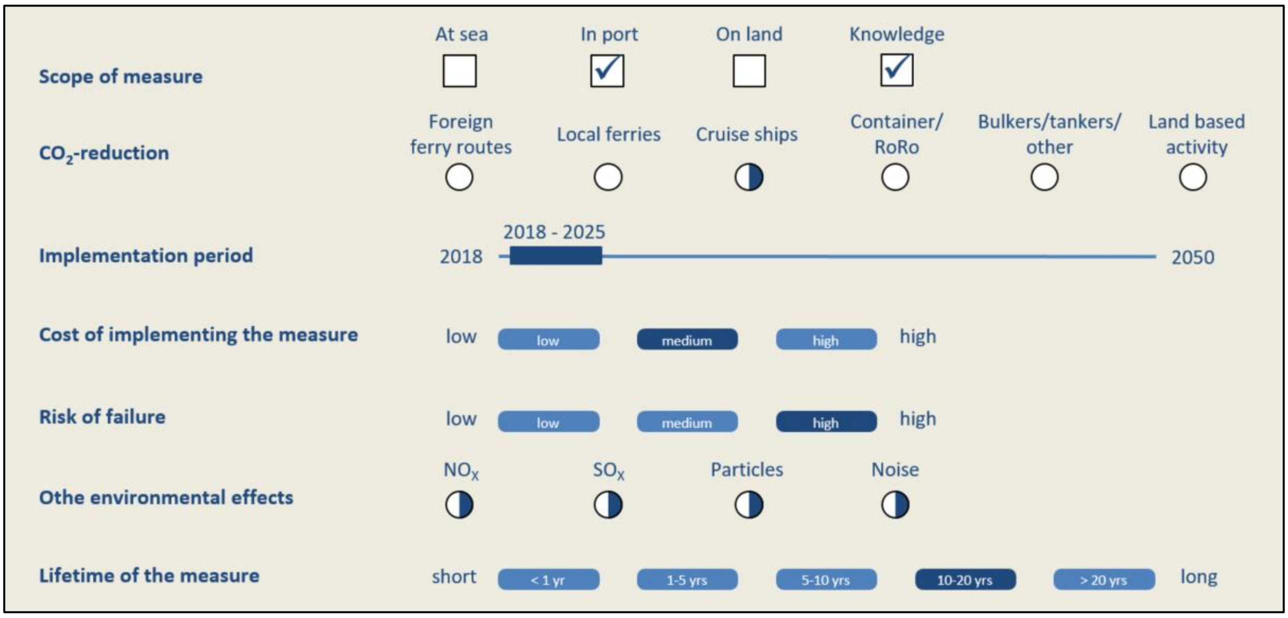
The Port of Oslo has investigated multipurpose options at Vippetangen, since the establishment of a high-voltage system for the Danish ferries at the quay have only demonstrated a usage level of around 30 per cent of the potential usage time for the facility. The facility has free capacity the rest of the time, 70 per cent. Powerful high-voltage cables have been laid in the area, and multipurpose areas were assessed in the pilot project entitled "Lavutslippsløsninger på Vippetangen" [Low-emissions solutions at Vippetangen]. The multipurpose options have proven to be small as few others need large amounts of power and current in the same way as these ships, but the Oslo Port Authority will be continuing to look for new opportunities in dialogue with the market.

Responsible: The Oslo Port Authority is responsible for implementing and funding the measure.

Barriers to implementation:

- Lack of willingness to invest among route operators
- Loss of funding from Enova

9.2.2 Cooperation with other cruise ports with a view to defining collective requirements relating to shore power and other environmental measures, with Oslo taking on a proactive role



Description

This measure involves discussion with other cruise ports and political leaders in these areas so that they can work jointly to define requirements for national and international authorities and the cruise industry with regard to technology for reduced emissions from cruise ships.

Scope

A number of representatives from the industry, the Norwegian Maritime Agency, larger cruise ports and municipalities experiencing a lot of cruise traffic were invited to attend a meeting in Oslo in order to discuss the issue of definition of common requirements for the cruise industry in August 2017. There was agreement on the issue, and it was agreed that emissions and pollution had to be reduced. Each port should not define its own rules, but there has to be cooperation in close consultation with the shipping companies, the industry and national authorities as well. The industry would like to achieve transparent processes. International ports and authorities also have to be involved. It was concluded that a works council for ports and port owners, in addition to the ongoing work groups, is desirable.

This work was continued at a meeting held in Stavanger in November 2017, where a decision was made to continue in the next round with political leaders from areas where there is a lot of cruise traffic. Kjetil Lund, Vice Mayor of Business Development and Public Ownership, is continuing with this work, and a meeting was held in April 2018 with political leaders from the areas experiencing the most cruise traffic. The members of this works council are now continuing to work together.

Discussions are also being held with the port in Hamburg, which up to now has had the only shore power facility for cruise ships in Europe. In April 2018, it became clear that the shore power solution for cruise ships (15 MVA) devised by supplier PowerCon in consultation with the cruise terminal in Copenhagen will now be constructed as the world's first pilot at the Port of Kristiansand, with EU funding amounting to EUR 4 million. This is an exciting project, and the City of Oslo will be monitoring its progress via the cooperation with cruise port owners.

Contact has also been made with individuals at a number of shipping companies representing a fairly large proportion of the cruise tonnage, with a view to discussing environmental adaptations.

In parallel, discussions have been initiated directly with Green Cruise Port. Green Cruise Port is a project that forms part of the of EU Interreg Baltic Sea Region Programme 2014-2020. Geographically, all the countries bordering on the Baltic Sea and the neighbouring countries bordering on the North Sea are covered: Bergen, Oslo, Amsterdam, Hamburg, Esbjerg, Copenhagen, Gothenburg, Rostock, Gdansk, Kaliningrad, Klaipeda, Riga, Tallinn, St. Petersburg, Helsinki and Stockholm.

Phase-in plan

This work has been implemented and will continue over time.

Climate effects and environmental effects

Any establishment of shore power facilities for cruise ships just in Oslo, or introduction of other environmental requirements applicable only to Oslo, will have relatively little impact on climate and will hardly persuade the cruise lines to refit their ships. Cooperation to meet collective requirements from a number of ports will give the industry a considerably stronger incentive to adapt as desired.

Costs

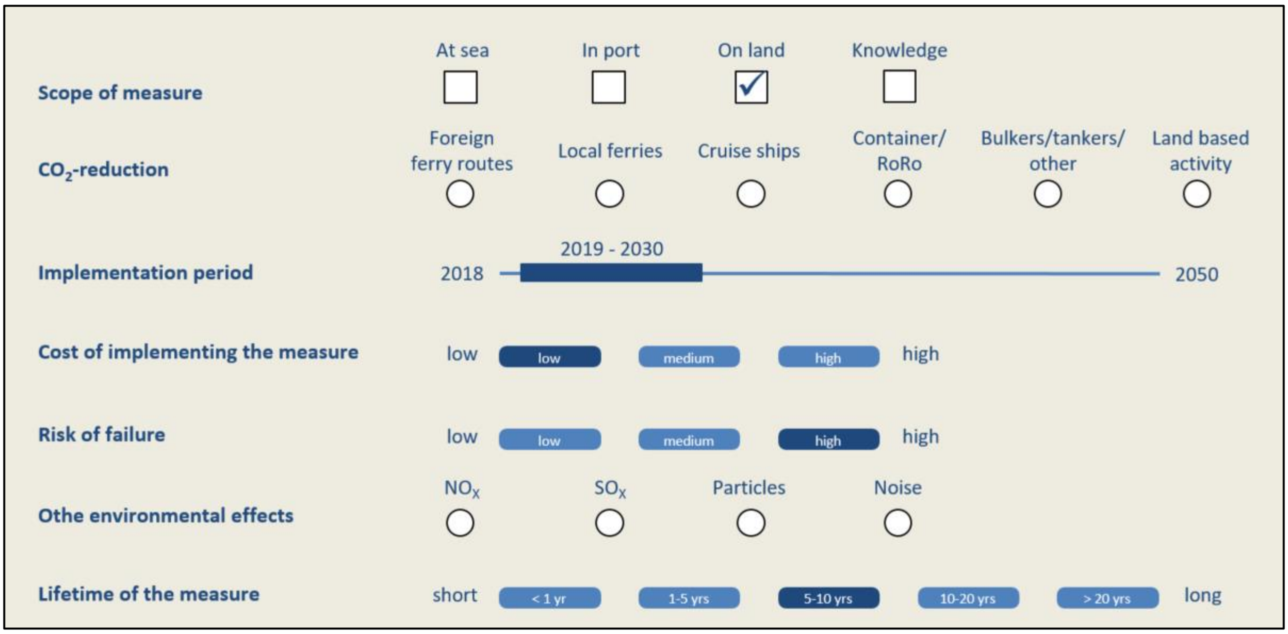
Costs linked with cooperation with ports and industry stakeholders are low. Costs for installation of shore power for cruise ships and other environmental measures, for instance, will be significant, both at the ports and aboard the ships.

Responsible

The City Council has taken the initiative to work in cooperation with other Norwegian and northern European ports of call for cruise ships with a view to defining collective environmentally appropriate solutions for cruise ships, and shore power requirements have been placed on this agenda. This work is being headed by Kjetil Lund, Vice Mayor of Business Development and Public Ownership.

9.3 Recommendations for new measures

9.3.1 Oslo is a driving force for moving more freight from the roads to the sea, and is working to implement equal environmental requirements for maritime transport throughout the Oslofjord in its entirety



Description: This measure involves arranging for major reorganisation of freight transport, transferring it from the road network to maritime transport via the Port of Oslo. This is in harmony with national objectives decided upon by the government declaration of January 2018, among other things, where the government wishes to follow up on its ambition to transfer 30 per cent of freight transported more than 300 km from road to sea and rail during the 2018-2029 plan period. This target has also been adopted by the Storting via a national transport plan.

Transferring more goods from road to sea is the most important initiative that can be implemented in order to reduce emissions from freight transport. Maritime transport is by far the most efficient form of transport, and it should be used more. Studies show that intermodal maritime transport systems consume considerably less energy and have significantly lower greenhouse gas emissions than vehicle-based transport systems for the same volume of freight. Transferring freight from road to sea will therefore make a significant contribution to reducing society's greenhouse gas emissions. Transport by sea represents the collective solution for freight. A standard container ship sailing into the Oslofjord replaces 400 semitrailers on the main roads into Oslo. Place one after the other, this would result in a 10 km queue of semitrailers on the road network.

Stakeholders at the port are working together with the Oslo Port Authority to increase capacity at Sydhavna with a view to increasing the throughflow of freight by 50 per cent in 2030. This is equivalent to increase from five to eight million tonnes of freight each year. The Port of Oslo has to work to transfer goods from road to sea in order to reduce transport and emissions and add greater value, particularly in the following four product streams:

1. Mass cargo (minerals, recycling, backloading)
2. European cargo (ferries and containers)
3. Norway cargo (Oslo as a logistics hub via sea and rail)
4. Oslo cargo (CO_2 capture, Fortum/Klemetsrud, project cargo for construction projects, etc.)

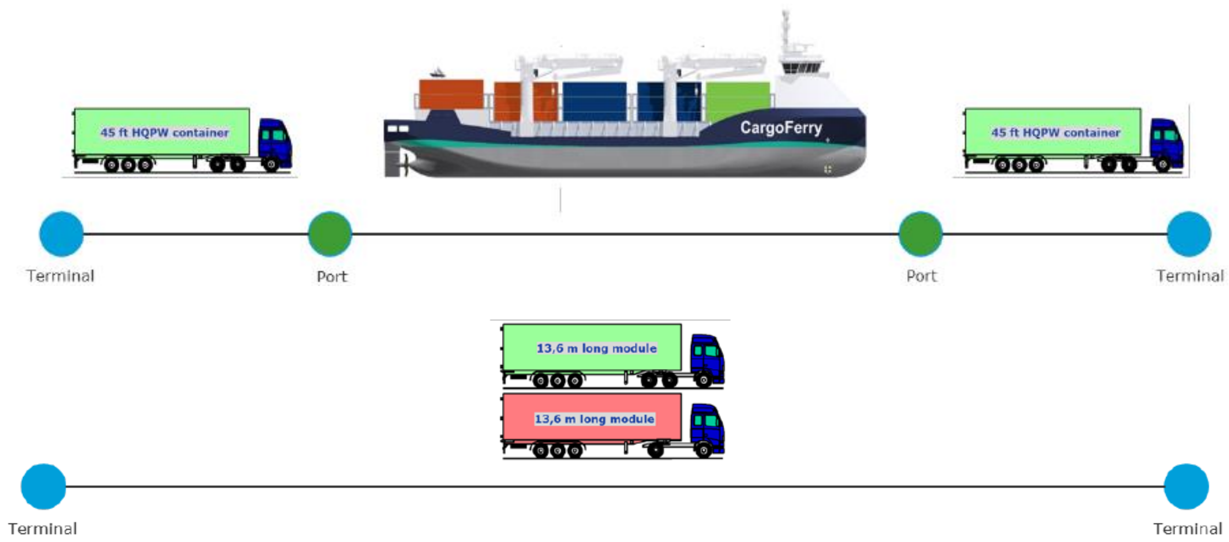


Figure 9-4: Various transport systems based on lorry-container ship-lorry (top) and standard trailers (bottom).

Scope: This measure will include relevant freight transport operating in Oslo, either as through traffic or originating in Oslo, travelling distances in excess of 300 km. Container transport and various forms of bulk transport will be the most relevant segments.

Phase-in plan: The Oslo Port Authority has a port plan for the 2013-2030 period that envisages 40 per cent more passengers and 50 per cent more cargo passing through the Port of Oslo in 2030. An increase of this kind is most likely to slightly increase emissions at the port, even though there will be major savings in terms of climate on a global level. Further efforts should be made to fulfil the objectives in the plan so that the future increase in freight volumes comes about via maritime transport, and not via road traffic.

Climate effects and other environmental effects: The transition from road to sea will potentially result in significant savings in terms of both energy and the environment. A study performed by DNV GL for the Norwegian Shipowners' Association in 2016, indicated a 50-80 per cent reduction in CO_2 emissions per transport route for two different routes currently using trailers:

1. trailer transport between Świnoujście in Poland to Oslo has been replaced with a container ship with a capacity of 120 x 45-foot containers, with around 73,000 container deliveries a year.
2. trailer transport between Oslo and Bergen has been replaced with a container ship with a capacity of 120 x 45-foot containers, with around 47,000 container deliveries a year.

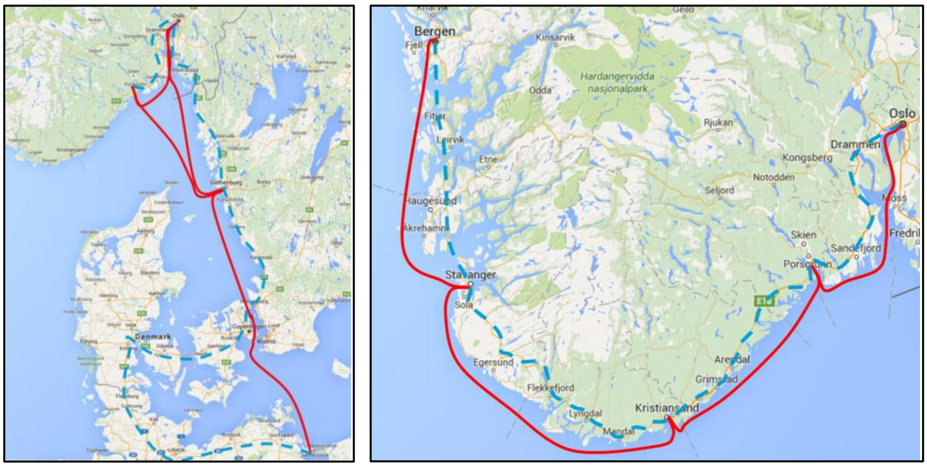


Figure 9-5: Two different transport routes (1) and (2) where trailer transport can be replaced with maritime transport

Although two relevant examples offering major potential for reduction have been highlighted here, other transport routes of a certain length with consistent freight volumes via Oslo would also achieve similar reductions. Your attention is drawn to the fact that the savings will not be included in the Port of Oslo's emissions report as these savings will be brought to bear on road services, beyond the system boundary of the port.

Figure 9-6 shows various emissions intensities [CO_2/per tonne-km] for various modes of transport.

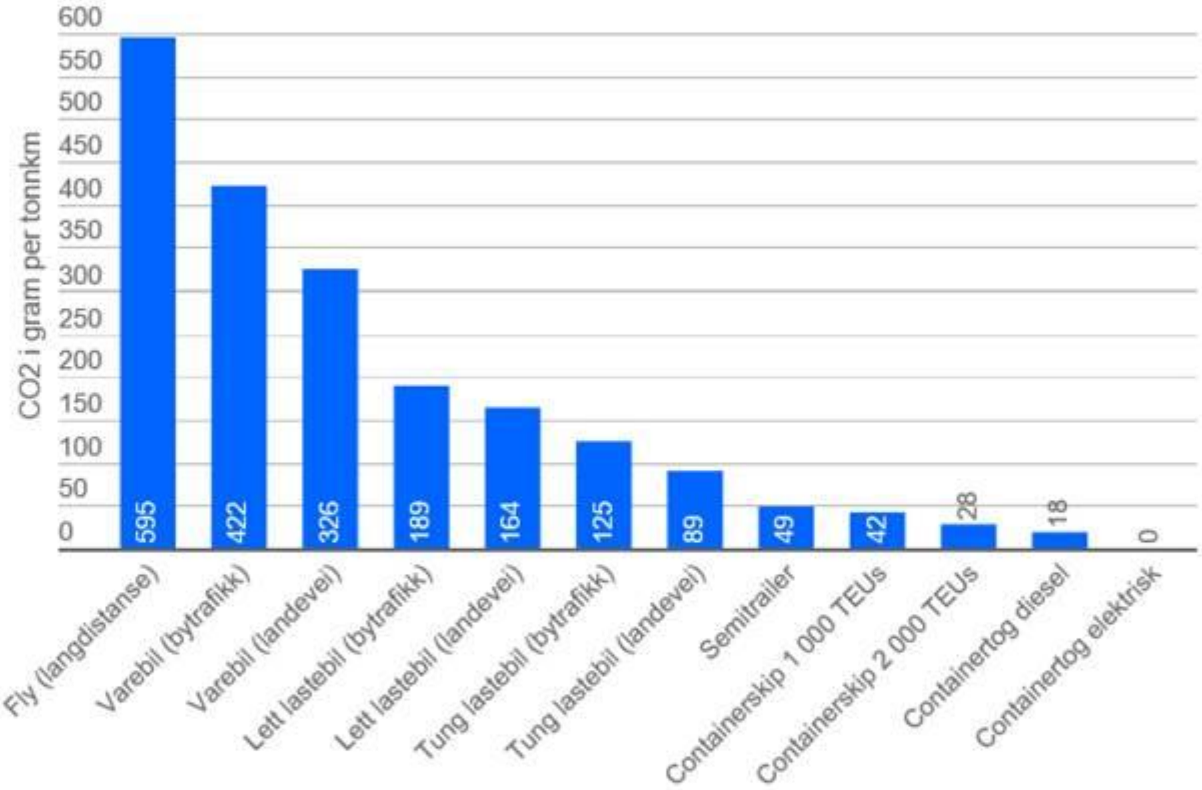


Figure 9-6: Emissions parameters [CO_2/per tonne-km] for various modes of transport (Lipasto).

"Marginale eksterne kostnader ved havnedrift" [Marginal external costs for port operation], a report issued by the Institute of Transport Economics, shows that maritime transport appears to be more eco-friendly than other modes of transport, even if we include external costs for port operation. This report shows that the costs for a large truck are more than eight times as great as for a small general cargo ship, similar to the ones that call at the Port of Oslo every week.

Duration of the measure: Escher will be restricted by each individual contract. The Port of Oslo and the City of Oslo should facilitate predictability in maritime transport so that it is possible to create new routes out of the Port of Oslo, with long-term perspectives.

Costs: Transferring transport from road to sea results in both social and commercial savings for the carrier and the owner of the goods, as well as socio-economic gains by transferring freight from road to sea. The City of Oslo pays for much of the freight to be transported to and from the city, and that is moved around Oslo; whether it relates to major construction projects or day-to-day operations. It would be reasonable, in both economic and environmental terms, for the City of Oslo to request more use of maritime transport. The study performed by DNV GL for the Norwegian Shipowners' Association concludes that there are commercial savings to be had by both the carrier and the owner of the goods, as well as socio-economic gains by transferring freight from road to sea.

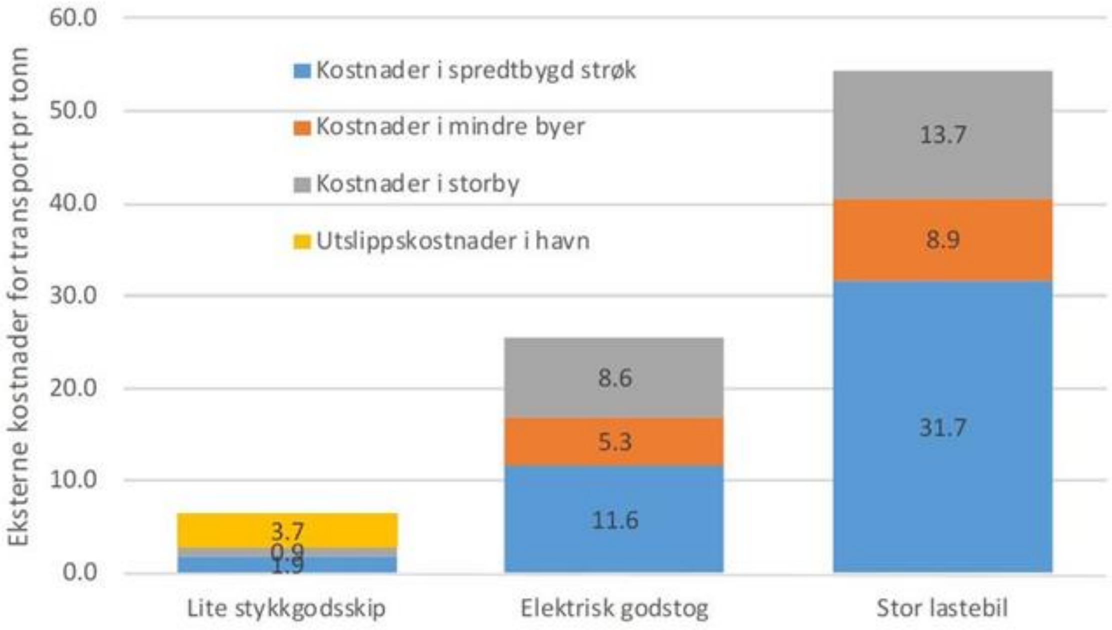


Figure 9-7: External costs [NOK/tonnes of CO_2] for transporting "the marginal average tonne" for a large truck, an electric freight train and a small general cargo ship (2,500 GT) between Rotterdam and Oslo, including external costs at the Port of Oslo (TØI, 2017).

Other measures/arrangements/instruments and other conditions:

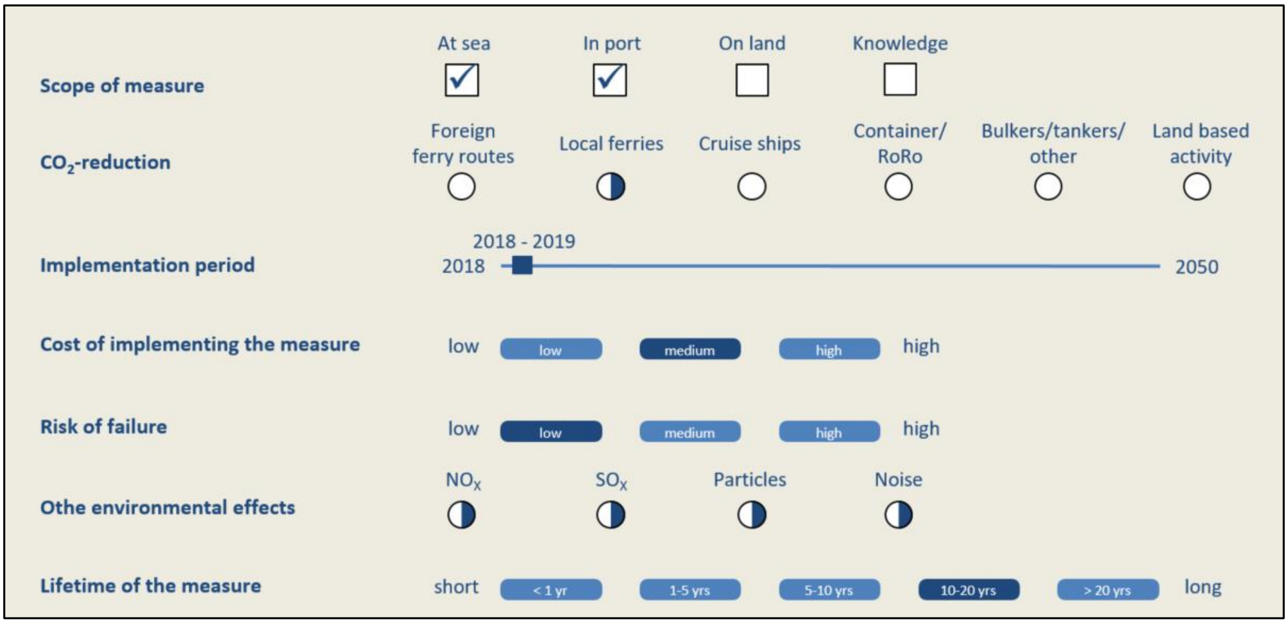
The transport industry is highly sensitive to changes in the competitive situation and economic framework conditions. If maritime transport out of the Port of Oslo is facilitated sufficiently, stakeholders are expected to readjust and utilise what is on offer. However, predictability in the framework conditions is absolutely crucial so as to be able to trigger the potential.

Responsible: The Oslo Port Authority, in consultation with private stakeholders, is responsible for further work on this measure.

Barriers to implementation:

- A lack of demand for maritime transport in private and public procurement procedures
- A lack of awareness among owners of goods that can cooperate with others in order to move their own goods collectively, not in individual trailers
- Sydhavna has to be developed in order to facilitate an increase in transportation by sea, now that Filipstad and parts of Vippetangen are to undergo urban development
- Low tolerance for processing of freight at the port
- A lack of security and long-term support to the port and maritime transport in Oslo, in order to guarantee long-term investments from the business community and stakeholders wishing to establish a presence at the port with potential for growth

9.3.2 Emissions-free operation for Nesoddbåtene (route B10)



Description: This measure includes establishing the necessary shore-based power supply and charging infrastructure for electrification of the Nesoddbåtene ships, and discussion and negotiation with Norled concerning the refitting of existing ships that serve the link with electric operation within applicable contracts.

Scope: A charging infrastructure for electric operation of the link will be established at the quay at either Aker brygge or Nesoddtangen. The three ships "Kongen", "Dronningen" and "Prinsen" that run on LNG and serve the link have to be refitted so that they can run on battery electric power.

Phase-in plan: This measure should be implemented immediately in order to facilitate prompt use. Ruter will facilitate implementation, as soon as possible, of electrification of the Nesoddtangen-Aker brygge shipping link. Necessary clarifications linked with the establishment of charging infrastructure will provide guidelines on the phase-in time. It is thought that it will be possible to implement this at some point in 2019 or 2020 at the earliest.

Climate effects and other environmental effects: The anticipated CO_2 reduction on making the switch from MGO and LNG to renewable power with a guarantee of origin is estimated at around 4,200 tonnes of CO_2 per year overall for the three ships, if we consider power to be an emissions-free energy carrier and assume full electric operation. This measure will also help to reduce greenhouse gas emissions by 100 per cent at the port and during crossings, and also reduce local emissions correspondingly. This is estimated to amount to around 14 tonnes of NO_X per year. The measure will also remove SO_X, particulates and dust in an area occupied by a lot of people and characterised by tourism.

Duration of the measure: Ruter's shipping services have been put out to tender, and Norled has a contract for this link (Nesoddtangen-Aker brygge) until the end of June 2024, with the option of a further 10 years of operation if the two five-year options are exercised. Therefore, this measure may take effect between 2019 and 2034. Ruter's ambition is to implement emissions-free public transport by the end of 2028, and emissions-free shipping links by the end of 2024. Future contracts for the link will also require similar solutions. Therefore, this measure will have a lasting effect.

Costs: Ruter is examining and calculating costs for various power supply solutions, positioning of substations and shore-based charging infrastructure, and in its negotiations with Norled it will clarify final costs linked with refitting the ships.

Applications for funding for onshore charging infrastructure can be submitted to Enova. In this event, an application must be sent to Enova before a decision is made to electrify the links so that the measures will qualify for funding.

The costs linked with the refit are as yet unclear. However, it will be possible to apply for funding from the NO_X Fund for the systems installed on board ships. This funding from the NO_X Fund is estimated to amount to NOK 20-30 million in total for the three ships.

Legal scope for action:

The regulations on public procurements define limits with regard to which changes are permitted within existing contracts. Significant changes to any contract that has been concluded are considered to be a new procurement procedure, which must be announced and put out to tender in accordance with the regulations on procurement. Ruter has concluded that refitting the Nesoddbåtene ships falls within Ruter's scope for action as regards the regulations on public procurements.

Other measures/arrangements/instruments and other conditions:

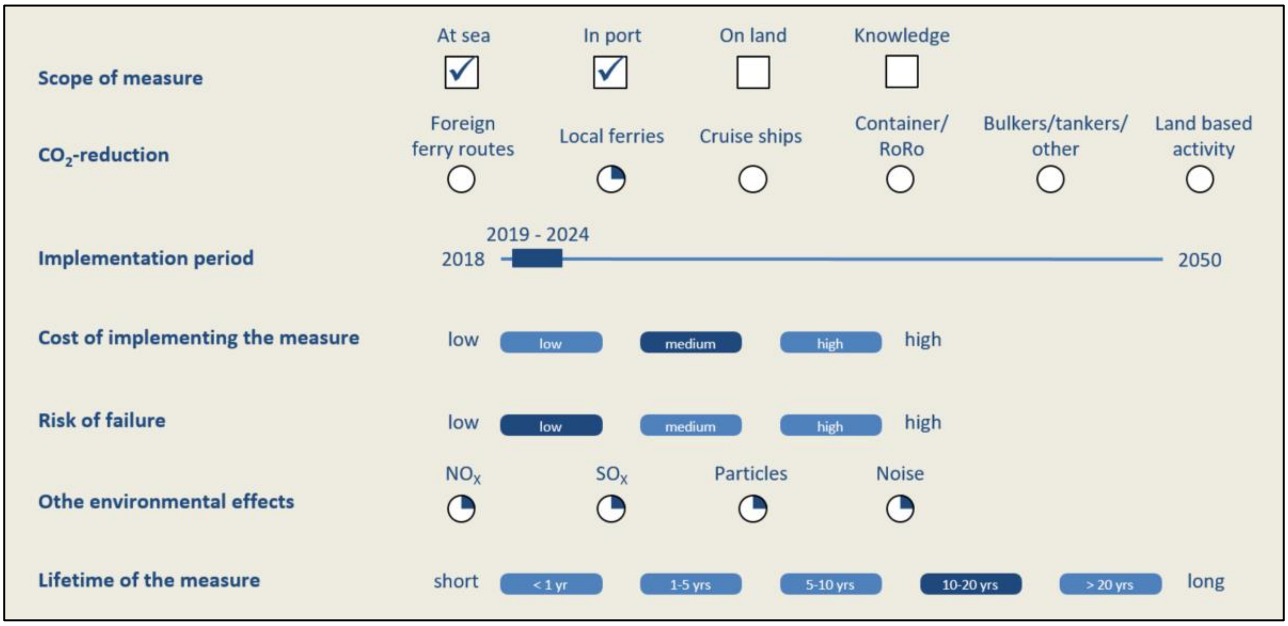
These ships currently operate with a holding time of around eleven minutes at Aker brygge, between every departure during rush hour. This is considered sufficient for fast charging of the batteries.

Responsible: Ruter is responsible for further work. This measure requires discussion and clarification with Akershus county council.

Barriers to implementation:

- Establishment and positioning of a power supply, substation and shore-based charging infrastructure, including necessary clarifications linked with planning processes and technical and financial challenges linked with making the necessary power requirement available at the quay.

9.3.3 Emissions-free operation for Ruter express services (routes B11 and B20-B22)



The current contracts for express services cover route B11 Nesodden-Lysaker, route B20 Aker brygge-Vollen/Slemmestad and route B21-B22 Aker brygge-Slemmestad/Drøbak/Son (the latter is only used in summer). Norled operates all these express services. The contract for Aker brygge-Vollen/Slemmestad expires at the end of June 2019, but Ruter will be exercising an option to extend this by five years. The contract for the other routes expires in June 2024. Ruter's ambition is to demand zero emissions when announcing new contracts, provided that an appropriate technological solution is commercially available for the high-speed ships. This measure includes establishing the necessary onshore infrastructure for electric operation and investing in ships using zero-emissions technology. Ships running on hydrogen appear to be the only relevant zero-emissions solution at present due to the organisation of the link (long, energy-intensive crossings) and the restrictions of the schedule (high speeds and some short holding times). However, battery technology is developing rapidly and should not be written off. Hybrid ships (battery electric and hydrogen) may also be an option.

Scope: The positioning and establishment of the necessary power supply infrastructure for the high-speed ships can only be assessed when an energy carrier has been selected. The refitting of the three high-speed ships ("Baronessen", "Baronen" and "Tidevind") within the applicable contract and being operated by Norled on the B11 and B20 routes at present is considered to be a significant change, and within the applicable contract only a transition to renewable diesel (HVO) is considered to be a potential solution.

Phase-in plan: Further effort should be invested in these measures in order to map the technical, financial and operational challenges inherent in offering full electric operation on these express routes. Ruter is calculating a timeframe of around five years in which to implement innovative procurement of shipping services whereby new ships with more or less untested technology will be offered and constructed. Therefore, it will only be possible to phase in this measure in the second half of 2024 at the earliest.

Climate effects and other environmental effects: The anticipated CO_2 reduction on making the transition from MGO to zero emissions is estimated at around 2,300 tonnes of CO_2 per year in total for the three ships operating the express services. This measure will also help to reduce greenhouse gas emissions by 100 per cent at the port, and also reduce local emissions to a similar level. This is estimated to amount to around 28 tonnes of NO_X per year. The measure will also remove SO_X, particulates and dust in an area occupied by a lot of people and characterised by tourism.

Duration of the measure: The measure has an anticipated technical service life of 10-15 years before the facility on board the ships has to be improved or undergo extensive maintenance. Norled has a contract with Ruter for operation of the link until June 2019, with an option for a further 15 years of operation if the three five-year options are exercised. Therefore, this measure may take effect from 2024, as it is considered unrealistic, in technological and contractual terms, to be able to implement it as early as 2019. Ruter's ambition is to achieve zero-emissions public transport by 2028, and zero-emissions shipping links by 2024, and future contracts for the link will also require similar solutions. Therefore, this measure will have a lasting effect.

Costs: The measure's costs linked with the necessary power supply infrastructure on land and additional costs linked with the purchase of shipping services where zero-emissions solutions requiring investments in new high-speed ships are demanded will be significant, but it is not possible to estimate them at present.

At present, it is difficult to say what public funding schemes will be available for zero-emissions measures to be implemented in or after 2024. However, it will be possible to apply for funding from the NO_X Fund for the systems installed on board ships. This funding from the NO_X Fund is estimated to amount to NOK 13 million in total for the three ships.

Other measures/arrangements/instruments and other conditions:

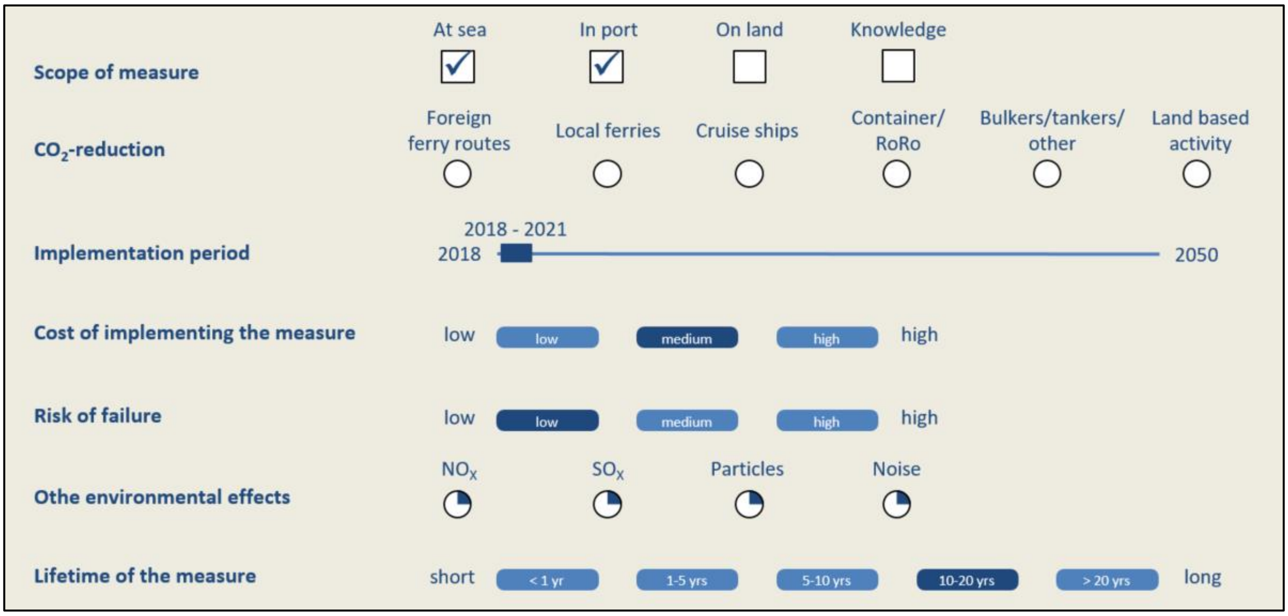
Establishment of a hydrogen initiative at sea ought to be considered against the use of hydrogen for other more central purposes. Positioning a filling station at Pipervika means that applications can be envisaged on the land side as well, for cars or utility transport.

Responsible: Ruter is responsible for further work. This measure requires discussion and clarification with Akershus county council.

Barriers to implementation:

- Lack of funding
- Requires appropriate zero-emissions technology to be commercially available for high-speed ships

9.3.4 Emissions-free operation for the Øybåtene service



Description: This measure includes implementation of a new tender requiring zero emissions, which requires establishment of shore-based charging infrastructure for electric operation.

Scope: Shore-based charging infrastructure for electric operation of the link will be established at the quayside. The Øybåtene service is currently operated by Oslo-Fergene AS. Ruter will be announcing a new tender in 2018 and will define requirements for zero-emissions technology at that time.

Phase-in plan: Ruter's present contract expired at the end of February 2018 but has extension options of up to 3 years. Procurement of shipping services takes a total of four to five years from commencement of preparations to a new contract coming into force. Ruter has therefore exercised its extension option on the current contract with Oslo-Fergene AS as sailing under a new contract will not commence until 1 March 2021. Whether electric operation will be possible for this link from March 2021 will be dependent on whether the power supply and shore-based charging infrastructure are in place.

Climate effects and other environmental effects: Given the way in which greenhouse gas emissions are calculated in the City of Oslo, there will be no reduction in CO_2 when making a transition from biodiesel to electricity. This is due to the fact that both biodiesel and electricity are considered to be climate-neutral energy carriers. However, the measure will reduce local emissions by 100 per cent. This is estimated to amount to around 11 tonnes of NO_X per year. The measure will also remove SO_X, particulates and dust in an area occupied by a lot of people and characterised by tourism.

Duration of the measure: Ruter as of the opinion that March 2021 will be the earliest time that a new tender can be put into operation, and therefore the measure will be unable to take effect until 2021 at the earliest. Ruter's ambition is to achieve zero-emissions public transport by 2028, and zero-emissions shipping links by 2024, and future contracts for the link will also require similar solutions. Therefore, the measure for establishing a charging infrastructure will have a lasting effect.

Costs: The costs of the measure linked with the onshore charging infrastructure (include establishing the necessary power supply for charging both the island boats and the Nesoddbåtene ships) are dependent on which solution is selected.

Applications for funding for onshore charging infrastructure can be submitted to Enova. In this event, an application must be sent to Enova before a decision is made to electrify the links so that the measures will qualify for funding.

The additional costs involved in demanding zero emissions when announcing a new tender are unclear. However, it will be possible to apply for funding from the NOx Fund for the systems installed on board ships.

Other measures/arrangements/instruments and other conditions:

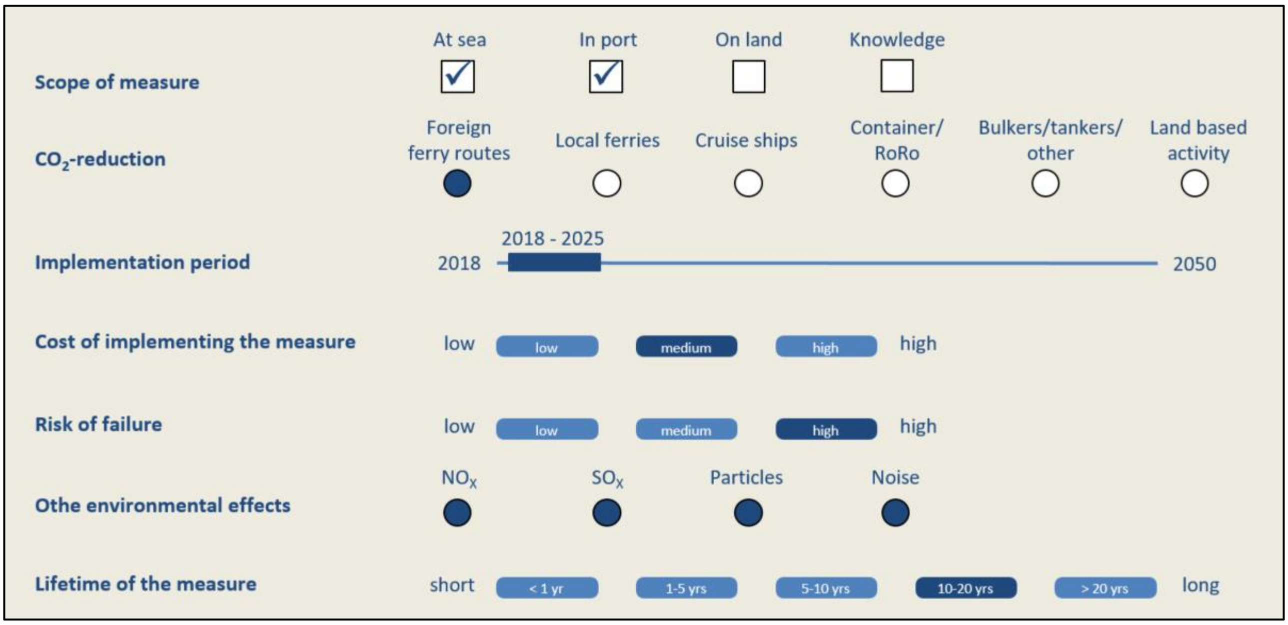
To be able to introduce battery electric operation of the island boat link, the schedule must allow time for charging at Rådhusbrygge 4. Furthermore, the vessels that will be operating on the link must be exempted from the Port of Oslo's length and width requirements and speed limits in the inner Oslofjord.

Responsible: Ruter is responsible for further work.

Barriers to implementation:

- Clarification of the planning process/permission to establish a substation on the quay
- Technical and financial challenges linked with making the necessary power requirement available at the quay
- A lack of competitive tenders from potential operators.

9.3.5 Requirement for zero-emissions solutions for foreign ferry routes with effect from 2025 if new routes are established, if existing routes are put out to tender, where contracts are renewed or where permitted by the situation



Description: Oslo City Council assumes that requirements will be defined for zero-emissions operation within the "Approach to Oslo" area for foreign ferry routes by the end of 2025. When updating this plan, the City Council will define similar targets for other segments such as cruise services. The scope of emissions from foreign ferry routes, the number of ships and the frequency of arrivals mean that measures in this segment have been given priority.

Scope: These requirements will apply to ships operating on existing routes, new ships on existing routes and ships that are planned for use on new routes to and from Oslo in a period extending beyond 2030.

Phase-in plan: Oslo City Council's target is for foreign ferry routes entering and exiting Steilene and the quay to operate with zero emissions by 2025. This is being communicated early so that industry stakeholders have the opportunity to adapt in time.

Climate effects and other environmental effects: The anticipated CO_2 reduction stands at an estimated 16,600 tonnes of CO_2 per year, if we assume that foreign ferry routes will operate at similar levels to today. As well as reducing all greenhouse gas emissions, this measure will also reduce local emissions to a similar extent. The measure will also reduce noise in an area occupied by a lot of people and characterised by tourism.

Duration of the measure: This will be considered to be a lasting measure as long as subsequent solutions and contracts will be at least as ambitious in terms of climate.

Costs: The level of costs for investments in shore-based infrastructure upgrades will be relatively limited as facilities already exist at Hjortnes and work is being done on new shore power solutions at Vippetangen.

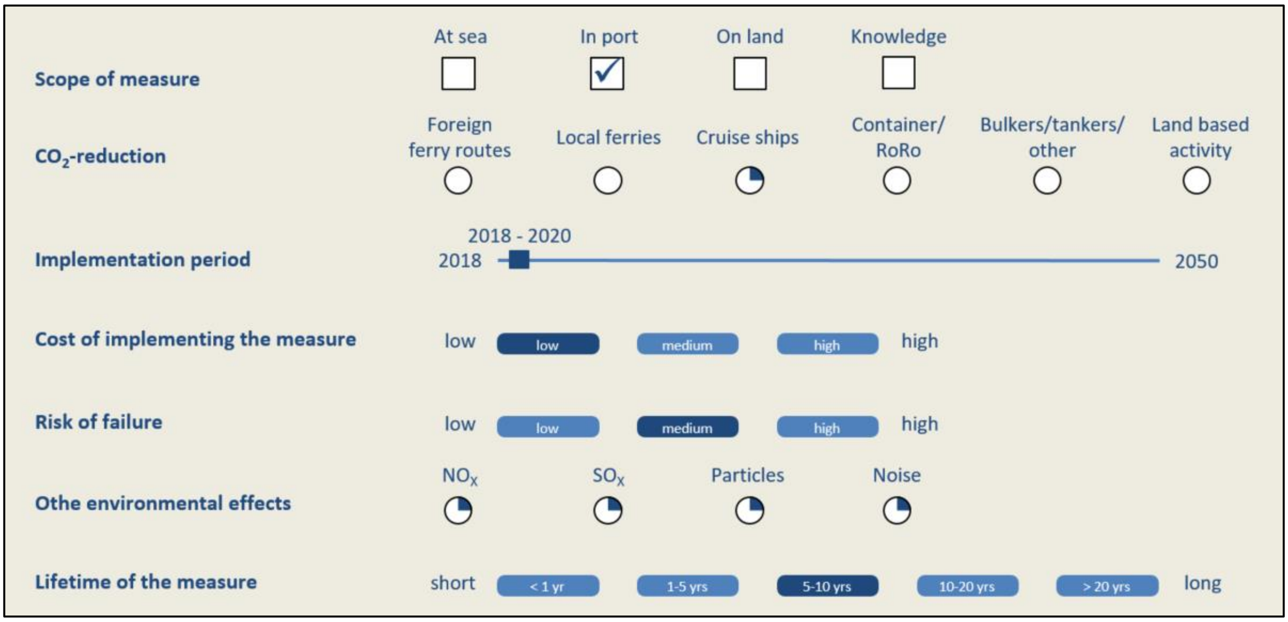
Other measures/arrangements/instruments and other conditions: Stena Line is planning to refit its ship "Stena Jutlandica", a slightly larger ship than "Stena Saga" operating on the Oslo-Fredrikshavn route, in order to cover electric operation over 10 nautical miles. This is approximately the distance between Steilene and Vippetangen. With this as a starting point, it seems likely that both new ships to be built and existing ships that can be refitted may be equipped with solutions that will allow them to sail emissions-free from Steilene to Vippetangen by the end of 2025.

Responsible: The Oslo Port Authority is responsible for further work on the scheme, in close cooperation with the shipping companies and the Department of Business Development and Public Ownership.

Barriers to implementation:

- Lack of willingness among route operators to invest in measures beyond statutory requirements
- The battery technology for large RoPax ferries has not been tested as yet, but it is being developed
- Loss of funding from Enova

9.3.6 Environmental differentiation of port charges in order to reward docked low-emissions ships via the Environmental Port Index (EPI)



Description: This measure will include introduction of the Environmental Port Index (EPI), a scheme that provides cruise ships calling at the port with a basis for discounts on port charges based on measures that reduce CO_2, NO_X and SO_X for docked cruise ships. The discount will be calculated on the basis of the technical environmental level of the ship and how it behaves in port according to the type of fuel and the consumption level. The measures must reduce emissions beyond requirements laid down in national and international laws and regulations.

The EPI is a cooperation project involving 15 Norwegian ports with significant cruise operations, in order to encourage environmental measures in the cruise industry. Cruise ships are highly costly and have a long technical service life (30-50 years). The average age of cruise ships calling at Oslo is 22 years, and a large number of old cruise ships, with no modern environmental technology installed, are expected to call at Oslo over the next 20-30 years.

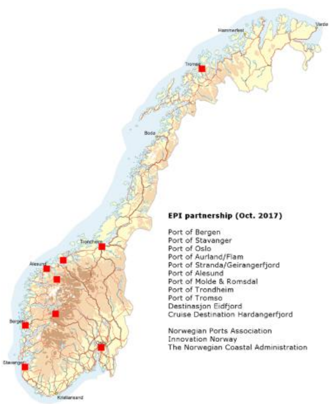


Figure 9-8: Partners in the “Environmental Port Index” cooperation project as at October 2017.

Scope: This scheme will include cruise ships in the first instance, but it may be extended to other segments if it proves effective and appears to be transferable. A total of 43 unique cruise ships called at the Port of Oslo in 2017. All cruise ships calling at the Port of Oslo will be incorporated in the scheme by carrying out an automatic preliminary assessment and declaration of the ship's environmental capabilities in respect of CO_2, NO_X and SO_X, based on data available in ship databases and environmental measures reported by the shipping companies.

Phase-in plan: The Port of Bergen, which was responsible for the original formulation of the measure, will be testing the system in April 2018, and its aim is for the EPI to provide discounts on quay charges for cruise ships with effect from 1 January 2019. The EPI scheme has been incorporated in the Grønn Kystfartsprogram for further development.

For Oslo, this measure should be implemented in close consultation with the other Norwegian ports, and with the Port of Bergen in particular. There should be further consideration of opportunities for cooperation with international port authorities and cruise ports in order to create a collective demand for environmental solutions: see also section 9.2.2. The scheme should be piloted in 2019, taking full effect as of 2020.

Climate effects and other environmental effects: The reduction in CO_2 when introducing environmental measures based on the EPI is uncertain. The scheme must be arranged so that it will be sufficiently beneficial in financial terms – due to reduced port charges – to invest in the environmental technology. Provided that the scheme is arranged appropriately, it is estimated that the sum of climate measures may reduce around 25 per cent of greenhouse gas emissions linked with cruise operations at the port. This is equivalent to around 900 tonnes of CO_2 per year. As well as reducing greenhouse gas emissions at the port, this measure will also be set up to trigger measures that could reduce local emissions. This will result in an estimated 25 per cent reduction as well, or around 12 tonnes of NO_X per year and 0.6 tonnes of SO_X per year. The measure will also remove a corresponding quantity of particulates and dust in an area occupied by a lot of people and characterised by tourism.

Duration of the measure: The duration of the measures will be dependent on the extent to which the measures are used by ships, and it is assumed that this will be of significance to the extent to which the scheme is upheld. If the scheme is formulated correctly, the effect of the measure is expected to be permanent, with progressively greater impact on the environment.

Costs: The costs associated with the measure are restricted to the reduction in port charges that the Oslo Port Authority is willing to agree to. Discounts given by the ports also mean lower revenues for the port. In order to maintain traffic revenues, this means that an increase in the price is to be expected for other ships with weaker environmental performance, as discounts are given to ships with good environmental performance.

There will be an additional cost for implementing the solution and monitoring the updated environmental status of each ship calling at the port if every port has to assess documentation and keep its own logs of ships calling there.

It may be appropriate to enter into communications with the Norwegian Coastal Administration in order to look at reducing state port charges, if it turns out that stronger incentives are needed in order to trigger measures. The state demands a security charge, pilot standby charge and piloting charge to the Norwegian Coastal Administration from ships calling at Oslo. It may be relevant to see whether a cooperation with the Norwegian Coastal Administration could bring about further financial environmental incentives in order to trigger measures on board ships.

Other measures/arrangements/instruments and other conditions:

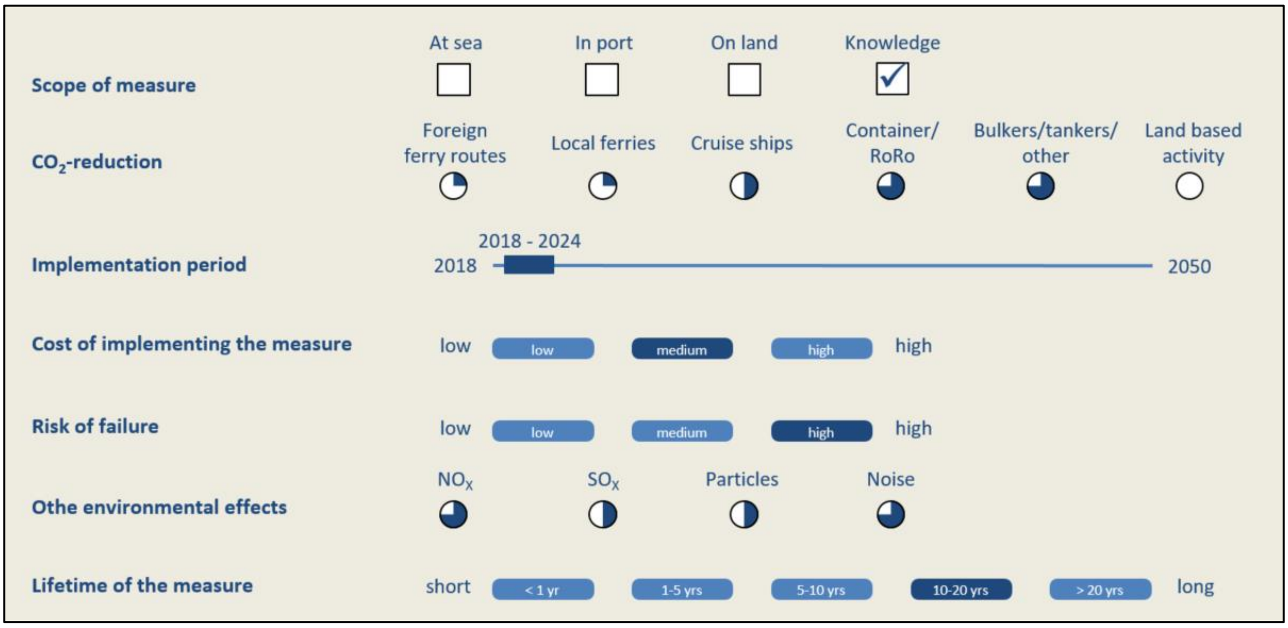
A coordinated initiative with other ports is key to successful implementation of the measure, making conditions for calling at Norwegian cruise ports as consistent as possible. Ensuring that the ESI scheme does not conflict with the EPI and result in unfortunate consequences for phase-in will also be crucial. Furthermore, the predictability of the scheme should be demonstrated to the industry so that investments made aboard ships provide a competitive advantage in the future as well.

Responsible: The Oslo Port Authority is responsible for further work on the scheme, in close cooperation with the Department of Business Development and Public Ownership and relevant national authorities and partner ports.

Barriers to implementation:

- The Oslo Port Authority already has low port charges, meaning that financial savings for triggering cost-intensive environmental measures are limited
- Lack of willingness among shipping companies to invest in measures that go beyond statutory requirements
- Efforts of the various cruise ports not very coordinated It is therefore important to use, and possibly to improve established international indices such as the ESI that are already in use.

9.3.7 Establish communication with national authorities for amendment of the Act relating to ports and fairways so that requirements can be defined for zero-emissions solutions when docked



Description: According to section 39 of the current Ports and Fairways Act, municipal and private ports open to public traffic have an obligation to accept traffic. The extent to which ports can define environmental requirements in relation to this obligation to accept traffic has been called into question.

The Ports and Fairways Act is currently being amended. A legislative committee was appointed, and on 1 March 2018 it submitted NOU 2018:4 Sjøveien videre, Forslag til ny havne- and farvannslov [NOU 2018:4 The future of transport by sea, a proposal for a new Ports and Fairways Act] to the Ministry of Transport and Communications.

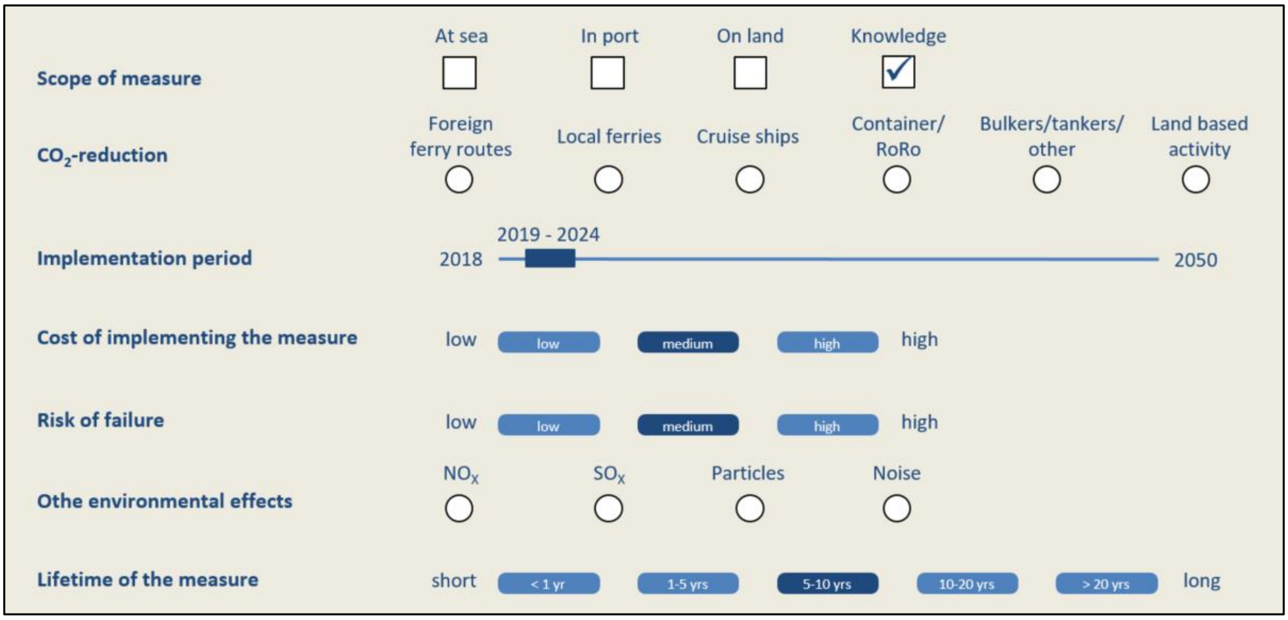
KS Storbynettverk, an organisation of which Oslo is a member, suggested at a meeting with the legislative committee that it should be possible in a new act to specify requirements concerning the use of shore power when ships arrive. The legislative committee has attempted to devise a technology-neutral act, precisely because technological development will nevertheless probably proceed more quickly than can be taken into account in a legal text. It would be unfortunate if there were to be any binding clauses in the legislation that could prevent such appropriate development.

NOU 2018:4 takes into account the fact that it may, for example, be appropriate to define requirements for energy infrastructure at ports, in that the committee has proposed a provision that gives the ministry the opportunity to define requirements for port operation on the basis of safety and environmental considerations.

Climate effects and other environmental effects: If the opportunity is given to define requirements concerning the use of new solutions established in terms of environmental technology, these will also take effect as desired; more quickly, and to a greater extent.

Duration of the measure: The City of Oslo is preparing a consultation statement for the new Ports and Fairways Act, with a consultation deadline of 15 June 2018. A request stating that a clear basis must be provided in the new act, so that demands can be made of shipping concerning the establishment of environmentally appropriate solutions such as connection to shore power, will be specified here on the part of the City Council.

9.3.8 Infrastructure for piloting autonomous ships



Description: This measure includes full-scale piloting of the port infrastructure necessary to allow one or more ships to operate autonomously out of the Port of Oslo. Emphasis is placed on compliance with established practice and standards from similar initiatives nationally (e.g. Yara Birkeland) and internationally.

Scope: The facility should allow at least one ship, or a transport route, to operate autonomously out of the Port of Oslo. This will include necessary infrastructure on land in the form of sensors and automatic mooring equipment, plus a route planner and management of cargo or passengers.

Phase-in plan: Efforts should be made as early as 2018 to identify a relevant stakeholder that would be willing to pilot autonomous operation out of or at the Port of Oslo. When a relevant stakeholder has been identified, targeted efforts should be made to establish infrastructure that paves the way for autonomous operation so that a pilot can be operational between 2019 and 2024.

Climate effects and other environmental effects: When designing an autonomous ship, it would be appropriate to equip the ship with electric propulsion systems, as these solutions normally require minimal maintenance and can be more readily controlled and monitored remotely. The actual environmental impact of such a pilot is very modest, but the ripple effect and experience acquired will be crucial for triggering potentially significant reductions in other large-scale concepts in the long term.

Duration of the measure: A successful pilot could be run for several years in order to gather the necessary experience and form a basis for larger and additional similar autonomous solutions. The fact that it should be possible to reuse the onshore infrastructure even beyond the lifetime of the pilot should be emphasised.

Costs: The costs for measures linked with such pilots are difficult to estimate as no similar concepts exist at present. Close consultation with Kongsberg and Yara, which developed "Yara Birkeland", is encouraged in order to devise good cost estimates.

Other measures/arrangements/instruments and other conditions:

The autonomous ship "Yara Birkeland" will be delivered in the second half of 2018 and is planned to operate autonomously between Herøya and Brevik as of 2020. This ship is 80 metres long, is fitted with a 7 MWh battery pack, has a maximum speed of 13 knots, is capable of carrying 120 containers and will transport 20,000 containers of artificial fertiliser each year from the factory at Herøya to the shipping ports at Brevik and Larvik. With this, the ship will replace 20,000 trailer journeys from Herøya that travel back empty. The total distance stands at around 1 million kilometres, with corresponding CO_2 emissions of 750 tonnes of CO_2/year.

A surface vessel for coastal product distribution is also being planned by a partnership involving Rakuten Institute of Technology (RIT) and Maritime Robotics (MR). The 22-metre-long concept ship K22, designed to carry two 20-foot containers (TEU), can operate autonomously and assessment of whether it should be built is currently in progress.

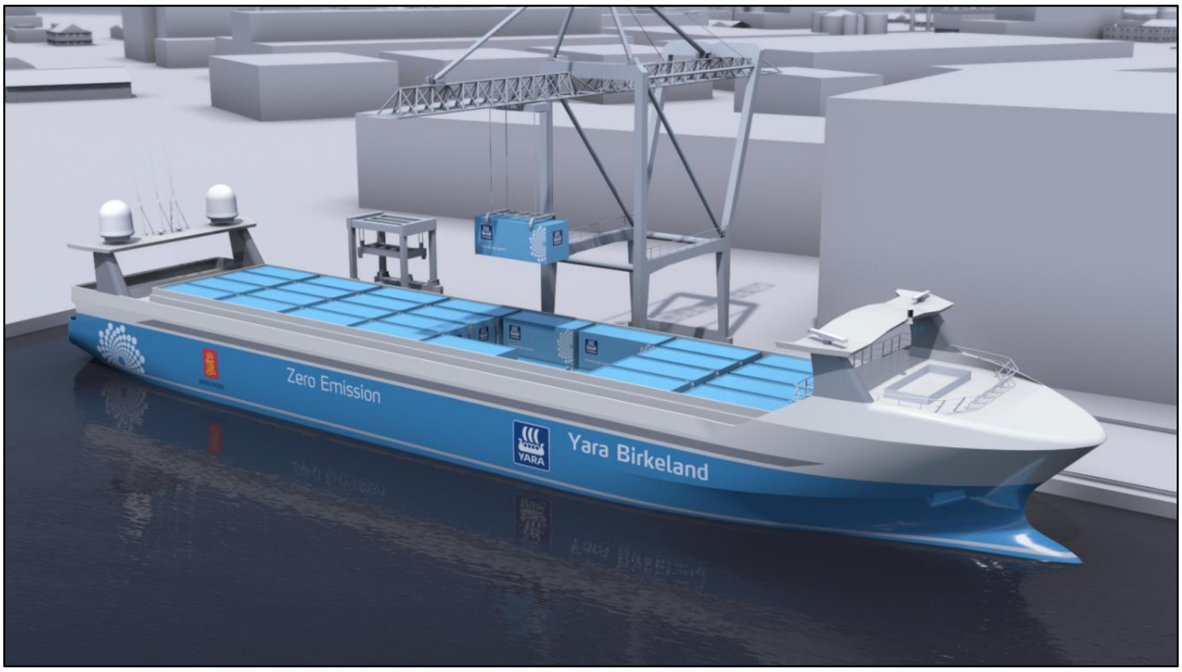


Figure 9-9: The autonomous ship "Yara Birkeland" will be delivered in the second half of 2018 and is planned to operate autonomously as of 2020 (Kongsberg, 2018).

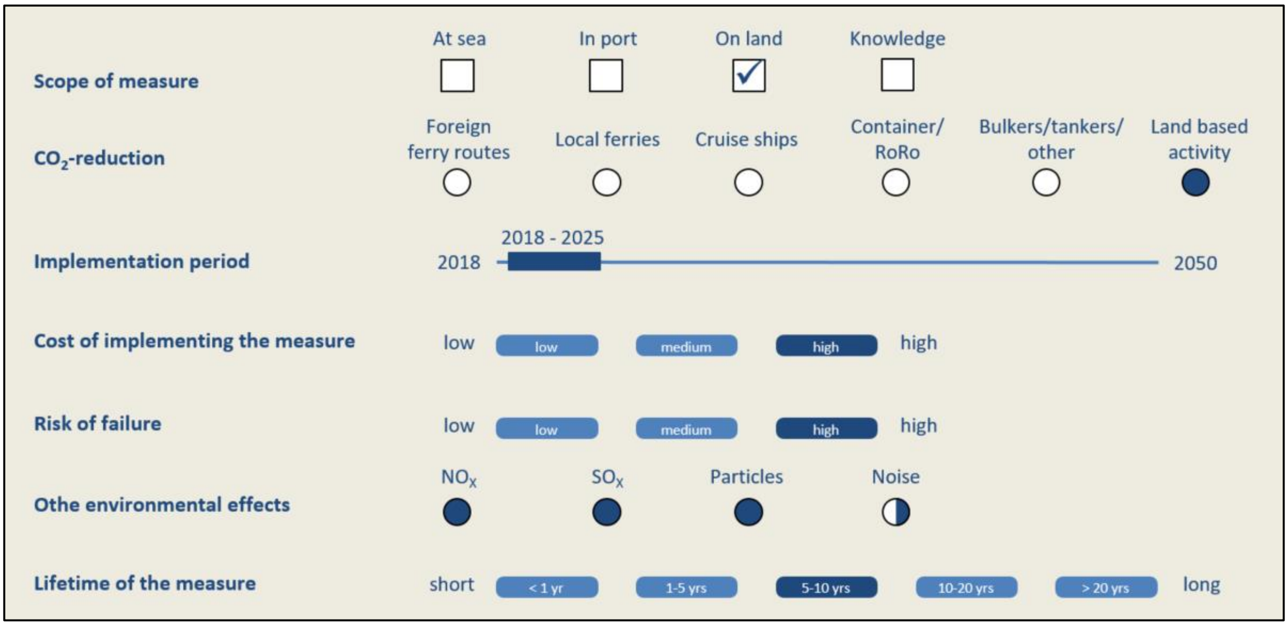
Figure 9-10: The 22-metre-long concept ship K22, designed to carry two 20-foot containers (Teknisk Ukeblad, 2018).

Responsible: The City of Oslo, via the Climate Agency and Oslo Port Authority, is carefully monitoring pilot project of this type via initiatives such as Grønt Kystfartsprogram, and this partnership will make it possible to learn, see and understand more clearly how Oslo can develop future solutions for maritime transport. Opportunities to implement such a pilot via Grønt Kystfartsprogram will also be considered.

Barriers to implementation:

- Limited funds and resources for implementing pilots
- Lack of routes/lines at the Port of Oslo that are appropriate for piloting autonomous concepts
- Unclear whether regulations for autonomous operation will be established for maritime activity at the Port of Oslo

9.3.9 Emissions-free activity when handling goods and freight at the Port of Oslo, and other activities on the port site



Description: This measure includes measures that together constitute a high level of emissions-free activity linked with the handling of freight and goods at the Port of Oslo, along with measures that contribute to a higher level of freight and goods processing on the port site in order to avoid unnecessary transport stages later on in the value chains.

1. **Emissions-free handling of freight and goods on the port site**. Use of electric cranes, forklift trucks and other load handling equipment in order to make onshore activities emissions-free. Sustainable biofuel – see section 8.4 – may be one alternative in an intermediate phase while waiting for zero-emissions solutions to be made available in segments where there is no satisfactory machinery in existence at present.
2. **Processing and secondary processing of cargo on the port site.** One important initiative to reduce the need for transport at the port and into and out of the port will involve making it possible for freight and goods arriving at the Port of Oslo to undergo processing and secondary processing on the port site, rather than being transported by road to a new location for secondary processing. Site measures at the port and measures that make it possible to implement operations that may involve noise, odour and dust on the port site may be measures that can assist with further processing of freight and goods.

Scope:

1. Emissions-free handling of freight and goods on the port site covers all activities and transport linked with the handling of goods that takes place internally on the port site. However, this does not include emissions from

loading and unloading operations handled by machinery and equipment on board ships. These emissions originate from the ships' respective machinery systems, which in most instances run on fossil fuels.

2. Processing of freight and goods includes a number of relevant types of goods that are currently transported from the port by truck/trailer for secondary processing outside Oslo, before then being returned to Oslo by road for use in the city centre.

   The transportation of spoil into and out of Oslo is one example of this. According to "Kunnskapsgrunnlag for mer klimavennlig næringstrafikk i Oslo" [Knowledge base for more climate-friendly commercial traffic in Oslo], a report issued by the Institute of Transport Economics in February this year, heavy goods vehicles operating in Oslo constitute a source of emissions of 75,500 tonnes of CO_2 equivalents per year. Heavy goods vehicles transported a total of 35 million tonnes of freight to or from Oslo, or internally within the city. Of this amount, transportation of spoil and waste accounted for almost 16.7 million tonnes, equivalent to almost half of the total amount transported. The transportation of spoil and waste is distributed over 870,000 journeys.

   Much of the spoil excavated in connection with construction and civil engineering operations in Oslo is sent to landfill in other counties. Disposal of spoil locally is one objective, along with its reuse in the local area where possible. A major contractor states that around 1 million tonnes of excavated spoil and demolition materials were transported out from Oslo two landfill sites in other municipalities in 2016. According to the contractor, this is equivalent to about 33,000 truckloads. The three biggest landfill sites – Aalerudmyra, Lindum-Egge and Esval miljøpark – are, on average, a distance of 46 km from central Oslo (one way). This transportation is a significant source of greenhouse gas emissions.

   Much of Oslo is close to the fjord. Solutions are in place to allow spoilt to be transported to the Port of Oslo for shipping to a landfill site close to the sea, or for further processing. Maritime transport will help to make the transportation of spoil more energy-efficient than if all spoil has to be transported by road. However, there is major potential for further expansion of this scope, and there are stakeholders wishing to develop recycling solutions at the Port of Oslo in combination with shipping. If transportation to and from the port can be made emissions-free while also guaranteeing extensive use of future hybrid cargo ships, transportation of spoil along the Oslofjord could help to reduce emissions significantly.

Figure 9-11: Terberg YT202-EV, terminal tractor with electric propulsion(Terberg, 2018).

Phase-in plan:

1. Emissions should be mapped for the 2018-2019 period, and a feasibility study should be implemented for the transition to zero-emissions solutions for machinery and equipment assisting with the handling of freight at the quay. Furthermore, a plan should be submitted in 2020 involving relevant stakeholders performing services at the port, for phasing in zero-emissions technology, and possibly biofuels during a transitional period, for the vehicle fleet. The Oslo Port Authority primarily wishes to see voluntary involvement of stakeholders in this, but it must also assess various instruments for encouraging stakeholders at the port to make the transition within a specified period.
2. The potential for reducing greenhouse gas emissions with local handling of rock debris, excavated spoil and demolition materials in connection with the port and maritime transport in the City of Oslo should be mapped in 2018. First, this study should reveal whether there are any existing landfill/recycling solutions close to the sea that could receive spoil from Oslo, or whether there are grounds to establish one or more such landfill/recycling solutions if they are not available at present. Depending on the results from this introductory survey, interest in a specific concept study and possibly a pilot project can be mapped. It should be possible to implement the study in 2018, and it may involve the Agency for Urban Environment, the Climate Agency, the Fornebu Line and the Oslo Port Authority.

Climate effects and other environmental effects:

1. The Oslo Port Authority has estimated that land-side activities account for around 7,500 tonnes of CO_2 a year. However, greenhouse gas emissions are significantly greater if transport flows to and from the port are included. Making activity at the port emissions-free will make it possible to reduce this

entire contribution to emissions by an estimated 7,500 tonnes of CO_2 per year in the long term. It will also be possible to cut NO_X, SO_X and PM in their entirety from this activity, along with a great deal of noise.

2. It will be possible to achieve major reductions in emissions by replacing the necessary transportation into and out of the port with more extensive use of separate areas for processing and secondary processing. It will be necessary to map the potential for reducing greenhouse gas emissions in order to quantify the scope.

   Your attention is drawn to the fact that reducing road transport into and out of the port will have no impact on the port's overall emissions level of 55,000 tonnes of CO_2 per year, as this is ascribed to emissions outside the port site.

Duration of the measure: All the measures proposed are considered to be permanent in the sense that subsequent solutions will be at least as ambitious in terms of climate, as long as the methods are maintained.

Costs:

1. Maritime Truck, which operates twelve terminal tractors under contract to Yilport at the Port of Oslo, states that electric terminal tractors of the relevant size cost about three times as much to buy as alternatives that run on fossil fuels (Terberg YT202-EV in Figure 9-11), not including any Enova funding. Furthermore, there are total savings of around NOK 1 million a year to be made in connection with reduced maintenance and fuel costs. It is anticipated that it will be possible to electrify other vehicles and machinery operating internally on the port site at a competitive price within a few years.
2. Arranging for processing of goods on the port site will be associated with low costs. Any costs will mainly be related to new areas or extended use of existing areas. At the same time, major operational savings will be made by reducing the need to transport goods by road.

Other measures/arrangements/instruments and other conditions: Enova will be able to support projects involving development of solutions for machinery-assisted handling of freight and goods that does not exist at present or is not widespread. Enova generally funds a maximum of up to 40 per cent of the additional costs associated with the investment, with some conditions.

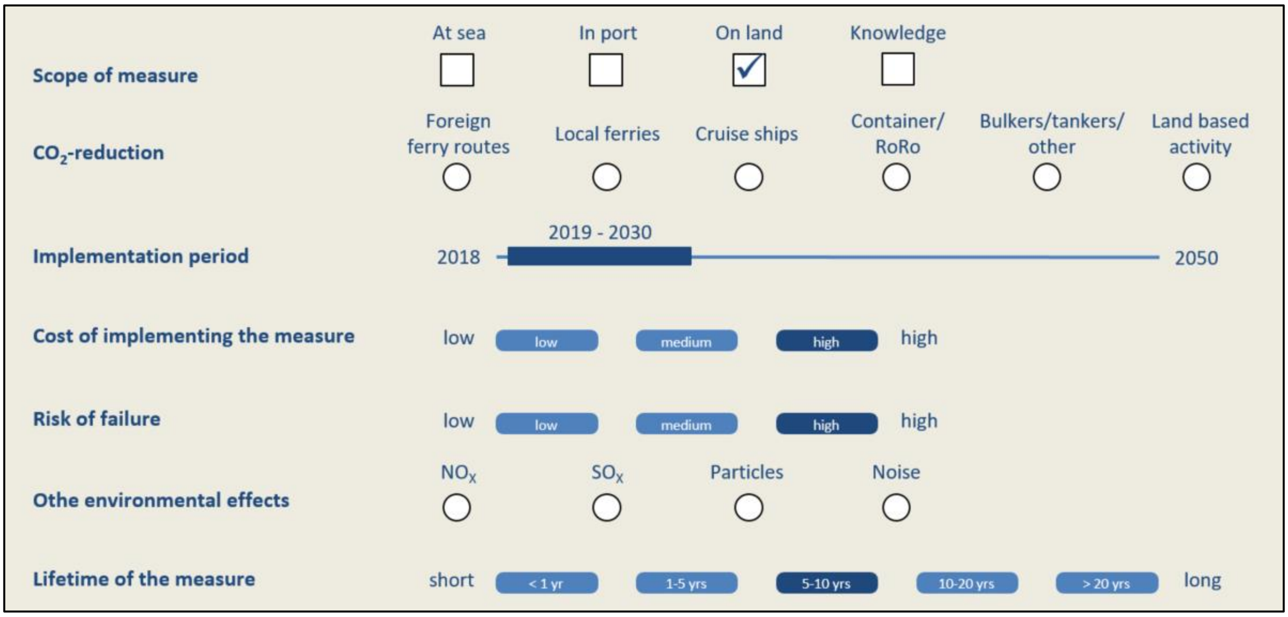
In connection with adjacent work within other municipal enterprises, work on processing goods at the port should be viewed in particular against the work done in packages of measures for “fossil-free building and construction sites in Oslo” and “more efficient and eco-friendly utility transport and transport of goods in Oslo”, as coordinated by the Climate Agency. These packages of measures will be completed in 2018 with a view to identifying, by 2020, new climate measures that will significantly reduce emissions.

Responsible: The Oslo Port Authority, in consultation with private stakeholders at the port, is responsible for further work on the concept and obtaining relevant partners.

Barriers to implementation:

- Zero-emissions technology for heavy vehicles is not available on the market at present, and current alternatives appear to be costly compared with present solutions that run on diesel, in a competitive market
- Limited funds and resources for implementing pilots
- Uncertainty with regard to the reliability and uptime offered by untested technological solutions
- Challenges associated with obtrusive activity at the port
- Restrictions in the potential use of port areas in general, linked with any resolutions pursuant to the Planning and Building Act

9.3.10 Emissions-free road transport routes to and from the Port of Oslo



Description: This measure includes emissions-free solutions for individual key transport routes where goods are transported by truck to and from the port. Sustainable biofuel (see section 8.4) will be one alternative in an intermediate phase while waiting for zero-emissions solutions to be made available in segments where there is no satisfactory equipment in existence at present. The description of measures is divided between (1) commercial transport routes to and from the port, and (2) transport services performed by the City of Oslo, or on behalf of the City of Oslo via municipal procurement procedures.

1. Emissions-free transport route for transportation of containers between the Port of Oslo and Alnabru. Various concepts have already been assessed and considered to be of interest for further investigation:
    a. Electric trucks specifically for the transportation of goods between the port and Alnabru. The concept can be designed with a loading option at the port, at Alnabru, or at both ends of the transport route. A survey has been carried out that maps opportunities and challenges involved in electrifying this transport route. PostenBring and CargoNet are involved in discussions with the Oslo Port Authority in order to concretise the project. Challenges identified include stringent uptime requirements and limited access to relevant zero-emissions technology for the trucks in question.
    b. The options for using an existing railway line to transport goods between the port and Alnabru have also been investigated. There is a railway track between Sydhavna/Sjursøya and Alnabru. The part of the track located on the port site is private, and the port owns the infrastructure for this part, which is not electrified. The line continues as a public track via the Bane Nor station in Lodalen and up Brynsbakken to Alnabru.

The railway track is currently used for transporting aviation fuel to Gardermoen, with an average of one departure per day. The train is pulled by a diesel locomotive to Lodalen, and then by an electric locomotive on to Gardermoen.

To be able to use this section for transporting freight, however, it will be necessary to reserve rail capacity on a section of track and tunnel that is already under pressure. Challenges associated with a lack of commercial conditions for the railway to become competitive have also been pointed out.

As regards transportation by rail between the Port of Oslo and Alnabru, a concept study should be carried out that visualises the realism and emphasises the advantages and disadvantages of a solution of this kind. This should be done for the 2018-2019 period so that it is possible to assess rail transport against transport using electric trucks.

Options for combining transport using electric trucks and use of the railway in order to make transportation more robust yet also less volume-intensive for the modes of transport in question should also be assessed.

The Oslo Port Authority as previously considered the options for electrifying the track: electrifying the track all the way down to the port has been considered challenging. This would possibly require relocating the fuel filling plants, as well as demolishing buildings and relocating the track in order to prevent conflicts between road traffic and the railway line.

2. **Use of a new municipal procurement strategy** to encourage the purchase of emissions-free transport services procured by the City of Oslo itself in the areas in and around the port

    a. The City of Oslo purchases large volumes of waste from the United Kingdom that are transported by sea to the Port of Oslo before being transported by road to Klemetsrud. Ash from the waste incineration plants at Klemetsrud and Haraldrud is then transported for sorting in Moss and then on to landfill. This transport chain, which currently operates using conventional trucks, could potentially be combined and electrified by establishing the necessary charging infrastructure between the Port of Oslo and Klemetsrud and Haraldrud, and establishing dedicated vehicles for the routes in question.

    b. The City of Oslo wishes to establish carbon capture facilities at Klemetsrud. A plant of this kind would require transportation of large volumes of CO_2 from the Klemetsrud plant. Establishing an emissions-free transport route between Klemetsrud and the Port of Oslo will allow further efficient transportation of CO_2 by sea from the Port of Oslo to the relevant recipient/landfill site. To transport CO_2 between Klemetsrud and the Port of Oslo, both electric vehicles and vehicles that run on hydrogen may be of relevance. However, running on hydrogen should be viewed against an overall hydrogen requirement in the area/region in order to make the concept cost-effective. A pipeline to the port is being assessed in this context.

c. Other municipal procurement procedures involving transportation to/from the Port of Oslo. If the municipality demands fossil-free/zero-emissions transport services from its subcontractors, this may significantly reduce greenhouse gas emissions, but above all help to bring about a larger market for fossil-free fuel. One example of a procurement procedure of this type may be the Agency for Urban Environment's use of the "Terje" snow melting system, which is located on a barge at Vippetangen. There was a great deal of truck activity through the city and down to the port throughout the winter of 2017/2018, when a lot of snow fell.

Scope:

1. This measure covers the transportation of goods between the Port of Oslo and Alnabru that are currently transported using trucks that run on diesel, and possibly other similar transport routes with significant transport volumes and predictable operation.
2. The measure covers all transport taking place to and from the Port of Oslo via City of Oslo procurement procedures. This may include the transportation of refuse between Alnabru and Klemetsrud/Haraldrud and other, similar municipal transport requirements based on the port.

Phase-in plan:

1. A final decision on selection of a concept for container transport on the Port of Oslo-Alnabru section must be made before the summer of 2019.
2. The City of Oslo's procurement strategy includes all purchases made by the City of Oslo. This means that all new procurement procedures taking place as of 2018 should follow the strategic guidelines indicating that "in all its planning of procurement procedures, the city must operate on the basis of its objective of becoming an emissions-free city". This means both procurement procedures for its own equipment and when purchasing transport services.

Climate effects and other environmental effects:

1. In the survey carried out in order to map the opportunities provided by electrifying container transport between the Port of Oslo and Alnabru, by using either electric trucks or the railway, potential has been identified for replacing 60,000 annual journeys by road, equivalent to 1,600 tonnes of CO_2 per year, and around 5 tonnes of NO_X per year. Similar figures will be achieved if a transition is made to the railway. The CargoNet pilot involving two electric tractor units replacing fossil trucks corresponds to a reduction of 135 tonnes of CO_2 per year and 0.4 tonnes of NO_X per year.
2. No detailed climate calculations have been carried out with regard to the use of a new municipal procurement strategy to encourage the purchase of

emissions-free transport services procured by the City of Oslo itself in the areas in and around the port To electrify the transportation of CO_2 in the event of potential carbon capture at Klemetsrud, a reduction of 500 tonnes of CO_2 per year and 1.4 tonnes of NO_X per year compared with fossil alternatives has been estimated.

Duration of the measure: All the measures proposed are considered to be permanent in the sense that subsequent solutions and contracts will be at least as ambitious in terms of climate.

Costs:

1. The cost scenario on electrification of tractor units of this type is uncertain, as the technology must provisionally be viewed as immature and limited in this segment. The estimated figures indicate an additional cost of around 1 MNOK for each vehicle of this type. Furthermore, charging infrastructure must be established at one or both ends.

   If a transition to transport by rail is made, there is an estimate need for major investments in order to transfer container transport to the railway. This includes rental of trains and track capacity. However, costs for handling the freight to and from the railway at both ends will also be expected.

2. No detailed cost calculations have been carried out with regard to the use of a new municipal procurement strategy to encourage the purchase of emissions-free transport services procured by the City of Oslo itself in the areas in and around the port

Other measures/arrangements/instruments and other conditions:

Enova will be able to support projects involving development of solutions for machinery-assisted handling of freight and goods that does not exist at present or is not widespread. Enova generally funds a maximum of up to 40 per cent of the additional costs associated with the investment, with some conditions.

In connection with adjacent work within other municipal enterprises, work on processing goods at the port should be viewed in particular against the work done in packages of measures for “fossil-free building and construction sites in Oslo” and “more efficient and eco-friendly utility transport and transport of goods in Oslo”, as coordinated by the Climate Agency. These packages of measures will be completed in 2018 with a view to identifying, by 2020, new climate measures that will significantly reduce emissions.

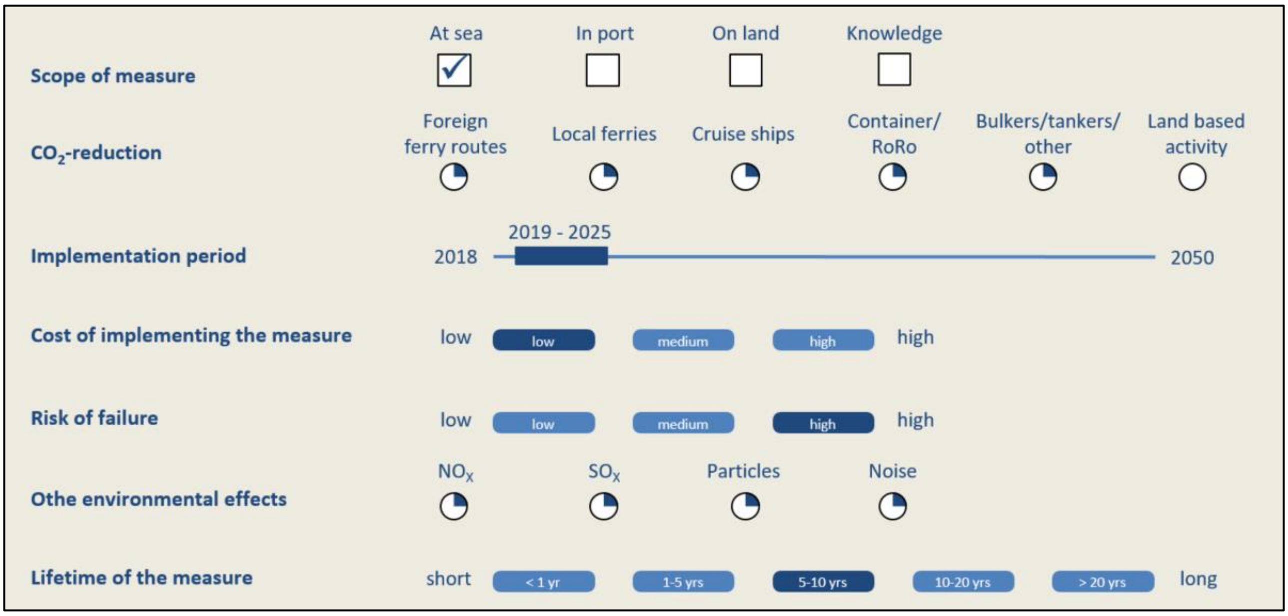
Responsible:

The Oslo Port Authority, in consultation with private stakeholders at the port, is responsible for further work on the concept and obtaining relevant partners.

Barriers to implementation:

- Lack of zero-emissions technologies for heavy vehicles
- Limited funds and resources for implementing pilots
- Unclear regulations and conditions for future funding schemes
- Reliability and uptime, which may mean a need for more vehicles in order to offer similar services to those available at present
- Capacity restrictions in terms of the current railway solution

9.3.11 Bonus for ships operating at reduced speed and investigation of the effect of speed limits for commercial shipping using fossil propulsion systems



Description: This measure includes a bonus scheme for ships that operate at considerably lower speeds than at present. There is no speed limit for ships travelling in the Oslofjord initially, just in areas 100 metres from shore. In practice, larger ships reduce their speed when passing Drøbak, while other small boats maintain high speeds in the City of Oslo’s sea area as well.

The shipping companies are very keen to save fuel, and their entire sailing routes are planned carefully to ensure the greatest possible reduction in fuel. Color Line, for example, has stated that reducing speed when a ship enters shallower waters saves a lot of fuel. This is because the ship experiences a great deal of resistance in shallower waters and requires more power for propulsion.

Changing speed limits from “Approach to Oslo” will involve consultation with the Norwegian Coastal Administration, which has authority over the area.

Reducing speed is a very effective way of reducing emissions from shipping. This measure is considered to be the most significant reason for the decline in greenhouse gas emissions from international shipping over the past few years. The impetus for the propagation of the measure in international shipping is linked with the price of fuel.

The specific effect on reduction of greenhouse gas emissions as a result of reducing speed can be calculated easily for a single ship. The ratio of speed to consumption is defined by a precise formula, but it will vary depending on the type of ship and the shape of the ship’s hull. Roughly, this ratio can be expressed by saying that the energy requirement is a function of speed to the power of three. In other words, reducing speed by 10 per cent will save approx. 25 per cent energy, while reducing speed by 20 per cent will save approx. 50 per cent energy.

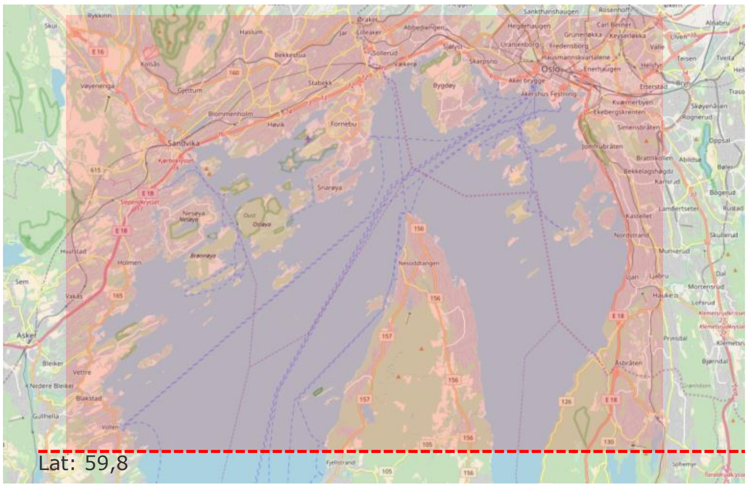


Figure 9-12: The boundary for "Approach to Oslo", south of Steilene at Nesodden

Scope: The bonus scheme could be applicable to all commercial traffic within "Approach to Oslo" (see Figure 9-12).

Phase-in plan: In 2018, a proposal may be sent out for consultation in order to investigate the scope for action for introduction of a bonus scheme of this kind in the inner Oslofjord. The effects of such an adjustment should also be examined; and if this is successful, piloting of the scheme should be arranged for the period 2020-2024, gathering experiences and making necessary adjustments. The fact that the scheme will be applicable should be communicated in plenty of time before it comes into force. Introduction of the scheme as of 2025 is recommended.

Climate effects and other environmental effects: Reducing speed may potentially result in major savings. A reduction of around 5-10 per cent of all emissions within the "Approach to Oslo" area, equivalent to 1,000 – 1,500 tonnes of CO_2 per year, is viewed as realistic. Some ships following timetables could potentially make up lost time from operation within the "Approach to Oslo" area by either remaining at the port for less time or maintaining higher speeds outside the "Approach to Oslo" area. The latter measure may potentially lead to higher CO_2 emissions for the journey overall. However, emphasis is placed on the fact that ships will invest in zero-emissions technology if reducing speed in the area is considered to be a challenge.

Duration of the measure: Adjusting the speed of ships is expected to have a lasting effect.

Costs: Costs could be accrued by parts of the shipping industry that are dependent on regular scheduled services. For some routes, reducing the speed may mean the need to increase capacity in the form of larger or additional ships.

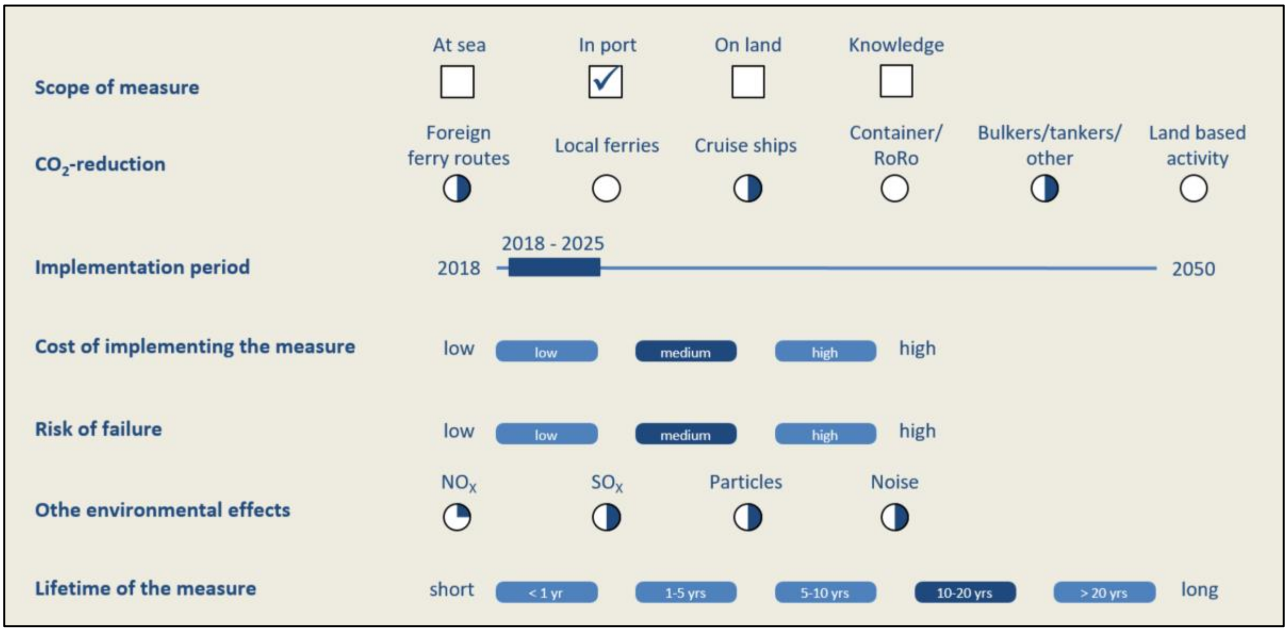
Other measures/arrangements/instruments and other conditions: The Norwegian Maritime Authority is considering a number of potential measures to reduce emissions from shipping at the fjords on the World Heritage List. One of the proposals involves reducing speeds on entry to and exit from the fjords. An analysis carried out by DNV GL shows that cruise ships and ships operating on express services are able to reduce emissions significantly if they reduce their speed from the current 14-16 knots to around eight knots. For large ships, a certain speed will be required in order to maintain manoeuvrability.

Responsible: The Department of Business Development and Public Ownership in consultation with the Oslo Port Authority is responsible for further work on the measure.

Barriers to implementation:

- A lack of opportunities for amendments to the regulations, requiring consultation with the Norwegian Coastal Administration/Norwegian Maritime Authority
- Significant speed increase is outside the “Approach to Oslo” area, with an increase in total emissions as a result

9.3.12 Adaptation in order to meet the steam requirements of relevant ship types at the port when using renewable alternatives



Description: This measure includes adaptation in order to meet the steam requirements of relevant ship types at the port when using renewable alternatives A feasibility study should be carried out in order to examine the technical and financial aspects of linking ships with significant steam requirements when docked to renewable solutions at the port in order to replace the use of oil-fired boilers on board the ships.

The most relevant solutions are considered to be:

1) **Shore power for use for electric steam boilers on board:** The powerful shore power system planned for Vippetangen in 2018 has already been dimensioned to cover the need for both electricity and heating. The shore power system at Hjortnes has to be upgraded in order to meet both of these needs. In both instances, ships have to be adapted for electric boilers. This may be costly for other potential shipping types with major steam requirements, tankers and – to an extent – container ships that do not have developed shore power.

2) **Linking to the existing Oslo district heating network:** Using the district heating solution will fully replace the operation of fossil-fired or electric boilers at the quayside by means of heat exchange with the water in the district heating network with the internal circuit on board the ship. Emphasis should be placed on opportunities for joint use of district heating in port areas with any buildings that could also make use of the infrastructure.

Scope: The feasibility study should not be restricted to individual ships or segments, but should consider all relevant ships calling at the Port of Oslo. Furthermore, ships and segments offering the greatest potential should be identified, while also viewing this in relation to the scope of the necessary development of the shore power/district heating network at the terminals in question. Opportunities for cooperation with other ports facing similar challenges should also be considered in order to create a larger experience base for solutions of this kind.

The Norwegian Coastal Administration’s next multifunctional vessel, to be delivered in autumn 2018, uses innovative boiler solutions. This ship is equipped with a “thermos solution” where the surplus heat from the ship’s main engines is stored in a “thermos” over the course of the working day. When the ship is then docked, the stored thermal energy is used instead of a traditional boiler to heat the crew area. The ship also has electric steam boilers that can run on shore power when docked.

Figure 9-13: The Norwegian Coastal Administration’s “OV Ryvingen”, to be delivered in autumn 2018, has a range of innovative solutions installed on board, including a plug-in hybrid propulsion system, a “thermos” for providing steam and Electric steam boilers (Teknisk Ukeblad, 2018).

Stena Line currently has a functioning district heating system in Gothenburg, where “Stena Danica” has been connecting to the city’s district heating network since the facility became available in 2014, in order to meet the need for heating on board the ship. Stena Line has invested around NOK 1 million in the project, in addition to the EU funding awarded. Stena Line states that the investment will have paid for itself in a few years on account of its savings on fuel.

Figure 9-14: Connection of the district heating solution on the docked “Stena Danica” in order to replace the use of diesel in oil-fired boilers (Norsk Fjernvarme, 2018).

Duration of the measure: Establishment of a system of this kind is expected to have a long-term effect.

Phase-in plan: Work on the feasibility study should take place in 2018 so that work on relevant pilots can be initiated in 2019 in order to gather the necessary experience before working towards greater penetration, where applicable. As of 2025, relevant shore power and district heating systems should be established for ships and segments with significant potential for reduction of emissions.

Climate effects and environmental effects: If a district heating connection is established for foreign ferry routes, cruise ships and relevant tankers and container ships with major steam requirements, a CO_2 reduction of around 3,500 tonnes of CO_2 per year is estimated. This measure will also help to reduce greenhouse gas emissions by around 50 per cent at the port, and also reduce local emissions. NO_X emissions will be reduced to a slightly lesser extent as boilers have a considerably lower NO_X factor than conventional internal combustion engines for maritime use. The measure will also reduce noise in an area occupied by a lot of people and characterised by tourism.

Costs:

The costs associated with the implementation of a general feasibility study are considered to be marginal. The costs for establishing a highly dimensioned shore power system and developing the district heating infrastructure at the quay are uncertain and should be investigated in the feasibility study.

Other measures/arrangements/instruments and other conditions:

The ReCharge project has previously identified costs for both the onshore infrastructure and aboard ships for establishing shore power at each of the terminals at the Port of Oslo. However, this investigation does not take into account the dimensioning of the system if the steam requirement is to be covered by shore power. Any system contributions from Hafslund Nett if the power grid down to the port and quays has to be extended have not been taken into account either.

Options for a district heating system for maritime use at Vippetangen have been investigated previously. The conclusion at the time was that district heating would be assessed in greater detail in the event of further plans and development of Vippetangen as an area, and must be viewed in context with urban development in general. Emphasis was placed on the fact that the ships using the solution would have a relatively short service life and that any development of the district heating network should therefore include users other than just maritime stakeholders.

Responsible:

Enova, DNV GL, Norsk Fjernvarmeforening [the Norwegian District Heating Association], the Oslo Port Authority and the Climate Agency in the City of Oslo are responsible for implementation of a feasibility study for a district heating connection. The City of Oslo, including the Oslo Port Authority, is responsible for any further work following the feasibility study, in consultation with relevant partners at the port.

Barriers to implementation:

- No guarantees as regards use of the systems as the ships themselves will choose when they are to use the solutions
- Costly investments at the port
- The need for district heating at the port is viewed in context with other buildings and plans for further urban development, e.g. at Vippetangen

10 ANALYSIS AND CONCLUSION

Port of Oslo

The Port of Oslo is the largest public freight and passenger port in Norway and is one of the bigger Norwegian ports in terms of emissions. Reducing emissions at the Port of Oslo will be key to compliance with both municipal and national targets. While efforts are being made to reduce emissions from port-related activities, increasing maritime traffic benefits the environment. Maritime traffic reduces greenhouse gas emissions by more than half compared with road transport, and so reducing emissions for shipping has to be balanced in order to achieve good, consistent climate solutions.

Emissions

The Port of Oslo is responsible for around 55,000 tonnes of CO_2e per year. This constitutes 4 per cent of total emissions of 1,280,000 tonnes of CO_2e per year in the City of Oslo (Figure 10-1). The greatest sources of emissions from the port are foreign ferry routes, accounting for around 40 per cent of greenhouse gas emissions, followed by shore activities linked with cargo handling and transport on the port site (14 per cent) and local ferries that form part of the Ruter public transport offering (12 per cent).

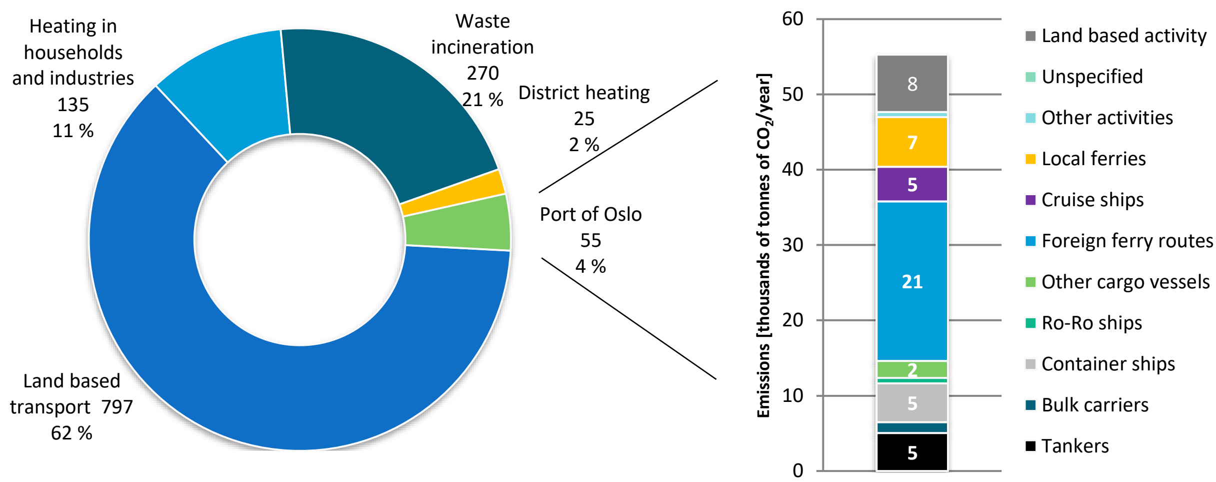


Figure 10-1: Distribution of greenhouse gas emissions in Oslo, per sector [thousands of tonnes of CO_2e/year] and [%], and distribution of greenhouse gas emissions per shipping segment [thousands of tonnes of CO_2e/year] within the Port of Oslo.

Measures

The measures discussed in the action plan are intended to provide an assessment of the potential for reduction of greenhouse gases, and the technical and economic aspects of each individual measure are highlighted at the same time.

The action plan includes 17 measures divided into three main groups:

- **Measures that should be continued (3 measures):** Measures that currently exist and should be continued with equivalent or greater focus over the next few years in order to maintain the effect of the measure in question.
- **Measures that should be reinforced (2 measures):** Measures that currently exist, wholly or in part, but that require greater focus and prioritisation over the next few years in order to trigger the collective potential of the measure.
- **Recommendations for new measures (12 measures):** Measures that do not exist at present but that need to be implemented in order to achieve the ambition of turning the Port of Oslo into a zero-emissions port in the long term.

Table 10-1 shows the recommended measures for the action plan divided into groups of measures, implementation time and estimated greenhouse gas reduction.

Table 10-1: Recommended measures in the action plan, by groups of measures, phase-in time and estimated impact

	ID	Description of measure	Phase-in time	Estimated reduction [tonnes of CO_2/year] and [% red.]
Measures that should be continued	9.1.1	Environmental differentiation of port fees in order to reward low-emissions ships via the Environmental Ship Index (ESI)	2018 - 2020	800 / 1%
	9.1.2	City of Oslo as a member of Grønt Kystfartsprogram [the Green Coastal Shipping Programme]	2018	-
	9.1.3	Update and revise the action plan for the Port of Oslo as a zero-emissions port and incorporate the measures in the climate budget	2019 - 2021	-
Measures that should be	9.2.1	Shore power for foreign ferry routes	2018 - 2020	2,300 / 4%
	9.2.2	Cooperation with other cruise ports with a view to defining collective requirements relating to shore power and other environmental measures, with Oslo taking on a proactive role	2018 - 2025	2,700 / 5%
Recommendations for new measures	9.3.1	Oslo is a driving force for moving more freight from the roads to the sea, and is working to implement equal environmental requirements for maritime transport throughout the Oslofjord in its entirety	2019 - 2030	-
	9.3.2	Emissions-free operation for Nesoddbåtene (route B10)	2018 - 2019	4,200 / 8%
	9.3.3	Emissions-free operation for Ruter express services (routes B11 and B20-B22)	2019 - 2024	2,300 / 4%
	9.3.4	Emissions-free operation for the Øybåtene service	2018 - 2021	-
	9.3.5	Requirement for zero-emissions solutions for foreign ferry routes with effect from 2025 if new routes are established, if existing routes are put out to tender, where contracts are renewed or where permitted by the situation	2018 - 2025	16,600 / 30%
	9.3.6	Environmental differentiation of port fees in order to reward docked low-emissions ships via the Environmental Port Index (EPI)	2018 - 2020	900 / 2%
	9.3.7	Establish communication with national authorities for amendment of the Act relating to ports and fairways so that requirements can be defined for zero-emissions solutions when docked	2018 - 2024	4,800 / 9%
	9.3.8	Infrastructure for piloting autonomous ships	2019 - 2024	-
	9.3.9	Emissions-free activity when handling goods and freight at the Port of Oslo, and other activities on the port site	2018 - 2025	7,500 / 14%
	9.3.10	Emissions-free road transport routes to and from the Port of Oslo	2018 - 2030	-
	9.3.11	Bonus for ships operating at reduced speed and investigation of the effect of speed limits for commercial shipping using fossil propulsion systems	2019 - 2025	1,300 / 2%
	9.3.12	Adaptation in order to meet the steam requirements of relevant ship types at the port when using renewable alternatives	2018 - 2025	3,500 / 6%
Total			**-**	**46,700 / 85%**

Important measures towards the objective of achieving a zero-emissions port in the long term

Even if all 17 measures help – either directly or indirectly – to make the port emissions-free in the long term, some measures are particularly crucial in order to approach the potential of an 85 per cent reduction.

Reducing emissions from foreign ferry routes (5 ships) and local ferries (10 ships), while also making operations on the port site emissions-free, will reduce emissions by about two-thirds. Measures in respect of the segments appear to be the three most important in the action plan, and implementation of these in the period up to 2030 is viewed as realistic.

About half of the emissions come from operations when ships dock. A major element of these emissions could be reduced cost-effectively by means of shore power development at the quayside and aboard ships. This should be prioritised for ship types where a relatively small number of ships are responsible for a large proportion of emissions when docked.

Maritime transport and ports are part of an international freight network and can help to halve transport sector greenhouse gas emissions if more freight is transferred from road to sea. Transport by sea has lost out to road transport over the past 50 years. More freight has to be transferred from road to sea in order to reduce global greenhouse gas emissions from the transport sector. Therefore, the action plan also focuses on ensuring that more people are able to request and demand transportation of freight that is as efficient as possible; and in many instances, this will involve public services by sea. Attention is drawn to the fact that this potential may increase local greenhouse gas emissions from shipping in Oslo due to an increase in activity, although it will be a very effective climate measure on a global scale.

A previous target involving a 50 per cent reduction in emissions from sea operations by 2030 was defined previously. The 85 per cent reduction in greenhouse gases as identified in the action plan is highly ambitious for a multipurpose port like Oslo, with more than 300 unique ships arriving each year. Some ships dock just once or twice a year, and these can hardly be approximated using the port’s instruments. It is therefore crucial for the highest-priority measures to focus on the biggest sources of emissions and facilitate the most cost-effective solutions.

11 REFERENCES

DNV GL. (2016). *Klimaeffekter ved overføring av gods fra vei til sjø.*

DNV GL. (2016). *Reduksjon av klimagassutslipp fra norsk innenriks skipsfart.*

DNV GL. (2016). *Samfunnsøkonomisk vurdering av tilskudd til miljøtiltak i havner.*

DNV GL. (2017). *Global sulphur cap 2020.*

DNV GL. (2017). *ReCharge - Analysis of charging and shore power infrastructure in Norwegian ports.*

DNV GL. (2017). *Study on the Use of Fuel Cells in Shipping.*

DNV GL. (2018). *Analyse av tiltak for reduksjon av klimagassutslipp fra innenriks skipstrafikk.*

DNV GL. (2018). *IMO NOx Tier III requirements to take effect on January 1st 2016*. Hentet fra https://www.dnvgl.com/news/imo-nox-tier-iii-requirements-to-take-effect-on-january-1st-2016-51970

DNV GL. (2018). *LNGi status update.*

DNV GL. (2018). *Miljørapportering Oslo Havn.*

Flowchange. (2017). *Mulighetsstudie: Elektrifisering av tungtransport.*

Klimaetaten, O. k. (2017). *Klimabudsjett 2018 - Faggrunnlag og vurdering av potensiale for reduksjon av klimagassutslipp.* Oslo.

Kongsberg. (2018). *Autonomous ship project, key facts about YARA Birkeland*. Hentet fra https://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/4B8113B707A50A4FC125811D00407045?OpenDocument

Kvaver. (2018). *http://kvaver.com/index.php/explore/recommend/vessel-traffic-online-ais*. Hentet fra http://kvaver.com/index.php/explore/recommend/vessel-traffic-online-ais

Lipasto, V. (. (u.d.).

Norsk Fjernvarme. (2018). *Stena Danica varmes med fjernvarme*. Hentet fra http://fjernvarme.no/index.php?pageID=29&openLevel=4&cid=3254

NOx-fondet. (2018). *NOx-fondets infomøter.*

Oslo havn. (2016). *Årsberetning 2016.*

Oslo havn. (2017). *Faktragrunnlag og HAVs vurdering knyttet til klimastrategien.*

Oslo Havn. (2017). *Klimastrategi for Oslo havn.*

Oslo kommune. (2016). *Klima- og energistrategi for Oslo.*

Oslo, B. (2016). Sak 260 Strategi for bruk av elektriske ferger i Oslofjorden og tilrettelegging av landstrøm.

Ruter. (2017). *Årsrapport 2017.*

SSB. (2016). *Lastebilundersøkelsen.*

SSB. (2017). *Utslipp og opptak av klimagasser.*

SSB. (2018). *Utslipp av forsurende gasser og ozonforløpere*. Hentet fra http://www.ssb.no/natur-og-miljo/statistikker/agassn/

Teknisk Ukeblad. (2018). Hentet fra https://www.tu.no/artikler/japans-svar-pa-amazone-til-trondheim-skal-knekke-kode-for-selvkjorende-skip-med-ai-og-big-data/432690?key=k5oEhYXW

Teknisk Ukeblad. (2018). *Kystverkets nye oljevernskip*. Hentet fra https://www.tu.no/artikler/fikk-massiv-kritikk-etter-de-forrige-bestillingene-kystverkets-nye-skip-blir-hybrid-og-bygges-i-norge/375861

Terberg. (2018). Hentet fra http://www.terbergbenschop.nl/en/products/tractors/yard-tractors/yt202-ev/

TØI. (2015). *Strategi for 50 % redusert miljøgassutslipp fra varedistribusjon i Oslo innen 2020.*
TØI. (2017). *Marginale eksterne kostnader ved havnedrift.*
TØI. (2018). *Kunnskapsgrunnlag for mer klimavennlig næringstrafikk i Oslo.*

12 APPENDICES

12.1 Appendix 1 – Characteristics and summary of emissions per shipping segment and size at the Port of Oslo (in tables)

Table 12-1: Average age per shipping and size segment for ships operating at the Port of Oslo in 2017.

Average age [years]	Size [Gross tonnes[9]]							
Ship type	< 1000	1,000 – 4,999	5,000 – 9,999	10,000 – 24,999	25,000 – 49,999	50,000 – 99,999	>= 100,000	Total
01 – Tankers	19	10	15	12	7	42		**15**
02 – Dry bulk carriers	49	19	7					**31**
03 – Lo/Lo container ships		20	12	11	19			**16**
04 – RoRo car carriers		48		20	34			**34**
05 – Other cargo ships	54	32	11	6				**26**
06 – Foreign ferry routes					29	11		**20**
07 – Cruise ships		42		29	23	11	7	**22**
08 – Local ferries	17	8						**13**
09 – Other	47	32	42					**43**
Total	**43**	**27**	**15**	**15**	**20**	**21**	**7**	**28**

Table 12-2: Operating hours per shipping and size segment for ships operating at the Port of Oslo in 2017.

Operating hours [hours]	Size [gross tonnes]							
Ship type	< 1000	1,000 – 4,999	5,000 – 9,999	10,000 – 24,999	25,000 – 49,999	50,000 – 99,999	>= 100,000	Total
01 – Tankers	41	731	1,402	1,766	74	14		**4,028**
02 – Dry bulk carriers	147	1,231	1,325					**2,703**
03 – Lo/Lo container ships		750	3,320	1,616	14			**5,700**
04 – RoRo car carriers		32		876	57			**966**
05 – Other cargo ships	5,626	13,582	2,258	62				**21,529**
06 – Foreign ferry routes					4,311	1,946		**6,257**
07 – Cruise ships		52		93	468	570	335	**1,518**
08 – Local ferries	33,314	25,664						**58,978**
09 – Other	22,902	263	1					**23,166**
Unspecified	100,203							**100,203**
Total	**162,233**	**42,306**	**8,306**	**4,412**	**4,924**	**2,530**	**335**	**225,046**

[9] GT, Gross Tonnage, is the target for the volume of all used, enclosed spaces aboard a ship and represents the size/volume of the ship.

Table 12-3: CO_2 emissions per shipping and size segment for ships operating at the Port of Oslo in 2017.

CO_2 emissions [tonnes of CO_2/year]	Size [gross tonnes]							
Ship type	< 1000	1,000 – 4,999	5,000 – 9,999	10,000 – 24,999	25,000 – 49,999	50,000 – 99,999	>= 100,000	Total
01 – Tankers	112	583	1,841	2,416	138	19		5,109
02 – Dry bulk carriers	10	200	1,241					1,451
03 – Lo/Lo container ships		206	3,170	1,820	16			5,214
04 – RoRo car carriers		3		700	29			733
05 – Other cargo ships	289	1,069	880	32				2,271
06 – Foreign ferry routes					12,335	5,227	0	17,562
07 – Cruise ships		16		186	1,291	1,808	1,403	4,704
08 – Local ferries	2,741	7,973						10,714
09 – Other	723	45						768
Unspecified								
Total	3,879	10,096	7,139	5,157	13,813	7,057	1,400	48,542

Table 12-4: NO_X emissions per shipping and size segment for ships operating at the Port of Oslo in 2017.

NO_X emissions [kg of NO_X/year]	Size [gross tonnes]							
Ship type	< 1000	1,000 – 4,999	5,000 – 9,999	10,000 – 24,999	25,000 – 49,999	50,000 – 99,999	>= 100,000	Total
01 – Tankers	267	3,798	11,951	18,531	673	267		35,486
02 – Dry bulk carriers	38	1,637	13,042					14,717
03 – Lo/Lo container ships		1,312	13,863	9,635	90			24,899
04 – RoRo car carriers		20		4,328	224			4,572
05 – Other cargo ships	918	8,360	6,544	287				16,109
06 – Foreign ferry routes					47,842	64,489		####
07 – Cruise ships		197		1,155	9,799	16,407	12,391	39,949
08 – Local ferries	4,912	11,332						16,245
09 – Other	5,574	472	1					6,047
Unspecified								0
Total	11,709	27,128	45,401	33,935	58,627	81,163	12,391	270,355

Table 12-5: SO_X emissions per shipping and size segment for ships operating at the Port of Oslo in 2017.

SO_X emissions [kg of SO_X/year]	Size [gross tonnes]							
Ship type	< 1000	1,000 – 4,999	5,000 – 9,999	10,000 – 24,999	25,000 – 49,999	50,000 – 99,999	>= 100,000	Total
01 – Tankers	69	363	1,148	1,507	87	13		3,187
02 – Dry bulk carriers	7	125	774					906
03 – Lo/Lo container ships		129	1,979	1,135	12			3,255
04 – RoRo car carriers		2		436	17			456
05 – Other cargo ships	180	666	550	21				1,416
06 – Foreign ferry routes					7,694	5,607		13,302
07 – Cruise ships		12		117	806	1,127	849	2,911
08 – Local ferries	1,710	0						1,710
09 – Other	397	28	1					426
Unspecified								0
Total	2,363	1,326	4,452	3,216	8,615	6,748	849	27,568

Table 12-6: PM emissions per shipping and size segment for ships operating at the Port of Oslo in 2017.

PM emissions [kg of PM/year]	Size [gross tonnes]							
Ship type	< 1000	1,000 – 4,999	5,000 – 9,999	10,000 – 24,999	25,000 – 49,999	50,000 – 99,999	>= 100,000	Total
01 – Tankers	60	255	822	2,183	148	13	0	3,482
02 – Dry bulk carriers	4	75	489	0	0	0	0	568
03 – Lo/Lo container ships	0	77	1,453	2,310	25	0	0	3,865
04 – RoRo car carriers	0	1	0	908	27	0	0	936
05 – Other cargo ships	108	400	371	13	0	0	0	892
06 – Foreign ferry routes	0	0	0	0	16,590	10,371	0	26,961
07 – Cruise ships	0	7	0	201	1,231	1,710	1,334	4,482
08 – Local ferries	1,026	0	0	0	0	0	0	1,026
09 – Other	238	17	0	0	0	0	0	255
Unspecified	0	0	0	0	0	0	0	0
Total	1,437	833	3,136	5,615	18,020	12,095	1,334	42,468

12.2 Appendix 2 – Port of Oslo – future scenario for 2030

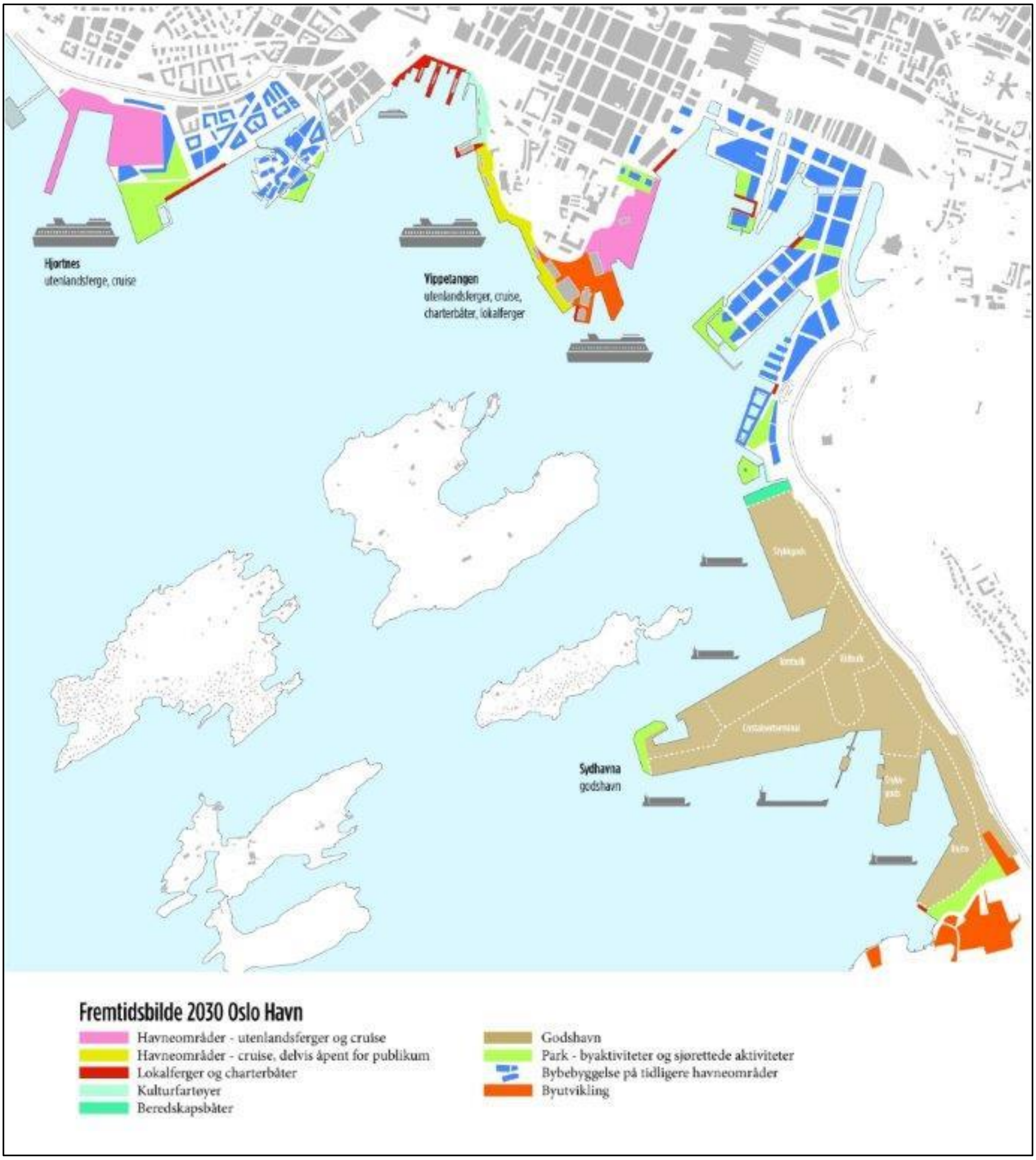


Figure 12-1: Future scenario for the Port of Oslo in 2030